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# Impact Assessment on the Environmental, Social and Economic Effects of the 2030 Sectoral Targets in the Federal Government's Climate Action Plan 2050

Summary

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The study was commissioned by the Federal Ministry for tthe Environment, Nature Conservation and Nuclear Safety


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# 1. Short Summary

The analyses highlighted three main issues:

1. The targets set for the various sectors can be achieved by means of a range of different strategies.
2. From a macroeconomic perspective, all implementation strategies covered by the study are linked with positive effects. This is especially the case where an efficiency-based implementation strategy is pursued.
3. In all sectors, specific challenges are faced which should be addressed when developing and implementing the first programme of measures under Germany's Climate Action Plan 2050.

To achieve the sectoral targets, considerable additional investment is needed in all sectors and/or investments need to be reallocated in relation to the assumed reference developmentdevelopment. The target pathways examined in the study point to the available scope for action.

In most sectors, it is evident that a strategy which primarily focuses on energy efficiency (described as Target Pathway A in the study) is linked with economic benefits. This means that the necessary investment is matched by similarly high or even higher savings.

In the macroeconomic analysis, positive effects are seen with regard to value creation, gross domestic product (GDP) and jobs. However, gains in many sectors are counterpointed by declines in value creation and jobs in others. These developments must be supported as appropriate. Also, certain positive effects are based on assumptions such as an unchanged high share of domestic production in the automotive industry, including where e-mobility is concerned. Policymakers must create the necessary framework conditions to ensure that this actually occurs.

In the analysis of electricity prices and energy costs, it is evident that their development in the target pathways when compared with the reference development mostly benefits industry or leads to only marginal adverse effects. For example, the assumed expansion of renewable energy in accordance with the Federal Government's 65 % target leads to lower wholesale electricity prices compared with the reference development.

The significant efficiency improvements in the target paths and the transition to e-mobility lead to considerable savings in the import of fossil fuels. There is no evidence security of supply in electricity generation would be put at risk and any such risk could be prevented by implementing relatively moderate measures.

Positive effects were also seen from the prevention of harmful emissions and the avoidance of external costs of climate, even though possible climate-related damage to the national economy and climate adaptation measures were not the focus of this study.

## 2. Introduction

For the past two decades or more, climatepolicy has been a prominent area of German policymaking. This rests on a comprehensive strategy which the German Federal Government initiated at a very early stage and has continually further developed since then. At European level, the Federal Government has, as a driving force, repeatedly helped to shape climate negotiations in the EU. With its ambitious national targets, Germany has assumed a pioneer role among the EU member states.

The Integrated Energy and Climate Programme of 2007, the Energy Concept (Energiekonzept) adopted in 2010 and the decisions on accelerating the energy transition announced in summer 2011 contain important energy and climate policy strategies, programmes and measures. In the Energy Concept, Germany adopted its first long-term energy and climate targets and goals. These see a 40 % reduction in greenhouse gas emissions in Germany by 2020 (based on 1990 levels), minimum reductions of 55 % by 2030 and of 70 % by 2040, reductions of between 80 and 95 % by 2050, as well as ambitious energy efficiency and renewable energy expansion targets and goals. The Climate Action Plan also sets out the 2050 vision of a Germany that is largely greenhouse gas neutral.

To ensure the 40 % target is achieved by 2020, the Federal Government adopted the Climate Action Programme 2020 (BMUB 2014) together with additional measures at the beginning of December 2014. However, current projections show that, compared with 1990 levels, reductions achieved by 2020 will only amount to approx. 32 % (Öko-Institut 2017). This falls far short of the 40 % target.

With the Climate Action Plan 2050 of November 2016, the Federal Government adopted a strategy document with which both the long-term and far-reaching goals of the Paris Climate Agreement and the targets contained in Germany’s Energy Concept are operationalised step-by-step. In addition to reaffirming the long-term goal of achieving largely greenhouse gas neutrality by 2050, the Climate Action Plan 2050 also contains sectoral interim targets, visions, milestones and, in some areas, concrete measures for 2030 . These are designed to ensure consistent long-term development while preventing structural upheaval, and maintain or improve Germany’s prosperity and competitiveness.

With the Climate Action Plan 2050, a comprehensive impact assessment was also adopted, which is designed to serve two different processes. On the one hand, it will be used as the basis for informed discussions with the social partners. On the other hand, analyses resulting from the impact assessment are to be used at least indirectly to develop and discuss well-founded policies and measures, i.e. concrete policy instruments, with which the 2030 targets can also be achieved under very different conditions.

Against this backdrop, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) commissioned a consortium comprising Öko-Institut, Fraunhofer ISI, Prognos, IREES, M-Five and FIBL to conduct the Impact Assessment on the Environmental, Social and Economic Effects of the 2030 Sectoral Targets in the Federal Government’s Climate Action Plan 2050.

At the forefront of the analyses is the classification of the various approaches with which the (in some cases provisional) 2030 sectoral targets can be achieved. Such a classification must take account of environmental, economic, social and cross-sectoral policy objectives and goals (for example, in the context of the European Union, its policies, objectives and goals). As an innovative feature, the relevant environmental aspects are to be considered, at least in part, based on monetised values and in the same analytical framework as regulatory impact assessments and infrastructure planning.

## 3. Methodology, combinations of reference and sectoral target pathways

The Impact Assessment of the 2030 Sectoral Targets contained in the Climate Action Plan 2050 focuses on the procedures and approaches used to estimate the cost-benefit categories for legislative regulations. For this, the methodology in the Federal Environment Agency's Guidelines for Cost-Benefit Analyses (Leitfaden für Nutzen-Kosten-Analysen) can be applied (Porsch et al. 2014).

It must be stressed that this impact assessment examines the effects of achieving the 2030 sectoral targets contained in the Climate Action Plan 2050. This differs significantly from the usual procedures involved in conducting regulatory impact assessments, which generally focus on specific implementation instruments and allow consequences such as distribution and competition-related effects to be determined with greater accuracy.

The approach taken in the impact assessment comprises the following steps:

i. **Determining the framework dataset:** In a first step, the general and specific framework data that form the basis of all further analyses were determined in agreement with the relevant Federal Government departments. The framework data involve, among other things, trends in demographic and macroeconomic parameters, the discount rate to be applied, the energy and EUA prices, transport demand and housing needs. Additional assumptions are taken into account in the form of sensitivity analyses.

ii. **Reference and target pathways:**

- **Reference development (REF):** In all sectors, the reference development largely matches the "with measures scenario" (WMS) from the Projection Report 2017 (Projektionsbericht) and the respective measures that were implemented. An adjustment was made to the reference data agreed with the respective government department, for example regarding trends in economic development and energy prices.
- **Target pathways (TPs):** For the target pathways, sectoral strategies and levers were identified which allow the sectoral targets to be met. For most sectors, two sectoral pathway combinations (also called target pathways) were derived. The target pathways are independent of any concrete instrumentation and do not constitute policy measures.[1] Guidance concerning strategies is either outlined in the Climate Action Plan or derived from it. Thus, the target pathways are not cost-optimised and do not present the only ways in which the targets can be achieved. In Target Pathway A, the main focus is placed on energy efficiency, while Target Pathway B focuses on renewable energy. For the sake of simplicity, in the following, the target pathway-based strategies, impact mechanisms and levers are called "assumptions". This is to ensure that they are clearly distinguishable from instruments or measures which are not covered by this target-oriented impact assessment. Table 3-1 gives an overview of the sectoral assumptions for the various target pathways.

[1] The term "measure" is often used in a vague way. Here, it normally means concrete implementation instruments and not solely the description of a desired development. For example, expansion of renewable energy use would not be seen as a measure itself, but its instrumentation would – such as via an amendment to the German Renewable Energy Sources Act (EEG).

### Table 3-1: Definition and key sectoral assumptions

| | Target Pathway A | Target Pathway B |
|---|---|---|
| **Definition** | ➢ Main focus: Energy efficiency | ➢ Main focus: Renewable energy or alternative strategies |
| **Buildings** | Extensive exploitation of energy-efficiency potential with minimal use of RES heat potential | ➢ Extensive exploitation of available RES heat potential while achieving a minimum in energy efficiency |
| **Transport** | ➢ Highly ambitious increase in efficiency and electrification of passenger vehicles<br>➢ Increased efficiency in conventional heavy vehicles<br>➢ Trolley trucks in road freight transport<br>➢ Modal shift effects (public transport, rail, inland shipping)<br>➢ Optimisation and change in demand | ➢ Ambitious increase in efficiency in passenger vehicles<br>➢ Increased efficiency in conventional heavy vehicles<br>➢ Greater modal shift effects (public transport, rail, inland shipping)<br>➢ Optimisation and change in demand<br>➢ Use of renewable-electricity-based fuels |
| **Industry** | ➢ Greater diffusion of efficiency technologies as the REF<br>➢ Intensified fuel switch (biomass, power-to-heat (PtH)<br>➢ Greater material efficiency and recycling | ➢ Less ambitious progress in energy efficiency as the REF, which is offset by a greater switch to renewable electricity generation |
| **Energy Industry** | ➢ Renewable energy sources (RES) – share in gross electricity consumption in 2030: 65%<br>➢ Assumption: Gradual shutdown of coal-fired power plants with a lifetime > 37 years<br>➢ Expansion of natural gas-CHP and renewable heat generation | ➢ Assumptions as for TP A<br>➢ Additional expansion of renewables to cover additional electricity demand in other sectors |
| **Agriculture** | ➢ Reducing nitrogen surpluses<br>➢ Expansion of slurry fermentation and slurry storage covers<br>➢ Reduction of fossil fuel use in agriculture (e.g. energy efficiency in greenhouses, reduced fuel use)<br>➢ Expansion of organic farming<br>➢ Reductions in dairy and cattle stocks<br>➢ Rewetting and wet management of wetlands used in farming (nitrous oxide) | ➢ Assumptions as for TP A<br>➢ Use of nitrification inhibitors to reduce nitrous oxide emissions<br>➢ Moderate reduction in dairy and cattle stocks |
| **LULUCF** | ➢ Reduction in peat extraction<br>➢ Rewetting and wet management of wetlands used in farming (carbon dioxide)<br>➢ Forest conversion and more extensive timber extraction | |

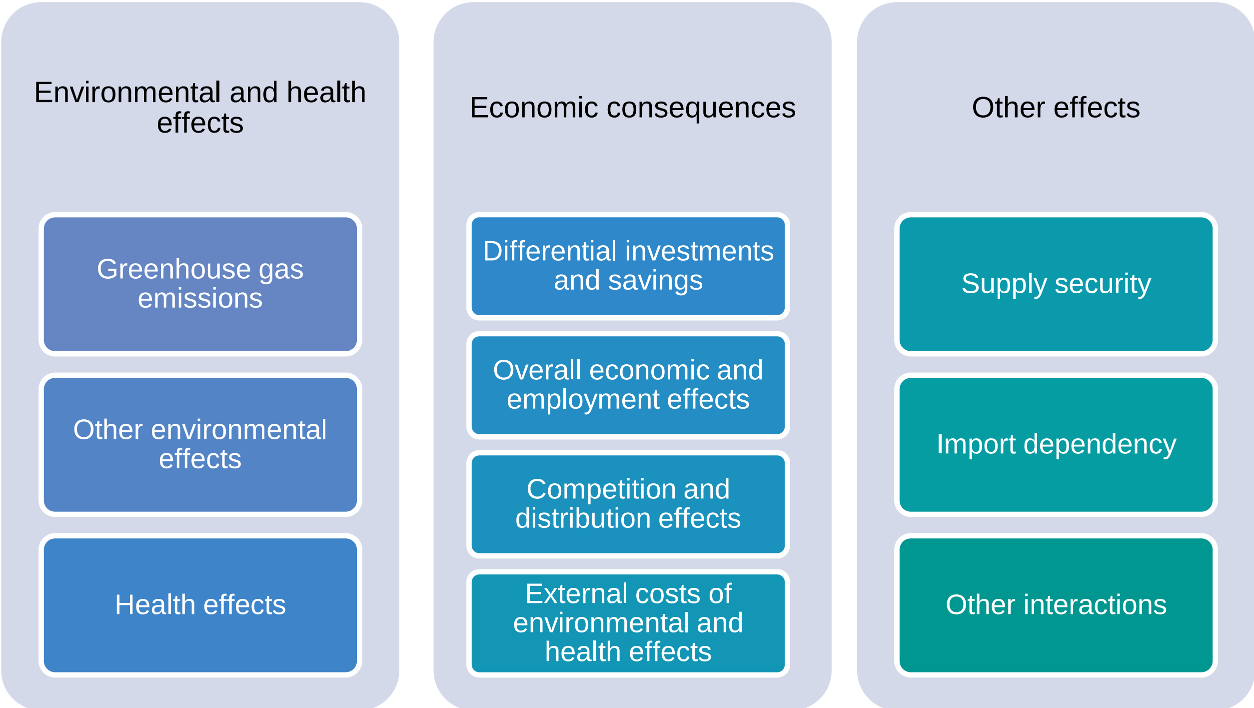
Source: own representation

iii. **Impact assessment**: In the next step, the impact assessment is performed in which the effects of the two target pathways are assessed in comparison with the reference.

- the analysis takes in **primary effects**, environmental and health effects, and direct economic effects such as internal costs (investment, fuel costs, other operational costs, internalised environmental costs incurred via the EU Emissions Trading System, etc.).

- **Secondary effects** are also identified and categorised. These include macroeconomic effects (value creation, GDP, jobs and competition) as well as the positive effects arising from the avoidance of external costs of climate and harmful emissions,[2] and the categorisation of non-monetisable values (supply security, health effects, etc.) and potential distribution effects which are primarily relevant in relation to supporting measures. The different categories covered by the impact assessment are shown in Figure 3-1.

**Figure 3-1: Categories covered by the impact assessment**




Source: own representation

To identify the impacts of the target pathways in achieving the sectoral targets contained in the Climate Action Plan 2050, a comprehensive set of model instruments is used which covers all industry sectors, all areas of energy consumption and greenhouse gas emission sources, and a wide range of other emissions and environmental effects. The secondary effects are calculated and evaluated using a macroeconomic model approach and on the basis of the UBA tool. Qualitative analyses are provided in appropriate places. Social aspects and distribution effects are addressed in those action areas that directly affect households (buildings, transport and electricity use).

## 4. Impact from greenhouse gas reductions

In addition to overall greenhouse gas reductions of at least 55 % based on 1990 levels, the Climate Action Plan contains a set of sectoral targets for 2030. The aim of this assessment was to achieve these targets

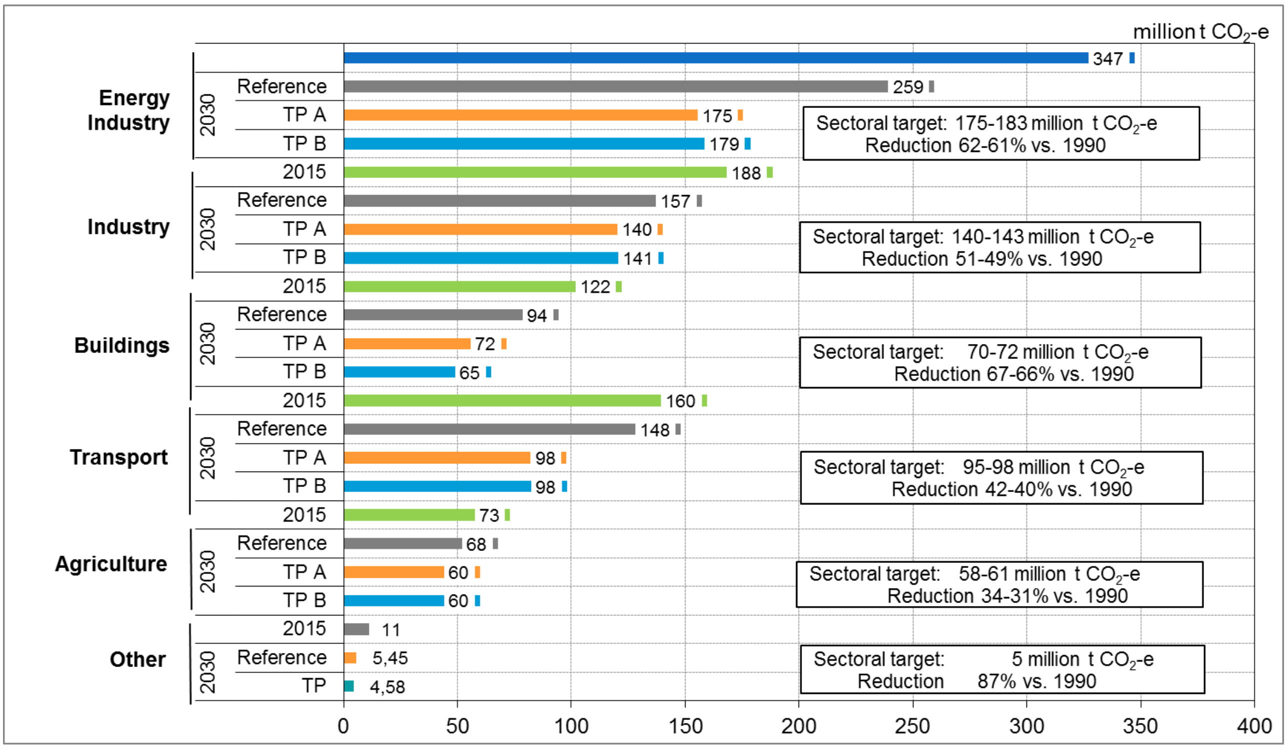
[2] Assuming that this can be identified on the basis of the Federal Environment Agency's Guidelines for Cost-Benefit Analyses (Leitfaden zur Nutzen-Kosten-Abschätzung umweltrelevanter Effekte in der Gesetzesfolgenabschätzung) (UBA–Texte 01/2015)

and compare them with a reference development. Figure 4-1 shows the results of the sectoral greenhouse gas emissions in 2015 and 2030 for the reference development and for both target pathways.

Even in the reference development, emissions are reduced to 732 million t $CO_2$-e by 2030, representing a reduction of 41 % compared with 1990 levels. This falls far short of the Climate Action Plan target of a minimum reduction of 55 %. Compared with the figures for 2015, the energy industry sector and the “other” sector can achieve the biggest reduction, totalling 88 million t $CO_2$-e (a 25 % reduction) by 2030. In the buildings sector, a reduction in the amount of 28 million t $CO_2$-e (23 %) is achieved. The smallest reduction occurs in the transport sector, where a reduction of only 12 million t $CO_2$-e (7.5 %) is achieved between 2015 and 2013.

In Target Pathway A and Target Pathway B, emissions drop to 548 and 545 million t $CO_2$-e, respectively, by 2030. This represents a 56 % reduction compared with 1990. The target set out in the Climate Action Plan is thus met in both target pathways. The sectoral reduction targets contained in the Climate Action Plan are also met and in the case of the buildings sector are actually exceeded in Target Pathway B. This is due to the increased use of electricity and district heating which leads to additional emissions in the energy industry sector.

**Figure 4-1: Sectoral GHG emissions in 2015 and 2030 (REF, TP A, TP B)**




Source: own calculation

# 5. Sectoral Analysis

## 5.1. Buildings

With regard to buildings, energy consumption for all types of use (with the exception of “mechanical energy”) in buildings belonging to the private households (PH) and trade, commerce and services (TCS) sectors are considered. With regard to the thermal conditioning of buildings, a sectoral strategy is already in place in the form of the Energy Efficiency Strategy for Buildings (ESG). The ESG was adopted by the German Cabinet on 18 November 2015 and forms the basis for the analyses conducted in here. The ESG covers energy demand for thermal conditioning of buildings (space heating, hot water, air conditioning) and the electricity needed for lighting in non-residential buildings. It covers buildings in the private households, TCS and industry sectors. The Climate Action Plan, in contrast, the buildings only covers buildings in the private households and TCS sectors. Building-relevant energy consumption and GHG emissions from buildings in the industry sector are thus addressed in Section 5.2, while agricultural buildings are included in Section 5.5. For uses that go beyond the scope of the ESG, electricity is the main source of energy supplied, which is why Section 5.1.2 addresses electricity consumption in private households and the TCS sector.

