Decentralized, Resource-Saving, Efficient:

Building Blocks for a Sustainable Energy Supply

A study on behalf of the Robert Bosch GmbH

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Content

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Preface

The decision for the “energy turnaround”, taken by the German government in the summer of 2011, poses a great challenge for companies, politicians, and society. The project leads the way into the future of energy supply in Germany and will require the active participation of all the parties involved.

It is up to politicians to set the objectives. Clearly defined and predictable framework conditions are necessary. Otherwise the climate and energy policy objectives which have been set within the energy turnaround cannot be achieved.

At the same time, companies have a part to play as well in this challenge. Their investments and innovations are the fundamental prerequisites for a successful energy turnaround. The spotlight is on sectors such as renewable energies, networks and storage technologies, but the focus also encompasses the energy efficiency of buildings and factories, products, and industrial processes.

It is equally important that citizens make their decisions with greater consciousness when it comes to energy supply and consumption, whether it is when purchasing energy-saving household appliances, using photovoltaic or solar thermal systems as well as state-of-the-art building technology for energy-efficient housing refurbishment. It is up to every one of us, not least the residents close to power generation facilities or new power grids.

A societal task of this scope demands a common understanding about the long-term goal, the appropriate technologies and the political instruments which we must use if we are to make any progress along the way. This is how we understand our role: the Robert Bosch GmbH wants to contribute to the achievement of the energy turnaround. The first step is an intensive and constructive dialogue between politicians, companies and societal actors. A common understanding of the facts and the current status quo therefore plays an important role.

Against this backdrop the Öko-Institut in Freiburg, with the support of experts from our company, has conducted this study. We hereby would like to give some impulses for a more decentralized, resource-efficient structure of energy generation, distribution and consumption.

Our thanks go to the experts from the Öko-Institut and the Bosch project team for their commitment to this effort. We are convinced that this publication will be a valuable contribution to the current discussion on energy policies and to the development of a sustainable energy supply in Germany.

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Executive Summary

During the summer of 2011, the German government decided with the so-called “energy turnaround” to discontinue the use of nuclear power and to shift the provision of energy to renewable energy sources, step by step. Moreover, the decision provides for a massive improvement in the energy efficiency of buildings, machinery and facilities and the expansion of combined heat and power generation. The realization of these objectives is a decisive prerequisite if Germany is to achieve the fast and extensive reduction of its greenhouse gas emissions required from the perspective of global climate protection. According to the latest findings from climate research, the industrialized nations must reduce such emissions by at least 90% in comparison with the volume of 1990 by no later than 2050.

This study, prepared on behalf of the Bosch Group, analyzes four selected technology areas which are of especially great strategic relevance for the realization of these objectives and identifies the need for political action for their continued development within the framework of the energy turnaround. It describes a “moderately decentralized” approach, i.e., the energy infrastructure is developed as a mixture of decentralized and centralized technologies. The decentralized option is always given priority if the centralized alternatives do not offer clear advantages, e.g. of economic or ecological nature. Special consideration is given to technologies which can be used in a decentralized system as a means of achieving the energy turnaround objectives at what will presumably be lower economic cost than would be the case for a strategy based largely on centralized technologies.

The first step of this analysis is found in a scenario for the possible development of energy demand and energy supply in Germany up to 2050. The scope is restricted to stationary energy demand; the transport sector was deliberately excluded in order to limit the complexity of the study. An up-to-date scenario for the development of energy demand was prepared on the basis of a study for the energy concept of the German national government, supplemented by recent long-term scenarios and own appraisals of the Öko-Institut. The results indicate that an average reduction of energy demand across all sectors of about 43% by the year 2050 is feasible, while retaining the current standard of living and positive economic development.

Particularly important gains in energy efficiency appear to be possible in the residential building stock where consumption could be lowered by about 57%. Moreover, about 80% of power generation could come from renewable energy sources by 2050. Renewable energy could also be used to replace about 50% of the consumption for the provision of heating in private households, the services and industrial sector by 2050. The developments described above would allow for reducing greenhouse gas emissions in Germany by more than 85% by the year 2050. This study also includes a discussion of the most important economic effects of such a scenario.

The first technological field identified as strategically relevant for the energy turnaround is the housing of the future. This is the sector where the German government, as well as many of the pertinent studies, sees the greatest potential for the reduction of greenhouse gases. The German government’s energy concept consequently targets a building stock in 2050 which is largely neutral in its impact on climate. In effect, a key challenge of the German climate strategy is the massive reduction of the demand for energy in both residential and commercial structures by increasing energy efficiency and covering this demand primarily with energy from renewable sources. In view of the building stock today this will require above all a substantial acceleration of the renovation rate for the building stock shells and the establishment of the passive building standard as the target state after renovation as quickly as possible.

