Summary

Project Report “Renewable Energy Projects in Coal-Mining Regions – A Contribution to Structural Transition?”

On behalf of the Federal Ministry for Economic Affairs and Energy (BMWi)

Berlin, October 26, 2018

Key points in a nutshell

1. Increasing the use of renewable energy (RE) and Power-to-X (PtX) systems can contribute to economically successful structural transition. Taking the region of Lusatia as an example, this study shows that by expanding renewable energy and energy efficiency in the electricity and heat sectors and through contributions to a transition in the mobility/transportation sector, the potential is generated for at least several hundred, possibly even several thousand jobs to be created.
2. Expanding photovoltaic and wind energy in open-cast mining areas offers substantial opportunities, especially deployed in tandem in the form of so-called hybrid large-scale power plants. Hybrid power plants can use freed-up grid capacity, leverage expertise available in the districts, and be built in parallel with the gradual reduction of coal-fired power generation. They also provide a basis for increased development of PtX plants. For the Lusatia region case study, the planning, construction and operation of the technologies mentioned here alone will result in up to 1,000 full-time equivalent jobs, irrespective of further employment potential from the production.
3. Specific measures are needed to exploit technological and regional economic potential. Actors from the federal government, the German federal states (Länder) and the municipalities must work together. Instruments for spatial planning and management of the facilities in the districts must be examined (e.g. special tenders, planning measures). The greatest possible local economic benefit must also be ensured through appropriate measures (e.g. revenue from taxes or fees, participation in investments, etc.). These measures are intended to keep value creation and employment in the region, and thus increase overall acceptance.
4. Attracting large, labour-intensive employers such industrial enterprises, non-academic research institutions or federal and state authorities is to be explored in its full implementation potential. However, it should be considered that large industrial companies are subject to (a generally global) market logic. Considering the development of the entire region, its prevailing structure around small- to medium enterprises, as well as the spectrum and diversity of energy transition potential, it is likely that a more fragmented and distributed research and economic development strategy would lead to more resilience.
5. The provision of suitable and available land can only take place within the mining regions themselves. The questions of availability and legal approval to secure suitable sites must be answered jointly with the regional actors. This requires a discussion of conflicts of use, particularly with nature conservation and protection of species, but also potential synergies with other options for reuse. Potential supporters must be identified and included as partners.
6. The findings and recommendations from this study focused on the Lusatia case study. However, they are in large part applicable to all coal-mining regions. To develop solar PV, wind or hybrid power plants on a larger scale, there is a need not only for instruments, but also for pioneers who – under the conditions of significant economic participation – want and can implement these projects.
7. For a targeted development of the broader range of possible energy transition areas, we recommend a specific support fund, which would allow municipalities in the coal-mining regions an individually-tailored composition of suitable climate protection measures and enable adequate financing.

Summary

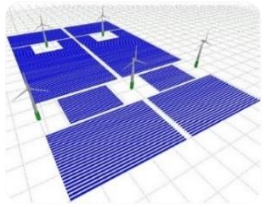
Background and Approach

Achieving climate protection goals will require gradually reducing the use of fossil fuels, particularly coal-fired power generation. The prerequisite for this is a socially just lignite coal phase-out in combination with the exploration of alternative economic prospects in the affected coal-mining regions. Implementing the energy transition – ranging from energy supply and energy savings to mobility – can contribute to this.

This report „Renewable Energy Projects in Mining Regions – A Contribution to Structural Transition?“ examines the question of which economic perspectives arise from an increased implementation of various energy transition areas.

The potential and effects of **solar photovoltaics** (PV) and **wind** energy are the focus of this study. These two technologies are analyzed in depth and depicted more precisely. Existing grid infrastructure and repurposing options for mining areas generally provide good conditions for capturing PV and wind potential. In particular, combining these technologies in wind-PV hybrid systems offers an innovative approach that enables the integration of already existing local skills, companies and employees in the region.

