Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

INVESTITIONEN WACHSTUM KLIMASCHUTZ

INVESTMENTS FOR A CLIMATE-FRIENDLY GERMANY

Study commissioned by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

SYNTHESIS REPORT
POTSDAM, 25 JULY 2008

IMPRINT

Published by: Federal Ministry for the Environment, Nature Conversation and Nuclear Safety (BMU)
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11055 Berlin
Germany
Email: service@bmu.bund.de
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Design: neues handeln GmbH
Printing: Silber Druck oHG

Photos: © plainpicture

Date: June 2008
First Print: 2,000 copies

European Climate Forum
Fraunhofer Institut System- und Innovationsforschung
PIK
Münchener Rück Munich Re Group
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EXECUTIVE SUMMARY

Advancing climate change, the increasing scarcity of fossil resources and fluctuations in price of fossil fuels are among the central challenges facing this century. If these challenges are to be met, the global economy must significantly improve energy efficiency and lower emissions. This, in turn, will require an appropriate restructuring of the world's capital stock. Only then can energy needs be met through renewable resources, achieving the required reduction of greenhouse gas emissions.

The German government has established a significant set of climate policy instruments, comprising a combination of emissions trading and the "Meseberg programme", which includes sector- and technology-specific measures. In its current form, the Meseberg programme is likely to lead to an emission reduction of nearly 34 % by 2020. The remaining six percentage points needed to meet Germany's 40 % reduction target can be achieved by implementing additional measures that would generate only moderate abatement costs throughout all economic sectors.

Now is the right time for an investment campaign, in view of high technical advancements in the energy sector, high primary energy prices and the backlog demand for investments in Germany. The Meseberg programme provides an important base for an ecological restructuring of Germany's capital stock. With appropriate implementation, the Meseberg package, together with several supplemental measures, could achieve multiple successes:

1. Realisation of an ambitious climate policy goal by 2020, as well as additional long-term goals oriented towards sustainable, climate-friendly and energy-efficient economic structures.
2. An increase of over €30 billion per year in net investments, beginning in the middle of the next decade.
3. An equally long-term increase of at least €70 billion per year in the gross domestic product.
4. The creation of at least 500,000 new jobs by the year 2020.

Nearly all the investments and organisational measures aimed at more efficient energy use are profitable in principle but they currently tend to be blocked by a wide range of market shortcomings and coordination problems. However, expanding renewable energy use does often generate additional costs during its initial implementation. This would also apply to CO_2 capture and storage systems, if such systems prove to be a viable option. Nonetheless, the rapid expansion of such measures and technologies is still justified, since they help to reduce climate risks, potentially lower costs and also strengthen the export economy by enabling a "first-mover advantage" on world markets.

Even in 2030, the potentials for improving energy and material efficiency and for expanding the use of renewable energies will be far from exhausted. In fact, until well into the second half of this century, they will pave the way for an effective and globally-sustainable industry with a global scope for a population of approximately 9 billion people. Research and development aimed at entrepreneurial innovation are particularly important for the spectrum of technologies involved in energy use and conversion, and materials efficiency.

This document and the German version of the report can be downloaded at www.kliminvest.net/download.html.

1 PROBLEM DEFINITION

The debate on future climate protection policy is increasingly an economic one. Since the publication of the *Stern Report,* "The Economics of Climate Change", by the British government in 2006, it has become clear that climate protection can be viewed not only as an environmental political necessity, but also as an economically wise investment in the future (Stern 2006)[1]. The review's standpoint is supported by the IPCC's Fourth Assessment Report, published in 2007 (IPCC 2007).

The Stern Report and the IPCC Report focus economic analysis on highly aggregated global perspectives that are still far from practical implementation. With the European resolutions of March 2007 and the resulting *Integrated Energy and Climate Programme of the German Federal Government* of August 2007 (also known as the "Meseberg Programme"), Germany now has a comprehensive range of climate policy instruments. These instruments are currently making their way through parliament, and are expected to begin having an impact in 2009.

The *Integrated Energy and Climate Programme*, which the Federal Government approved at its cabinet meeting in Meseberg, defines the following aims for 2020:

- a 40 % reduction in Germany's greenhouse gas emissions compared to 1990 levels,
- a 25 – 30 % share of electricity to be generated by renewable energy,
- 14% of heat production to be generated by renewable energy,
- an increase in the use of biofuels, with the aim of lowering fuel emissions by 10 % (equivalent to having biofuels account for up to 17 % of all fuels),
- a doubling of energy productivity compared to 1990.

In order to achieve these aims, the Meseberg programme aims to apply a 29-point package, in addition to emissions trading and other already existing sectoral measures. With this package, Germany is proving itself a pioneer of international climate policy, noted John Ashton, the British government's Special Representative for Climate Change (*Der Tagesspiegel,* 2008).

The present interdisciplinary study, commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), represents the first attempt to examine such a package of measures in terms of its ecological, economic and overall societal impacts, and to assess it from an integrated perspective. The study has been able to draw on work carried out last year by a range of authors (in particular UBA 2007b; McKinsey 2007; Fraunhofer-ISI et al. 2008a; 2008b).

1 A detailed list of relevant literature and a list of abbreviations are included in the final report "Investitionen für ein klimafreundliches Deutschland". The report can be downloaded at www.kliminvest.net/download.html. The methods and assumptions of the analysis presented here are described in detail in the final report.

2 THE ECOLOGICAL CONVERSION OF CAPITAL STOCK

It is an enormous challenge to guide a modern economy towards a more climate-friendly development path. The German economy has capital stock of some €7 trillion, a figure equivalent to nearly three times the country's gross national product (see Table 2-1). A large share of this capital stock will have to be renewed within the next 10–15 years. This process must make it possible to use the capital stock profitably by significantly lowering energy use and emissions; the long-term advantages of renewable energy sources must therefore be carefully considered. The reduced use of non-renewable resources implies additional investments and new technologies. For this reason, implementing the Meseberg programme will give the German economy substantial impetus for investments, and also open up new export potentials to meet global challenges.

Table 2-1: Structure of German capital stock (2005) by types of asset (in trillion euro; figures rounded off)

Residential buildings	3.4
Non-residential buildings	2.3
Machinery	0.7
Vehicles	0.2
Remainder	0.2
Total	**6.8**

Fixed assets by types in euro 2000 net („net capital stock").
Remainder = Farm animals and crops from the area of tangible fixed assets, plus intangible assets
Source: DESTATIS (2008a)

Needless to say, such trends and their impacts cannot be predicted with accuracy decades in advance. The present study thus uses applicable numbers and calculations primarily to estimate the magnitude of the potential impacts of the Meseberg programme and other measures. In this section, we first describe the current structure of the capital stock and relevant investments. Then we show how sluggish German investments are hampering economic growth and hindering a renewal of the capital stock. Finally, we explain how carefully designed climate protection and energy policies applied in the face of current energy price trends can trigger a great push towards environmentally-oriented innovation.

Currently, the total German capital stock amounts to some €7 trillion. This can be roughly broken down as follows (see Table 2-1):

– residential buildings account for about half,
– non-residential buildings account for about €2.3 trillion,
– machinery accounts for about 10%, and
– vehicles account for less than 4%.

The large share of buildings indicates the high investment demand in this segment of the capital stock. A breakdown by sector shows that the industry and energy sectors account for a relatively small share of total capital stock, but a large proportion of machines and equipment in the industry sector (compare Table 2-2). Although energy supply, industry, and transport make up 13% of the capital stock, their green house gas emissions amount to some 836 million t CO_{2eq} or 83% of total emissions.

When the capital stock is renewed through annual gross investments, a positive difference between gross investments and write-offs leads to an increase of the capital stock, the net investments (see Table 2-3). In 2005, net investments in Germany, at €69 billion, amounted to only about 17% of gross investments. Net investments in industry and the energy and agricultural sectors actually dropped, and a distinct trend towards investments in the service economy was noted.

Net investments, as a share of gross domestic product, have been decreasing in Germany for decades. While this share stood at 10 to 15% in the 1960s, it has been less than 5% since 2003 and, as an international comparison shows, it is currently smaller than the corresponding figures for many other countries (Figures 2-1 and 2-2).[2]

2 Although it has been reliably established that Germany's net investment share has been decreasing, the reasons for this downward trend are by no means clear. For further information about the pertinent discussion see Bond et al. (2003) and Culpepper (1999).

Table 2-2: Structure of German capital stock, and of greenhouse gas emissions (2005) by sectors (in trillion euro and million t CO_{2eq}; figures rounded off)

	Buildings	Other facilities and vehicles	Total	Emissions [million t CO_{2eq}]
Services and private households	5.3	0.6	5.9	169
Energy supply	0.1	0.1	0.2	366
Industry	0.2	0.3	0.5	213
Other (transport et al.)	0.1	0.1	0.2	257
Total	**5.7**	**1.1**	**6.8**	**1,005**

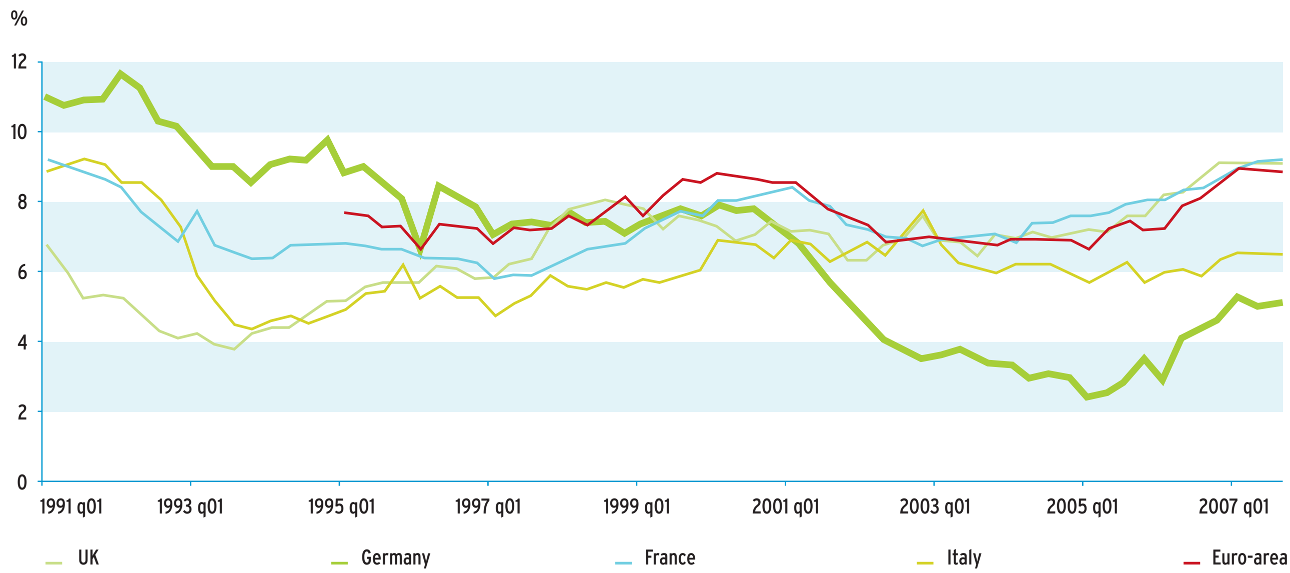
Source: DESTATIS (2008a), UBA (2007a), calculations of the PIK and the ECF

