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Green Paper on Energy Efficiency

Discussion Paper of the Federal Ministry for Economic Affairs and Energy

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Federal Ministry for Economic Affairs and Energy (BMWi)
Public Relations
E-Mail: publikationen@bundesregierung.de
www.bmwi.de

Central procurement service:
Tel.: +49 30 182722721
Fax: +49 30 18102722721

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Foreword

Ladies and Gentlemen,

Energy efficiency is a key requirement for a successful energy transition and implementing the results of the most recent climate conference in Paris. Efficiency First means that the energy saved does not need to be generated, stored and transported. Energy efficiency permits us to reduce the costs of decarbonising our economy. What is more, the energy saved does not need to be paid for.

The progress made in the recent past clearly shows that economic growth and falling energy consumption are mutually compatible. The National Action Plan on Energy Efficiency (NAPE) presented by the Federal Ministry for Economic Affairs and Energy back in December 2014 is a comprehensive package of measures to step up energy efficiency. All main measures have since been implemented so that we are making energy efficiency one of the key pillars of the energy transition.

However, it is also necessary to give thought today to the additional steps needed to halve energy consumption by the year 2050. We must also develop answers to new questions such as how energy efficiency and renewables can be ideally interconnected or how the integration of energy sectors (sector coupling) can contribute to decarbonisation. We must also take care not to lose sight of the costs for the consumers concerned.

In order to achieve our long-term goals we must make systematic use of all opportunities presented for more energy efficiency, with both tried and tested and innovative approaches. This is why we are initiating a process of consultation with the Green Paper on Energy Efficiency which is aimed at achieving a mid- to long-term strategy on reducing energy consumption in Germany.

I would ask you to become actively involved in this consultation. Your opinion and your suggestions on the topics and key issues of the Green Paper are important to us! The energy transition is entering the next phase. Be part of the discussion!

Sigmar Gabriel
Federal Minister for Economic Affairs and Energy

1. The Green Paper on Energy Efficiency: goals and dialogue

With its energy transition, Germany has embarked on a comprehensive and far-reaching transformation of its energy supply. The energy transition is founded on two basic pillars: expanding renewable energies and stepping up energy efficiency. Focus was initially placed on phasing out the use of nuclear energy whilst developing new power generating capacities from renewable energies with the attendant demands on infrastructure (networks, storage facilities), costs and conventional power production.

With the National Action Plan on Energy Efficiency, the Federal Government has strengthened the pillar of energy efficiency in the energy transition in this legislative period with the aim of reducing energy consumption by raising energy efficiency. The cost efficiency of the energy transition must be enhanced and the dependence on energy imports reduced in the medium to long term. At the same time, the reduction of energy consumption is of paramount importance for the success of German energy and climate policy as a contribution to implementing the results of the 2015 United Nations Climate Change Conference in Paris (COP21). This is because the resolutions made in Paris define a goal to restrict the rise in temperature, from which only a very tight budget for global greenhouse gas emissions can be derived. Together with the EU's climate protection goals this leads us to the conclusion that emissions from the combustion of oil, coal and gas fossil fuels must be broadly reduced. The fastest and direct path to achieving this objective is to cut our energy consumption by investing in efficiency technologies. The remaining energy requirements are covered by renewable energies – directly in the individual sectors or in the form of renewable power, primarily from wind and sun. Furthermore, we must pursue an integrative approach for the power, heat, transport and industrial sectors of the future: power from renewable energies will become increasingly important in the medium and long term for the extensive decarbonisation of the other sectors.

We have already made good progress in Germany in reducing energy consumption, as the Fourth Monitoring Report on the Energy Transition has shown, for example. However, the ambitious goals of the energy concept require us to step up the speed and make even better use of the existing efficiency potential. This is why with the "Green Paper on Energy Efficiency" the Federal Ministry for Economic Affairs and Energy (BMWi) presents hypotheses, analyses and key questions on the central fields of action and challenges for the enhancement of energy efficiency and energy savings.

The triad of the energy transition

Guidelines for the efficient use of energy: The Green Paper on Energy Efficiency focuses on the question of how energy efficiency can be further increased in all sectors. During the course of the year, the Federal Ministry for Economic Affairs and Energy will also be launching a dialogue process entitled "Power 2030" on how a cost efficient power supply (generation, use in heat, transport and industry, transport through the power grids) can be guaranteed.

Power is a valuable and scarce commodity. Macro- and micro-economic costs must be taken into consideration regarding the three cornerstones "energy efficiency", "directly used renewable energies" and the "use of power from renewable energies". The following guidelines result for this triad:

Firstly: The demand for energy must be distinctly and sustainably reduced in all sectors ("Efficiency First"). Germany has set itself ambitious climate goals. Consequently, the use of the fossil fuels of oil, coal and gas must be reduced as best possible. The fastest and direct route to achieving these goals is to cut our energy consumption by investing in efficiency technologies. Renewable energies largely cover the remaining energy demand.

Secondly: Direct use of renewable energies. Technologies such as solar thermal and geothermal energies or biomass apply renewable energies directly without converting them to power. Solar and geothermal energies are used in particular for the heating and air-conditioning of buildings and the provision of hot water. Where the use of these technologies is not expedient for economic or other reasons, power from renewable energies is used. Biomass plays an important role primarily in industry (production processes, for example) and in transport (air transport, for example). This also applies to the existing building stock where solid biomass is concerned. Biomass is universally deployable but scarce. It is therefore used selectively where solar or geothermal energies as well as wind and solar power cannot be used rationally.

Thirdly: Renewable power is used efficiently for heat, transport and industry (sector coupling). The demand for energy that remains despite efficiency measures and direct use of renewable energies due to economic or other reasons, is covered by power from wind and sun - primarily in technologies which replace many fossil fuels with a small amount of power (for example, in heating pumps and electric vehicles) or convert power into other energy sources such as hydrogen (power-to-gas).

Consultation process for the Green Paper

A process of consultation is launched with the Green Paper on Energy Efficiency which is aimed at achieving a medium to long-term strategy on reducing energy consumption in Germany through an efficient use of energy. To this end we wish to discuss the Green Paper with interested citizens in a consultation process and jointly work on solution approaches. The hypotheses and key questions set out in the Green Paper serve to focus the dialogue on the most important aspects from our point of view. Additional ideas and suggestions are, of course, welcome.

The process of consultation consists of the following elements:

- **Online consultation:** The Green Paper is published online at https://gruenbuch-energieeffizienz.de. All interested citizens and all stakeholders have the opportunity to send their comments on the BMWi's Green Paper directly online or at gruenbuch-effizienz@bmwi.bund.de by 31 October 2016;
- **Energy Efficiency Platform:** Discussion of the Green Paper with the participants in the Energy Transition Platforms on Energy Efficiency and Buildings as a focal topic for 2016;
- **Regional events** on the Green Paper, about which the BMWi will publish information on the Green Paper website https://gruenbuch-energieeffizienz.de.

The BMWi will also be discussing this Green Paper with the federal ministries concerned and similarly plans a close policy exchange with the federal states. Not least the BMWi is also interested in entering into dialogue with the other EU member states and the EU Commission on the further development of energy efficiency policy.

Following the consultation phase, the BMWi will submit a report on the dialogue process and the comments and suggestions received. On this basis, conclusions will be drawn and recommended actions for a medium to long-term efficiency strategy elaborated and brought together in a BMWi White Paper on Energy Efficiency. For the area of buildings, the main foundation will be provided by the Energy Efficiency Strategy for Buildings (ESG) already adopted by the Federal Cabinet in November 2015.

2. The energy consumption chain – an overview

Whether for steel production, as fuel for vehicles or to heat homes, energy in its very broad variety of forms is a central production and mobility factor and a basic prerequisite for everyday life. This will continue to be the case in the future. Two lines of approach have been established in the energy concept to achieve our energy and climate goals: the expansion of renewable energy sources and the reduction of primary energy consumption coupled with the enhancement of energy efficiency. The energy efficiency of final energy consumption, whether in industry, private households, the transport sector or in trade, commerce and services, must be increased distinctly whilst maintaining a high level of well-being. The energy consumption of buildings must be further reduced, household appliances made more economical, and production processes optimised in terms of the energy they consume.

Greater efficiency is required along the entire process chain which starts long before final energy consumption. The primary fuels which cannot be used directly by man provide a starting point here. These are firstly fossil fuels such as crude oil, coal or natural gas and secondly renewable sources such as the sun, wind and water as well as geothermal energy and ambient heat. Energy must be converted into a useful form from these “raw sources“. This happens using processes – complex and multi-staged in part – to produce “final energy” in the form of diesel, petrol, natural gas or electricity as well as useful energies such as heat or light. The extraction, conversion and transportation of the energy sources similarly require energy. The principle applies here that the more complex and intricate the upstream process is, the more energy must be produced.

Further losses are sustained on the last stage of the energy consumption chain – the transformation of final energy into useful energy. Only a part of the final energy is used for the actually intended purpose such as in the form of propulsion in cars, communication, light or heat in a building. The rest of the final energy typically occurs as waste heat. Efficiency potential must be exploited here too.

The Green Paper focuses on the efficient use of final and useful energy and the efficient transformation of final energy into useful energy. The difference between primary and final energy consumption primarily results within the power sector (conversion losses in power generation, grid losses) and from conversion processes in refineries. The Federal Ministry for Economic Affairs and Energy discusses the further development of the framework conditions for the electricity market in the Discussion Paper entitled ‘Power 2030’ *(Strom 2030).*

Fig. 1 illustrates the path from primary energy extraction to final energy consumption. Accordingly, 13,132 PJ primary energy was transformed into 8,648PJ useful final energy in Germany in 2014. The conversion losses and the consumption in the energy sector to maintain this conversion system (e. g. in the form of electricity for consumption by the power stations themselves, transmission losses in power lines and also the fuels and power consumption for the operation of refineries or the transportation of fuels) totalled 3,482 PJ in 2014 and therefore accounted for a good quarter of primary energy consumption.