Wind-PV-hybrid systems combine the use of wind energy and photovoltaic (PV) within a power plant. **Surface-and grid infrastructure are jointly used in an efficient way**. In addition, the PV and wind power profiles complement each other over the course of the year, resulting in **more stable power generation**. Such hybrid power plants on a gigawatt scale are currently being built in multiple regions around the world, particularly due to the low production costs of both technologies.



Given the rapid increase in fluctuating quantities of electricity on the grid due to the expansion of photovoltaics and wind energy, the construction of **power-to-x** systems (PtX) may be beneficial. In this context, the generation and adoption potential of these technologies was also considered in greater depth. Other aspects of renewable energy, energy efficiency and mobility can also contribute to economically successful structural transition, which is why the potential effects have been analyzed more broadly (though without specific modeling).

This study looks at the **four German coal-mining regions**: the Lusatia coal-mining region (Lausitz), the Middle German mining region (Mitteldeutsches Revier), the Rhineland coal-mining region (Rheinisches Revier) and the Helmstedter coal-mining region (Helmstedter Revier). The analysis of PV and wind energy potential as well as hybrid power plant potential was carried out for all open-cast mining sites except for the Helmstedter region, as sufficient data for this region was not available. Both **active** and already **decommissioned, passive open-cast mining sites** (coal-mine rehabilitation sites) were considered. Particularly in the Lusatia region, there are geotechnical restriction areas with increased risks, in which only a very limited use is permitted.

Using a GIS-based land use system, the **wind and PV potential** in the regions was estimated, including possible PV-wind-hybrid systems. Building on the resulting estimated potential, the analysis of the **PtX potential** and consumer structures was carried out for the three investigated coal-mining regions.

A more in-depth analysis of regional economic effects and their prerequisites could only be carried out for one coal-mining region within the scope of this study; in consultation with the client, **Lusatia** was chosen as the **case study**.

Since the **regional economic analysis** relates to the entire Lusatia region, wind and PV potential for the entire Lusatia region was estimated in addition to the potential specifically in the open-cast mining sites. In parallel, potential local value creation and employment effects were also identified and modeled in detail. Similarly, the value chains for the investigated PtX technologies were also modeled and the effects estimated. Furthermore, the case study addressed additional potential from other components of the energy transition and summarized their potential effects. The case study provides specific recommendations for the analyzed coal-mining region as well as a variety of findings that may be transferrable to other regions.

Legal analyses were carried out comprehensively and in interplay with the findings of the potential and regional economic analyses, particularly regarding land protection matters, location-based control of plant construction and the feasibility of economic participation in the coal-mining regions.

Resulting from the potential analyses, the in-depth case study on Lusatia and the legal analyses, this report formulated comprehensive cross-cutting **recommendations** for all coal-mining regions as well as proposals for instruments for active players at different political levels.

Figure 1: Research design – inductive approach

For methodological reasons (related to technology and cost development), a **target year** was selected for the scenarios, as both the estimated potential and the possible regional economic effects had to be determined for a specific year. The year chosen for modelling this scenario, 2030, can be adapted in line with the fossil-fuel phase-out. The fundamental effects and interrelations do not change significantly, but rather shift accordingly. The choice of the target year thus does indicate any implications on the period or extent of reduction in coal-fired power generation in the coal-mining regions.

Potential and Effects

Potential for wind energy and photovoltaics as well as hybrid power plants in the open-cast coal-mining areas

A **differentiated, GIZ-based area analysis** served as the basis for the potential analysis of wind and PV power plants on the mining areas within the investigated open-cast mining regions.