Table 2-3: Gross and net investments and write-offs by sector in 2005 (in billion Đ; figures rounded off)

	Gross	Write-offs	Net
Services	326	246	80
Energy supply	9	10	-1
Industry	55	63	-8
Remainder	14	16	-2
Total	**404**	**335**	**69**

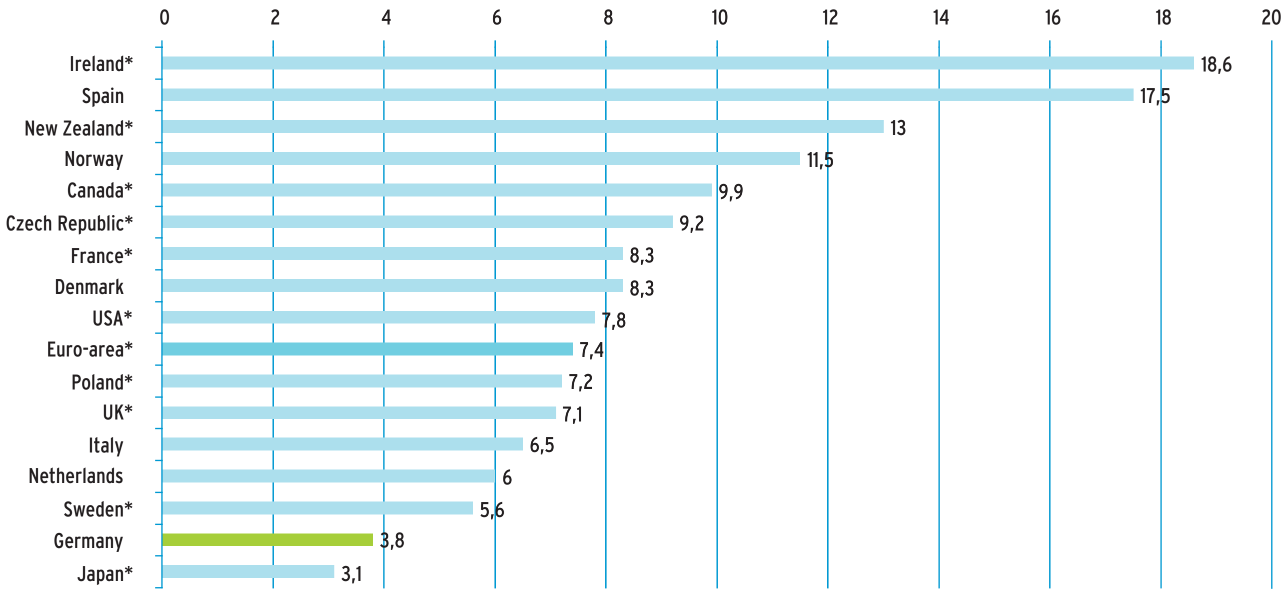
Source: DESTATIS (2008a)

Figure 2-1: Net investments in fixed assets as % of net domestic product in selected Eurozone countries, 1991–2007



Source: Horn, Rietzler (2007)

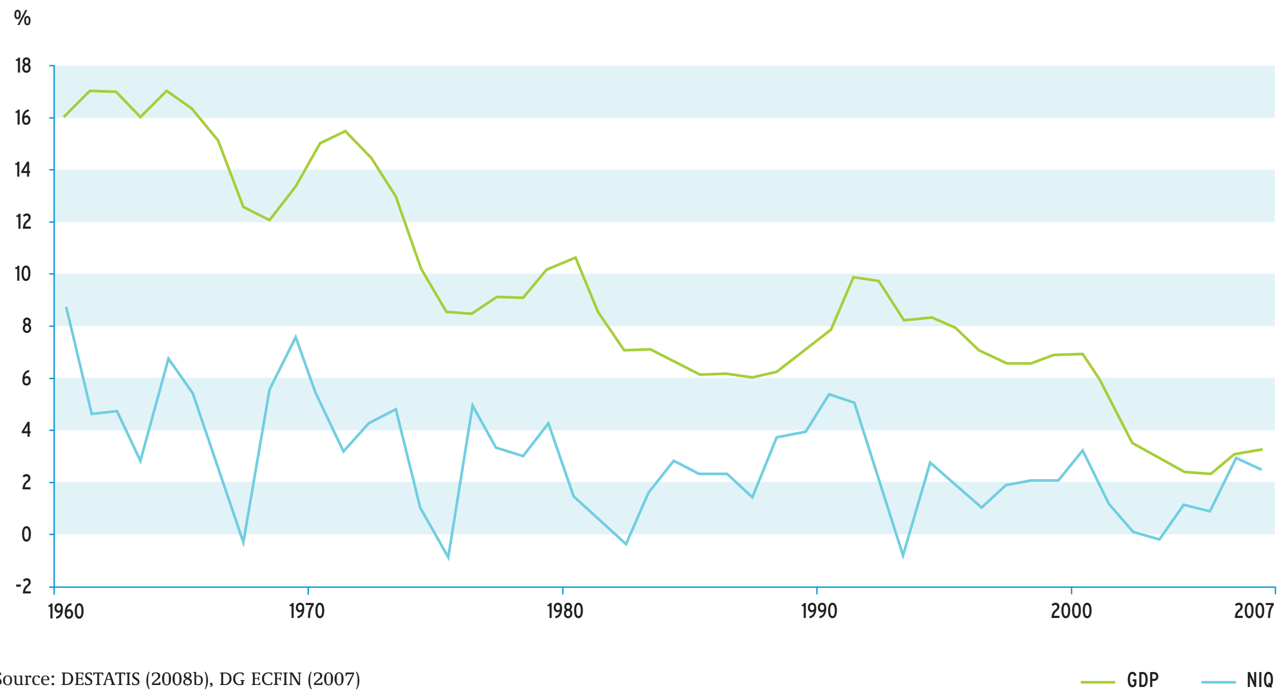
Figure 2-2: An international comparison of the net investment quota (in %), 2006



Source: Sinn (2007)

* = Values of 2005

Figure 2-3: Net investment quota (NIQ) and growth rates (GDP) in Germany, 1960 to 2007



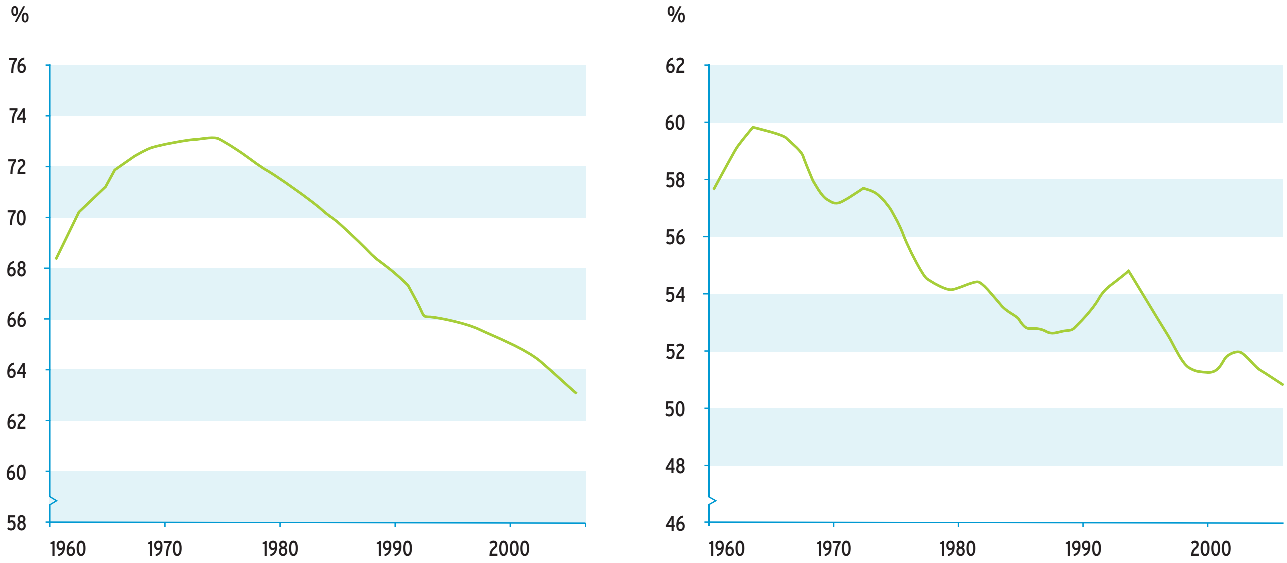
Source: DESTATIS (2008b), DG ECFIN (2007)

Germany's overall economic growth has also been slowing over the past decades, in a trend that is remarkably synchronous with the decrease in its net investment share (see Figure 2-3).[3]

The decrease in the net investment share has gone hand-in-hand with the ageing of German capital stock (Figure 2-4). As a result, the opportunity now presents itself to build a new base of resource-efficient capital stock relatively quickly. There is a particularly good opportunity in the construction sector, in which new investments are urgently needed in buildings built between 1946 and 1973.

3 In its 2002/03 report, as a result of careful empirical analysis the German Council of Economic Experts concluded with regard to economic trends: "To begin with, growth needs to be assured primarily via a continuing increase in private investments." (SVR 2002:336). In the past two years, Germany's net investments have increased, in what may be a short-lived fluctuation. Any continuation of this increase may well depend on whether a major increase in environmentally-oriented investments occurs in the next few years.