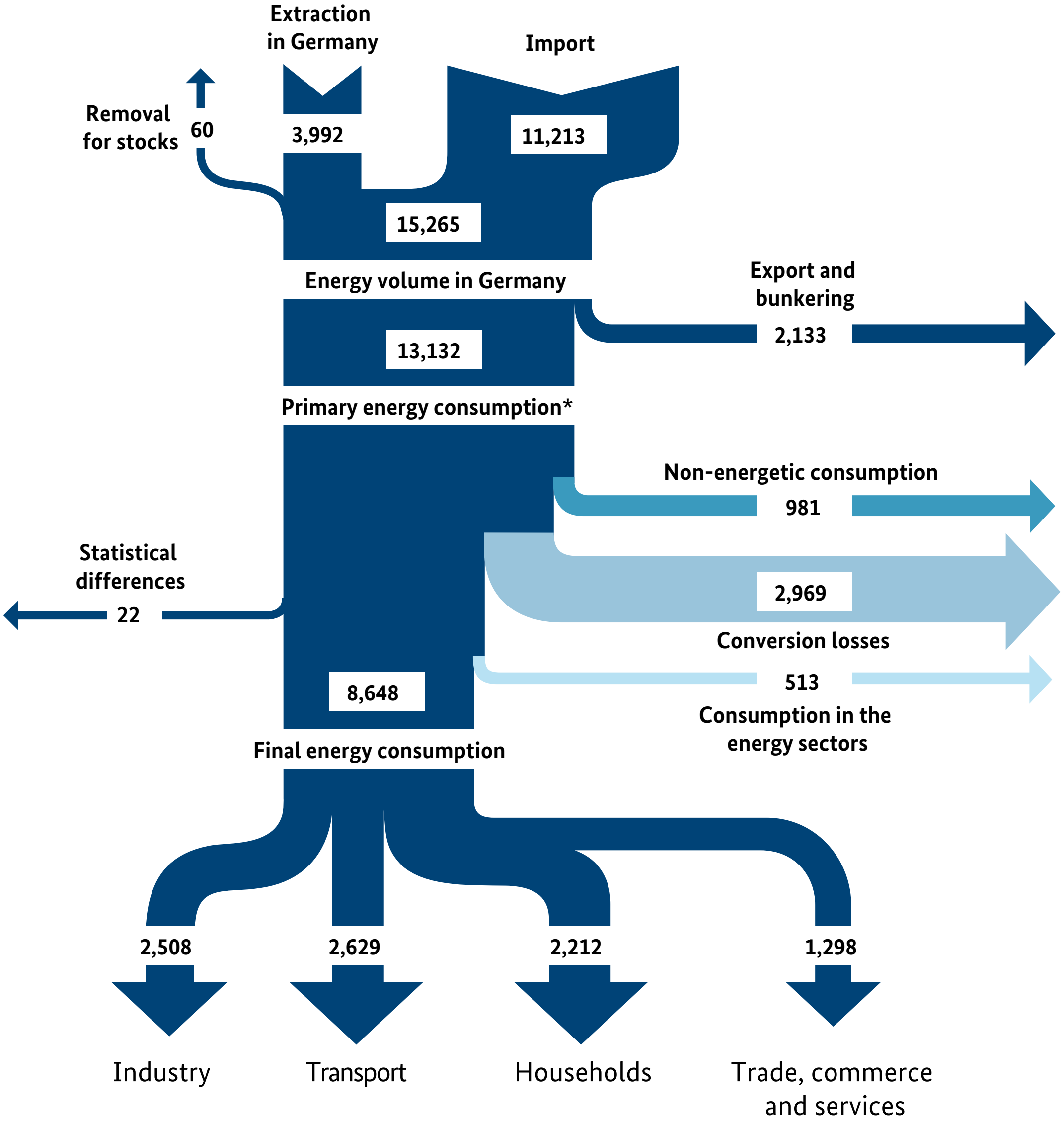
The final energy amounts actually demanded in the sectors were as follows in 2014:

- in transport: 2,629 PJ
- in industry: 2,508 PJ
- in private households: 2,212 PJ
- in trade, commerce and services: 1,298 PJ

By comparison: the entire (gross) power production in 2015 was some 2,340 PJ, of which wind and solar power generation as renewable energies accounted for more than 680 PJ.

These figures clearly show the challenge of decarbonisation and the necessity to use energy efficiently. The central questions are therefore as follows: how can we lower the demand for energy and how can energy be converted and used more efficiently in future?

Figure 1: Energy flow chart 2014 in petajoules (PJ)



The proportion of renewables energies as a part of primary energy consumption is 11.3 %.
Any deviations are the result of roundings.
* All data preliminary/estimated.
29.308 Petajoule (PJ) ≙ 1 mt coal equivalent

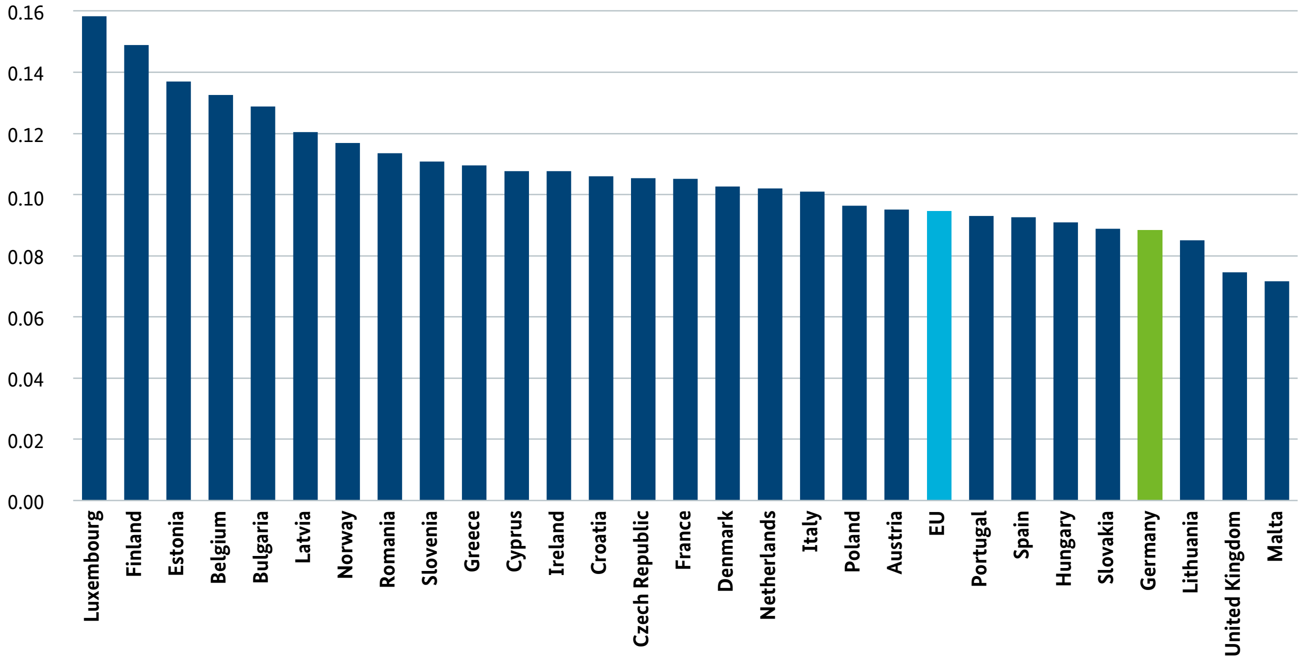
Source: Arbeitsgemeinschaft Energiebilanzen (AGEB) 08/2015

3. Energy saving in Germany: much achieved but still much to do

The development of energy consumption in Germany impressively shows that a good and stable economic development whilst consuming less and less energy is feasible. Taking into account the large share assumed by the manufacturing industry in overall economic output, Germany is one of the countries with the highest energy productivity and lowest energy intensity in Europe.

In recent years it has been possible to noticeably reduce primary energy consumption in Germany – in the period from 2008 to 2014 by 8.3 per cent. However, it has emerged that the development differs from sector to sector. For example, marked progress has been seen in the lowering of energy consumption in buildings. By contrast, the energy consumption in the transport sector actually rose in the period from 2005 to 2014 and therefore clearly lags behind the sectoral goal of the energy concept. Power consumption in Germany has so far developed in line with the goal of achieving a 10 per cent reduction by 2020. By contrast, the power generation decisive for primary energy consumption tends to stay at a constant level in Germany due to rising electricity exports.

Figure 2: Final energy intensity by European comparison, 2012



Source: Odyssee database; final energy intensity adjusted for economic structure and climate and measured as kilogramme of oil unit per euro of gross domestic product (in purchasing power parities and prices of 2005)

Figure 3: Energy consumption and energy efficiency indicators of the energy concept

Indicator	Target 2020	Target 2050	Level of implementation 2014
Primary energy consumption (compared with 2008)	-20 %	-50 %	-8.3 %
Gross electricity consumption (compared with 2008)	-10 %	-25 %	-4.2 %
Final energy productivity	2.1 % per annum (2008 – 2050)		1.6 % per annum (Average 2008 – 2014)
Primary energy consumption in buildings (compared with 2008)	–	in the magnitude of -80 %	-14.8 %
Heat consumption in buildings (compared with 2008)	-20 %	–	-12.4 %
Final energy consumption in transport (compared with 2005)	-10 %	-40 %	+1.1 %

Source: The Energy of the Future: Fourth “Energy Transition” Monitoring Report, updated.

In the medium and long term too, it can be assumed that the absolute energy consumption in Germany will drop further. However, a correct analysis of the state of affairs must also take into consideration the fact that the ambitious efficiency targets in the energy concept will not be reached solely by the measures taken so far. The commission of experts on the “Energy of the Future” monitoring process points out in its comments on the Fourth Energy Transition Monitoring Report that significant differences are to be observed between the progress made so far and the target paths for energy consumption and productivity. Accordingly, primary energy consumption declined by 0.5 per cent per annum in the period from 1990 to 2014. By comparison, it would be necessary to triple this figure to 1.6 per cent from 2020 on if primary energy consumption is to be halved by 2050.

