gws Discussion Paper 2009/1
ISSN 1867-7290

Economic impacts of the RES Obligations in Austria – an Application of the Macro-Econometric Model e3.at

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Osnabrück, January 2009

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1 Introduction

The year 2008 started in January (Jan 23, 2008) with ambitious European initiatives on climate change when the European Commission suggested a climate packages with new targets for energy from renewable sources (RES), for the design of the third phase of the emission trading system, for a directive on carbon capture and storage systems (CCS), for the fuel directive, and a directive on CO_2 limit for new vehicles. Several of these proposed directives have been an issue of fierce discussion during the year, especially as the extent of the financial crisis gradually came to the fore and the fears of a worldwide economic crisis grew. At the end of 2008, however, the package passed the European parliament (Dec. 17, 2008) though several concessions had to be made concerning the emission trading system or the vehicle directive.

However, seemingly unaffected by current fears and therefore largely unaltered the directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources in Europe passed with a rather high amount of "yes" votes of the whole package, indicating that the support for energy from renewable sources still seems strong. The Directive "establishes a common framework for the promotion of energy from renewable sources. It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport." (COM(2008)0019 – C6-0046/2008 – 2008/0016(COD) The national overall targets are set individually for each country and the required increases compared to 2005 are as low as 22% (Sweden, Latvia) or as high as more than 1000% in the case of the UK (c.f. full table in the Appendix).

Each country will have to develop a strategy for a sustainable pathway to reach the target. Though the strategic decisions will be on the national levels for each country, the knowledge of the targets for the European Community provides useful information to back the decision. Domestic support of RES technologies can induce a lead market and create international export opportunities. Observing the strategies of the other EC member states will affect the choice of the national efficient and effective policy mix.

Austria is an interesting case study insofar as it already uses renewable energy to a large extent (23.3% in 2005) and still has to increase it by almost 50% to 34% by 2020. This increase will come with large necessary investments and will require a combined energy-efficiency strategy. To answer the question how and at what overall economic costs in terms of GDP and employment effects the targets can be reached a scenario has to be developed and tested with the help of a model that reflects the economic and environmental interdependences. Therefore, to analyze the overall effects a highly interdependent resource economic modeling approach is needed. The macro-econometric model e3.at has been developed to answer such questions.

The article is organized as following. Section 2 describes the model e3.at. Section 3 suggests an energy-efficiency scenario that meets the EC's targets. Section 4 presents modeling results and section 5 concludes.

2 An Environment-Energy-Economy-Model for Austria

The model e3.at (*e*nvironment, *e*nergy, *e*conomy in *A*us*t*ria) has been developed by GWS mbH (Gesellschaft für Wirtschaftliche Strukturforschung, Osnabrück) in co-operation with SERI (Sustainable Europe Research Institute, Wien). E3.at is designed to answer questions about the sectoral and the overall economic situation in Austria, about energy consumption and energy supply, about the development of environmental indicators such as CO_2-emissions as well as questions about material and resource consumptions. A baseline projection is contrasted with scenarios on certain developments and relative changes can be read as results from the respective policy measures. E3.at thus far has been used for the analysis of the use of renewable energy under different scenarios and the economic consequences (Stocker et al. 2007). The results of a study on the impacts of the 34% target (Lehr et al. 2008) are presented in this contribution.

2.1 The Economic Core

The sectoral disaggregated model e3.at has been constructed following the principles "bottom-up" and "full integration"[1]. *Bottom up* modeling accounts for each sector in great detail within an Input-Output framework and for the derivation of macroeconomic variables such as GDP or investment from explicit aggregation within the model. *Full integration* stands for complex and consistent modeling within the framework of SNAB (system of national accounts and balancing items), for instance simultaneously accounting for income creation and distribution in four institutional sectors, redistribution among those sectors und use of income for intermediate and final products. The model is highly endogenized. Tax rates, population development and world energy prices are exogenous. The domestic economic situation is connected to the world economy with a soft link to GINFORS (Global INterindustry FORecasting System) (Meyer et al. 2005).

The equation system comprises behavioral (estimated) equations and definitions. The behavioral equations base on the assumption of bounded rationality rather than strict optimizing behavior. The model parameters are estimated using OLS (ordinary least square) on time series from 1980 (1995 some) until 2005. The best estimate is used according to its test statistics. The system of national accounts, for instance, is filled using over 150 behavioral and defining equations.

Model specification, however, does not end with single equation estimates. The nonlinear, dynamic system of equations is solved using the Gauss-Seidel-Algorithm and converges due to certain criteria. Otherwise the specification starts again and equations have to be re-estimated.

The input-output-table lies at the economic core of the model. Here the multiple interdependent interactions between the different economic sectors such as agriculture, con-

[1] E3.at has been constructed in analogy with the German PANTA RHEI model which is an environmental economic extension of INFORGE (Interindustry Forecasting Germany)and as such part of the INFORUM (Interindustry forecasting at the University of Maryland) family of models (Almon 1991).

struction, production and energy supply take place. With the input-output structure direct as well as indirect effects of political measures are modeled.

We start from *households' consumption* (cpn_i) as the most important component *of final demand*. It is analyzed according to the k=37 categories of usage ($cpvn_k$). The determinants are the available income, general consumer prices and the prices of the respective usage. The explanatory variables are the same as in the Almost Ideal Demand System (Deaton and Muellbauer 1980) or the Perhaps Adequate Demand System (Almon 1991), but neither system is applied here. As mentioned above, we rather model bounded rationality and try to abstain from a preset bundle of consumption goods allowed for substitution processes. Therefore, consumption is directly modeled as a function of price adjusted available income (AVINC) and levels of consumer prices, interest rates (r) and other variables such as population, assets etc. (eq. 1).

$$cpvr_k[t] = f\{AVINC[t]/PCPV[t], pcpv_k[t]/PCPV[t], r[t], other\ldots\} \qquad \forall\, k \qquad (1)$$

Government consumption (CSN) in the current model version is determined by government's available income (AVINCG). This implies that additional tax income will lead to additional consumption (eq. 2).

$$CSN[t] = f\{AVINCG[t]\} \qquad (2)$$

As an alternative approach we could determine Government consumption from the requirements and needs on the demand side; then additional taxes would improve the budget balance.