Plans that were not digitally available, particularly the lignite coals plans including statements on the planned subsequent use of these areas, could not be included in the study. Areas deemed unsuitable were excluded, whether due to the designated land use, applicable regulations on distance, designation as protected areas, use as a military training area, or, with regards to PV, due to high plate numbers. For the resulting areas identified within the open-cast mining areas, the potential for PV, wind and PV-wind-hybrids was then determined based on technical and economic assumptions. The **baseline scenario** assumes that the use of wind energy will have an 80% utilization rate in the identified areas, at least a 70% “site quality” index, and that existing facilities will be repowered. The utilization rate assumes that 20% of the theoretically identified potential is available for other uses that are not compatible with wind turbines. In the baseline scenario for Lusatia, the restricted areas were completely excluded, i.e. their possible future use was not included in the calculations. Utilization quotas for the PV potential was differentiated by land use and only coherent areas of at least ten hectares were considered.

The values determined on the given assumptions reveal a heterogenous picture of the potential for the mining regions: **all areas have significant potential, but in different composition, as shown in the accompanying figure**. This can be specified as: in the Lusatia region, just under 2 GW potential for wind energy and around 9 GW potential for PV were determined. With 4.5 GW, the Middle German coal-mining region has high potential in solar, but little in wind energy. With more than 1 GW each, the Rhineland coal-mining region has potential for both technologies.

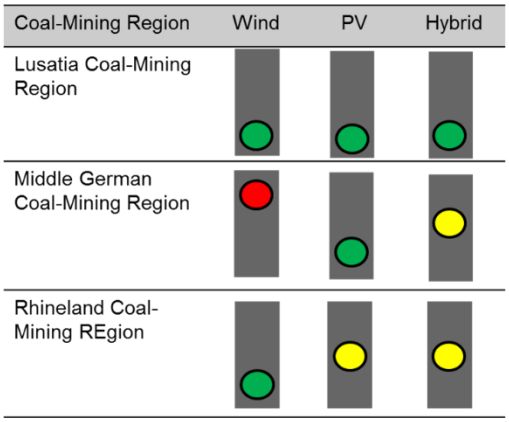


Figure 2: Wind, PV, and Hybrid in Coal-Mining Areas

The renewable energy potential shown here reacts sensitively to changes in the given assumptions and is therefore considered a first estimate of the extent to which there are potential uses for wind energy and PV, as well as possible hybrid systems, in the analyzed open-cast mining areas. It is not possible to make concrete statements about implementable potential. In the context of the planning procedures as well as the approval procedures for specific plants, further restrictions may apply, for example, through **possible conflicts** with other repurposing using, such as for leisure and tourism as well as nature and species conservation. Despite these potential limitations, however, the estimated potential remains significant even if there are substantial shortfalls of the scenarios considered in the study (see below). Dialogue with regional planners and decision-makers as well as land owners will be required to develop suitable sites, solve conflicting goals and develop possible regional economic effects (see below).

Potential for PtX-plants in Lusatia

Power-to-X allows for flexible energy consumption using electricity, which, during times of electricity surpluses and network congestion, cannot be transported to the electricity consumer. In addition to battery storage, materials such as syngas (**power-to-gas, PtG**), which binds energy through electrolysis and catalysis processes, serve as a storage medium. The electricity can also be converted into heat and then stored or fed into heat networks (**power-to-heat, PtH**).

All three investigated coal-mining regions have PtX potential. Both in Middle Germany and in the Rhineland coal-mining region, the consumption potential is significantly higher than the calculated potential generation. In comparison, the Lusatia region is particularly well suited as **a pilot region / real laboratory for PtG and PtH projects**: combining a high generation potential for wind and solar power with a high consumption potential in the investigated radius of about 200 km, which includes the potential for the Middle German coal-mining region, under good conditions. The hydrogen produced, in particular, could be used in the industrial sector, fed into the natural gas network, or used in public transport. The potential for PtH can contribute to a proportionate replacement of district heating from lignite coal-fired power plants. Although renewable electricity should primarily be used directly, potential shortages in the power grid with rapidly increasing generation make regional electricity use appear sensible for PtX projects.