In this field and in new construction, the combination of photovoltaic systems and power storage units could also realize zero-energy and energy-plus buildings. In the course of such overall refurbishment measures for buildings, but also in the course of measures applicable to buildings which for technical, economic or other reasons can only be partly renovated, substantial emission reductions can be realized in the coming years by the installation of new, highly efficient heating equipment based on renewable energies or natural gas, including systems using combined heat and power. If the renovation possibilities are limited, prioritizing the renewal of the heating system can be a sensible idea; in any case, the current backlog in the modernization of heating systems must be overcome as soon as possible.

Whenever heating systems are overhauled,

renewable energy should be integrated to the greatest possible extent, and consideration must be given at the same time to the longer-term complete renovation of the building. In the long run, the heating structure of the facility will clearly be shifted to renewable energies so that these sources provide 32% of the coverage of heating demand by 2030. Furthermore, ventilation systems with incorporated heating elements will increasingly gain market share over conventional heating technologies, although the amount of this gain will be subject to the reduction in heating energy demand which is achieved. Technologies used to supply hot water will continue to develop as well and will be increasingly operated independently from heating. The greatest potential for centralized systems within buildings is found in solar thermal systems. To the same degree that power generation will be shifted to renewable energy sources it will even be sensible to install decentralized, electric water heaters in buildings which have been renovated according to energy-saving standards. The demand for electric power in buildings can be reduced significantly in the medium term as well. The successive and foreseeable technical evolution of household appliances will contribute to this.

The second strategically relevant field of technology concerns the energy efficiency of industrial applications. Today, about 28% of final energy consumption in Germany is on the industry side. Besides the production processes of specific sectors, crossover technologies such as engines and pumps, compressed air, lighting, etc., are of substantial importance. About one-fourth of the demand for industrial energy can be saved by the year 2030 if the best technology available on the market is installed and the structural transformation of the industrial sector to knowledge-intensive industries is completed. The greatest obstacles to these measures, often reasonable from an economic perspective, are the high expectations of industrial players with respect to the returns on the invested capital and the time period for its refinancing. In the future, a successful business model featuring differing expectations for the return on capital could be created by service providers specializing in energy efficiency. A systematic approach based on optimized energy use, recovery of waste heat and the provision of energy-on-demand in facilities that have been optimized accordingly is a reasonable means of exploiting the potential for energy efficiency in the industrial sector to the greatest possible extent. Priority should be given to renewable energy sources and combined heating and power plants for the generation of power.

Moreover, the time curve of industrial energy demand should be adapted to the local or supra-regional availability of renewable energies as far as this is possible. The use of decentralized storage technologies can play a role here.

Power generation using photovoltaic and wind energy was identified as the third strategically relevant field of technology. There are clearly defined political objectives in this sector to be achieved by the year 2020 in Europe, especially in Germany, where there is also a stable political environment as a consequence of the prioritization and support pursuant to the German Renewable Energies Act (EEG). If the political goal of covering half of the power demand in Germany from renewable energies by the year 2030 is to be achieved, however, the Feed-In-Tariff (FIT) system of the EEG and the design of the power market must be developed in such a way that technologies close to the market, in particular on-shore wind energy and, in the near future, photovoltaic energy, can be integrated into the market successfully and without any disruptions in investment activities.

Off-shore wind energy, on the other hand, will continue to require substantial financial and administrative support. Rapid conversion of the power grids and expansion of power storage units will also be required so that the electricity from renewable energy sources can be transmitted to consumers and fluctuations in generation and consumption can be balanced. The selective expansion of power generation from renewable sources in the southern German states can presumably contribute to partly avoid the otherwise necessary grid expansion. More effective steering of decentralized power generators and, in particular, of commercial and industrial power consumers should be realized for the same purpose within the framework of “smart grids”.

Based on today’s developments in prices and technologies, the electricity price for households and the generation costs of photovoltaic energy, including the decentralized storage capacity in Germany, will be at a similar level by the year 2020, enabling a high degree of internal self-consumption of about 60%.

Manufacturers of wind power and photovoltaic components have in the meantime become active on a European and global market for which the middle- and long-term outlook is excellent. The markets in Asia and the USA will also play a major role alongside the demand in Europe. However, competition with manufacturers from Asia is becoming stiffer, making it

necessary to assure the strengthening of Germany as a business location so that its position on the world market can be maintained. The technological lead is essential for Germany's role in the world market.

