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The Economic-Environmental model PANTA RHEI and its Application

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by

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1. INTRODUCTION

The global dimension of environmental problems stresses the need of an internationally linked environmental policy. The example of climate change policy shows, that environmental policy has to be a subject of a globally oriented international policy formulating operational targets that allow for global sustainable development in the environmental, economic and social dimension. Further, a set of policy instruments has to be installed, that will enable to reach global sustainability.

Already from a political point of view of a single country the task seems to be huge, and there are many sceptical voices, whether the big political bargaining process could ever converge. A necessary but by no means sufficient condition for this is the solution of a big information problem: What does sustainable development mean for the different countries, when it comes to the formulation of *operational* targets for the use of the environment, the economic and social development for the future? How are the *relations* between the targets? What do we know about the interdependencies between the environment, the economic and the social development in the different countries? How do the different instruments affect nature and the paths of economic and social development? How is the efficiency of these instruments?

Only simulations and forecasts with models, which depict the interdependencies between the environment and economic and social development, can give us answers to these questions. Of course, such models have to fulfil certain requirements.

Economic-environmental models in general have a disaggregated economic structure because the impact of the economic development on the environment has a sector specific profile. With respect to the modelling philosophy of the economic parts of the models two approaches can be distinguished: The so called “Computable General Equilibrium“ models (CGE) assume a neoclassical world in which perfectly informed “homines oeconomici” make there optimizing decisions on perfect markets (Shoven/Whalley 1992). In most cases central parameters of the models are taken from the literature and the rest is given with the information of one data point by the method of calibration, which means, that there is no empirical validation of the models. One exception of a CGE-model with econometrically estimated parameters is the model of Jorgenson/Wilcoxen (1993).

The alternative to CGE modelling is the construction of an Econometric Input-Output Model (West 1995). These models assume that agents are acting under conditions of bounded rationality on imperfect markets. Since there are competing hypothesis about the behaviour under bounded rationality the application of econometric methods is necessary for the discrimination of the structure of the systems. This procedure gives an empirically validated parameterization of the models. The name „Econometric Input-Output-Models“ refers to Almon (1991), who first combined econometric methods in input-output-modelling. Economic-environmental models with this type of the economic structure are the models of Barker (1997) and the model PANTA RHEI.

The name „PANTA RHEI“ is not an abbreviation, it cites a reflection of the Greek philosopher Heraklit and means in English: All things flow. This characterizes the model, because it depicts the change of economic structures and the interdependencies of the environment and the economy.

PANTA RHEI is an extended version of the pure economic model INFORGE (Interindustry Forecasting Germany), which exists since 1994. The evolution of PANTA RHEI reflects the development of the Systems of National Accounts and the Economic-Environmental Accounts in Germany. The first version PANTA RHEI I was an economy-energy-model for Western Germany (Meyer/Ewerhart 1997). In Version II the modelling of energy demand and emissions was improved (Meyer/Bockermann/Ewerhart/Lutz 1998, Lutz 2000). Version III was the first model for unified Germany. It is documented in Meyer/Bockermann/Ewerhart/Lutz (1999). Version IV additionally integrates a land-use module; Version V is estimated with a new data set, which is based on the NACE classification. Further the energy module and the land-use module could be improved and a traffic-and a dwelling module could be integrated. Documentation is given in Distelkamp et al. (2003). The actual version VI was extended by a resource- module. With every new version the system has been updated.

The evaluations of PANTA RHEI by Frohn/Leuchtmann/Kräussl (1998) und Frohn et al. (2003) confirmed the model as a useful instrument for economic- environmental forecasts and policy simulations. The system has been used for many simulations of suggested policies (see for example Meyer 2001, Meyer/Welfens 2001, Lutz/Meyer/Nathani/Schleich 2005) as well as for the evaluation of realized policies as for example the ecological tax reform in Germany (Bach et al. 2002). Further the model was a central part in several studies, which searched strategies towards sustainability for Germany (Spangenberg 2003, Coenen/Grunwald 2003, Keimel/Berghoff/Klann 2004, Bockermann/Meyer/Omann/Spangenberg2005, Fischer/Lichtblau/Meyer/Scheelhase 2004).

The paper at hand explains the structure of PANTA RHEI in chapter 2. Then in chapter 3 a baseline forecast for Germany shows, that the already implemented policy instruments might allow to reach the Kyoto climate target, but that we will not meet targets for land-use and resource consumption, which have been formulated by the German Sustainability Council. In chapter 4 we focus on resource consumption and analyze with PANTA RHEI the effects of information and consulting policy that tries to use a material saving potential in manufacturing sectors. The government could be the moderator of a process, in which private firms organize the knowledge transfer, which is necessary to dematerialize production processes. The simulation results with PANTA RHEI show, that such a program for the acceleration of material saving technical progress will yield a double dividend for economic targets and resource input reductions. Some conclusions about a more efficient design of such a program close the paper.

2. THE MODEL PANTA RHEI

2.1 The General Properties

The special ability of PANTA RHEI is based on two principles of construction: ***bottom- up modelling*** and ***full integration,*** which are typical for the INFORUM philosophy (Almon 1991). Bottom up means, that every sector is modelled in great detail - PANTA RHEI has more than 600 variables for each of the 59 sectors. Macroeconomic variables like gdp or disposable income or the consumer price index are calculated by explicit aggregation. Full integration implies a complex modelling, which depicts simultaneously the interindustry connections, the generation, distribution and redistribution as well as the use of income for the demand of goods.

The disaggregated structure of the model is necessary, because the linkage between the economy and the environment needs a detailed structure of production. This creates a huge but consistent processing of information for about 50 000 variables. From the data point of view time series of input-output-tables are consistently linked with the time series of a full SNA system.

The model has a very high degree of endogenization. Exogenous are the tax rates, labour supply. Sectoral exports and import prices are given from the global model GINFORS (Meyer/Lutz/Wolter 2004), but are endogenous to that system. It is possible two run GINFORS and PANTA RHEI simultaneously, but both models can also stand alone. The high degree of endogenization has the advantage, that the effects calculated in simulations are complete.

Besides the usual interdependencies of the circular flow of income PANTA RHEI depicts the interdependencies of prices and volumes as well as of prices and wages. The model is non-linear, because there are many multiplicative connections of variables in definitions, and many behavioural equations are estimated in double-logarithms. It is a dynamic model, because of the capital stock adjustment and the lags in behavioural equations. The nonlinearity combined with the interdependency of the system requires an iterative solution procedure, which is given with the Gauss-Seidel algorithm. The dynamic structure allows a year by year solution for a longer time path. The model is running in historic time, and time can not return.

If we combine these properties of PANTA RHEI with the already mentioned assumption of bounded rationality of the agents, which underlies the specification of the behavioural equations, the system can be qualified as an evolutionary model (Meyer 2005).

On the other side it could be called an econometric input- output model (West 1995), since the econometric estimation of parameters takes place and the input- output connections are there. But here a careful interpretation is necessary: This does not mean, that it is a Leontief-type model with constant structures. The input-output approach gives only a set of definitions. All technological coefficients are dealt as variables, which are changed by cost-push induced technical progress.

Technical progress is depicted by price and trend dependent input-coefficients. For some energy intensive sectors like iron and steel and others a very detailed modelling was chosen (Lutz /Meyer/Nathani/Schleich 2005): The technology was identified as putty clay, what means, that the firms can make their choice between different technologies only in the moment of investment. For these sectors the available technological paradigms are explicitly modelled and the best practice technology of every paradigm is depending from relative prices. The investment decision implies not only the decision for the volume, but also for the technological paradigm and in this way changes the input coefficients.

For a better understanding of the theoretical position of the model the following point should be marked: In general the input-output approach is demand-driven. This is not the case for PANTA RHEI. It is right, that demand determines production, but all demand variables depend from relative prices, and prices are given by unit costs of the firms using the mark up hypothesis, typical for oligopolistic markets. In that point the difference between neoclassical models and PANTA RHEI lies in the assumed market structure and not in the accentuation of this or that market side. Firms are setting the prices depending from their costs and the prices of competing imports. Demand is reacting on price signals and thus determining production. So the modelling of PANTA RHEI has both demand and supply elements.

