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Strategy and implementation of the scientific work

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Joint research on systems analysis at Department BEN / Division BS: Mission, approach and planning

This paper describes the research objectives of the joint activities of the departments BEN (UFZ) and BS (DBFZ) up to the year 2025. The basic research theses, research fields and questions and approaches are supported and regularly updated in the TB6 research strategy of the UFZ and the roadmap of the DBFZ.

1 Research objectives

Progressive climate change and resource scarcity compromise the supply of sufficient food, energy and raw materials to a growing world population (WBGU 2011, UBA 2014). The transformation towards an increasingly renewable resource base and the management of the associated far-reaching changes is one of the major challenges of the 21st century (UN 2012, BMEL 2014). This results in new requirements for the use of renewable resources and the necessity to further develop the system are introduced.

The overall research goal of the departments BEN and BS is to support this transformation process in a system-oriented manner, i.e. across sectors, technologies and disciplines, as well as through forward-looking impact assessments, and to build up broad expertise for this purpose, which is based on the missions and core competencies of the two research institutions UFZ and DBFZ (for the history of origins and embedment: see appendix).

The aim is to research the sustainable use of renewable energies and the integrated material-energy use of renewable raw materials and biogenic residues and waste in the bio-economy as a contribution to the implementation of the Sustainable Development Goals (SDGs) of the United Nations (UN). In order to achieve this, social challenges, innovative technologies, economic effects and environmental concerns must be comprehensively taken into account and answers to the urgent issues must be provided both methodically and in terms of content using system-oriented approaches.

2 Research Theses

The use of renewable resources is characterised by a variety of influencing factors and interactions. The availability of land and resources is the starting point for the establishment of most efficient value-added chains, which should meet increasing supply requirements with innovative technologies. The stakeholders involved are diverse; they include actors along the value chain (producers, processors, service providers, users, recyclers or their association in clusters) as well as more far-reaching actors who design, evaluate and further develop the framework conditions (science, NGOs, trade associations, politics, media, etc.) The resources and value chains are spatially integrated. This requires contextualized analyses and options for action as well as suitable formats and media in order to put scientific findings into practice. The priority setting is guided by the following three hypotheses:

1st thesis: Bioenergy can contribute as a flexible renewable energy in combination with fluctuating renewable energy sources to a substantial reduction of GHG emissions.

The increasing use of renewable energies is the precondition for achieving the Paris climate protection goals and - due to their changed characteristics (such as low energy density, partly fluctuating supply, changed sizes and cost structures of the production plants compared to fossil energy sources) - requires the almost area-wide supply of electricity and heat from wind, sun and biomass as well as intermediate products that can be stored. The transformation of the energy system runs parallel in various areas (energy system transformation, heat system transformation, transport system transformation, etc.) and is only partially coordinated. The safe and sustainable provision of energy in this new and changing energy system will therefore be a central challenge. Wind energy and solar plants will be the central pillars of a renewable energy system. However, bioenergy, as the crucial bridge technology, makes this possible due to its storage capacity and its flexible and demand-oriented feasibility in the most diverse forms (solid, liquid, gaseous) and for any sectors (electricity, heat and transport). Apart from the combination with other renewable energies, bioenergy can also be combined with material biomass use options. For bioenergy, questions of system integration are therefore becoming increasingly relevant (cf. also Thrän (ed.; 2015): smart bioenergy). If the climate protection goals are to be achieved, the role of bioenergy will also increase considerably in the coming years. In the future, therefore, bioenergy will be needed less for the general coverage of energy demand, but more for meeting specific requirements of a sustainable energy system (flexibility, CCU/CCS, addressing path dependencies). As a technology in private households, bioenergy can contribute to the avoidance of lock-in effects (replacement of fossil heating systems by the same) in heating renovation. Moreover, bioenergy enables users to create a decentralised, independent and self-managed energy supply based on regional raw materials.

2nd thesis: Biomass is required due to its material properties as a renewable solution for material use.