The results of this cross-sectoral impact assessment are supplemented with the existing sector-specific results of the scientific research conducted in support of the ESG (Prognos et al. (2015)) and the macroeconomic classification of the ESG (Prognos; Ecofys; dena; PwC 2017).

### 5.1.1. Buildings – "thermal conditioning" (ESG)

#### 5.1.1.1. Assumptions

The requirement for the two target scenarios in the ESG is a minimum 80 % reduction in non-renewable primary energy consumption by 2050 compared with the base year 2008. The two target scenarios serve as examples of two different strategies to achieve the target on the fringes of the ESG target corridor. Achievement of the target is restricted by the maximum achievable energy efficiency and by the availability of renewable energy. The target can only be achieved through a combination of energy efficiency and renewable energy. Focusing solely on one or other of the strategies is not enough.

The reference and the target pathways for buildings (residential and non-residential buildings) are as follows:

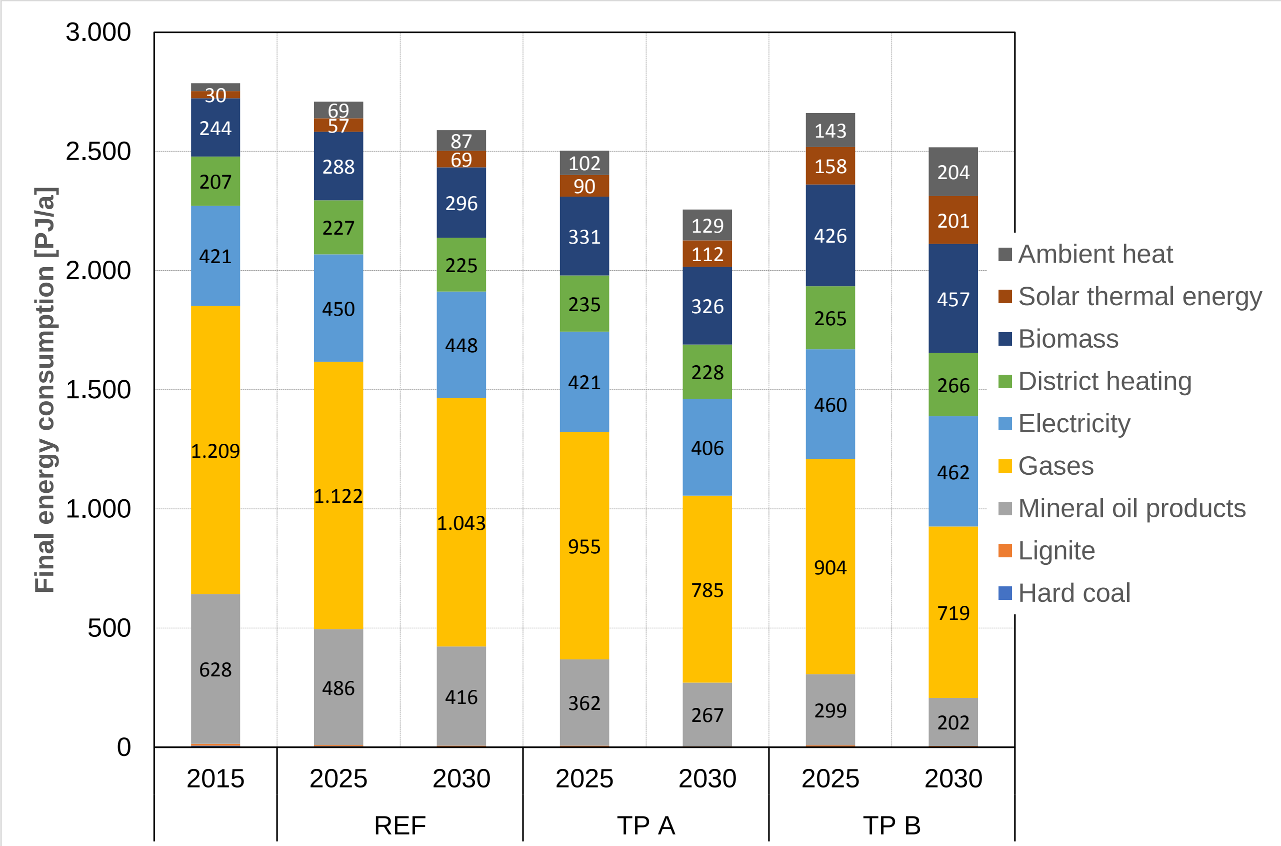
- **The ESG reference scenario** considers policies in existence up to the end of 2013 and largely matches the reference scenario contained in the Energy Reference Forecast (Energiereferenzprognose) published by the Federal Ministry for Economic Affairs and Energy (BMWi) (Prognos AG, EWI, GWS (2014)).
- **Target Pathway A** (efficiency): The main measure taken to achieve the target is the far-reaching exploitation of available energy-efficiency potential with minimal use of RES heat potential.
- **Target Pathway B** (renewable energy): The main measure taken to achieve the target is the far-reaching exploitation of the available RES heat potential while achieving a minimum of energy efficiency.

#### 5.1.1.2. Final energy consumption and direct greenhouse gas emissions

Final energy consumption

With the agreed framework data on developments in population size, living space and economic growth, and the assumptions for the target pathways outlined above, the scenario analysis shows the following final energy consumption for the buildings sector (see Figure 5-1).

**Figure 5-1: Final energy consumption in buildings by energy source**




Source: Based on Prognos et al. (2015)

In Target Pathway A, which focuses on the greatest possible reduction in final energy consumption by means of efficiency measures and taking restrictions on insulation into account, and where the remaining energy needs are partially covered by renewable thermal energy, final energy consumption is reduced by 19 % in the period of 2015 to 2030. Use of fossil fuels drops by 42 % and electricity consumption by 2 %. Use of district heating rises by 10 % to 228 PJ. The biggest increase is seen in renewable energy, rising by 79 % to 567 PJ in 2030.

In Target Pathway B, which focuses on the greatest possible substitution of fossil fuels through renewable energy use (decarbonisation) and the use of supplementing strategies for increased energy efficiency (energy-efficient building refurbishment), final energy consumption reduces by 10 % in 2030 (compared with levels in 2015) – far less than in TP A. Use of fossil fuels is almost halved (-49 %), while in some places final energy consumption for electricity (+10 %), district heating (+24 %) and renewable energy (+154 %) increases significantly. One particularly critical aspect in all of this involves the intensive use of biomass, which requires exploitation of additional potential through the expansion of short-rotation crops.

Greenhouse gas emissions

Looking at greenhouse gas emissions, the target corridor for the building sector in the Climate Action Plan 2050 is a 66 to 67 % reduction in GHG emissions compared with 1990. This corridor is achieved at the top of the range in Target Pathway A, with a reduction of 67 %. In Target Pathway B, a 69 % reduction is achieved compared with 1990. Here it must be noted that in Target Pathway B, significantly more electricity and district heating is used than in Target Pathway A. Because the Climate Action Plan uses the source principle for GHG emissions, the emissions that are attributable to the thermal conditioning of buildings under the polluter pays principle (ESG) are classified as belonging to the energy industry sector in the Climate Action Plan. This is why GHG emissions for the building sector are lower in Target Pathway B.

From the analyses on energy consumption and GHG reductions, it is clear that the building sector targets contained in the Climate Action Plans 2030 and 2050 can only be achieved through a combination of energy efficiency and renewable energy use.

#### 5.1.1.3. Socio-economic aspects

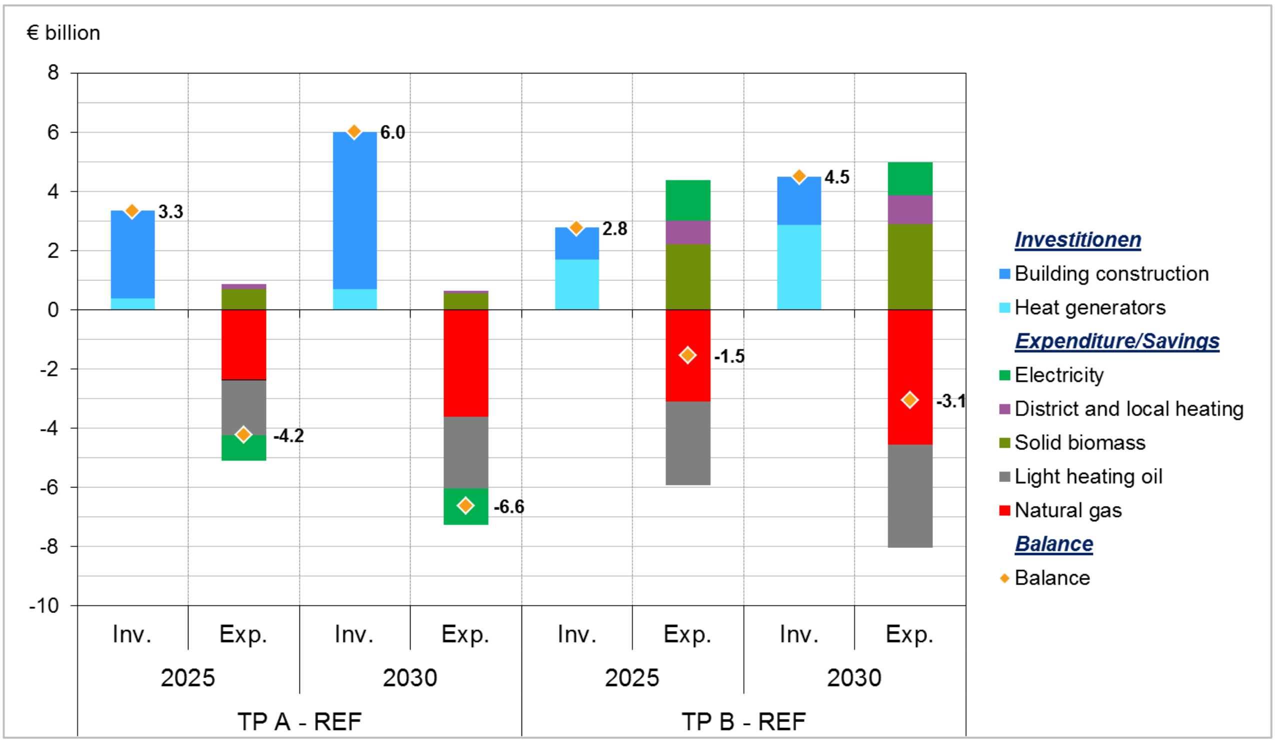
In the sectoral economic assessment, the investments made are compared with the savings in a direct cost-benefit analysis. Only the additional energy efficiency-related investments and the resulting operational and fuel-related savings or additional expenditures are compared against the reference development. The calculation takes a bottom-up approach using the Prognos AG building stock model. Among other things, this shows the area of residential building space and the energy efficiency per year up to 2050 by building type and age classification. For each year, the specific investments for building refurbishment are determined in relation to the energy efficiency and building type per square metre of living space. The product of refurbished space multiplied by specific investment costs produces the overall investment sum. Energy-related investments largely comprise the costs involved in modernising the building envelope and those required to renew technical systems. The additional investment in 2030 in Target Pathway A (compared to the reference) is approx. € 14 billion for heat generation and energy-efficiency modernisation of building envelopes. In Target Pathway B, the differential investments amount to € 7.5 billion for heat generation and building envelopes. Compared with the total construction volume in Germany, the additional investment in building construction in Germany required to achieve the targets is relatively low, at between 2 and 5 %.

Additional investments are counterbalanced by considerable savings in operating and fuel costs. Savings of € 6.6 billion in TP A and of € 3.1 billion in TP B are achieved by 2030 alone. With an expected savings lifespan of 25 years for heat generation systems and 40 years for building envelopes, the savings significantly outweigh the differential costs in TP A.

To compare the differential investment costs at the time an investment is made and the savings made over its lifetime, the differential investments are shown in the form of annuities (i.e. constant cash flows over the lifetime of the repayment of the investment) and comapred to the annual savings and expenditures in two reference years (Figure 5-2).[3] The annuities in reference years 2025 and 2030 include the annuity payments for all investments made in the period up to the respective reference year. The cost analysis is conducted from a macroeconomic perspective.

[3] The investment costs are annuitised over the lifetime of the investments with a suitable discount rate of 2 % (see Section 5.1).

**Figure 5-2: Comparison of annuitised differential investments and expenditure / savings for buildings**




Source: own calculation

In Target Pathway A, which focuses largely on improved efficiency, the annuitised costs – meaning the investments made in various years distributed over the lifetime – of refurbishing the building envelope and new construction/replacement of heat generation systems amount to € 6 billion in 2030. This leads to a significant reduction in energy consumption, leading to savings in the heating costs of € 6.6 billion in 2030. In the net analysis, the savings made in Target Pathway A slightly outweigh the additional costs. The biggest savings are seen in relation to the fossil fuels natural gas and heating oil. From a macroeconomic perspective, Target Pathway A can be seen as cost-effective.

On the other hand, the annuitised investment costs in Target Pathway B, which focuses more on renewable energy and less on efficiency, are well above the savings in 2030, at € 4.5 billion. Due to the lower efficiency efforts in TP B, the energy demand is higher, which translates into higher heating costs. The annual savings in 2030 amount to € 3.1 billion (compared to € 6.6 billion in TP A). Although demand for oil and gas falls significantly in both scenarios, the lower efficiency gains mean that the demand for electricity for heat pumps and biomass in TP B is higher than in TP A.

In addition to the macroeconomic analysis, social aspects of the two target pathways were also analysed. The effects on the cost of living in residential buildings were examined from the perspective of private households (tenants, owners, and transfer payment recipients). In both pathways, the cost of living increases slightly when compared with the reference. As investments have greater weight from a private sector perspective, the increase in the cost of living in TP A is more pronounced than in TP B. However, as shown in the sector-specific analysis of the ESG scenarios conducted by Prognos et al in 2017, due to the positive effects on jobs, the additional income available for consumption in private households also rises in both target pathways.

In Target Pathway A, after deduction of the additional cost of living, approx. € 33 billion more is available for consumption than in the reference scenario. This compares with only € 23 billion in TP B. The comparison highlights the following situation: In terms of household incomes, TP A has the advantage that, after deduction of the cost of living, disposable income is greater, than in TP B.

In 2030, the average additional costs compared with the reference amount to 0.55 % of available household income in TP A and to 0.22 % of available household income in TP B. This represents an average rise in expenditure of € 17 per month compared with the reference in TP A and of € 7 per month in TP B. These are average values. In some cases, the costs can differ greatly depending on the situation. This must be taken into account when designing the instruments, measures and their various support programmes.

Additional expenditure rises with the income because it is linked to living space, which in turn increases with the income. The relative cost remains almost constant across the income groups. In the lower income groups, adjusted transfer payments largely cushion the additional costs. In sensitivity analyses with higher price projections for heating oil, natural gas and electricity, the results are largely the same.

#### 5.1.1.4. Key messages

The Climate Action Plan targets for the building sector can only be achieved through a combination of energy efficiency improvements and greater renewable energy use. Energy efficiency plays an important role in limiting the use of biomass and electricity (heat pumps) to heat buildings. When it comes to the availability of these limited resources, the building sector stands in direct competition with other sectors (primarily industry and transport).

If the minimum efficiency targets set out in TP B are missed, it will either not be possible to meet it or only possible at great financial cost and with negative impacts on other sectors. The following measures could be considered – measures which due to their high costs are rarely included in scenarios: use of heat pumps in poorly-insulated buildings, increased use of biomass, broad use of synthetic fuels and a second refurbishment cycle outside of the usual maintenance cycles.

The ambitious efficiency measures in TP A substantially reduce the final energy consumption and reduces pressure on the total energy system. High energy efficiency also reduce the path-dependency of other developments and increase the likelihood of the targets being achieved. The more efficient buildings tend to be “immune” to the failure of decarbonisation strategy in terms of electricity and district heating. Even moderate failure to meet the efficiency targets can be countered in TP A with additional measures in the conversion sector. Where high GHG reductions of up to 95 % are aimed for by 2050, TP A has significantly greater benefits than TP B because additional GHG reductions are comparatively easier to achieve through greater exploitation of RES heat potentials. By contrast, TP B exhausts the available RES heat potentials at GHG reductions of 80 %.

From the perspective of private households, the cost of living rises slightly in the target pathways compared with the reference. This is countered by the positive effects on jobs and income, which are significantly greater than the increase in living costs (Prognos et al. 2017). With regard to the income situation in private households, it is evident that after deduction of the cost of living, disposable income is greater in TP A than in TP B.

In sum, the results indicate that Target Pathway A makes more sense in macroeconomic terms, but is more difficult to achieve. The introduction of new policy instruments and further development of existing ones is thus urgently needed for the thermal conditioning of buildings. It will be of central importance to make it more attractive to invest in the energy efficiency of buildings.

### 5.1.2. Buildings – electricity consumption in private households and the TCS sector

#### 5.1.2.1. Assumptions

The scenarios for "households – electricity" cover electricity demand in private households (appliances and lighting), but not that for technical building systems (heating, air conditioning and hot water). These scenarios are based on earlier model results, and especially on the Projection Report 2017 (Projektionsbericht 2017) (Bundesregierung 2017a), and were adjusted to the changed framework dataset for the purposes of the impact assessment (higher population and higher number of households). Changes in user behaviour (positive, for example, due to measurement and feedback functions, or negative, for example, due to rebound effects) were not explicitly included.

- In the reference development, this sector soon shows the impacts of the latest technological advancements and political requirements, especially the EU minimum energy efficiency requirements (Ecodesign Directive and the requirements for the different product groups). The scenario assumes that in the absence of additional incentives, further technological advancements will be slow to take hold in the market and that the price for highly-efficient appliances and equipment will fall as a result.
- In Target Pathway A, existing energy efficiency potentials are exploited to the greatest possible extent and quickly. To meet minimum energy efficiency requirements, regulatory processes are accelerated under the provisions of the Ecodesign Directive and are significantly more ambitious in order to keep pace with technological advancement so that, in most cases, only highly-efficient products are available on the market.
- In Target Pathway B, existing efficiency potentials are exploited. However, in contrast to TP A, the measures implemented are slower and less extensive.

In the TCS sector, the scenarios cover the total electricity consumption minus that for technical building systems (such as heating, air conditioning and hot water) and lighting. The framework data (GDP) is also adjusted. In calculating the reference scenario and the Target Pathways A and B, the simulation model from the Projection Report 2017 (Projektionsbericht 2017) (Bundesregierung 2017a) was used and built based on the scenarios used in the report. For the TCS sector, TP A and TP B do not differ.

#### 5.1.2.2. Final energy consumption

Through the existing measures in the reference scenario, electricity consumption falls from 110 TWh p.a. to 97 TWh p.a. between 2015 and 2030. According to the current status of EU regulations that have already been agreed, there is no relevant new minimum energy efficiency requirement after 2020, with the result that electricity consumption per household remains more or less stable up to 2030.

In Target Pathway A, the assumptions enable savings in total electricity consumption amountin to 20 % compared with the reference scenario. In 2030, savings in electricity consumption amount to 21 TWh (21.4 %) compared with the reference scenario.

In Target Pathway B, the measures lead to tangible medium- and long-term savings, but not to the same extent as in the TP A. In 2030, however, savings in electricity consumption amount to 11.4 TWh (13.4 %) compared with the reference development.

Electricity consumption in the TCS sector remains almost constant in all three scenarios up to 2030. However, the structure of the consumption changes. There is greater growth in data processing centres and a significant decline in street lighting and cooling appliances.