Figure 2-4: Fixed assets that have not yet been written off as a share of all capital stock (on the left, buildings; on the right, plants and equipment)



Source: BMF (2005)

Table 2-4: Emissions-reducing investments, 2005 (in billion euro; figures rounded off)

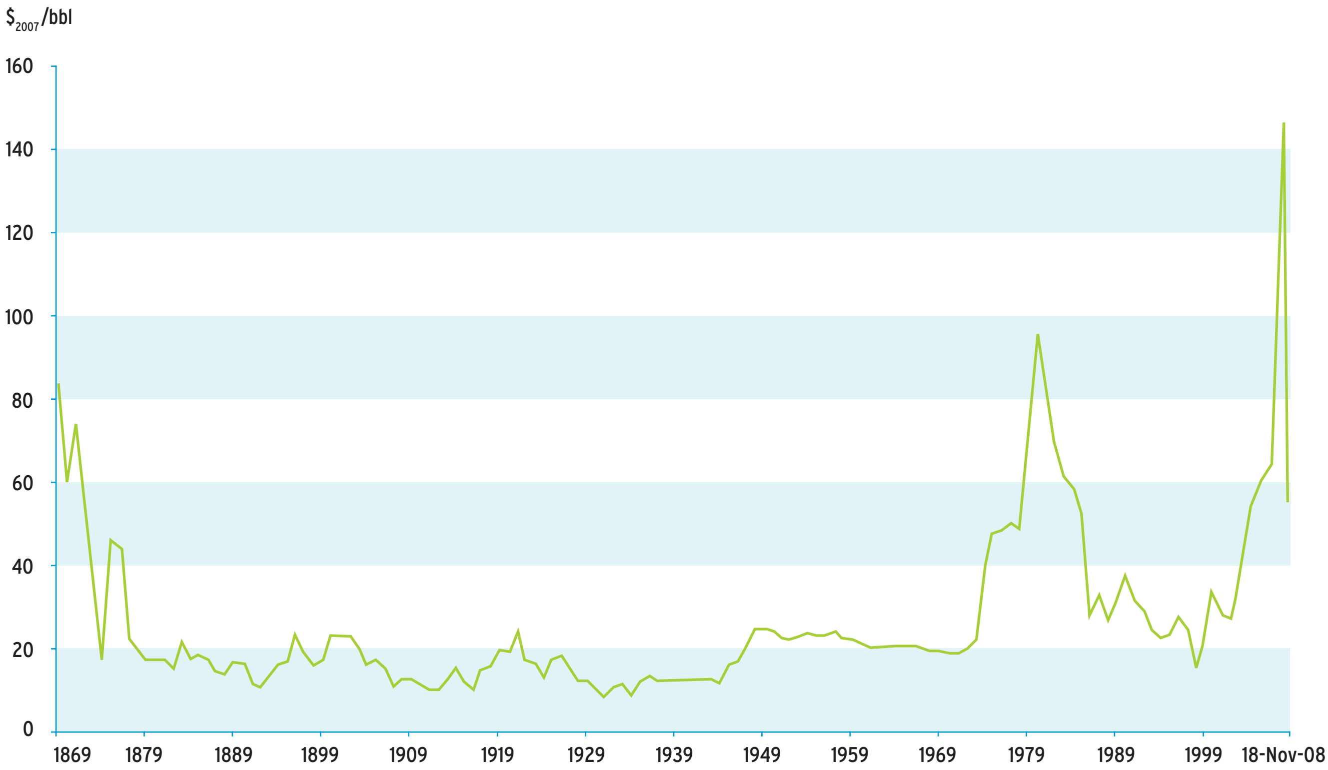
	Gross investments	Of which, emissions-reducing investments	Additional investments required via Meseberg programme
Buildings	197	40	14
Machinery	121	39	3
Power stations/grids[1]	12	5	10
Vehicles	50	10	2
Remainder	20	1	1
Total	**400**	**95**	**30**
Share of GDP (%)	20	5	1.5

1 Including renewable energies.
Source: DESTATIS (2008a), BEE (2006), BDEW (2008), Calculations of the PIK and the ECF

A successful implementation of the Meseberg programme would induce additional net investments in the order of €30 billion per year up to 2020. If such an increase is not achieved by 2015, significantly larger investments will be required in the years thereafter if climate targets are to be reached.

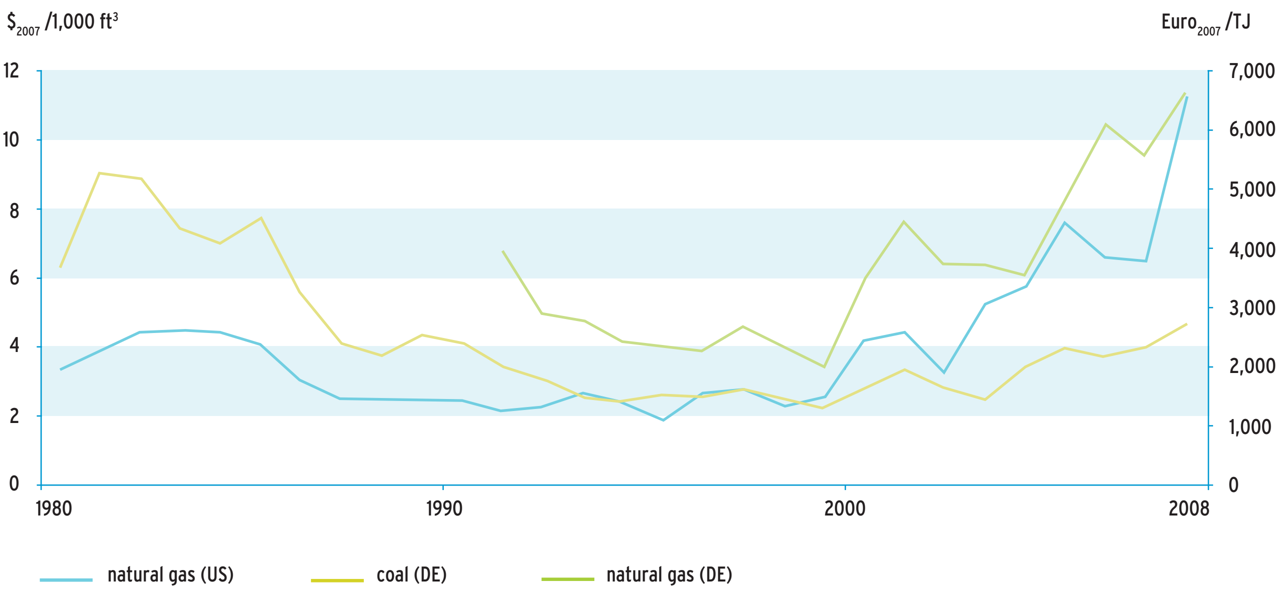
It must be remembered that emissions-reducing investments amounting to about 5% of GDP are already being made. The Meseberg programme would increase such investments by about one third, to 6.5% of GDP (see Table 2-4).

Figure 2-5: Development of the actual oil price, 1869–2008 [$\$_{2007}$/bbl]; annual mean prices for type WTI. The last two values are the WTI spot prices as of 3 July and 18 November 2008.



Sources: WTRG (2007), Inflationdata (2008), Bloomberg (2008)

Figure 2-6: Development of real gas prices (U.S. natural gas prices) [$\$_{2007}$/1,000 ft^3] and (import prices for Germany) [$euro_{2007}$/TJ], and development of real CIF prices for third-country hard coal [$euro_{2007}$/TJ]



Sources: BAFA (2006), EIA (2008), Bloomberg (2008), BMWi (2008), VdKI (2008)

The Meseberg programme is also an answer to the problem of the long-term trends of energy prices – especially the price of oil. The oil price has recently reached all time highs that considerably exceeded the price levels seen during the two global oil crises of 1974 and 1979 (see Figure 2-6). The present price level is more than twice as high as it has been between 1985 and 2001.

Gas and coal prices have also fluctuated by more than 300 % in the past few decades (see Figure 2-6). In view of the increasing demand from China, India and other emerging nations on the one hand, and problems with expanding extraction on the other, constant energy prices or price falls in the long term can no longer be expected in the coming decades.

This situation is increasingly becoming one of the central challenges for today's national economies.

In this situation, a major boost in ecologically-oriented investments can

- reduce the German economy's vulnerability to energy price volatility,
- bring about the development of technologies and infrastructure for a climate-friendly and energy-efficient economy, and
- help to overcome the slowdown in investments seen in the past years, thereby generating growth and employment. pected in the coming decades. This situation is increasingly becoming one of the central challenges for today's national economies.

3 A STRATEGY FOR GROWTH, EMPLOYMENT AND CLIMATE PROTECTION

Progress in energy technology, a higher degree of efficiency and reduced emissions will be realized "without fail" through the learning processes enabled by reinvestment. Higher energy efficiency and fuel substitution can be achieved even without further energy and climate policy intervention during the reinvestment and investment expansion cycle. This technological progress, depicted here in a reference trend for the energy sector, means that the German primary and secondary energy demand (about 14,500 PJ) would hardly change over the next 20 years. The autonomous technical progress, in combination with the energy and climate policy measures already in place today, would enable further economic growth in Germany without a corresponding increase in its energy demand[4]. This stabilization of the primary energy demand, in spite of economic growth of 1.5% per year on average, has already been observed in Germany over the past 17 years.

With the policies in existence today and assuming the reference trend, Germany's greenhouse gas emissions would stagnate at their present level until 2020, i.e. at about 980 million t CO_{2eq}/a, which is about 20% lower than the corresponding level for 1990. By 2030, greenhouse gas emissions would even have decreased slightly to 955 million t CO_{2eq}/a (Fraunhofer-ISI et al. 2008b). Emissions could, however, be lowered significantly through effective implementation of the Meseberg programme. The following section describes this in detail and its overall implications for the economy.

3.1 The Meseberg programme measures: impact on energy demand, emissions and investments

An effective implementation of the programme finalized in Meseberg in 2007 would lead to the following results in the overall picture of energy management:

- From 2010 until 2020, net electricity demand (not including power stations' own consumption) would first remain at current levels, and then drop by 8 % to some 1,890 PJ (524 TWh). In the decade thereafter, it would decrease still further, by nearly 9 %, to 1,712 PJ (476 TWh). Based on the reference development, electricity-saving technical advancements would increase by approximately 1 %, a plausible result considering the additional measures adopted from the Meseberg Programme.
- Between 2010 and 2020, heating fuel, transport fuel and district heating demands would decrease by 8 % to around 7,000 PJ and by an additional 6 % in the following decade to 6,570 PJ. The efficiency gains achieved through the Meseberg measures would thus amount to approximately 0.8 % per year (not including fuel requirements for thermal power stations).
- With regard to the reference trend, net energy requirements would drop by 11 % in 2020 and by approximately 16 % in 2030. This means that the Meseberg programme would increase the energy saving technological progress by 1 % per year.

According to the calculations made as part of our analysis, the Meseberg programme would reduce greenhouse gas emissions by approximately 173 million t CO_{2eq} by 2020 in comparison to the relevant levels in 2007 (compare Table 3-1, which covers all domestic emissions effects). The calculations do not include the moderate abatement in methane and N_2O emissions that would occur due to reduced fuel consumption.

