Strategic research objectives

- Future mobility based on renewable energies
- Integration of renewable energies into electricity and heat supply
- New strategic challenges for research and development of renewable energies
- Research for global markets – Strategic approaches of the BMU
- The area of conflict between technology transfer and intellectual property protection
- Innovation structures in Germany for technological leadership – Solar Valley Central Germany
- Panel discussion: Are Germany’s economy and research in renewable energies fit for international competition?
Future mobility based on renewable energies

In Germany, traffic accounts for about 20% of all CO₂ emissions. The main pollutant is individual traffic, i.e. cars and lorries, with about 80%. The average consumption of fossil fuel per vehicle has fallen in recent years but worldwide the total number of vehicles is continuing to increase beyond the current 900 million and therefore also the consumption of fossil energies and CO₂ emissions along with it. High CO₂ emissions that acutely threaten our environment and the finite reserves of fossil fuels such as oil and gas are therefore, in addition to the increasing air pollution in urban areas, the main reasons almost all major vehicle manufacturers are working intensively on alternative vehicle concepts.

The German federal government has recognised the problem and supports the development of technologies for battery and fuel-cell assisted electric vehicles with its „National Electromobility Development Plan“. Both share the extremely energy-efficient electric drives and the option of using renewable sources such as solar or wind energy for their energy supply. Another promising approach is supply based on biofuels. The ecological potential and the characteristics of all three vehicle concepts will hereinafter be briefly described and compared (Figure 1).

**Battery electric vehicles (BEV)**

Vehicles powered by electricity alone have an electric motor that draws its power from an onboard battery, in contrast to conventional combustion engines that are powered by petrol or diesel. The battery is regularly recharged with power from the stationary grid. Electric motors are very efficient with energy. Petrol or diesel vehicles convert the bulk of the chemically bound energy within the fuel into heat. Electric drive systems, on the other hand, use the electrical energy stored in the battery almost entirely for the drive system. Therefore, they only need about ¼ of the energy that a combustion engine needs (Figure 2).

However, there is still a significant disadvantage: Batteries can store only a relatively small amount of energy per volume or weight, which is more than an order of magnitude lower than that of liquid fuels. The result is that the range of these electric vehicles is still limited to around 150-200 km. However, these vehicles still suffice for many tasks because most of our daily journeys are relatively short, such as the drive to work or to the supermarket. They are therefore suitable as vehicles for commuters, as second family cars or as an urban vehicle.

<table>
<thead>
<tr>
<th>Drive system</th>
<th>(Mobile) energy carrier</th>
<th>Energy source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric motor</td>
<td>Battery</td>
<td>Electricity from renewable energy sources</td>
</tr>
<tr>
<td>Electric motor</td>
<td>Fuel cell</td>
<td>H₂ from renewable energy sources</td>
</tr>
<tr>
<td>Combustion engine</td>
<td>Biofuels</td>
<td>Biomass</td>
</tr>
</tbody>
</table>
Drivers who have to travel longer distances sometimes should opt for a so-called plug-in hybrid electric vehicle (PHEV). In addition to an electric drive, these vehicles also have a combustion engine that is used when the battery is empty. In extreme cases, the combustion engine only serves to generate electricity for charging the battery. This allows for very simple vehicle designs without any kind of mechanical connection between combustion engine and wheels. Such plug-in hybrid electric vehicles are ideal for the transitional phase from conventional combustion-driven vehicles to electric vehicles. They are mostly electrically driven but since they do not abruptly stop when the battery is empty, which is what drivers might fear, they have great market potential as universal vehicles. Electric vehicles show virtually no local CO₂ emissions. For the total balance, however, the source of the electricity is crucial. If it is from a coal-fired power plant, which also transforms a high proportion of primary energy into heat instead of electricity, the emissions turn out to be about 160 g of CO₂-equivalent for a small car – more than petrol and diesel vehicles. In this case, nothing would be gained.

With the current German electricity mix, things are already looking better. With just under 110 g, there is already a modest improvement over conventional vehicles.

However, electric vehicles only really make sense if the electricity is largely generated with renewable energy sources, in which case negligible CO₂ emissions are achievable. Therefore, the introduction of electric vehicles has to be inextricably bound to rapid increases in the share of renewables in our electricity generation (Figure 3).
Electric vehicles require infrastructures. They account for about 16% of electricity generation today. According to the pilot study of the federal government, this percentage should increase to 30% by 2020, 50% by 2030 and 80% by 2050. As the change-over to an electric vehicle fleet should take place in similar time frames, the supply of electric vehicles with renewable energies would be guaranteed in the medium term.

Electric vehicles primarily draw their energy from the electricity grid. Thanks to the economical electric drive, this kind of supply can be managed without any further problems. If, following the objective of the federal government, one million electric cars were driving on German roads by 2020, our total electricity consumption would increase by less than 0.5% and even if in a few decades all 45 million cars were to be electrically powered, electricity consumption would increase by only 20-25%. However, temporal concentrations of recharging processes could lead to undesirable load peaks. If all vehicle owners were to recharge their cars at night, it could very well lead to grid overload assuming a strong market penetration of electric vehicles. These effects can be avoided with modern control technologies and flexible tariffs, made possible with the introduction of electronic meters. Battery electric vehicles still have to be recharged at regular intervals but the exact timing is somewhat flexible.

This will often make it possible to recharge the vehicles selectively during favourable generation and consumption periods (Figure 4).

Imbalances in energy generation and consumption can be offset within certain limits by choosing the time for recharging the vehicle. In addition to these temporal load shifts, it is even possible to feed back the electrical energy from the vehicle batteries into the electricity grid and thus compensate, or at least mitigate, deficits caused by a high consumption or a momentary lull in the output of wind power plants. This is possible because the vehicles are stationary more than 90% of the time and are available to be connected to the grid. With a high proportion of electrical vehicles, a huge electrical energy storage can be realised that can effectively dampen the fluctuations of wind and solar energy, thus facilitating the further expansion of renewable energy.

**R&D requirements:**
In addition to the further development in lightweight vehicle construction, which is especially important for electric vehicles, battery technology in particular needs to be advanced.
Storage capacity, durability, cost, safety and recharging times are all still not really sufficient for a wide acceptance of electric vehicles.

The introduction of electric vehicles also requires the creation of a recharging infrastructure. As electric vehicles only have a limited range, they should always be connected to the grid while stationary. In addition to domestic sockets that can be used for basic requirements, recharging possibilities at work, in front of supermarkets, in car parks or public parking areas have to be implemented in the future. Individual charging stations as they are already installed today on hand-selected sites are not sufficient and above all, too expensive in order to achieve a sufficient density. A universal, affordable, user-friendly charging and billing process is required that allays the consumer’s fear of searching for recharging options.

**Fuel cell vehicles**

For many years, a number of major vehicle manufacturers have been working on electric vehicles with fuel cells as an energy source. Worldwide, there is a lot of practical experience with cars, lorries and buses. Currently, the vehicles on the road are in their second and third generation. In 2010, Daimler are planning a further development of their B-Class fuel cell technology during test operation. For 2015, a general market launch is planned. Compared to the previous versions, improvements in the lifetime of the fuel cell stack (> 2000 h), its performance (65 kW to 100 kW), range (from 160 km to over 400 km), reliability and cold start ability were achieved.
Fuel cell vehicles also have an electric motor that draws its energy from a fuel cell. The fuel cell runs on pure hydrogen, which is usually stored compressed in a tank. As is the case with battery electric vehicles, virtually no CO₂ is emitted while driving. Of greater importance to the environment, however, are the total emissions of the system. These depend on how the hydrogen was produced and processed. Conventional production from natural gas leads to emission values similar to those of battery electric vehicles that run on the current German electricity mix, which means they are only moderately more favourable than conventional diesel and petrol vehicles. CO₂ emissions can only be reduced to very low levels if the hydrogen is produced using renewable energy, such as via electrolysis (Figure 9). The prerequisite here is that the electricity is to be supplied from renewable energy sources as well.

One difference to battery electric vehicles still remains: Compared to battery electric vehicles, the energy loss in the entire process from supplying power for electrolysis up to filling the pressure tank is several times as high, leading to a significant cost disadvantage for fuel cell vehicles in the future.

The higher energy density (Figure 5) of hydrogen allows for perfectly acceptable ranges of 400 km and more (Figure 6).

That means that the application of fuel cells in buses and lorries remains viable. There is still much room for improvement of fuel cell technology, however. Above all, this includes the high costs, which are expected to be significantly reduced along with further technical progress but above all, by the start of mass production.

Further improvements in the durability, robustness and in the storage capacity of hydrogen are desirable. Another major hurdle to market introduction of fuel cell vehicles is the lack of a hydrogen supply infrastructure. A sufficiently dense network of hydrogen filling stations is a prerequisite for consumer acceptance but it also requires large investments. Nevertheless, an industrial consortium consisting of car manufacturers and energy suppliers have recently declared they want to establish a dense filling station network by 2015.