Regional economic effects through the expansion of wind, solar and PtX plants in Lusatia

In the context of the Lusatia case study, possible regional economic effects were calculated based on further development of wind energy, photovoltaics, PV-wind-hybrid power plants as well as PtX plants in the entire region for the target year (see above). For this calculation, a gradual expansion of technologies up to the target year was adopted in accordance with the baseline scenario. In addition to the detailed analyses on the open-cast mining areas, further wind and solar potential in the region was estimated – based on available energy plans – to analyze potential for local value creation and employment. Furthermore, the energy transition-based economy in Lusatia was examined to demonstrate reliable and sustainable developments.

For the target year, the results show that the planning, installation and operation of the open-cast mining facilities between 2018 and 2030 alone would generate a **regional added value of over € 120 million and would have an employment effect of more than 1,000 full-time equivalent jobs.**[1]

The employment effects of the production of renewable energy power plants and components were not included in the study for the target year, as future developments with manufacturing are dependent on a large number of factors and can therefore not be estimated reliably for the target year; Lusatian-based manufacturers currently employ around 1,250 people. If the current production conditions remain the same, more than

[1] A full-time equivalent (FTE) is a unit of measurement that corresponds to the working time of a full-time employee. For example, a half-day job corresponds to a full-time equivalent of 0.5.

2,000 employees will be hired for the target year. Expanding production capacity in the production of power plants and components could create additional jobs in the region.

As shown above, the potential for wind energy and photovoltaics (including PV-wind - hybrid) on open-cast mines reacts sensitively to changes in the assumptions. If only half of the calculated potential is realized, this cannot directly be translated into halving the potential regional economic effects. In the case of larger renewable energy projects, it was assumed that only a portion of the work related to the construction and operation of the installations was covered by regional companies and only a share of the capital to finance the investments of companies is contributed by citizens in the region. If the number of wind and PV projects on open-cast mines decreases, the proportion that can be implemented and financed by companies and investors based in the region increases in relative terms. In addition, the construction of smaller facilities such as PV roof systems occurs regardless of the restrictions on the open-cast mining areas. As a result, it can be assumed that, if the wind and PV development on coal-mining areas is halved, it is possible to exploit significantly more than half of the identified value creation and employment potential.

Regional economic effects through further energy transition areas

In addition to the technologies focused on in this study, there are many other energy transition areas that can generate **added value and employment effects in the region**, some of which are significantly high. These include other renewable energies in the electricity and heating sectors, such as solar thermal energy, heat pumps, the use of biomass for energy purposes (e.g. the provision of biogenic fuels). The area of energy efficiency also holds potential for the energy efficiency retrofits of residential buildings and the public building stock as well as the exploitation of energy efficiency potential in industry and businesses. In addition to that, the implementation of a transition in the mobility sector, with components such as public transportation, car-sharing, e-mobility and synthetic fuels, offers important reference points for regional renewable energy production and can extend and strengthen regional value chains. Significant regional economic effects can occur in all these areas, resulting in a potential for several thousand additional jobs through increased energy transition activities in Lusatia.

The development of these diverse areas should be systematically supported by tailored or complementary funding programs specifically designed for the mining regions (or structurally weak regions as a whole) and aiming at high regional-economic effects (see below).

Recommendations

To implement the identified potential in the open-cast mining regions and shape a successful structural change in line with the energy transition and its diverse benefits, various prerequisites must be met. The plants are not guaranteed to be driven locally in the various regions; and local added value and participation can be certain. The following summary gives an overview of the most important tools to leverage the identified potential and effects.