All in all, greenhouse gas emissions would decrease by nearly 34 % in comparison to their 1990 levels, i.e. this programme would not be able to completely meet the Federal Government's target of reducing greenhouse gas emissions by 40 %.

Some aspects of the greenhouse gas reductions by 2020 are listed below:

- The largest contributions to reductions can be expected from the sectors a) residential and non-residential buildings (including heating from renewable energy sources) and b) electricity generation from renewable energies, each responsible for a reduction of nearly 50 million t CO_2.
- In the two sectors of commerce/trade/services and private households, decreased fuel and electricity consumption will lead to a reduction of nearly 14 million t CO_2. Reduced consumption is achieved through smart procedures for measuring electricity use, energy-efficient products (primarily electrical appliances in households) and energy management.
- In industry, significant contributions come from the reduced use of fluorinated greenhouse gases (−17.5 million t CO_{2eq}) and energy management (−9 million t CO_{2eq}). The slight increase in fluorinated greenhouse gas emissions indicated in Table 3-1 is due to the reference trend (+19 million t CO_{2eq} by

4 Compare the "without measures" scenario in: Fraunhofer-ISI et al (2008b): Politikszenarien für den Klimaschutz IV.

Table 3-1: Greenhouse gas emissions reduction, induced investments and specific reduction costs under the Meseberg programme until 2020

1990 emissions baseline: 1,228.1 million t CO_{2eq}		Reduction 1990–2007: 20.1 %	
2007 emissions baseline: 981.3 million t CO_{2eq}			
Measure	Emissions reduction [millions of t CO_{2eq}]	Investment volume 2008–2020 [billions of euro]	Specific abatement costs in 2020 [euro/t CO_{2eq}]
Comprehensive measures			
Measures applying to buildings	48	150	- 80
Of which, Renewable Energy Heat Act (EEWärmeG)	15	39	73
Energy management industry	8.9	7.2	- 80
Energy management commerce/trade/ services	2.3	3.3	- 47
Combined Heat & Power Act (CHP Act)	20	- 0.3	9
Households, commerce/trade/services			
ISmart electricity metering procedures	3.4	5.0	- 105
Energy-efficient products	8.2	0.8	- 330
Measures in the transport sector			
CO_2 strategy for automobiles (incl. hybrid vehicles)	17	60	- 130
Expanding the use of biofuels	4.6	1.3	170
Motor vehicle tax based on CO_2 emissions	3.1	0.0	- 470
Fuel consumption labelling for automobiles	3.5	0.0	- 450
Electric mobility (excl. hybrid vehicles)	1.3	2.5	290
Improved toll charges for trucks	0.5	0.5	78
Air transport (international in 2020: 1.9 million t)	0.4	2.7	- 95
Ship transport (international in 2020: 0.5 million t)	-	0.4	- 390
Measures in industry			
Fluorinated GHG (effect: 17.5 million t)[1]	- 1.3	12,0	120
Measures in the energy conversion sector			
Electricity generation from renewable energies	50	67	45
Feed-in of biogas into the gas network	3.5	1.1	55
Total for Meseberg programme	173	314	- 38
Reduction Meseberg programme from 2008 (1990 basis)	14.1 %		
Reduction for the period from 1990 until 2020	34.2 %		

1 To calculate the average abatement cost, the total effect (17.5 million t) was taken into account
Source: Calculations by the ISI, the BSR, the PIK and the ECF

2020), which is not fully offset by the emissions reduction of 17.5 million t.
- An additional emissions reduction of approximately 20 million t CO_2 occurs due to the effects of the Combined Heat and Power Act (Kraft-Wärme-Kopplungs-Gesetz, KWKG). While the KWKG is primarily effective in the industrial sector, it also provides relevant incentives in heat-intensive commerce/trade/services companies and in district and local heat generation.
- In the transportation sector, the greatest reductions take place in the automobile segment (about 30 million t CO_{2eq}). These come from a faster phasing-in of low-emission vehicles and an increased use of biofuels (biofuels are assumed to make up 14 % of all fuels in the year 2020). The measures concerning air and ship transportation will primarily impact international routes and only affect domestic traffic to a very limited degree.

Greenhouse gas emissions reductions normally involve a switch from non-renewable resources to renewable resources, increased energy efficiency and/or improved organisation, maintenance and servicing of industrial processes. Between 2008 and 2020, the Meseberg programme will directly spur investments of more than €310 billion (see Table 3-1). In order to properly interpret the investment figures for the period 2008 to 2020, the following points should be noted:

- The level of investments in the construction sector (including renewable heat) appears at first glance to be relatively high with around 150 billion measured against the investments in energy-efficient appliances or the values allocated to industry. This can be explained by the fact that investments in appliances and equipment are often more cost-effective and, relative to the building measures, have a significantly shorter re-investment time.
- By contrast, some investment values may seem too low – for example those in energy-efficient products, in expanded biofuel use or in combined heat and power generation. The reasons for these "low" investment figures include the high returns on complementary investments (for example in the area of equipment), the higher operating costs involved (for example in connection with biofuel use) and the high levels of avoided investment costs (for example CHP systems instead of thermal power stations and heat generation systems).
- Two organisational measures in the transport sector – the motor vehicle tax based on CO_2 emissions and fuel-consumption labelling for automobiles – do not presuppose investments. However, the resistance of important stakeholders is standing in the way of the effective implementation implied in this study.

As part of the capital costs, the specific abatement costs are based on measure-specific interest yields ranging from 4 to 10 %. The energy prices used for evaluating saved and substituted energy quantities were taken from the study "Politik-Szenarien für den Klimaschutz IV" ("Policy scenarios for climate protection IV"; Fraunhofer-ISI et al. 2008b). For each measure, the annual total costs (or revenues) in 2020 were regarded in relation to the applicable greenhouse gas emissions avoided in 2020.

The findings for the specific abatement costs for the year 2020 vary between −470 and 290 €/t.[5] At the same time, the figures for the specific abatement costs do not include secondary benefits, such as the improved noise insulation also provided by double- and triple-pane windows, lower amounts of production waste and higher product quality due to improved temperature control for industrial processes, and avoidance of other types of customary, local emissions from combustion processes. On average, the specific abatement costs in 2020 under the Meseberg programme amount to −38 €/t, i.e. on average, the Meseberg programme offers investors slight economic advantages as a group in the form of long-term cost reductions of 38 € per avoided t CO_{2eq}.

3.2 Greenhouse gas emissions reduction, and induced investments from measures supplemental to the Meseberg Programme

Because the Meseberg Programme measures are estimated to result in a reduction of 34 %, which is not sufficient to meet the German federal government's reduction target of 40 % for the year 2020, *additional measures and investments* are also identified and analyzed here. These additional measures in the various sectors shown in Table 3-2 reflect discussions from relevant studies involving different stakeholder groups. As a result of their implementation there would be additional savings of another 74 million t CO_2, approximately, but with necessary investments of close to 90 billion € to be made between 2008 and 2020.

If these measures are realized to the fullest possible extent, the 40 % reduction target of the German federal government could be achieved.

A significant share amounting to some 9 million t CO_{2eq} comes from a range of measures in the non-CO_2 area of greenhouse gas reductions that would be carried out mainly by industry, the energy sector and the agricultural sector. The specific measures are de-

5 The figures obtained by McKinsey (2007) are of the same order of magnitude. The primary reason for any specific differences is that this study did not consider changes in the relevant product types (for example, changes from emissions-intensive to low-emissions automobiles).

Table 3-2 Greenhouse gas emissions reduction, induced investments and specific reduction costs of additional measures until 2020

1990 emissions baseline: 1,228.1 million t CO_{2eq}		Reduction 1990–2007: 20.1 %	
2007 emissions baseline: 981.3 million t CO_{2eq}		Reduction Meseberg programme: 14.1 %	
Additional measures	Emissions reduction [million t CO_{2eq}]	Investment volume 2008–2020 [billion euro]	Specific abatement costs in 2020 [euro/t CO_{2eq}]
Comprehensive measures			
Accelerated refurbishment of buildings	4.2	19	– 10
Eco-design industry	12	15	– 15
Eco-design commerce/trade/services	3.0	5.2	– 5
Material efficiency	10	n/a	n/a
Private households, commerce/trade/services			
Incentives for organic farming	1.8	0.0	10
Measures in the transport sector			
Amendment of the Ordinance on company cars (Dienstwagen-VO)	2.6	0.0	– 560
Mandatory use of low viscosity oils (automobiles)	2.5	11[1]	– 190
Measures in industry			
Non-fluorinated non-CO_2 GHG	8.5	20	n/a
Measures in the energy-conversion sector			
Three state-of-the-art lignite-fired power plants	7.4	2.3	15
CCS for the three state-of-the-art lignite-fired power plants	13	5.7	50
HVDC/wind North Sea (3 GW)	9.0	6.0	29
Total for additional measures	74	84	– 21[2]
Reductions additional measures	6.0 %		– 34
Total (Meseberg & additional measures)	247	398	
Reductions 1990–2020	40.2 %		

1 Costs for low-viscosity oils (i.e. the figure does not represent investments)
2 While the measures "non-fluorinated non-CO2 GHG" and "material efficiency" are included in the table, they were not included in calculating the specific abatement costs.
Source: Calculations of the ISI, the BSR, the PIK and the ECF

scribed in the Policy Scenarios IV (Politik-Szenarien IV) (lower CH_4 emissions from waste management, the energy sector and metals production; abated N_2O emissions from industrial processes).

Additional measures that could provide reductions of 7 to 13 million t CO_2 each have been identified. These include early replacement of 3 to 4 old, low-efficiency, lignite-fired power stations by 3 new, highly efficient power stations (each with an output of 800 MW). If, in addition, these three new power stations were equipped with systems for CO_2 capture and storage, an additional reduction of the same order of magnitude could be achieved. However, plans for storing CO_2 in depleted natural gas fields or aquifers are subject to a range of uncertainties (especially with regard to additional safety requirements, monitoring and insurance; costs of about €50 €/t CO_2 currently seem realistic). Another comparable contribution could be made by 3 GW of additional wind power capacity with power transmission via high-voltage direct-current (HVDC) lines. An additional reduction of 2.5 million t CO_2 could come from the obligatory use of low-viscosity oils in automobiles.

The heterogeneity of the measures and the options for expanding or reducing the scale of the measures allow a flexible use of market opportunities as they arise. Any relevant decisions should take account of other pertinent aspects, such as the potential for exports and for cost reduction through economies of scale (for example, in the area of renewable energy and building modernisation) that cannot always be predicted at present.