To achieve a climate-neutral economy, the material use of biomass must increase. The combination of material-energetic use as well as the requirements for the (raw) material use of renewable resources therefore requires an extension of the systems analysis approach in the form of a comprehensive bio-economy. This, however, is much more complex not only due to the diversity of objectives, products and concepts/processes, but especially also due to the model of a comprehensive circular economy with diverse use cascades, changed material qualities and the associated intersectoral interaction. The increasing importance of the material dimension of the bio-economy will lead to a corresponding rededication of resources previously used for energy, which can call previous solutions and infrastructures into question.

3rd thesis: Interdisciplinary and multi-scale assessment approaches are necessary to shape the sustainable transformation to renewable energy systems and a bioeconomy.

This is aggravated by the fact that the sustainable use of renewable resources involves complex socio-economic and ecological interactions and their evaluation has not yet been satisfactorily resolved. The results that can be generated so far can, therefore, only be verified to a limited extent with regard to the achievement of objectives and certainty of direction, in terms of the desired transformation of the raw material base and necessary social and economic change. At the same time, the expected effects of various options for action can only be assessed to a limited extent with regard to foresight. Uncertainties include not only technical development dynamics but also the question of which actors and other influencing factors will affectsystem design and in which way. The Sustainable Development Goals (SDGs) adopted in 2015 and to be implemented by 2030 provide the framework for action and a suitable basis for evaluation. The 17 SDGs as political objectives of the UN are intended to guide sustainable development on an economic, social and ecological level. The provision of energy and materials on the basis of biomass should make the most comprehensive contribution possible to achieve these diverse sustainability goals. The research results so far have shown that the bio-economy, as a transdisciplinary, cross-sectional issue, affects social (SDG 1 and 2), ecological (SDG 6, 13, 14, 15) and economic aspects (SDG 7, 9, 12). However, in order to build up expertise and develop options for action and instruments, a focus on selected SDGs is necessary.

3 Fields of Research

If one follows these theses, there is a need for a comprehensive system view, which must take into account the dynamics and uncertainties mentioned above, from the individual procedure to the overall economic view and the political and social framework conditions. The system fundamentally considered in this context comprises the entire value chain of resource provision and use as well as their interactions with the natural and social environment in different geographical and temporal system boundaries. A more precise specification must be made depending on the issue at stake. The research fields of systems analysis are summarized in Figure 1.

The analysis for energy and supply systems on the basis of renewable resources shall:

(i) Identify the possibilities and limits of resource provision and use (systematicresource information),

(ii) Describe technology and supply options both intersectorally and with regard to the various sustainability dimensions, and map the possible development paths and assess their impacts (dynamic technology assessment),

(iii) Derive targeted instruments and develop adapted monitoring systems and indicators that can classify the transformation of the resource base (scientifically based implementation strategies) and

(iv) Prepare the methods and results in such a way that they can be understood and used in different social contexts (e.g. different actors or regions).

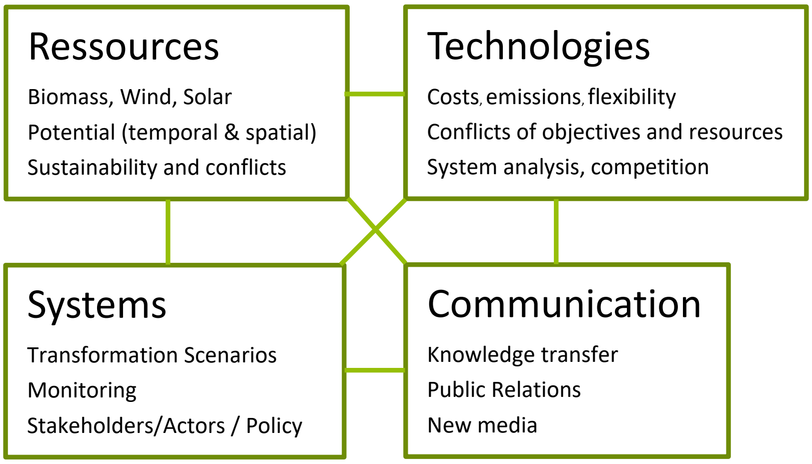

Figure 1: Research fields of systems analysis

Solutions for SDG 7 (Energy), 12 (Sustainable production and consumption) and 13 (Climate action) are being developed.