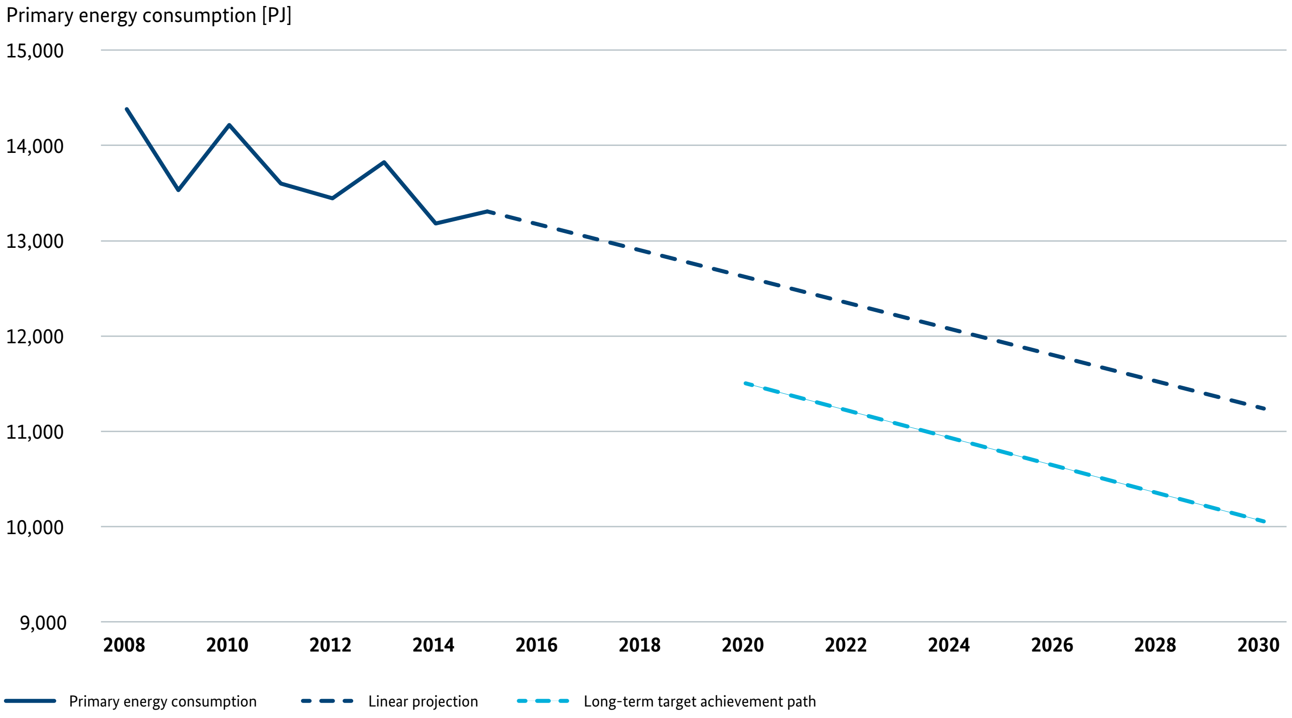
A look at the current trend also shows the need for action. A rise – albeit only moderate – is expected in the consumption of primary energy in 2015.

Primary energy target 2050: a look at energy consumption as a whole

A main objective of the energy concept is to halve primary energy consumption by 2050. Primary energy consumption comprises the entire energy consumption in Germany and therefore the energy we extract from fossil and other sources. Pertinent primary energy factors (PEF) are used in energy statistics for conversion from final to primary energy. They make it possible to show the different conversion efficiencies in transforming one energy form into another.

While the instruments and measures for saving energy are primarily aimed at saving final energy, they also lead to savings in the supply chain and therefore to a reduction of the primary energy consumption.

Figure 4: Development of primary energy consumption, 2008 – 2030



Source: AG Energiebilanzen, BMWi; linear projection based on the 2008 – 2015 period.

This means that the trend achieved so far in the lowering of energy consumption in Germany must not only be continued, but intensified. In addition to further developing and optimising the existing instruments and the associated investment costs, new challenges are also to be met. It is against this background that the BMWi's Green Paper opens the debate on which additional measures and instruments are necessary to sustainably intensify the trend towards energy efficiency.

Energy efficiency: opportunities for growth and employment

The energy transition will only be successful if we distinctly lower energy requirements on a sustainable basis also in future. At the same time everyone can win from cutting energy consumption: businesses and private consumers benefit from falling energy costs; growth and employment rise due to more value creation and greater investment in Germany.

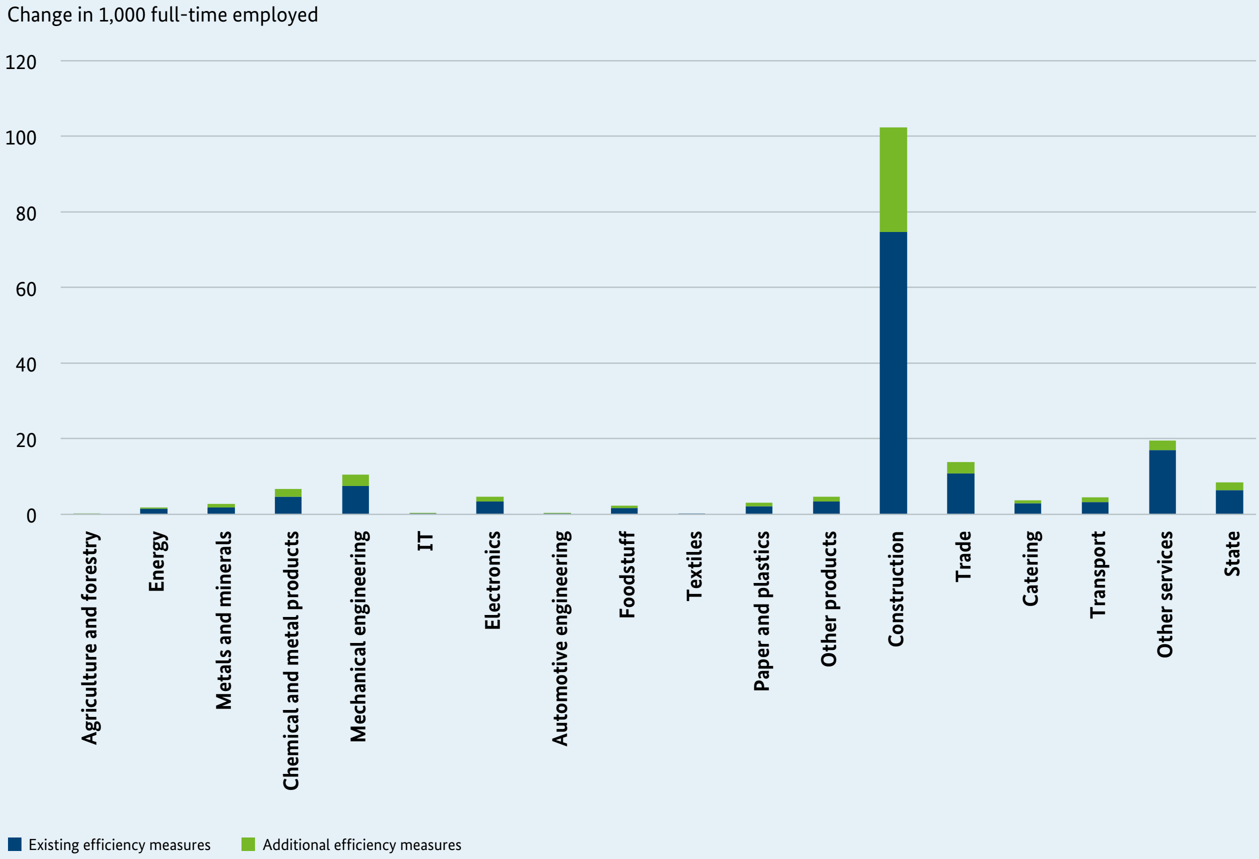
The positive overall economic effects of the energy efficiency policy are illustrated by a current model calculation (Ecofys/Fraunhofer ISI/IREES/Öko-Institut, 2016). Effects between 2014 and 2020 are determined here by comparing a projected trend with a hypothetical reference trend without existing and intended efficiency instruments. For this purpose, the investments induced inter alia by efficiency instruments (including those of NAPE and the Climate Action Programme 2020) and employment effects were analysed.* According to the model calculations, the efficiency policy is expected to trigger additional investment of well over € 100 billion2005. A large part of these investments is in the construction industry.

* It was assumed here that the fiscal incentives for energy efficiency measures in buildings provided for in NAPE will be implemented. As a replacement, the Government has implemented additional funding instruments for buildings with the Energy Efficiency Incentive Programme.

Both the costs for government aid mechanisms and for the funding of investments of private households and companies were taken into consideration in the model calculation.

The conclusion reached is that the efficiency measures result in a positive growth effect: by comparison, the gross domestic product in the efficiency scenario is around euros 40 billion 2005 or 1.6 per cent above the comparative figure for the reference trend (i.e. without efficiency instruments) in the year 2020. The study also shows a positive effect for employment in Germany with almost 190,000 full-time jobs in 2020. The authors point out here that the estimate of the macroeconomic effects can be influenced by the currently low energy prices.

Figure 5: Increase in employment in individual sectors as a result of efficiency measures, 2020



Source: Ecofys/Fraunhofer ISI/IREES/Öko-Institut, 2016

4. Central challenges for the energy efficiency area

The National Action Plan on Energy Efficiency (NAPE) strengthens incentives for energy efficiency investments with a large number of individual measures and subsequent work processes. We can expect considerable progress to be made in improving energy efficiency by 2020. However, even today thought must be given to the future beyond this date and the strategic challenges arising for energy efficiency policy – particularly with a view to the goal of halving primary energy consumption by the middle of the century. We wish to kick off the analysis with the Green Paper and also discuss the conclusions for today's mix of instruments. With this aim in mind the Green Paper focuses on five key areas:

- ***Efficiency First* (chapter 4.1):** How can the basic principle of the primacy of avoidance and reduction of energy consumption be specifically applied in planning and steering processes of energy policy and of the energy market?
- **Further development of the instruments (chapter 4.2):** How can today's instruments be further developed to achieve the goal of halving the primary energy consumption by 2050? How can fundamental challenges (e. g. rebound effects) and current trends (e. g. falling energy prices) be met?
- **Energy efficiency policy at a European level (chapter 4.3):** How is the European framework for efficiency policy developing and how can an effective distribution of tasks between European and national levels be achieved?
- **Sector coupling (chapter 4.4):** When growing portions of renewable energies in the power sector are used for further decarbonisation in other sectors, which requirements are to be formulated for an energy-efficient use of power from renewable energies considering other decarbonisation options?
- **Digitalisation (chapter 4.5):** Which challenges and opportunities are presented by the use of digital technologies for the control of energy consumption and generation? How will "digital business models" alter the energy market, and what does this mean for energy efficiency policy?