The demand for investment -*gross fixed (real) capital formation* (baisr) of the economic sectors - closes the demand side, since exports are given from the GINFORS model. It depends on the development of real production (ysr) and of capital stock (ksr) (eq. 3).

$$baisr_j[t] = f\{ysr_j[t], ksr_j[t-1]\} \qquad \forall\, j \qquad (3)$$

If capital stock increases more rapidly than production, investment has to decrease. Increases in production on the other hand lead to increasing investment. Capital stocks result from last year's capital stock plus this year's investment minus depreciation. Since e3.at is an energy economic model, it is interesting to point out that investment in real estate follows a different logic. It depends on households' available income and population growth. Increasing incomes yield increasing demand for (better quality, larger) housing.

The *supply* side of the economy follows the input-output logic. Nominal *production* (y) is given by

$$y_j[t] = (I_{ij} - A_{ij}[t])^{-1}\,(fgun_i[t] - imn_i[t]) \qquad \forall\, i,j \qquad (4)$$

with nominal input coefficients $A_{ij}[t]$. The energy module and the material balances module use variable input coefficients. *Production* is determined by final demand (fgun) and feeds back to it by means of prices. The imports (imn) in the disaggregation of 57 product groups are a function of the sectoral gross production as well as the proportion of the domestic prices to the import prices. The latter are calculated within the GINFORS model.

Prices (pcpv) in the k=37 usages include the development in the producer prices, taxes such as VAT, energy taxes and special taxes on certain consumption goods (tobacco, liquor), and trade services. Therefore prices are explained by producer prices (ps) and goods specific add-ons (add)(eq.5).

$$pcpv_k[t] = f\{ps_i[t], add_i[t]\} \qquad \forall\, i \in k \quad (5)$$

Producer prices are determined by the unit costs (uc) of the firms, containing depreciation (ucaf), labor costs (uclk), the costs for domestic and/ or imported intermediate goods (ucvl) and other costs (ucelse) (eq. 6).

$$uc_i[t] = ucvl_i[t] + uclk_i[t] + ucaf_i[t] + ucelse_i[t] \qquad \forall\, i \quad (6)$$

$$ps_i[t] = f\{(1-\beta)\, uc_i[t] + \beta\, pim_i[t]\} \qquad \forall\, i \quad (7)$$

Producer prices then depend on domestic unit costs, import prices and a markup (7). The markup pricing hypothesis is typical for oligopolistic markets. Since supply-side related basic prices do not directly determine the demand side, the model contains the complete transition from production prices to final demand market prices for all components of final demand. This detailed modeling facilitates the evaluation of effects for instance of commodity-specific tax changes.

The *labor market* consists of an aggregated and a disaggregated section. In the aggregated section labor supply follows demographic quantities. To calculate the macroeconomic labor demand, firstly, an aggregate wage function (JLS) is estimated and the average total annual wage is determined from macroeconomic labor productivity, consumer price development, and the labor market situation. The respective average annual wage in each industry (jls_i) is correlated with the general macroeconomic development as well as sector-specific variables. The most significant determinants of the sectoral labor demand are gross production and real labor costs of the respective sector (eq. 8).

$$jls_i[t] = f\{JLS, ysn_i[t]/bas_i[t]\} \quad (8)$$

Labor remuneration and profits result from definition, all other components of primary inputs (net product taxes and depreciation) are explained econometrically. Employment (bas) is a function of the development of production, real wages and time trends, which can be interpreted as technological trends (eq. 9).

$$bas[t] = f\{ysr[t], jls[t]/ps[t], time\} \quad (9)$$

The data for the labor market module have been supplemented with data on average weekly working hours and qualification levels of the employed (Mikrozensus Arbeitskräfteerhebung 2005, 2006). We assume that the level of qualifications remain the same along the projection time. Further, we currently derive the labor supply from projections of the population.

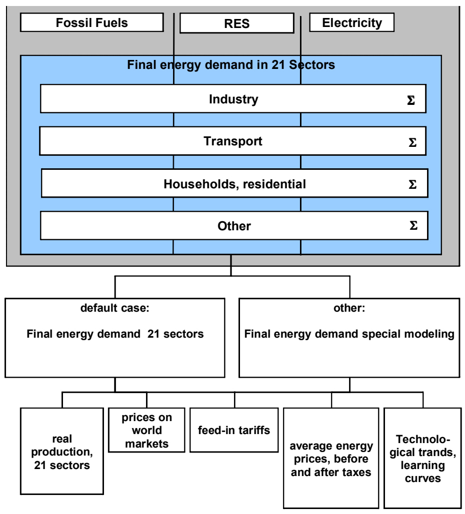
$$B6N00BH = \text{primary income} - \text{tax} + \text{transfers} + \text{income from self employment} + \text{income from assets} \quad (10)$$

$$B9000BG = \text{taxes} - \text{transfers} - \text{government consumption} - \text{government investment} \quad (11)$$

The quantities of the SNAB are consistently linked with the I-O system. Going through all accounts would exceed the scope of this paper. Because of their relevance for the results presented in section 4, the equations for households' income (B6N00BH) and governmental net financial balance (B9000BG) are given (eqs. 10, 11).

2.2 The environment-energy-Economy Module

E3.at has been developed to answer questions on the economic impacts of environment-energy-economy related measures and policies. Variables from the input-output-model influence energy demand and therefore energy supply and investment in the energy supply structure have an overall macroeconomic effect. Environmental policies aiming at a reconciliation of economic development and environmental sustainability have always been the subject of impact assessments. Such an impact assessment includes the analysis of the effects of environmental taxes, subsidies, levies or other types of regulation on the economy, preferably on a sectoral disaggregate level, to distinguish between different effects on industries and sectors. Therefore, the energy module has to capture primary energy supply, energy transformation and final energy consumption specified by fuel type and has to allow for all necessary connections to and from the economic model.



