The Voice of
German Industry

Priorities for energy research in Germany in 2016

Recommendations for a competition-oriented technology and business framework policy in an age of energy transition

Foreword

Power stations, wind parks, grid technologies, technologies for energy use – German industry offers all this and much more. Specifically, when it comes to the development and conversion of energy infrastructure worldwide, our companies are in the lead. And German industry is also well positioned with a view to the challenges of the future.

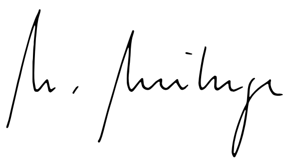
But it is also the case that the domestic market is making demands on companies in an age of energy transition. The energy transition – as a laboratory for industrial standards – can ensure that not only suppliers and users of energy technology enjoy a potential head start in intensifying international competition. As part of the conversion of the electricity system, industrial consumers must also meet changed requirements. Flexible production aligned on a fluctuating electricity supply appears necessary. Where appropriate in terms of technology and process, energy efficiency measures can cushion cost increases due to growing environmental demands or higher energy prices. Many sectors – for instance car construction or the chemical industry – can still more clearly become players in the energy world of tomorrow.

Research, technological development and innovation in the framework of the energy transition must therefore continue to be driven forward with high priority – after all, they are already the basis for the growth and success of German industry and will be for the foreseeable future. In their own interest, researchers, engineers and project developers in industry are constantly seeking responses to the new challenges. However, especially in the area of long-term, high-risk technological developments and for projects which can only be implemented using multiple technologies and in cross-sectoral cooperation, business needs support from the State.

Consequently, research locations are the indispensable foundation for value-creating industrial production. Worldwide competition surrounding these research locations for more sustainable and more efficient technological solutions is therefore intensive. Inadequate State support for research or even falling behind the position of non-EU countries would lead to competitive disadvantages for German and also other European companies and research institutions. Accordingly, both applied research and in particular research in the demonstration phase must be enabled more strongly than hitherto. It is important markedly to increase public resources as a complement to expenditure by companies, and to deploy this support with improved effectiveness.

Therefore, for the second time since 2011, BDI formulates positions on research policy and highlights technological priorities. Consistently coming to grips with the priority research and technology fields set out here will help to implement the energy transition in a targeted and efficient way, and will at the same time strengthen the position of German industry on worldwide markets. Among twenty-seven technology fields, BDI has identified ten themes which are particularly deserving of support and which we believe offer a high level of effectiveness for the further shaping of the energy world of tomorrow. Particularly important for us is the possible leverage effect of State support for research. The latter must serve first and foremost to stimulate and complement private sector activities in areas which are as yet economically unviable but promising. Against the background of scarce public resources, we think it necessary to prioritise those themes which benefit to a marked degree from State support.

We are convinced that a strategically oriented energy research policy strengthens Germany as an industrial country and supplements the targets of the energy transition and its implementation as a technological basis.



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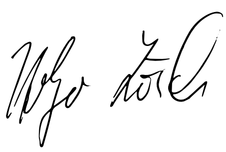
Group Representative of Siemens AG and Chair of BDI's Energy Research and Energy Technologies Working Group



Holger Lösch
Member of the Executive Board
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Trends for tomorrow and research priorities for today

Industry in the context of rapidly developing energy markets

At the climate summit in Paris the world agreed to halt further net increases in greenhouse gas emissions from the second half of this century. The goal is to restrict global warming to less than 2°C. At the same time, at lower than USD 30 a barrel, oil fell into a price category which last occurred in May 2004. In addition, 2015 set a new record of USD 330 billion spent on investments in renewable energies. As a result, capacity-building in wind and solar outstripped all other electricity generation sources combined. In Germany, additional construction and favourable weather conditions increased the share of renewable energies in electricity consumption to 32.5 %. These examples show that the energy sector is undergoing radical change. This dynamic is also influencing industrial branches closely associated with the energy sector.

For German industry, decisive trends are crystallising at European and global level – not least with a view to research priorities. In this regard, it is primarily the global market for energy technology products and solutions which is driving the research and development efforts of German industry.

- The world's hunger for energy will continue to increase. Thus, according to the International Energy Agency, electricity consumption will grow by around 70 % by 2035 as compared with today.