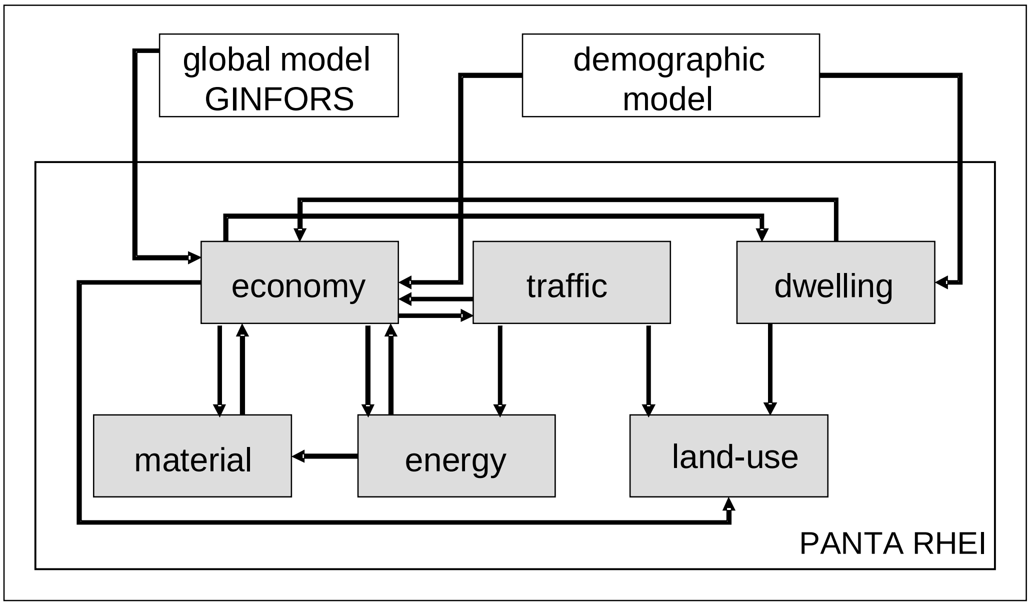
The specification of the model starts with a set of variables, that are declared as endogenous. From that starting point the construction of the model is a very much time consuming iterative process with six stages. First the parameters of the behavioural equations have to be estimated using the simple but robust OLS procedure of the verification period 1991 to 2002. With respect to the magnitude of the model more sophisticated estimation procedures can not be taken. Data before the year 1991 can not be used, because Germany did not exist before that year as a unified nation, so that there would be a structural break in the system. The discrimination of competing hypothesis starts with a plausibility check: Based on theoretical a priori information about the sign of the coefficients all unplausible results are eliminated in stage 2. The remaining estimations are been tested statistically in stage 3 looking at the t-statistic of the parameters. If at that stage discrimination was not possible, the estimation with the best coefficient of determination was taken. So it can be expected, that the system has theoretically plausible behavioural equations with a good fit to the data.

Since the tests are always related to the single equations, one might doubt, whether the interdependent nonlinear dynamic system has suitable properties. The first test therefore is the solution of the whole system including all behavioural equations, definitions and budget constraints in stage 4. The question is, do the iterations converge? If this is not the case, a new specification of the responsible equations has to be done and the process starts again at stage 1. But convergence is only a necessary but not a sufficient condition for suitable properties of the whole system. So in stage 5 an ex-post forecast is done. If the system is able to reproduce the historic development for the main variables with a sufficient precision, the last test in stage 6 is done, if not, the procedure starts with stage 1. The last test is an ex ante forecast for 25 years.

2.2 Overview of the Structure of the Model

Picture 1 gives a first impression of the structure of the actual version VI. All subsystems are interdependently linked, so that for the solution of the system the whole information is needed.

Figure 1: The Structure of the Model PANTA RHEI



The economic part of the system is given with the module INFORGE, which gets export demand and import prices from the global model GINFORS (Meyer/Lutz/Wolter 2004). GINFORS calculates the development of 53 countries, which are linked by a bilateral multisector (25 commodities and one service good) trade model. The demographic evolution of Germany is forecasted by our model DEMOS (Wolter 2005). It influences the behaviour of the economy (consumption, social security system, labour market). INFORGE calculates consumption, investment, imports, intermediate demand, production, value added, wages, taxes, depreciation, profits and prices for 59 sectors. A complete SNA system aggregates the generated income, distributes and redistributes it between firms, private households, the government and the rest of the world, calculates disposable income and financial surplus for these aggregates. The SNA system incorporates also the social security system of Germany.

The dwelling module calculates investment in dwelling-houses of different size and their stocks and prices depending from income and price information coming from INFORGE.

The traffic-module estimates for diesel and gasoline passenger cars the usage measured in kilometers driven. For trucks the relevant information is measured in ton-kilometers. Further the stocks of cars and trucks and the consumption of diesel and gasoline are calculated in a vintage-approach.

The energy module calculates the demand for 30 energy carriers of 121 production sectors and the private households in physical units and in money terms. Further the emissions of fossil energy carriers are given.

The land- use module analyses the settlement area for 59 production sectors and the Private Households and the traffic area, that is needed for streets, railways, waterways and airports.

The material input module calculates the used and unused extractions of biomass, metallic minerals, non metallic minerals and fossil fuels (crude oil, gas, coal) in Germany and the imported materials, which are induced in other countries by the German imports.

2.3 The Economic Module INFORGE

Picture 2 gives an overview of the structure of the economic module. The GINFORS model delivers the vector of exports and the vector of import prices for Germany.

Final demand consists of the components private consumption, public consumption, investment in equipment, construction, investment in stocks and exports. Each of these components has a disaggregation in 59 product groups. The most important variables for the explanation of domestic demand variables are disposable income of the government and private households, relative prices, interest rates and profits (investment).

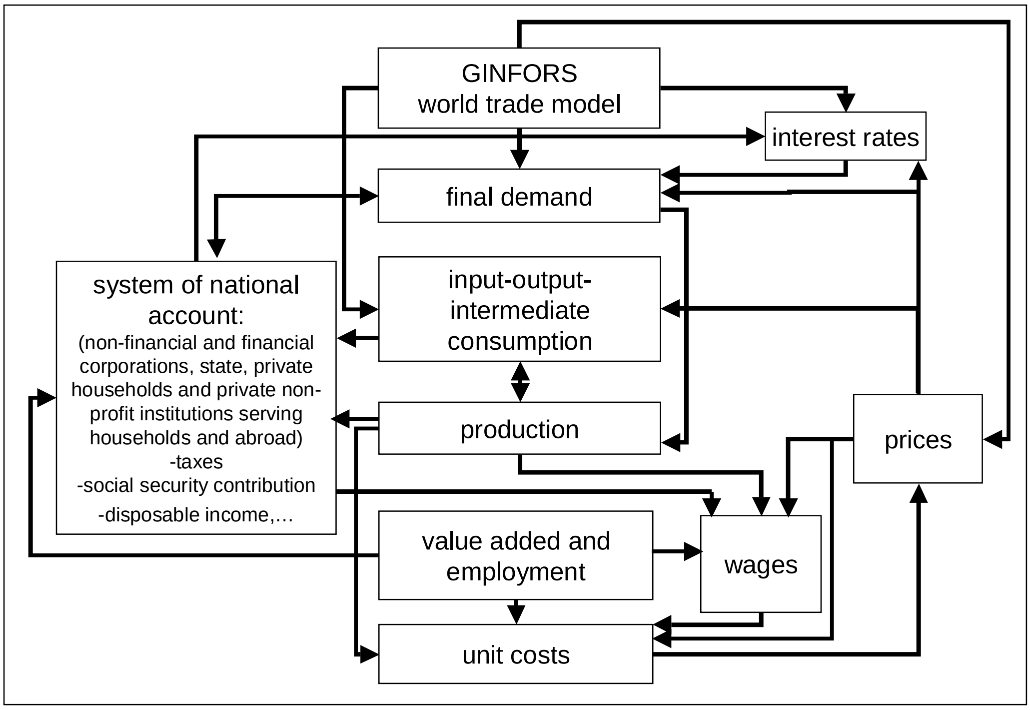
Private consumption functions are built for 43 consumption purposes. Here disposable income, relative prices, interest rates are in general the explaining variables. For the consumption purpose “energy for heating” the energy module gives the demand. The demand for cars and the demand for fuels is taken from the traffic-module. With a bridge matrix the demand of the 43 consumption purposes is transferred in the demand for the 59 product groups.

Investment in equipment and in construction is seperately explained for each of the 59 investing sectors. Gross production, profits and capital productivity of the sector and interest rates and the rate of inflation are important determinants. Investment for construction in sector 47 (house renting) is taken from the dwelling module. Investment and depreciation allows calculating the capital stocks for every sector. The vector of investment in equipment and the vector of investment in construction are then transformed in investment vectors of demand for goods using bridge matrices.

Intermediate demand is explained for 59 product groups for each of the 59 production sectors. The relation between the input of a intermediate good and the output of the demanding sector - the input coefficient - is explained by relative prices and time trends, which is interpreted as the influence of technical progress, as is discussed above. The inputs of energy are calculated for 30 energy carriers in the energy module and the results are taken in aggregated form from their, since the input-output system has only four different energy inputs (coal, oil and gas, coke and refinery products, electricity).

Final demand plus intermediate demand less imports determines production.

Figure 2: The Structure of the Economic Core of the Model PANTA RHEI



Demand for labour demand is explained for each of the 59 production sectors by gross production and the real costs of labour of that sector per head and a time trend. A macro wage rate is calculated in a function, which forecasts the result of the bargaining process between the unions and the firms: Macroeconomic labour productivity, the deflator for aggregate consumption together with the rate of unemployment determine the macro wage rate, which then explains - next to some sector specific variables - the sectoral wage rate. Addition of the social security contributions yields the labour costs per head. The social security contributions are calculated in the SNA system in a way that the expenditures of the social security system are covered by its revenues. Unemployment is given as a macro variable by definition, subtracting the exogenously given labour supply from the aggregated labour demand.