Source: e3.at, Großman et al. (2008)

Figure 1: Modeling energy demand

Energy quantities in e3.at are based upon the Austrian energy balances. The Austrian energy balances report the energy demand, transformation and supply for 17 selected energy sources and fuels. Energy transformation is reported for 7 sectors (cookery, refinery, power generation, heat generation, CHP (combined heat and power generation), gas generation and furnaces), energy consumption is given for 13 production industries, agriculture, transport, households and services, and non-energy usage. The transport sector is differentiated into railways, other land traffic, transport in pipelines, ships, and airplanes.

Total final consumption (TFC) can be calculated from total energy inputs minus total transformation output plus demand of the energy sector, the non-energy usage, transport losses and the final energy consumption *or* from domestic energy supply plus imports and inventory fluctuations and minus exports. Therefore, energy balances are closed accounts of the energy demand and supply *quantities* (in Terajoule). Household energy demand results predominantly from heat demand and is therefore tied to the heat requirements of buildings, the same holds for commerce and service sectors. However, electricity demand will gain importance due to an increasing the use of electrical appliances.

Future final demand is estimated as a function of production and relative prices individually for each fuel except for light fuel oil, which is determined as a residual. This approach facilitates modeling policies which aim at increasing the shares of non-oil fuels by setting quantitative targets. Energy demand from production is estimated in total for each sector, finding that the distribution over the fuels remains constant for most sectors. Fig. 1 shows the modeling approach for most sectors except for households and "Iron and steel", on which detailed information exists.

Energy prices, import prices and consumer energy prices are taken from Statistik Austria and international statistics. Future energy prices can be adjusted in different scenarios. Output from energy transformation is the result of total energy consumption by fuel. Input to transformation on the other hand depends on the technology mix in the heat and power generation utilities. The choice of this mix is an issue of scenarios and can be set exogenously. The energy module is especially designed to model the use of renewable energy sources (RES) in great detail. For instance, learning curves, cost degressions and investment in RES are explicitly considered. Domestic exploitation of energy resources cannot be increased by much in Austria. It is highly unlikely that new fossil resources will be discovered, but also the supply of biomass is almost at its max. Therefore, imports are treated as a residual in the module.

Apart from forecasts for the energy balances the connection to the economic model has to be attended. The main links are between the electricity generating technology and the input structure of the energy sector, and between the energy inputs of different production sector into the respective rows of the input-output tables. Paralleling the energy module and the economic model is especially important since prices are modeled in the economic core model. This way, we guarantee for inclusion of all fiscal effects in the model of final energy demand.

2.3 Classification of the Model e3.at

According to the classification of West (1995), the e3.at model is an "econometric + Input-Output model" that belongs to the family of national inter-industry models of the INFORUM family. The sectoral I-O results are consolidated via explicit aggregation to form macroeconomic variables. Beside this, these aggregate variables are consistently assigned to the relevant macroeconomic variables in the sequence of accounts and balancing items of the SNAB within the modeling framework. While the I-O approach is commonly classified as demand oriented, this is not the case for e3.at[1]. It is true that the demand determines production in the e3.at model, but all demand variables depend among other things on relative prices. The latter are determined by the unit costs of the firms in the form of a markup pricing hypothesis, which is typical for oligopolistic markets. Obviously, the difference between neoclassical CGE models and e3.at lies in the assumed market structure and not in the accentuation of either side of the market (West 1995, p. 216). Consumers react on price signals with their decisions, which then determine the production. Supply and demand elements are thus equally present (Frohn et al. (2003), Meyer et al. (2003, 2009), Lutz et al. 2009). For a model along the same logic for Germany see Meyer et al. (2007) or Lutz et al. (2005).

The e3.at model is nonlinear because there are many multiplicative linkages of variables in definitional as well as many behavioral equations estimated in double logarithms. Beside this, the model is dynamic because of capital stock adjustments and the lags in behavioral equations.

A recent comprehensive compendium on I-O analysis by EUROSTAT (EUROSTAT 2008) summarizes the strengths of the modeling approach by the INFORUM models and especially the German models INFORGE and PANTA RHEI: "An INFORUM model does not rely upon ex-post scaling to produce reasonable forecasts, though it may explicitly show statistical discrepancies necessitated by conflicting official data. It builds up macroeconomic totals, like gross domestic product, from industry level variables. It does not start with aggregate totals and spread them to industries. The model traces the development of the economy over time and may definitely show business cycles. It does not concentrate on an equilibrium condition at some future date (…) There is no attempt to determine centrally the form of the behavioral functions used."

Comparing e3.at such as other INFORUM models to other modeling approaches shows that compared to classical econometric models the linkage between inputs and outputs is more systematic, compared to classical input-output-models the use of behavioral equations is of advantage and compared to general equilibrium models the time paths of an economy that has business cycles and may not reach the steady state equilibrium can be modeled. E3.at as much as INFORGE has been explicitly designed to and can reflect structural change (Meyer, Ewerhart 1998 on INFORGE)

3 Renewable Energy in Austria – current Situation and future developments

Compared to its neighbors, Austria already uses renewable energy to a very large extent. Due to its large hydro-energy and biomass resources almost 60% of the electricity

[1] The same reasoning holds for INFORGE and PANTA RHEI, models of the INFORUM family for Germany (Meyer et al. 2007, p. 41).

generation in Austria stem from renewable sources and the overall share of RES in final energy demand is 23.3% (Statistik Austria, 2005). However, to meet the EC targets, additional efforts are called for. Currently, Austria misses its own ambitious CO_2 targets more or less in all sectors. In 2006, the emissions in the households sector (heat) have been 2.3 million tons of CO_2 equivalents higher than projected in the climate strategy of the Austrian government. Traffic and transport exceeds the climate strategy targets by more. Between 2005 and 2006 a decrease of emissions has been reached due to admixing of biofuels, but a sustainable development in this sector still is to be seen. Production and industry exceeded the targets of the climate strategy by 2.2 million tons CO_2 equivalents.

The energy and climate package of the EU foresees for Austria a 34% share of RES by 2020. This share refers to “Total energy consumption” which is defined as final energy consumption plus transport losses. The target will be met by increasing efforts mainly by electricity and/ or heat generating technologies, since the transport sector has its own target of 10% biofuel share, which will act as an upper boundary to the efforts in this sector.