- Renewable energies will be able to cover an ever greater share of this energy demand. However, particularly in OECD countries, their dissemination will go hand in hand with changed requirements on networks, storage technologies and the energy system overall.

- The share of electrical energy in all parts of the overall energy system will increase disproportionately due to electro-mobility, progress in energy storage technologies (for electricity, heat or intermediate products of different types) as well as digitisation and the associated possible closer linkage of consumption sectors. A decisive role is set to be played by information and communication technology. It will become the enabler of change.

- There is no way to sidestep a reduction in emissions from fossil fuel sources. Alongside the development of renewable energies, more sustainable oil and gas extraction methods, more efficient power stations as well as technologies and processes for separating greenhouse gases for industrial use will be necessary.

Technology providers and industrial undertakings must adjust to these trends and adapt their products and processes to the realities of tomorrow. State and private energy research programmes must find a response to these trends.

„Priorities for energy research" – mission, approach and target audience

Against the background of these trends, more sustainable and more efficient energy and industrial technology are key components for a German industry that maintains its competitiveness into the future. In its own interest, German industry therefore focuses its research and development efforts. Yet, as companies develop solutions, they increasingly find themselves in a global contest which is being conducted in many countries with competition-distorting handicaps. Failure to respect patent rights and intellectual property is just one problem. Generous research subsidies or even companies protected by the State supplement the picture. It is therefore absolutely essential for German and European industry always to be one step ahead in terms of technology.

State support for research is called for here. It is good that spending by the German Federal Government on energy research has almost doubled over the last ten years. Still small as compared with other competitors, the budget for energy research and more particularly for energy research in industry must be further increased under stable framework conditions. Research efforts can bear fruit in cooperative clusters between the public authorities and the private sector.

In this respect, with a view to the specific challenges of the future energy world, a targeted and strategic approach seems pertinent. Given the scarcity of public resources, it is necessary to prioritise key technological themes. The basis for the selection of the technologies to be evaluated in this paper is the earlier version dated 2011. The thirty-one technology and thematic fields from all important energy technology fields evaluated then have been reduced to twenty-seven. The technology fields were then evaluated against each other using the criteria "Benefits of the technology", "R&D effectiveness", "Economic significance for Germany as a business location" and "Societal and political acceptance/relevance". On the following pages you will find the 2016 ranking, the methodological approach including a detailed description of the criteria, a specification of the research challenges in each prioritised thematic area as well as an overview of the most important shifts vis-à-vis the previous version.

"Priorities for energy research 2016" is addressed first and foremost to the German Federal Government's lead departments for energy research, to which BDI would like to offer support in the policy route on which they are embarked. BDI invites the German Federal Government to prioritise the key technologies identified in this brochure. The publication is also addressed to policy-makers in the German Länder and in the university and wider research landscape who are important partners of industry. Lastly, we commend this brochure to decision-makers at European level. Not only is energy research and technological development a stated priority of the Energy Union launched by the EU in 2015. Europe has set itself the reindustrialisation target of 20 % of gross added value as early as 2020, a target which is also necessary in times of crisis. Research and development in key technologies of tomorrow are preconditions for meeting this target.

Methodology, changes vis-à-vis the earlier version

Technology selection only slightly amended vis-à-vis 2011 version

"Priorities for energy research 2016" is closely oriented on the previous 2011 version in terms of content and methodology. A core component is an evaluation of the energy technologies/ technological fields described on the basis of the criteria listed on page13. Both determination of the relevant criteria and the technology selection was carried out around the turn of the years 2015/2016 by BDI's Energy Research and Energy Technologies Working Group (members of the drafting group are listed in the colophon). In 2011 the technologies were determined drawing deep inspiration from the German Federal Ministry for Economic Affairs and Energy's study "Energy technologies 2050". Since the energy sector is a very long-term business field and it can take decades before new technological developments make their entry into the market, the technology selection 2016 has not changed dramatically. All areas of extraction, conversion, storage, transport and use of energy sources are covered. As compared with the first version, some new themes have been set out and evaluated (fracking, sector linkage, substance networks). Similarly, technological fields have been regrouped, renamed or split (energy-storage technologies, mobility technologies, nuclear technology, CCS/CCU, etc.).