The focus of BS is on application-oriented questions, such as current biomass availability and its use status, development and evaluation of concepts for the integration of biomass into the energy system or agricultural and industrial material cycles as well as the evaluation of use concepts and necessary political and administrative measures for their implementation.

On the UFZ side, the focus is on the system perspective and the connection to modelling expertise. Spatial location and social aspects are considered, as well as non-biogenic renewable resources (wind and solar).

4 Research Questions

The research fields are supported by research questions in the following.

4.1 Systematized resource information: How does the availability and accessibility of renewable resources develop?

Information about the supply and current use of renewable resources is key for the strategic evaluation of possible options for action. To fulfill this purpose, transparent and efficient monitoring systems on various scales (from regional to global) must be developed and linked across institutions. Since the results are essentially input data for further systems, special emphasis is placed on an user-friendly and dynamic provision of results.

The evaluation of local or regional optimisation strategies requires extensive and spatially differentiated information (e.g. availability of raw materials, motivation of stakeholders and shareholders, technology park, infrastructure, actual production, actual demand, etc.).

4.2 Dynamic technology assessment: Which generation technologies make what contribution to a sustainable supply and how does it change over time?

4.2.1 How can the technologies be presented systematically?

On the one hand, the technology assessment should aim to record the partly, very heterogeneous technology options in their current form in a standardized way and, on the other hand, to design them in such a way that technical developments can be mapped over time. A starting point for this can be a categorisation of existing technology options, which allows a categorisation and simplified description of the determining techno-economic indicators in a defined scheme and covers the areas of CHP, heat, fuels and bioeconomy. With a unified nomenclature, different technology options can be recorded, tracked (monitored) and their potential assessed-, and standardized- interfaces to modelling activities can be provided. Based on this structured know-how, the development potential of bio-based key technologies is evaluated. This assessment is carried out by defining development scenarios and modelling individual technologies, as well as by modelling certain subordinate systems of the bio-economy (e.g. biofuels, HTP, BECCS) in order to assess the possible effects of implementing these technologies on various assessment scales (regional, national, global).

4.2.2 How can the technologies be integrated into the requirements of food security, climate-neutral energy supply, recycling management, etc.?

Supply systems based on renewable resources require a comprehensive circular economy approach, because renewable resources are also associated with costs in their provision and are characterised by various (ecological, economic and social) limitations with regard to sustainable use. A comprehensive transition from the current "end-of-pipe economy" to a circular economy thus forms an important basis. It requires both a more detailed description of the system and a variety of regulatory adjustments. Challenges for research here are a holistic system description of the use of renewable resources and the derivation of material flow scenarios under different boundary conditions. To ensure that these considerations remain manageable, the SDGs 7, 12 and 13 form the starting point for the central considerations, while the expansions to other SDGs are carried out with various cooperation partners.

4.2.3 What contribution can technologies make to a sustainable material and carbon balance (cascades, CO_2 use, negative emissions)?

In order to achieve the ambitious climate protection goals, greenhouse gas emissions must be drastically reduced. This means a reduction of material flows, an extension of lifetimes and the establishment of cascade uses and the permanent separation of. CO_2 The necessary technological approaches will be described and evaluated with regard to their market introduction options (costs, market entry barriers, markets for biogenic CO_2, carbon storage forms, combination with PtX, social effects etc.). The CO_2reduction potential, through the material and energetic use of biomass, should be described and evaluated against the background of achieving negative emissions. Furthermore, the effects of associated changes in priorities of use are to be considered from a system perspective. In this way, it will be promising to identify and evaluate the possible trade-offs between the energetic and material use of biomass and the CO_2emission reduction potentials.

4.2.4 What are the concepts and scenarios of an environmentally and cost-optimal system integration (e.g. bioenergy in transport, flexible electricity supply, coupled material and energy use)?