Hypotheses on these subjects will be set out and discussed in the following chapters. The sections close with key questions for the consultation process.

4.1 *Efficiency First*

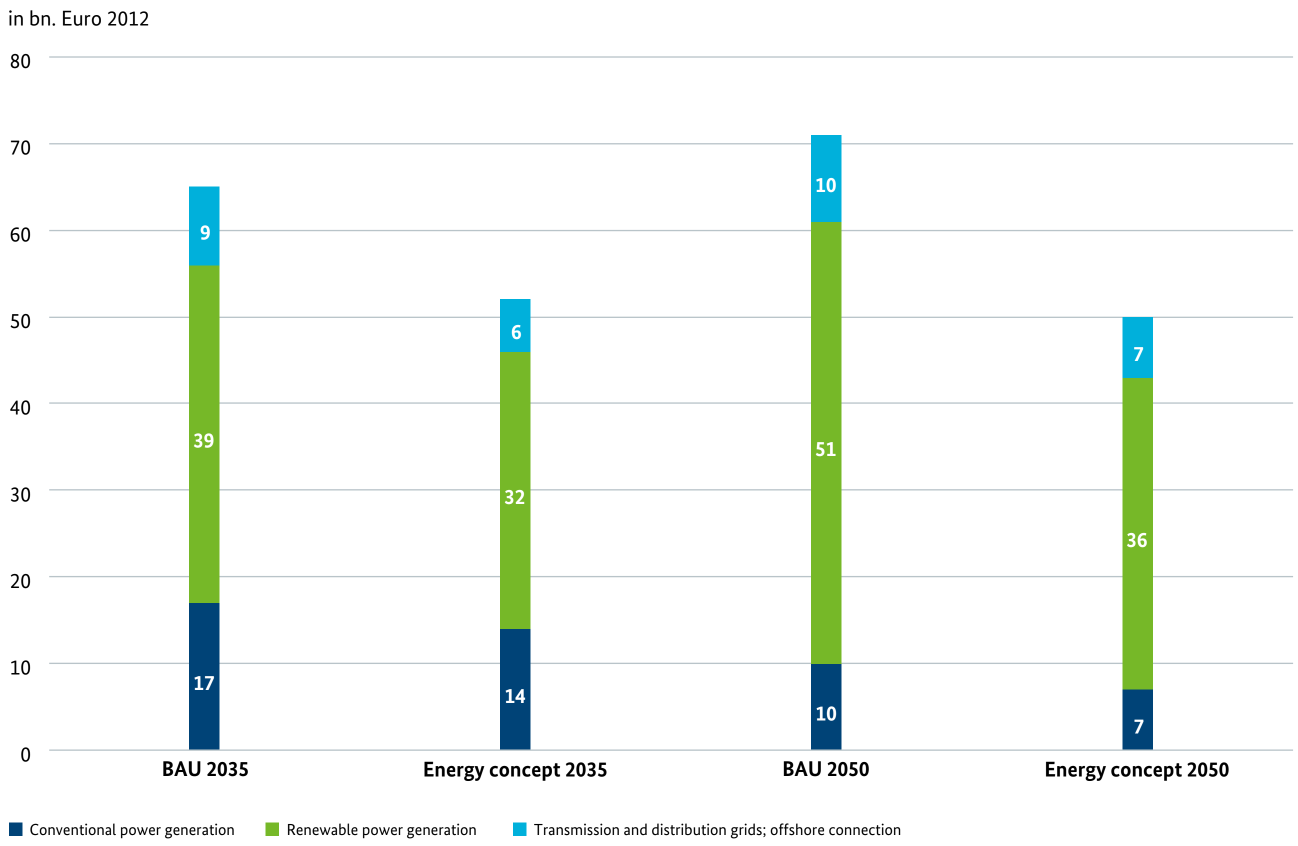
Hypothesis 1: *Efficiency First* leads to a cost optimisation of the Energy Transition and strengthens the decarbonisation effect of renewable energies.

"A unit of energy that can be saved need not be generated, stored or transported" is the basic *Efficiency First* premiss. Energy efficiency saves energy, contributes to lowering greenhouse gas emissions and therefore generally facilitates the transition of our energy supply to renewable energies.

Comparison of total costs of power generation and transport with and without the achievement of energy efficiency goals of the energy concept

As a study conducted by Prognos and IAEW in 2014 shows, if the goals of the energy concept are vigorously pursued, more than € 12 billion can be saved in 2035 and 21 billion in 2050 in the power system alone on the generation and grid side, and the need for future expansion of the electricity grids reduced considerably. This accounts for cost savings in the electricity system of some 13 cents per kilowatt hour of electricity (in 2035) for generation and grid capacities which are then no longer required.

Figure 6: Total costs of power generation and transport



Source: Prognos AG and Institut für Elektrische Anlagen und Energiewirtschaft (IAEW). Overview of the total costs to be expected in the areas of power generation and transport in the implementation of the energy efficiency goals of the energy concept (the energy concept scenario assumes a 20 per cent reduction in power consumption between 2011 and 2050) compared with a "business-as-usual" scenario (BAU).

In future, the energy policy direction is to be more closely aligned with the basic aim of making far-reaching and financial savings as far as possible in all areas where this is cheaper from a macro-economic point of view than building new generation, storage and grid capacities. A sensible and contextual prioritisation of energy efficiency before expanding generation capacities can lead to optimising the costs in the energy system and increase the opportunity to stay within the remaining greenhouse gas budget. From a planning perspective, the implementation of *Efficiency First* means that the sizing and shaping of the system is primarily determined by the demand side.

Hypothesis 2: The guiding principle of *Efficiency First* becomes the strategic planning instrument for our energy system.

If the energy system is planned primarily from the supply side (import, production, generation and distribution), a risk of over-dimensioning the infrastructures exists, where either savings with a high system benefit are not made or foreseeable consumption cuts are not included in the planning and organisation of the energy infrastructure. This effect is particularly defining because there are considerable path dependencies in the energy system due to long-term investment horizons (capital-intensive investments in infrastructures with long serviceable lives). This also applies to a great extent to efficiency investments (e.g. in building envelopes, products, production apparatus, plant infrastructure etc.).

With the *Efficiency First* approach, the planning and organisation of the energy system is primarily demand-led. In order to avoid additional costs in system planning and extension, different scenarios for the development of energy demand are intended to show which alternative options exist to avoid or save energy or to improve energy efficiency. On this basis, the supply system can be dimensioned and shaped in a cost efficient manner in overall economic terms. In addition to the higher ranking planning instruments (and the change in planning routines), the principle of *Efficiency First* is to be reflected particularly in those operative instruments with which the investments and costs of the energy system can be controlled in the medium term.

Energy Efficiency Strategy for Buildings

The Energy Efficiency Strategy for Buildings (ESG) adopted by the Federal Government in November 2015 shows how the two options of *energy saving* and *use of renewable energies* may be systematically analysed and incorporated in an integrated action approach. For this purpose, two target scenarios have been developed which aim at achieving a virtually climate-neutral building stock by 2050 and therefore define a corridor within which the aspired-to reduction of the primary energy requirements can be achieved:

- **Target scenario “energy efficiency”:** This scenario aims at a maximum increase in energy efficiency up to 2050 by energy savings up to a maximum achievable limit according to current estimates of -54 per cent compared with 2008. This results in a lower demand for renewable energies.
- **Target scenario “renewable energies“:** This scenario places greater emphasis on expanding renewable energies and a somewhat smaller increase in efficiency.

The target scenario “energy efficiency” has a distinctly smaller power demand in 2050 than the target scenario “renewable energies”, i.e. the need to adjust the expansion path for renewable power ought to be smaller. This scenario also requires less biomass. However, the scenario would lead to higher investment costs in residential buildings. Considerable efficiency potential therefore exists in the area of buildings through measures such as insulation of the building envelope, use of efficient windows and equipment. But there are technical and financial limits. Firstly, the energetic quality, of the building envelope for example, cannot be indefinitely improved. Secondly, the initial efficiency gains from the renovation of buildings can be achieved relatively cheaply but additional progress is often associated with rising costs.

The target scenario “renewable energies” shows that mentionable potential exists for the use of renewable energies in the area of buildings. This potential can be increased by using sustainable, predominantly solid biomass, environment heat, solar thermal energy and photovoltaics. However, here too, there are technical and financial limits. The scenario assumes a distinctly higher use of biomass than the efficiency scenario. In view of the fact that biomass for energetic use is limited so that the different uses compete with each other, the question arises in which energy sectors it can be used efficiently in the long term. With an overall lower increase in efficiency, the use of heat pumps is distinctly more limited because they can only be operated economically and efficiently in the low temperature area of panel heating systems (usually underfloor heating) in very well insulated buildings.

Key questions:

1. **How can the principle of *Efficiency First* be systematically applied in all sectors?**
2. **What could be the foundations (e.g. cost indicators) for a systematic consideration of the fundamental decision of *“Cutting energy consumption versus maintaining or creating capacities to cover demand”*?**

Hypothesis 3: The creation of a common legal framework for energy efficiency enables the principle of *Efficiency First* to be anchored in law.

There has not so far been any cross-sectoral legal framework for the action field of energy efficiency. Corresponding sets of regulations and legal foundations exist for different areas. Different legal foundations apply depending on the stakeholder or sector concerned.

The extent to which anchoring *Efficiency First* as a planning and organisational principle in the entire efficiency area could be moved forward by statutory measures is to be clarified. For example, an energy efficiency act could define a cascade for the relationship between energy savings, efficient use and energy generation. The advantages and disadvantages and the different options for bringing together the various pieces of energy efficiency legislation in a common legal framework should also be determined.