Qualitative evaluation based on expert discussions within industry

The individual dimensions are evaluated using a scale of 1 to 5 (-- to ++). For instance, an "++" for photovoltaic under the criterion "Climate and environmental protection" means that the Working Group assigns to the technology a very high qualitative significance for the dimension of climate and environmental protection at global level. The evaluation results in a qualitative comparison with the other technological fields described. By way of example, the technological field "highly efficient/ flexible power stations, CHP" is assigned only a high significance in this dimension because CO_2 emissions in electricity generation are merely reduced and not completely eliminated. BDI also evaluates technologies which do not – in themselves – save any CO_2. However, new and better network technologies for electricity transmission are the basic precondition for integration of renewable energies in an industrial country, hence it is perfectly possible to assign a high significance to this technological field as an enabler in the dimension "Climate and environmental protection".

Special position of the ICT theme is also highlighted in graphic form

The theme of "Information and communication technology (ICT)/digitisation" occupies a special position in this version. In 2011 this thematic field was included merely under the heading of "smart grids". In the meantime it has become clear that "ICT" comprises very much more than this application. The thematic field therefore appears as an extensive "bubble" in the diagram on pages 8 and 9. The BDI Working Group assigns very high importance to the introduction of "ICT" as an interface technology in virtually all technological fields. In consequence, a focus of research should be placed here. Hence, you will find a more detailed description of the technological field and the relevant research and development issues in this area on page 12.

Selection and weighting of criteria reflects changed energy policy debate

Following the individual evaluation, the dimensions have been summarised to give an overall value for the technology. The different criteria have been given different weightings which differ from those of the earlier version.

R&D effectiveness
(new weighting 30 %, 2011: 20 %)

Economic importance for Germany
(new weighting 25 %, 2011: 30 %)

Societal and political acceptance/relevance
(new weighting 20 %, 2011: 10 %)

Benefits of the technology
(new weighting 25 %, 2011: 40 %)

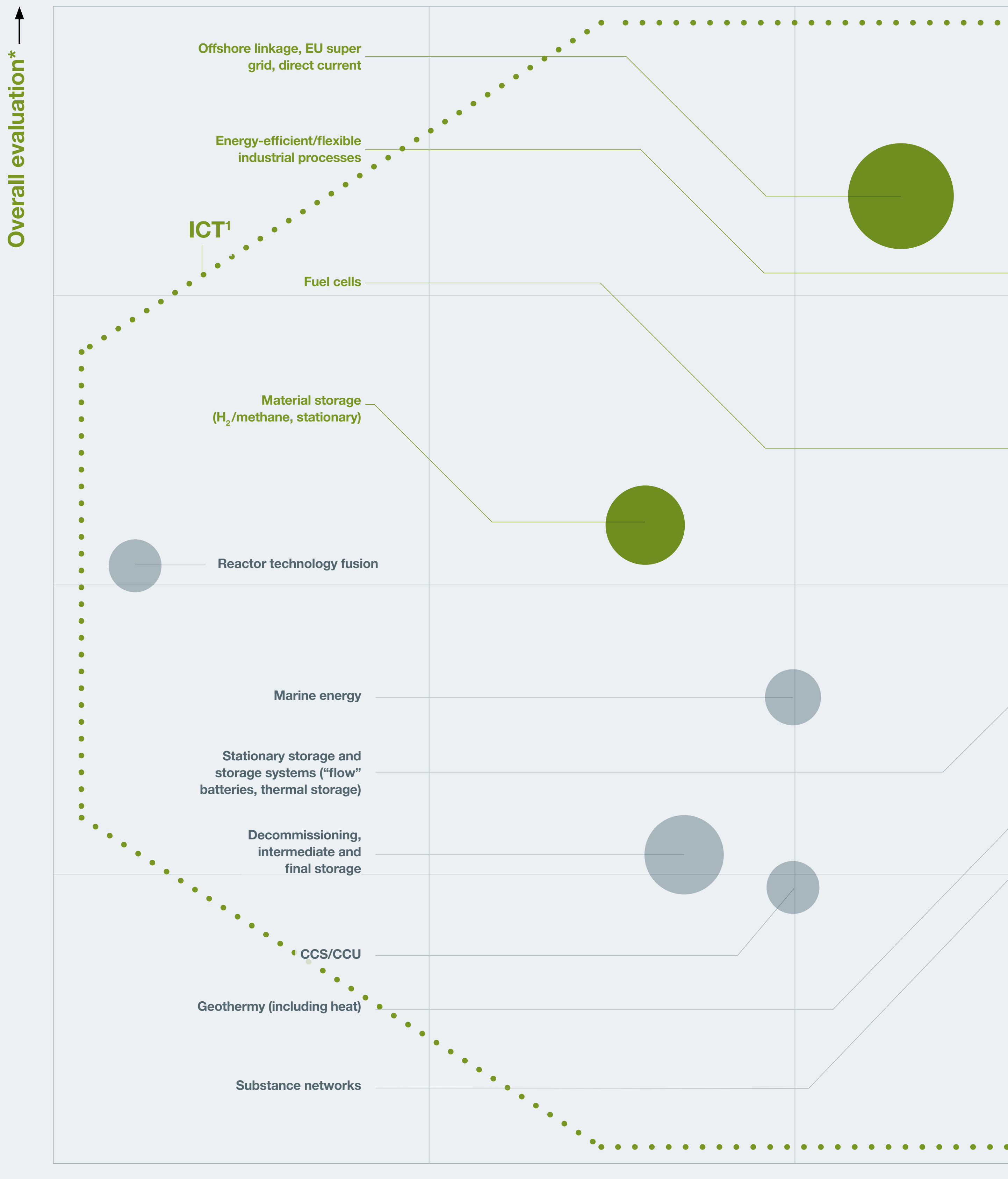
In this way, BDI also takes developments within society into account. Thus, "Societal and political acceptance/ relevance" has been upgraded by 10 percentage points. As mentioned in the foreword, the greatest individual weighting is assigned to R&D effectiveness at 30 %. This underlines the need for public funds to be spent first and foremost where it has the greatest leverage effect. This is above all the case where private companies may shy away from investments due to risk considerations.