"The conversion of the current systems of use should [...] be carried out by 2050, taking into account future demands on the type and quality of raw materials and the changing demand for energy services. This means that bioenergy should be used in such a way that the benefit for the overall system is maximized (flexible provision of electricity and heat, marine and aviation fuels, industrial high-temperature processes, etc.). The expectations for bioenergy are constantly changing depending on the development of the rest of the energy system, for example the spread of electromobility and the development of storage systems and processes for generating fuels from wind and photovoltaic power (power-to-gas, power-to-liquid). In order to meet the requirements of the future energy system and climate protection, [...] priority should be given to the conversion of biomass already used for energy purposes." (Klepper, G., Thrän, D. (2019): Biomass in the field of tension between energy and climate policy. Potentials - Technologies - Conflicting goals). From an economic perspective in particular, it is decisive in which sectors and in what form the limited use of bioenergy should take place. Crucial to this is the consideration of technological alternatives in the respective sectors and the different requirements for biomass-based technologies (e.g. demand-oriented energy supply). Scenarios are understood as possible future scenarios that are developed, taking into account influencing factors. With the help of scenarios, possible (transformation) paths can be shown, system interrelationships can be better understood and consequences of current decisions can be derived. Further scenarios for current political and economic issues are to be developed or existing scenarios are analysed and expanded. Assistance for the presentation and interpretation of the results from numerous scenarios, in connection with the influencing factors and methods are to be developed.

4.3 Science-based implementation strategies: Who can support and implement the sustainable transformation from a fossil to a renewable resource basis, and with which measures?

The basis for the development of scientifically based implementation strategies is the question of how to comprehensively describe and evaluate the material-energetic use unde aspects of sustainability and under consideration of the spatial and temporal contexts. This requires considerations of the overall system (see above), which in part must be expanded to include the stakeholder perspective and the involvement of other social actors. On this basis, national and regional strategy elements for the bio-economy, energy policy and climate policy can be derived, concrete policy instruments (e.g. renewal approaches) can be proposed and further developed, but also further-reaching instruments for the identification and reduction of risks (e.g. certification approaches) can be inferred. The set of instruments also includes the development of approaches and indicators for describing and evaluating transformation over time and comparing it with the goals-set (monitoring).

4.4 How can the scientific results be brought to the relevant target groups in an appropriate form?

Networking & transfer: The aim is to ensure that the research activities of BEN/BS are more widely disseminated nationally and internationally and that the staff are increasingly networking with actors from R&D, politics and industry. At the national level, the focus is particularly on the BMWi research networks and the exchange within the framework of the doctoral colloquium as well as the participation in regional and national advisory boards and "councils" (Climate Advisory Council Thuringia, Bioeconomics Council, etc.). In the EU context, the participation in EERA and in important technology platforms (ETIB, Heating and Cooling Platform, IEA bioenergy tasks) is envisaged. In the international field, cooperation in the IEA bioenergy task and international rollout strategies are to be intensified. Furthermore, the preparation and development of standards, certification systems and terminologies of biomass in the energy system and the support of ongoing standardisation activities (ISO standards) are an integral part of the BS activities in cooperation with other DBFZ divisions.

The transfer of knowledge and results is achieved primarily through various target group-specific formats in the areas of events, communication, PR/media, training and further education, as well as publications. The measures result in joint specific products, such as recommendations for action, statement papers, rollouts of proven methods (e.g. raw material monitoring, feasibility studies) and e-learning courses. Furthermore, new formats and media are to be developed and used.

4.5 Fields of research and related questions

In the following box, concrete questions are compiled from the research fields in Figure 1, based on the overarching research questions in Chapters 4.1 to 4.4.

Box 1: Specification of questions for the system analysis "Renewable Resources", status May 2019

1. **How is the availability and accessibility of renewable resources developing?**
   - Which factors determine land use for wind and solar energy?
   - Which quantities and qualities of biogenic raw, residual and waste materials are where, to which time and under different (ecological, economic and social) boundary conditions sustainably available?
   - Which drivers influence resource availability to what extent (including which actors with which expectations and preferences)?
   - How can the expansion of renewable energies be analysed regionally and what are the differences?
   - At which locations are there still potential for RE expansion or which expansion paths make sense for a sustainable energy system transformation?
   - What other overall effects can be expected from expanding resource use?