Profits and unit costs for every sector are given by definition. Together with the import price of the specific good, the unit costs determine producer prices, which are done for each of the demand components (intermediate, equipment, construction, private consumption, public consumption, exports) and for each of the 59 products. Since demand decisions are driven by purchasers' prices, the transformation from producer prices to purchasers' prices is explicitly depicted by adding trade- and transport costs, sales taxes, specific goods taxes to and subtracting subsidies from each of the 354 producer prices. This very detailed modelling of prices is necessary, since goods taxes and subsidies are favourite policy instruments, and it must be shure, that the model is able to calculate the effects in deep detail.

The system of national accounts with the five institutional sectors “non financial capital corporations”, “financial capital corporations”, “government”, “private households” and “rest of the world” is completely part of the model and consistently linked with the input-output-system. The following functional accounts are represented for each of the institutional sectors: production, primary distribution of income, secondary distribution of income, use of income, change in net worth, financial account. The behavioural equations of this system explain its expenditures; the revenues are given by definition. The detail of this system allows identifying the expenditures and revenues of the social security system, so that it is possible to link it with the labour market and other parts of the model.

Integrated in the SNA model, fiscal policy is completely endogenized. Central instrument of monetary policy is the interest rate of the central bank, which influencies together with the US interest rate for government bonds, the European interest rate for government bonds.

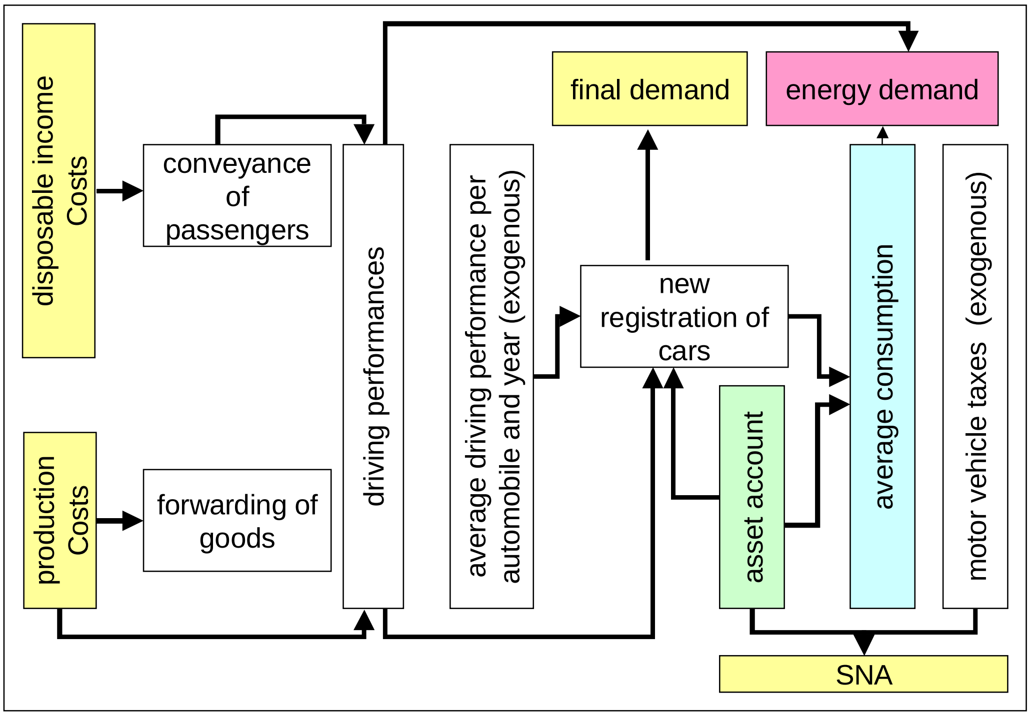
2.4 The Modules for the Environment

The linkage between economic development and the use of the environment without the analysis of the use of stocks remains incomplete. PANTA RHEI therefore has a traffic-module and a dwelling-module for the analysis of the use of these stocks and their adjustment.

2. 4.1 The Traffic- Module

Picture 3 gives an overview of the structure of the traffic- module. The model distinguishes between the transportation of goods and the transportation of persons for diesel cars and gasoline cars. In the case of private households the transportation of persons - measured in personkilometers - is depending from income figures and costs for transportation. In the case of firms the transportation of persons is explained in deep sector detail by production and transportation costs. The transportation of goods with trucks - measured in tonkilometers - is explained in deep sector detail by production of the sectors and the transportation costs. Next to other variables the transportation of goods determines the stretch of the trucks measured in Kilometer. The corresponding modelling is given for diesel and for gasoline cars.

Figure 3: **The Traffic Module**



Agents further decide about the use of the available vehicles in kilometers per vehicle and year. For trucks this figure is constant in history and therefore is set as a constant Parameter in the model. For passenger cars there is a negative dependency from disposable income. Given the stretch in kilometers for a year (seperately for trucks, diesel and gasoline cars) and the use per vehicle and year, the wanted number of vehicles can be calculated by definition. Given the numbers of vehicles, which become obsolete, the number of new demand for cars can be calculated. Theses figures for trucks, diesel and gasoline cars explain the demand for vehicles in the economic module.

Basen on the number of neu demand for cars and trucks and their losses a vintage model for the stocks of vehicles can be calculated. Since for the new vehicles forecasts of technicians about the fuel consumption in liters per kilometer are available, it is possible to forecast the average fuel consumption of the fleet per kilometer. Multiplication with the stretch in kilometers gives the fuel consumption in liters. These figures for diesel and gasoline give the volumes for the calculation of monetary energy demand of these energy carriers in the economic module. The numbers of vehicles can explain vehicle taxes - information, that is needed in the SNA module.

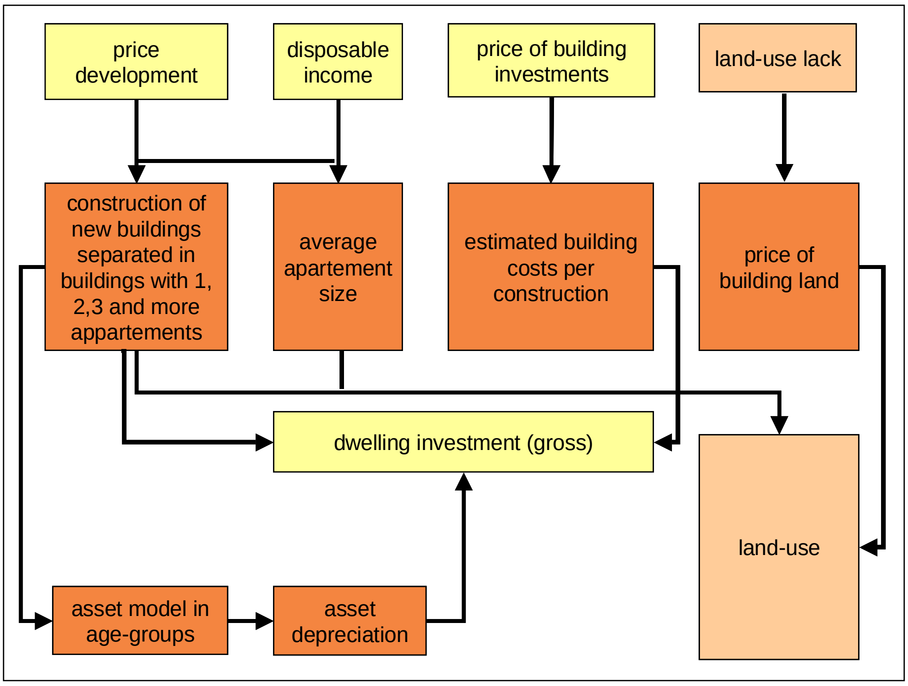
2. 4. 2 The Dwelling-Module

Picture 4 shows the structure of the dwelling module. Disposable income of private households and relative prices influence the demand for habitations in single houses, in houses with two habitations and in houses with three and more habitations. Also the average area per habitation is depending from disposable income and relative prices.

Together with land prices the total area for habitation is an important variable for the land use module.

The number of new habitations together with the number of losses - given as percentages of stocks in the different vintages - allows the calculation of stocks in different vintages. The number of losses and the number of new habitations together with the average costs of construction explain gross investment in construction in monetary terms for the economic module. The average costs of construction are determined by the price index for construction, which is a variable of the economic module. The land price is explained by the relation between the agriculture area and the total area in Germany.