#### 5.1.2.3. Key messages

Under the Ecodesign Directive, a large portion of the economic savings potential for the products covered was already exploited in the reference scenario. From an economic perspective, it is evident that forfinal electricity consumers, the TP B scenario is balanced in the period 2025 to 2030, while the TP A scenario, in which the efficiency of the products (household appliances and lighting) is even higher, is uneconomical.

The energy savings and cost-effectiveness could, however, be further improved in the TP A and TP B scenarios if the purchasing decision (in respect of size and functionality) and the use of appliances (e.g. selecting the right wash programme) are better aligned to actual needs. These aspects were not considered in the model. With regard to lighting, energy consumption drops further still in both the TP A and the TP B scenarios. However, possible rebound effects (more light sources and higher intensity of use) could have a negative influence on total electricity consumptionfor lighting.

## 5.2. Industry

### 5.2.1. Assumptions

The reference scenario is largely based on the with measures scenario in the Projection Report 2017. It was, however, adapted to the changed framework data, especially to the greater economic growth and the lower energy prices.

The target pathways are based on the premise that the 2030 targets contained in the Federal Government's Climate Action Plan are met. For the industry sector, GHG emission reductions of at least 49 % are aimed for compared with 1990. The targeted emissions corridor amounts to 140-143 million t $CO_2$-e. According to the definition of the sectoral target in the Climate Action Plan, the industry sector comprises emissions from energy consumption for process heat generation and electricity generation in industrial power plants, process-related emissions and F-gases. Industrial power plants, including CHP plants, are calculated in the section on the energy sector. A summarised GHG balance for the industry sector is provided in Section 4.

The target pathways are as follows:

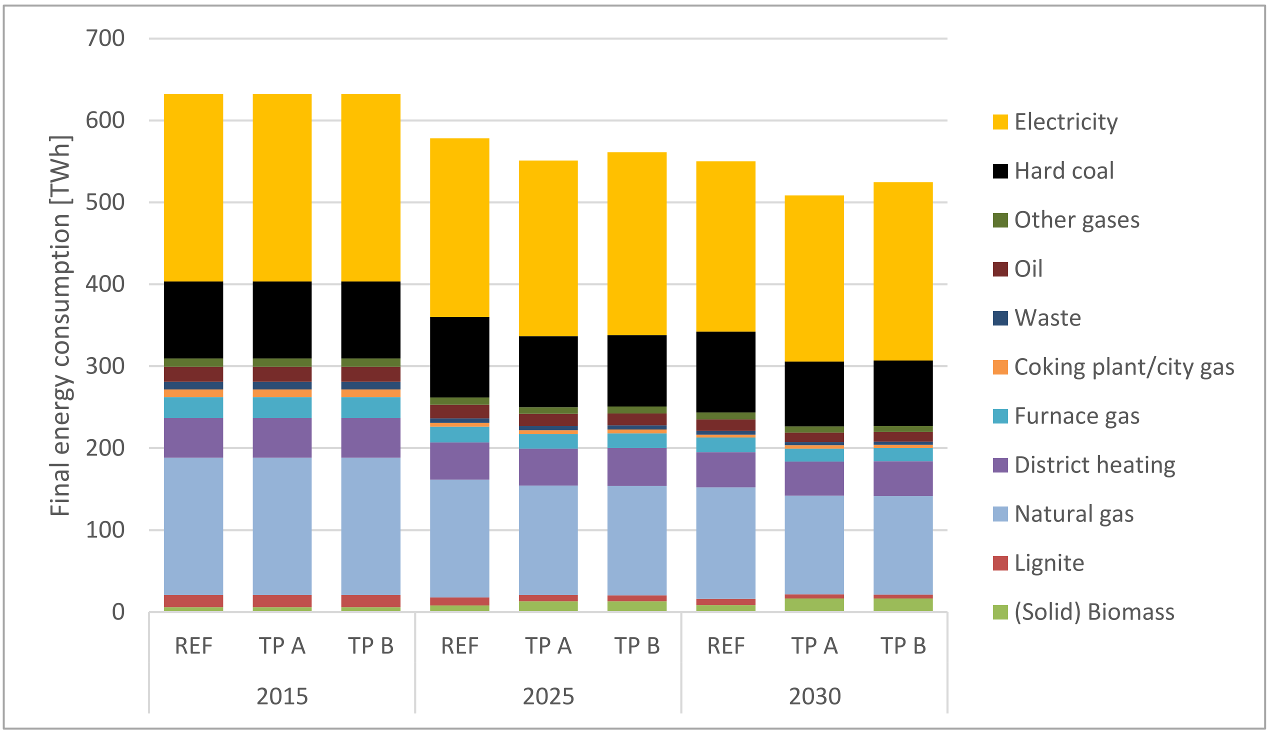
- Target Pathway A focuses on greater diffusion of efficiency technologies and a fuel switch towards biomass and power-to-heat (PtH). Recycling and material efficiency play a larger role.
- Target Pathway B is to be seen as a variation of Target Pathway A. It involves less ambitious progress in energy efficiency compared with the reference, which is compensated by a stronger switch to RES electricity. Biomass, material efficiency and recycling remain unchanged.

### 5.2.2. Final energy consumption and direct greenhouse gas emissions

<u>Final energy consumption</u>

With the agreed framework assumptions on industry development and energy prices, and the assumptions for the target pathways as outlined above, the scenario analysis shows the following final energy consumption for the industry sector (see Figure 5-3).

**Figure 5-3: Final energy consumption in industry by fuel (excl. CHP heat generation)**




Source: own calculation

Between 2015 and 2030, the resulting final energy consumption in industry is reduced both in the reference scenario (-13 %) and in Target Pathways A (-20 %) and B (-17 %). This trend results from a combination of more or less constant production volumes in energy-intensive raw materials and ambitious improvements in energy efficiency.

Electricity consumption is reduced in all scenarios, from 229 TWh in 2015 to 208 TWh in the reference, to 203 TWh in Target Pathway A and to 218 TWh in Target Pathway B. The share of power-to-heat (PtH) in Target Pathway B is highest, at 17 TWh. The increased electricity consumption in TP B compared with TP A is due both to greater use of PtH and less ambitious improvements in energy efficiency. Use of PtH is largely limited to the use of heat pumps where temperature levels allow. Despite the provision of subsidies, use of electric boilers to generate heat is not yet profitable, even in TP B, when compared with biomass and natural gas.

Greenhouse gas emissions

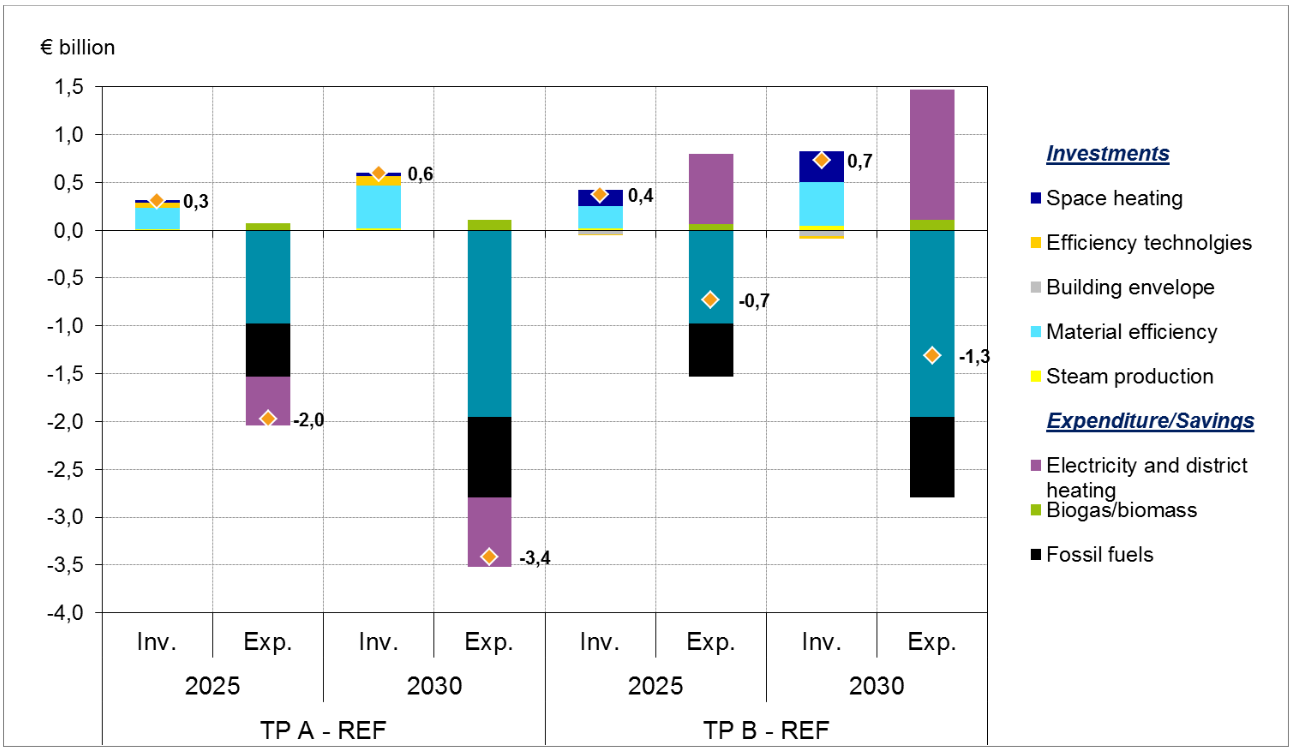
For the industry sector, the targeted reductions of greenhouse gas emissions compared with 1990 amount to 140-143 million t $CO_2$-e or between 49 and 51 %. It must be remembered that emissions from electricity and heat generation in industrial power plants are accounted for in this sector. The target pathways lead to emissions of 140 million t $CO_2$-e in 2030 in Target Pathway A and to 141 million t $CO_2$-e in Target Pathway B. Both pathways thus lie at the more ambitious end of the sectoral target.

### 5.2.3. Economic aspects

In the main, the developments described in the reference and in the target pathways require investment in the generation of space heating, building envelopes and material efficiency. Investment in efficiency in cross-sectoral technologies and process technologies is comparatively low. Investment in material efficiency was implemented exogenously by means of reduced production volumes of selected energy-intensive raw materials. Operating costs largely result from the use ofenergy sources. Added to these come changes in operating costs resulting from the assumed improvement in material efficiency, which in turn lead to lower material costs in the consuming sectors.

A direct comparison of investment and operating costs is only partially helpful, because investments made before 2030 will impact operating costs long after 2030 on account of their longer lifecycles. The comparison can be made with the annuitised investments.[4] Figure 5-4 shows that, correspondingly, the annual net costs as the sum of annuitised investments and energy costs in both target pathways are lower than in the reference. The investments made are thus overcompensated by the savings in energy costs. For 2030, this means cost savings of € 3.4 (TP A) and € 1.2 (TP B) billion. The net savings in TP B are somewhat lower than in TP A due to the higher electricity consumption. Stronger use of PtH and the less ambitious energy efficiency improvements compared with the reference development are seen as key causes of this trend in TP B.

**Figure 5-4: Annuitised differential investment and additional expenditure/savings in industry**




Source: own calculation

### 5.2.4. Key messages

In sum, it is evident that, with the given assumptions on economic growth, the 2030 target for the industry sector in the Climate Action Plan can be reached with a combination of ambitious gains in energy efficiency,

[4] The investment costs are annuitised over the lifecycle of the investments with a suitable discount rate of 2 % (see Section 6.1).

a fuel switch (biomass partly replacing natural gas, coal and oil) and increasing recycling and material efficiency shares.

Implementation of efficiency measures with fast efficiency gains is already very ambitious in the reference scenario and leads to considerable emission reductions. This calls for increased levels of investment in efficiency. Target Pathway A shows that, in economic terms, even more ambitious implementation than in the reference scenario pays off. Efficiency gains not achieved, as in Target Pathway B, go hand in hand with increased needs for electricity and district heating. This puts pressure on other sectors which must then cover the increased demand. However, both target pathways show that comparatively low investment in efficiency is more than offset by savings in cost.

With regard to the 2050 reduction path, it must be remembered that from 2030 to 2050, new mitigation levers will be needed which will not yet be reflected in major investments made in the period of 2015 and 2030 covered by this study. However, the long-term abatement options must still be activated in the period of 2020 to 2030 as well. In addition to the policy and legal frameworks this includes, first and foremost, the necessary technological advancements, including investments in demonstration facilities and infrastructure. The conditions needed differ relative to the mitigation lever involved. Examples include the use of renewables-generated electricity (PtH) and methane/hydrogen (PtG) for heat generation, a closed-cycle economy, material efficiency and substitution along the value creation chain, especially carbon capture and use and perhaps also storage (CCU/CCS), along with innovative low-carbon production processes and products.

## 5.3. Transport

### 5.3.1. Assumptions

The assumed reference development in the transport sector is largely based on the with measures scenario contained in the Projection Report 2017 and thus also on the Mobility Mix Forecast 2030 (Verkehrsverpflechtungsprognose 2030), but was adapted for the changed framework data – especially in respect of the less pronounced fuel price development, the higher population figures and greater economic growth, and other measures agreed.

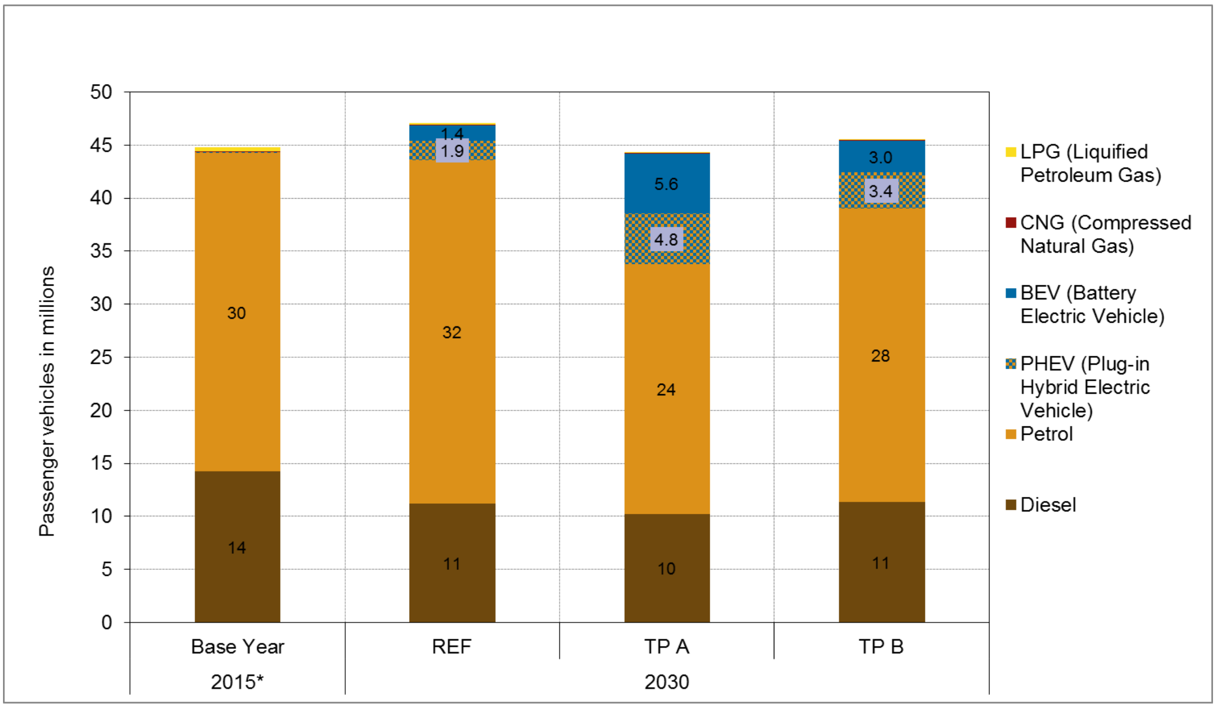
The target pathways were designed on the premise that the 2030 targets contained in the Federal Government's Climate Action Plan will be met. For the transport sector, greenhouse gas reductions of at least 40 % are targeted compared with 1990.

- Target Pathway A focuses on improved efficiency and electrification in passenger cars (-75 % $CO_2$ for new models compared with 2021), improved efficiency for conventional heavy vehicles (22 % compared with 2015) and the introduction of trucks powered by overhead lines (10 % of mileage in 2030) with an additional modal shift to public transport, rail transport and inland shipping as well as optimisation and shift in demand.
- Target Pathway B describes a less efficiency-focused pathway than Target Pathway A (improved efficiency and electrification in passenger cars of 63 % $CO_2$ reduction compared with 2021; 25 % in conventional heavy trucks compared with 2015). Here, additional reductions are achieved by means of a very high share of decarbonised fuels (6 %) in combination with a greater modal shift and changes in chosen transport mode (modal split), as well as optimisation and shift in demand.

### 5.3.2. Vehicle fleet and transport demand

The targets set lead to changes in the vehicle fleet and transport demand. With the efficiency targets, significantly more battery-powered electric vehicles (46 % in Target Pathway A and 30 % in Target Pathway B) are registered in 2030 compared with the reference (9 %). The share of plug-in hybrid passenger cars also increases, while the share of new diesel and especially petrol-driven vehicles drops significantly. The passenger vehicle fleet in Target Pathway A decreases by 6 % compared with the reference development in 2030, to some 44 million and is thus 1 % below the baseline from 2015. In Target Pathway B, the passenger car fleet of 45.5 million in 2030 is 3 % lower than the reference, but are still slightly higher than in 2015. The fleet differs depending on the form of propulsion and scenario (shown in Figure 5-5). The greater reduction in the passenger car fleet in Target Pathway A is explained by the slightly higher costs for new passenger cars (electric and plug-in hybrid vehicles and efficient conventional passenger cars).

**Figure 5-5: Passenger car fleet in 2030 by propulsion type and scenario**




Source: own calculation

Demand for passenger transport across all modes decreases in the target pathways compared with the reference (in 2030 by 6 % in TP A and by 8 % in TP B). This does not necessarily mean that mobility is restricted or that the number of journeys declines. With improved local services, advancing urbanisation and greater use of other transport modes, closer destinations are chosen. There is also a shift towards cycling and pedestrian traffic. Only marginally fewer journeys are made. In the transport sector, the growing importance of a sharing economy has climate action potential. This trend is accompanied by a modal shift towards public transport, which is greater in Target Pathway B than in Target Pathway A.

With freight transport, demand decreases in both target pathways by approx. 7 % compared with the reference. The modal shift effect from road freight to primarily rail (30 %/33 % in TP A/B) and also to inland shipping (17 %/18 %) is similar in both pathways, but is only slightly higher in Target Pathway B compared with Target Pathway A. The decrease in overall freight transport mileage results largely from a reduction in journey lengths due to improved route optimisation enabled by advancing digitalisation and greater demand for regional products.

Concrete reactions depend, of course, on the instruments chosen (e.g. the extent to which cycling is promoted and external costs are reflected in pricing). As per the specifications of the study, no assumptions were made in this regard.

#### 5.3.3. Final energy consumption and direct greenhouse gas emissions

Fuel demand develops similarly in both target scenarios in terms of total demand. Compared with the reference, a reduction in end energy demand of around 25 % is seen in 2030. In TP A, demand is 35 % lower than the reference for petrol and 28 % lower for diesel. The huge savings made are slightly offset by the fact that electricity demand for electric vehicles more than doubles. In TP B final energy demand reduces by some 30 % for petrol and by 25 % for diesel. These reductions are also partly offset by a significantly higher demand for electricity for electric-drive vehicles. Domestic electricity demand is significantly lower than in the efficiency-focused TP A. For a share of around 6 % of electricity-based fuels in TP B and reduced energy demand compared with the reference, additional electricity in the region of 70 TWh would be needed. It must be noted that both target pathways assume that all renewable electricity-based fuels are imported. The electricity demand needed has not been calculated as a result. In line with the configuration of the respective target pathways, the share of electricity-based fuels in Target Pathway B is significantly higher than in Target Pathway A. It remains unclear as to whether these shares can be produced sustainably in sufficient quantities (abroad) in the period up to 2030.