Other measures cause moderate abatement costs, and a range of measures would also generate earnings. The total average abatement costs for the additional measures would amount to about −21 €/t CO_{2eq}, i.e. participating investors as a group would enjoy cost reductions in 2020. But these would be significantly smaller than those resulting from the Meseberg programme measures discussed in Chapter 3-1.

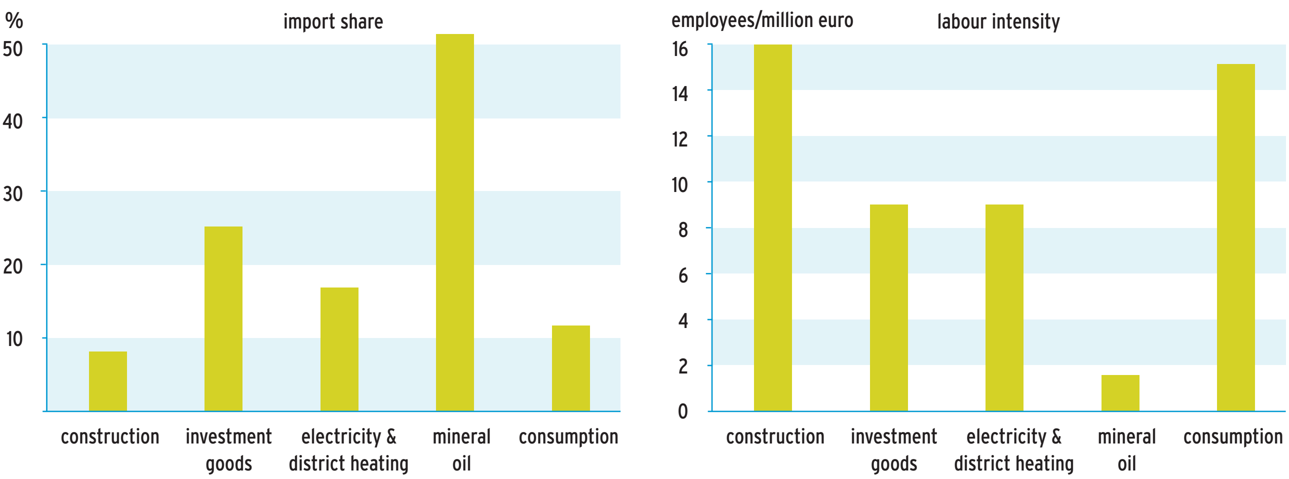
The total volume of investments for the period from 2008 to 2020 would amount to almost €400 billion (see Table 3-2). In 2014, investments would exceed €30 billion per year, and by about 2020 they would total nearly €35 billion per year. This equals an increase in investments by a good third compared with existing net investments. Clearly, this represents a major challenge for the capital market. Investors would realise total specific returns averaging €34 €/t CO_{2eq} in 2020.

3.3 Impacts on economic growth, consumption and employment

The gross investments required to implement the relevant measures would also have indirect effects. In order to prepare the ground for investments, other sectors also have to undertake a series of preparatory efforts. Consequently, the Meseberg programme would cause a shift in the economy's sectoral structure. There might also be significant macro-economic effects if climate-protection measures led to changes in the flow of imported goods. Furthermore, employment effects might be felt if the affected sectors have a significantly different import or employment intensity.

These structural effects are expected to have positive effects for Germany as the additional net investments of 30 to 40 billion euros are more likely to favour domestic and employment-intensive sectors (such as industrial goods); moreover, Germany continues to have available capacity in the employment market (compare Figure 3-1).

Figure 3-1: Import shares and labour intensity levels of different value-added chains (cumulative direct and indirect effects)



Source: IEKP (2008)

Climate protection measures provide three main types of direct impetus for the economy as a whole:

1. Additional investments in climate protection, investments which also reduce or eliminate the need for certain other types of investments
2. Changes in energy costs and energy expenditures
3. Changes in energy imports, especially imports of fossil fuels

Along with additional climate protection investments – which have been differentiated by sector for each measure – changes on the cost side (both increased capital costs and reduced energy costs) are also taken into account. Data on investment and cost changes are determined in this project by means of a detailed enquiry on a technological basis and serve as input for the macro-economic modeling.

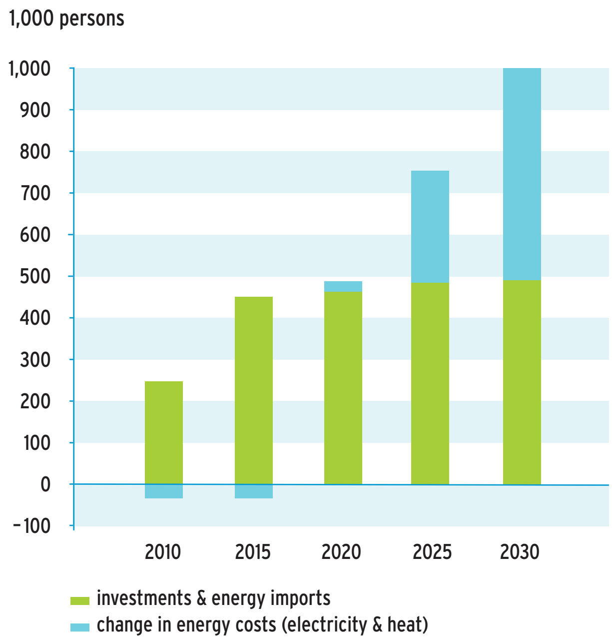
The analysis showed that energy costs increase to a limited extent in the first decade (in the industrial sector by up to 6 % and up to 1.5 % in the transportation sector), while efficiency-enhancing measures result in falling energy costs over time, both for households and industry. By 2030, such reductions would actually translate into savings of about 20 % of energy expenditures.

Such savings are also reflected in the reduction of Germany's energy imports, which would sum up to €38 billion by 2030. The most recent information implies that these estimated import savings may still be too low as the scenario assumptions according to EWI, Prognos (EWI, Prognos 2006: Fraunhofer-ISI et al. 2008b) have already been overhauled by the development of the crude oil price. In addition to such direct effects of the climate protection package, comprehensive overall economic analysis must also take account of indirect effects – for example, multiplier and accelerator effects that can reinforce the initial impetuses.

The macroeconomic analysis has been carried out with the ASTRA economic model. Considerable positive effects result in the economy as a whole:

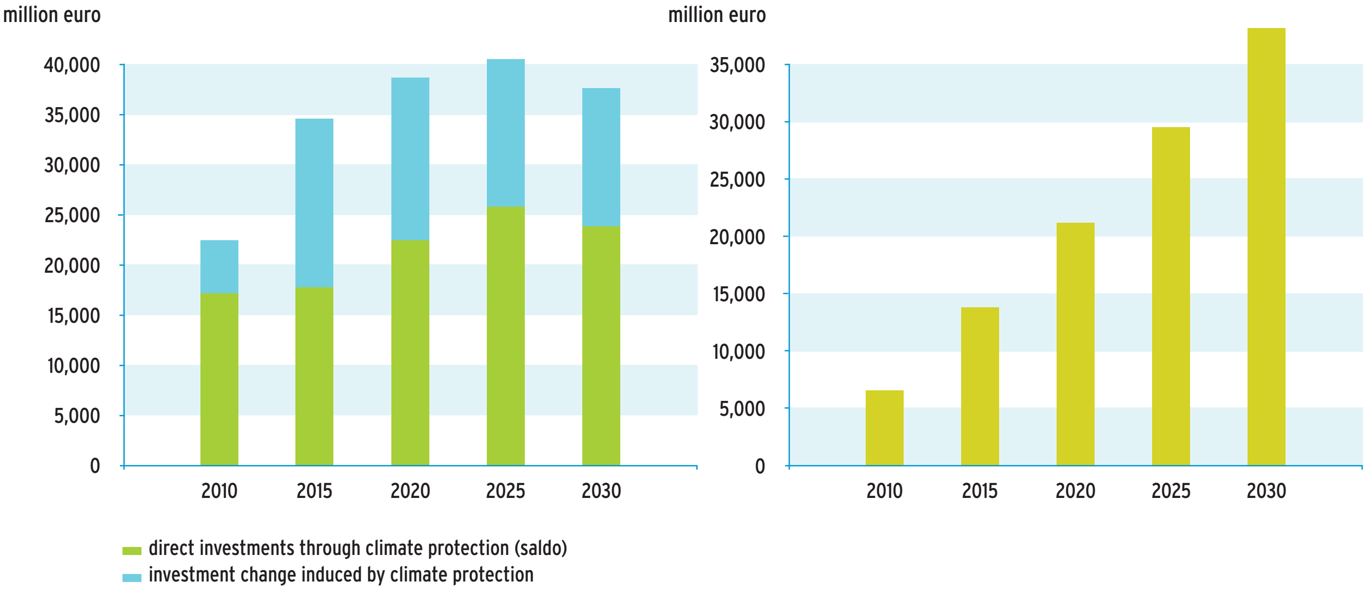
1. On average, the GDP lies some €70 billion above the corresponding figure in the reference case, i.e. in terms of the economy as a whole, the Meseberg programme and the additional measures will not (in contrast to what is sometimes expected) slow economic growth.
2. Throughout the period as a whole, the cumulative impetus resulting from additional investments, energy costs and energy imports savings and the induced structural changes benefiting labor-intensive sectors will lead to significant growth, amounting to at least 500,000 additional jobs in 2020, and to at least 900,000 additional jobs by 2030 (see Figure 3-2). A breakdown of the effects into components shows how their impact changes over time. While induced investments and import savings clearly dominate in the first decade, energy cost reductions become more and more significant later on, and the impacts of investments stagnate.