Following the principle of *Efficiency First*, the national efficiency goals could be anchored in an energy efficiency act, for example. In terms of the statutory framework, an energy efficiency act could contribute to standardisation and ensure that the legal material could be developed consistently. New demands which are to be expected in future (e.g. implementation of EU law, quality assurance in consulting) could also be integrated into an energy efficiency act. An act of this type, which includes the goals, could in the long term also facilitate an interconnection of power from renewable energies and energy efficiency, e.g. in terms of a consistent stipulation of targets. This interconnection will become increasingly important for the action field of sector coupling, for example.

Depending on content, new issues would also arise from an energy efficiency act which will have to be discussed. Does the anchoring of goals in law actually help with the main problem in the efficiency area, that of reaching existing ones? Does the added value of an efficiency act outweigh the costs and possible disadvantages which could be associated with the merging of the existing legislation (growing complexity of the goals in the energy area, possible new target conflicts, relationship with the existing goal hierarchy of the energy concept)?

Key questions:

1. **Does a merging of existing energy efficiency legislation and anchoring energy efficiency goals in a common legal framework create added value?**

2. **If this is the case, which areas should be covered by an energy efficiency act, and how could the principle of *Efficiency First* be anchored in a general part?**

4.2 Further development of the instruments of an energy efficiency policy

Hypothesis 4: The existing instruments of energy efficiency policy have permitted a rise in energy efficiency but must be further developed and supplemented if the long-term objectives are to be reached.

A central and ambitious goal to halve primary energy consumption by 2050 has been formulated in the energy concept. The achievement of this goal is at the same time a fundamental condition for the success of the energy transition as a whole. What is more, distinctly reducing the consumption level will enable the challenges of system integration and affordability of renewable energies to be met more easily.

The instrument canon of energy efficiency policy

Information and advice: This instrument category includes the promotion of advisory products, such as in-situ advice, alongside the provision of information by the public sector. The Federal Government will be implementing a comprehensive communication strategy in 2016. It will also be important to better interlink different advisory products, particularly advice on material efficiency and energy efficiency.

Financial support: Traditional support instruments include in particular direct subsidies and low-interest loans in connection with repayment bonuses (such as in the CO_2 building rehabilitation programme) for investments.

Regulatory law: Provisions of national or EU regulatory law comprise bans and requirements, technical standards and mandatory product labelling. Examples are the provisions of the EU Building Directive and the EU Ecodesign Directive as well as energy efficiency standards for buildings stipulated in energy saving law at a national level. The most important condition for the efficacy of instruments of regulatory law is securing its implementation.

Price measures: Price measures are, for example, energy charges and taxes as well as certain toll models.

Quantitative measures: Quantitative measures target the quantity of energy consumption or of emissions using quotas or certificates. It is frequently associated with a trading component which serves to enhance the market incentive. Examples include EU emission trading or the energy efficiency obligation schemes which exist in many EU countries.

Research & Development: Broad-based and well-networked energy research is an important condition for the testing and bringing to market of energy-efficient technologies.

German energy efficiency policy is based on a broad instrument mix in accordance with the principles of inform, support and demand. The Federal Government has launched numerous additional measures with the National Action Plan on Energy Efficiency (NAPE). The portfolio of energy efficiency policy has grown noticeably particularly in recent years. As a result, a large number of stakeholders and sectors are addressed and the “white spots” have become smaller in many places. It is also essential to take a look at other policy areas. For example, an increase in efficiency in the use of raw materials can also have an impact on energy consumption. Accordingly, the Federal Government set itself the goal in 2016 in its updated national resources efficiency programme – ProgRess II – to interlink materials and energy efficiency more strongly in order to use synergies and identify – and where possible remedy – target conflicts.

However, the challenge in view of the future long-term trend of energy consumption is how the instruments used so far can be further developed (see chapter 3). Even though existing measures will continue to have an impact on consumer savings, the set of instruments must be further developed and supplemented. What is more, energy efficiency policy faces known and new challenges, which will be outlined in the following.

Specific versus absolute energy consumption reductions

Whilst the energy concept sets an absolute target to halve primary energy consumption by 2050, the instruments of energy efficiency policy in Germany are primarily directed at specific energy savings (e. g. per kilometre travelled or square metre to be heated). Economic and income growth facilitates not only investments in energy efficiency but frequently leads simultaneously to a growing demand for goods and services which are associated with energy consumption in products, provision and use. Ultimately, the absolute reduction in energy consumption can lag behind the specific one.

One aspect of this issue refers to so-called rebound effects which lead to a diminishment of energy savings from energy efficiency measures (see box). Prominent examples of rebound effects are to be found in the area of power, buildings and transport. For example, more energy-efficient lighting invites more frequent use, whilst buildings which have been rendered more energy efficient make higher inside temperatures more affordable so that the demand for heat increases.

If changes in behaviour which lead to greater energy consumption following efficiency measures can be avoided or reduced, distinctly higher absolute energy savings can be achieved. Instruments of energy efficiency in use so far, which are typically directed at specific efficiency increases, manage to do this to only a limited extent. This is why energy efficiency policy should be further developed with the challenge of mitigating possible rebound effects in mind.

Rebound effects: Definition, extent, solution approaches

A rebound effect in connection with stepping up energy efficiency is said to exist if the efficiency increase brings about a greater demand or use, thereby diminishing the actual saving. From an economic point of view, it can be explained by the fact that the costs of using a product drop. But psychological and regulatory factors which influence individual behaviour can also lead to non-realisation of expected efficiency potential. A distinction is made between the following types of rebound effects:

- **Direct rebound effects:** Greater demand for the more efficient product or the more efficient service may ensue following an increase in efficiency.
- **Indirect rebound effects:** Following an improvement in efficiency, energy consumption may increase in the form of higher demand for other products or services, e. g. because the more efficient product frees up financial resources and therefore purchasing power.
- **Overall economic rebound effects:** A greater demand for energy in a macro-economic context may arise as a result of altered demand, production and distribution structures based on technological improvements in efficiency.

Empirical findings indicate that the extent of rebound effects varies greatly, depending on sphere of action and design of the efficiency measure. The German Environment Agency (UBA) has currently had studies analysed on this topic. Direct consumer-side rebound effects in the magnitude of 20 to 30 per cent are determined for different energy services, i. e. the possible savings are 20 to 30 per cent smaller. Added to this are indirect consumer-side rebound effects of 5 to 15 per cent on average.

Instruments of energy efficiency policy are sensitive to rebound effects to different degrees. At the same time, there are accompanying measures which facilitate the exploitation of potential to reduce energy consumption in absolute terms also in the face of rebound effects. These include consumption-specific taxes and charges and quantity-controlling systems of tradeable certificates.

Low-price environment

The price declines in important energy markets are currently intensifying the existing impediments – such as the rebound effect – on the path to lower energy consumption. The oil price, for example, dipped to below 30 US dollars for a barrel in phases of spring 2016, and, at a current 50 US dollars per barrel, is at a low level by long-term comparison. The financial incentives to conduct energy efficiency measures also drop as energy prices decline.

Whilst it is not clear which price trends are to be expected in the short, medium or long term, it can be said without doubt that a systematic global climate protection policy based on the agreement achieved in Paris can contribute to lastingly reducing the demand for fossil energy sources, thereby curbing the prices of fossil fuels.

Furthermore, even short-term price declines can have long-term consequences for energy consumption if the low price level leads to investments in durable goods and technologies which are less efficient (so-called lock-in effects). Against the backdrop of the current price environment and precisely in view of the price uncertainties and volatilities, the instruments of energy efficiency policy should therefore be able to “cope” better with price trends and contain enough elements with effects which are not dependent on the price level.

Incentive effects of low energy prices – example of replacing heating boilers

Family A lives in a typical house with 150 m² living space heated by an old and oversized oil-fired boiler. Every year family A uses an average of 2,600 litres of heating oil. Due to the strong fluctuations in the heating oil price, they have paid between 1,250 and 2,500 euros for it over the past 15 years. The old heating pump consumes around 400 kWh of electricity per year, burdening the household budget by just under 120 euros annually.

A new pellet-fired boiler with optimum heating performance has an annual degree of efficiency of over 85 per cent in terms of the calorific value. The heating system is also balanced hydraulically and a new heat pump installed. This package of measures saves operating and fuel costs of some 400 to 1,000 euros per year. The hydraulic balancing and the new pump reduce the power consumption by 300 kWh or the costs by a further 90 euros per year. The new pellet-fired boiler is subsidised by 4,200 euros per annum in the renewable energies Market Incentive Programme and the Energy Efficiency Incentive Programme. The total investment amounts to 18,900 euros. After deduction of the government subsidy of 4,200 euros, family A still needs to find 14,700 euros.

The savings are an important incentive for family A to decide to invest in a new heating system. If the fuel prices for heating oil and pellets are high, the entire investment will have been paid back completely from the savings after only 13 years. By contrast, if the fuel prices drop permanently to the current level, 28 years will pass until the investment is repaid completely. This refers to a repayment of the entire investment costs by the lower operating and fuel costs as a result of the measures. In fact, the old oil-fired heating would have to be replaced anyway in the long-term. The repayment of the additional expenses solely for a pellet-fired boiler compared with a conventional oil-fired heating system is possible distinctly faster.

Government funding is already well established

An effective incentive for greater energy efficiency can be set by government funding for private and commercial investors in the implementation of energy efficiency measures. Incentives motivate investors to use particularly efficient or innovative technologies which prepare for market launch and improvements to be made in the competitiveness of these technologies. A good example of this is the CO_2 Building Rehabilitation Programme with which the Federal Government is already preparing to introduce nearly zero energy buildings, for example, in accordance with the EU Buildings Directive. In a similar way, the requirements of the Market Incentive Programme to promote measures to use renewable energies in the heating market is driving the use and development of heat technologies of renewable energies. The government funding policy has been given considerable impetus in recent years, not least by the National Action Plan on Energy Efficiency (NAPE). Offers of state and regional funding now exist for almost all relevant stakeholders and sectors.