Essential changes since the previous version

It is not only technological development that has been given fresh impetus over the last five years. There have also been changes in society, the economy and politics as compared with 2011. Hence, "Priorities for energy research 2016" gives comparatively greater importance to the thematic field "Multimodal systems/sector linkage". This is primarily down to the more rapid than expected penetration of the electricity market by fluctuating renewable energies. These are also increasingly a challenge for electricity-consuming industry so that research for "energy-efficient and flexible industrial processes" is becoming more important. Alongside "E-mobility (including batteries)", further technologies which are also becoming more important for the integration of renewable energies in Germany but also worldwide are also experiencing an upgrade. Accordingly, research in the area of "Material storage (H_2/methane, stationary)" and for storage technologies more generally must continue to be given priority. Network technologies also continue to be important for security of supply and value creation, as they already were in the earlier version. This is precisely why "PV" finds its way into the 2016 priorities. It is true that the economic significance of the sector has declined as compared with 2011. Nevertheless, the technology continues to be given priority due to research clusters and the great global potential. You will find a fuller description of the various research themes in the corresponding "specification" on the backside of the central diagram.

However, some technologies are also assigned reduced priority. These include "CCS/CCU", "energy-efficient and flexible power stations" and "solar thermal electricity generation". Either the political climate/acceptance of these technologies have markedly deteriorated or progressive commercialisation (power stations) among key themes has led to reduced R&D effectiveness. Yet the selection of ten priority themes for energy research should not be regarded as absolute. The recommendations for energy research are also made on the basis of the previously listed criteria. This notwithstanding, high importance is also attached to a few non-priority themes, for instance "high efficiency power station technologies" and "CCS", because of value creation and climate protection aspects. However, the major tasks to be addressed for the future are no longer to be found in the area of energy research and innovation policy.