Figure 3-2: Employment growth over time differentiated by driving factors (investments, energy imports and changes in energy costs)



Source: Calculations of the ISI using the ASTRA model

Figure 3-3: Increases in investments (left) and reduction in energy imports (right), 2010 to 2030



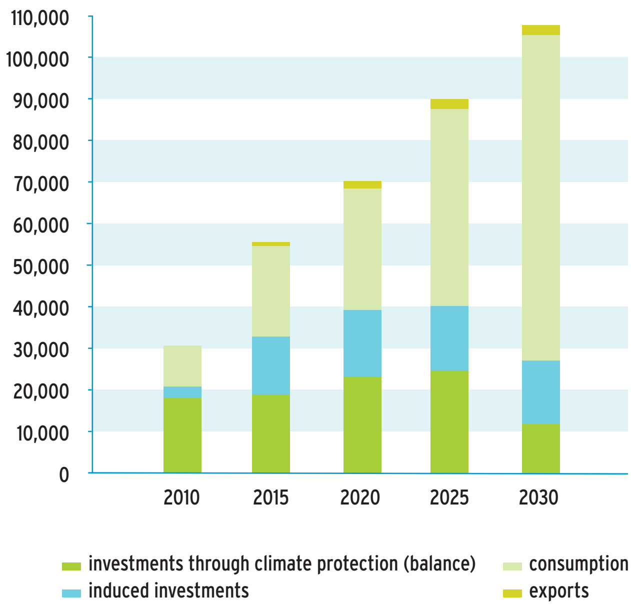
Source: Calculations of the ISI, using the ASTRA model

In these trends, it is important to note the dynamics of change (compare Figure 3-3). Initially, the predominant investments consist of those triggered directly via climate protection efforts. These investments can be interpreted as the balance of additional and avoided investments resulting from climate policies. Until 2020, both additional and avoided investments increase. Thereafter, there is a marked drop in both types of investments. The balance increases until 2025 and then decreases with the result that induced investments become more important in the second decade. Savings in the area of energy imports grow continuously throughout the entire period.

The overall economic impacts of the Meseberg programme can be broken down into two distinct phases (see Figure 3-4):

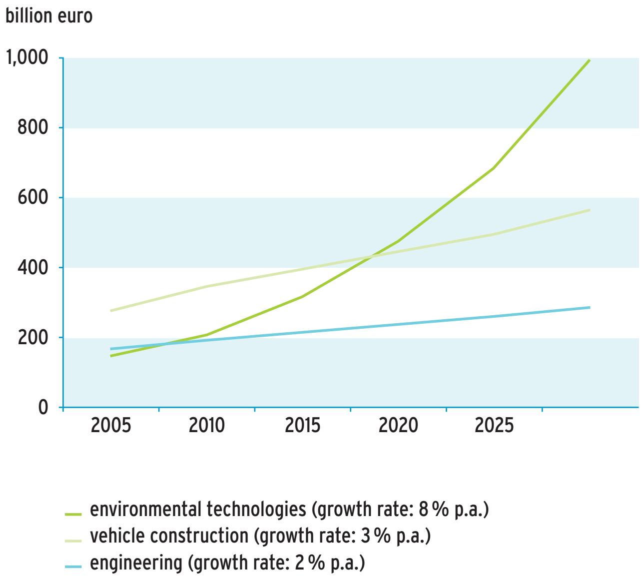
1. During the first phase, growth in the investment component is driven primarily by additional investments in climate protection. The largest contribution to growth in 2020, amounting to about 60 % of investments, consists of about two thirds of direct climate protection investments and one third additional investments induced by second round effects.
2. At the beginning of the second phase after 2020, consumption growth is driven by multiplier and accelerator effects. By 2030, such growth contributes nearly 60 % to the increased GDP. Since ASTRA was designed as an economic model for the EU29, the increased German GDP leads to additional imports from EU countries, causing those countries' GDPs to grow in turn and resulting in

Figure 3-4: Dynamics of growth contributions of GDP components



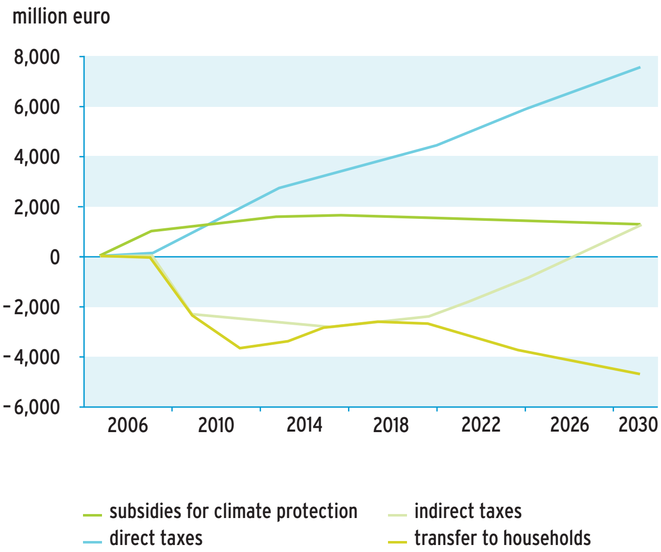
Source: Calculations of the ISI using the ASTRA model

Figure 3-5: Forecast of turnover trends for the environmental technologies sector and for two other sectors in Germany until 2030



Source: Roland Berger (2007)

Figure 3-6: Changes in key components of the national budget



Source: Calculations of the BSR

them importing more goods. Germany is the supplier for some of these additionally imported goods. Such feedbacks in trade flows cause the described slight increase in German exports.

According to Roland Berger (2007), the world market for environmental technologies is expected to grow to about €2,200 billion, of which about € 1.7 trillion would be in the area of climate protection (including transport technologies) in 2020. Overall, climate protection technologies – and other environmental technologies – are expected to grow significantly for the German industry (compare Figure 3-5).

The implementation of the Meseberg programme will help to further improve Germany's position in the growing lead market for environmental technologies, thereby ensuring its success in this world market. In a scenario analysis in which such market success is assumed, some € 17 billion of additional demand for German climate protection technologies results in 2020 due to foreign trade. This increases the GDP still further, by an average of 20 billion euros/year, between 2010 and 2030. In the decade from 2015 to 2025, such export impetus could lead to the creation of approximately 200,000 jobs.

The national budget would also profit from implementation of the climate protection package. In spite of decreases in indirect tax revenue (for example, decreases in mineral oil tax revenue), the nearly €2 billion in additional subsidies needed to implement the climate protection package would be more than offset by the growth in direct tax revenue, and from the decreases in transfer payments from increasing employment (see Figure 3-6). As a result, the national debt in 2030 would be some € 180 billion lower than it would be without the climate protection policies.

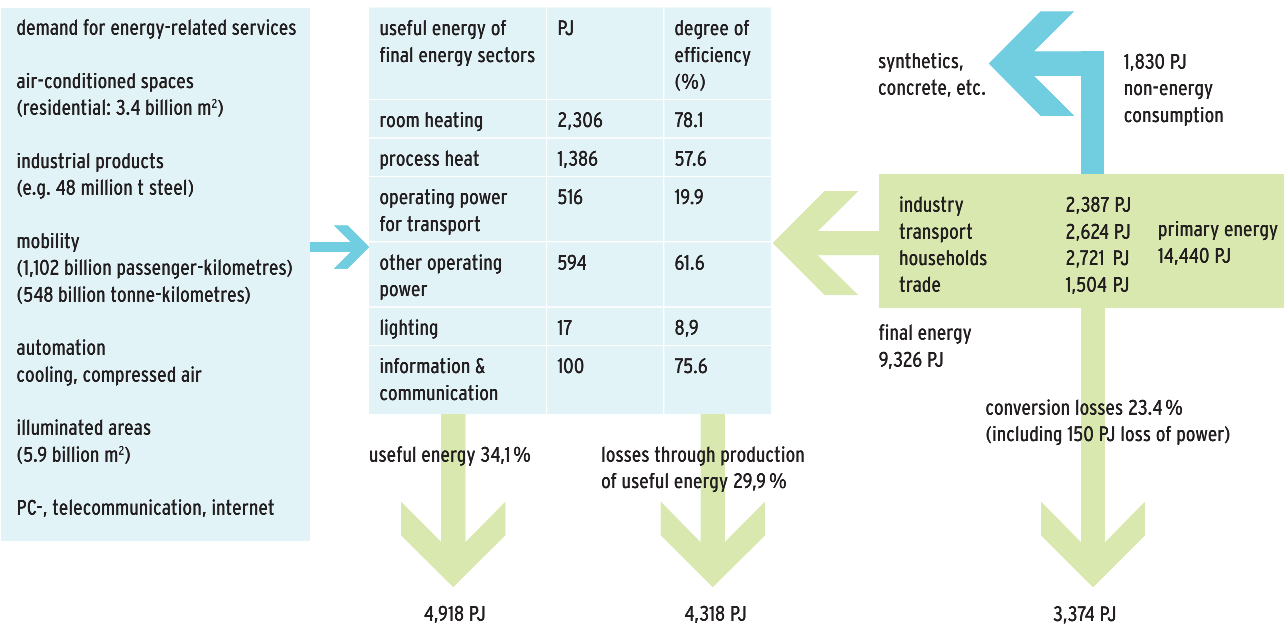
4 CLIMATE PROTECTION INNOVATIONS: A LOOK BEYOND 2030

The time horizon of the Meseberg Programme extends to 2020, but the quantification of Germany's energy requirements and greenhouse gas emissions presented here has a time horizon until 2030. If the climate problem is to be solved, it is necessary to look beyond the year 2030, especially with regard to developments in emerging countries. It is clear that any forward-looking climate policy and energy policy strategy must be based on two central principles: first, a vast increase in energy efficiency (which would reduce energy requirements significantly) to levels that could be met with renewable energies; and second, coal-fired power stations equipped with CCS – assuming that CCS technology fulfils its promise.

Occasionally, concern is expressed as to whether energy efficiency potentials might be exhausted in 20 to 30 years. Furthermore, the prospect of an expected global population of 9 billion people by the turn of the century and of a gross world product, which is 10 to 15 times higher, imply that the expansion of the energy supply would have to be given political priority. This allegation is then underlined by the fact that the specific requirements of energy-intensive processes in the base industries are only about 10 to 20 % above the theoretically possible minimum levels, and that similar efficiency gains have been made in many types of energy transformation devices, including electric motors, generators, boiler systems, etc.

However, concerns about the so-called "escalator effect" overlook the fact that per capita primary energy requirements in industrialised countries could already be reduced fivefold. Such reductions would involve not only the technological potentials for enhancing energy efficiency, but also a) greater efficiency and greater substitution of energy-intensive materials and b) social and entrepreneurial innovations that can change demand behaviour, decision-making routines, priorities and preferences. Knowledge and use of relevant innovation systems will play a central role in any fast realisation of the existing potentials for efficiency and the use of renewable energies.

Figure 4-1: Energy flow diagram showing energy losses on all three levels of energy use and transformation, Germany 2004



Source: Fraunhofer-ISI (2006)

Today's energy losses point to future efficiency gains
Energy losses are still very high on three levels – useful energy, final energy conversion and primary energy conversion (see Figure 4-1).

- It is often assumed that, for any given type of desired work, the effective energy consumption per unit is a constant. And yet the amount of energy consumed always depends on the efficiency of the technology being used, as the example of the so-called ‚passive' house illustrates. Passive houses are far more energy-efficient than average, conventional structures. Energy losses on the effective energy level amount to about one third with regard to primary energy in Germany (the largest losses occur in the area of building heating, where at least 90 % of the consumption of about 2,300 PJ must be considered losses).
- In final energy transformation, losses of 30 % can occur (with the largest contribution from road vehicles, amounting to nearly 80 % of all petrol/diesel fuel consumption).
- In the transformation of primary energy into final energy, losses amount to 23 % (with the largest losses occurring in thermal power stations; losses here range between 41% and 67 %).