2. **Which generation technologies make what contribution to a sustainable supply and how does it change over time?**
   - How can the performance (e.g. costs, emissions, efficiency, flexibility etc.) of a technology be assessed?
   - Which boundary conditions (e.g. sustainability criteria, costs and dynamics of competing technologies, factors influencing the availability of biomass, potential for negative emissions) drive technology developments and their market entry in the bioeconomy?
   - How can the system contribution of the material and energy use of biomass (e.g. energy, carbon cycle) be described and evaluated?
   - How can system integration be organised in specific study areas/for specific supply issues (e.g. energy, carbon cycle)?
   - What role could/should biomass play within energy system transformation in order to achieve climate objectives in a cost- and GHG-optimal way, and how can conflicting objectives be quantified?
   - Which business models are available for existing and new plants?

3. **How and by whom is the transformation of the raw material base from fossil to renewable as a whole (energetically and materially) sustainable?**
   - Which expansion paths for renewable resources require a sustainable energy system transformation?

- How can the future combination of material and energy use be comprehensively described and evaluated from a sustainability perspective? How can transformation paths and bioenergy concepts into the overall system be examined with the help of scenarios?
- What strategies does the bio-economy need at national and regional level?
- What are the effects of use from the nexus perspective (energy - water - land area - food)?
- Which parameters characterize the transformation?
- How can this transformation be accompanied and supported by functional monitoring systems? What contribution is being made to the political goals of sustainable development and the transformation of the raw materials base? (especially SDG 7, 12 and 13)
- In which sectors does actor behaviour influence a sustainable transformation, how can this be analysed quantitatively and how can preferences for a sustainable transformation be integrated efficiently?

4. How can the scientific results be brought to the relevant target groups in an appropriate form?

- Who are the relevant target groups and how to reach them?
- Which networking and transfer formats are suitable, especially considering the cost/benefit perspective?
- How can new media and innovative formats be used for knowledge transfer?

5 Approach - methods, models and data

A variety of methods and models are used to answer the research questions. These are adapted and applied according to the task and cover a wide range of possible subjects of investigation. The methods are used to determine and analyse technical, economic, social and societal parameters and the various ecological and socio-economic effects.

Potential assessments are an important part of research to determine the extent of current and possible use of biogenic raw, residual and waste materials. GIS-based methods represent a central tool for this purpose. It must also be considered that biomass is also traded worldwide.

GIS-based analyses are also used to study future energy supply, where wind and solar energy are important components in addition to biomass. When expanding the relevant technologies, conflicts over land use and environmental effects must be investigated, for example with regard to competing water uses or the threat to biodiversity. The time-variable generation of electricity from fluctuating renewable energies also poses a challenge, which is analysed using various methods and models.

When analysing different options for the use of biomass - from electricity or heat generation, fuel production, as a raw material for the chemical industry or for other material uses, as well as for capture and storage or for the use of CO_2 from the atmosphere (BECCS/BECCU) - a holistic analysis is required. For this purpose, life cycle assessments (LCA) and economic efficiency calculations are central, which are supplemented by innovative methods, such as social or regional LCA. Simulation and optimization models support these analyses and integrate many of these aspects in increasingly holistic system analyses. This makes it possible, for example, to determine the effects of political decisions on the future use of bioenergy and to model socio-economically optimal target systems.

Further methods are necessary for analyses of the design of control instruments at different levels. Here, certification approaches represent a possibility for risk reduction; they are being further developed at BS. In parallel, dialogue-oriented approaches to risk identification are being pursued on the BEN side. Multi-criteria evaluation approaches and indicator systems are also used to classify the development of the transformation and to evaluate it through monitoring systems. In addition, interfaces are systematised and data is catalogued in order to provide comprehensive support for the development of knowledge.

With developed tools, sustainable options are specified for the transformation of the resource base, use of technology and energy system change. For example, in the case of limited space and diverse usage requirements, a continuous increase in resource efficiency should be created, or conversion plants should be placed in such a way that the functions of the environment are fully maintained or even improved. As a result, realistic goals and steps for the transition to a more renewable resource-based economy will be defined. The resources such as sun, wind, hydropower and biomass are considered, whereby biomass is the most complex in the study.