Energy storage has been identified as the fourth strategically relevant technology field. As described in the above section, storage units can play an important role in the creation of an intelligent power infrastructure with a decentralized orientation. This is primarily a matter of planned balancing of fluctuating power generation from wind and photovoltaic energy and the provision of balancing power for unscheduled fluctuations. In this situation, storage units can, just as the steering of decentralized generation facilities and the load management on the demand side within the framework of "smart grids", serve as a supplement to the required grid expansion and limit the extent to which this expansion is required.

Widely divergent technologies can be used to achieve this purpose, ranging from a number of types of electro-chemical battery systems to the conversion of power into hydrogen and synthetic natural gas to mechanical storage. Moreover, thermal storage units used in CHP plants and solar thermal power plants can contribute to the decoupling of power generation and heat supply. This study provides an overview of the available power storage technologies, each of which can be used in specific areas, as well as the limitations and needs for developing each of them. Storage technologies require a lot of further research and development before the goal of application-oriented system solutions with a competitive cost structure will be reached. The market potential for power storage units can be appraised as very high, both in Europe and worldwide and is further increasing. Global market volume in 2020 is expected to reach €10 billion. Synergies with battery development for electric vehicles can be exploited here.

Taking the analyses of the scenario for the long-term development of the energy sector in Germany and of the four selected technology fields as the starting point, the study has determined a series of recommendations for action in energy policies which will support a reasonable mix of decentralized and centralized optional solutions for the energy turnaround. By implementing this program of action, German politicians can give investors and technology providers in the four technology fields considered here the required security for planning and offer the necessary economic incentives.

The following recommendations have been drawn up:

(a) Buildings of the future

- Increase the financial incentives for the energetic renovation of buildings
- Further tighten the energy-saving requirements for buildings
- Successively develop of the German Renewable Energies Heating Act
- Incentivize power-saving for households and businesses
- Improve in public relations and information

(b) Energy efficiency of industrial applications

- Introduction Energy Saving Obligation Scheme for energy providers
- Consider mandatory energy management systems for industry
- Intensify of support mechanisms for energy efficiency networks in industry
- Review the introduction of a heat utilization regulation
- Expand ecodesign and labeling

(c) Power generation from wind and photovoltaics

- Improve and further develop of the power market design

- continuously develop of the German Renewable Energies Act EEG
- Develop relevant infrastructures, especially power grids
- Improve the planning schemes for wind power and photovoltaics

(d) Energy storage units

- Increase incentives for decentralized energy storage units within the EEG
- Simplify the use of storage units by network operators
- Create investment support mechanisms for decentralized storage units
- Provide additional R&D support for technological innovations

General recommendation:

- Intensify R&D funding in all scientific fields relevant for climate protection

Recommendations for action in energy policies

Comprehensive signposts must be set in energy policies aimed at the development of an energy system which will meet the demands of the future while burdening the climate as little as possible. This comprises measures such as the setting forth of long-term, binding climate protection targets, including suitable procedures for monitoring progress in the different sectors of the economy.

Moreover, the key overall instrument of climate protection policy, which is the emission trading system, must be further developed in accordance with middle- to long-term climate protection goals. However, the recommendations for action given in this section have deliberately been focused on those instruments which can develop the potentials for climate protection in the areas of the four key technologies from the previous chapters.

The following types of instruments are available to policymakers: (a) a change in market design through appropriate regulation (b) creation of financial incentives; and (c) regulatory requirements. Depending on the concrete conditions for implementation in the respective fields of action, the instruments should be applied in the order described below.

The recommendation to intensify research funding in scientific fields relevant for climate protection is a priority. Development and testing of innovative processes and technologies as well as accompanying research in social sciences are fundamental prerequisites for the achievement of the climate policy goals

1. Realizing the Buildings of the Future

Recommendations for Action – Buildings:

1. **Increase the financial incentives for the energetic renovation of buildings**
2. **Further tighten the energy-saving requirements for buildings**
3. **Successively develop the German Renewable Energies Heating Act**
4. **Incentivize power-saving for households and businesses**
5. **Improve public relations and information**

The housing sector is one of the most important areas for action of the energy turnaround and for the achievement of the climate targets. The overall objective is the comprehensive reduction of greenhouse gas emissions and of the primary energy demand of buildings. Residential buildings are of great importance and especially the building stock, which will continue to dominate the energy demand for space heating even until 2050. This overall objective can be achieved by the following measures:

- Increase the renovation intensity of (residential) building inventories (significant rise in renovation quota and in-depth renovations)
- Shorten the backlog in modernization of heating systems
- Increase the market share of heating systems based on renewable energies
- Expand of the heating grids for the provision of spatial heating where practical in terms of energy provision technology (e.g. the use of existing industrial or commercial waste heat potential), incl. integration of heat storage units
- Reduce of power consumption in (residential) buildings

One key prerequisite for the achievement of the climate goals is reconciling the interests of various players in the building sector with these objectives. The user-investor dilemma must be resolved for simplifying investments in building renovation and renewable energy systems in the rental residence

sector. Tenants and landlords must equally profit from the required investments. Rental laws should be adapted accordingly. Since the comprehensive renovations required for achieving the demanding climate protection targets are often economically unrewarding from the perspective of investors and tenants, therefore support mechanism are necessary for many investment activities.

A comprehensive restructuring and possible integration of the regulatory instruments EnEV (German Energy-saving Regulations) and EEWärmeG (German Renewable Energies and Heat Act) and of the corresponding regulations at state level, maybe joint into a "Energy and Heating Act" for new construction and building inventories and consistently applicable at national level, are not realistic at this time. As long as these instruments exist parallel to one another, they must be developed in a way to avoid incompatibilities between them.

RECOMMENDATIONS FOR ACTION

The realization of ambitious climate protection targets in the building sector will require a well balanced mix of financial funding, regulatory provisions and changes of the market conditions.

Recommendation for Action – Buildings 1:

Increase the financial incentives for the energetic renovation of buildings

Investors need sufficient and long-term project funding in this sector in order for the political targets for the energetic renovation of buildings to be achieved. The required funding volume for low-interest loans and direct investment grants amounts to a minimum of €10 billion annually.[1]

In addition to that, tax credits for investments in energetic building renovation should be re-introduced as another financial incentive, including a long-term depreciation of the investments which have been made. The procedure should assure the social balance of the funding impetus, e.g., by issuing tax credits instead of tax write-offs.

Under certain conditions, modernization of heating systems could be subsidized as well. Such conditions would include the avoidance of a delay in comprehensive building renovation, e.g., by focusing on buildings for which comprehensive energetic renovation seems not to be possible or reasonable in the foreseeable future, owing to technical, economic or other reasons. The long-term objective of energy policies, the extensive replacement of fossil fuels with renewable energy sources for 2050, must not get lost in the shuffle.

There should be a review to determine opportunities to provide the required funding for energetic renovation by means of a nationwide surcharge financing, similar to that of the EEG, on fossil fuel prices. The advantages of this type of solution would be the provision of the required funds independently of government budgets and a reinforcement of the economic incentives for the installation of heating systems running on renewable energy or making more efficient use of fossil fuels. A disadvantage of this solution would be the lack of social balance inherent in a flat-rate price increase by utility companies. This would possibly mean a necessary and suitable form of compensation so that hardships could be avoided.

The enumerated measures serve to support the broad regulatory provisions for building renovation (see the following Recommendation for Action - Buildings 2).

[1] *The Deutsche Energieagentur (German Energy Agency) speaks of the need for €5 billion in funds. However, this figure is based on the renovation costs for the energy standards realized today. But since the energy standards for building renovation must be raised if the climate protection targets are to be achieved (see previous chapter), the Öko-Institute sees the necessary subsidy funds at a much higher level. According to studies done by NABU (2011), the subsidy volume will be €5 billion/year in 2015, rising to just under €9 billion/year by 2020.*

Recommendation for Action - Buildings 2:
Further tighten the energy-saving requirements for buildings

Suitable revisions of the German Energy Conservation Regulations (EnEV) should lay the foundation for a complete and high-quality energetic renovation rate of building inventories by the year 2050. The revisions should be aimed at stimulating the development of innovative technologies and creating the market framework conditions for their application. Renovations up to 2020 must as a minimum achieve the level of low-energy houses ("3-liter house"); subsequent renovations must attain the level of passive, zero-energy, or energy-plus houses.

The catalog of obligatory conditions in the EnEV should be expanded. In view of the many non-financial obstacles (e.g., in the case of owner cooperatives), renovation duties coupled with attractive subsidization measures must be provided under certain exceptional conditions. Such mandatory renovations could be introduced along the lines of the legal provisions for construction on inner-city property.

Alternatively or as a supplement to subsidization (see Recommendation for Action Buildings 1), the EnEV could provide for an obligation to replace especially old heating systems (> 25 years). Such a mandatory replacement could possibly be implemented by way of the regulations of the BImschG (German Federal Emissions Protection Act).