In the final analysis, only about one third of input primary energy is actually used for mobility, production, heating and services.

Furthermore, about 12 % of total primary energy consumption is used for non-energy purposes – for plastics, asphalt, etc., i.e. especially for oil-/gas-based products. Finally, the efficiency of energy-intensive materials can be significantly increased via a wide range of measures. It is estimated that such measures could reduce primary energy requirements by 0.5 % per year (Enquete Commission 2002).

Technical potential for increasing efficiency
As the (1990) study of the German Bundestag's Enquete Commission on "Preventive Measures to Protect the Earth's Atmosphere" showed, and as more recent studies have confirmed, the primary energy consumed to satisfy human energy services requirements could conceivably be reduced by more than 80 %, i.e. by a factor of 5 within the next 60 to 80 years. The potential efficiency improvements can be grouped into four technological categories (Jochem et al. 2004):

1. Improvement of energy efficiency in the energy conversion sector (i.e.: motors, turbines, compressors, heat exchangers, heat pumps, photovoltaic systems).
2. Reduction in effective energy demand through process changes and substitutions (i.e.: use of passive houses and ultra-light vehicles; the substitution of thermal separation and synthesis processes by physico-chemical and biotechnological ones).
3. Intensified recycling and improved efficiency in the use of energy-intensive materials (i.e.: prevention of faulty batches, improved material qualities, higher recycling levels (with better separation), reuse).
4. Replacement of currently utilized materials and substances by less energy-intensive materials (for example, light metals, new types of plastic, biomass-based plastics, natural fibres, wood, etc.).

Overall, these four areas have significant potentials to increase energy and material efficiency, and the possible increases are often still grossly underestimated. Research and development have created enormous opportunities for long-term reductions – amounting to a factor of five in comparison to current levels – in the primary energy requirements of industrialised countries. At the same time, efficiency improvements could be amplified via organisational and entrepreneurial innovations, such as the intensified use of investment goods and long-lived consumer goods (for example, in areas such as construction machinery, automobile transportation (car sharing) and energy-intensive processes, as in subcontracting). In Switzerland, this vision of a highly efficient industrialised society at the end of this century has been described and named the "2,000-watts-per-capita society".

Renewable energies and CO_2 capture and storage
Recent studies (such as Nitsch 2007) have shown that renewable energies have the potential to provide more than 50 % of Germany's current final energy requirements, i.e. more than 3,000 PJ/a, by 2050. Renewable energy sources could provide about 80 % of final electrical energy requirements and over 40 % of heating and fuel requirements. These high levels will be achieved using biomass, solar and wind energy, geothermal and hydroelectric power. The various types of systems involved are assessed as follows in terms of their adoption over time and their cost reduction potential:

- Biomass currently accounts for a large share of renewable energies – about 68 %. By 2050, this share will decrease to about 38 %, although absolute final energy generation from biomass could still increase considerably to about 1,200 PJ. Biomass resources will peak around mid-century unless new forms of industrially produced biomass (such as algae) are introduced.
- Solar energy (photovoltaic systems, thermal collectors, and solar power from a European network and from North Africa) has the largest growth potential;

its share in renewable energies could grow from its current level of about 2% to approximately 24% in 2050. The highest cost reduction potential is also anticipated for solar technologies. While grid parity with end consumer prices for electricity can be achieved with photovoltaics by 2020, competitiveness with thermal power plants is anticipated by 2050.
- By mid-century, Germany's wind power sector is expected to reach about 60 GW of installed capacity and have an electricity output of about 200 TWh. Offshore wind energy offers great potentials for growth and innovation, and offshore systems could be meeting more than one fifth of electricity requirements by 2050. Power generation from ocean currents is an additional option.
- Geothermal systems are expected to be able to provide about 20 TWh electrical power and about 100 TWh thermal energy by 2050. Geothermal systems have great potential for cost reduction, especially in the area of hydrothermal applications.
- Hydroelectric power is now almost fully exploited in Germany. This sector can be expected to experience slight growth of about 10 to 20% through performance enhancements due to reinvestments in and the revitalization of small systems.

If these potentials are to be exploited, a range of non-economic obstacles will have to be overcome, electricity grids will have to be converted (a process that will include the use of high voltage direct current lines, known as HVDC transmission) and other technical and organisational innovations will have to be introduced on a significant scale. Furthermore, to ensure a rapid decrease in costs, the use of such technologies will have to be quickly expanded on an international level as well.

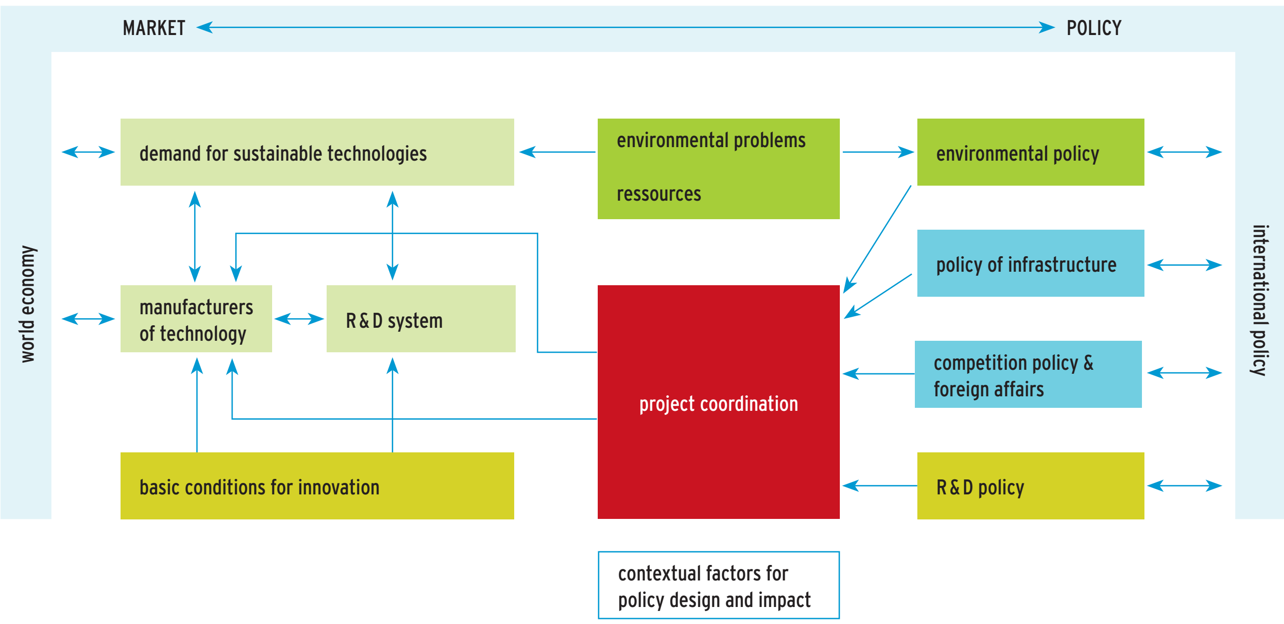
In light of the importance of coal in electricity generation in Germany and around the world, CO_2 capture and storage systems for large thermal power stations will play an especially relevant role in climate protection. Such technologies could become available on an industrial scale by approximately 2020. By 2050, they could play a significant role in making it possible for economic growth to go hand-in-hand with reductions in global greenhouse gas emissions.

Accelerating innovation through use and concerted action

Today's research and development of products, facilities and vehicles need to be more oriented towards resource efficiency criteria than was previously the case. This refers not only to the resource efficiency of individual products, machines, plants and vehicles, but also to that of the respective systems (for example air vs. rail transport, urban planning efficiency of mixed use vs. that of single use housing developments).

An efficiency strategy and a renewable energy use strategy will involve a large number of technologies and stakeholders. If each technology is considered in isolation, it only shows limited potential. This, along with communication failures and past reliance on large-scale plants and systems, has meant that the different technologies' cumulative potentials have not been adequately exploited in the past.

Figure 4-2: Schematic diagram of the "Systems of Sustainability Innovation" approach



Source: Walz et al. 2008a

It is necessary to intensify innovation in these areas. The necessary increase in innovative dynamics can only be successful if conditions for the further development of climate protection technologies are taken into consideration. Consequently, active government innovation and technology policies are essential. Learning success in the market as well as the path dependency of technological developments are of considerable importance. And it must be remembered that it is often sensible to develop a number of competing, innovative technologies. If the pace of innovation dynamics is intensified, support should not be limited to just a few selected climate protection technologies.

A functioning system of innovation is characterized by **network building among research, development and application** (see Figure 4-2). Such a system's ability to produce useful innovations that quickly become accepted will depend on how well the system's stakeholders interact with each other. As economies strive to make a transition to largely emission-free operation, such interactions will take place within the framework of an open technology race.

5 FLAGSHIP PROJECTS

To counter the problem of climate change, humanity needs innovations along the lines of Einstein's statement: "We cannot solve the world's problems with the same thinking that created them". In addition to relevant analysis, the aim of the present project is to develop exemplary activities that can accelerate the innovation process through flagship and market introduction projects that have been identified as useful. The following section lists five examples of flagship projects that have the potential to trigger innovation and promote new approaches. Any successful implementation of the Meseberg programme would be based on flagship projects such as these and many others as well.

Example 1: Intelligent local energy-efficient networks as a highly efficient mechanism for increasing energy productivity in industry (Jochem et al. 2007). This refers to moderated meetings of company networks. Through lectures by experts and the regular exchange of experience and lessons learned among the parties responsible for energy issues, sector managers and participants receive all the relevant information to quickly implement energy-efficient and substitution measures in their companies. At present, 70 energy-efficient and climate protection networks are in place in Switzerland, while 10 such networks now exist in Germany. These networks achieve 2 to 3% annual reduction in their specific energy consumption, while the average corresponding reduction in industry amounts to only 1% per year.

Example 2: Installation of high-voltage direct-current (HVDC) transmission lines in Germany – a step towards a "SuperSmart Grid" for pan-European use of renewable energies (Czisch 2006, Battaglini et al 2008). Losses in HVDC lines are only about 50% of the losses in today's alternating current lines. By improving the efficiency of power transmission from production sites to consumption areas, HVDC lines would facilitate the intensified use of electricity from renewable sources. With such technology, Germany could lower its emissions and gain valuable experience with regard to the pan-European use of solar power from the Mediterranean and wind energy from the Atlantic, North Sea and Baltic Sea.