6 Interfaces and cooperation

The following interfaces are seen for the content and methodological design and processing of research questions in the FOEN and NB:

- The **resource analyses** of the DBFZ/BS focus on the material-energetic use of biomass, the work of the UFZ/BEN considers the other systems of renewable resources (e.g. other renewable energy sources). For Germany, spatially resolved information systems are available. In interaction with these systems, the state of use of renewable energies can be presented in spatial-temporal details.
- In the field of **technology analysis**, both areas jointly contribute to the analysis and evaluation of technical systems for the use of renewable resources. The aim is to achieve close coordination with the technical departments of the DBFZ and TB4 of the UFZ, as well as with the social science departments (TB6) of the UFZ. The work of the DBFZ/BS focuses on technical, economic, ecological and social parameters. The work of the UFZ/BEN tries to integrate further - especially environmental and social scientific - dimensions.
- For **system assessment**, the work of the DBFZ/BS focuses on the application and further development of established socio-economic methods (e.g. LCA, cost-benefit analyses, smart bioenergy indicators, etc.). The work of the UFZ/BEN has a stronger focus on the development and testing of new evaluation approaches (e.g. sLCA, spatial LCA) and model-based optimisation. In scenario development, different methods are applied in each working group (and often in cooperation with external partners). The aim of the cooperation is to support the model development by providing application-oriented data

(on the part of BS) and to enable the promopt the wide use of the assessment approaches by providing simplified meta-models (on the part of BEN). In such a joint development, the quality of both methods of system assessment will be greatly improved. The inclusion of temporal and spatial dynamics is of great importance.

- In the field of **communication**, BEN and NB each have experience with different target groups in science, politics and society in the form of policy papers, manuals, decision support tools, monitoring approaches and proposals for certification systems. First common strategies have been initial tested (e.g. statement on bio-economy), however,with regard to research, the focus and definition of interfaces are still pending.

An important goal in the medium term is the step-by-step development of a (common) model system that can map the functional relationships and generate scientific statements about the overall system of renewable resources, at the technology-environment interface with high temporal and spatial resolution (in sub-areas). For the BEN Department, understanding the complex systems and answering the research questions addressed in POF4 (see Annex A2) is central in order to further develope and integrate the models to successfully design a transformation. It is also a priority of the department to process different questions concerning the implementation of sustainable bioenergy and bio-economy concepts. The guiding principle of "smart bioenergy" is decisive in this context.

Furthermore, the following strategic cooperations are relevant for answering the research questions:

- For **resource analyses,** in the context of the material-energetic use of biomass, cooperation with raw material-specific experts/institutions from the fields of agriculture, forestry and waste management is required. In addition, cooperation with industrial partners who use or plan to use the corresponding raw materials must be intensified. For resource analyses of non-biogenic renewable options, cooperation with other interdisciplinary scientific institutions is important. Especially for the topic of wind, there are numerous conflicts of objectives in nature conservation, the evaluation of which requires a broad range of external competences and cooperation.
- In the field of **technology analysis**, cooperation with relevant practitioners and application-oriented science should be sought on a case-by-case basis.
- For **system evaluation**, external cooperation is needed to develop and test new assessment approaches (e.g. sLCA, spatial LCA) and model-based optimization methods, especially with energy system (electricity, heat), land use and (macro)economic models. Furthermore, the holistic approach to system modelling requires expertise on demand developments in the sectors under consideration, which can be supplemented by building and transport models, among other things. Further cooperation on renewable energies for the development and analysis of integrative RE concepts is desired. In order to cover the social aspects of (bio)energy use, cooperation with experts in this field should be pursued.
- For communication and transfer, strategic cooperation partners will be defined in the further specification of the implementation.

7 Measures to implement the research objectives

In order to implement the research objectives, measures are required that focus on the further development of methods (and models), the provision of systematised data and the elaboration of key results. These should be generated and established step by step (Figure 2).