However, the effects of funding programmes cannot be scaled randomly – not least due to the limitations to the budgetary resources available for this purpose. In the commercial sector, the incentives (funding rates and intensities) are also restricted to a specific level due to the EU legal framework for subsidies. Funding programmes for efficiency measures in private households are also subject to budgetary limitations, e. g. with respect to the involvement of energy efficiency service companies. This framework is particularly suitable to tap additional efficiency potential in the area of replacement and modernisation. By contrast, the incentive for making efficiency investments outside the regular replacement and modernisation cycles based on funding measures alone is less effective. An example of this is the rate of renovation of the building stock which has been relatively constant for many years.

A hike in demand for efficiency measures through more funding would require a far higher funding intensity. This policy would hardly be affordable and the use of efficiency potential cannot be made solely dependent on the offer of public assistance programmes.

This environment leads to a clear need to further develop the energy efficiency policy.

Key questions:

1. **Which measures are appropriate and sensible in addition to the current instruments of energy efficiency policy to achieve the goal of halving primary energy consumption by 2050?**

2. **Which instruments are suitable by preference to increase energy efficiency in a low energy price environment?**

Further development of energy efficiency policy: instrument categories

In simplified terms, (combinable) options can be presented for a further development in the form of different instrument approaches; these are based on the instrument mix in use to date, but are supplemented and taken to the next stage by new measures.

Quantitative measures:

For the area of standardisable technologies – with which the transaction costs tend to be low – an exemplary key instrument could be the introduction of a system of tradeable energy saving quotas (white certificate model). The latter could be modelled precisely on final energy consumption which is not currently covered by emissions trading. Alternatively, a saving model could be introduced at the level of the placing of energy sources on the market (so-called upstream approach), e. g. with respect to the use of primary energy. The energy saving effects of these two instruments are not impaired by rebound effects or the current low-price environment. Both approaches are also market-compliant and lead to a cost-efficient solution because the decision to take individual saving measures is left to the market players.

Regulatory law:

In the area of buildings, a further development of regulatory law for the building stock would be conceivable. Minimum standards could also contribute to avoiding any impending lock-in effect, for example the installation of durable and comparatively inefficient technologies. In the transport sector too, further savings could be achieved, for example, by the planned obligatory calculation and statement of the specific fuel consumption of commercial vehicles on the basis of certified measured values of relevant components. The measures which can bring about decarbonisation in the transport sector are also being discussed at a European level. The EU Commission has announced that it is also examining the introduction of efficiency standards for engines of heavy-duty commercial vehicles. An important supportive function is attributed to strengthening the regulatory law so far in place, which primarily comprises energy saving law for buildings, the EU ecodesign and labelling directives.

Price measures:

Instruments targeting the price of energy are in principle in line with the market, guarantee cost efficiency and comply with the polluter-pays principle. They also have the advantage that the incentive to lower energy consumption remains equally high with every unit of energy consumed. Mechanisms to adjust to fluctuations in the raw material prices for energy sources would be conceivable, e.g. by indexing tax rates. However, the impact on the tax revenue must also be considered here. Resultant tax revenue should be used to support measures to implement the energy transition, particularly in the area of energy efficiency. As higher ranking price measures effective in all sectors, both an adjustment of the existing energy and electricity tax, the introduction of a CO_2 tax (possibly levied throughout Europe) and bonus-penalty systems are all conceivable.

Hypothesis 5: Market solutions and new services will accelerate the increase in energy efficiency and make an important contribution to implementing the energy transition.

Investments associated with energy efficiency measures typically assume expertise and empirical values, which is why a dynamic market for professional energy efficiency services is an important condition for a sustainable increase in energy efficiency. With its National Action Plan on Energy Efficiency, the Federal Government has set the parameters for the further development of the market for energy efficiency services. For example, at the beginning of 2016, it improved the framework for default guarantees and therefore the funding conditions for contracting services.

The market for energy efficiency services

The market for energy services comprises the four product groups of information, consulting, energy management and contracting. In the residential building sector, offers exist both for owners and for tenants. Numerous offers also exist for companies of all sizes, such as on the optimisation of the energy efficiency of production plants. Some 19 per cent of home owners and at least 23 per cent of SMEs have currently already taken up the offer of high-quality energy advice with an on-site analysis by a consultant.

Energy management systems are widespread, particularly in companies which benefit from exemption from energy-related taxes or surcharges. As much as 12 per cent of companies with 50 to 249 employees now have a certified energy management system. Many companies are also using energy controlling solutions.

In the area of energy performance contracting, the willingness of property and plant owners to bind their assets to long-term contracts continues to be limited. Only 1.6 per cent of all SMEs have so far made use of extensive energy performance contracting. Instead, offers for energy supply contracting continue to dominate.

All in all it can be said that the market for efficiency-enhancing energy services in Germany has basically established itself both in terms of the breadth and the depth of the offers. However, if the entire market potential is to be used, the framework for the energy efficiency services market must be further developed.

Irrespective of this, structural impediments remain, the dismantling of which can make an important contribution to developing the market for energy efficiency services. However, different interests must be taken into consideration here, e.g. in terms of funding efficiency investments and the possibility to use the profits of efficiency investments. The existing legal framework frequently fails to solve this investor-user dilemma. In some cases, the owners are required to make the decision to invest in measures designed to enhance energy efficiency but the incentives to do so are inadequate because the energy costs are borne by the users.

With a view to the specific shaping of the framework conditions of the energy service market, it can be said that the identification of suitable and in particular innovative technologies and weighing up different technological alternatives – where they exist – is primarily the task of market players. Technological solutions will only be financially tenable in the long term if a corresponding profit- and use-orientated demand for them exists, which is why energy efficiency policy should in future be structured such as to leave the choice of technology open. Competitive tendering models could be given greater consideration here.

We also believe it to be necessary to check how and in which areas a standardisation is to be brought about at a national and European level as a prerequisite for a cross-border single market for energy efficiency services. Enhanced market transparency and standardised business models (e.g. for accounting, measuring energy savings, cost distribution) could contribute to reducing transaction costs and risks and therefore to making the funding of investments in energy efficiency easier.

Key questions:

1. **Which instruments are particularly suited to providing an incentive for energy services to increase energy efficiency?**

2. **In which areas is standardisation advantageous or necessary to develop the market for energy efficiency services?**

4.3 Energy efficiency policy at a European level

Hypothesis 6: An effective energy saving policy at a European level works best with clear targets.

Not only at a national level but also throughout the EU, there can only be a sustainable energy supply system and a successful decarbonisation strategy if additional energy savings are made. This requires close interaction at European and national level to coordinate energy saving efforts ("governance"). This coordination essentially covers three areas: 1) targets and assignment of contributions to achieve the targets; 2) the selection of suitable instruments; and 3) the development of markets for energy efficiency services.

Indicative European savings targets currently exist for the years 2020 and 2030. The attainment of the 2020 target is based on a system of voluntary contributions by the member states. Whether this approach is also to be used for the 2030 target has not yet been finally decided. The contributions to the achievement of the 2030 target by further energy efficiency directives (e.g. for buildings, products and cars) and the Energy Efficiency Directive (EED) designed as a cross-sectional measure are still to be evaluated. The implementation of the directives is a matter for the member states. In addition the figures in the Directive are geared to savings against a reference trend. The current coordination system guarantees flexibility in the choice of instruments and control, but entails the risk of failure to meet targets and can lead to friction between member states and the European Commission.

The options for action are reflected in the following two alternatives:

a) Continuation of the status quo: indicative targets associated with a mix of European and national instruments;

b) Binding target distribution/effort sharing and binding European instruments for target attainment.

An aspect to be considered for alternative b) is the expected greater political effort involved and possible time delays which could be expected in the negotiations and implementation of binding targets and mechanisms. The current approach would have the advantage of being able to better adjust the energy saving policy to national circumstances and would leave greater leeway to use suitable national instruments. It would therefore do better justice to the principle of subsidiarity. However, it is questionable whether the target achievement can be adequately secured in this way. Using a harmonised policy approach, a clear target distribution and the securing of target achievement could be guaranteed through strong and clearly structured European mechanisms than is the case in the status quo.

Key questions:

1. **Which advantages and disadvantages speak in favour of strengthening the Community level in the implementation of the European energy efficiency goal for 2030?**

2. **Should the EU efficiency goal for 2030 be formulated in a more binding manner beyond the existing directives and political decisions?**

Hypothesis 7: The greater use of EU Community instruments supports and strengthens the national energy efficiency instruments.

The more sophisticated target definitions will presumably require additional instruments to achieve the respective energy saving targets. In addition to the question as to which instruments could be suitable for this purpose, the level on which these instruments are to be placed must also be clarified. The use of "Community instruments" would strengthen the European dimension of energy saving policy and can contribute to avoiding distortions of competition. We see two approaches here, which could be combined with each other: firstly, the extension and further development of existing regulatory instruments, such as ecodesign and labelling, and secondly, the introduction of new instruments such as the reduction of the specific fuel consumption of heavy-duty commercial vehicles.

Ecodesign and labelling have proven to be very successful instruments of enhancing energy efficiency. Both instruments are responsible for approximately 80 per cent of the power savings instigated in Germany by state measures. An expansion and further development of these instruments would have a larger leverage effect for further energy savings – also in Germany.

The stronger use of Community instruments also offers the possibility of avoiding distortions of competition between the member states in the implementation of efficiency measures.

Key questions:

1. **Which Community-wide instruments should be strengthened or which additional Community instruments could be set up at an EU level to support German efficiency targets?**

2. **Which instruments used in Germany are particularly suitable for transfer to an EU level so as to stimulate new energy savings throughout Europe?**

4.4 Sector coupling

With the integration of energy sectors (sector coupling), the power supply meets the demand for energy in households (heat and cooling) and transport (propulsion), as well as in industry and trade, commerce and services (heat, cooling and propulsion). Sector coupling contributes to the goals of the energy transition if power from renewable energies is used efficiently, and fossil fuels can therefore be replaced. Building on market forces, sector coupling places new regular consumers on the electricity market. On the demand side, it can provide flexibility for the electricity market and also be useful in cases of bottlenecks in electricity grids but should not be misunderstood as a targeted instrument to take up “surplus electricity” from renewables. In the medium and long term, power is to come from renewable energies if sector coupling is to serve the energy transition.