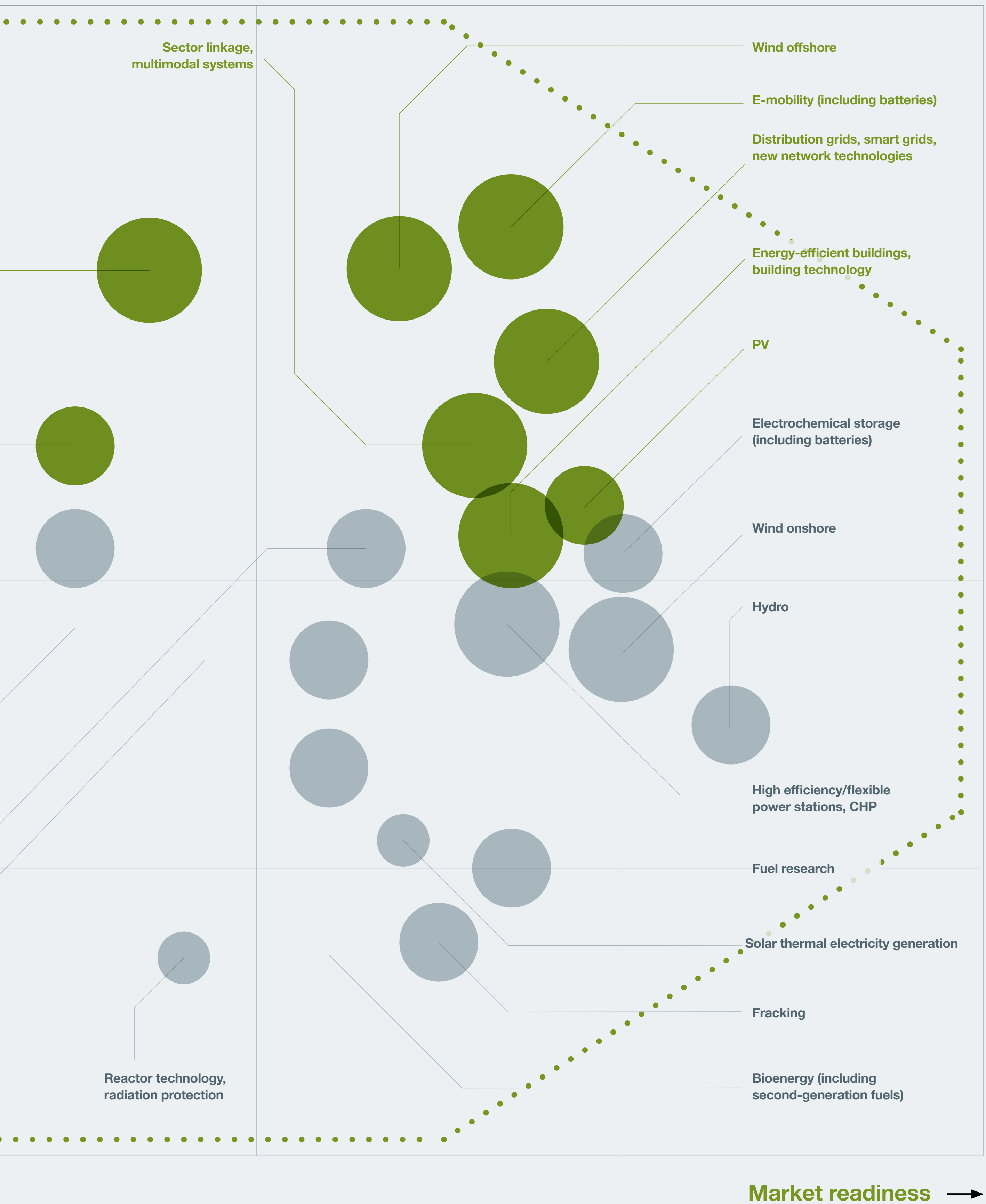
Priorities for energy research in Germany 2016



* New weightings: “R&D effectiveness” at 30 %, “Benefits of the technology” at 25 %, “economic importance” at 25 %, “Miscellaneous/acceptance” at 20 %

[1] Elements of digitisation are penetrating all areas of tomorrow’s energy world. As an interface, digitisation is an overarching research area and is therefore represented extensively with a dotted line.