**Biofuels**

In addition to battery electric and fuel cell vehicles, vehicles running on biofuels also offer a high ecological potential. Biofuels either are a part of a closed cycle and the related plants absorb similar amounts of CO₂ during their growth phases as are emitted by the vehicles during operation or they are produced with already existing biomass. CO₂ emissions range from low to significant when compared to fossil fuels and depend both on the method and the individual design.

First-generation biofuels such as biodiesel from rape or ethanol from sugar cane that only use a certain part of the plant are considered moderately ecologically effective. In contrast, second-generation biofuels use the whole plant, resulting in a significantly higher CO₂ reduction.

Today, biofuel has found widespread use in some countries as diesel additive or as ethanol. Worldwide however, only about 2.4% of fossil fuels are substituted by this. In general, biofuel is a limited resource. If one were to use the entire potential area of 3.2 million hectares for cultivating biofuel crops in Germany, a maximum of 20% of today’s fuel requirements could be covered.
However, competing alongside normal traffic, there is also air traffic for which biofuels possibly represent the only viable alternative to fossil fuels, as well as the stationary sector with combined heat and power plants in which biofuel can be used to an even greater advantage. For example, 6 t of wood is enough to produce 1 t of diesel but it can also substitute 2 t of heating oil. The application of biofuel should therefore mainly take place where its advantages are fully realised. One such an area of application is the plug-in hybrid vehicle or vehicles for which an electrification will be much more difficult to realise.

A disadvantage is the high demand for land that biofuels have when compared to wind or solar energy. In order to generate the annual electricity demand of a small car running on biofuel, an area of about 5000 m² of arable land is required. For an electric vehicle with the same annual mileage, the roof of a single-family house with about 20 m² would suffice (Figure 7).

A relatively new approach relies on the production of substitute natural gas called SNG. Hydrogen, produced via electrolysis powered either by wind or solar energy, is methanated in the presence of CO₂ (see Figure 6 on p. 118). This methane can then be distributed via conventional natural gas pipelines and used for local electricity and heat generation and for the operation of natural gas cars. The advantage of this approach is basing the vehicle’s supply on renewable energies, the uncomplicated long-term storage, the presence of a distribution infrastructure and the universal useability of the energy carrier methane. In addition, methane produced from biomass can be included. A disadvantage, however, are the high energy losses in the process chain.

Summary

It is safe to assume that vehicles with battery and/or fuel cell aided electric drives will successively replace our conventional, primarily fossil-powered, vehicles in the private transport sector in the decades to come because of their potential environmental advantages.

Prerequisite, however, is a consistent focus on research and development to improve on the still existing weaknesses such as insufficient energy density, durability, safety, road capability and cost-effectiveness. Furthermore, the rapid creation of a corresponding filling or recharging infrastructure is called for.
Regarding biofuel technology, especially the CO$_2$ emissions from production have to be reduced. The current processes for producing biodiesel can only be a beginning. In general, biofuels will remain a limited resource and should therefore mainly be used in those niches that do not offer any other solutions.

Luckily, the federal government is supporting all target areas with subsidy funds. This responsibility is shared by five ministries responsible for research and development, economy, the environment, transport and agriculture.
Integration of renewable energies into electricity and heat supply

The challenge of today’s global primary energy demand and its expected increase can be met by renewable energy sources, which are known to have a sufficient potential (Figure 1). In terms of quantity, the sun and the wind could even meet the demands alone but they are subject to great fluctuations and their availability depends on the geographical location. The task is thus essentially defined as the technical and economical development of renewable energy sources, their integration into the supply structures and the transformation of energy systems.

Where are renewables today?

Photovoltaics presently have a global share of only one-tenth of a percent but their learning curve shows a decrease in costs by 20% for each doubling of installed capacity. The global share of wind energy is already at around 1.5%. In recent years, wind energy had annual growth rates of 30-40%.

The coming years will be slightly lower, although the learning curve here shows a decrease in costs by 10% for each doubling of installed capacity.

Looking at the costs plotted against the generated energy is a feasible economic comparison (Figure 2). One can see that all renewables become competitive with conventional fossil fuels when their share is at approximately 20%. This applies to them all equally; cost-effectiveness is not a fundamental but rather a temporal question.

Any sole supply with renewable energies should be based on several pillars due to fluctuations in the availability of the wind and the sun. These include, for example:

- Use of energy stored in biomass
- Demand side management
- Appropriate integration of large pumped storages for medium to long-term compensation
- New storage approaches for short-term grid support as they may arise, for example, with electromobility

Profit, Krengel et al. • Integration of renewables
FVEE • AEE
Topics 2009
How can we significantly increase the efficiency of our energy supply?

Two-thirds of the primary energy stored in the energy source are lost as waste heat in conventional power plants.

For every kilowatt-hour generated directly from renewable energy sources, three kilowatt-hours are replaced on the primary side of conventional power plants (Figure 3). On the other hand, we have to utilise the heat losses for our own thermal demands via a rapid and widespread application of combined heat and power generation.

Another important component is the electrically powered heat pump. It utilises 75 percent environmental heat from the air or the ground and 25 percent operating energy to power heating and water heating. The higher the portion of renewable electricity used, the better the heat pump’s efficiency and environmental balance (Figure 4).

The third major portion of primary energy is used for our mobility needs in the transport sector, with current average efficiencies of...
Efficiency leap in the heating sector thanks to regenerative heat pumps and combined heat and power (CHP)

Figure 4

Leap in the efficiency of the transport sector owing to electromobility

Figure 5

around 20%. Here, electromobility powered by regenerative energy is the most efficient alternative (Figure 5).

Transformation of energy systems

The transition from today’s energy system to a sustainable, zero emission system has to be conducted in a way that avoids misguided technological developments while ensuring supply during the transformation phase (no regret strategy).

As is already becoming apparent today, the increasing shares of renewable energies from wind and the sun in the energy mix will see the current load supply types – base, intermediate and peak load – disappear.

With an increasing share of fluctuating electricity sources, Europe needs a new, highly efficient electricity transmission system that on the one hand compensates the fluctuations resulting from local generation on a large scale (the wind will always blow somewhere in Europe) and on the other allows for the integration of the enormous storage power plant capacities, especially of those in Norway.
If the expansion of this trans-European super-grid takes too long or is incomplete, so-called residual-load power plants would have to compensate on a national level. In contrast to previously employed base and intermediate load power plants, these would include the fast-reacting gas power plants with combined heat and power and virtually connectable small-scale systems such as CHP stations, microturbines and fuel cells. Electrical energy storage as it is often proposed could, in principle, also provide for this compensation but it is not competitive with strong grids or residual-load power plants, at least not in the foreseeable future.

Today’s large-scale power plants are not suitable for any kind of fluctuation compensation because they do not adapt quickly enough to power fluctuations. Suitable power plant types would include: gas power plants and combined heat and power plants (engine generators, microturbines, fuel cells) that can be controlled via the appropriate communications facilities.

The expansion of natural gas-based power plants and combined heat and power could be started immediately. The initially growing demand for fossil natural gas is compensated in the medium term by the dropping demand for natural gas heating systems (with increasing combined heat and power and electric heat pumps).

The long-term natural gas demand will eventually drop to zero due to its substitution with sustainably produced biomethane and synthesised methane from electrical surpluses (Figure 6). This methane supply also implies that the future natural gas grid – just like the future electricity grid – must be able to handle varying directions of flow. To this end, new management strategies are required (smart grids). The current expansion rate of liquid gas terminals should be upheld in order to allow for an adequate capacity of, for example, methane produced by wind energy surpluses from particularly high-yield locations.

To offset the sharp increase in future fluctuations in solar and wind energy production, the following instruments are available:

- High-performance, high-voltage direct current transmission networks in Germany and Europe for coping with optimally located energy sources from wind and sun, for the large-scale horizontal compensation of power fluctuations and for the connection to large storage power plant capacities, for example to those in Norway.

Figure 6
Conversion of wind, sun and biomass into SNG for storing renewables and distributing them with the existing infrastructure by coupling the electricity and gas grid
(Sources: Sterner, Fraunhofer IWES and Specht, ZSW)
- Responsive, decentralised power plants (preferably combined heat and power plants or gas power plants) that are supplied via natural gas grids from biomass and waste-gasification plants with CCS or renewable methane produced from electricity surpluses.

- Interactive grids for electricity and gas (smart grids) in conjunction with load and feed-in management (combined power plants).

The environmental friendliness of electric heat pumps and electric vehicles, including trains, trams and buses, is improved with an increasing portion of renewable energies in the electricity mix.