For the transport sector, a reduction of between 40 and 42 % of greenhouse gas emissions compared with 1990 is targeted. Here, it must also be noted that emissions in the Climate Action Plan are calculated based on the source principle. Emissions which arise from the use of electricity to power electric vehicles are thus accounted for in the energy industry sector. In accordance with the assumptions, all electricity-based fuels are imported and are thus not accounted for when calculating emissions.

The target pathways lead to emissions of 98 million t $CO_2$-e in 2030, meaning that both lie at the lower end of the sectoral target (a 40 % reduction compared with 1990).

#### 5.3.4. Socio-economic aspects

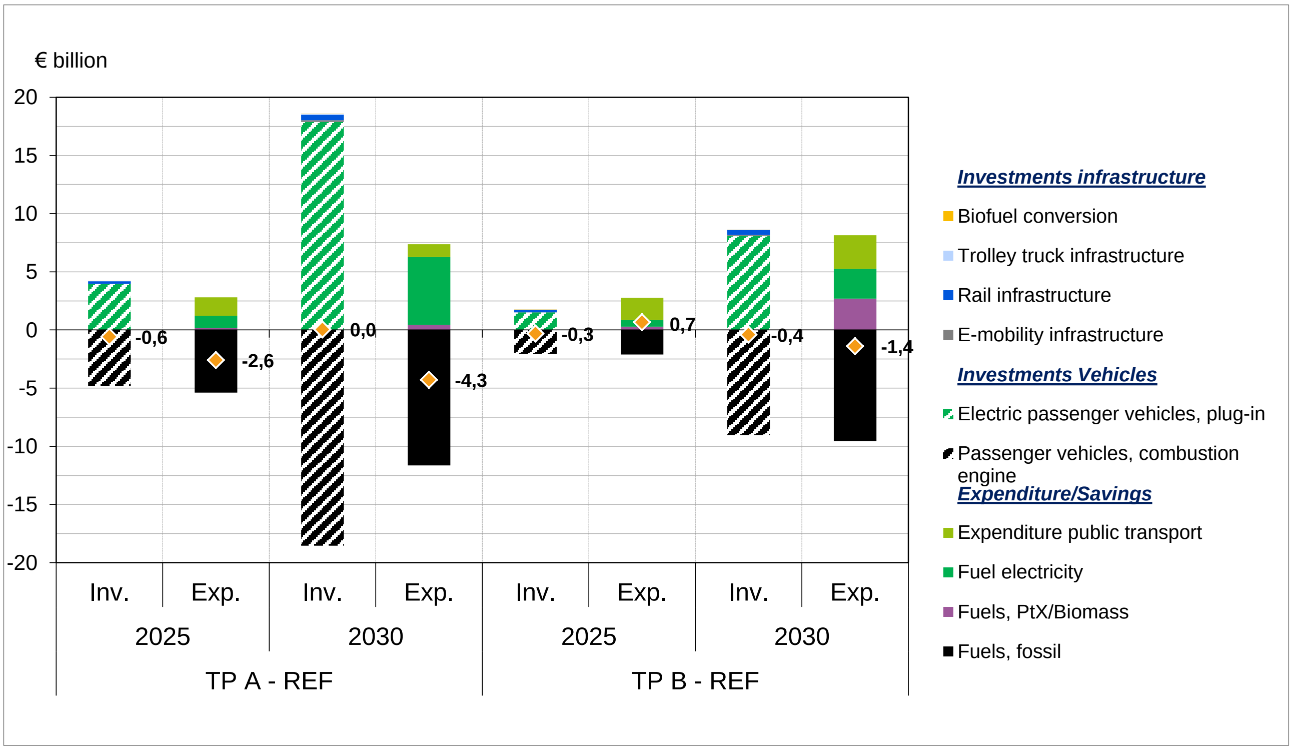
The developments described in the reference and in the target pathways require investment in infrastructure and vehicles, and effect changes in expenditure for fuels and public transport. The production cost of vehicles depends in particular on the trends in battery costs and the costs of efficient technologies. For battery system costs, the study uses the assumptions from the Federal Government Projection Report 2017 (battery system costs of € 100/kWh in 2030). A sensitivity calculation is also performed with lower costs (€ 61/kWh) (Bloomberg New Energy Finance 2017). The production costs for vehicles were derived from the TEMPS model for vehicles with internal combustion engines based on ICCT efficiency assumptions and cost curves, and for electric drives on the basis of the assumptions for battery system costs.

With regard to infrastructure, investments are needed in charging infrastructure for e-mobility, rail infrastructure, overhead-line infrastructure for trolley trucks and for conversion plants for PtX fuels. In accordance with the assumptions, electricity-based fuels are not produced domestically until 2030. This could make investment in infrastructure necessary in Germany. Compared with the reference, savings are achieved in the target pathways for fossil fuels, which are less in demand, while expenditure increases for electricity, public transport and PtX fuels.

For direct cost-benefit comparison, investments are weighed against savings and additional expenditure. Only the additional investments as well as the resulting cost savings or additional expenditure compared to the reference development are taken into account. Key aspects include vehicle production costs, which in turn depend on the trend in battery costs and the costs of efficiency technologies, and also infrastructure costs, especially for charging infrastructure, rail infrastructure, overhead line infrastructure and conversion infrastructure for biofuels. On the expenditure side, there are significant savings for fossil fuels, but additional spending on electricity, as well as for biofuels and PtX fuels and public transport in the course of a modal shift.

For comparability of the differential investment costs incurred at the time at which an investment is made and the lifetime savings, the investments shown in Figure 5-6 take the form of annuities (i.e. as constant cash flows over the lifetime to repay the investment)[5] and the annual savings or expenditure in two respective projection years compared with the reference. The cost analysis is carried out from an economic perspective.

**Figure 5-6: Annuitised differential investment and additional expenditure/savings in transport**




Source: own calculation

Both target pathways result in significant shifts in investment and expenditure. On the investment side, additional investments in electric and plug-in hybrid vehicles offset investments in vehicles with internal combustion engines in both target pathways, so that the net investment effect is close to zero. This effect is most pronounced in the efficiency and e-mobility-oriented Target Pathway A, especially in 2030. This zero-sum game is characterised by two effects. On the one hand, the prices for passenger cars in the target pathways increase due to efficiency-enhancing and electric technologies, while on the other, the number of new car registrations in the target pathways decreases, so that the overall vehicle-related investments

[5] The investment costs are annuitised over the lifetime of the investments at a suitable discount rate of 2 % (see section 6.1).

needed are lower than in the reference. As the battery price trends used in the scenarios are considered to be conservative, in the sensitivity variant (along the currently lower battery price projections) the additional investment in battery-powered vehicles would not increase to the same extent and the net effect would indicate decreasing investments compared with the reference.

On the expenditure side, fossil fuel costs decline, whereby the drop is far greater in Target Pathway A due to the greater increase in efficiency and higher share of e-mobility than in Target Pathway B, because additional spending on electricity-based fuels and higher public transport expenditure due to modal shift come into play. In the two target pathways described, the investments are offset by the savings and the effect is much more pronounced in Target Pathway A. Thus, from a macroeconomic perspective, Target Pathway A is the preferred target pathway. However, this only applies on the premise that the changes in vehicle costs and also the resulting reduction in passenger transport demand will lead to a decline in the vehicle fleet.

From the perspective of private households, average savings compared with the reference can also be expected in the target pathways. This is especially due to the reduced distance travelled. Even if the price of fuel in the target pathways increases against the reference, no financial burden is expected on average. How the target pathways affect private households depends on the instruments used to achieve the target. Even if no additional costs are expected on average, there may be groups that are exposed to additional costs because reducing their mileage would prove difficult. On the other hand, increased efficiency of new passenger cars could also lead, via the used car market, to fuel savings for second and third-line users (mostly low-income households). An analysis of these effects is necessary, but can only be performed when potential instruments for target achievement have been more clearly defined.

#### 5.3.5. Key messages

To achieve the climate action target in transport, a modal shift, optimisation and a change in demand as well as a significant increase in efficiency and electrification are needed, with e-mobility and passenger car efficiency showing the highest emission reduction potentials.

Increases in the efficiency of newly registered trucks – due to the relatively short lifetimes of these vehicles as opposed to passenger cars – have a comparatively faster impact on the fleet and thus make an important contribution. Trucks powered by overhead lines (“trolley trucks”) are interesting in strategic terms and, when compared to PtX trucks, are a cost-effective option when it comes to decarbonising long-distance road freight.

However, focusing solely on vehicle efficiency and electric mobility is not enough. Even if the potential for increasing the efficiency of vehicles is exhausted in a very ambitious way, there remains a gap when it comes to achieving the climate action target. This gap must therefore be compensated for by the fact that transport demand also changes, both for passenger transport and for freight.

The contribution made by biofuels depends on the reduction of final energy consumption as it is assumed that the absolute quantities available in the reference development will not be further increased. This means that sectors will compete against each other and only limited quantities will be available to each sector. Electricity-based fuels can make a certain but limited contribution to the achievement of the sectoral targets (see Target Pathway B). They are, however, associated with high conversion losses and relocation of production, and thus with energy supply problems abroad.

Despite the great structural differences, the changes in investment can be balanced across categories when the sectoral target is achieved. The additional expenditure on electricity consumption for e-mobility, biofuels, electricity-generated fuels and additional expenditure for public transport are more than offset in both target pathways by significantly lower costs for fossil fuels. All in all, expenditure falls if the changes in vehicle costs and the on-going reduction in demand for passenger transport result in a decline in the vehicle fleet. From an economic perspective, Target Pathway A is preferable in terms of pure cost savings. Possible social implications depend largely on the design of the instruments used to reach the target.

Possible risks for the automotive industry arising from a structural change should be addressed at an early stage. With a shift in production towards electric propulsion, efforts should be made to maintain added value in Germany in order to create jobs and promote innovation.

With regard to further environmental and health effects, the analysis shows that a sustainable overall approach to transport, one which also takes mitigation and modal shift potentials into account, offers significantly better opportunities by improving urban quality of life, reducing both land use and pollutant emissions, improving health through the promotion of more active, non-motorised mobility, reducing traffic congestion and even more.

## 5.4. Energy industry

### 5.4.1. Assumptions

The reference development is based on the assumption that the climate action measures adopted on 31 July 2016 will be implemented. Renewable energy sources will thus account for 52 % of gross electricity consumption by 2030.

The target pathways were created on the premise of achieving the Federal Government's 2030 climate action targets. For the energy industry, a reduction of at least 61 % of greenhouse gas emissions compared to 1990 is targeted. The aimed-for target emissions corridor is 175-183 million t $CO_2$-e.

- Target Pathway A is expected to increase the use of renewables up to 65 % of gross electricity consumption in 2030. Concerning coal-fired power plants, for the purposes of modelling it was assumed that plants with a lifetime of more than 37 years will be phased out by 2030. In addition, natural gas CHP and renewable heat generation will be built up.
- In its assumptions, Target Pathway B largely corresponds to that of Target Pathway A. However, lower efficiency increases in other sectors lead to increased demand for electricity when compared with TP A. This demand is covered by the additional expansion of renewable energy use. The renewables share in this scenario is 67 %.

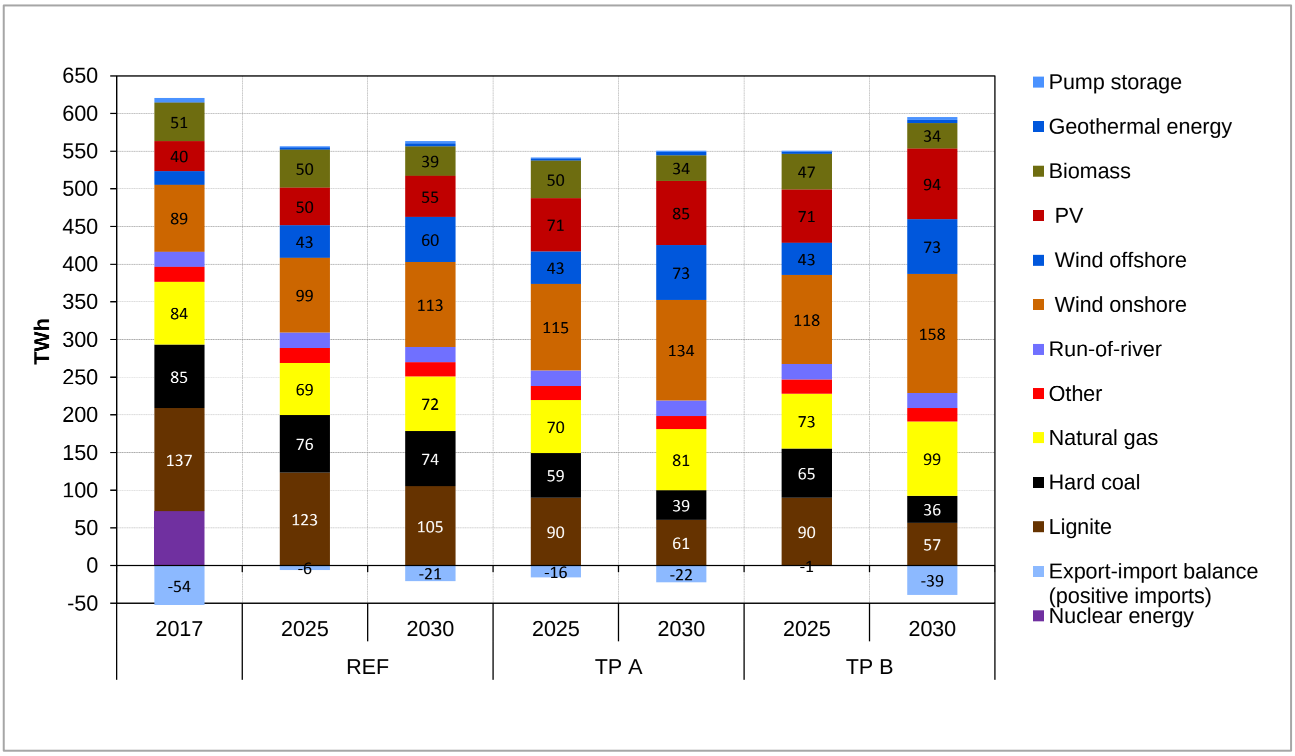
### 5.4.2. Net electricity generation

While generation of electricity from coal in the target pathways is significantly lower than the reference, by definition renewable electricity generation in both scenarios is well above the values in the reference scenario (see Figure 5-7). In TP A, the share of renewable energy in gross electricity consumption in 2030 is 65 %, meaning that the target contained in the Coalition Agreement is met.

In TP B, the greater demand for electricity (especially from the industry and transport sectors) is offset by the additional expansion of renewable energy use. This will result in a 2030 share of renewable energy in gross electricity consumption of 67 %.

Natural gas-fired power generation increases slightly over time in both target pathways. This is due to the replacement of coal-fired CHP plants with natural gas-fired CHP plants. At the same time, the expansion of renewable energy use increases the need for flexible natural gas power generation. This is more pronounced in TP B. Electricity exports tend to decline over time. In TP B, however, exports rise again in 2030 as a result of stronger expansion of renewable energy use.

**Figure 5-7: Net electricity generation in the reference scenario and Target Pathways A and B in 2025 and 2030**




Source: own calculation

### 5.4.3. Economic aspects

In the target pathways, more is invested in the electricity system than in the reference development. The additional expansion of renewable energy use accounts for more than half of additional investments. At the same time, fuel and operating costs decline in the target pathway compared to the reference development. For example, less coal is imported into the target pathway than in the reference.

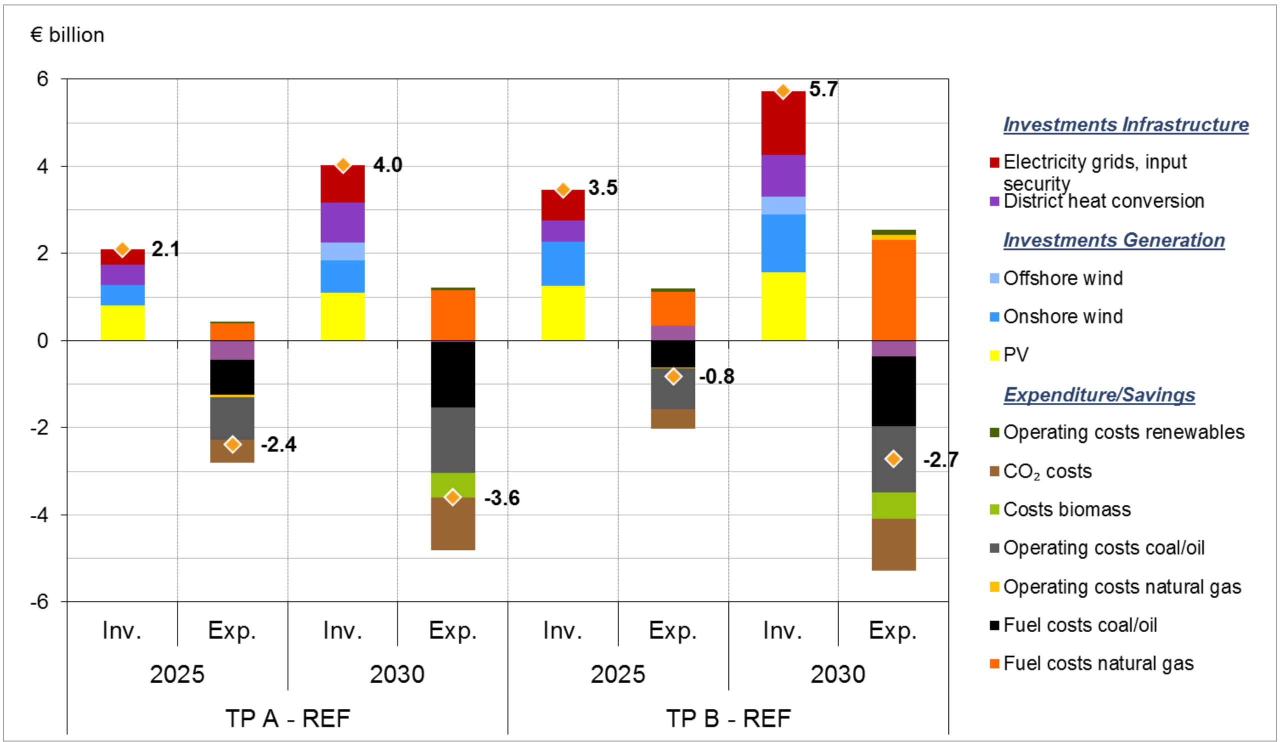
A comparison of the additional annuitised differential investments[6] and the cost savings in the target pathways with the reference scenario is shown in Figure 5-8.

In Target Pathway A, annuitised differential investments of € 4 billion in 2030 are offset by roughly equivalent cost savings of € 3.6 billion in fuel and operating costs.

Above all, due to the additional expansion of renewable energy use in Target Pathway B, the additional annuitised differential investments of € 5.7 billion are higher in 2030 than in TP A. The annuitised additional investments are also twice as high as the simultaneous cost savings in fuel prices and operating costs. Thus, in economic terms, Target Pathway B is less advantageous up to 2030.

6 The investment costs are annuitised over the lifetime of the investments at a suitable discount rate of 2 % (see section 6.1).

**Figure 5-8: Annuitised differential investments and additional expenditure/savings in the energy industry**




Source: own calculation

### 5.4.4. Key messages

Achieving the sectoral target in the energy industry requires a significant reduction in coal-fired power generation. To decarbonise the energy industry, one of the basic prerequisites is accelerated expansion of renewable energy use, especially wind energy and photovoltaics.

To aid renewable energy integration, electricity grid expansion must be promoted further. And to secure supply, additional power security in the form of storage, flexible demand and gas turbines is a must.