Source: BDI



Technologies/processes prioritised for State research support

Bubble size reflects economic importance of the technological field for Germany as a business location

Description of technology / technological field	Essential points for evaluation / essential research fields
Offshore linkage, EU super grid, direct current	**Basic precondition for Europe-wide integration of renewable energies in the electricity sector. High importance for climate and environmental benefit, security of supply and business location advantage with simultaneously high R&D effectiveness. Positive evaluation for acceptance and political relevance.**
Direct current	- Improvement of existing, close-to-market technology - Efficiency gain for high-voltage direct current transmission (HVDC) - Multi-terminal and DC networks and their components - Direct DC/DC transformation
Power electronics	- Urgently needed technologies for maintaining voltage and frequency stability, creation of alternatives for the network-stabilising characteristics of generators in large power stations
Offshore linkage	- Reduced complexity and costs in the electricity trajectory from wind park to grid connection point. Planned demo for new connection concept for offshore wind parks
E-mobility (including batteries)	**High R&D effectiveness, high economic importance for Germany as a business location. Political and societal acceptance very high. Positive contribution to environmental and consumer benefit.**
	- Across-the-board, sustainable implementation of electro-mobility necessary to reach climate goals. Inadequate ranges and charging convenience which lags behind user expectations are the main obstacles to greater acceptance and market penetration - Development of future battery systems as well as their performance data for higher reliability, service life, quality and safety - Priority for research on energy storage technologies which are regarded as the most promising for use in plug-in hybrid electric vehicles (PHEV) and purely battery-operated electric vehicles (BEV) to 2030 - Lithium-based (third-generation) and non-lithium-based energy storage technologies. Development of fuel cell technology as the reference technology (proton-exchange membrane fuel cells already have a higher energy density than lithium-based batteries) - Optimisation of energy densities in solid body batteries but also for future cathode materials - Exploration and further development of charging technologies, optimisation of interfaces and achieving the greatest possible energy efficiency during charging through to development of smart business models
Energy-efficient flexible industrial processes	**High R&D effectiveness, great importance for energy-intensive industries in Germany, efficient CO_2 avoidance.**
Energy-efficient industrial processes	- New concepts and process developments, modular processes, micro-reactors - Combined production and separation processes - Catalytic processes (homo- and hetero-catalytic)
Flexible industrial processes	- Processes with electrical energy input, electrification of batch processes - Electrochemical processes - Further development and implementation of processes for the use of H_2 as a platform chemical (methane synthesis, hydrogenation and synthesis gas generation) - Electrolysis processes, processes to produce and use H_2 on the basis of regenerative electricity (e.g. arc technologies), air separation, industrial smart grids - Centralised/decentralised power-to-heat processes, processes for power-to-steam/gas-to-power - Efficient fluid-fluid separation processes, membrane separation processes, gas separation processes
Wind offshore	**Offshore wind energy as a further pillar for reliable supply with renewable energy in Germany and Europe. Characteristic features: high efficiency and more than 4,000 hours a year at full load. High climate and environmental benefit, high R&D effectiveness. In addition, high importance for the business location with high political relevance.**
	- Long project realisation periods and ambitious technology call for a stable long-term policy framework. Further cost reductions through research and development of central importance for the competitiveness of the technology - Development priorities above all in new and further developments of foundation variants and processes and/or improved concepts for foundation structures of offshore wind parks - Further developments on the simulation and validation of hydrodynamic loads and investigations into load simulations in conjunction with further ambient variables (seabed, waves, etc.)
Distribution grids, smart grids, new network technologies	**High economic importance for business location Germany. High evaluation on the "societal and political acceptance/relevance" dimension.**
Direct current networks	- In conjunction with power electronics, improved integration of battery and dispersed generation, e.g. PV - Still at an early stage of development; industrial implementation by 2025 minor and limited to smaller network sizes (micro-grid)
Power electronics	- Improvement of grid-conducive power converter functions. Saving potential through network development thanks to wide dissemination in the area of decentralised/dispersed feed-in
ICT	- Improved observability and control of the energy flow through information and communication technology. High saving potential through network development with better exploitation of the existing transmission capacity
Micro-grids	- Energy management into small details for creation of communicating energy cells. Early stage of development; saving potential where balancing power demand has primacy and improved resilience
Sector linkage, multimodal systems	**Sector linkage: increasing intermeshing between electricity, heat and mobility sectors. Necessary in order to drive further decarbonisation of energy use forward through increasingly renewable mobility. Sector linkage also through renewable energy sources (e.g. hydrogen, methanol) which are required for the decarbonisation of non-electrifiable energy end use (long-distance mobility: air, maritime, road). High climate and environmental benefit, high importance for business location Germany.**