Example 3: Infrastructure for electric cars in selected urban agglomerations. The company "Project Better Place", whose founder and CEO is Shai Agassi, former SAP board member, has joined forces with Israel and Renault-Nissan in launching an ambitious pilot project to promote solar-powered electric cars. In addition, a similar project using wind energy has begun in Denmark. In Germany, municipalities can promote the use of electric cars for city and commuter traffic by offering parking and charging facilities. Experience could be gathered with electronic control of the charging processes in distributed networks. If electro mobiles are to take hold, their development must go hand-in-hand with the use of additional renewable energy capacity as part of a "SuperSmart Grid" (see flagship project 2), in order to achieve overall emissions reductions.

Example 4: CCS Power plant pilot projects for the assessment and – should this prove positive – development of this very promising technology (Wilson et al. 2008). In principle, it is possible to capture the CO_2 produced by fossil fuel-fired power stations and store it in geological formations. If the technology does not entail any unmanageable long-term risks or excessively high additional electricity generation costs, it will play a key role worldwide. Pilot projects that can provide the information now required in this area are thus urgently needed.

Example 5: The German Climate Fund (GCF – Deutscher Klimafonds (DKF) is the building block of an effective regime for worldwide financing of climate protection policy in the 21st century (Jaeger et al. 2008). In the interest of German climate policy's internal consistency, it is crucial to draw a substantial share of the revenues from the public sales of emissions rights.

The GCF would promote innovative solutions, both within Germany and abroad, via public-private partnerships. Similar instruments could be created on an international level. In Germany, the "Finance Forum: Climate Change" within the Federal Government's High-Tech Strategy could serve as an important discussion platform for preparation of the GCF.

In order to develop meaningful flagship projects on climate protection, an *Innovation Competition* should be held. Project ideas with the potential to make a significant contribution to the abatement of greenhouse gases or adaptation to climate change can be screened and encouraged. Prizes could be awarded for outstanding project ideas and initiatives. The German Climate Fund could back such ideas with co-financing in the framework of public-private partnerships, providing the full spectrum of support from the seed phase, through start-ups, up to successful marketing. As described in Chapter 6 of the final report "Investitionen für ein klimafreundliches Deutschland" (only available in German), a comprehensive approach needs to be taken:

Along with making the financial means available, the respective pioneering personalities are brought into contact with a network of stakeholders from marketing, organizational development, production and financial management, who together provide a sounding board for climate-friendly investment.

6 CONCLUSIONS

The Federal Government's aim of reducing Germany's greenhouse gas emissions by 40 % by 2020 compared to 1990 levels requires an additional emissions reduction of nearly 250 million t CO_{2eq} between 2008 and 2020. The present study shows that not only is this goal realistic, but that the German economy could profit considerably from a well-planned implementation of climate protection measures.

Such a "win-win" situation results because efforts to reduce emissions trigger investments if the right incentives are provided – investments that accelerate the pace of technical progress of the German economy. In the process, Germany develops expertise which will open up favourable export opportunities in the coming years. In order to take advantage of this chance, the financial sector will have to play an active role with new forms of public-private partnerships to provide and efficiently allocate the necessary investment loans and other funding.

By placing the abatement potentials examined here in the order of their currently anticipated abatement costs (see Figure 6-1), the following picture emerges:

- About half of the required reduction could be profitable on the micro-economic level. This conclusion does not take into account positive secondary effects such as improved noise protection, enhanced product quality and reduced waste. Information deficiencies, high transaction costs, the lack of market structures, coordination problems, stakeholders' other preferences and system inertia (such as badly adapted technical guidelines) have prevented such reductions taking place in the past.
- The other half would entail abatement costs ranging from € 10 to € 100 per abated tonne of CO_{2eq}.
- Revenues of 34 euros per ton of abated CO_{2eq} have been calculated for the investors as the average for the entire measures package in 2020 because the share of profitable measures is slightly higher.
- Two measures (biofuels and electric cars) would entail abatement costs higher than € 150/t CO_{2eq}. These measures involve still young technologies that need further development – biofuels with respect to biomass-to-liquid systems, and electric cars with a view to improving efficiency battery technology and low-emissions provision of the additionally required electricity.

The estimated abatement costs are comparable in magnitude with those identified by earlier studies (compare McKinsey 2007, IEKP 2008). At the same time, point-by-point comparisons are not practically feasible, primarily because the present study includes operational costs, makes more up-to-date energy-price estimates and takes the latest applicable political decisions into account when describing the measures.[7]

The estimates made in the study are oriented to a situation in which the German economy has responded to an important political signal from European emissions trading. The study shows that a combination of emissions trading and sectoral or technology-specific measures can produce climate, energy and economic policies that are benefical for Germany.

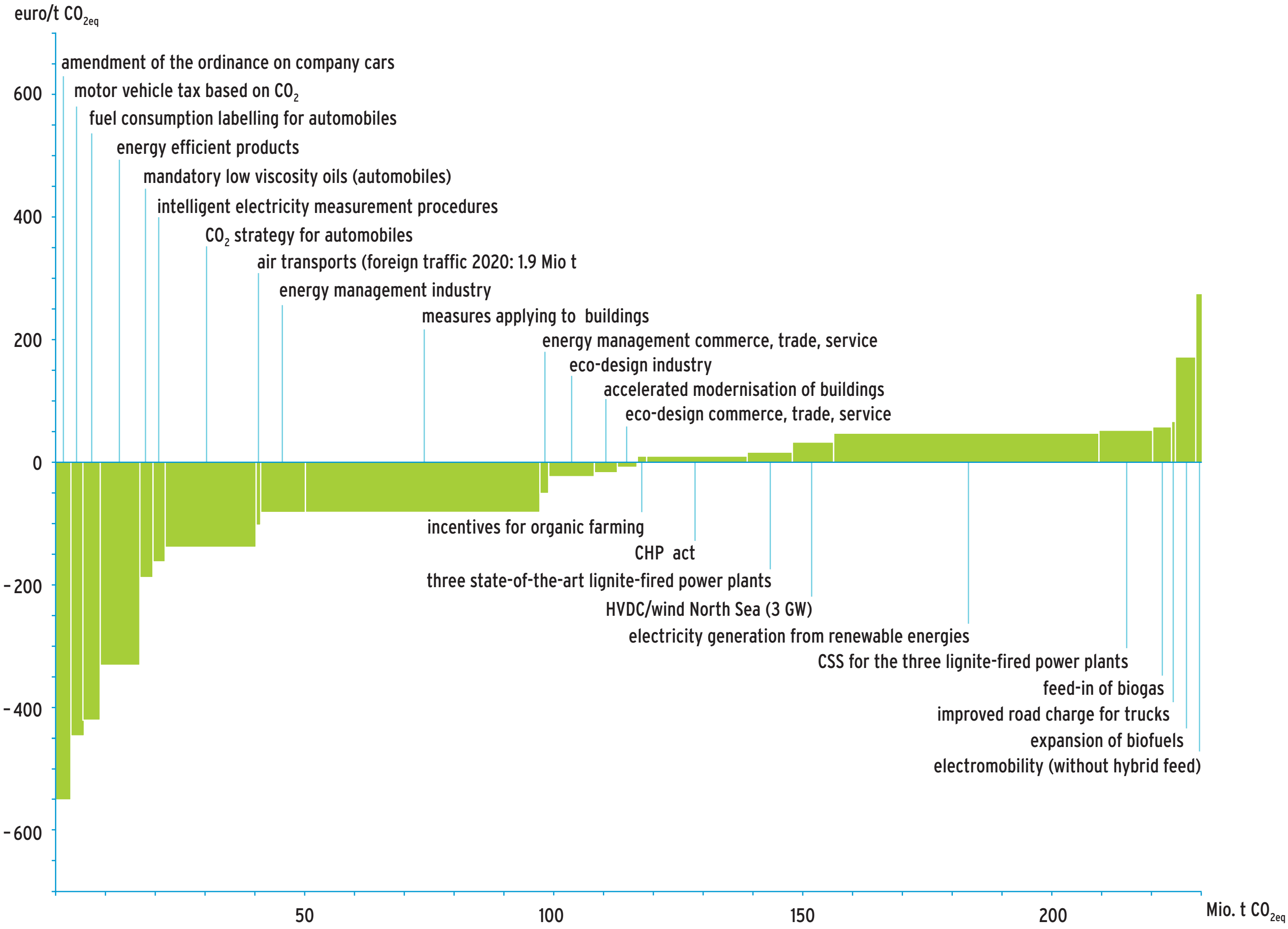
The outset situation in Germany is especially favourable for ambitious climate policy, because the following three factors coincide:

- German industry has an historic competitive advantage in products manufactured with extensive know-how and requiring a large number of employees;
- In spite of Germany's now brighter economic data, the country still has considerable unexploited capacities in the labour market;
- Finally, in recent decades the German economy has been suffering from increasingly weak investments, but this trend could be reversed by innovation-oriented climate protection and energy policies.

In this situation, the Meseberg programme, along with the additional measures discussed (amounting to about 74 million t CO_{2eq}), make it possible to meet the Federal Government's target of reducing greenhouse-gas emissions by 40% by 2020 compared to 1990 levels. Additional technical progress, along with continued increases in energy prices, would make the measures even more attractive. The Federal Government's aim presents a great challenge to the country's industry, its population and policy makers, as it goes hand-in-hand with a process of rethinking. However, the message is clear: climate protection represents a great opportunity for the German economy, and a great opportunity for the world to realise a global energy system that is sustainable in the long term. Effective implementation of the Meseberg programme, and relevant additional measures, would create at least 500,000 additional jobs in Germany by 2020 and over 900,000 new jobs by 2030.

The examples of the flagship and market launching projects outlined in the study show, firstly, that the affected industrial, administrative and applied research sectors must cooperate extensively and, secondly, that real-time, innovative, entrepreneurial concepts and financing methods must be developed

Figure 6-1: Currently expected emissions reduction and abatement costs of various measures [6]



Source: Calculations of the PIK

in the short term in order to facilitate rapid market adoption of pertinent new products and services.

The clearer the signals sent by government and businesses that a new industrial revolution is beginning – triggered by the challenge of climate change in the coming years – the sooner the German economy can begin to profit from it.

6 The figure does not show the measures “fluorinated GHG”, “materials efficiency” and “non-fluorinated, non-CO_2 GHG” since they are not illustratable.

7 As a result, the potential reductions are in part even higher than those estimated by McKinsey – although it must be remembered that the McKinsey study explicitly ruled out any changes in product design.

PUBLICATION ORDER:

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