The role of CHP plants in the electricity system is changing. Older coal-fired CHP plants are being replaced. At the same time, operation of CHP plants is more flexible against the backdrop of expanded renewable energy use and innovative CHP systems contribute to decarbonisation of grid-connected district heating.

The two target pathways differ mainly in terms of electricity demand. Compared with Target Pathway B, Target Pathway A is based on more ambitious efficiency gains in demand sectors. The associated increase in energy demand in Target Pathway B thus requires a more rapid expansion of renewable energy use than does Target Pathway A. The ratio between necessary investments and simultaneous savings in Target Pathway A is thus far better proportioned.

## 5.5. Agriculture

### 5.5.1. Assumptions

The reference scenario in the agriculture action area is based on the existing projections in the Projection Report 2017 (see Section 4). However, in contrast to the with measures scenario contained in the Projection

Report, ambitious implementation of the prevailing Fertiliser Ordinance (Düngeverordnung) was taken into account in the reference pathway analogous to the with-further-measures scenario contained in the Projection Report. In addition, the trend in fermentation of energy crops was aligned to take account of demand trends in other sectors (lower than the reference level) and energy-related emissions were recalculated for the agricultural sector.

In the target pathway, the 2030 sectoral targets for agriculture contained in the Federal Government's Climate Action Plan must be met. Compared with 1990, a reduction of between 31 and 34 % is targeted for the agricultural sector. This represents an emissions corridor of 58-61 million t $CO_2$-e.

- In Target Pathway A, the sectoral target, including energy-related emissions, is offset by a further reduction in nitrogen surpluses and a 6 % reduction in both dairy and cattle herds compared with 2015, the expansion of organic farming[7] to 20 % of the agricultural area and a reduction of energy inputs (greenhouses and fuel inputs). In addition, a 20 % rewetting or wet management of agricultural moorland in the LULUCF sector leads to a reduction of nitrous oxide emissions from agricultural soils.
- In Target Pathway B, the emission reduction takes place via the same assumptions as in Target Pathway A, but in Target Pathway B additional nitrification inhibitors are used on 25 percent of the conventionally managed area from 2026 onwards. There is also a smaller reduction in livestock (3 % compared to 2015 than in Target Pathway A).

### 5.5.2. Socio-economic aspects

Changes in operating costs between the reference pathway and the target pathways are mainly due to changes in the purchase of fertilisers. There is potential for savings here at the farm level, especially with regard to the use of mineral fertilisers. Over the entire period from 2018 to 2030, substantial savings are made in target pathways A and B compared with the reference scenario. However, the decline in energy crop fermentation residues leads to a slight increase in mineral fertilizer use in 2030 compared with the reference scenario. At farm level, the annual additional costs incurred in agriculture primarily relate to the use of nitrification inhibitors in Target Pathway B. As their use was not taken into account until 2026, differences between 2025 and 2030 occur.

For comparability of investment costs, which only arise once, with savings or additional expenditure, which arise over several years, the investments in Figure 5-9 take the form of annuities, meaning constant cash flows over the lifetime for the payment of the investment, for each of the two projection years 2025 and 2030.[8]

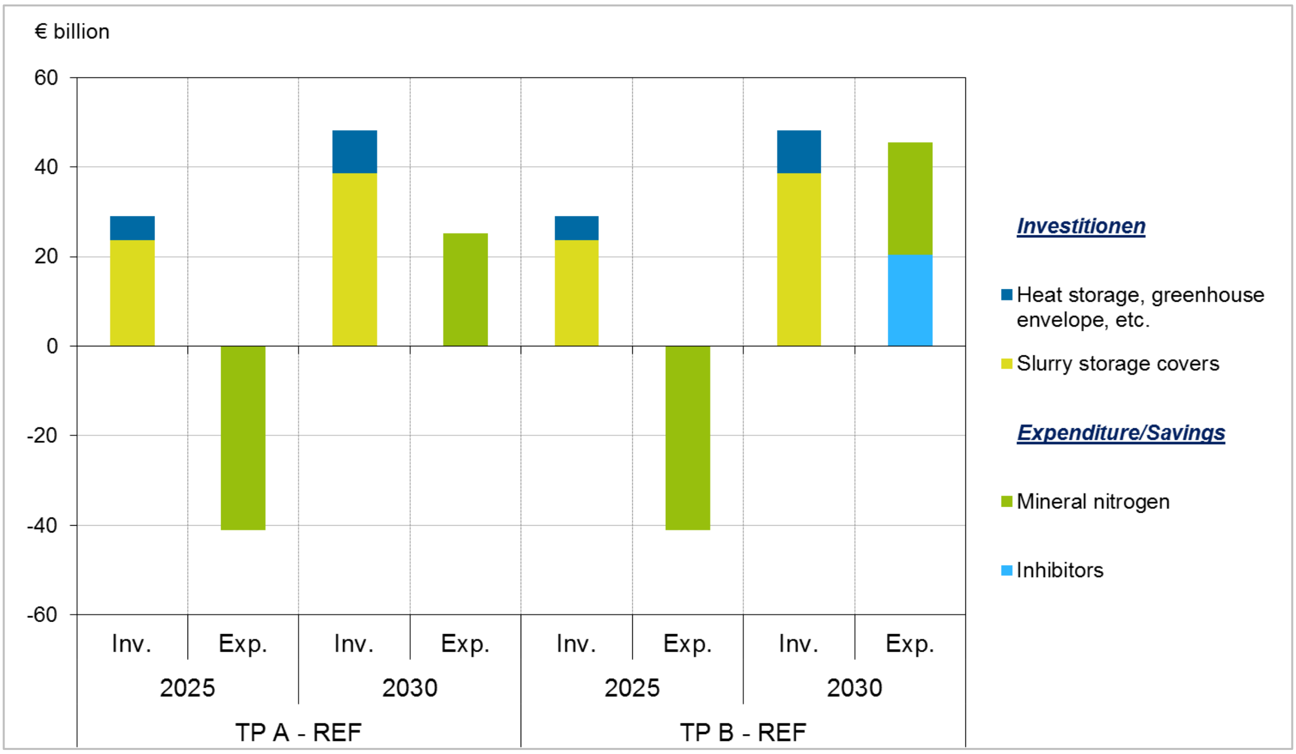
Further investments required for the expansion of liquid manure fermentation, in particular for slurry store covers, are likely to be made only with additional financial support from the state or with appropriate regulatory provision for existing facilities.

In addition to the changes in operating and investment costs compared with the reference development, far higher costs result from the introduction of subsidy programmes, especially with regard to organic farming, and also for a livestock reduction bonus and compensation payments for wetland management, both of which require state subsidisation. In addition to climate mitigation effects, these programmes offer a wide range of additional environmental benefits.

[7] The assumed reduction in greenhouse gas emissions refers to the farmed area, not the production volume.

[8] The investment costs are annuitised over the lifetime of the investments at a suitable discount rate of 2 % (see section 6.1).

**Figure 5-9: Annuitised differential investments and additional expenditure/savings in agriculture**




Source: own calculation

### 5.5.3. Key messages

Under the assumptions made, achieving the climate targets for the agricultural sector by 2030 is difficult with technical measures alone, such as covering slurry stores and reducing the energy consumption in agricultural buildings or of agricultural machinery. Thus, up to 2030, structural changes in management have been taken into account in both target pathways – for example, the expansion of organic farming, a moderate reduction of livestock and wet management of agricultural wetlands, which in the agricultural sector lead to a reduction of nitrous oxide emissions from soils and in the LULUCF to a far-reaching reduction of $CO_2$ emissions.

Further possible reduction potential with regard to technical measures involved the use of nitrification inhibitors in Target Pathway B. Although already approved in practice, their use is highly controversial as great uncertainties abound with regard to their environmental impact, for example on water and water quality. Further uncertainties exist with regard to the mitigation effect and durability (resistance-building capacity) of this measure. In achieving the climate targets for the agricultural sector, use of nitrification inhibitors is currently not suitable for certain measures which are backed by reliable data.

In contrast to other sectors, the cost of measures implemented in agriculture is rarely offset by lower operating costs as an economic incentive. This applies both to technical measures (such as gas-tight storage of fermented manure) and to structural changes in management. Therefore, subsidy programmes or other instruments must overcome barriers to investment and implementation.

In addition to reducing greenhouse gases, the changes that are needed to achieve the 2030 climate action targets in agriculture have many other additional benefits and synergies in relation to the environmental objectives of other EU requirements (Nitrate Directive, Water Framework Directive, NEC Directive). These include lower ammonia emissions, lower nitrogen inputs, fewer pesticide inputs, positive impacts on biodiversity, etc., and help to make agricultural production more sustainable. Until such time as these co-benefits can be reflected in product pricing, successful climate action in agriculture will only be possible through funding programmes and other financial transfers.

## 5.6. Other (waste management)

### 5.6.1. Assumptions

This field of action only takes into account non-energy-related waste sector emissions originating from landfills, organic or mechanical waste treatment and wastewater.

The reference scenario in the waste action area is largely based on the framework data and the assumptions of the with measures scenario in the Projection Report 2017. Compared with the Projection Report, a slight shift of biogenic waste from composting plants to biogas plants was already assumed in the reference pathway. Improvements to biogas plants in the treatment process and in product storage were also assumed.

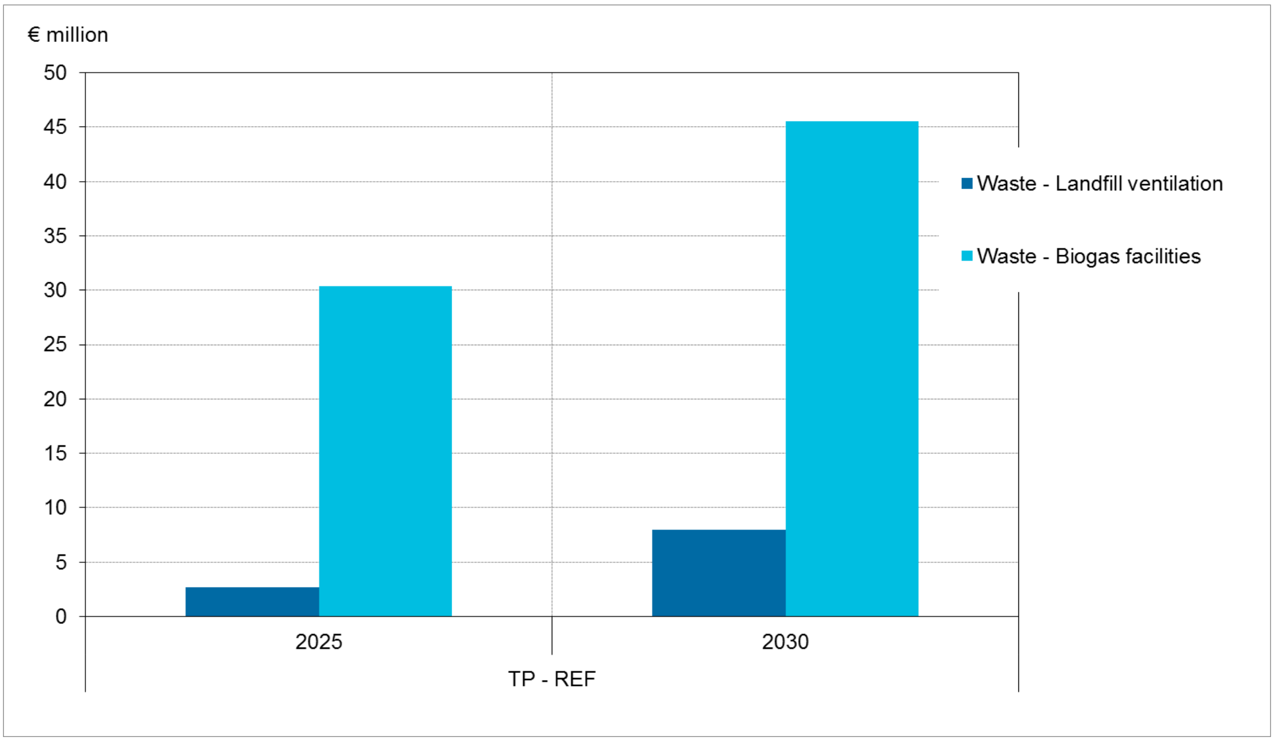
In the waste sector, only one target pathway was taken into account. This mainly assumes an expansion of landfill ventilation, but also takes the increased use of residues laid down in the Climate Action Plan into account.

### 5.6.2. Economic aspects

To achieve the climate action target, investments are also needed in the waste sector. These relate primarily to technical measures for landfill ventilation as well as the construction of new biogas plants for the fermentation of waste. Investments are shown in Figure 5-10 in the form of annuities, meaning constant lifetime cash flows to repay the investment, for each of the two support years 2025 and 2030.[9]

9 The investment costs are annuitised over the lifetime of the investments at a suitable discount rate of 2% (see section 6.1).

**Figure 5-10: Annuitised differential investments in the waste sector**




Source: own calculation

### 5.6.3. Key messages

Since 1990, non-energy-related emissions from the waste sector have reduced by 70 %. Thus, in comparison with other sectors, significant emission reductions have already been achieved in this sector over the past 10 to 20 years by means of consistent environmental protection policy.

Greater technical reduction potential in the waste sector largely involves the expansion of landfill ventilation. While the target pathway took account of intensified landfill ventilation, further reduction potential exists.

The increased use of bioenergy from waste does not directly lead to emission reductions in the waste sector, but it does replace the use of other energy sources, thereby ensuring a more sustainable energy supply.

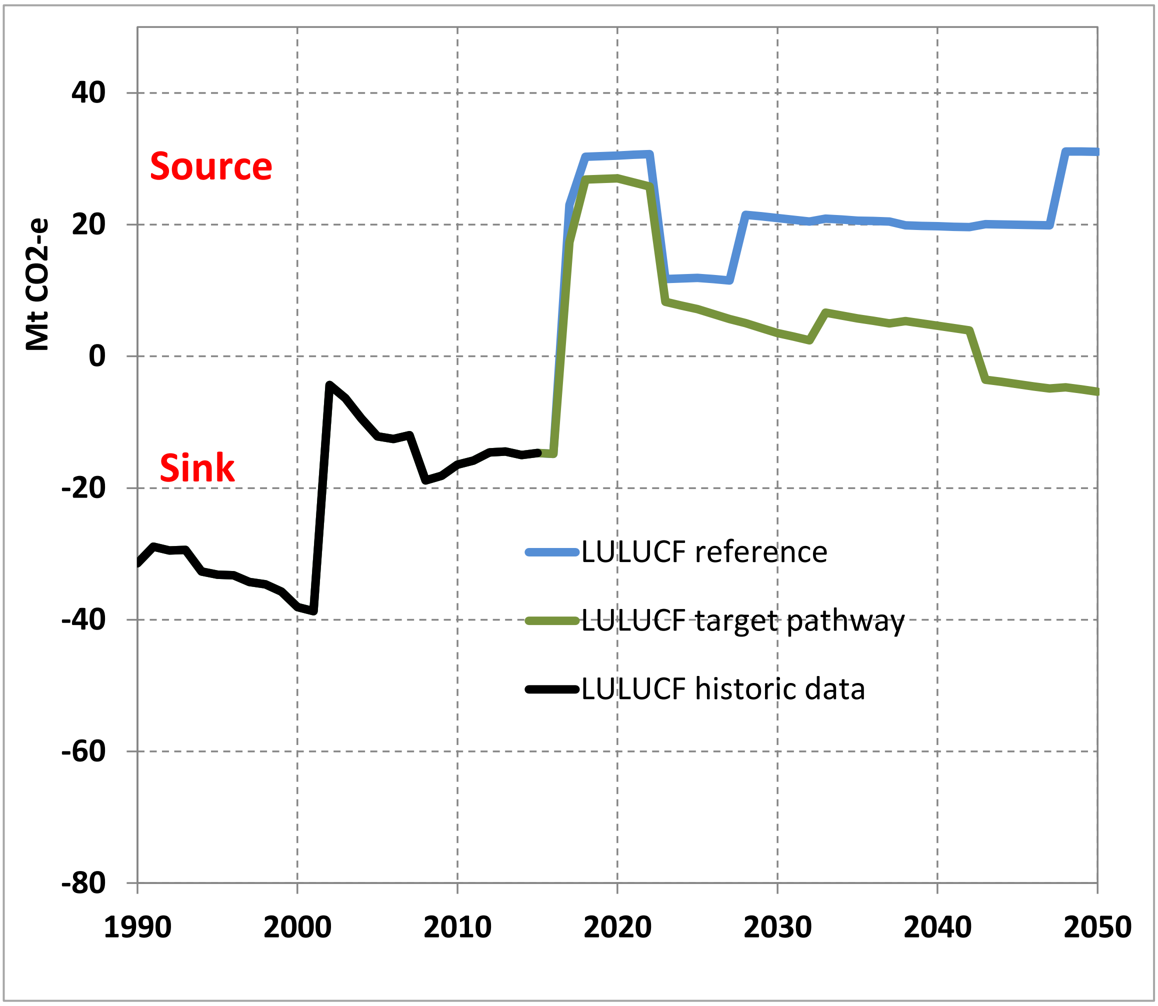
Irrespective of sector classification and how emission reductions are accounted for, the greatest savings potential in the waste sector can be achieved by avoiding waste. In the longer term, further potential exists to reduce emissions in the closed-cycle economy as a whole.

## 5.7. Land use, land-use change and forestry (LULUCF)

### 5.7.1. Assumptions

The LULUCF sector (land use, land-use change and forestry) had net carbon deposits of approximately 15 million t $CO_2$ across all land uses in 2015. In the categories of arable land use, grassland use, settlements and wetlands, net emissions amounted to 45 million t $CO_2$. Most of these emissions came from agricultural organic soils and from grassland to farmland conversion. At the same time, a good 60 million tonnes of $CO_2$ were sequestered each year in existing and new forests and in wood products. The reference development in the LULUCF sector corresponds to the with measures scenario (WMS) of the Federal Government's Projection Report 2017 (Federal Government 2017). This already contains an obligation to conserve grassland (through protection/conservation or re-seeding after ploughing) and a restriction on land reclamation by settlements, which should be limited to a maximum of 30 ha per day up to 2030. According to the assumptions in the reference scenario, the sector will develop into a net source after 2020, among other things by reduction of the forest sink (Figure 5-11).

**Figure 5-11: Reference and target pathway trends LULUCF**




Source: own calculation, Thünen-Institut 2017 WEHAM Nature Conservation Preference Scenario

The Climate Action Plan contains the requirement that the sector's net sink should be preserved and secured with further measures. The assumptions in the target pathway are thus chosen so that the projected net source in the LULUCF sector would switch back to a sink in the period 2040 to 2045 (Figure 5-11). Until then, average annual emissions would amount to about 10 million tonnes of $CO_2$. The target pathway for the sector differs from the reference by a rewetting or wet management of wetlands, near-natural forest management and halting of peat extraction. To ensure conservation of existing peatland soils and to reduce emissions from these soils, agricultural peatlands are rewetted. This occurs on 20 % of grassland and 20 % of arable land with such soils. On 75 % of these areas, paludiculture crops are grown which can be used as biomass for energy generation. In forest management, implementation of nature conservation measures in forests is assumed based on the assumptions contained in the WEHAM nature conservation preference scenario.[10] In comparison to the basic WEHAM scenario, on which the reference is based, this describes the development of near-natural tree stands and higher proportions of deciduous wood. Use of areas with existing usage restrictions will be further reduced and old forests will not be used. As a further assumption, a 100 % reduction in peat extraction will be implemented by 2030.

#### 5.7.2. Economic aspects

The costs of rewetting, and thus of reducing $CO_2$ emissions from organic soils, are taken into account in the LULUCF sector. These include funding costs for project preparation (planning, hydrological reports, feasibility studies) as well as hydraulic engineering and operating costs for pumping stations, weirs, pumps and other facilities. Additional costs in the form of incentive programmes are also incurred as compensation for sustainable peatland management in the agricultural sector.