3.1 The reference scenario

Lately several scenarios for the development of the Austrian energy supply have been suggested (cf. Kratena, Würger 2005 und 2007, Task Force 2008). Our goal therefore has not been to add yet another approach to the already carefully developed scenarios, but create a reference scenario and a line, which reaches the European targets for modeling uses and make these scenario descriptions workable for our model. The reference scenario mainly stems from the business as usual (BAU) development in Großmann et al. 2008, but includes a relatively higher efficiency than BAU in the transport sector and in production and has been adjusted for the (then) higher oil prices. Even though the oil price currently (Dec. 2008) is at its 4 year low due to low demand as a consequence of the current world wide economic situation, long term projections assume oil prices at a higher level again. The falling current energy prices cannot hide the fact that the years 2007/2008 saw the highest energy prices (in real and nominal terms) that ever have been asked. The structural problems (underinvestment in several oil producing countries, finite reserves etc. (cf. IEA 2008)) have not changed. Due to the sinking demand in the face of the current worldwide economic situation, the actual pressure on oil prices has slowed, but in the future, the upward tendency will prevail. The world energy outlook 2008 (IEA 2008) sees real prices ($2007) for IEA crude oil imports at $116. Our assumptions in the Austrian case study imply a real oil price of €100 for 2020. For this matter, our scenario is held comparable with the Austrian literature (Kratena, Würger 2008, KW80). However, KW80 and the reference scenario are not identical, mostly due to updates from Statistik Austria. These new data have been built into our reference scenario. Also, (autonomous) efficiency gains in the industry in KW80 are very high (>20%) and the data thus far do not support such a development.

3.2 Economic development in the reference scenario

Future overall economic development in the reference scenario will be a continuation of the recent past (cf. Statistik Austria, 2007). Gross real domestic product will be growing on average with 2.1% p.a. until 2015 and 2.3 % p.a. until 2020, if we suppose improving trade balances and a sustainable worldwide development. The Austrian industry had a rather good starting position on world markets. The current (as of Jan 2009) financial crisis is not regarded in our analysis, mainly because we focus on long term development and investment and because no sensible conclusions can be drawn from the currently available data and observations. The suggested growth paths, however, could be reached with delay.

Table 1: GDP and labor market

	1995	2000	2005	2010	2015	2020
GDP and its components in bil. Euro						
GDP	182	210	226	251	281	318
Private consumption	107	120	129	141	155	173
Government	35	39	41	42	43	46
Investment plant and equipment	41	48	47	53	58	65
Exports	52	83	110	147	191	245
Imports	59	85	110	143	180	227
GDP and its components, growth rates, 5year periods						
GDP		2,9	1,4	2,1	2,3	2,5
Private consumption		2,2	1,5	1,8	2,0	2,1
Government		2,0	1,0	0,7	0,6	1,3
Investment plant and equipment		3,2	-0,2	2,1	2,0	2,2
Exports		9,7	5,7	6,1	5,4	5,1
Imports		7,6	5,3	5,4	4,7	4,7
Labor market						
Employment in 1000	3.070	3.133	3.235	3.290	3.362	3.469

Source: Own calculations.

Private consumption grows slower than overall GDP. Public expenditure stays aimed at consolidation. Investment on buildings and equipment follows GDP to the most. Employment increases by 6% between 2005 and 2020 (200.000 people). Exports from Austria increase and industry increases its share in overall production. Services, including public services decrease in their share.

The distribution of employment on the different sectors shows a slightly different picture. Due to an increase in labor productivity, the share of industries in overall employment decreases. Industry related services can increase their share; all other services and trade stay approximately the same.

3.3 Development of the Energy Indicators in the Reference Scenario

The reference scenario suggests a higher decoupling of energy and growth until 2020 than it has been observed in the past. This reflects the idea that also internationally the support for efficiency increasing technologies has been rather large in response to the high energy prices in 2006/07/08. This technology path will not be reversed in response to current low oil prices.

Therefore the reference scenario supposes an autonomous efficiency increase of 10% by 2020 in production as well as in transport. An EU-wide limit to CO_2-emissions can lead to a decrease in energy consumption. Historically a decoupling of transport and energy used cannot be proven. In Austria, exogenous effects make the development in the transport sector difficult to interpret: since a law change in Germany, Austria observes large increases in energy consumption due to increasing "fuel tourism", i.e. cross-border shopping for gasoline especially from Germany.[1]