Figure 4: The Dwelling Module

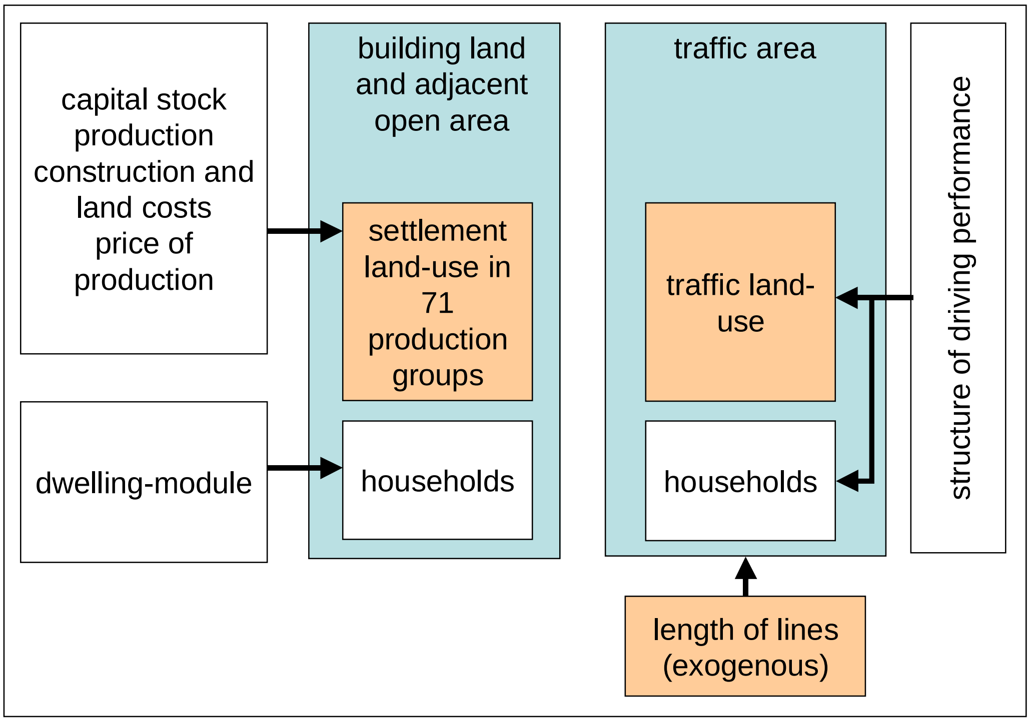


2. 4. 3 The Land-Use-Module

The area of Germany is divided in the settlement area, traffic area, water area, agricultural area and wood. The land use for settlement, traffic and agriculture is explained in deep detail, the water area is constant and the wood area is the rest of the 360.000 square kilometres of Germany.

The settlement area contains the building and adjacent open area, operating area, recreation area and cemetery area. The land use for buildings is depicted for 71 production sectors with a factor demand modelling approach, in which relative prices play an important role. The land use of households for buildings is related to the living area, which is determined in the dwelling module, and the relative price of land. The operating area for the production sectors and the households is calculated in constant relation to the building areas. The land use for recreation is linked to the economic activities of some specific production sectors (hotels, restaurants, sport, culture etc.). The cemetery area is growing with a trend.

Figure 5: The Land-Use Module



The land use for traffic consists of areas for streets, waterways, railways and airports. The land for streets is explained by the length of local streets and the length of national streets. The traffic land use of the 71 production sectors and the private households is explained by their driving activities, which are calculated in the traffic module. The area for water ways is linked to the length of the water ways, the area for railways is linked to the length of railways, and the area for airports is related to the number of starts and landings. Capacity utilization figures are calculated for every traffic carrier, dividing the driving activities of cars, ships and trains, which are calculated in the traffic module, by the length of the traffic carrier. The capacity utilization figures are influencing factor costs in transportation.

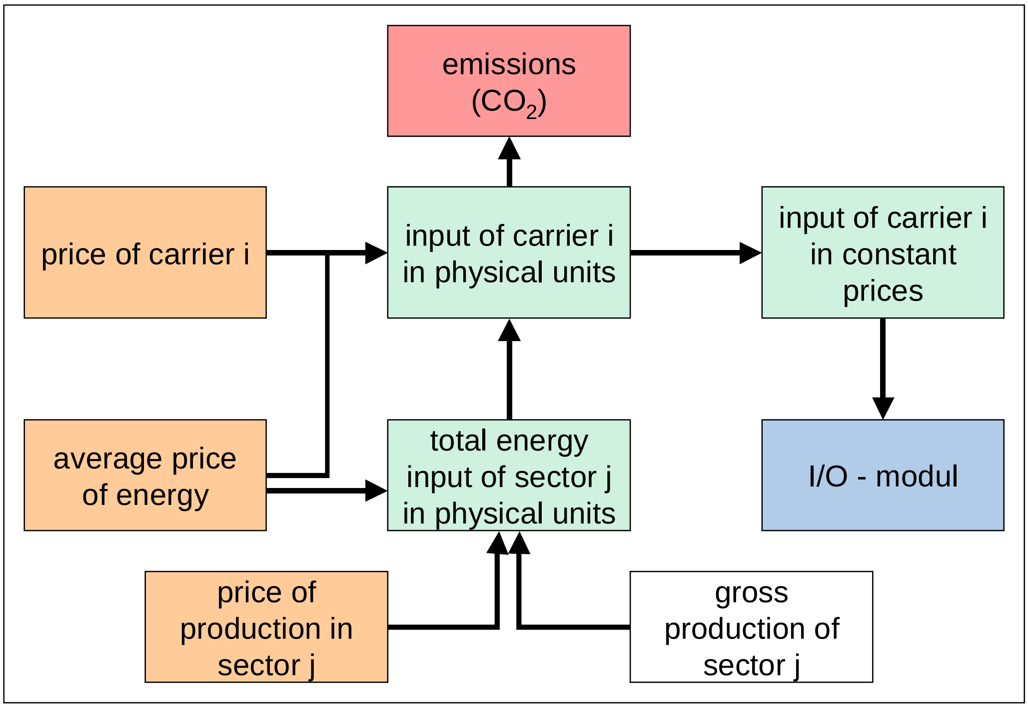
The land use for agriculture is explained as factor demand of the production sector “agriculture”.

2.4. 4 The Energy Module

The model explains the demand of 121 production sectors and the private households for 30 energy carriers. The demand for diesel and gasoline is explained in the traffic module as shown above. The energy demand for heating of private households is related to the variables of the dwelling module and relative prices.

Figure 6 shows the modelling of the energy demand of the 121 production sectors for the other 27 energy carriers:

Figure 6: The Modelling of Energy Demand in the Standard Case (Without Diesel and Gasoline)



The total energy demand of the sector in physical units is explained by gross production and the relation of the aggregated energy price and the production price of the sector. The energy mix of that sector is explained by relative energy prices. Then the physical energy inputs of the sector explain its emissions of air pollutants (CO2) and the energy inputs in monetary terms in constant prices. This result is then aggregated to the four energy lines for 59 production sectors in the input-output-module.

2.4.5 The Material Input-Module

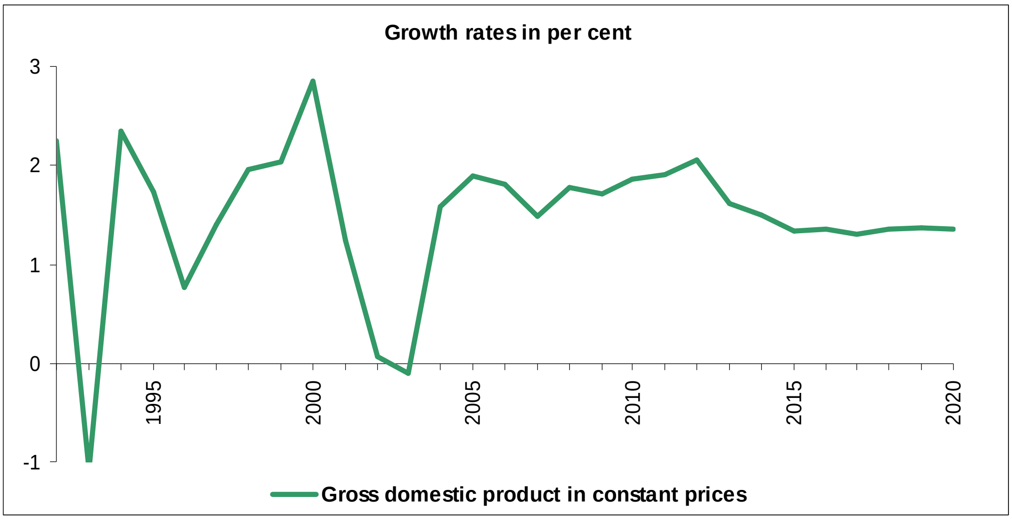
The material input module calculates the used and unused extractions of biomass, metallic minerals, non metallic minerals and fossil fuels (crude oil, gas, coal) in Germany and the imported materials, which are induced in other countries by the German imports. Used domestic extraction is linked to the extracting production sector. Unused extraction of a material in a specific extracting sector has a constant relation to its used extraction figure. In the case of imports for every imported good in every sector the hidden material inputs in physical units are linked to the import values in constant prices. In all equations for the explanation of material inputs the significance of relative material prices was tested.