The reduction of peat extraction results from the fact that no further extraction permits are granted. It is estimated that from 2021, a linear decrease in peat extraction will lead to zero extraction in 2030. As the switch to substitute substrates can also lead to a decline in yields, it is assumed that the decrease takes place first in private gardening, since there are clearly fewer negative economic effects in this area compared to commercial cultivation of crops. With regard to additional costs, it is currently to be expected that costs will double in replacing peat. It is further assumed that a peat replacement strategy will be developed at the federal level and that from 2020 to 2022, this will be flanked by research and development programmes which will enable low-cost, high-quality production of peat substitutes and thereby reduce additional costs.

The costs of forest conversion and nature conservation measures, as implemented in the nature conservation preference scenario (NPS), can be determined by comparing key economic values from the baseline scenario (reference development) and the NPS. For this purpose, calculations produced by the Thünen Institute as part of the WEHAM scenarios project were used. These determined the silviculture profit contribution, i.e. the non-harvest-related proceeds (income from the sale of timber minus the costs of cultivation and refining). The resulting deviations between the reference pathway and the target pathway are interpreted as costs if a change leads to a reduction in contribution margins. Through promotional programmes, this loss of income incurred by forest owners would have to be neutralised through subsidies and compensatory payments.

**Table 4-1: Summary of annual additional costs in the LULUCF sector resulting from the target path**

| Cost type | Assumption | 2025 | 2030 |
|---|---|---|---|
| LULUCF Operator | Expenses for peat substitution material | 56 million €/a | 56 million €/a |
| LULUCF Program-me | Water engineering/technologies for rewetting of organic soils | 153 million €/a | 153 million €/a |
| | Forest transformation and more extensive timber extraction | 100 million €/a | 100 million €/a |

Source: own calculation

[10] Sustainability assessment of alternative forest treatment and timber use scenarios with special consideration given to climate and biodiversity conservation (WEHAM scenarios), www.weham-szenarien.de

#### 5.7.3. Key messages

The LULUCF assumptions in the target pathway to conserve peatland soils, change forest management and, to a lesser extent, reduce peat extraction could reduce greenhouse gas emissions in Germany by some 17 million t $CO_2$-e in 2030. The anticipated costs amount to around € 300 million/year.

These assumptions are also expected to have positive effects on nature conservation in Germany, as the land-use changes can be expected to result in a positive change in habitat structures (more hardwood, more mature trees, more deadwood and new rewetted wetland sites).

Despite more extensive hardwood extraction, a slight increase in timber extraction can be expected in the target pathway up to 2030 due to increased felling of conifers in the course of forest conversion compared with the reference development.

## 6. Macroeconomic effects

Economic consequences arise when a policy requirement changes the level or structure of expenditure on the part of the state, citizens and companies (see "Guide to the cost-benefit analysis of environmentally relevant effects in the regulatory impact assessment"[11]). A distinction must be made between:

i. Direct economic impacts by economic segment or action area, which are created by the policy decisions in individual sectors.

ii. Direct and indirect macroeconomic effects brought about by upstream or downstream economic segments and the interplay between the different segments, as well as induced effects resulting from changes in overall demand.

iii. The social or distributional effects that arise for households and citizens due to changes in the structure of income and expenditure.

iv. The external costs that can be saved by means of, or which additionally result from, environmental effects.

Sectoral economic effects as well as social effects and distributional aspects have already been described in the respective sector-specific sections. This section outlines the macroeconomic effects (GDP, gross value added, jobs), while the other economic effects (external costs, import dependency, supply security and competition effects) are addressed in Section 6.

### 6.1. Investment needs and savings made

To achieve the sectoral targets, investments in climate action and efficiency technologies are vital. Many of these investments involve extensive modernisation, infrastructure development and digitalisation, which can highlight new opportunities in the German economic system, drive technological development and expertise, and initiate a transformation towards a climate-friendly economic system. The additional investment that would be required on the part of industry or the consumer would be offset by a variety of savings, such as energy costs, operating and maintenance costs, and insurance costs, which in many cases could more than make up for the additional investment.

[11] UBA-Texte 01/2015 (https://www.umweltbundesamt.de/publikationen/leitfaden-zur-nutzen-kosten-abschaetzung).

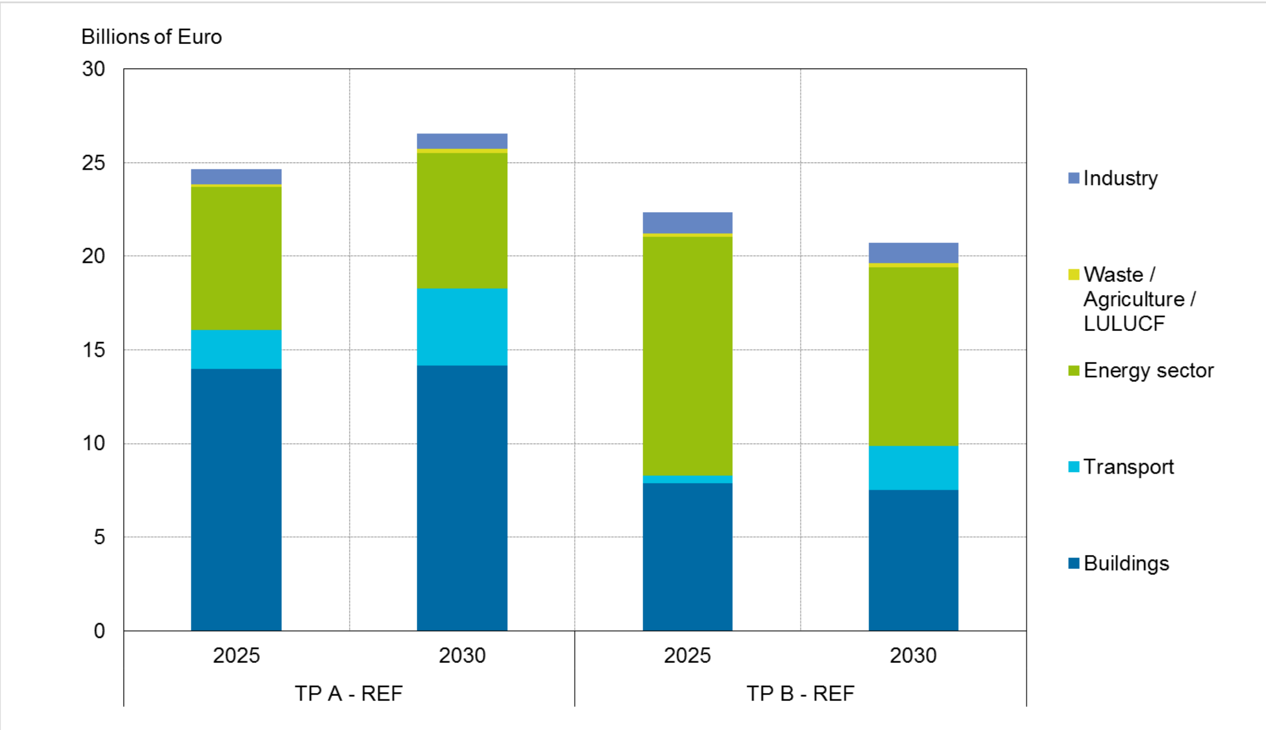
On the investment side, reaching the sectoral targets by 2030 calls for additional investment of approximately € 270 billion in Target Pathway A and approximately € 240 billion in Target Pathway B (cumulative differential investment compared to the reference period from 2018 to 2030). Figure 6-1 shows the investments for each projection year (2025 and 2030). In Target Pathway A, investment amounts to € 23 billion in 2025 and to just over € 26 billion in 2030; in Target Pathway B to approx. € 22 billion in 2025 and approx. € 21 billion in 2030.

**Target Pathway A**, with its focus on energy efficiency, requires additional investment, especially in building renovation (cumulated approx. € 160 billion in the period up to 2030). Achieving the renewable energy targets in the energy sector means a total of approx. € 80 billion in differential investment (cumulated from 2018 to 2030) in Target Pathway A. Figure 6-1 again shows the investments for each projection year (2025 and 2030). In Target Pathway A, this amounts to approx. € 14 billion for the building sector and to € 7.5 and € 7.8 billion for the energy industry in the respective projection years.

**In Target Pathway B**, with its focus on electricity-based technologies in most action areas, the energy industry invests in additional renewable energy generation technologies to meet the electricity demand in the other action areas. This results in a cumulative investment requirement of approximately € 110 billion by 2030 or, taking the projection years 2025 and 2030 into account, an investment requirement of € 12.5 and almost € 10 billion respectively.

In the building sector, a stronger focus on electricity-based heat generation systems means that fewer refurbishment-related investments are made, so that the cumulative investment in Target Pathway B (compared with the reference) is approximately € 100 billion (approximately € 7.8 billion and € 7.5 billion respectively in the projection years).

### Figure 6-1: Investments – differential investments by sector

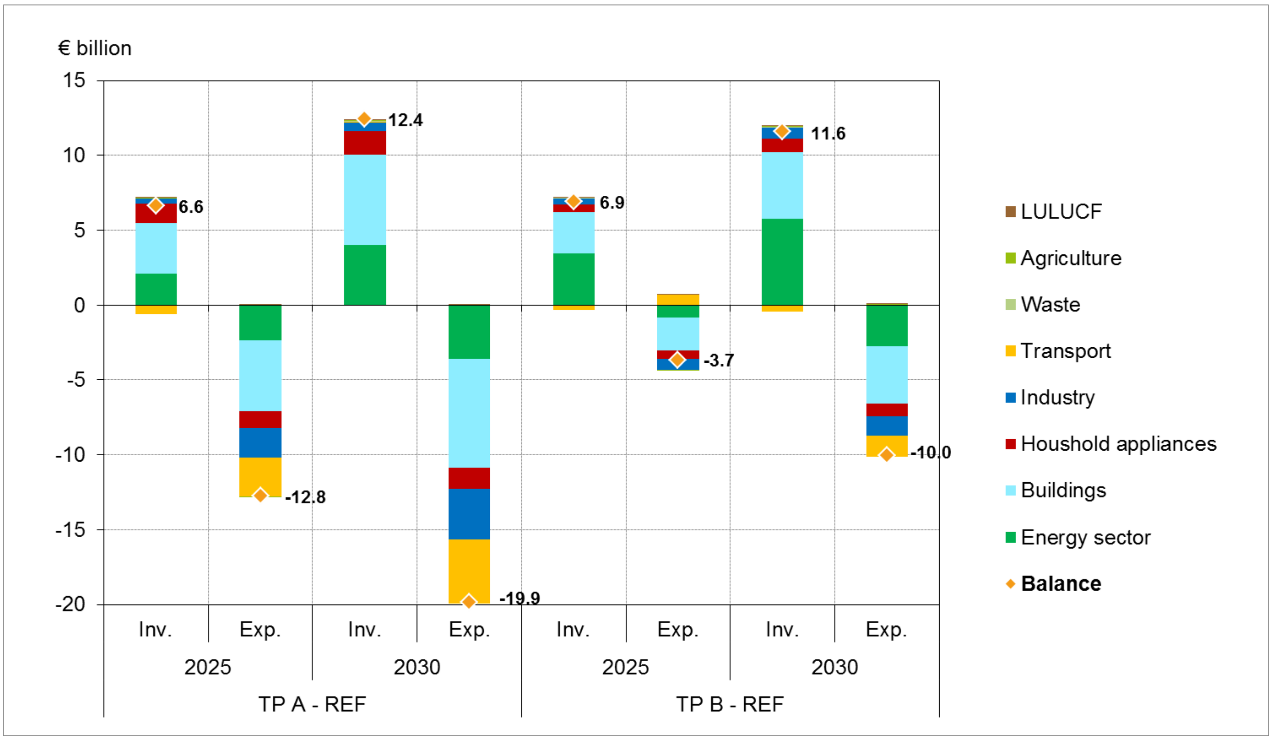



Source: own calculation

However, an examination of solely the investment needs does not create a differentiated picture of the sectoral target-related burden on the German economy or on consumers. Of greater interest is the extent to which the additional capital expenditures are offset by the resulting savings in energy costs, operating, maintenance, repair, insurance and other costs, and thus pay for themselves or return a profit over a suitable period of time.

To take account of the timing issues, given that investments are made at different times and lead to changes in fuel and operating costs over different periods, the investments are turned into annual costs over the lifetime of the measure (converted into annuities) and then compared with the annual savings in energy and operating or other costs. The balance gives the net cost or revenue of the investments per year (Doll et al., 2008). Figure 6-2 illustrates this for the two projection years 2025 and 2030. All investments made thus far are annuitised over the lifetime of the investments at a suitable discount rate of 2 %. The annuities incurred in the year under review are then added up. From this group of annuities, the operating and energy costs saved in the year under review are deducted to arrive at the net differential costs for the year.

**Figure 6-2: Annuitised illustration – investment versus expenditure**




Source: own calculation

Note: Annuities calculated with a 2% discount rate and individual lifetimes of technologies (e.g. building refurbishment 40 years, fuel conversion 30 years, vehicles 14 years, electricity: natural gas CHP 40 years, renewable technologies 20 years, power grids 40 years, material efficiency in industry 15 years).

Figure 6-2 shows that the savings in Target Pathway A clearly exceed the annuitised differential investment in both support years, whereas this is not the case in Target Pathway B. This also applies to the individual action areas. It must, however, be stressed that the total investment volume in Target Pathway A in 2030 is higher than that in Target Pathway B.

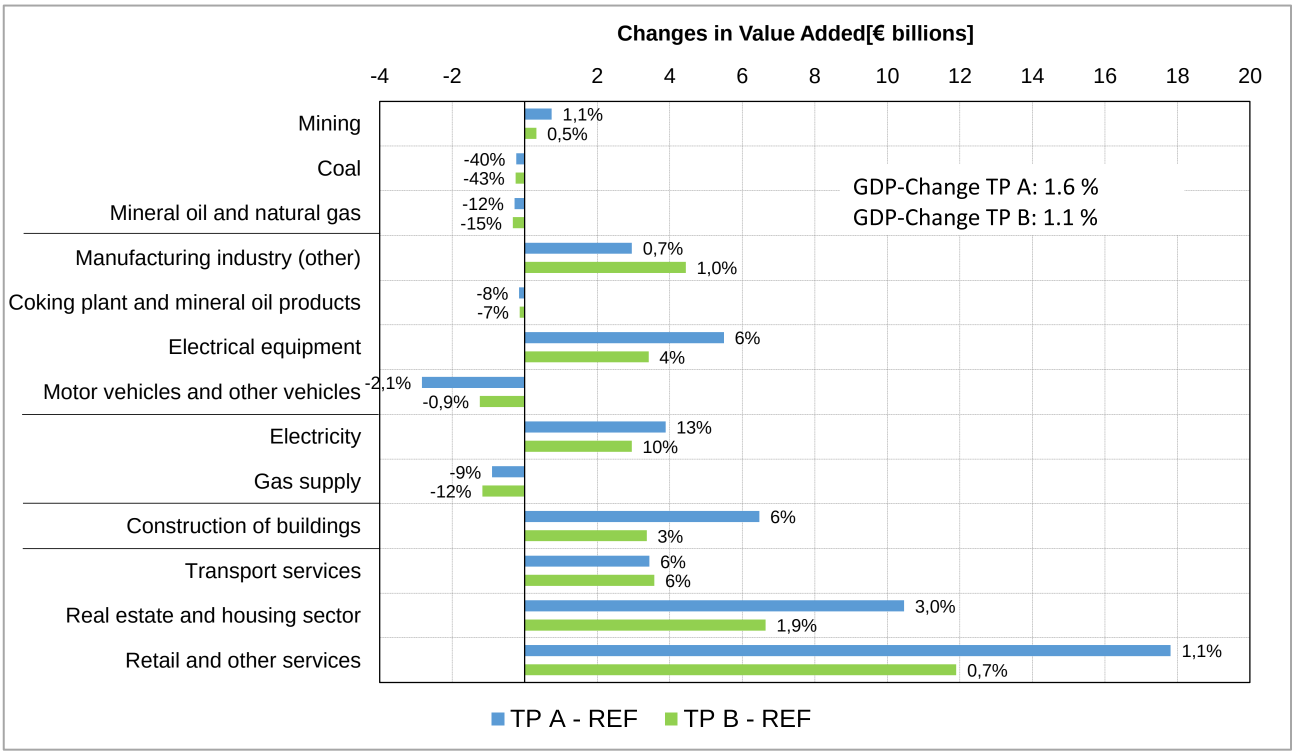
From a micro-perspective, it can be noted that Target Pathway A leads to efficiency-oriented, economically feasible modernisation in all action areas. Innovations and investments are initiated early on, allowing learning effects and technological progress which lead to significant savings and also open up new markets. An initial need for additional investment creates savings and yields a return over time. Possible barriers to such (initial) investment activities differ between the action areas and can be addressed by means of appropriate policy measures (which are not, however, a feature of this impact assessment).

## 6.2. Gross domestic product, value creation and jobs

The assessment of macroeconomic consequences builds on integration of the individual sectors and is determined using the ISI-Macro model. The model uses differing influences from the sectors which can be categorised into changes in end demand (in the form of investment and private consumption) and changes in deliveries between industry sectors (in the form of changes to the input matrix). Changes in the influences and the interaction effects of the interplay between investment, consumption and input influence gross value added.

Both target pathways show slightly stronger economic growth compared with the reference. Gross domestic product in Target Pathway A is 1.6 % higher in 2030 than in the reference and 1.1 % higher in Target Pathway B. The stronger economic growth can be explained in particular by the higher level of investment and the decline in demand for imported fossil fuels. Absolute and relative changes in gross value added in the target pathways compared with the reference in 2030 are shown for individual sectors in Figure 6-3.

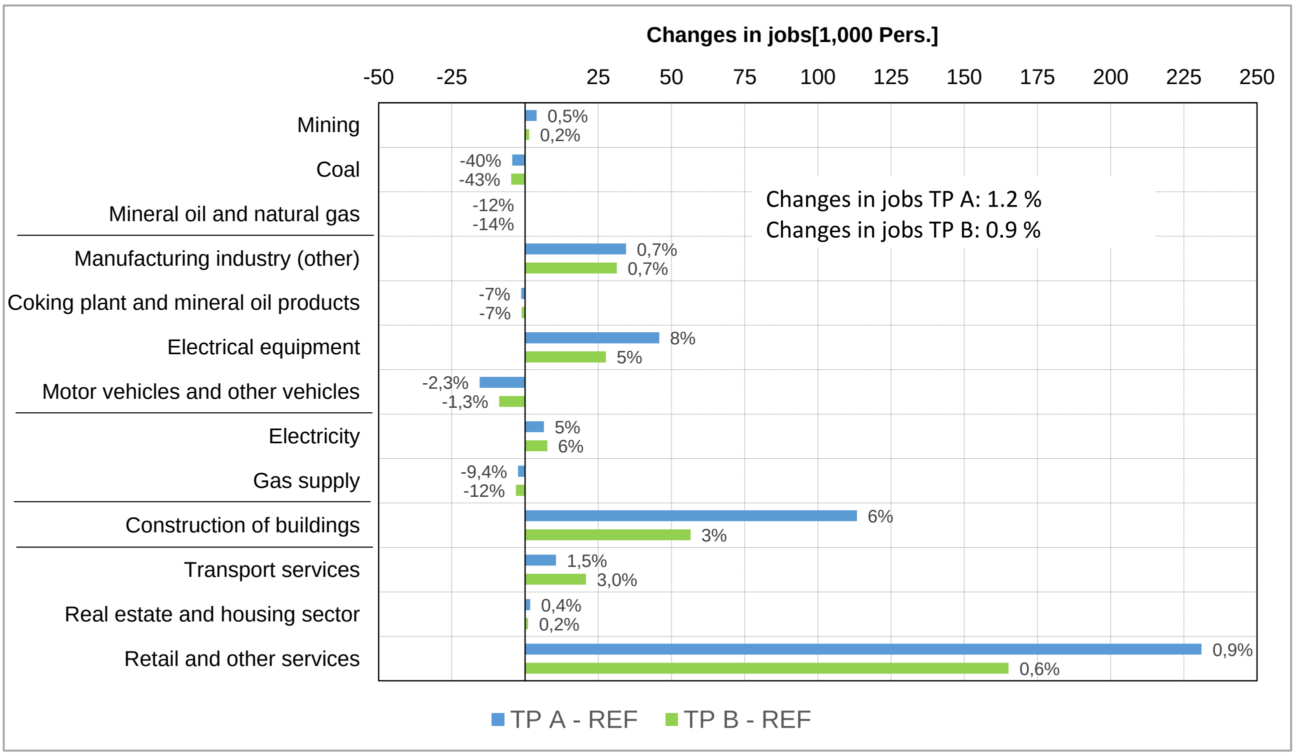
**Figure 6-3: Gross value added by economic segment – changes in 2030 compared to reference**




Source: own calculation

It is not only the value added and the gross domestic product that can be derived from changes in the output of individual sectors, but also the demand for labour. For this purpose, the changes in terms of jobs are determined by taking sectoral productivity into account. The effects on jobs are positive, analogous to the value added effects. The relative change in jobs compared with the reference is shown in Figure 6-4 for specific industry sectors. The change is slightly lower than for GDP, which means that the target pathways are characterised by slightly higher productivity compared with the reference. As with the growth effects, the 427,000 (TPA) and 307,000 (TPB) additional employees in 2030 must also be seen as potential based on the demand for labour.