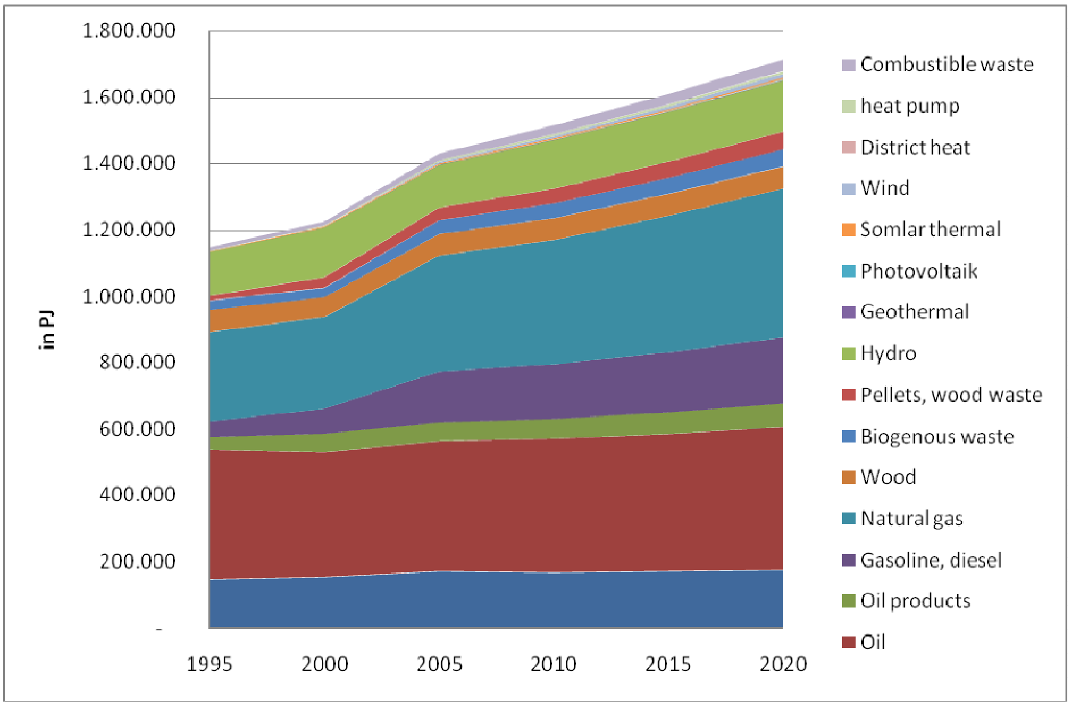


Figure 1: Total primary energy supply, categories of following Austrian energy balances in PJ 1995 to 2020

Figure 1 shows the development of Total Primary Energy Supply (TPES) in the reference scenario. While the supply of hard coal remains roughly constant, among the fossil fuels natural gas is rising. Increases in the gasoline and diesel mainly reflect higher average consumption, for instance due to larger vehicles, apart from sales to the neighbor country (cf. Statistik Austria 2007). Renewable energy increases very moderately.

Final energy consumption exhibits shifts between the different sectors. Industry and transport will take a larger share though the reference scenario already assumes larger efficiency gains than the past (for a discussion see section 2 above). Private households increase their final energy consumption but less than the other sectors, therefore their share slightly falls. Services increase in importance also partly due to increasing electricity consumption from electrical appliances.

[1] Estimates go as far as 25% of total fuel consumption. (Molitor 2004)

3.4 Target-oriented Scenario

The reference scenario reaches a 25% share of RES by 2020. It therefore misses the EU targets by a large amount. In the following, we develop a target oriented scenario (TOS) following a twofold strategy: firstly the scenario taps some of the lower cost potentials of RES that are still available in Austria, especially with solar thermal applications and heat pumps. This first step is aimed at increasing the enumerator of the target quantity. Secondly, final energy consumption – the denominator of the target quantity - has to be significantly lowered. We suggest a thermal insulation push to exploit the large efficiency potentials in the buildings' sector. The twofold strategy has been chosen out of several reasons: Austria already developed large parts of its RES potential for electricity generation. Energy consumption of households on the other hand exceeds most European countries and exhibits a potential thus far undeveloped. Ambitious goals can be reached in the medium term to realize large savings on households' energy expenditure in the long run. Both aspects of the TOS scenario will be described in the following sections.

3.4.1 Renewable Energy

Two recent Austrian studies explore the potentials for RES in Austria (Table 2). The Austrian Environmental Agency (AEA) developed together with the Federal Agency (UBA) a scenario oriented towards the 34% target for the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management. The so-called Task Force (TF) had earlier been asked by the Ministry to develop a scenario, which was oriented towards the goals of the Austrian National Climate strategy.

Table 2: Comparison of different scenarios

	TF	AEA/UBA	TOS
Hydro	167,0	151,0	160,1
Bio-diesel	8,2	6,7	6,7
Bio-ethanol	5,1	5,1	5,1
Imported fuels		31,1	31,1
Geothermal		1,6	2,1
Photovoltaic	10,8	0,3	5,1
Wind	26,5	14,9	19,1
Solar thermal	28,0	16,0	22,5
Heat pump	27,0	12,0	20,9
Waste	12,0	3,5	7,8
Waste lye	18,8	18,8	18,8
Forestry	117,6	119,5	119,0
Agriculture		10,5	12,8
Other.	37,0		
SUM	458,0	396,1	430,1

Source: Own calculations, Task Force 2008, AEA/UBA 2008.

These were higher (40% renewable energy) than the European targets. The TOS uses these studies as an orientation, partly follows the suggestion and partly for reasons specified below, deviates from them.

For *hydro power* the additional potential is seen in the literature between 11 and 25 PJ. For the maximal increase large hydro power has to be extended beyond the ecological limits. Therefore we suggest an increase of 16 PJ in a combination of small hydro (6PJ) and large hydro within ecological limits.

Electricity generation from *photovoltaic* appliances (PV) in Austria starts from a very low level. For comparison: in Germany, which is similar in conditions concerning possible yields, 16 times more per capita installation is observable. Though PV currently has the highest per kilowatt hour costs of all renewables, it also exhibits the steepest cost reduction curves. It can be expected to reach grid parity by 2015. Therefore we assume a total of 5.4 PJ by 2020.

Although Austria does not own the huge coastal *wind* energy potential of other countries, some interesting wind power locations remain unused. Moreover, the yield from existing locations can be increased by repowering. The gains from repowering can reach up to three times the original yields. Therefore, we set 19.1 PJ wind energy by 2020.

Like in most European countries, the heat sector exhibits vast potential. Private households as well as office buildings, schools, hospitals and sports facilities can switch to solar heaters for hot water generation and to the use of heat pumps for heating and/or cooling the buildings. The demand for *heat pumps* has increased in 2006 by 37%, a development that has also been observable in Germany. The TOS contains 20 PJ heat from heat pumps with 13 PJ in private homes and 7 PJ in office buildings (2020).

The technological development of solar heating has gained immense speed in the last years. As a consequence, we assume application beyond hot water generation and suggest 28 PJ by 2020 in accordance with Task Force (2007) or Haas et al. (2007).

Though the domestic biomass potential is almost at its limits, we suggest an overall contribution of biomass in fuels from agriculture and forestry of 135 PJ. Taking stock of the possible increases in RES in Austria shows that the share of RES does not fulfill the EU targets if final energy consumption stays in line with the reference scenario. To cover this gap, we suggest major improvements in the energy efficiency of buildings.

3.4.2 Efficient buildings

The average size of apartments in Austria rose in the past as in other European countries, as well as the per capita size due to an increasing number of single person households. In rental apartments the average size is 67.5 sqm, owner used freehold apartments have an average size of 82.6 sqm and houses have on average 120 sqm.