A consistent implementation of this strategy does not require additional storage capacities for stabilising the electricity grids. However, this is true only for a pan-European concept. Close coordination on the one hand between all European member states and on the other by, for example, the European Commission is key for successful implementation.
New strategic challenges for research and development of renewable energies

Context

Renewable energy sources have increased considerably in all sectors in recent years. This is especially true for the electricity sector: While 10 years ago, less than 5 percent of the German electricity consumption came from renewable energies, their share has tripled to more than 15 percent today. In 2008, they already generated about 93 billion kilowatt-hours.

This development was primarily the result of the successful and efficient German Renewable Energy Sources Act (EEG). On the one hand, it has enabled private investments to build renewable power plant capacities and on the other, it has served as a strong incentive for technological developments. Regarding renewables, there was an extremely productive relationship between German innovation and research and the young emerging industry.

To date, the heating sector lacks a similarly effective instrument like the EEG, so developments in this area have moved on at a far slower pace and have been less continuous. The Renewable Energies Heat Act, which entered into force at the beginning of this year, now sets out a fixed portion of renewable energies for new buildings. However, the larger segment of the existing buildings is still slow to be upgraded to higher energy efficiencies and renewable energies. In the heating sector, the share of renewables therefore only doubled from 3.5 to 7.4 percent in the same time period. Expressed in absolute numbers, however, this is a similar order of magnitude as seen in the electricity sector. For example, a total of about 104 billion kilowatt-hours of renewable heat was generated in Germany in 2008.

In the transport sector, development was erratic. This is due to the lack of reliability on the part of the political framework. Initially, the Red-Green government supported the rapid expansion of the biofuel industry and created a strong investment incentive for the sector with the tax exemption for pure fuels. In 2006, the grand coalition then decided to terminate the tax exemption for pure fuels and to start to gradually fully tax them instead. To compensate for the expected capacity crunch in the industry, the same government then introduced a quota system for biofuels. Nevertheless, this system change massively slowed down the dynamic development of the market. Added to that, the overall quota was lowered to 5.25 from initially 6.25 percent at the end of the grand coalition government in 2009. The share of biofuels in fuel consumption, which had started from almost zero percent in 1998 and had increased to 7.2 percent in 2007, fell sharply in 2008. Today, the share of biofuels is only about 6 percent. This is equivalent to an energy supply of around 37 billion kilowatt-hours.

Industry forecast 2020

What is going to happen with renewable energies? The industry has set itself ambitious goals. The BEE member companies want to significantly exceed the requirements of the EU and the federal government for 2020. In order to succeed, we need the right political framework conditions. This means, for one, a successful mix of administrative law and market incentives for the rapid expansion of renewable energies in all three sectors – electricity, heat and transport. By 2020, we could then cover 28% of the total final energy consumption in Germany with renewable sources.
It also means appropriate research promotion. This is a matter of supplying the excellent capacities of the German Renewable Energy Research Association and others in Germany with adequate resources and appropriate targets so that we can lay the foundations for further growth and continued technological development to 2020 and beyond.

Electricity generation forecast

We still expect a continuation of the dynamic developments in the electricity sector. With sufficient efforts targeted to efficiency and with a slight decline in consumption of 620 billion kWh in 2007 to 595 billion kWh in 2020, renewables will already cover 47 percent of the German electricity demand in 2020. This corresponds to about 280 billion kWh of generated electricity. Slightly more than one half of this is wind energy (149 billion kWh), followed by bioenergy (54 billion kWh), photovoltaics (40 bil-
lion kWh), regenerative hydropower (32 billion kWh) and geothermal energy (4 billion kWh).

As of yet uncertain remain the effects of the life extension for nuclear power plants as announced by the new federal government, a decision we consider to be wrong. It unsettles investors, impedes competition on the electricity market, reduces pressure for innovation in the energy industry and hinders developments in research and, ultimately, progress in the field of renewables. Depending on the final formulation of the life extension, its negative effect on the expansion of renewable energies will be weaker or stronger. From the industry’s point of view, the decisive factor is that the priority for electricity supply remains on renewables and is not undermined in practice.

**Heat generation forecast**

There need to be more causes for renovation in the heating sector as the biggest potential lies in the insufficient energetic quality of heating systems in Germany; only 12 percent of German heating systems are state of the art. We therefore are in favour of a new instrument. It could be an energetic quality standard that is raised at fixed intervals and requires renovation in all buildings that fail to meet this new standard.

In a second step, renewables should then be a binding part of these renovations. In addition to this regulatory approach, especially financial incentives are still required to promote a faster transition to renewables. To this end, the market incentive programme requires at least 1 billion euro a year and has to be independent from the financial situation of the federal budget. This instrument is a very effective stimulus programme. After all, one euro from public funds triggers private investments eight to ten times that amount. As a result, renewables could achieve a share of 25 percent of the heat supply in Germany by 2020.

**Biofuels forecast**

In the transport sector, only biofuels are available to any significant extent as to limit the use of fossil fuels and replace them. Therefore, a funding re-start of this sector is necessary. The new federal government has taken the first steps towards this goal within the framework of its Growth Acceleration Act. It contains a change in taxation which is to help rehabilitate the pure fuel market for biofuels.

The increase in the overall rate, the next important step, is still pending. The proposed suspension of the planned tax bracket is not sufficient either. The tax rate for biodiesel and vegetable oil should be limited to a maximum of 10 cents per litre.
If the promotion of electromobility is backed by concrete actions – namely, in the field of battery research and during market introduction – the aim of the federal government of putting one million electric vehicles on German roads by 2020 can be achieved in the opinion of the BEE. Overall, the share of renewables in the transport sector’s energy consumption could then rise to 19 percent.

A share of 100 percent renewables is only possible with R&D. But the year 2020 only represents an intermediate step in transforming our energy supply. The long-term goal must be switching to 100 percent renewable energy. Only then can we engage in economic activities in an environmentally friendly way while escaping ever rising fossil raw material prices. So after 2020, we will still need a dynamic growth of renewables in all areas. Here, the great importance of research comes into play again. While we are mostly familiar with, and dispose of, the means to promote the expansion of renewables for the next ten years, we still need significant technological and social advances for the years after.

The consequences restructuring our energy supply has on research and development in renewables can be roughly divided into two categories. In the broadest sense, one concerns “technical” and the other “social” issues.

Technical aspects of research

We still require major progresses in our efficiency of energy use. This applies to the entire energy sector, as well as to plant production and the plants themselves in the field of renewable energies. After all, there are also limiting factors in this area, such as the extent of usable land. Regarding plant manufacture, material and energy use have an impact on the remaining balance of CO₂ emissions from renewables.

The main technological challenge, and thus the most important research task, can be described with the term “system integration of renewable energies”. This mainly pertains to the electricity sector, but not only. The higher the share of renewable energies in our electricity system, the lower the remaining fossil capacities.

With this, however, there are less capacities initially remaining to compensate fluctuations in solar and wind energy. New and more powerful storage media, technologies and structures are called for. We also need intelligent control systems that on the one hand help balance power generation and demand, and on the other efficiently coordinate several decentralised power plants.
This concerns not only electricity but also the heat sector in which major advances are needed to optimally connect generation, storage and supply to an ever-increasing share of renewables. Here, the major focus is primarily on heat storage, local heating networks and modern efficiency technologies in private and industrial use.

Combining electricity, heat and mobility is becoming ever more important because the utilisation of renewable technologies is increasingly cross-sectoral in nature. Prototypes such as the hybrid plant in Prenzlau (Brandenburg) that combines electricity, heat and fuel production, point in the right direction. The important thing in the relatively young field of renewable energies is research that is diverse and open to new technologies because setting course too early towards a certain goal would hinder promising developments in other sectors. The best technologies and concepts can only be proven in practice. In addition, different technologies also have different time horizons in which they mature and become fully effective.

In the field of electricity supply, smart grids and smart metering will play an important role in the future. There are a number of problems that research has yet to solve to allow for their extensive and successful application. In the future, the electricity infrastructure must therefore allow for both an increased decentralisation of power generation and improved networking over longer distances in order to make power plants feasible for regional supply on the one hand, and on the other to redirect large amounts of power from, for example, offshore wind farms to more remote consumption centres.

A key strategic issue for the energy supply of the future are the regenerative combined power plants. They link various regenerative production units and combine the specific strengths of the individual applications. In order to ensure that the operators of, for example, wind turbines and biogas plants cooperate on a large scale in the future, an appropriate stimulus for regenerative combined power plants has to be integrated into the EEG as soon as possible. In the past, valuable impetus for such an instrument also came from the Renewable Energy Research Association. The increasing proliferation of regenerative combined power plants will then have to be accompanied by research that is in step with actual practice. The therein employed IT components have to be optimised and the communication between plant and grid operators has to be improved.