Furthermore, the profitability requirement of the Energy Conservation Act (EnEG) should be expanded to a greater scope. In the future, it should anticipate the energy prices in the middle and long terms provide longer periods for the refinancing of measures and introduce reasonability in place of profitability as the leading criterion.

The energetic requirements for new buildings in the EnEV must also be tightened step by step.

Regular random inspections by construction supervisory authorities, whose personnel should be increased for this purpose, should be instituted as an effective means of monitoring compliance with the energy requirements during renovations and new construction. Violations should be punished by the levying of severe penalties. A possible alternative to the expansion of the role of construction authorities would be the "privatization" of the inspections by assigning operational control of execution to recognized experts.

Recommendation for Action Buildings 3:
Successively develop the German Renewable Energies Heating Act

Long-term minimum targets for the share of heating from renewable energies in the national provision of heating and air-conditioning should be set forth in the Renewable Energies and Heating Act (EEWärmeG), building on the foundation of current indicative targets for 2020, as this would give technology providers security for their long-term planning.

One possible way to optimize the concrete regulations of the EEWärmeG is the introduction of a bonus model replacing the previously applicable minimum share regulation for renewable energy heating in new construction. This model could be designed along the lines of the compensation system of the Renewable Energies Act in the power sector. A bonus (or award) model offers a high level of investment security for investors in heating technologies based on renewable energies in combination with a good steering effect. Since the response to and the call of the bonus is uncertain, there is a risk in volume which requires regular adjustments by lawmakers. This leads to a certain administrative work load, but it would fall far short of exceeding the benefits of such a regulation. The price surcharges for private households will presumably remain moderate; they will be even lower for industrial large-volume customers with the corresponding market power than in private households. (Seefeldt, F., 2011; Nast, M, et al., 2006) A bonus model can be implemented as a substitute or supplement to the market incentive program. If the mandatory use for renewable energy based heating on the basis of the minimum share regulation is retained, the mandatory use should be expanded at national level to include the existing building stock. The minimum share of renewable energies should be increased step by step for new construction and the building stock with the long-term goal of completely replacing fossil energy sources with renewable energies.

Moreover, the EEWärmeG should be supplemented by concretized requirements for the air-conditioning of buildings on the basis of renewable energies. Effective controls of the realization of the EEWärmeG should be assured. This could be achieved in combination with an intensified monitoring of compliance with energy conservation requirements during renovations and new construction (cf. Recommendation for Action Buildings 2).

Recommendation for Action – Buildings 4:

Incentivize power-saving for households and businesses

The systematic increase in energy efficiency of household appliances should follow the top-runner principle in the future. This means that the regulatory instruments of the EU must be adapted dynamically and ambitiously. Such instruments include energy labeling using constantly changing new classes and prohibitions within the framework of the Ecodesign Directive. This can also include the type-specific power consumption of respectively the best appliances. Since this lies in the competence of the EU, initiatives must be launched at European level.

The energy consumption labeling should be extended to include household appliances which are currently not covered, e.g., small electric appliances and entertainment electronics. Authoritative parameters such as different performance categories must be taken into consideration though.

The purchase of best performing appliances of certain categories can be promoted with the help of financial support measures.

Recommendation for Action - Buildings 5:

Improve public relations and information

The general public and media still tend to relate the energy turnaround primarily with issues from the electric power sector. Ultimately, however, the heating sector is of equal importance for the success of a comprehensive climate protection strategy. There is a need for appropriate public relations measures which will improve the state of information regarding the significance of this sector as well as the technical solutions which are available and the advantages they offer.

Moreover, the public building stock should be developed as a showcase for good examples of comprehensive energy-saving renovations and for the use of renewable energy based heating technology. Public buildings, being used by millions of people every day, are especially important as role models. Energetic renovation measures in such buildings should go to the greatest depth possible and serve as an opportunity for the complete conversion to renewable energies. (BEE, 2009)

2. Increasing the Energy Efficiency of Industrial Applications

Recommendations for Action - Industrial Energy Efficiency:

1. **Introduce Energy Savings Obligation Schemes for energy providers**
2. **Consider mandatory energy management systems for industry**
3. **Intensify support mechanisms for energy efficiency networks in industry**
4. **Review the introduction of a heat utilization regulation**
5. **Expand ecodesign and labeling**

Large parts of the greenhouse gas emissions from industry are subject to the emission trading system. The overriding objectives for supplementary measures in the industry sector should consequently be aimed at increasing energy efficiency when using electric power in industrial production processes and should be guided by the feasibility to standardize technical saving measures (e.g., in crossover tech-

nologies such as electric motors, ventilators, pumps) as well as process-related saving measures (process re-engineering). Special attention should be paid to the possibility of increasing efficiency in the supply of process heat and to the efficient use of industrial waste heat.