Hypothesis 8: The decarbonisation of the sectors of private households, trade, commerce and services, industry and transport requires the use of electricity from CO_2-free, renewable sources.

Sector integration is necessary to drive further decarbonisation in all sectors as effectively and economically as possible. In cooperation with traditional energy efficiency measures and the direct generation of heat and propulsion energy from renewable sources (e. g. through biomass or solarthermal energy), it contributes to reducing greenhouse gas emissions and primary energy consumption. As far as is known today, it will not be possible to decarbonise the respective sectors solely through efficiency measures and the direct use of renewable energies. In order to achieve decarbonisation nevertheless, it is necessary to make use of renewable electricity in all sectors.

A suitable policy framework must be established at an early date for the process of increasing sector coupling so that the necessary requirements placed on efficiency, flexibility and economic efficiency are satisfied.

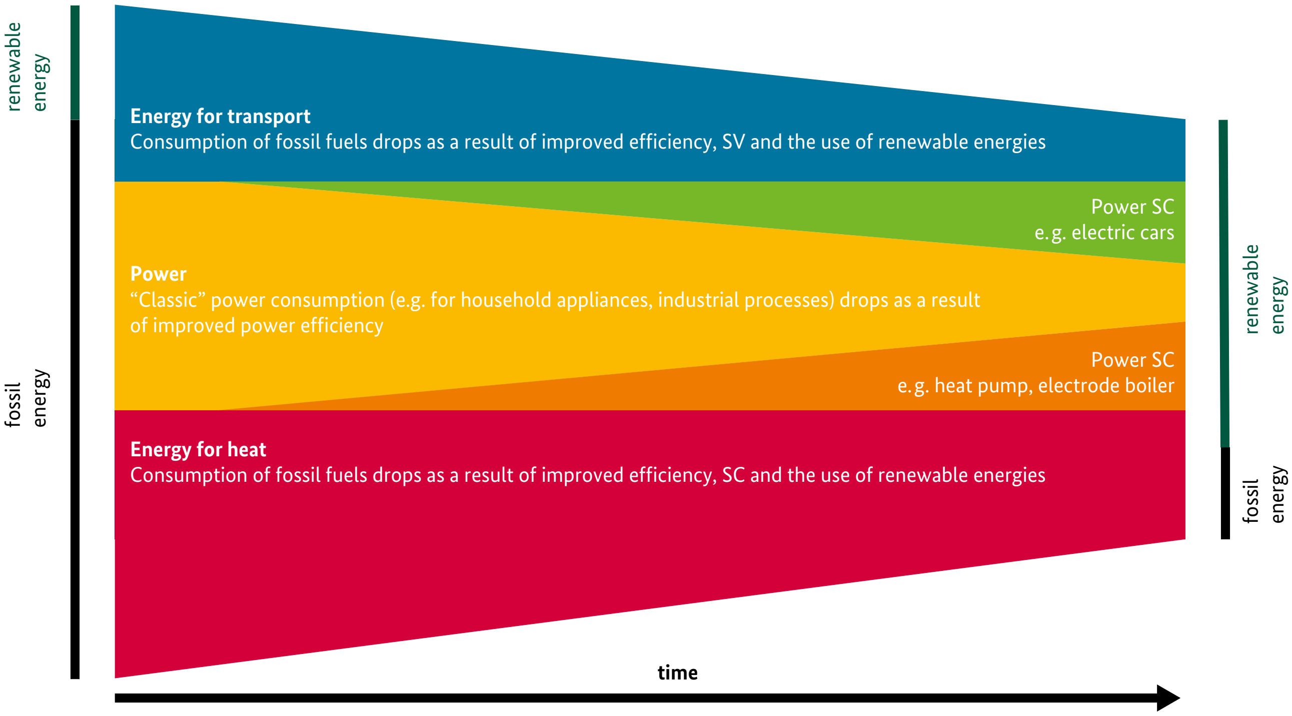
Key question:

Are there alternatives to the use of electricity from CO_2-free, renewable sources for the decarbonisation of the sectors of private households, trade, commerce and services, industry and transport?

Hypothesis 9: For sector coupling, primarily those technologies are used which efficiently convert electricity into heat, cooling or propulsion and therefore which replace as large an amount of fossil fuels as possible with the smallest amount of renewable power.

Power from renewable energies is also a scarce economic good and consumes space and resources as well as costs for generation, distribution (grids) and storage. If final energy demand does not drop, the demand for power generated

Figure 7: Illustration of sector coupling (SC) and energy consumption



Source: Own diagram building on IWES et al. (2015). Classic efficiency measures (e. g. building renovation or the use of more efficient equipment) and sector coupling reduce the final energy consumption overall; the direct use of renewable energies (e. g. solarthermal energy) and sector coupling increases the share of renewable energies in final energy consumption as a whole.

by renewable sources would rise massively and increase the overall costs of the energy transition. What is more, the increased use of intermittent renewable energies can also increase the demand for flexibility on the supply and consumer side.

"*Efficiency First*" is the planning principle here. The lower the demand for heat in industry, trade, commerce and services and households and the lower the demand for propulsion energy in the transport sector, the lower the demand for power from renewable energies, which must be provided for these applications, and the lower the resultant costs will be.

Even now, electricity-powered technologies for the generation of heat and cooling and for the provision of propulsion energy are in use for many applications. Two types are possible here. Whilst, for example, air-conditioning systems or electric motors convert electricity into heat, cooling or propulsion energy, others exploit further renewable energies by using electricity. Electricity-powered heat pumps make use of ambient heat, for example.

Not every sector coupling technology that converts electricity into heat, cooling or propulsion energy uses power equally efficiently. In particular, technologies which require several conversion steps, such as the conversion of power firstly into gas, which is then to be used to generate heat or as propulsion energy, are currently less efficient. In the case of applications which tap an additional source of renewable energies, such as heat pumps which make use of ambient heat, the decarbonisation effect is further enhanced by using renewable power. But there are also differences between the technologies which use electricity. For example, the annual performance of heat pumps depends on the type (air or geothermal pump), the quality standard considered, the settings, the area of use (low or high temperature) and the temperature of the heat source of the heat pump.

In order to keep the additional demand for renewable power and the associated costs as low as possible, technologies should be given priority which convert electricity efficiently into heat, cooling or propulsion or which exploit as many renewable energies as possible by using electricity and which therefore replace as many fuels as possible with the

Figure 8: Presentation of different sector coupling technologies

	Households / TCS	**Heat networks**	**Transport**	**Industry**	
Power-to-Heat	Heat pump Direct electric heating	Large-scale heat pumps Electrode boilers		Process heat generation in electrode boiler, heating panel, light arch etc.	**← Sector-coupling technologies**
	Heating boiler (natural gas and heating oil)	Heating boiler (natural gas and heating oil)		Direct combustion Natural gas	**← Substituted technologies or fuel sources**
Power-to-Gas	Combustion in heating boilers and CHP plants	Combustion in heating boilers and CHP plants	Fuel cell Combustion engine Gas turbine	Process heat generation Use as a material	
	Natural gas	Natural gas	Combustion engine (petrol, diesel)	Natural gas and coal	
Power-to-Liquid	Possibly combustion in heating boilers		Combustion engine, turbine	Use as a material	
	Heating oil		Combustion engine (petrol, diesel) Turbine with kerosene	Crude oil derivatives	
Direct electric propulsion in transport			Electric car Rail transport Trolleytruck		
			Combustion engine (petrol, diesel)		
New electricity-based methods				New method (plasma etc.)	
				Conventional methods (various)	

Source: ifeu, Fraunhofer ISI

smallest amount of renewable power. As far as known today, this applies primarily to highly efficient heat pumps and electric vehicles. Both require comparatively little power. They can make a large contribution to the decarbonisation and efficiency enhancement in the heat and transport sector. In view of their far higher demand for power, other technologies such as electric boilers and heating rods or electrolysers (power-to-gas) are only used where no more efficient technologies are (yet) available. This applies, for example, to the provision of high temperature heat in industry. Even with very few hours of use per annum or a very low heat demand, the use of less efficient technologies may be sensible in individual cases from the point of view of economic efficiency. In the transport sector, synthetic fuels – the production of which demands far more power – will probably be used , particularly in cases in which the use of direct electric drives is not viable for technical or economic reasons. Nevertheless, the use of these innovative fuels with the necessary comprehensive approach to reducing emissions in transport should also be given careful consideration.

The policy framework and instruments must be designed such that technical, economic or political lock-in effects in favour of less efficient sector coupling technologies are avoided. A technology-neutral approach guarantees that in competition the most efficient technology is used first. Technological progress, investment cycles and infrastructure costs must be considered and a balance achieved for the entire system between technical and economic efficiency which also permits companies to realise their business models. Further research and testing of innovative conversion technologies can also lead to improving levels of efficiency. A development of this kind can be promoted by this holistic approach.

Figure 9: Example of heat pumps and electromobility: little power replaces as much fuel as possible

Quelle: Eigene Darstellung in Anlehnung an IWES et al. (2015)

Key questions:

1. **In sector coupling, which instruments are suitable for avoiding path dependencies which lead to an economically inefficient use of power?**

2. **With which specific applications and to what extent can sector coupling contribute to decarbonisation?**

Hypothesis 10: Sector coupling offers cost-effective flexibility on the demand side to balance out the fluctuating supply of power from renewable energies.

Both in the heat area and in the transport sector, potential exists to shift and feed in loads to balance out the fluctuating supply from renewable energies in a relatively cost effective manner. Higher costs currently arise from the transformation of power into other energy sources (e.g. hydrogen, methane). Heat storage systems can store energy for a fraction of the costs of other technologies. In the transport sector, intelligent charging structures for electric vehicles can facilitate flexibility. This load management potential can be used by intelligently designing sector coupling. In this way, the synergies between sector coupling and the electricity market 2.0 can be increased and the costs in the power sector for flexibility options reduced, thereby ultimately also lowering the overall costs of the energy transition. Sector coupling technologies should therefore be as flexible as possible and be used in interaction with storage systems so that they can be used for efficient load connection for electricity markets.