Sociological and economic aspects of research

Now to the socio-political aspects. In this case, too, will the restructuring of our energy supply entail a considerable demand for research. First, there are the business sciences: Existing value-added models have to be advanced and refined for the area of energy generation and supply with regard to renewable energy sources. This is the only way to establish precise distinctions within the production chains and to provide reliable information on business costs and the economic effects of renewables. In this context, new models for technology assessment and evaluation of specific funding instruments are required.

An important research field – also beyond the interests of the renewable energy sources industry – is the question of monetising external effects of energy supply.

Only someone who knows how high the costs of coal and nuclear power are for climate, environment, health and for the availability of resources can properly value the benefits and advantages of expanding renewable energies. Scientific assessment and mathematical models are prerequisites for politicians if they are to develop and apply effective management instruments, thereby promoting the transformation of our industrial society into a sustainable economy.

In social sciences, the expansion of renewable energies opens up new fields in acceptance research. Phenomena such as the contradiction „Renewables yes – but please not on my lawn“
call for scientific investigation. Using the results, appropriate communication and action strategies can be derived, allowing for an expansion of renewables that is in line with the involved locals. Here, it could be possible to develop new public participation models and evaluate the effects of various methods and communication strategies.

Renewable energies depend on an effective legal framework while its formulation is significantly influenced by jurisprudence. This raises the question of how to proceed adjusting legal instruments to promote renewable energies and illuminating hidden obstacles in existing statutory provisions hindering their further advancement. As science, in the field of energy law, has been previously dominated by the perspective of traditional energy production from fossil and nuclear sources, it is now required to increasingly incorporate renewables’ point of view into this area and to close the strategic gap by establishing think-tanks promoting the advancement of renewables.

Conclusion

Overall, renewables have grown steadily since their introduction and have long left their niche. With continued growth, they will become an increasingly dominant factor in our energy supply – with significant consequences for the whole power generation infrastructure, the grids, and ultimately the consumers.

Research has a central role in ensuring a smooth transition towards a new, safe and sustainable energy supply with the goal of 100 percent renewable energy.

German research and development has a top position in the field of renewable energies. So far, the excellent results have been quickly implemented and efficiently applied to technology. A globally leading industrial sector with a high export potential has formed in Germany that is also able to contribute successfully to job and value creation. Despite the previous achievements, research and development in this sector continues to be necessary at a high level in order to increase the considerable potential for innovation and to enable the rapid and complete transformation of our energy supply.

This requires constant impetus from an active research community which rapidly transfers innovative technological developments to the mainly medium-sized companies of the industry. The required research capacity has to correspond to the growth of the markets and has to be guaranteed by an increasing flow of research funds. Research and development of a renewable energy mix must therefore be given priority in energy research.

FVEE and BEE recommend raising funds for research and development of renewable energies and energy efficiency by 20 percent annually, as done so in the last three years, in order to achieve at least a doubling in the medium term. This is the only way Germany can keep up with global market dynamics and meet requirements of the EU as well as its own energy policy objectives for 2020 and beyond. This is the only way the German industry can maintain its leading position in the face of the rapidly increasing international competition.
Research for global markets – Strategic approaches of the BMU

Strategic approaches of the BMU

Energy research is part of our energy and climate policy. The key objectives of energy research in the BMU are:

1. Reducing greenhouse gas emissions
   - Increasing energy efficiency
   - Expanding renewable energies – reducing costs
   - Improving quality and efficiency (e.g. efficiency rates)
     – System integration (e.g. storage, smart grids)
     – Opening up new fields of application (e.g. process heat in the solar thermal field) – Environmental and ecological compatibility, acceptance

2. Creating options for the future
   - Institutional support of the BMBF
   - BMBF research programme “Basic Energy Research 2020+”
   - BMU projects for preliminary research, e.g. at the Fraunhofer ISE, ISFH and ZSW (PV) and the DLR (Concentrated Solar Power – CSP)

3. Jobs in Germany
   - Promotion of technologies lacking potential applications in Germany (e.g. CSP, and to a lesser extent ocean energy)

All of this ultimately serves competitiveness on the world markets!

Who is funding what?

Institutional funding (basic research)
- BMBF and BMWi:
  HZB, FZ Jülich, Fraunhofer Institute
- Federal states: HGF, Fraunhofer, ISFH, ZSW, ZAE, universities

Project funding: basic and applied research
- BMBF:
  – Basic research – Applied research in multidisciplinary programmes
- BMU (renewable energies), BMELV (biomass only):
  – Applied research – As well as preliminary research
- Federal states:

RE research funding overview
- Project funding of the BMU and the BMELV
- Institutional support of the BMBF and the BMWi
- BMBF: “Basic Energy Research 2020+”
- Multidisciplinary programmes of the BMBF: PV cluster of excellence, PVcomB in Berlin
- Project funding of the BMWi (shallow geothermal energy, integration/grids/storage)
- Federal states (The Fraunhofer Centre for Silicon Photovoltaics in Halle, Competence Centre Thin-Film- and Nanotechnology for Photovoltaics Berlin)
- German Environment Foundation
**Figure 1**
RE research funding by the various ministries in 2008

**Figure 2**
Energy research (actual) by German government

**Figure 3**
International RE research
Export successes of renewables

- PV export quota: 48%
- Wind energy export quota: 82%

Germany plays a technologically leading role in almost all renewable energies worldwide.

Research expenditure for PV in 2008

![PV research expenditure in 2008](image)

Private research expenditure

- R&D expenditure of companies for RE increased by 80% in 2008 (source: EU Commission)
- 5 of the 6 “top-spending green energy firms” were from Germany (source: EU Commission)
- Companies have their own research centres or research organisations (e.g. q-Cells, SolarWorld, Würth Solar, Enercon)

![Private research expenditure](image)
The German Renewable Energy Sources Act (EEG) as an innovation driver

- Private R&D expenditure is ultimately based on the EEG, thus being “induced by the government”.
- The degression of the feed-in tariff provides incentives for innovation.
- The technology bonus provides for additional incentives for innovation in some selected areas.
- The market incentive programme (MAP) also provides incentives for innovation.

Research funding of the BMU in the area of renewables

- Optimisation of energy supply/System integration: 9.7%
- Solar thermal power plants: 7.3%
- Low-temperature solar thermal: 5.9%
- Geothermal: 12.6%
- Wind: 23.8%
- PV: 26.6%
- Other: 14.2%
- Integration: 9.7%
- CSP (Concentrated Solar Power): 2.6%
- Low-temperature solar thermal: 5.9%
- Geothermal: 12.6%
- Wind: 23.8%
- PV: 26.6%

Figure 6
BMU budget estimates for R&D in the area of RE

2002 2003 2004 2005 2006 2007 2008 2009
0 20 40 60 80 100 120 Mio. Euro
60 68 53 86 83 103 110

Figure 7
Newly approved projects of the BMU in 2009 (118.44 million euros)

Figure 8
New grants of the BMU from 2004 to 2009
**Conclusions**

- Public RE research funding is well-positioned in Germany.
- EEG and MAP are the innovation drivers.
- Excellent research landscape: HGF, FhG and other institutes, universities and private research centres.
- Germany is the technological leader in almost all RE.
- But: there are new developments in other countries, notably the USA and China.

**Further information**

  bmu@broschuerenversand.de
- Newsletter of the BMU
- Homepage: “Research” at www.erneuerbare-energien.de
- Research year-book and CD with a brief description of all funded projects (available from PTJ and BINE)
The area of conflict between technology transfer and intellectual property protection

1. Introduction

Against the backdrop of a changing climate, the transfer of clean technologies to emerging and developing countries is urgently called for. At the same time, there is also the legitimate interest of protecting the intellectual property for these technologies. To answer the question whether this area of conflict affects the mitigation of or the adaptation to climate change, the framework of technology transfer and the herein existing obstacles shall be explained.

2. Transfer of clean technologies essential for climate protection

Mainly due to the demands of developing countries, global energy consumption is set to rise; these countries will be responsible for two thirds to three quarters of the total increase in energy-related emissions. In 2004, developing countries caused 40% of all emissions from fossil fuels but will probably replace the OECD countries as the main emitters by the beginning of the next decade.

In this scenario, China will soon replace the USA as the No. 1 emitter (Figure 1).

Consequently, it is not enough that individual countries or groups of countries implement climate protection programmes. Only if all countries participate, will we be able to stop climate change.

The extent of the required economic transformation can be equated to that of the industrial revolution, except that it has to be three times as fast and encompass the whole world. Not only industrial greenhouse gas emissions must be reduced quickly and dramatically but also the outdated and therefore greenhouse gas intensive technologies used for everyday purposes, which are an important factor in respect to climate change due to their high numbers [1].