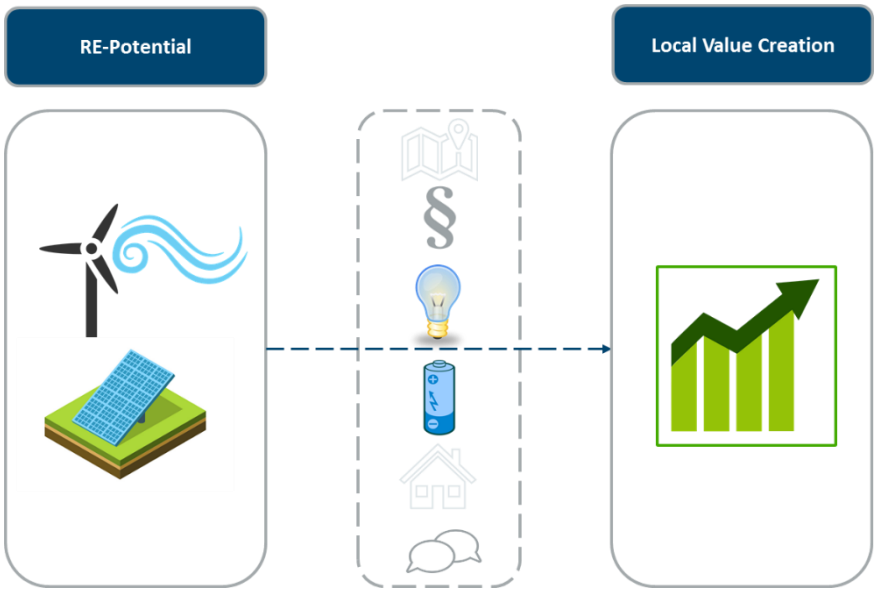


Figure 3: Recommendations for the implementation of regional value creation from renewable energy potentials
Source: own research

Securing suitable areas

To be able to use (decommissioned) open-cast mining areas to operate wind and photovoltaic plants, they must be permitted under zoning law and the availability of suitable land must be ensured. For this purpose, it is important to consider planning, mining and civil law requirements, whose interaction is regulated by the planning and licensing regime.

Activities to secure suitable land for renewable energy projects are **the responsibility of the coal-mining regions**. Here, the federal states, regional planning authorities and local authorities can lay the foundation with zoning law requirements on repurposing coal-mining land for renewable energy projects. In this context, it may be appropriate to increase the acceptance for renewable energy both in the national and regional context (see below).

The ownership of the suitable land must also be clarified; for a closer evaluation, corresponding documents should be made available. In any case, it is recommended to critically examine the further sale of suitable land that is now owned by public authorities (federal, state, local). This applies in particular to the not yet sold land in the LMBV, in which the Federation is the owner. Until a general strategy is developed, a halt on sale of land should be considered.

§ Framework conditions for the expansion of renewable energy in open-cast mining regions

To develop the potential, framework conditions are required that specifically facilitate the realization of renewable energy projects on open-cast coal-mine areas or in an open-cast mining region. The existing federal funding scheme for renewable energy has not provided any approaches to this. The federal government and the federal states should consider, for example, if regional tenders and a suitable design of the

funding instruments would enable a targeted regional control of the expansion of renewable energy in the open-cast coal-mining regions. Within the scope of the study, the following options were investigated:

- Specific tenders tailored to the coal-mining regions
- Privileged treatment of tenders for renewable energy plants in the open-cast coal-mining region
- Tenders for renewable energy plants on federal land

A further approach could include pilot projects in laboratories with experimentation aspects or clauses. To avoid legal risks, the requirements of the Environmental and Energy Aid Guidelines (UEBLL) must be fulfilled or examined as to whether they can be further developed to address the specific requirements set by national legislation for projects in open-cast coal-mining areas. Irrespective of this, adjustments to funding regimes in other relevant areas should also be considered, as well as in planning and zoning law (including, among others, land use categories and special features of wind-PV-hybrid plants).

Framework conditions for improving Power-to-X potential

Under the current framework conditions, PtG projects considered cannot yet be expected to be economically viable until the target year. An expansion of electrolysis systems, as assumed in the study, would therefore have to be stimulated by **additional funding** and **appropriate framework conditions**. The development of hydrogen production and utilization offers the opportunity to develop this technology path.

To be able to value the potential, appropriate conditions would have to be created. At a higher level, meaningful improvements to the framework conditions for the PtX generation and use must be reviewed, including regulations for hydrogen production and feed-in into the natural gas grid. Pilot projects are recommended to test the interaction of new technologies and innovation-friendly framework conditions. Lusatia could serve as a pilot region for feeding in high levels of renewable heat from PtH and solar thermal energy and the modernization of the heating networks.