Description of technology / technological field	Essential points for evaluation / essential research fields
	- Sector linkage: alongside power-to-heat (heat pump, e-heater) and power-to-gas/fuel applications (electrolysis, methanol synthesis, fuel cells), also electro-mobility/PHEVs - Determination (through interdisciplinary investigations where appropriate) of a suitable sequencing for electrification of further sectors taking various influence factors into account (economy, ecology, acceptance, etc.) - Investigation of the impact of sector linkage on the individual sectors - Investigation of the repercussions on the necessary secure power station output with increasing electrification of the heat market - Assessment of economically useful negative residual loads (including fluctuations over years and their local characteristics, role of "surplus electricity") - Comparison of different renewable energy sources (hydrogen, methanol, methane) with respect to their suitability for decarbonisation of further sectors (air, maritime, road; long-term storage; industry) - Drafting of recommendations for a revision of regulatory incentives for/against sector linkage in Germany - Evaluation of the effect of sector linkage on distribution and transmission networks - Investigation of the possibilities for establishing access for consumers and industry to the electricity clearing price (for the building sector and beyond)
Fuel cells	**Fuel cells recover electricity and heat electro-chemically from hydrogen. Advantages: high level of electrical efficiency, few harmful substances and carbon dioxide emissions. Broad deployment: cars, decentralised CHP. Range of technologies: low and high temperature polymer electrolyte membrane fuel cells, phosphoric acid fuel cells, molten carbonate fuel cells, solid oxide fuel cells. Technological development has moved forward in the last five years so that economic importance is evaluated as higher today. Strengthening of the technological position of plant engineering, automotive, electro and chemical industry.**
	- Support necessary as a precondition for successful market introduction - Broad, attractively priced hydrogen supply - Improved reliability and service life - Reduction of system complexity and costs - Improved, attractively priced core components such as catalysts, membrane and electrodes - Investigation of the possibilities for improving efficiency and reducing investment costs of fuel cells for use in the building sector
Photovoltaic (PV)	**Germany with worldwide leading clusters in PV research and in mechanical and plant engineering. However, economic importance has declined due to the difficult competition situation in final assembly. Worldwide high importance of PV for climate and environmental protection. High values for acceptance and political relevance. Goals for energy research: efficiency gains, reduced costs, longer service life, use of less and more sustainable resources.**
Targeted material and technology development of dye cells and perovskite cells as well as organic cells	- Improvement of photon management in existing technologies (e.g. crystalline cells) - Tandem and concentrator cell concepts - Photo catalyst cells for direct production of hydrogen from sunlight and water - Thin film cells (reduction of material volumes, avoidance of critical materials)
Improved module technology	- Encapsulation of modules - Integration in building structures - Recycling and recovery
System integration of PV	- System optimisation including multifunctional PV current inverter with high reliability, service life and the possibility of extended system services (networks and generation) - PV systems with battery storage units and their integration in networks (inter alia own consumption optimisation, system services)
Material storage (H_2/methane, stationary)	**Conversion of "surplus electricity" into hydrogen, methane or other hydrocarbons for storage and subsequent conversion back into electricity or for further use in the heating or transport sector. However, known technologies are currently non-economic. High investment costs, low number of hours at maximum output with the use of fluctuating renewable energies. High R&D effectiveness, high political relevance**
	- Fundamental research: elementary electrolysis processes - Applied research: reduction of investment costs, economic operation with fluctuating load, high stability despite load changes
Energy-efficient buildings	**40% of primary energy is consumed in the building sector. Considerable possibilities for efficiency gains with great benefit for climate protection and reduced use of resources. Great economic benefit with high political relevance.**
Network infrastructure for more cost-efficient use of building technology	- Development of an electricity price information and signalling system. Implementation in the electricity grid. Enables consumers to use building technology more cost- and energy-efficiently
Hybrid energy systems for the building sector	- Further development and improvement of hybrid energy systems for using fossil heating systems (e.g. calorific value technology) as well as electricity-based heating systems (e.g. heat pumps)
Investigation and further development of high performance materials for the building sector	- Investigation of the possibilities for using individual materials and different materials in combination with a marked insulation effect and/or a particular added value - Further development of the recyclability and resource efficiency of construction and other materials in the building sector
Digitisation in the building sector	- Investigation and definition of standards and development of standardised solutions for bridging interfaces between planning, production and operation - Further development of multimodal energy system designs for buildings as well as possibilities for incorporating the building in supply networks (multimodal smart grids) - Analysis of the possibilities for integrated building management (local, dispersed or in the cloud) to increase the building's flexibility (more climate-, environment- and resource-efficient consumption)