The UNFCCC, the Kyoto Protocol and the Bali Action Plan encourage developed countries to take all possible measures to facilitate the transfer of clean technologies. Different views and positions have crystallised and those pointing to intellectual property rights are hindering the transfer of clean technologies.
3. The relationship between technology transfer and intellectual property

Intellectual property rights are basically understood as a privilege granted to the inventor and developer as a compensation for research and development expenditure. It is supposed to be an incentive for further innovations. Intellectual property rights include an exclusive right of exploitation for a limited period, by virtue of which the holder can set a higher price than he could in a competitive situation. This right was added to the General Agreement on Tariffs and Trade (GATT), a pillar of the World Trade Organisation, within the framework of the Trade Related Intellectual Property Rights (TRIPS) in 1994. The agreement strengthens intellectual property rights, its implementation is mandatory and it includes an enforcement mechanism.

Against the backdrop of climate change, technology transfer refers to the requirement of introducing clean technologies to mitigate and/or adapt to climate change in regions where such technology is not yet generally available [2] (Figure 2). Successfully transferring technology includes learning, understanding, using and copying technology with the ability to choose the technology, adapt it to regional conditions and combine it with indigenous technologies [3]. These factors form the so-called technological “hardware and software”, where hardware mainly includes devices and software consists of training, education and management.

Intellectual property rights shape technology transfer: There are two kinds of paths along which such technologies can be transferred: horizontally and vertically.

- **Vertical technology transfer** implies relocation or sale of a technology without sharing the underlying intellectual property rights, usually by selling finished products to end users or by transferring all production rights to an investor [2].

- **Horizontal technology transfer**, on the other hand, implies the exchange of intellectual property, mostly in the context of joint ventures or between a foreign direct investor and a native company located in the target countries [2].

---

**Figure 2**

Relationship between technology transfer and intellectual property

**Intellectual property**
Exclusive right of exploitation for a certain period as a compensation for research and development expenses

**Technology transfer**
Technology transfer involves learning, understanding, using and copying a technology with the ability to choose the technology and adapt it to local conditions but to also combine it with indigenous technologies.
4. Causes for stagnation of the transfer process

Certainly, a manufacturer and developer of clean technologies does not „lose“ know-how if he makes it available to emerging and developing nations at no costs, however third parties may now benefit without consideration of costs and efforts of developing said new technologies; undercutting and the resulting market displacement imperil the company’s economic survival. Intellectual property rights are based on these considerations and they serve to protect from exactly these losses, but at the price of complicating technology transfer [1].

In order to ensure that intellectual property rights do not hinder the transfer of clean technologies, an extensive transformation, or even re-establishment, of administrative and legal institutions is necessary (Figure 3). Most developing countries, however, lack the required means. On top of that, the necessary skills and expertise need to be acquired. So instead of directly using their resources to reduce poverty and stop climate change, developing countries would first have to establish an extensive bureaucratic and legal apparatus for the protection of intellectual property rights of developed countries, and even that would not guarantee a quick and widespread implementation of clean technologies. Of course these countries will be reluctant to adjust a part of their public institutions to cater to the specific interests of foreign companies. They would then be in a situation in which they would be allowed to use technologies they cannot use due to lack of resources and know-how [1]. Intellectual property rights play a role in technology transfer but only regarding emerging and developing countries’ access to advanced technologies, not to common technologies [4]. So the question is: Who is responsible for capacity building? And so one side pushes this responsibility to the other.

5. The area of conflict

The problem with so many industrialising countries is that they cannot jeopardise their economic growth aiming towards a higher quality of life for the population and that they have to avoid an energy-intensive, unsustainable and environmentally harmful industrialisation process at the same time.

Vertical technology transfer unfortunately ignores this dilemma. It may be entirely possible to spread the technology for solar cells, for example, by selling them in developing countries
From an environmental perspective, this might even be satisfactory but the interests of developing countries in capacity building and application expertise, for example, would be undermined [5].

To date, almost all organisations mainly follow a project-oriented approach, which lacks a strategic dimension with regard to the integration of renewable energies into the energy supply systems. Coordination is informal, meaning that there are no evaluation reports for assessments, lessons learned and experience gained from the projects. Another risk of lacking networking lies in the fact that projects are carried out independently or in competition with one another, and in occurring redundancies [6].

In short: The problem is characterised by heated and biased questions of responsibilities and operating primarily without a solid empirical foundation.

6. A step-by-step approach based on economic criteria

Technology transfer usually starts with local development projects. This is mostly about improving the living conditions of the locals and building their confidence in the new technology. Even if this can be accomplished, the following steps will have to be taken to ensure a successful technology transfer (Figure 5):

A) Pilot project

In addition to the objectives of a project, the potential of a further technology transfer should be analysed, too. Here, one quickly comes across criteria of economic efficiency, in addition to political and/or environmental aspects, which should be evaluated in a structured analysis. When selecting the pilot projects, the subsequent spreading to the larger region ought to be an important selection criterion.

B) Service and maintenance

Securing an active and operating system includes two aspects:

- Storing spare parts on site, in order to start repairs quickly and avoid lengthy and costly ordering processes.
Experience from previous projects has shown that complete system failures were often caused by apparently small problems. For example, the lack of a suitable fuse costing just a few cents resulted in failure and even ruined the whole system in a short time.

- Equally important is a more thorough understanding of the products in order to maintain an adequate quality level of service and operation.

C) Installation of products

This requires furthering one’s understanding of existing technologies and products significantly. At the same time, entrepreneurial structures have to be established, including project management, logistics, quality management and after-sales service.

D) Production

This will usually only be useful if the market volume of the specific region is large enough for an adequate sales volume.

It is also necessary to build a working network with suppliers, customers and universities to develop own processes and patents and thus limit licensing costs. It is suggested that from steps A to D, the plant sizes increase from the sub-kW into the MW-range and thus the extent of the intellectual property (IP) to be transferred. By step C or D the latest, companies will usually only agree to a transfer if the economic exploitation of IP rights is clearly regulated.

Technology transfer to emerging and developing countries should not only be a matter of economic criteria but also of environmental and developmental goals. Only with the role of a “central coordinating body” that controls this area of conflict, that considers IP an economic good and does not lose sight of the steps A to D will it be possible to ensure transfer of technology to these regions to the necessary extent and with long-term success.
Literature


See also:
Innovation structures in Germany for technological leadership – Solar Valley Central Germany

Summary

The federal states of Saxony-Anhalt, Thuringia and Saxony have developed into a region with the highest photovoltaic industry density in Europe. In the regional cluster “Solar Valley Central Germany”, a comprehensive innovation concept was launched, made possible by a cooperation between the industry, research, education and politics, allowing for the implementation of the latest solar technologies in the industry and which aims to create additional jobs in the region, beyond today’s 11,000 up to 40,000 by 2020. This concept allows solar power to reach competitiveness with electricity from conventional fuels.

1. Introduction

In the cluster “Solar Valley Central Germany”, winner of the Cluster of Excellence innovation competition held by the German Federal Ministry of Research in 2008, this international leadership is further expanded upon with an alliance of industry, silicon photovoltaics research and educational institutions. With appropriate cooperation and topical coordination, solar power is to reach competitiveness with electricity from conventional fuels. With the planned investments by industry partners and with public funding, “grid parity” can be achieved within a few years. This would mean that solar power would cost less than “electricity from the socket”. This is the crucial milestone.

2. The world’s leading photovoltaic region

The region – consisting of the three federal states of Saxony, Saxony-Anhalt and Thuringia – has Europe’s highest density of photovoltaics companies (Figure 1). In 2009, 11,000 workers were already employed in this area. The industry-specific growth rate in recent years was over 35 percent; a similar average growth rate is expected for the coming years.

The leading manufacturers in the region – representing 43% of the German PV industry turnover – are the motor of the innovation concept “Solar Valley Central Germany”.

3. The innovation strategy in the “Solar Valley Central Germany”

Currently, 29 global companies, 9 research institutes and 4 universities are cooperating to pursue three interrelated goals in a jointly adopted strategy:

- Technology development
- Education and
- Cluster management

The strategy is being implemented in 98 individual projects with a total budget of €150 million over a period of five years. The public sector – the Federal Ministry of Research and the state ministries – are funding 50% of the expenditure. The cluster is managed by the industry, which is responsible for work themes, partner selection and financing the equity ratio.
This tightly coupled approach to development is effectively supported by the regional network of stakeholders. Technological development is forced within the framework of a long-term innovation strategy incorporating all steps of the value chain in order to promote solar power system efficiency, product reliability, service life and reduction of production costs. All innovations share the ultimate goal of reducing the costs per kilowatt-hour of energy. The development concept extends from basic research to applications in innovative production technologies.

Of particular importance to achieving the ambitious goals is the adaptability of the respective development results to the interface of the following value-added step.