Age structure of the real estate determines energy efficiency. The range goes from 300 kWh/sqm for old buildings (pre 1900) to 15 kWh/sqm for so-called passive buildings. Annual refurbishment rates have been around 1% in the past (Amann, Komendantova, 2007). With this speed, no significant improvement of the overall efficiency will be reached by 2020. Any building that has been built before 1980 plus a share of the buildings from between 1980 and 1991 is considered due for refurbishment in the following in accordance with the literature. One percent reduction in the building sector leads to 0.2%

reduction in overall final energy consumption. We model a twofold improvement of energy efficiency of buildings. Firstly, the annual rate is increased to 3% and secondly, changes of the heat and hot water system to modern standards are enforced.

Investments for such an efficiency push lie between €1.7 and $€_{2007}$1.4 billion per year. If we include the current year as a starting year, aggregate investment until 2020 will be around €30 billion. The energy savings at the end of this measure will amount to 35 PJ and will remain at this amount for the following years.

3.4.3 DISCUSSION OF THE SUGGESTED SCENARIO

The TOS sets an ambitious framework for the green house gas mitigation and the achievement of the European targets in Austria. The key factor is the combination of RES increase and efficiency increase. One measure alone could not attain the same results. To trigger the measures, a balanced mix of different policies is needed and the existing support mechanisms have to be more strictly enforced.

In the e3.at model we assume that 50% of the necessary investment is borne by private households. We assume complete credit based financing and an imputed effective interest rate of 6%. At the same time we assume short pay back times; with 10% initial pay-off the loan is paid back after 7 years. The modeling approach has been chosen to be able to model most of the effects on private budgets within the given time frame until 2020. With lower pay-off rates the overall economic results can be improved but some of the effects took place after the timeframe of our analysis.

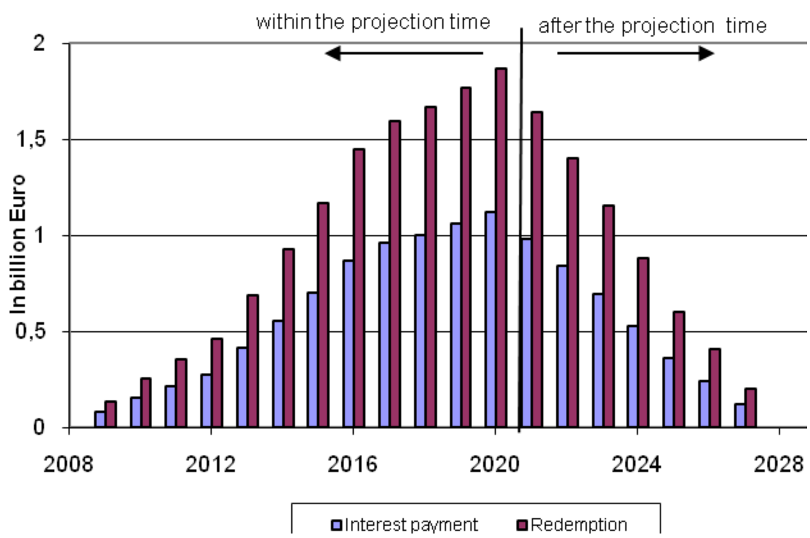


Figure 2: Interest payments and redemption payments of private households

Payments to the loan affect households consumption decisions since part of their available income is tied to the pay-offs. Figure 2 shows the development of the payments for interest and redemption by private households. Both reach their maximum in 2020 and decrease afterwards. From 2017 on the increase in payments slows, because very early investments by that time will be fully paid. The number of paid investments will increase over the year. When the program is finished by 2020, this effect shows in full.

4 Economic impacts of TOS

The specifications of the TOS trigger numerous effects in a highly interdependent model such as e3.at: Imports of RES facilities increase when domestic investment in the technologies grows. Import of fossil fuels decreases when energy is generated from domestic sources. Dynamic effects of a changing economic structure and technological progress are modeled to the extent possible on the historic database. Increasing labor productivity leads to increasing output per employee. Energy efficiency will also increase autonomously and lead to a decreasing share of energy expenditure in GDP. Budget effects due to decreasing energy imports are fully considered.

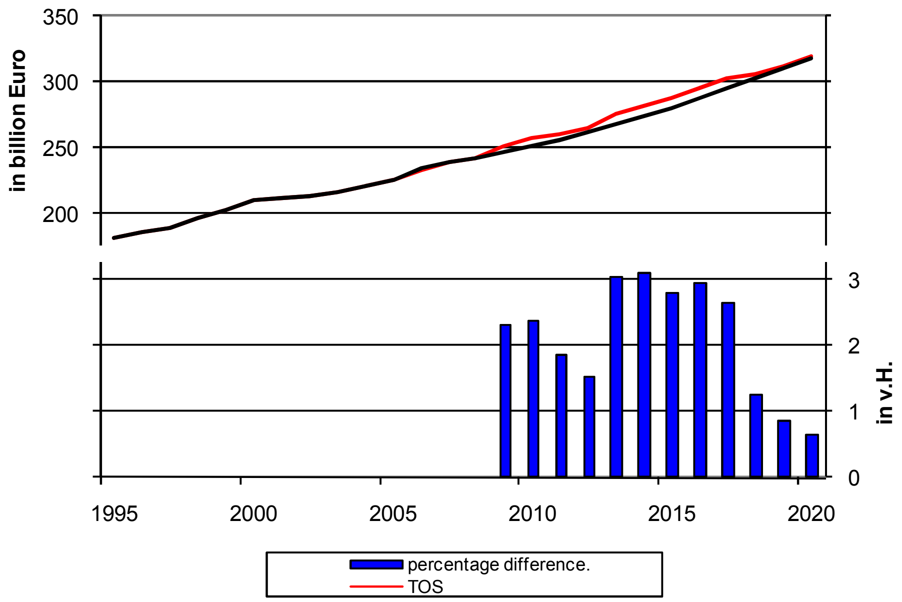


Figure 3: GDP – Comparison of the reference scenario and the TOS

Overall economic development is characterized in the TOS by large increases in investment, compared to the reference case. Exports of RES technologies increase, but they are smaller than investments and therefore do not affect the overall development as much. The increasing application of renewable energy for heating purposes taps a large innovation potential. Already Austria is leading in heating systems with low particulate emissions and heat recovery systems. The market position of Austria on the European markets will get stronger as the neighboring countries are striving to fulfill their RES targets. Similar effects have been shown in Staiß et al. (2006) or Lehr et al. (2008) for Germany. For Austria, supposing the DCP (Dynamic Current Policy) scenario by EREC (European Renewable Energy Council) 2004 world heat generation from renewables will triple to quadruple by 2020. Assuming further that the current export share of 50-70% of the respective Austrian industries will be maintained at least 0.75 billion Euro can be expected in this sector.