RECOMMENDATIONS FOR ACTION

Recommendation for Action – Industrial Energy Efficiency 1:

Introduce Energy Savings Obligation Schemes for energy providers

Operators that provide energy for use in stationary facilities of end consumers (alternatively: the power grid operators) could be bound to realize efficiency measures or their financing by purchasing "white certificates". The obligation should begin with a reduction of 1.5% in the final energy sale of each company each year and successively increase. The basis of the system is a positive list of project types and appropriate methods for determining the baseline which serves as reference for the energy savings of a specific measure. The costs for the measures are allocated to the energy prices (or grid charges). This instrument is also suitable for power usage in private households and the service sector. Here the results of further studies on the feasible implementation of the instrument have to be awaited.

Recommendation for Action – Industrial Energy Efficiency 2:

Consider mandatory energy management systems for industry

Companies in the production segment should be obligated to implement energy management systems or comparable instruments as a means of systematically improving their energy efficiency. This could be carried out in a complementary way to the reductions in energy taxes, e.g., to a reduction in the energy tax rate.

During the implementation phase of the energy management systems, the focus should be on the systematic collection and use of available waste heat. The goal is to create the prerequisites for a systematic use of waste heat by quantifying in detail the volume and quality of the waste heat.

Recommendation for Action Industrial Energy Efficiency 3:

Intensify support mechanisms for energy efficiency networks in industry

Currently there are 30 publicly supported pilot grids for energy efficiency in small and medium – sized companies in Germany. Switzerland (since the middle of the 1980s) and Germany (since the beginning of the new millennium) have gained positive experiences with energy-efficiency networks. It indicates that progress in energy efficiency in the participating companies can be doubled.[2]

This is why the public support for energy-efficiency networks in combination with appropriate information campaigns and consulting should be extended as quickly as possible to include a large number of regional and/or local networking activities.

[2] *www.industrie-energieeffizienz.de*

Recommendation for Action Industrial Energy Efficiency 4:

Review the introduction of a heat utilization regulation

The exploitation of the enormous potential of waste heat in the German industrial sector should be encouraged by reconsidering the issue of a heat utilization regulation. The possible designs for such a regulation, the related costs for the companies and the expected benefits for climate protection should be scientifically examined in light of the current legal framework conditions of energy and climate policies.

A heat utilization regulation should be incorporated into the regulatory framework of the BImschG (Bundes-Immissionsschutzgesetz – Federal Law on Environmental Permits).

Recommendation for Action Industrial Energy Efficiency 5:

Expand ecodesign and labeling

The regulations of ecodesign and energy consumption labeling are intended to create additional incentives for efficiency in commercial and industrial businesses. The inclusion of suitable crossover technologies which can be standardized into the Ecodesign Directive should be enforced. Additional efficiency labeling would be practical above all for technologies which can be standardized such as motors, pumps, etc.

3. Expansion of Power Generation from Wind and Photovoltaics

Recommendations for Action - Power from Renewable Energy Sources:

1. ***Improve and further develop the power market design***
2. ***Continuously develop of the German Renewable Energies Act EEG***
3. ***Develop the relevant infrastructures, especially power grids***
4. ***Improve the planning schemes for wind power and photovoltaics***

The key objective in this field of action is the exploitation of the commercially usable potential for power generation from wind energy and photovoltaics in order to increase the share of power generation from renewable energy sources to a minimum of 50% by 2030. Priority should be given to decentralized renewable energy potentials, provided an overall examination (incl. the effects on the power grid) reveals overall advantages over centralized renewable energy technologies (e.g., off-shore wind power, Desertec). The development of an appropriate power market design and the consistent further development of the German Renewable Energies Act (EEG) are indispensable prerequisites. The provision of the necessary power grid infrastructure in due time is equally essential.

RECOMMENDATIONS FOR ACTION

Recommendation for Action - Power from Renewable Energy Sources 1:

Improve and further develop the power market design

To enable the change in power supply to renewable energy sources in a middle and long term perspective, the power market must be restructured in a way to have adequate price signals for investments in and the operation of power plants even with a high share of renewable energy. A number of different strategic options are currently being discussed for the further development of the power market design.