The cost targets for these innovation goals are based on past experiences: When the installed PV capacity doubled, the price dropped by 20%. The Solar Valley concept will ensure that this price-learning curve (Figure 2) will be carried forward into the future – while maintaining margins for the manufacturers. It will thus make a major contribution towards achieving the grid parity milestone.
With the prevailing solar irradiation in this region, this will already be achieved well before the year 2015.

The field of education includes the specific measures to meet the needs of this rapidly growing industry with regard to professionals and managers on all levels of qualification. An integrated education system for all steps of the value-added chain and for comprehensive strategic tasks is to be established in a coordinated effort of the federal states.

Cluster management supports the professionalisation and expansion of the network as well as the coordination along the value-added chain of the regional PV industry.

Of particular importance are measures for increasing the attractiveness of the region for national and international investors, supporting the foundation of spin-offs and the coordination of joint appearances for international industry representatives, expert panels and political authorities. For the operational implementation, a management platform with regional offices has been established in the three participating federal states, cooperating as an umbrella organisation with the industry representatives on site.

4. Technologies and products for grid parity

The research and development programme for grid parity is being realised in a system of 12 joint projects that are coordinated in terms of content and schedules.

In the key activity area of the crystalline silicon (c-Si) technology line, the objective is to produce a maximum of electricity with a minimum of silicon. This means decreasing the thickness of silicon wafers from today’s 180 micrometres to about 100 micrometres and increasing the efficiency rates of solar cells and solar modules. To reach the ultimate goal of reducing the cost per generated kWh of energy, we need new solutions both at the level of the product and of the manufacturing technology.
In addition, product reliability and a service life of over 30 years have to be guaranteed to the end user.

The milestones on the way to grid parity are agreed upon, what now counts for the year 2011 is:

- More than 30% material savings
- Increasing efficiency to 20% module efficiency for c-Si and 10% for thin-film solar modules
- Increasing reliability and service life of the module to over 30 years

5. Education and research for a future technology

The high-tech photovoltaics industry has an extraordinary demand for highly qualified specialists and managers. In addition to the purely quantitative number of required staff for the rapidly growing industry, the challenge lies in meeting the quality demands of an industry that wants to remain competitive especially in the international high-end segment.

The achievement of cost targets is closely linked to the growth scenarios of the industry. By the year 2020, 40,000 jobs have to be filled, corresponding to 50% of all jobs in the PV industry and its suppliers in Germany.

An integral, cross-state education system is to meet this demand. As an immediate measure, four new bachelor and master degree programmes were launched, six endowed chairs were established and a competence centre for vocational education and training was built.

For the 2011 milestone, the following targets are to be realised:

- Qualification of 5,000 skilled workers in the region
- Recruitment of 2,000 professionals from the region
- Academic education network with 400 bachelor/master degrees per year
- Expansion of PhD positions for 40 graduations per year

6. High-tech region highly attractive to economy and society

With the innovation concept of the Solar Valley Central Germany, structures for technological leadership in international competition are created. This results in new opportunities:

- Environmental policy – CO₂ reduction with solar power
- Economic policy – solar power as a driver for clean energy
- Regional policy – Central Germany is developing into a leading high-tech region highly attractive to investors
- Corporate policy – accelerating the innovation process to consolidate the technological lead

An interdisciplinary cooperation of manufacturers and users, planners and architects allows for innovative solar power system solutions that meet technological and economical demands as well as those of architectural designing, landscaping and urban landscaping. These model solutions can affect the manufacturer’s product range and secure unique selling points in the booming buyers’ market. An example is the newly established international conference series BauhausSolar in Erfurt. Bauhaus tradition – with its roots in Weimar and Dessau – and the regional industry see the development of new system solutions and the future paths for an “energy culture”.

In the “Solar Valley Central Germany” cluster, the stage is being set for a change in the energy strategy – in addition to excellence of product and technology suppliers, the announced 40,000 jobs and the qualitative development of the region all being on the agenda.
Are Germany’s economy and research in renewable energies fit for international competition?

Panel discussion with representatives from research, politics and business

Shorter innovation cycles require more research and development

Aulich: In photovoltaics, prices have fallen dramatically, the competition is very strong. The Spanish market declined strongly in 2008, leading to a build-up of high excess capacities and manufacturers were pressured into disposing their products. In addition, the production technologies for renewables, developed mainly by German plant constructors, spread rapidly and become internationalised. This means that the cycle from the good idea in a research institute leading to production is not 7-8 years like it used to be, but only two years now. The only chance we have is to increase the pace of innovation and thus increase R&D expenditure even further. Otherwise, Germany will lose its leading position. It also requires greater willingness on behalf of the industry to implement new ideas to reduce costs. This is a prerequisite to keeping the jobs in Germany.

Competition from Asia puts pressure on industry and research

Stadermann (FVEE): My question is somewhat provocative: Research funds have increased slightly and the industry itself is also engaged in research. Why are Chinese solar cells as good as ours? Why have we lost the lead?

Aulich: Germany has been working on the subject for a long time and did all the preliminary work. Other countries, such as China, did not. But if you want to build a solar manufacturing facility in Asia today, because it is a future technology that generates profit and jobs, then you will be able to find a general contractor who will build the facility using the latest technologies, guarantee efficiency rates and even show you how it is done. That was not the case 7 or 8 years ago. If you go to China or Malaysia, you will see German plants that have been built by German plant constructors. These German plant constructors have strong links to the German research landscape. This landscape continues to supply good ideas for further developments. This should indeed be the case but the rate of know-how transfer has increased enormously. If you want to maintain the lead as a solar cell or wafer manufacturer, you already need to have the next technology in store in addition to the one used for constructing the plant. And you should also try to ensure that not all of the know-how remains with the plant constructor; a part of it should be kept to yourself so it is not as easy to resell the technology. But we should not fool ourselves. China is putting a tremendous effort into making its own developments with many engineers and scientists. It is not like they only plagiarise and nothing else is happening. In this respect, there is enormous pressure not only on the German industry but also on German research.
Hoffmann: I would like to mention another factor regarding the competitiveness of German companies: A few months ago, the Landesbank Baden Württemberg (LBBW) published a study demonstrating that there is a 40 percent cost disadvantage for German manufacturers. To my knowledge, there is an investment assistance in China for production facilities of 20, 30 or 40 percent – it depends on the region – until the end of the first quarter. The Chinese manufacturer is provided the rest of the money by the Chinese state bank at a low percentage for 15 years. Added to this is the 10-year tax holiday. And when you add the dollar/euro currency factor to this, it is the “last nail in the coffin”. For these reasons, there are heavy investments in new production facilities in China despite excess capacities. When German or European companies go to their banks, however, there will be long debates whether they get the money at all and on which terms. In other countries, people openly talk about the importance of domestic value creation when public market development programmes are being discussed. I am not suggesting to erect trade barriers to keep out foreign products but we have to react to these international challenges with our framework to be able to maintain Germany and Europe as a centre of technological innovation. So far, I have found no answer as to what exactly this is to look like. We need to consult with colleagues from all ministries and the EU and find out which measures are suitable for preparing us for the future.

International comparison of economic promotion

Kaiser: Yes, the Chinese are subsidising their PV production. But so did we: European structures provide grants to countries, there is support for municipalities, the KFW and funds from federal programmes. Germany, too, used its instruments to promote the domestic PV industry. Now it is a bit more difficult but nevertheless there are still investments in that area. Mr Asbeck is currently expanding his production. And that we now have competition in the market, that module suppliers are having difficulties with the new prices, is normal – it is, after all, a free market economy. We have allowed profit margins of 30-40 percent in the production of PV modules. With this continuing for several years, it does not come as a surprise that we now have a bandwagon effect in this area that is building up excess capacities. The answer can only be: when the Chinese are coming, you have simply got to be better! First, you need innovation to stay ahead in production and cost structures. Secondly, you have got to be better in customer care. Advertise the fact that you manufacture in Germany and treat your customers well. I would like to give an example of what I mean with customer care. The magazine Photon asked a few people to get offers for a photovoltaic roof system with 6 KW. After one month and 30 inquiries, there were 5 more or less serious offers. This is the situation on the market. You really need to take better care of your customers before you step up to politics and demand protection or import restrictions!