Strengthening research and promotion of entrepreneurship in the context of the energy transition

Research and entrepreneurship are important building blocks for regional economic stabilization and development, especially in structurally weak coal-mining regions. Due to the substantial importance of universities as an employer and driver of innovation, it is recommended for the coal-mining regions to guarantee an **improved financial standing** that is at least equal to the national average.

In particular, for the case study Lusatia, additional research opportunities should be created in future-oriented areas, particularly in fields related to energy transition. It is important to consider establishing and developing several **non-academic research institutions**, given the illustrated diversity of topics and the heterogeneity of the energy transition, but also the degree of suitability to the small and medium-sized enterprises in the region**.**

For all coal-mining regions it is recommended to combine their **placement/marketing and transfer activities**, and to design them to be more visible, more effective and more subject-specific. This applies to the structures for promoting entrepreneurship and innovation as well as for economic and regional support.

Ensuring regional economic effects through energy transition

The establishment of wind and solar power plants as well as other energy transition projects in the open-cast mining regions does not per se bring added value and employment into the regions. For coal-mining regions to benefit economically from the diversity of technologies associated with energy transition over the course of structural change, further **economic policy instruments** must be used.

The identified added value and employment effects are highest in Lusatia when **as many regional players as possible** are involved along the energy transition value chains (service providers, plant operators and investors). To date, however, in renewable energy projects, especially in large parts of Eastern Germany, institutional investors based outside the region often make up the majority. This is a major cause of acceptance problems and resistance to further renewable energy development. To foster acceptance of further renewable energy development and the implementation of energy transition projects, it is therefore crucial for the region to also profit economically from the renewable energy projects. Only then can the energy transition make a corresponding contribution to structural change in the open-cast coal-mining region.

The implementation of energy transition projects must therefore be accompanied by a **mix of specific instruments and measures** that address different parts of the value chain and address different target groups (municipalities, citizens and companies). The goal must be to enable or maintain as much of the added value and employment in the region as possible. This applies to the design of the energy transition, but especially to the structural change in the somewhat structurally weak coal-mining regions. **Effective regional economic instruments** to support available development instruments include:

- citizen, business and municipality participation in investments in the region[2]
- participation in debt capital of an operating company (e.g. via loans from citizens to the operating company or savings agreements with regional financial institutions)
- increase of revenues to municipalities through levies and taxes (e.g. through direct payments of the plant operators to the local municipalities)
- promotion of regional businesses in all sectors of the energy (transition) industry (e.g. via certification and training programs, new or (re)location of business to the region, support of citizen-owned energy companies)
- (co) financing of energy and climate protection measures in the municipalities of the regions, which have significant regional economic effects
- expansion and promotion of low-emission mobility concepts (environmental networks) as well as e-mobility in public transport and motorized private transport (i.e. private cars).

[2] An example of a legal regulation on compulsory public participation in Germany is the Citizen and Municipal Participation Act Mecklenburg-Vorpommern. The model for a mandatory participation of municipalities is the regulation of citizen energy companies in § 36g EEG. This dictates that the local community or corporation in which the municipality owns 100%, must be offered an opportunity for financial participation/ownership in the community owned energy company.

Exkurs Batteriezellenproduktion in der Lusatia

The establishment of a battery cell production is increasingly seen as an economic opportunity that can result in substantial value creation, employment and export potential for the German industrial and plant manufacturing, as well as for the consumer industries. The construction of a battery cell gigafactory, however, is very capital intensive and risky considering the huge competition with established companies in Asia and the United States. Considering already established companies, the establishment of factories must therefore consider relevant location factors for production. Experience has shown that the availability of sufficiently large sites and the duration for approval are critical. Therefore, the designation of suitable areas, the reduction of approval procedures and the alignment of approval standards in EU countries are important prerequisites. Considerations for Lusatia have shown that due to the still existing industrial conditions, the comparatively good access and proximity to customer locations and the existence of large numbers of STEM graduates, several positive factors exist. However, increasing skilled labor shortages and some infrastructural deficiencies have contrary effects and must be remedied. Future electricity surpluses caused by renewable energy on a gigawatt-scale could, in the future, have a positive impact on the currently critical electricity price factor, as well as the development of a concept for flexibly mobile battery cell production.