3. A BASELINE FORECAST

The Baseline forecast assumes “business-as-usual” in respect to economic policy (labour market, income taxation, social security system etc.), energy taxes, subsidies for renewable energies and the phase-out for nuclear energy. Insofar the baseline reflects the policy situation of 2004, especially concerning the labour market and the social security system. In other words: The actual structural economic reforms are not mentioned, so that the baseline may underestimate the future economic development. But in relation to the climate target the baseline goes beyond a “business as usual”: We assume, that the European instrument of pollution rights for CO_2 emissions and the truck toll will be dynamised, that obsolete nuclear electricity plants will be replaced by gas plants, and that the targets of the government of a 12% share in energy supply for renewables will be reached in 2010. Insofar it is a very optimistic scenario in respect to the climate target: The parameters of these instruments are calibrated, so that the Kyoto target for Germany will be reached in 2010, and that for the period 2010 till 2020 there will be the same reductions of CO_2 emissions as in the period 2002 till 2010. So the climate target is not in the focus of the paper. We are more interested in the results for other ecological targets like land use and resource consumption.

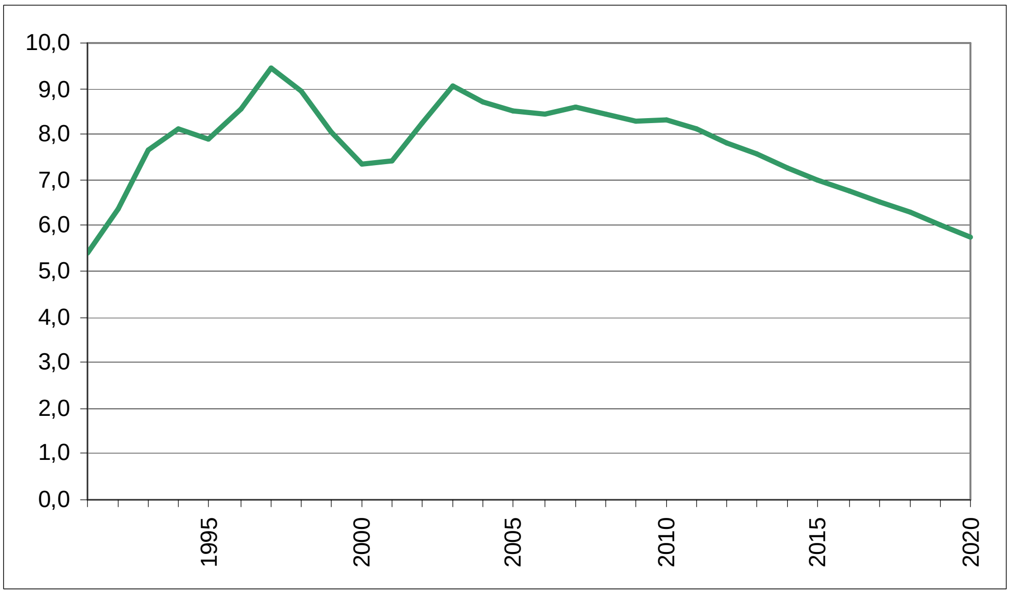
Under these assumptions the solution of the model gives the following results: The German economy will recover from three years of stagnation and reach growth rates of real GDP around 1.8% during the next years. Figure 7 further shows, that the growth rates reduce a little bit after 2014, which is caused by a weaker development of domestic demand, especially of investment in construction.

Figure 7: Base-Line Forecast: Growth Rates of Real GDP in %



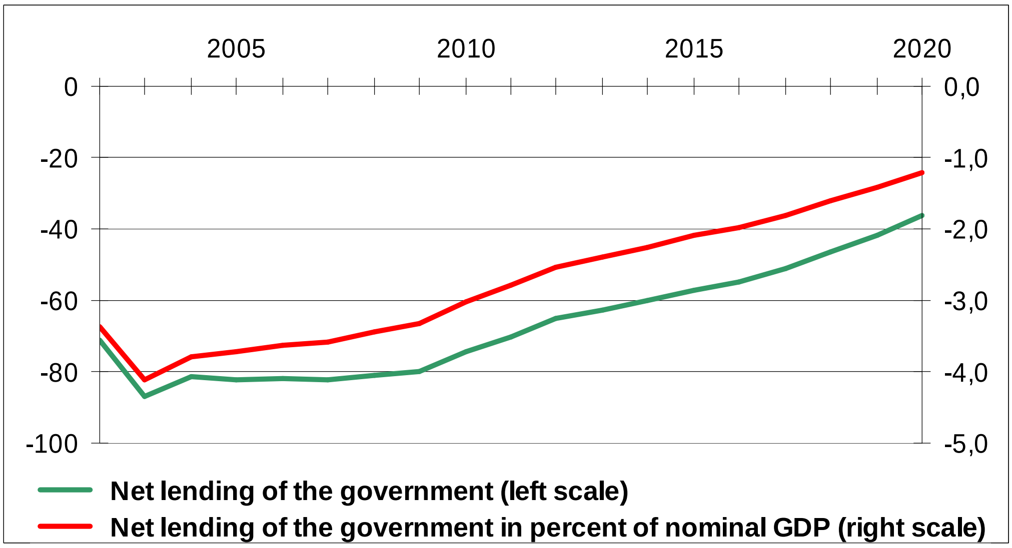
The stable growth path in the next ten years will increase employment by about 0.5 % per year, but since we will have during that time a rise in labour supply of women, the unemployment ratio will fall only slightly till 2015. This expectation shows that the structural economic reforms are essential to get a better performance on the labour market. Figure 8 further shows that after 2015 there will be a substantial reduction of unemployment in spite of the slightly diminishing growth rates of GDP. The reason is that after 2015 the demographic change will reduce labour supply.

Figure 8: Unemployment ratios (ILO concept) in the Baseline



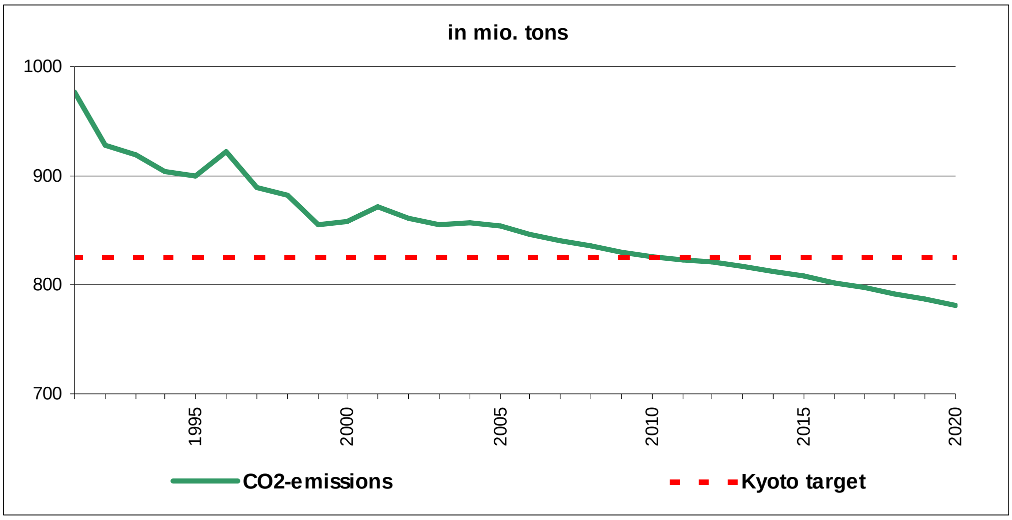
Net lending of the government will still be a problem during the next years. The Maastricht-criterion of less than 3% net lending in relation to nominal GDP will be reached not earlier than 2010. Only in the long run we can expect an improvement. Here we can also hope, that the structural reforms will improve the future development. Figure 9 gives the forecast in billion EUROS (left hand scale) and in percent of the nominal GDP (right hand scale).