With respect to conventional power plants, the introduction of capacity markets is being examined which allow for compensation for reliable availability of capacity at specific times, e.g., during peak load periods. Such an instrument could assure sufficient remuneration flows for (new) conventional power plants which could balance potential shortfalls in the fluctuating power generation from renewable sources. In addition to a comprehensive capacity market which would also incorporate existing power plants, selective capacity mechanisms can also be taken into consideration (e.g., selective tenders or defined bonuses for the provision of certain generation services) for which concepts and assessments are currently being worked out. (Matthes, F.C., 2011)

With respect to power generation from renewable energy sources, there are options to carry on the priority regulation and feed-in compensation pursuant to the EEG and, alternatively or as a supplement, the conversion of the funding system to systems including more market-based mechanisms (cf. also Recommendation for Action - Power from Renewable Energy Sources 2). (Matthes, F.C., 2011)

In addition to that, increased funding of opportunities to influence controllable, decentralized power generators and consumers and the expansion of storage facilities and power grids can partly replace the otherwise necessary investments in grid expansion. The need for action in this case translates into an increase in flexibility on both the power generation and the demand side. This means that the technical and organizational conditions needed to orient end customer prices towards actual power market prices should be created. This also includes measures to increase the possibilities for generators and consumers to control energy production and output. The selective use of power generated from renewable energy sources during times of high availability and the moderation of demand during times of low availability are essential elements for increasing the flexibility and overall efficiency of the system. (Cf. also Siegmeier, J. and C. v. Hirschhausen, 2011)

There is a pressing need for additional research on the requirements of future power market designs. The issue of minimum price limits for renewable energy feed-in tariffs will also have to be discussed.

Recommendation for Action - Power from Renewable Energy Sources 2:

Continuously develop of the German Renewable Energies Act EEG

The EEG is the key instrument for the integration of power from renewable energy sources into the market and system. The long-term prospects of the EEG should be clarified as quickly as possible so that companies and investors have a reliable basis for their planning. Even as the various technologies for renewable energies successively become competitive, the feed-in and dispatch priority for power from renewable sources in grid connection and power plant use will continue to be necessary in the long term for many renewable energy technologies. This will also be true for market integration rules and for support schemes for self- consumption.

The instrument of feed-in compensation needs to be more predictable in terms of degression paths in order to imp rove the planning conditions for investors and manufacturers. Whenever a particular renewable energy technology becomes marketable, the mandatory feed-in compensation can expire, provided that the power markets can pay reasonable prices for this technology (cf. Recommendation for Action - Power from Renewable Energy Sources 1). The feed-in tariff structure for PV power should be monitored in the coming years. There is no need for massive short-term shortening of this feed-in tariff structure. Depending on the monitored impacts of the instrument financial incentives for the new installation of PV facilities must be accordingly further developed.

It will be necessary to continue the EEG subsidies, which are currently subject to a time cap, for own consumption of PV power since this supports the objectives of an increasingly decentralized energy generation and creates an incentive for the expansion of storage technologies. Their effectiveness in realizing these objectives must be appraised at regular intervals and the framework must be adapted as necessary. The effectiveness of market bonuses as foreseen by the EEG 2012 should also be examined. Finally, a successive replacement of fixed feed-in tariff compensation in the form of market bonuses for specific renewable energy technologies, e.g., wind farms with a favorable location, should be sought whenever these technologies get closer to

marketability. In which way the instrument of market bonuses can be further developed should be analyzed promptly and depending on the experiences made after its introduction.

Ultimately, the costs for expanding the use of power from renewable sources should be reduced and not further increased. This goal seems to be achievable, even as the share of renewable power generation sources further increases, owing to the degressive feed-in tariff rates and the presumably rising prices for conventionally generated power in the long run (increasing fuel costs, increasing costs for CO_2 certificates). According to the Pilot Study 2010 from the German Federal Environmental Ministry, a significant rise in costs for fossil fuels will have positive economic impacts on renewable energies from 2025 and for wind power even earlier on average (from 2020). If fuel costs increase less rapidly as predicted, positive economic impacts will not occur until 2032 (Nitsch et al., 2010)

Recommendation for Action - Power from Renewable Energy Sources 3:

Develop the relevant infrastructures, especially power grids

In general, the need for power grid expansion should be limited as much as possible and in a comprehensive, economically reasonable way by means of decentralized power generation and decentralized energy storage facilities (in combination with photovoltaic and wind energy facilities as well) as well as demand side load management. To what extent the above-mentioned measures can reduce the necessity of extending the power grid should be further examined.

Moreover, the European power grid must be transformed in such a way that high levels of power from renewable sources desired for in the future can be reliably managed. In particular, the connection points to other countries and the important north-south grid connections must be expanded in a short-time perspective. Transparent planning processes and comprehensive participation opportunities for the general public and the parties affected by the transmission lines at an early stage are of great significance in order to accelerate the planning and approval procedures as a whole.