**Figure 6-4: Changes in jobs by economic segment, in 2030 compared with the reference**




Source: own calculation

<u>Interpretation relative to action areas</u>

With regard to the action areas, direct and indirect value added and impacts on jobs are evident in various economic segments. For the transport sector, it can be seen that although there is a decrease in vehicle production for conventional vehicles compared with the reference (motor vehicles and other vehicles), other sectors (such as the electrical equipment sector) are affected by increased production of electric vehicles and benefit more strongly from demand for corresponding components (batteries, charging infrastructure). Similarly, relocation has sparked increased momentum for transport services, so that potential decreases in value creation and jobs in motor vehicles and other vehicles are offset by positive influences in other economic segments. A prerequisite for these offsets is that appropriate value creation structures for battery production are also established and located in Germany, and with positive economic effects.

In the buildings action area, the Climate Action Plan encourages positive differential investments, especially in the construction industry and also in mechanical engineering. However, the lower demand for heating energy due to improved refurbishment of buildings leads to a decline in momentum where gas supply services are concerned. There is also positive added value momentum in the real estate and housing services segment. However, this is also countered by owners' imputed rents, so that these revenues do not lead to an increase in jobs. The influences distributed across all action areas also create positive value added and effects on jobs in the building sector.

The strategies in the energy industry action area ensure a positive effect on output value in the electricity sector. In addition, there are also positive effects in the value chain for renewable energy use (manufacturing and maintenance) and areas involved in grid expansion (electrical equipment for turbines and infrastructure, other manufacturing industries for building materials for wind turbines). There is, however, a reduced demand for fossil fuels, which is reflected in reduced imports as well as reductions in added value and jobs in the domestic coal sector. The shifts in investment due to differences in power plant construction cannot be easily offset: in the assessment the varying labour productivity in the individual sectors also plays a role. Uncertainties exist both in the transfer of investments to the price of electricity and in the creation of additional provisions and their effects on value creation.

For industry, increased value added and jobs arise from energy and material savings in some of the segments of manufacturing industry, but also a decline in energy and material supply. The "other manufacturing" sector shows positive effects overall. For agriculture, land-use change generates neither value added, nor effects on jobs.

In sum, the effects for each action area are distributed across different economic segments and must always be considered in the context of the overall situation if any meaningful conclusion is to be reached.

# 7. Other economic effects

## 7.1. Environmental and health effects and external costs

### 7.1.1. Environmental and health effects

In the impact assessment, environmental and health effects are considered for greenhouse gas emissions, air pollutant emissions, heavy metal emissions, nutrient inputs, land-use change, biodiversity and noise. As regards the methodology used, the procedure is based on the guidelines on cost-benefit analysis of environmentally relevant effects in regulatory impact assessments, which are issued by the Federal Environmental Agency (Porsch et al., 2014).

A quantitative assessment of the two target pathways compared with the reference pathway was carried out both for GHG emissions and for:

- Air pollution and heavy metal emissions: $SO_2$, $NO_x$, volatile hydrocarbons (NMVOC), $NH_3$, particulate matter PM2.5 and mercury;
- Nitrogen inputs in the soil by agriculture;
- Land use aspects (forest, wetlands, wind energy).

Compared with the reference pathway, both target pathways lead to noticeable improvements in the impact situation in almost all dimensions considered. These improvements are usually in the order of 5 to 30 %. One exception is land use for wind energy, which is about 15 % and 30 % higher than the reference in target pathways A and B up to 2030.

In a comparison of the two target pathways, Target Pathway A and Target Pathway B are more or less equivalent in environmental terms. Target Pathway A has slight advantages due to lower particulate matter emissions and lower demand for wind energy sites.

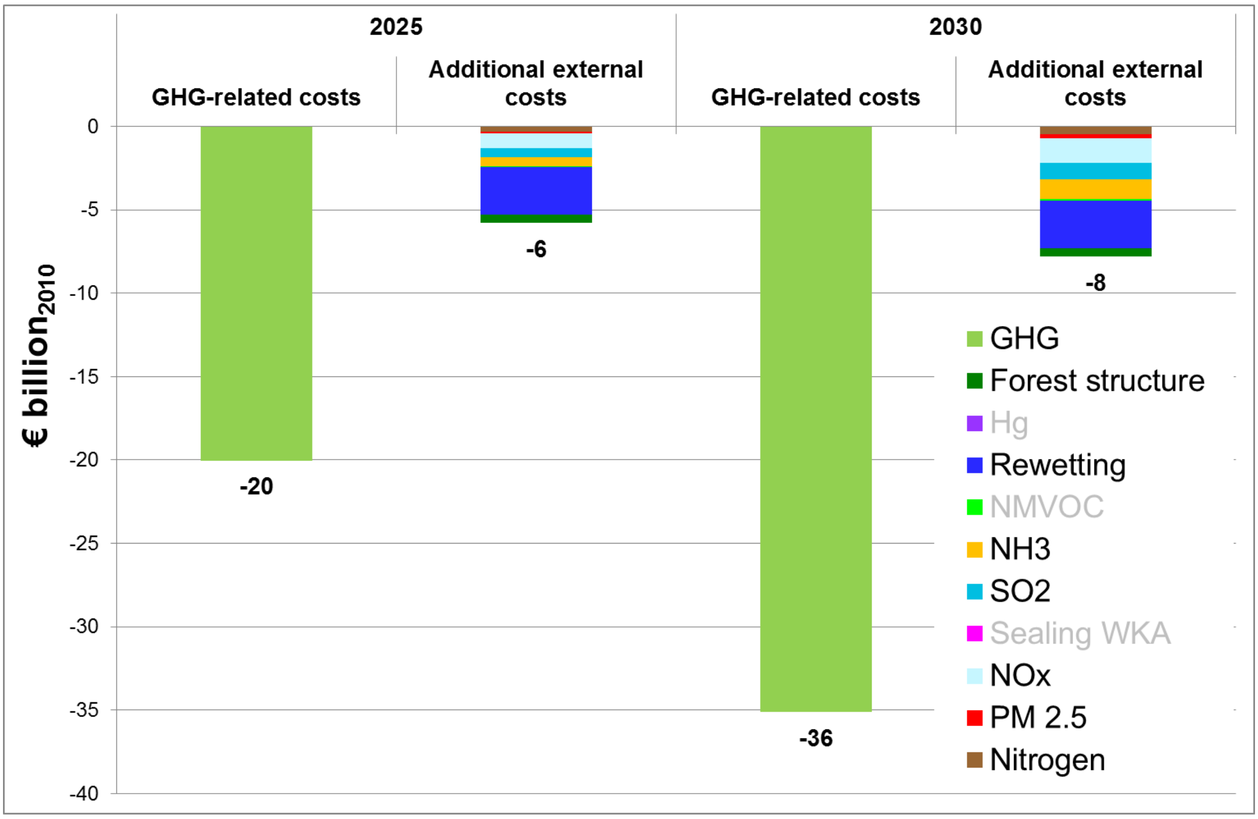
### 7.1.2. External costs

The quantified environmental and health effects were converted into avoided external costs using the methodological approach described in (Porsch et al., 2014). The most recent available cost rates for environmental costs were taken into account in accordance with Methodology Convention 3.0 (Federal Environmental Agency (UBA) 2018).

The environmental benefits of the target pathways compared with the reference pathway translate into avoided external costs of about € 26 billion in 2025 and about € 43 billion in 2030 (Figure 7-1). This applies for both Target Pathway A and Target Pathway B despite the small differences in environmental assessment.

The largest share of avoided costs – about 80 % – is accounted for by a reduction in GHG emissions. The other quantitatively relevant cost categories are land improvements (rewetting and forest management), reduced nitrogen inputs into the soil and reduced emissions of air pollutants (NOx, $NH_3$, $SO_2$ and particulate matter).

**Figure 7-1: Avoided external costs in the target pathways compared with the reference scenario**




Source: own calculation

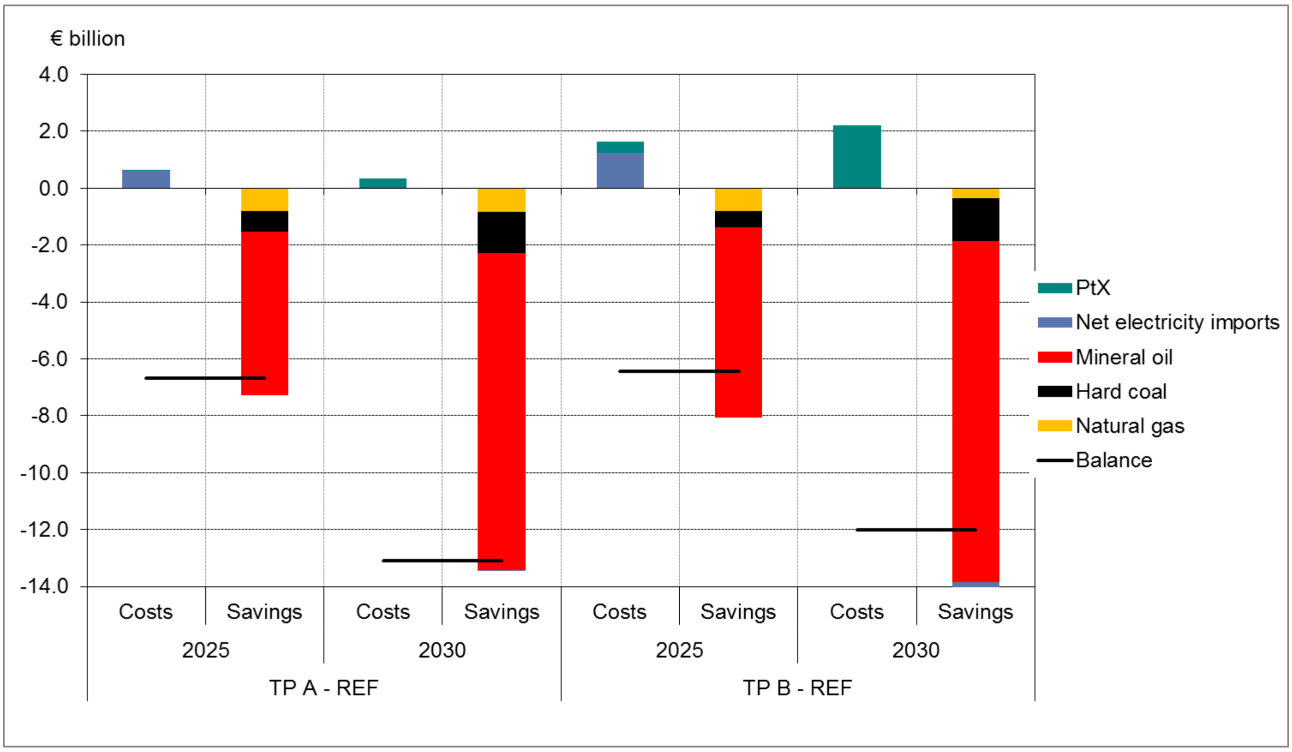
Note: Quantitative cost contributions that are not visible are marked grey in the legend..

## 7.2. Import dependency

The target pathway combinations cause changes in both final and primary energy demand which also affect energy imports. In 2015, 97 % of petroleum consumption, 90 % of natural gas consumption and 89 % of coal was imported (AGEB 2017). As coal mining in Germany ceases in 2018, the import quota rises to 100 %. In line with changes in primary energy demand in the target pathways and expected import quotas, imports of coal decrease by 46 % in TP A and by 48 % in TP B in 2030 compared with 2015. Over the same period mineral oil imports decrease by 28 % in Target Pathway A and by 30 % in Target Pathway B, and imports of natural gas decrease by 11 % in TP A and by 19 % in TP B. It is assumed that electricity-based fuels are fully imported by 2030.

An important factor from an economic perspective involves the cash flows that go abroad via trade. Figure 7-2 thus shows the changes in the monetary value of energy imports compared with the reference development. The minor additional costs for PtX and imported electricity are offset by far greater savings in fossil fuels, especially mineral oil. The net savings in imports in 2030 will amount to € 13 billion in Target Pathway A and € 12 billion in Target Pathway B compared with the reference.

**Figure 7-2: Import dependency (energy sources)**



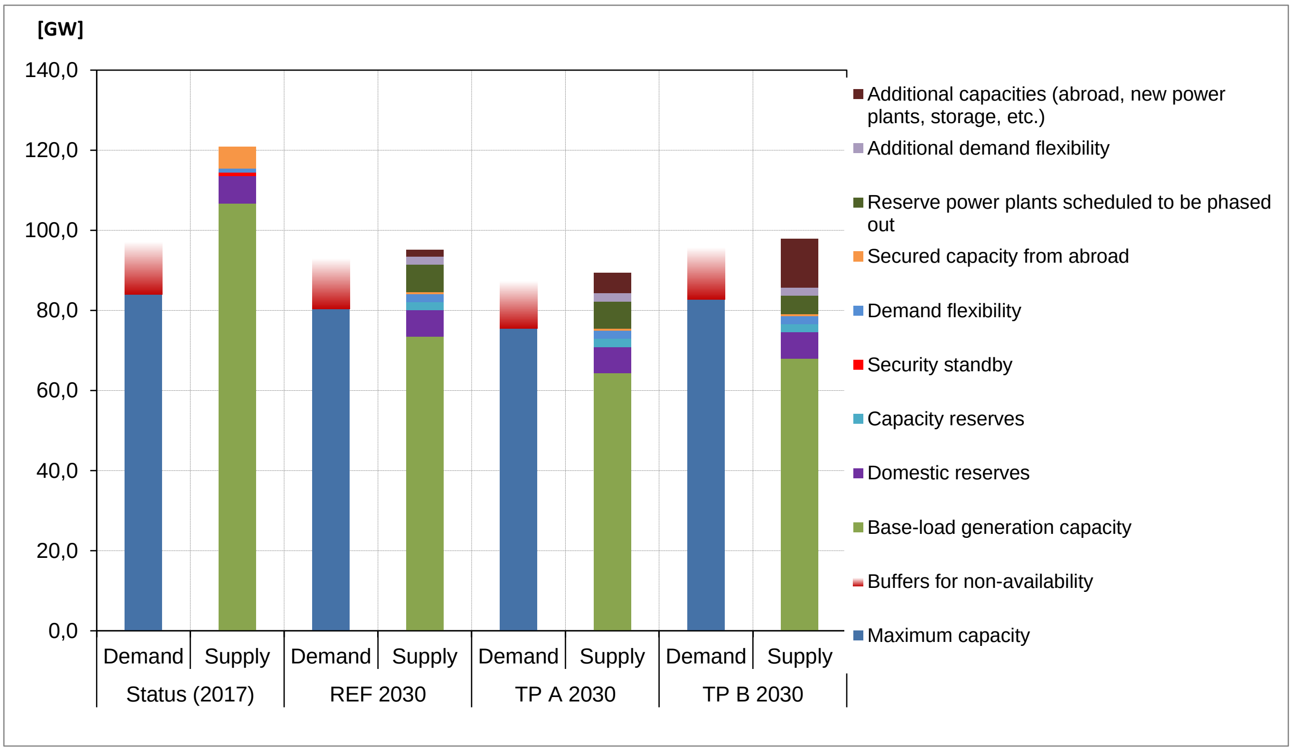

Source: own calculation

## 7.3. Supply security

Ensuring a high degree of supply security involves various different dimensions, of which the impact assessment takes only the needs-based design of the electricity system into account. Issues involving supply reliability and system security, which mainly concern distribution and transport networks, were not analysed in depth.

In-depth assessment of supply security takes place within the framework of the corresponding monitoring process pursuant to Section 51 of the German Energy Industry Act (EnWG), in which comprehensive variant and probability calculations are carried out relating to the integrated European electricity market. In light of this, a simplified assessment was conducted on the needs-based design of the power generation system as part of the impact assessment.

## Figure 7-3: Supply security




Source: own calculation

The gradual transition of the German electricity system to one based predominantly on variable renewable generation options (onshore and offshore wind, solar power) and the gradual reduction of $CO_2$-intensive coal-fired electricity in 2030 are accompanied by a decline in base-load generating capacity, i.e. capacity that not reliant on wind and solar power (nuclear power stations, coal and lignite-fired power plants, natural gas and other fossil fuel-fired power stations, hydropower and biomass plants).[12] In the reference scenario, power stations' net base-load capacity decreases from approx. 107 GW to 94 GW in 2020 and to 79 and 73.5 GW respectively in the scenario years 2025 and 2030. In the two target pathway scenarios, base-load generating capacity decreases to 72 and 73 GW in the scenario year 2025 and to 64 and 68 GW in the scenario year 2030.

There is, however, little change in peak load demand compared with the current situation for the reference scenario, which ranges from between 80 GW and 86 GW in the scenario period up to 2030. In Target Pathway Scenario A, which is strongly focused on energy and electricity efficiency, both peak load demand and electricity demand decrease to about 79 and 75.5 GW respectively in the period 2017 to 2025 or 2030. For Target Pathway B, which has a higher electricity demand, the assessment of the needs-based design of the power system arrives at reference levels of 85 GW and 83 GW respectively for 2025 and 2030.

Taking into account the necessary reserve buffer for non-availability etc. of base-load power plants, the existing reserves or reserve arrangements (which decline over time in accordance with previous plans) and the previously planned contributions from demand flexibility and power plant contracting abroad, there is a need for additional secure power plant capacity in all scenarios. In the reference scenario, this amounts to around 8 GW in 2025 and 10.5 GW in 2030. In Target Pathway Scenario A, the corresponding values are

[12] At this point, it is not taken into account that conventional capacities can be saved by exploiting diversification effects, especially in wind energy. Viewed for Europe as a whole, this effect is much more pronounced than in a purely national view.

approximately 10 GW in 2025 and 13 GW in 2030; in Target Pathway Scenario B they amount to 17 GW for 2025 and 19 GW in 2030.