Figure 9: Net Lending of the Government in Billion € and in Percent of nominal GDP in the Baseline



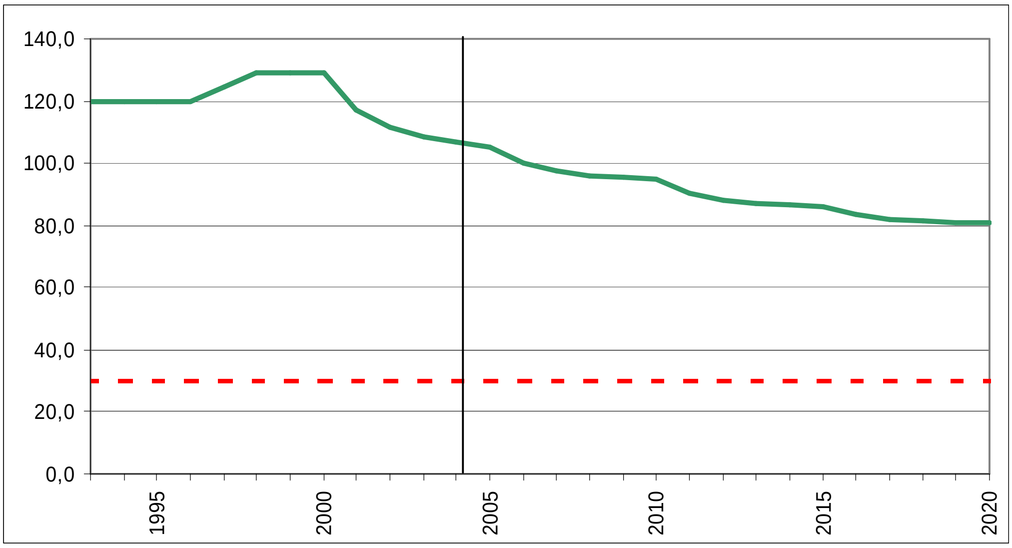
The **climate target** of the Kyoto protocol will be met because we have chosen - as already shown - optimistic assumptions about climate policy instruments. Until 2020 CO2 emissions of less than 800 Million tons will be possible (Figure 10)

Figure 10: Baseline, CO_2-Emissions in Mill. Tons and target



The **land use for settlement and traffic** in Germany grows and dislodges natural areas. In the forecast this development can only be decelerated, but not stopped. Figure 11 shows that the change in land use for settlement and traffic measured in hektar (10000 m2) per day will be reduced to 80 ha per day, but this will be much more than the 30 ha per day, which is a target of the German Sustainability Council. So there might be a big sustainability gap in land use.

Figure 11: Baseline, Land use for Settlement and Traffic in Hektar per Day and Target



For **total material requirement** (TMR, domestic and imported material consumption incl. rucksacks) we face in the baseline forecast a rise, which is in contrast to the reductions, that can be observed in the past (figure 12). This can be explained by the strong reductions of fossil fuels in the form of coal in West Germany and of brown coal in East Germany during the years 1991 to 2000, which will not happen in this magnitude in the future. On the other side there has been a growth of imported metals in the past, which will accelerate in the future and by far will overcompensate the further reductions of fossil fuels. The driver of this movement is the production of investment goods, which is much more determined by exports than by domestic investment demand.

Total Material productivity - measured as GDP in € in constant prices per kg total material requirement - has had an average annual growth rate of 2.5 % in the period 1991-2000. This number will reduce to 0.6 % for the period 2005 - 2020. If we eliminate the domestic extraction of fossil fuels from these calculations we get the same average annual resource productivity growth rate for both periods.

The target of the German Sustainability Council is a growth of material productivity of 250 % till the year 2020 based on the number, which has been realized in the year 1993. The comparison of the baseline development with the target in figure 13 shows, that there will be a big sustainability gap.

Figure 12: Baseline, Total Material Requirement in Million Tons

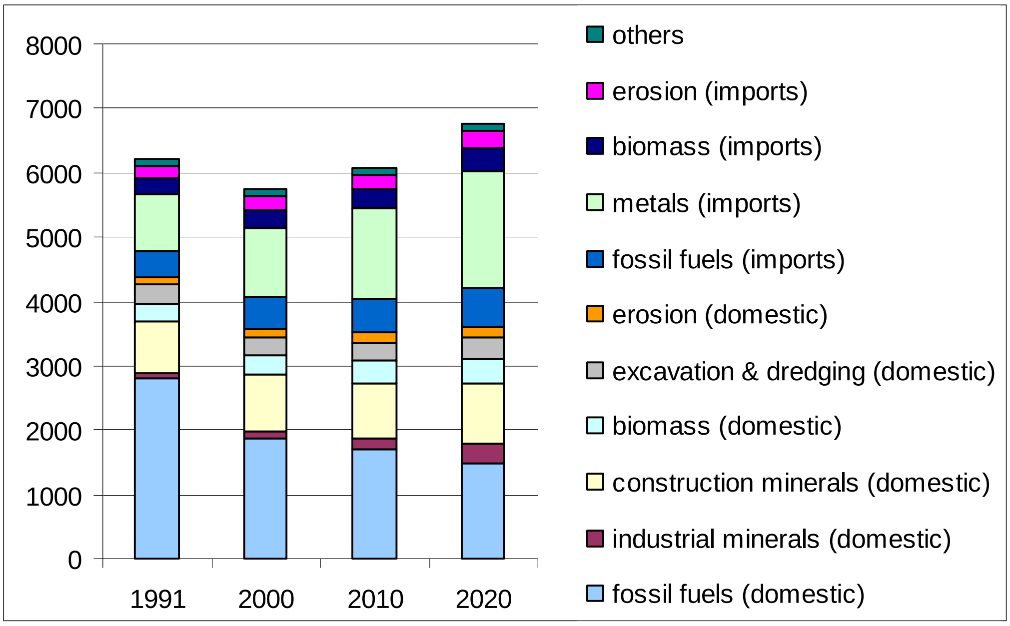
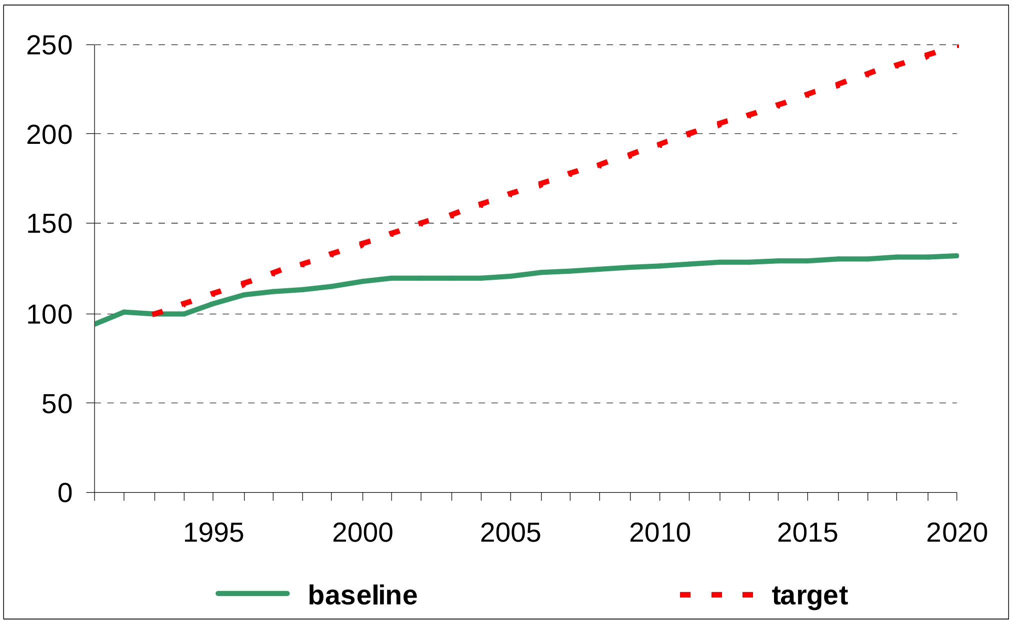


Figure 13: **Baseline: Total Material Productivity, Index 1993=100 and Target**



Summarizing we see, that in a baseline scenario, which has optimistic assumptions about the further climate policy in Germany, it may be possible to reach the Kyoto targets, but that land use targets and resource consumption targets may not be met.

4. A Program for Growth of Material Productivity: The "Aachen" Scenario

How can the ambitious targets of the German government for material productivity be met? The foundation „Kathy Beys" - located at the city of Aachen - has induced two studies, which are based on the idea, that there is a material saving potential in manufacturing sectors, that can be used by information and consulting. The government could be the moderator of a process, in which private firms organize the knowledge transfer, which is necessary to dematerialize production processes. With respect to the foundation "Kathy Beys" we speak of the "Aachen" scenario. Firms like Arthur D. Little and others have practical experience, which allows estimating the dematerialization potential and the costs, which arise. Based on these experiences Fischer/Lichtblau/Meyer/Scheelhase (2004) first used the economic module INFORGE of PANTA RHEI to calculate the macroeconomic effects. Distelkamp/Meyer/Wolter (2004) used the full system PANTA RHEI for the simultaneous computation of the effects on the economy and on resource consumption. Their results are discussed in this chapter.

The experience of Arthur D. Little and other consulting firms is, that material costs of manufacturing firms, in construction and in public administration can be reduced by 20% of the total costs. Of course, this can not be achieved without additional costs for consulting and investment in machinery. The experience of the consulters is, that savings of material inputs induce for one year additional consulting and capital costs of the same magnitude and in the case of energy inputs the induced costs equal the savings of six years. One third of the additional costs are consulting costs, two third are capital costs. The economic advantage is given, because the additional consulting and capital costs take place only once, whereas the savings of material and energy inputs are given forever.

In our "Aachen-scenario" we take these assumptions, but we are conservative in relation to the consulting experience:

- We assume, that material end energy costs of manufacturing sectors, construction and public administration can be reduced by 20% of the material costs and not of total costs. The reductions of material and energy inputs start in the year 2005 and will be raised linearly to 20% in the year 2016.
- The scenario focuses on those sectors, that have the greatest potential of dematerialization, but a political program, that favours consulting in dematerialization would also effect other sectors of the economy
- In reality there will be product innovations, which will raise final demand. This effect can not be modelled.