Communicating processes and strengthening acceptance

The development of potential can only be achieved **in cooperation with local stakeholders**:

Activities to secure suitable land for renewable energy projects must be initiated by the affected federal states, regional planning authorities and municipalities. Creating planning and zoning requirements for the use of land for renewable energy projects – for wind power projects in the context regional planning, for PV projects on the level of municipal land-use planning, for enabling innovative wind-PV hybrid systems closely coordinated between them – is the first requirement for developing potential and thus closely linked with the opportunity of regional value creation. The precondition is a minimum level of social acceptance and regional and local political willingness in the coal-mining regions that requires **participation and ownership**. Financial participation options must be examined and, if necessary, created. It should be noted that a high level of acceptance can only be achieved if not only purely financial participation possibilities are created, but also, as far as possible, joint decision-making with local residents is possible.

The question of renewable energy development and the associated regional economic effects generated as a contribution to structural change is not a purely rational question, but rather one that is closely linked to emotions. Possible negative effects of renewable energy power plants as well as conflicting potential are to be discussed and evaluated, which requires an **open dialogue** beyond planning procedures. Images of wind-PV hybrid plants or PV systems on lakes and visualizations of specific open-cast coal-mines can support the debate. Likewise, communicating the regional economic benefits from concrete renewable energy projects can be helpful.

To derive value from renewable energy potential for structural change, the local actors, their skills, and their visions for the future must be fully engaged. This requires **accompanying communication and acceptance work** with well-designed dialog formats, the involvement of relevant regional decision-makers and selected local proponents of

implementation, as well as clear signals from the Federal and State levels to create effective instruments.

The **relevant actors for implementation** and possible **supporters** must be identified and included as partners. As outlined above, PV-wind-hybrids can also be implemented modularly; thus, it is conceivable that one or more open-minded municipalities start with pilot projects and then, in case of positive regional economic effects, emulating municipalities and actors would follow.

The results of this study provide a **basis for further discussion**. To create a foundation for further discussion, in particular to further develop the land potential, the perspective of the regional planning practitioners would be helpful. The next step should be an expert dialogue to compare land and generation capacity potential with other plans that have not been taken into consideration and to further develop them. Based on this, **sensitivity analyses** can compare the regional economic effects relative to the available area and the resulting renewable energy and PtX potential.

In further communication, it is important to demonstrate the benefits instruments can be enable in the coal-mining regions as precisely as possible. **The points of connection** between with renewable energy and PtX projects and further stimulus for development must be presented in detail, while focusing and presenting more on already existing and expandable **skills** available within the coal-mining regions. The contribution of renewable energy projects to successful implementation of structural change in the mining regions as part of the report will then become even more tangible.

This project report was created in cooperation with:

IFOK GmbH

Martina Richwien
Britta Baums

Deutsche WindGuard GmbH

Dr. Knud Rehfeldt
Jutta Simmering

Solarpraxis Engineering GmbH

Karl-Heinz Remmers
Fabian Krömke

Prognos AG

Marco Wünsch
Eva-Maria Klotz
Hans Dambeck
Sven Kreidelmeyer

Institut of Ecological Economy Research GmbH (non-profit)

Prof. Dr. Bernd Hirschl
Katharina Heinbach
Dr. Steven Salecki
unter Mitarbeit von Jan Bahnsen

involved in the subcontract:
Brandenburgische Technische Universität Cottbus-Senftenberg
Dr. Bruna Leuner
in collaboration with Henning George

Becker Büttner Held PartGmbB

Dr. Wieland Lehnert
Andreas Große