To cover this additional capacity demand, three different variants are presented which largely depend on basic economic beliefs or fundamental policy decisions. In a first “integration-intensive” pathway, the necessary secure demand is largely or fully secured via portfolio effects with connected foreign electricity systems and markets. In addition or as an alternative to this, a second option is to limit or replace the contributions from abroad by reserving power plants or, over a period of time, setting aside new power plants as power reserves without them being able to participate in the electricity market. The corresponding mechanisms are in place in the current electricity market structure and are currently in use (security standby for coal-fired power plants, special grid-related equipment) and would have to be expanded accordingly if necessary. As a third step, either as an alternative or in addition, the existing electricity market structure could be changed towards a system in which the provision or creation of base-load capacity or corresponding equivalents on the demand side are put out to tender and corresponding income streams are generated. Such mechanisms already exist, at least for certain segments, and are being used (the German Combined Heat and Power Act and the German Ordinance on Interruptible Loads).

For the reference scenario and Target Pathway Scenario A, each of these three pathways of moderate severity and, of course, any combination thereof would provide sufficient capacity (or corresponding equivalents on the demand side) to ensure a high level of supply security. For Target Pathway Scenario B, at least two of the named pathways would have to be combined if the output potential they each make available is to be moderately tapped.

The flexibilities associated with the different pathway choices means that, when it comes to the variants mentioned above, basic policy decisions are not unavoidable in the short term, but need to take effect by the mid-2020s.

Finally, it should be noted that the pathway of gradually phasing out coal-fired power generation is the most challenging variant in terms of supply security. Other instrumentat variants, which can also be used to reduce utilisation of emission-intensive power plants or limit rebound effects by transferring production to other power plants (e.g. by means of effective carbon pricing), may lead to a smaller decrease in base-load generating capacity in the periods considered.

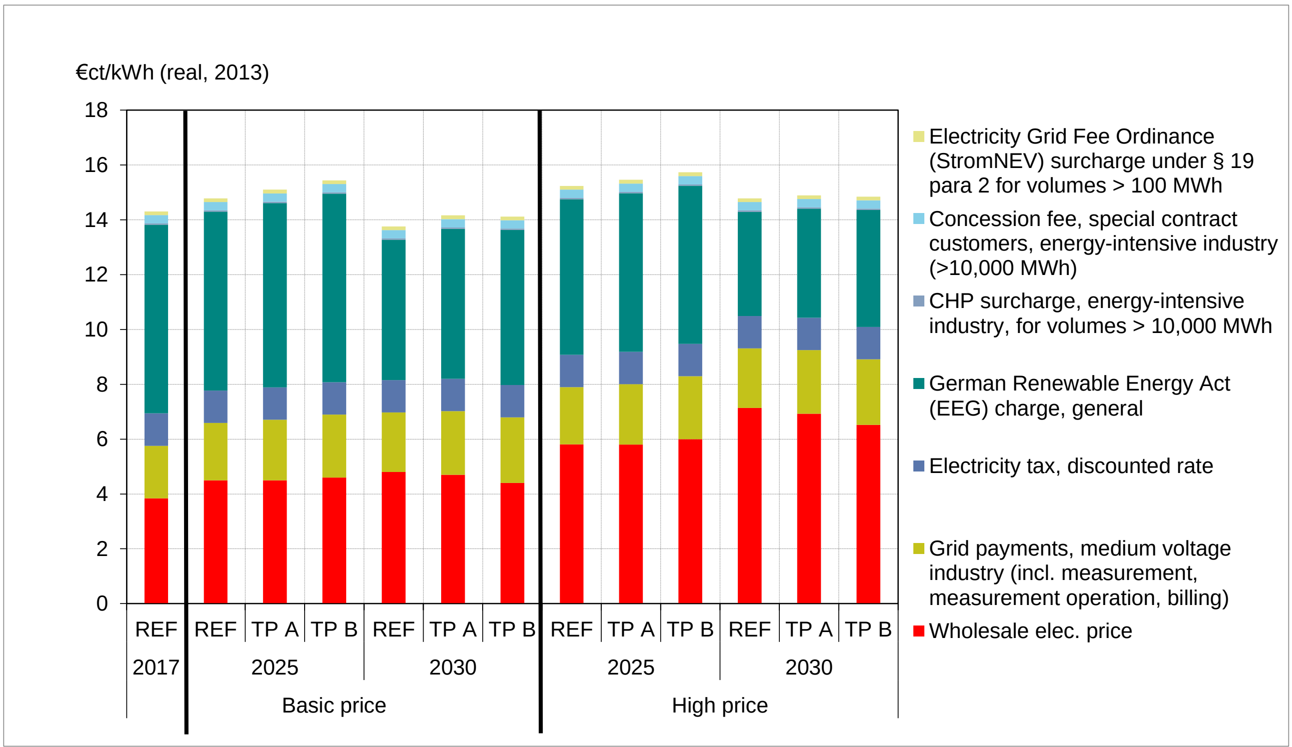
## 7.4. Competition effects

The impact assessment shows that achieving the sectoral targets contained in the Climate Action Plan can bring about net savings and thus lower production costs for most sectors, which can allow more scope for price-based competition. Climate protection opens up opportunities for future technologies to be located in Germany. Companies can exploit new export options. Most competitive factors (such as capital, wages/salaries, raw materials, profile/networking, location, products (specialisation)) are rarely negatively impacted by activities to mitigate climate change.

In a few sectors, however, climate protection costs may increase competitive and locational disadvantages. This is currently being counteracted by the fact that industry is exempt from most costs associated with climate protection. But exemptions are not sustainable in the long term. Policy measures must be designed in such a way that they stimulate innovation and investment, have a steering effect and thus result in businesses and consumers making a sustainable contribution to decarbonisation. In general, potential distortions in competitiveness caused by national-level climate protection are largely dependent on the climate protection efforts of other states. This is where implementation of the Paris Agreement creates a level playing field worldwide.

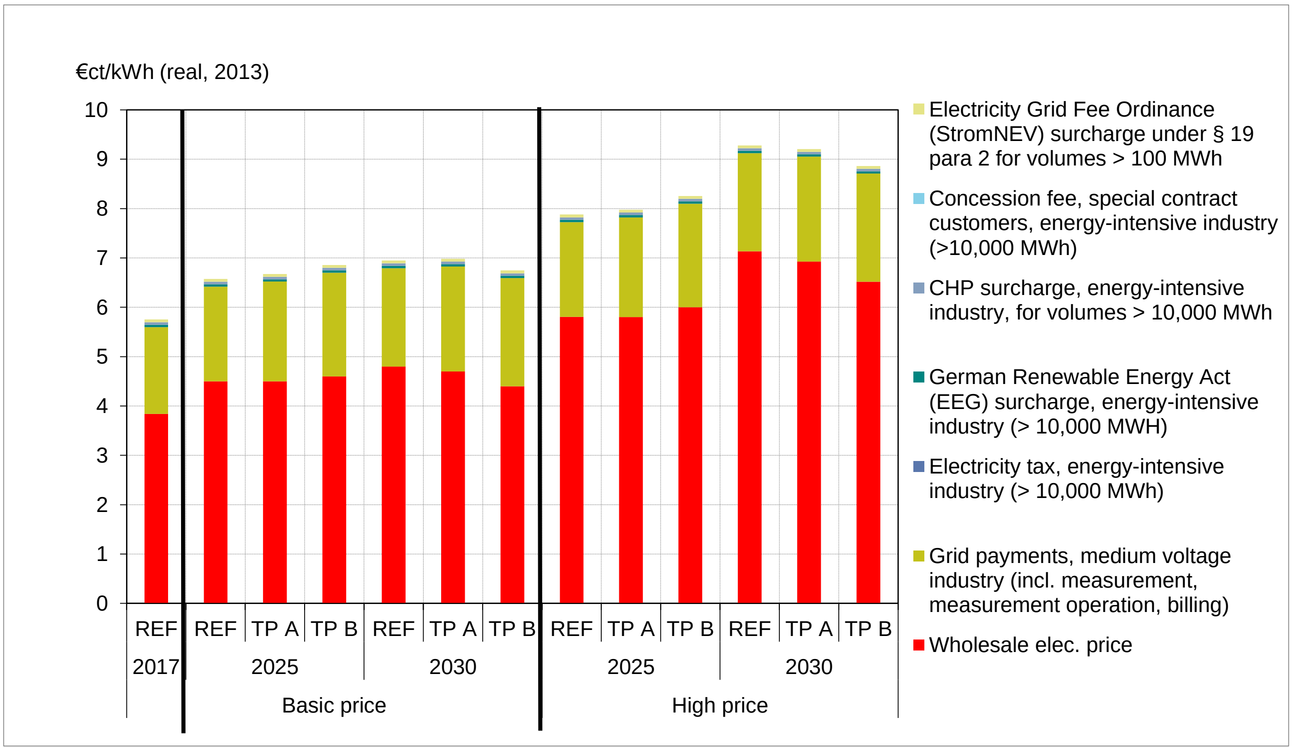
In the impact assessment, particular attention was paid to energy prices, which are reflected in the target pathways and may indicate a possible loss of competitiveness. Figure 7-4 and Figure 7-5 show the electricity prices for non-energy-intensive and energy-intensive industries respectively for the reference development, the target pathways, the framework data and a high price variant for fuels. In the basic and high price scenarios, electricity prices for non-energy-intensive industry decline over time, both in the reference and in the target pathways. The difference between the reference and the target pathways is marginal. For energy-intensive industry, the electricity price in the target pathways is even below that in the reference development – in fact, the industry faces no distortion with regard to price.

**Figure 7-4: Industrial electricity price in non-energy-intensive industry: reference and target pathways**




Source: own calculation

**Figure 7-5: Industrial electricity price in energy-intensive industry: reference and target pathways**

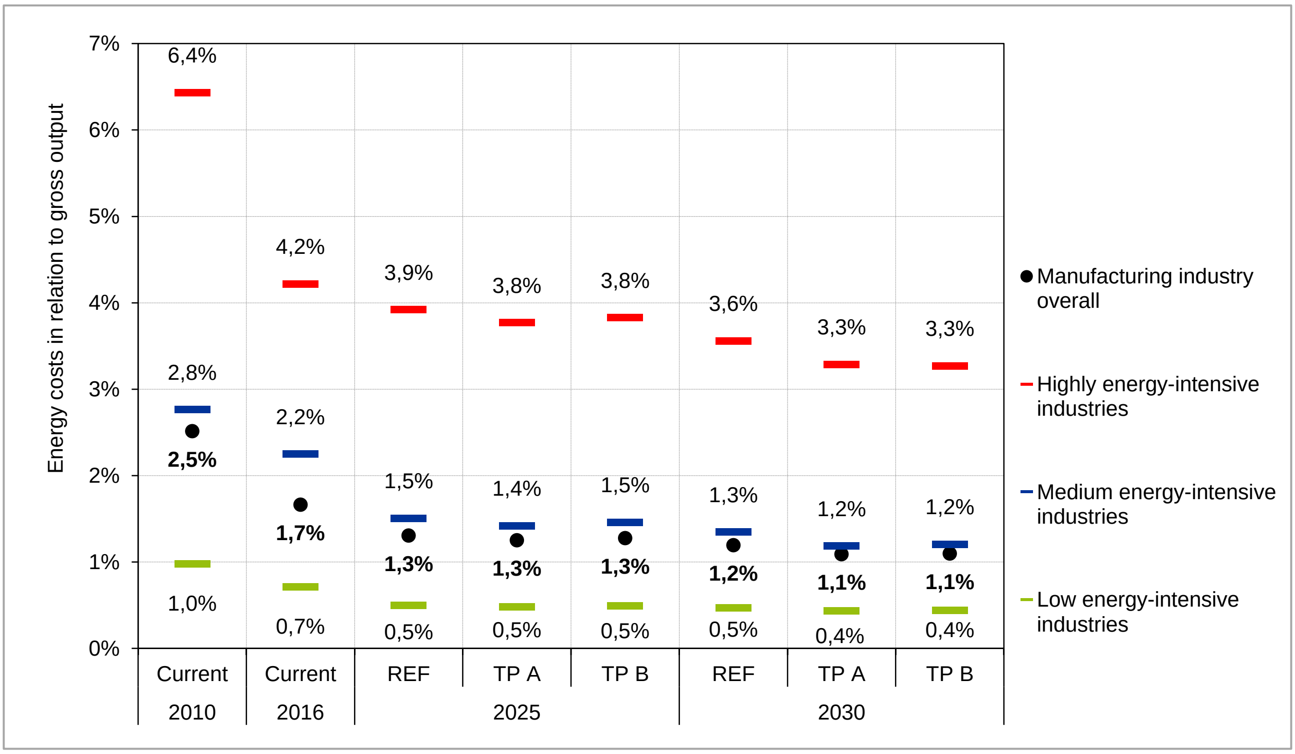



Source: own calculation

However, as an isolated indicator, energy prices have only a limited explanatory value for classifying (international) competitiveness. Significantly more explanatory is the development of energy costs per unit, i.e. the energy cost burden in relation to production value. the energy unit costs were calculated for three areas of manufacturing industry. These calculations were based on a real energy cost burden calculated econometrically, i.e. taking into account the real costs arising in the various sectors with a view to wholesale prices, trade margins, taxes, levies and fees, and fuel purchases that arise (taking account of energy efficiency, etc.) for the various segments of manufacturing industry, and the development of sectoral value added.

The historically observed energy unit costs (share of energy costs in gross production value) decrease substantially in all scenarios for 2025 and 2030 and for the high, medium and low energy-intensive segments of manufacturing industry and in manufacturing industry overall. In the energy efficiency-focused Target Pathway A, all energy unit costs are slightly below those for Target Pathway B and all values for this scenario are below those for the reference scenario.

**Figure 7-6: Energy unit costs for manufacturing industry overall and for different segment groups, 2010-2030**




Source: own calculation

For highly energy-intensive industry sectors, the energy unit costs decrease compared with the most recent official statistics reported in 2016, i.e. down from 4.2 % to between 3.8 and 3.9 % in 2025, and 3.3 to 3.6 % in 2030. For the medium energy-intensive industry sectors, the decrease in energy unit costs is far greater, dropping from 2.2 % in 2016 to between 1.4 and 1.5 % in 2025 and 1.3 % in 2030. For the less energy-intensive industry sectors, the energy unit cost is reduced from 0.7 % to values in the range of 0.4 to 0.5 % in the different scenario years. If the energy unit costs are calculated on the basis of gross value added rather than gross production value, identical development dynamics result.

## 8. Target pathway assessment and conclusions

In the overall assessment of the target pathways, it can be concluded that both have positive economic effects overall. Differences are evident between the target pathways and in some cases can also been seen over the period up to 2030 and beyond. In sum, Target Pathway A represents the more robust path towards achieving the long-term, GHG-neutral reduction target in 2050. It paves the way for innovative transformation beyond 2030.

*Target Pathway A*

Target Pathway A aims to modernise the economy in all sectors in an efficiency-oriented way. This stimulates innovation and investment, which in turn stimulates technological advancement and allows learning effects. At the same time, the innovations enable markets to be tapped at an early stage or market positions to be improved, with positive effects on the competitiveness of German business.

With its focus on efficiency, Target Pathway A substantially reduces final energy demand. This increases the climate protection effect of expanded renewable electricity generation on the basis of wind power and photovoltaics, and limits the need to make an additional biomass potential available. The investment needs in Target Pathway A are offset by substantial savings which yield returns over time. Target Pathway A is more positive than Target Pathway B, both in the individual sectors and in their interaction in the economy overall.

*Target Pathway B*

Target Pathway B is geared towards an economic structure with high electricity and biomass needs. In all sectors investments are made in electricity-based technologies or low GHG fuels. Less use is made of efficiency potentials than in TP A or such potentials are used only secondarily to achieve sectoral targets. As a result, investments are concentrated in the energy industry, while other innovation potentials in other sectors go partly unused so that corresponding markets are not tapped. Even though domestic investment needs remain slightly below those of the efficiency-oriented Target Pathway A, investments are offset by lower savings in fuel and/or operating costs, so that lower rates of return can be achieved on balance. This is also reflected in the macroeconomic effects as well as the effects on jobs, which in Target Pathway B lag behind those of Target Pathway A. In addition, greater use of PtX increases the import dependency on other countries. Similarly, use (and import) of PtX increases electricity demand abroad with possible consequences for the environment.

*Climate protection calls for decisive mobilisation of innovation and investment*

There are, of course, challenges in implementing both target pathways. These must not be ignored and can give insights that can be used in a possible program of measures. The main focus for both target pathway combinations is that substantial mobilisation or stimulation of additional innovations and investments is needed in order to pursue these pathways. With regard to building refurbishment and infrastructure for e-mobility in particular, investments are needed right from the outset and are only offset by expected savings over time and the promise of a return on the investment made. Possible barriers to these necessary (initial) investment activities vary between sectors and require different stimulation strategies. Current policy does not provide the stimulus needed to meet the climate policy goals and objectives. Additional policies are urgently needed as a result.

*Focusing on the long-term perspective: 2030 targets must be in line with long-term targets*

Challenges also arise with regard to a longer-term perspective. Focusing on or working towards the target year 2030 alone in respect of the sectoral targets is not enough to achieve the Federal Government’s long-term greenhouse gas reduction target or the Paris Agreement goals. This means that strategies geared to 2030 can lead to lock-in effects, which may seem cheaper in the short term, but lead to higher costs in the long term. To foster climate protection that is efficient and effective in the long term, optimum use must be made of windows of opportunity that arise, such as planned renewals, and the dynamics of what are in some cases very long investment cycles. At the same time, research and development must be continuously advanced so as to be prepared for the period beyond 2030.

*Managing the transition: Structural change/ jobs/social issues*

To make the transition to a GHG-neutral economy, new low-emission technologies are just as needed as changes in economic structures, in ranges of employment opportunities, and in everyday routines. All these changes pose challenges for actors at all levels and require appropriate strategies and ideas for overcoming them. New technologies call for the construction of new (or the adaptation of existing) domestic value creation structures. A prominent example of this is e-mobility. The transition requires an increase in skilled workers and experts whose training and specific jobs must be ensured. The demand for skilled workers, for example for building refurbishment, already exceeds today’s existing supply. There are also regional or structural changes that must be overcome. The loss of employment sectors with associated regional implications calls for new perspectives to be created for affected regions and sectors (lignite mining and the automotive industry). Social aspects must be taken into account and distortions must be avoided.

*Cross-sectoral approach*

At the level of resources or limited availability of inputs and products, there are also challenges that need to be tackled in a cross-sectoral approach. Notable examples include limited availability of biomass as a GHG-neutral energy source supplied in different forms and RES electricity as a climate-friendly alternative. A systemic approach must be taken to meet competing needs and promote alternative approaches and investments.

*Conclusions concerning a 2030 programme of measures*

A number of these challenges can be solved by the market. Many companies are waiting, however, for a reliable signal from the Federal Government and are either prepared to invest in climate-friendly technologies or approaches or are already actively involved. Other challenges require stimulation and planning certainty to encourage action. This enables conclusions to be drawn for the development of a programme of measures for the 2030 sectoral targets contained in the Climate Action Plan with an outlook for 2050. The impact assessment highlights the fact that, from an economic perspective, an energy efficiency-focused strategy is advantageous. It also highlights the need for early action, especially with regard to infrastructure, with long planning periods and lifetimes. To overcome barriers to investment and implementation, measures can and should be designed to provide incentives. These measures must also take a cross-sectoral approach to dismantle competition in biomass utilisation, electricity use and infrastructure development. Here, the redesign of levies and fees provided for in the Climate Action Plan as well as measures for carbon pricing are of great importance. It is particularly important that policies and measures are transparent and credible for all actors and provide planning certainty to ensure that these policies and measures have their steering effect. This means that they must be designed efficiently and effectively, and take account of both social and distributional effects. As distributional effects only really materialise at the policy instrument level, they must be made an indispensable component of the impact assessments conducted on the respective measures. The design of these measures should ensure that they steer the attractiveness of investments and activities. Climate-friendly approaches can sometimes be uncomfortable or unattractive, especially when they involve efficiency and savings measures that require high levels of investment and affect everyday routines. Special attention to their design and how they are communicated with appropriate (if necessary, target group-specific) framing can significantly increase both the readiness for and likelihood of implementation.

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