This is a rather conservative estimate that does not assume further consequences of the developing lead market.

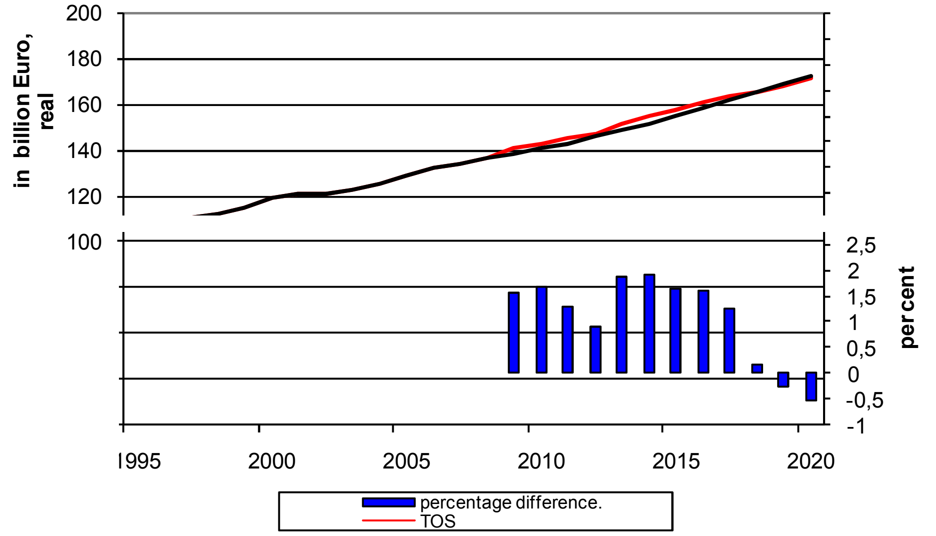
GDP will be larger by 0.6% in the TOS in 2020. Along the timeline considered, increases of up to 3% can be observed, which decrease partly due to increasing energy costs (from the increasing share of RES) and the burden on the households from refurbishment investments and pay-offs for debts. Table 3 shows the percentage differences between the TOS and the reference case for selected variables. For interpretation, the reader has to keep in mind that the TOS considers a “solo-attempt” of Austria. Since the EU directive holds for all EU member states, it is likely that Austria can gain on the international markets for energy efficient technologies and for heat pumps as well as biomass heaters. For clarity’s sake the table shows selected years. E3.at of course is based on annual data and produces results for each year. Employment in 2020 will exceed employment in the reference case slightly. Along the timeline, employment increases by 75.000 people.

Table 3: Economic indicators in TOS, percentage differences to the reference case

	2010	2015	2020
Bruttoinlandsprodukt	2.4	2.8	0.6
Konsumausgaben der privaten Haushalte	1.7	1.6	-0.5
Konsumausgaben des Staates	2.5	3.5	1.6
Anlageinvestitionen	8.2	12.5	7.0
Exporte	0.2	-0.1	-0.3
Importe	1.6	2.1	0.9
Beschäftigung	1.6	2.1	0.8

Source: Own calculations.

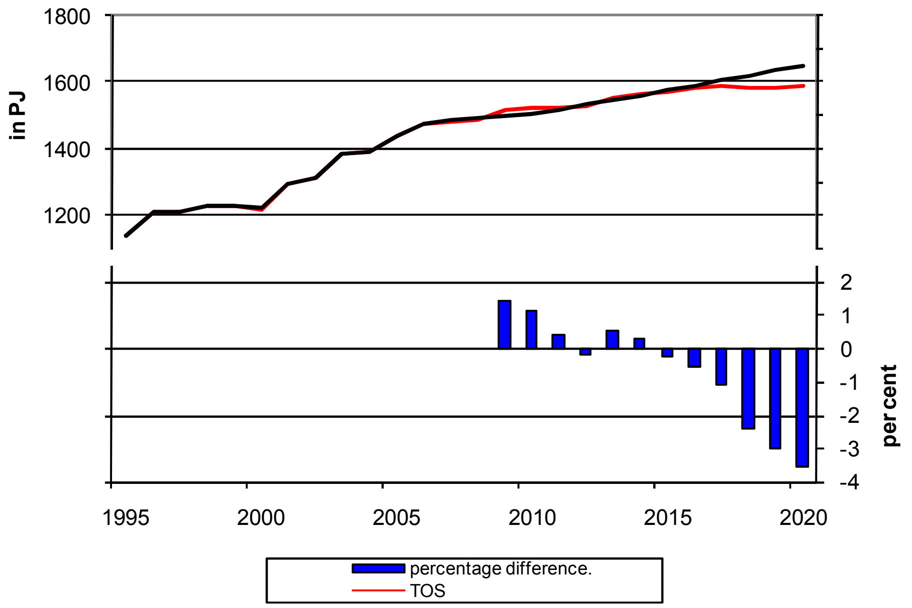
The winners of the strategy are found in the building sector, industries and in services for the industry. Of course, there are not only winners. Sectors without direct impact from the program suffer from the overall budget effect and employment in these sectors declines. Exports from the RES technology industries increase. They lead (gross effect) to 4.300 additional jobs.



Source: Own calculations.