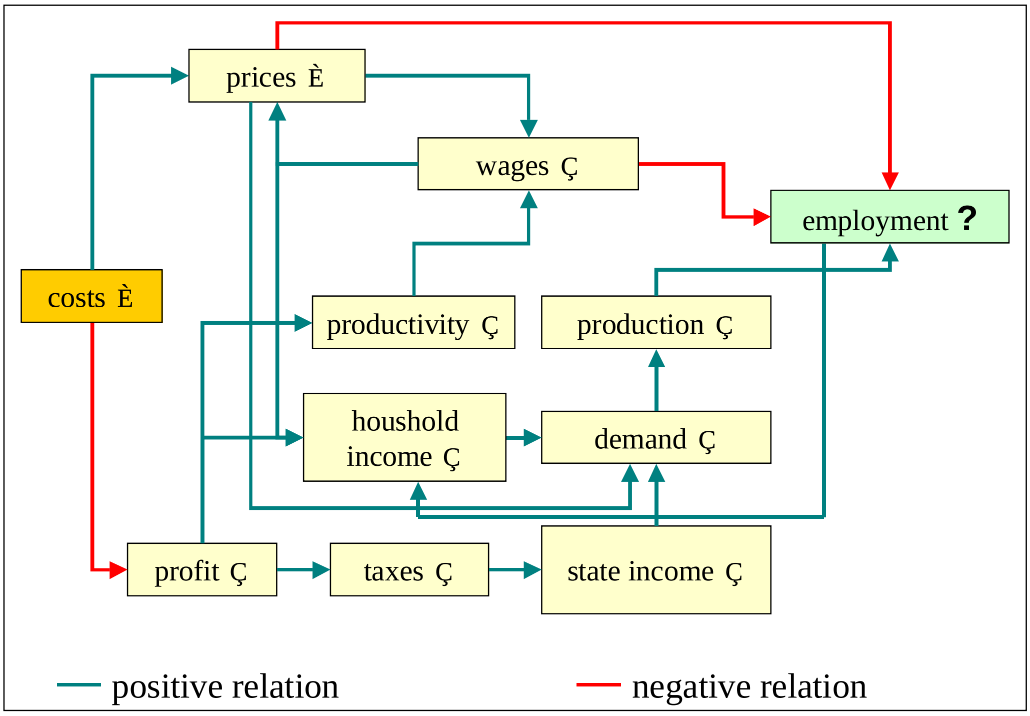
We further assume that wages are not reacting on the impact of the dematerialization program and grow with the rates of the baseline scenario. This requires a consensus of unions and entrepreneurs, since there are strong productivity effects, which normally influence wage bargaining.

Dematerialization has two direct effects on the macroeconomic activity. First there is the cost reduction in manufacturing, construction and public administration, and secondly the sales of the deliverers of material – which belong to the manufacturing sectors – will be reduced. So there are winners and losers. The winners are all domestic firms, but the losers are domestic firms and firms of foreign countries, so that imports will be reduced, which raises GDP.

There are lots of indirect effects. The most important ones are depicted schematically in figure 14. Cost reductions induce lower prices. If prices reduce less than costs – which is normally the case – profits will rise. This will raise tax revenues and income of households. Both effects will vitalize final demand and sales, production and employment.

Higher profits mean higher value added and rising labour productivity. This variable and the price development are the central determinants of the outcome of wage-bargaining. Falling prices reduce wages, but rising labour productivity raises wages. Since productivity rises stronger than prices fall, there would be without the consensus of unions and entrepreneurs a rise of wages. In this case the effect on employment would be not clear. Employment is depending from production and the real wage rate, which is the relation between the wage rate and price development. Production has a positive effect on employment, the real wage rate has a negative effect. If the wage rate does not react – as we assume in our scenario – the negative effect on employment from the real wage rate will be so small, that it will be overcompensated by the positive production effect. Rising employment means a further positive effect on household income and from there to final demand.

Abbildung 14: Macroeconomic effects of Dematerialization



In total, dematerialization will induce a strong vitalization of the economy. During the duration of the program the growth rate of GDP will lie about one point above the rate of the baseline (see figure 15).

Employment will rise continuously, so that in the year 2017 this figure will be 1 Million higher in the “Aachen Scenario” than in the baseline (see figure 16). In the following years there will be a smaller positive effect, since the program is finished.

Figure 15: GDP in the Baseline and in the “Aachen Scenario”

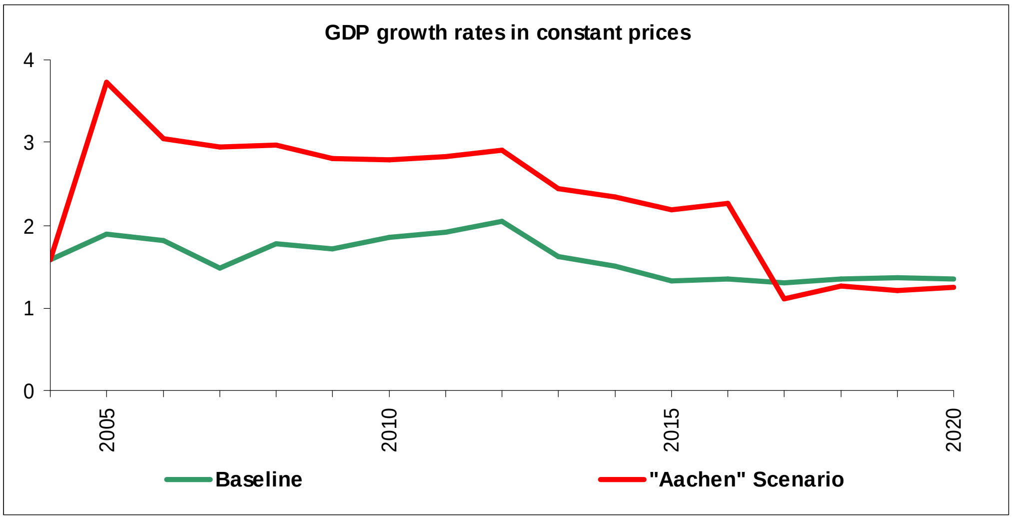
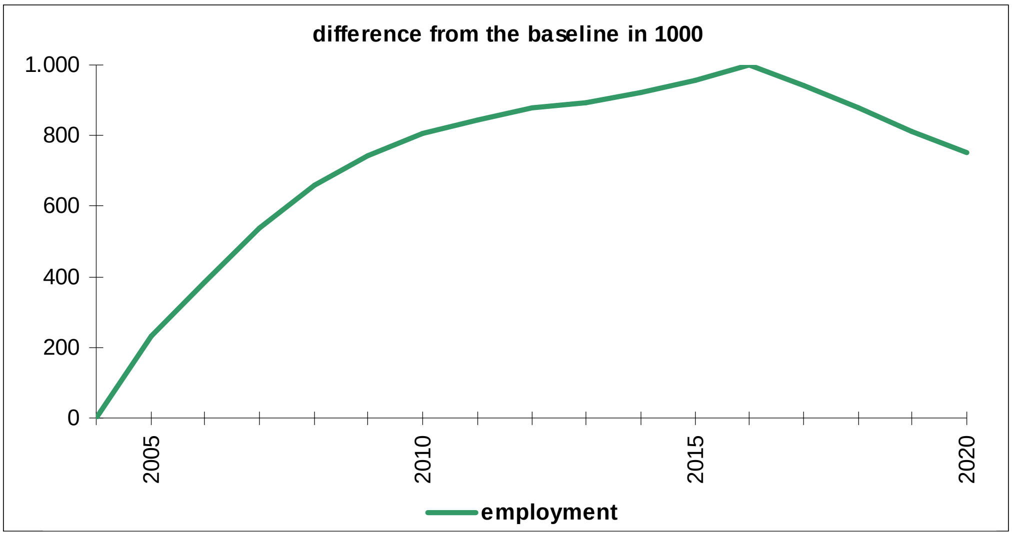
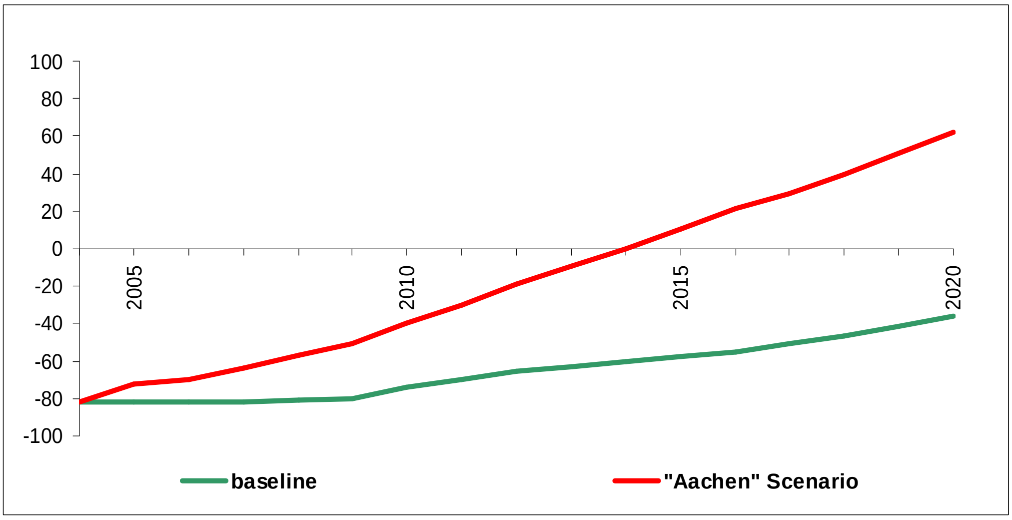


Figure 16: **Aachen Scenario: Effects on Employment**



The budget of the government (see figure 17) is influenced positively by the „Aachen Scenario“: The direct effect is induced by the growing tax revenue. This gives a reduced net borrowing. In the long run there is an important indirect effect: The interest payments for the debt reduce and this additionally diminishes net borrowing. At the end of the forecast horizon there will be a net lending of 60 billion €. So the government will get back an activity potential.