Recommendation for Action - Power from Renewable Energy Sources 4:

Improve the planning schemes for wind power and photovoltaics

Improving planning schemes can create conditions for the further expansion of on-shore wind power, especially from repowering, and the expansion of wind energy in southern Germany. The conditions for grid connections of off-shore wind farms must be improved proactively. Up to now, there is no answer to the question regarding the extent to which centralized power storage (e.g. close to connection points of off-shore facilities to the grid) can reduce the necessity of power grid expansion and therefore requires examination. Moreover, potential locations for PV solar parks should be zoned as part of regional planning and the grant procedures should be simplified.

4. Development of Energy Storage Units as Part of an Intelligent and Decentralized Energy Infrastructure

Recommendations for Action – Energy Storage Units:

1. ***Increase incentives for decentralised energy storage units within the EEG***
2. ***Simplify the use of storage units by network operators***
3. ***Create investment support mechanisms for decentralized storage units***
4. ***Provide additional R&D support for technological innovations***

The overall objective here is the creation of framework conditions for the profitable construction and operation of power storage facilities as components of a decentralized, intelligent power infrastructure. This means not only to speed up further the research and development on available technologies, but also to create the necessary regulatory preconditions. However, a broad introduction of energy storage facilities will be difficult to realize without initial funding. This has been similarly assessed at international level; e.g. in China and the USA, where various governmental funding programs for energy storage technologies were initiated only a short time ago.

RECOMMENDATIONS FOR ACTION

Recommendation for Action – Energy Storage Units 1:

Increase incentives for decentralized energy storage units within the EEG

The operation of storage units close to the feeding-in power facilities as a means for improving the regulation of consumption, storage and feed-in should be supported in the EEG. The feed-in tariff rates of the past have proven to be effective instruments for the promotion of renewable energy technologies; however, they also lead to an economic disadvantage for energy storage units. With this in mind, it is a good idea to incorporate storage units and as a consequence also the basic concept of harmonizing power generation and demand into the EEG funding schemes.

This has already been realized for photovoltaics by supporting self-consumption regulation. In this context, one could also imagine an additional bonus for fluctuating renewable energy technologies if they are coupled with energy storage units. This bonus should be coupled to additional requirements, e.g. the design and operation of the storage facilities in order to achieve optimum system efficiency.

At the same time, energy storage units spatially independent of generation or consumption should also be promoted reasonably (by the EEG or other regulations which go beyond the exemption of storage facilities from grid charges). A possible flat-rate bonus for avoiding grid expansion costs should also be taken into consideration in this context. The expansion of the system service bonus in the EEG should be analyzed as well.

The overall objective for all of these measures is to make energy storage units marketable.

Recommendation for Action – Energy Storage Units 2:

Simplify the use of storage units by network operators

There are currently a number of obstacles to the optimum use of energy storage units by network operators. The operation costs of storage units should in the future be recognized as network operating costs in order for the expansion of storage capacities to be equally competitive with grid expansion. Moreover, the integration of storage units into the power market should quickly be advanced. At the moment, network operators are not permitted to operate storage facilities themselves because of unbundling requirements. At the same time, however, there is no adequate market design for a functioning market for storage services or for independent storage facility operators to be actively involved. This problem could be solved by exempting network operators from the unbundling requirements and allowing them to operate storage facilities. Alternatively or supplementary, conditions for successful activities of a new, independent market player, the "storage facility operator", could be created.

In the same way the aggregation of small storage units (e.g., in household applications) should be simplified to open up access to attractive markets such as the power stock exchange or the controlling power range markets. Section 3.4.2 describes how this type of combined applications can increase the storage unit load and improve their profitability.

Recommendation for Action – Energy Storage Units 3:

Create investment support mechanisms for decentralized storage units

Once marketability of the relevant technologies has been achieved, the broad introduction of decentralized storage units should be promoted by tax credits. In California, for example, such funding instruments (Self-Generation Incentive Program and Federal Investment Tax Credit) currently lead to a strong increase in storage projects investments and research activities.

Recommendation for Action – Energy Storage Units 4:

Provide additional R&D support for technological innovations

Regarding the great challenges to be tackled in research and development of decentralized storage technologies, support for research and demonstration projects in form of governmental funding is indispensable. Here the aim is to drive innovative storage technologies which are still in their very early stages by providing research funds and making technologies currently close to the market ready for industrial series production by supporting demonstration projects.