Figure 4: Households'consumption (reference and TOS)

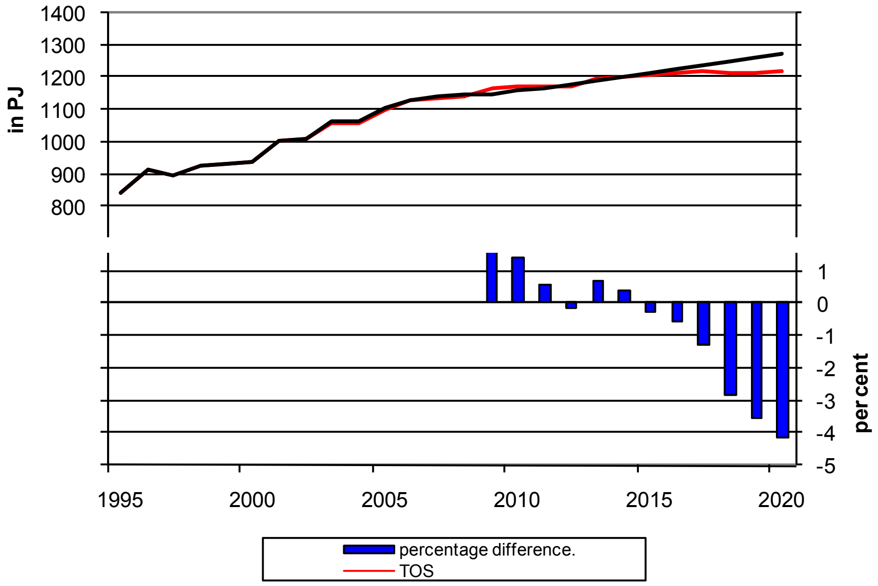
Increases in operation and maintenance of the RES facilities create an additional 1000 jobs. Private households bear a large share of the burden. Prices for apartments (+4.4% in 2020) and energy (+1.4%) increase. Increasing interest payments (+1.2 billion Euro in 2020) add to the burden and are balanced by consumption losses. In 2020 households contribute negatively to growth. Total primary energy supply increases at first due to the economic activities and decreases from 2015 because efficiency gains start working.



Source: Own calculations.

Figure 5: Total primary energy supply (reference and TOS).

Final energy consumption shows similar effects. At the beginning the additional activities lead to an increase and savings come into effect from 2015. The more efficient use of energy can be seen in the CO_2 emissions per unit GDP. This indicator drops significantly compared to the reference case.



Source: Own calculations.

Figure 6 Development of CO_2-emissions

Overall CO_2 emissions increase at first due to additional activities and falls after 2012. Thus the modeled measures mitigate the need for CO_2 certificates in the future. For a price of 40€ per ton of CO_2 savings will be around €140 million annually, starting in 2012. Overall savings could amount to €1.12 billion until 2020.

5 Conclusions

The debate on investments in climate change mitigation in the face of the financial and economic crisis is at its beginning. First effects could be observed in the discussions before the approval of the European Climate Change Package in December 2008. For a fruitful discussion it might be important to lead a separate discussion

on the effects of the *financial crunch* on investment in renewable energy and efficiency – i.e. the difficulties to provide appropriate credit lines for such an investment in the current atmosphere of mistrust in the financial sector – and on the effects of the economic downswing on climate change mitigation strategies.

The latter aspect can be an important input to current debates of growth programs and support measures of different countries and within the EC. This paper contributes insofar as it shows the impacts of a rather ambitious program to be positive for the overall economy. For a detailed analysis which includes sectoral effects a macroeconomic model is needed. We developed such a model for Austria, the e3.at model. It includes the full Austrian SNAB, the Austrian Input-Output tables and the energy balances and connects them in a consistent framework it thus yields a consistent picture of the economic development in Austria under a strategy to meet the EC targets.

The key element for the Austrian target of 34% RES is the combination of improved efficiency in the housing sector and an increase in renewable energy for heating purposes. The improved housing efficiency can only be pursued by a policy mix of support measures, regulatory measures, and incentives from tenancy law. Support measures have to exceed the existing measures. The main problems with existing programs seem to be acceptance, information deficits and unattractive by-conditions. Further, the diversity of programs and regulations across the Austrian states proves as a barrier for larger companies because the information costs are rather high. Tenancy law could provide incentives to improve the efficiency of buildings if rent ceiling were including heating costs (cf. Lehr 1994).

To show the most of the induced effects we have modeled a rather fast redemption of credits by private houses. This way the investment effects and the decreased consumption effects take place in the same time period and can be compared. After the considered time line, only the later investors still have to pay off their credits. The early investors start collecting the saved costs for oil and gas as gains from the increased efficiency.

Decreasing requirements of natural gas can also means an immense improvement of Austrian energy security. The latest gas conflict between Russia and Ukraine led to a total stop of natural gas delivery from Russia to Austria on January 7, 2009. The storages generally last for 3 months but Austria already switches power plants from gas to oil, with all the disadvantages of this measure.

Investment into energy efficiency and domestic renewable energy can, as we show in this contribution, lead to sustainable growth and secures employment.

Acknowledgements

This paper is based upon research for the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management, published May 2008 under the title: “Gesamtwirtschaftliche Effekte der Umsetzung der EU-Ziele im Bereich Erneuerbare Energien und Gebäudeeffizienz in Österreich bis 2020”.

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7 Appendix

	Share of RES in GFC, 2005 (S2005)	Target for share of RES in GFC, 2020 (S2020)
Belgium	2.2%	13%
Bulgaria	9.4%	16%
The Czech Republic	6.1%	13%
Denmark	17.0%	30%
Germany	5.8%	18%
Estonia	18.0%	25%
Ireland	3.1%	16%
Greece	6.9%	18%
Spain	8.7%	20%
France	10.3%	23%
Italy	5.2%	17%
Cyprus	2.9%	13%
Latvia	32.6%	40%
Lithuania	15.0%	23%
Luxembourg	0.9%	11%
Hungary	4.3%	13%
Malta	0.0%	10%
The Netherlands	2.4%	14%
Austria	23.3%	34%
Poland	7.2%	15%
Portugal	20.5%	31%
Romania	17.8%	24%
Slovenia	16.0%	25%
The Slovak Republic	6.7%	14%
Finland	28.5%	38%
Sweden	39.8%	49%
United Kingdom	1.3%	15%