The **method development** includes

- Tools for systematising resource data for regular data provision (1)
- Further assessment approaches, especially of risks of future resource availability (2)
- Tools for systematisation of technology parameters/charts of reference (3)
- Extension of the parameters of future technology options under consideration of markets, drivers and barriers in technology-specific system analyses (4)
- Models for system description, which, based on the status quo, show development paths both for the overall system of renewable resources and for subsystems (especially energy sectors) (5)
- Tools for further assessment of renewable resource systems, in particular policy analyses, technology assessments and uncertainty analyses (6)
- Further assessment approaches for the analysis and design of regional renewable resource systems (7)

Methods are developed and tested using case studies (marked (a)) and, based on these, a cumulative evaluation of the case studies and further information (meta-information, marked (b)). The methods are made available in easily accessible tools and easy-to-understand manuals.

Consistent data is central to the various target areas. They should be updateable, transparent, clearly retrievable, stored in databases and organized with data management systems. They include:

- Time series of supply and demand of solar, wind, biomass and possibly other renewable resources in high spatial resolution (8)
- Information on the current state of use of renewable energies and resources in high spatial resolution (9)
- Bandwidths and background information on scenarios (especially the bio-economy) (10)
- Consistent depictions of the sustainable use of renewable resources in the future (11)
- Monitoring the development of renewable resource systems or sub-systems (including energy sectors) (12)

The consistent data are to be established in a basic logic (ontological) and also gradually extended beyond Germany. Quality requirements for an easy transfer will be taken into consideration at an early stage.

Based on the consistent data, **key information** is to be compiled as aggregated results for the various target areas, i.e.

- Aggregated information of supply and demand for renewable resources (in different spatial and temporal resolution) (13)
- Aggregated information on the performance of technologies for providing electricity, heat, fuels and materials from biomass in combination with other renewable resources (14)
- Aggregated information on the system contribution of renewable resources (with different spatial and temporal resolution) - both as transformation and target paths to achieve closed carbon cycles (15)
- Systematically obtained recommendations for action / instruments to achieve the identified system contributions (16).

The key information should be displayed in corridors with references to uncertainties. Adapted methods and formats will be developed for the transfer of key results, but also for the transfer of methods and "data" (start: 2020).

	2019	2020	2021	2022	2023	2024	2025
Methods - Resource analysis	1a	1b	2a		2b		
Methods - Technology analysis	3a	3b		4a		4b	
Methods - System analysis	5a	6a	7a			5b	6b
Methods - Transfer		*Start*					
Data	8	9	10	12		11	
Key Information		13			14		15 (16)

a) Testing on the basis of case studies,
b) Cumulative evaluation and generation of meta information

7.1 Short term implementation and measures

The short-term milestones for achieving the research goals are regularly updated and reviewed in the roadmap of the DBFZ and in the short-term goals of BEN.

A 1 Background: anchoring BEN and BS in the research institutions UFZ and DBFZ.

With the foundation of the Bioenergy Department at the DBFZ (2008) and the establishment of the Bioenergy Department at the UFZ (2010), the cornerstone was set for the development of system analysis of bioenergy and renewable resources. Since then, it has been continuously developed further, taking into account social developments and scientific findings, while referencing the strategies of the superordinate institutions (DBFZ and UFZ).

The resulting research profiles for the work units BEN and BS represent partly for themselves, but due to the complementary anchoring in two different research institutions, they offer extraordinary possibilities to approach upcoming questions in a scientifically networked way.

The aim of this paper is therefore to derive the research priorities and approaches of BEN and BS from their respective strategies and, building on this, to develop a common approach in which the core competencies can be developed well and synergies can be fully exploited. It is based on the white paper BEN/BS of July 2015.

A 2 Mission and Motivation: The BEN Department at the UFZ

Progressive climate change and resource scarcity are endangering the supply of sufficient food, energy and raw materials for a growing world population (WBGU 2011, UBA 2014). The transformation towards an increasingly renewable resource base and the management of the associated far-reaching changes is one of the major challenges of the 21st century (UN 2012, BMEL 2014). System understanding and forward-looking impact assessments can support the transformation process. The UFZ has comprehensively embraced this task in its mission (see Box A). Systematic research in both natural systems and selected production systems is considered necessary (UFZ strategy paper). As part of the Helmholtz Association, the UFZ carries out research in the medium and long term.