ICT/digitisation – across technologies and increasingly important

Description of technology / technological field

All levels of information and communication technology are currently developing very rapidly. In the area of sensor and actuator technology, there is a wide range of new options which are essentially leading to improved economic viability of the production process. Extreme speed can be observed in changes to the individual elements through to comprehensive connectivity of all systems hitherto seen in isolation. Moreover, this is combined with increased requirements regarding security issues (public discourse on data security and data sovereignty), across-the-board broadband transmission technology (5G – fifth-generation mobile telephony) through to cloud-based applications (globalisation of systems). The resulting system landscape with clearly larger data volumes and the derived information (big data and cognitive computing) constitute a new quality across the whole of ICT. No longer is it the individual element that should be regarded as a challenge but the new interplay of effects in a very high process dynamic. By way of an example for the energy sector, the importance of ICT can be observed very clearly in the drastically increasing number of installations that can be connected as well as the intelligence needed to steer processes and use infrastructure. Highly complex and critical infrastructures can be navigated properly only through the use of modern ICT and require the corresponding attention – also for future research questions.

Essential points for evaluation

The current development of ICT has a significant influence an every individual technological field. Given this fact, ICT is represented in the diagram as a circle which penetrates all individual themes and can be found in every partial aspect. As part of the quest to document energy research priorities, a representation as a discrete technological field makes no sense – rather, the research area is the interaction of all elements as such. In particular, socio-economic components of research will also become increasingly relevant.

Essential research fields

Within the overall ICT complex, a series of R&D issues need to be clarified despite a high degree of commercialisation. This relates in part to technical developments which essentially relate to data interchange via standardised services, e.g. through platform approaches. In addition, it is important to settle issues linked to data protection (personal data) as well as essential questions about the ownership of data acquired in the process of interpreting processes. In this regard, the R&D interest relates to a considerable extent to value changes within society alongside technical developments proper.

Taking the dynamic of the current trend as a starting point, it is of decisive importance for Germany as a business location to support ICT penetration in the other technological fields and to achieve market leadership at the corresponding interfaces. Without targeted R&D activities in the ICT sphere, economic disadvantages in international competition are inevitable.

Criteria for prioritising technologies for State research support

1. Benefits of the technology

Effects of successful deployment of the technology (or the progress brought about by R&D) on a plausible future scale within the defined essential benefit dimensions (e.g. as reflected in the sides of the energy dilemma *"triangle"* – economy, ecology, security of supply). The evaluation should be determined irrespective of the country of deployment (by contrast with the *"Economic importance"* criterion, which is evaluated from the angle of the German economy).

1.1. Climate and environmental protection

Can CO_2 be saved, on a sustainable basis where possible? Are there other emissions and/or further environmental impacts such as exhaust gases, noise nuisance, etc. (compare with the state of the art)?

1.2. Resource efficiency

Estimation of resources (raw materials, water, soil, air) saved in the production process/in use over the service life.

1.3. Security of supply

Can materials and fuels be acquired easily and affordably, also in the future, from a secure source of supply? Contribution to ensuring a reliable energy supply. Estimate of the availability of resources taking economic viability from today's standpoint into consideration.

1.4. Customer benefit

Are there economic advantages? Do further forms of customer benefit come into play beyond the pure benefit of energy supply (convenience, additional functions)?

2. R&D effectiveness

Can the State effect perceptible improvements in technology development (position on the learning curve) with relatively little research money?

3. Economic importance

The effect of public R&D on the German economy is evaluated in this category. A positive effect can arise as a result of production, value creation and research infrastructure in Germany being strengthened. Potential world market shares for German companies are also taken into consideration here.

4. Societal and political acceptance/relevance

4.1. Acceptance

Is the technology under review seen in a positive light by large swathes of the population? Is there broad societal acceptance for the production and use of the technology?

4.2. Attractiveness

Is use of the product positively perceived by individuals and in the public presentation (lifestyle, prestige, etc.)?

4.3. Political relevance

Does the technology support policy goals? And vice versa: is the technology supported by policy-makers?

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