Sector coupling technologies in the individual sectors must, of course, be designed in line with user requirements. For example, electric vehicles cannot only be charged when there is a plentiful supply of power from renewable energies. “Mobility” must be available when it is required by consumers. In addition, aspects such as available range and finance models for the requisite infrastructure must be considered. Implementation in line with user requirements is also a decisive aspect in the heat sector. Consumers must be able to use heat and cooling as required and not only at those times at which this would be conducive to the system. It must also be considered that a flexible operation of production processes can lead to losses in efficiency but can also have positive effects on energy efficiency.

If sector coupling technologies are used in a manner which is conducive to the energy system where possible, this will be reflected in lower overall system costs. By contrast, if they are not used in this way, the costs for grid expansion and operation and the peak load capacity will unnecessarily increase. Sector coupling should not increase the need for flexibility unnecessarily. Use in a manner which is conducive to the system is incentivised in the electricity market 2.0 via the electricity price signals including gird charges. Certain conditions must be satisfied to permit consumers to react to the electricity price signals. For example, the scale of the application should permit a certain degree of flexibility, it should be possible to control the application via corresponding interfaces or smart meters and the electricity supply agreement should permit a reaction to the electricity price signal. The extent to which the flexibility is used in everyday operations results from user preferences, production requirements and the competition of flexibility options. In this way, sector coupling and the requirements of the electricity market can be jointly considered.

Key questions:

How can it be guaranteed that sector coupling provides flexibility for the electricity market on the basis of efficient technologies?

Hypothesis 11: Each sector makes an appropriate contribution to the costs of decarbonisation.

Sector coupling must be economical, i.e. cost efficiency must be taken into consideration at both a macro- and micro-economic level. It offers the opportunity to reduce greenhouse gas emissions and primary energy consumption and, through additional flexibility potential, the overall economic costs of the energy transition. All stakeholders benefit from this. From a macro-economic point of view, energy consumption reductions and the lowering of greenhouse gases should be achieved through the most cost-efficient avoidance option for the respective area of use. The overall system must be considered here, particularly when weighing up the necessity of government funding measures for the launch to market of specific technologies – through direct funding or special circumstances. In principle, a flexible approach which is open to the choice of technology should be pursued when shaping the policy framework. Attention should be given to avoiding a lock-in in inefficient sector coupling technologies. The market players make the decision between decarbonisation options on the basis of price. This requires state-induced price components of fossil and renewable energy sources to reflect the relevant costs and favour decisions which are conducive to the energy transition.

To ensure that the required investments are made, the use of sector coupling technologies must also be viable from a commercial point of view. This means that their use must be cost-effective for the users themselves. For this purpose, it must be possible to refinance investments on the basis of solid business models and planning certainty. For reasons of a just distribution, it is of central importance that the respective sectors make a fair contribution to the costs of decarbonisation. Solutions must therefore be found as to how the sectors of private households, trade, commerce and services, industry and mobility can make their contribution to converting the generation of power from fossil fuel to renewable sources.

Key question:

1. **With which instruments can investments in technologically and economically efficient and flexible infrastructures (e.g. heat networks supplied from renewable energies) be induced at any early date?**

2. **How can the conditions of competition between renewable electricity and fossil fuels be improved in the different sectors? And who is to decide this and when?**

4.5 Digitalisation

Hypothesis 12: Digitalisation opens up new possibilities for added value services and efficiency services.

Digitalisation creates new potential for stepping up energy efficiency. Not only are key technologies such as broadband internet to be implemented in an energy-efficient manner. Rather, digitalisation and continuous consumption metering open up new possibilities of analysis and user information. On this basis, value added services and (finance and consulting) services for energy efficiency can be developed which – in this form – used to be technically and organisationally impossible or (too) expensive. Similarly, digitalisation facilitates new forms of organisation and control of industrial production processes (Industry 4.0) which can be used to optimise the use of energy and enhance energy efficiency. In the transport sector, digitalisation and the networking of vehicles with each other and with the transport infrastructure can contribute to improved traffic flows. New mobility offers and a more intelligent combination of different means of transport can make a decisive contribution to reducing emissions in the transport sector.

Automated consumption metering and precise user feedback can create the foundation for recognising and quantifying individual saving potential, using new business models to make it individually available and commercially viable. This creates new opportunities, for example to develop the market for energy saving contracting.

A digital user infrastructure could give rise to several innovations, such as:

- Continuous, fully automatic and individualised energy advice without any mentionable additional costs for all providers of advisory services (“marginal costs virtually zero“);

- Quantification of direct rebound effects – including any tips on how to limit them;

- Combination of individualised energy advice with finance offers to facilitate efficiency investments.

Furthermore, digital measurement methods can contribute to establishing new performance-dependent funding measures. So far, performance-dependent instruments have been the exception because the targeted energy savings can only be quantified individually at great expense. New and automated systems which observe high data protection standards can help here. This also refers to the saving measures which are to be increased in a particularly cost-favourable manner, such as changes in behaviour or servicing.

Example: “Pilot programme for energy savings meters”: using the opportunities of digitalisation for more energy efficiency

The aim of the new funding programme “energy savings meter“ of the Federal Ministry for Economic Affairs and Energy is to provide assistance to consumers in households, in the area of trade, commerce and services and in industry through the use of options to reduce energy consumption. Innovative and IT-based pilot projects are supported for this. Companies who develop energy savings meters and demonstrate their use to (voluntarily participating) end consumers can take part. Through energy consumption information tailored to his individual equipment and systems alongside energy saving tips, the end consumer is to be put in a position to estimate

- how high the power consumption of the different devices is (identification of “power guzzlers“ and cost drivers);

- how and to what extent energy and costs can be saved using simple means;

- how much energy and costs have actually been saved;

and on this basis to make decisions on energy saving measures.

In the pilot phase of 2016 – 2018, this project focuses on developing and using (IT-based) innovations for the savings on energy which are necessary for the energy transition. In addition, added value services, such as load management for sector coupling or private sector financial services for energy efficiency, are to be tested and incentivised.

Key questions:

1. **How can the new possibilities of measuring consumption, user information and added value services for efficiency be tapped by digitalisation?**

2. **How can the recording of individual energy savings be used for funding approaches which allow for technology-neutral solutions and take the savings actually achieved into greater consideration?**

Hypothesis 13: Digitalisation and the use of renewable energies alter the cost structure of energy generation – a long-term efficiency strategy must take this into consideration.

The development of renewable energies together with the use of digital control technologies leads to a fundamental transformation of the energy market. The system of the future is increasingly based on an interlinked and decentralised form of intelligent control of energy consumption and generation.

However, this also has consequences for the incentive structure for an economical and efficient approach to energy. This is because, with the exception of biomass, the use of renewable energies to provide heat such as wind and solar power do not cause fuel costs. The importance of “operative costs” for fuels in future energy generation therefore lessens whilst the significance of fixed capital costs increases. This could result in a trend in the business models of the energy providers to increase the portion of basic financing for the provision of energy but reduce the consumption-dependent portion. The development of “flat-rate” business models for the energy sector would appear to be quite conceivable. This development must be considered in the further shaping of energy efficiency policy. It offers opportunities and risks for the goal of energy saving. For example, stepped marketing models with particularly favourable conditions for low consumption volumes could lead to a strengthening of the incentive for energy efficiency amongst end consumers. By contrast, a situation must be avoided in which new business models lead to a careless attitude to energy by end users.

Key questions:

1. **Which energy marketing models arise through digitalisation?**

2. **What opportunities and risks result from this for energy saving?**

Hypothesis 14: Digitalisation contributes to balancing the demand for energy with a decentralised and volatile generation of energy.

Digitalisation will contribute to increasing the efficiency of energy and synchronise it with growing shares of volatile energy generation. New digital services will become established in the market which develop their own “digital logic”. The increasing number of smart control systems based on different digital technologies will facilitate an optimisation at subsystem level which need not necessarily be in line with the requirements of the next higher system level. Every digital smart system can in future pursue a different self-defined goal.

Examples: The intelligent integration of PV self-consumption systems increases their use to the system, a “fuelling” system of a battery-driven vehicle pursues the objective of having reached the highest charging level at a specific time, and a smart energy management system for buildings or a production plant in its turn pursues its inherently set regulation and control logic.

This raises the question of whether and to what extent the many different subsystems with their own target definitions and control logics form a complex structure of overlapping subsystems, and whether this increases efficiency, stability and controllability or makes them more difficult from the point of view of the overall system.

The further challenge is that when converted to digital systems, the energy system could become more vulnerable to hacker attacks, virus infection or cyberwar attacks. The question is therefore the extent to which smart systems (smart home, smart building) introduce an additional degree of vulnerability to the power system as they become more widespread, and which recommendations are to be derived from this.

With the “Act on the Digitalisation of the Energy Transition”, Federal Government and Bundestag have created a legal framework which introduces a new technology in the form of the intelligent measurement system. It will serve as a secure communication platform at the grid interface between generation and consumption to make the power supply system fit for the energy transition and raise energy efficiency potential. In order to guarantee a uniform and high level of security, protection profiles and technical guidelines for intelligent measurement systems will be declared binding in order to guarantee data protection, data security and interoperability (www.bsi.bund.de). Only those systems will be given the BSI seal which demonstrably provide a very high level of data protection and security.

Intelligent measurement systems will be an important component for the improved balancing of generation and demand. This will facilitate the change to a power supply system that is increasingly based on volatile decentralised producers.

Consumers are to benefit from the use of intelligent measurement systems in many respects. In future, visualising power consumption will put consumers in a position to handle energy more consciously. The costly manual reading of meters will be a thing of the past, and gas and heating readings can similarly be integrated. The introduction of variable electricity rates is predicated on intelligent measurement systems.

All in all, it can be said that digitalisation can make a considerable contribution to implementing the energy transition. The legal, technical and economic framework conditions must be continuously further developed if this opportunity is to be used whilst maintaining data protection and system security.

Key questions:

1. **How should legal, technical and economic framework conditions be further developed so that the “innovative strength of digitalisation” is conducive to the system, compatible with the energy transition and can be implemented safely? How can high standards of data protection and system security be guaranteed?**

2. **Is a greater coordination of digital subsystems necessary in future? If this is the case, what should they look like, which interfaces and protocols should they use and who is to stipulate them and when?**

www.bmwi.de