Box A: The mission of the UFZ

"The employees of the Helmholtz Centre for Environmental Research - UFZ are united by the goal of showing ways to reconcile social development with a healthy environment in times of global change. To this end, the internationally oriented UFZ creates well-founded knowledge to permanently safeguard the natural foundations of life and the opportunities for human development. It makes use of extensive expertise in the natural sciences, engineering and social sciences and many years of experience in integrated research to identify complex problems in the environment and society at an early stage and to develop precautionary solutions. Professional infrastructures, a trend-setting programme and the dialogue with all relevant actors in society make it possible to provide politicians, the public and the economy with needs-oriented knowledge and technological solutions.”

The research is organised in six thematic areas - the BEN Department belongs to the "Environment and Society" thematic area. It is dedicated to the systems analysis of material-energetic use concepts for renewable resources and their interactions, with the aim of describing them in a forward-looking manner with regard to sustainable design and developing methods to test the success of the transformation. A fundamental understanding of current and future supply technologies and their integration in the natural environment, is the basis for the knowledge-based support of decision-makers in the fields of renewable energies and bioeconomy. The interaction between technical system solutions and the changing pressure of use on the environment and society is a central issue that will be integrated into the research programme "Earth and Environment", Topic 5 (Dynamics of the Terrestrial Environment & Freshwater Resources under Global and Climate Change). The tasks of the next research period (POF4) are defined as follows:

Sustainable renewable resources and energies 2050. *The research on renewable resources will build on assessing decision-making in highly uncertain and regionally differentiated processes, such as the energy and bioeconomy transformations. We will contribute by developing* ***spatially explicit implementation scenarios, indicators and governance arrangements*** *with integrated assessment and systemic approaches. In doing so, our focus is on the nexuses of energy sector coupling; of energy with material use and cascading issues of new bio-based materials; and between new bio-based materials and bioenergy with carbon capture and storage. We will integrate these nexuses in a comprehensive way at the landscape level for Germany (ST5.4) by spatially explicit modeling and by life cycle assessment of renewable energies and bio-based products (RF Energy and Topic 7). This will be embedded in an analysis of human and societal drivers, impacts and governance options (in order to identify policy options and preconditions for a successful transformation of* *the German energy system (Energiewende). In addition, we will explore scenarios to translate our research results into internationally viable lessons for achieving the SDGs for both renewable energies and renewable resources.*

Deliverables and milestones.

- *D5.18 (2027): Scenarios, indicators and governance arrangements for sustainable renewable resources and energies. M5.18-1 (2022) Spatially explicit modeling and life cycle assessment of renewable resources and energy at landscape level in Germany. M5.18-2 (2024) Analysis of drivers, impacts and governance options for a successful transformation of the German energy system. M5.18-3 (2027) Policy recommendations for achieving the SDGs for renewable energies and renewable resources.*
- *D5.21 (2027) Barriers and enabling factors of transformations towards sustainability.*

A 3 Mission and motivation: The area BS at the DBFZ

Limited resources and diverse areas of demand pose new challenges for the use of biomass in the energy system. The DBFZ has adopted, as its mission, the sustainable provision of biomass, its conversion into material-energetic coupling and cascade systems and its efficient use integrated into the overall energy system. The Smart Bioenergy Concept (BoxB) was developed as a mission, which is supported by five research focal points on the level of process and technology development as well as on the level of overall conception and evaluation. The research focus "System contribution of biomass" is assigned to the BS division. Its aim is to further develop concepts for smart bioenergy use, from the mobilisation of raw materials to the continuous analysis and evaluation of current use and sustainability assessment for material-energy applications, in close cooperation with the technical division of the DBFZ.

Box B: The Smart Bioenergy Concept

Smart Bioenergy comprises the further development of modern biomass utilisation systems towards integrated systems, which, on the one hand, consist in the optimised interaction with various renewable energy sources and, on the other hand, the combined material-energetic use within the framework of the bio-economy. This presumes changed consumption patterns, energy savings and an increasing demand for sustainability with changing target values. The concept thus makes an important contribution to a sustainable energy supply in the future.