Figure 17: **Net Lending/Borrowing of the Government in the Baseline and in the „Aachen Scenario“ in Billion €**



The reduction of material inputs has a strong positive impact on material productivity. Figure 18 shows, that in the „Aachen“ scenario we reach in the year 2020 the level 171 of the productivity index, whereas in the baseline only 132 can be met. But the ambitious target of 250 is still far away. In average annual growth rates for the period 2005 to 2020 we compare 0.6 % for the baseline, 2.4 % for the „Aachen“ scenario, and 6.3 % that have to be realized year by year, if the ambitious target shall be reached. The question arises, whether the target may be too ambitious. Even during the "active Phase" of dematerialization - in the "Aachen" scenario the period 2005 to 2017 - the average growth rate of material productivity is only 2.9 %.

Figure 18: Material Productivity in the Baseline, the „Aachen" Scenario and its Target

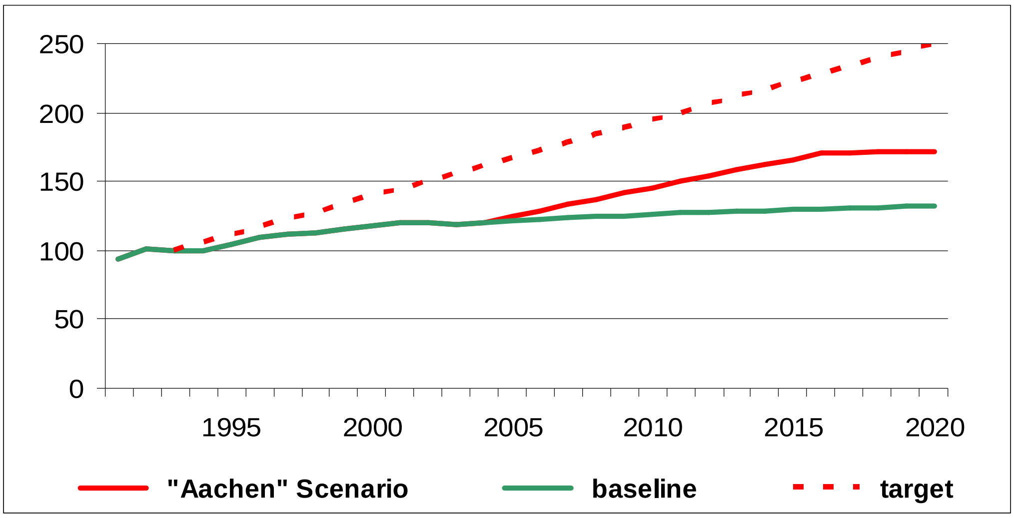
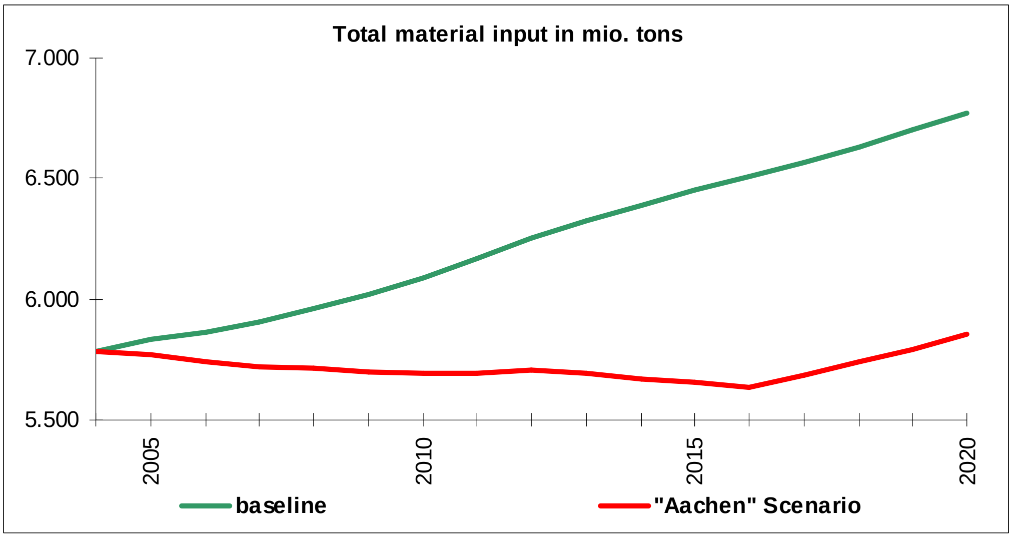


Figure 19 shows the levels of total material input for the baseline and the „Aachen" scenario. Since GDP grows from 2005 to 2020 in the baseline in the average with about 1.6 %, and total material productivity will grow with 0.6 % per year, total material input will grow in the average with 1.0 % per year. In the "Aachen" scenario - period 2005 till 2017 - there will be a material productivity growth of 2.9 %. Since the average GDP growth rate is about 2.6 %, there will be a reduction of material inputs of only 0.3 percent in the average per year. We further see that this small reduction during the active phase of the "Aachen" scenario is lost during the following years till 2020, when the "normal" productivity growth will be back.

The discussed dematerialization policy creates a double dividend of a rising material productivity and a rising GDP growth rate. Both figures are lying in the same range, so that the level of total material consumption will be more or less constant. But compared with the baseline there is a strong reduction of material consumption. In the year 2020 the difference will be about 13 %.

Figure 19: Material Consumption in the Baseline and in the „Aachen" Scenario



With respect to the different kinds of materials the results are very heterogenous. The main reason is, that the rebound effect of higher economic growth is very different for the economic sectors, which have a great variety in their material input profiles.[1]

5. CONCLUSIONS

In Germany since many years climate policy is in the focus of environmental policy. The simulations with the economic- environmental model PANTA RHEI have shown, that a set of instruments has been installed, that allow – if they are applied consequently – to reach the Kyoto target and till 2020 a further reduction of greenhouse gas emissions. In the case of land use and resource consumption there is a big sustainability gap. In these fields the targets, which the Sustainability Council – an institution installed by the government – has formulated will with a business as usual policy by far not be met. This is not a common assessment; we are even missing instruments, which could help to reach the ambitious targets.

For the case of resource consumption the paper points out, that Germany as a country, which exports with high growth rates especially investment goods, will have strongly rising metal consumption. This can not be avoided, otherwise Germany would loose its comparative advantage in international competition. Only a technological change with a bias for rising material productivity can help.

The "Aachen" scenario assumes, that there is a material saving potential in manufacturing sectors, that can be used by information and consulting. The government could be the moderator of a process, in which private firms organize the knowledge transfer, which is necessary to dematerialize production processes. The simulations with the model PANTA RHEI show, that a double dividend of rising material productivity

[1] For more details see Distelkamp/Meyer/Wolter(2004), pp.35.

and rising GDP growth can be achieved, but the productivity growth is still less than targeted by the Sustainability Council. Nevertheless the result is remarkable: The performance of the German economy would be improved strongly and economic growth and resource consumption could be disparted, so that material consumption remains constant.

But it might be possible to reach a better performance of material consumption with the "Aachen" scenario, if dematerialization policy is structured strategically: In our simulations we assumed, that the efforts to reduce resource inputs are the same in all manufacturing sectors, in construction and public administration. But it might be more efficient to concentrate the activities on those sectors and technologies, which have the strongest direct and indirect impact on material consumption. We just have finished a further study for the foundation "Kathy Beys", which identifies those technologies. In simulations all 3481 input coefficients of the 59 production sectors, which define the technology of the economy, have been changed and the effects for domestic and imported consumption of biomass, fossil fuels, industrial and construction minerals, metals have been calculated. Based on these results a very efficient design of an information and consulting policy to improve resource productivity will be possible.

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