European research policy

Hoffmann: I am not at all satisfied with the recent research policy on the European level. Mr Nick-Leptin from the BMU had shown in his presentation that more than 50% of the energy sector research expenditure in Germany is for nuclear energy and significantly less than 50 percent for the renewable sector. Matters regarding distribution are even worse in the seventh EU Research Framework Programme – the eighth is currently underway. This inadequacy in resource allocation should be made more public! We should point out clearly that renewables have already proven what they are capable of – in contrast to the promises we heard in the last 50 years, for example from nuclear fusion. We already know it will be cheaper to generate electricity with renewables in 10 years than any of those systems will ever be able to – if at all. The title to decommission nuclear facilities is a necessity, which is bad enough. But as of now, we are not investing enough in technologies that are supposed to supply us in the future. I therefore have to admit that I am highly dissatisfied with the priorities set by our research policy.
Aulich: When the EU reveal their research and development funding, you can see that those funds are often spent at the national level but presented as part of the EU budget. I would consider it reasonable for the EU to draw up their own budget, handle topics themselves and focus more on renewables than they did in the past. As of now, the R&D budget for hardware, system development and grids is dominated by interests that are not consistent with promoting renewables. From the perspective of the manufacturing industry, the main demand on the national and European level especially is that the funds are not only extended, but granted sooner and more specifically.

Kaiser: Of course we welcome the fact that the EU are supporting research efforts. It is also very fine when they introduce their own programmes. However, they should be oriented towards the politically set priorities. These include climate protection, energy efficiency and, above all, renewables. 20 percent renewables by 2020 is the mandatory target set by the EU. A meaningful way to back this is with increased research efforts.

Weber: I would like to defend the way Germany promotes research in the area of photovoltaics. I believe that we are as strong as we are because we use our relatively small budget to support projects in a very sensible manner. For example in comparison to the NREL in the U.S., a huge institution with a strong institutional funding which is used to little effect in the industry in relation to their resources. In my opinion, the PV industry is well-suited to project-oriented funding in which you propose innovative projects which then should, of course, have at least a 50 percent chance to succeed. Regardless of the allocation procedure, we definitely need the doubling of funds as proposed by the FVEE.

Kaiser: In Germany, research funding is adequate and purposeful. Our next evaluation of our research programme will be in 2011. You are welcome to forward us your suggestions. This is also about more money of course. For example, the approval rate for PV has decreased substantially. That is not because the applications have gotten worse but because there is simply more work to be done in this area. A market has developed there and the pace of innovation has increased. Therefore, there is actually more room for applications. Instead, however, the research budget for PV was frozen. Albeit at a high level – which was politically highly controversial, so the BMU was proud of being able to maintain this level – but frozen nonetheless. We had to grant other areas an increase in research funds. Result: declining approval rate for PV – a very bad situation for German research, very bad for the prices in this area.

Hoffmann: The extension of funds is an important issue. In order to maintain the industry in Germany, it is absolutely necessary to make even more use of existing collaborations between research institutes and the industry in the future. We must work together to achieve an increase of the research budget for renewables and that good applications can be successfully approved with a rate of at least 60 percent. This will require a budget three times as high. It is also to help the German industry remain internationally competitive. The means to this end are certainly not sufficient.

Staß: Every innovation starts with a fundamental invention. Then there is the pioneer market such as we have today for solar thermal power plants. Then there is the market introduction, as now in photovoltaics. Market penetration comes next, such as for onshore turbines. This is followed by market saturation, now seen with hydroelectric power plants. The question is: Do we engage in research for the next 2 years to maintain a delta of technological advantage? Yes! But we also need preliminary research to discover revolutionary innovations for new applications which may only come about in 10 years time. This is the art of balancing, both of PV but also of other areas such as solar thermal

Panel discussion
power plants, geothermal energy, ocean energy and energy storage. A healthy balance has to be found.

Rau (Roth und Rau AG): My comment regarding the BMU: Of course it is important to do preliminary and strategic research here in the Renewable Energy Research Association. But when we file an application as an industry, it is usually for projects that really need a fast implementation for reasons of competitive advantage. When we engage in a specific technology, we need it to be ready for the market by the year after next the latest. The application phases are too long in many cases. After all, the innovation advantage of German companies is the rapid realisation of these projects.

Competitors in Asia or wherever need 2 years as well. They do not necessarily rely on our work but conduct their own R&D. Our research environment is in direct competition to them, too. You have to consider that when you are thinking about deadlines.

Kaiser: To me, it seems a bit too hectic to say “If we do not make it in two years, then it is over”. The bureaucratic response: We are talking about the federal budget 2010 at the moment. It will come into effect in April 2010. Then you can apply for funding in May and it is decided on in September.

Now the research policy response: If the Americans put a lot of money into renewable research now, it will not terribly surprise us at the Ministry. Americans are quick to put a lot of money into an area but two years later, they also withdraw it just as quickly. The strength of Germany was and is continuity. The combination of short-term and long-term projects and the persistent pursuit of many different paths.

We also view the fact that there are several ministries active in research funding as a strength because it provides for a plurality of approaches. There simply are several decision-makers, all of which are important and related in a very interesting way. This is a good structure as long as we work together and not against each other, as long as we share and avoid overlapping research, utilise synergies and encourage plurality.

Not underestimating competition from the U.S.

Staß: At this point, I would like to disagree quite strongly with Mr Kaiser because this American in-and-out policy has now taken on a wholly different quality. The Solar Energy Technology Programme rules that the solar research budget will be doubled for 2010, so another added 100 million euros. Of this amount, nearly 70 million goes to the National Renewables Energy Lab, and they work at a high level. Indeed, we are also competing for research leadership in several other fields. We have to be careful here, and there are also some industrial policy arguments. The U.S. would be so stupid if they would let their market for renewables, as it is visible today, be taken away from them. They are extremely professional and when they start something, they see it to the end. Underestimating the Americans would be fatal. This is why the FVEE recommends increasing funding significantly. The 20 percent per year we suggested is an enforceable compromise in politics but in fact, research needs considerably more.

Kaiser: What was NREL’s problem in the USA? Their financing was secured via institutional funding but for whom were they supposed to do research? They had a buyer market which was hinged on tax concessions that had to be passed through congress every year – or sometimes not. You will not find a continuous partner there. In Germany, we have a solid research landscape based on continuously developed project funding. We have an excellent research landscape and we have an attractive domestic market on which you can put your research products and where you can find industrial partners. And we have a broad political consensus through all parties in the Bundestag, without any exception – this is a fantastic constellation. Now it is important that we, after having invested a lot in the past to develop this potential, put it to use. We cannot allow ourselves to make mistakes at this point.

We have to keep on improving. So my appeal to you is: Let us fight together, and not as competitors in the various renewable energy source fields, to ensure that we all make progress. We
must pull together and clearly show the
decision-makers that this is not for amusement
but rather for our medium-term future.

Research funding as an
industrial policy?

Oberzig: There is the expectation that research
policy increases competitiveness and creates
jobs. Is research policy also an industrial policy?

Kaiser: Of course we have an interest in the
continued development of our research land-
scape, in its stability, networking and good line
to industrial applications. Our impression is that
this works quite well. During the presentation
by Mr Nick-Leptin (BMU), you heard that of the
research titles of the Federal Ministry for the
Environment for photovoltaics, about half of the
funds go to the Renewable Energy Research
Association but a good third goes to industrial
projects. I think this distribution is very reason-
able. We should continue to carefully pursue
this transfer from research to practical applica-
tions. In this sense, research policy is indeed in-
dustrial policy with a strong scientific backdrop.

Staß: Science is not an end in itself. The effects
of 20 years of Research Association demonstrate
this. Today’s companies would certainly not be
as successful as they are if they had not received
the technological input. This is also a question
of cycles. Public research funding heavily
invested in photovoltaics in the beginning; the
institutes – also those of the Research Associa-
tion – took part in the technology transfer.
There are very close partnerships with the
companies in which we conduct joint R&D.

In the meantime, the sum of research invest-
ments from the PV industry is four times the
public research funding, and that is only right
and fitting. It is a stated objective and mandate
of the Research Association to support the
industry, but also to work out new scientific
ideas that may only become important at a later
time.

Industrial policy: Clusters of
excellence

Oberzig: Is the Solar Valley in Saxony, Saxony-
Anhalt and Thuringia a concept with which one
can improve efficiency in research and which
could also be part of an industrial policy?

Aulich: We have an excellent research and
development landscape in Germany, we have
outstanding people, we have scientists who
enter into the field of solar energy – a very
attractive subject – and want to work hard. On
the subject of clusters of excellence, it is still too
early for a final evaluation because it is only a
year old. I think the approach is very good, it
could be implemented very quickly but also
proved quite complex here and there, a fact
that should not be overlooked. In Solar Valley,
there is a total of more than 98 individual pro-
jects in the various programmes that all need to
be coordinated. Given the international compe-
tition, I think it is very fortunate that there are
companies of many stages of the value-added
chain located there, all within a radius of 100
km. You can even work together with your
competitors because the problem is perhaps
3-4 years ahead. It is a good thing when more
people come to the region – whether they are
suppliers or investors. A cluster of excellence is
like a boiling pot with the lid pressed onto it:
pressure builds up faster and new ideas will
bubble up. I think it is a very good approach.
Research and development as an industrial policy

Schiel: The German Engineering Association VDMA represents manufacturers who offer products for all kinds of energy technologies, not just for renewables. We have had difficulties in the VDMA, for example regarding the integration of photovoltaics on the manufacturer side because we do not want to politically support the high PV remunerations. However, we recognised early that there is a strong group of manufacturers within the VDMA that is engaged in exploring photovoltaic production facilities. This group receives far too little attention in German discussions. The photovoltaics industry is often spoken about as if it lacks sufficient export quotas. Indeed, production technologies in Germany achieve a turnover of over 2 billion euros and 80% of this is exported. In this respect, we have a very strong photovoltaic production facility industry in Germany – in addition to the well-known end-product manufacturers.

The photovoltaic and wind industry provide good examples of a successful industrial policy encompassing basic research, demonstration projects and market introduction back-up. With the aid of energy policy instruments, an entire industry has been established. This holds especially true for the wind energy industry with the 100 and 250 MW Programme. We are attempting something similar in the area of fuel cell technologies with the National Innovation Programme. Something like that sometimes goes well and sometimes it does not. Back when the 100,000 Roofs Programme was discussed and implemented, I was working for a Member of Parliament and still vividly remember the difficulties of this process. We are now experiencing something similar with the market introduction of fuel cells, and electromobility powered by batteries will probably face the same problems. It seems very important to me that the various industrial policy tools – and R&D funding is, in my view, such an industrial policy tool – go hand in hand and ensure there are no gaps between research, development, demonstration and market introduction, or else the industry will fall into a recession.

If you have found an industry to be innovative with a promising export potential, then you have to engage in R&D even if it is ready for the market. There are research papers, such as that of the Helmholtz Association, that regard the wind industry as a market-ready technology no longer as worthy of research funding as other industries. I think that R&D has to remain an instrument of industrial policy – even if a technology is relatively close to the market or even ready for market launch.

Research for other climate regions

Uh (GTZ): I would also like to address some sectors other than PV for emerging and developing countries. An example from Morocco: Solar thermal systems are mainly used in combination with thermosiphons there. Such a system has a size of 2 m², produces 200 litres of warm water and costs about 1,000 euros. The mean per capita income in Morocco is 1,000 euros a year as well. So you can roughly estimate the proportion of the population that could afford it. And who needs 200 litres of hot water per head and day in Morocco? Storage collectors are, I am convinced of that, a fast seller for the whole MENA region. To do this, you need partners and possibly a trans-national research programme with a university in Morocco or in another country. This is just one example, but you always have to look very carefully as to what the markets beyond the developed countries actually need.

The same with medium wind power: This technology fully evolved in developed countries and was subsequently never optimised to meet the demands of the countries where it was newly deployed. Actually, it would have had just the right size for many electricity grids in developing countries but technically, it is still stuck in 1985. The demand for optimisation has to be looked at.

There is also a lot of work to be done regarding grid integration. But – and this important point is addressed to Mr Wollin from the BMBF and Mr Kaiser from the BMU – you cannot achieve all that from here. That is, we actually have to
think about getting the products from German manufacturers to the right place. What drives us is the climate problem and that is a global one.

**Shortage of skilled workers – promotion of young talent**

**Schneider** (University of Applied Sciences Berlin, HTW): We have talked a lot about development and growth now. To what extent do you consider the limits of available technical staff? Some graphs show an almost exponential growth for renewables but the universities do not provide this kind of output. How do you respond to this fact?

**Schmid**: The promotion of young talent is an extremely important issue and I think that academic and institutional research is suitable for this in order to add to the educational and training spectrum. We have a massive shortage of engineers in the entire machine and plant construction sector, even so during the economic crisis. We have a demand for additional experts especially in the rapidly growing renewable energy industry. This is particularly true for the wind industry. The graphs for Germany shown to us by the German Renewable Energy Federation may yet be accommodated somehow. But when installation is ready and done with in Europe, then there will be a lack of experts to manufacture to capacity. This is one of the key tasks for the next few years and it is not only specific to renewable energies. The manufacturer of a bearing or a gear box does not necessarily have to have special training as a “renewable energies engineer”, but has simply to be a good mechanic or mechatronics engineer.

**Aulich**: I would like to differ from Mr Schmid on this. Photovoltaics have a huge demand for junior staff as skilled workers and in the bachelor’s and master area. There are many approaches that can be supported by joint campaigns, allowing you to exercise some pressure on politics.

This is one of the advantages of a cluster formation such as the Solar Valley Central Germany. In Erfurt, for example, a training centre for photovoltaics and advanced technology is being built in which several hundred apprentices will be trained in the coming years. There are also endowed chairs ensuring that the subject of photovoltaics is taught at universities.

**Staß**: I think young people are in a position to properly assess their future prospects – perhaps the 130 students at this meeting are a good example. Regarding renewable energies, we do not necessarily need specialists but generalists in certain sectors such as process engineering, mechanical engineering, electrical engineering, chemistry and physics that focus on renewables. Asking actively teaching colleagues of the institutes in the Research Association, I learned that the number of students quadrupled in the last 2 to 3 years. I think that the students themselves make a statement with their participation, and universities will listen to this statement. There are now a one and a half dozen interdisciplinary master’s and bachelor’s programmes. So I am quite confident regarding the future. The one and a half million employees in the green industry give cause for a positive outlook.

**Kaiser**: The courses at the universities and universities of applied sciences are the federal states’ responsibility. As the federal government, we cannot do much for the promotion of skilled workers except help by forming opinions. But the decisions made on the federal state level have long-term effects. If you fully develop a course, it will have consequences on the labour market 4 to 6 years later. This only makes sense if you find a stable environment, when you can plausibly say that those people you are now attracting to the courses are needed in 5 to 7 years time. Therefore it presupposes that we, in the federal government, pursue a policy that has a long-term orientation.

Do you understand what I am talking about? We have to create a remuneration structure in the area of photovoltaics that enables people to do good business not only in 2010 and perhaps in the first half of 2011. We have to set down a stable political foundation that can bear the load up to 10 years in advance.
International cooperation

Staß: We heard many presentations at the annual conference regarding the adaptation of technology to local conditions in other countries, to the regional climates, to grid integration, but also to the respective societies and cultures. To these ends, we require specific knowledge from the user countries. In this respect, an ideal research partner for global markets should offer competencies that complement our own. We can learn much from one another and especially from developing countries. So it does not always have to be an East-West partnership, it can also be a South-North partnership. There are many good examples in the Research Association. For example, when it comes to solar construction it is a wholly different story for Asia than it is for Central Europe. In this respect, it is obvious that you are going to look for a partner that can provide a lot of input based on experience with the climatic requirements.

Our deficit lies in non-European research collaborations. Americans and Europeans mainly engage in science in a competitive way. This leads to a healthy competition. But on the other hand, we are not utilising synergies and have duplications of effort. There is practically no budget provided jointly that allows to increase the attractiveness of international and non-European research by offering a budget that can be applied to together. In Europe, we have the advantage of being strongly networked in scientific efforts. This is missing at the international level and is urgently required for global markets.

Kaiser: Yes, we do have budgets for international cooperation, allowing for joint applications. We have an agreement with Israel. My suggestion would be a reverse approach: If you find a meaningful level of cooperation, then file a request to the BMU or the BMBF for a joint project. The ministries would like to support such non-European cooperations because we perceive this deficit in the same way as you do. But we believe that this ought to grow from the bottom up, from the initiative of specific agreements between the institutes, rather than us developing a framework agreement and then desperately searching for participants.
Public relations for renewables

Hoffmann: This mix of measures still requires a key element: communication! There is not enough publicity to generate the necessary pressure. At this conference, we have heard a lot about price learning curves. We, as an industry, believe that it will continue to hold true for the next 10-15-20 years due to technology-driven products. But it is an important task to communicate this fact to the general population. The renewables industry – and I include research – has to create a very different understanding of the necessity of renewables in the general public to carry it successfully into the future.

Of course, this includes inspiring young people to enter into these professions. The topic of renewables, especially photovoltaics, suffered an almost exclusively negative reporting in the media in the last three months: the discussion of the energy feed-in act, quotations from the RWI Essen and the Photon magazine, reports in Zeit, Handelsblatt, Financial Times Germany and Der Spiegel.

At the weekend preceding the coalition consultation, we placed a half-page ad in the Frankfurter Allgemeine with Mr Weber from the Fraunhofer ISE to counter the bad press with a few positive facts about photovoltaics.

I think we are all prompted to put things into perspective here. Positive communication will hopefully also encourage more young people to start scientific studies and achieve something in this great environment. I hope that we can get more people involved across the entire value-added chain. Generally speaking, we need mechatronic engineers, solar engineers and people skilled in individual technologies such as wind energy or fuel cells. We need more young people in all of these fields if we are to realise the goal of 100 percent renewables.