MOVE2 – Simulation model of the (Upper) Austrian economy with a special focus on energy

incl. the socio-economic module MOVE2social: integration of income, age and gender

Sebastian Goers
Martin Baresch
Robert Tichler
Friedrich Schneider

November 2015

ENERGIE INSTITUT
an der Johannes Kepler Universität Linz

JKU
JOHANNES KEPLER UNIVERSITÄT LINZ

Owned and published by

ENERGIEINSTITUT AN DER JOHANNES KEPLER UNIVERSITÄT LINZ

Altenberger Straße 69, A-4040 Linz

Phone: +43-732-2468-5656 / Fax: DW 5651 / office@energieinstitut-linz.at / www.energieinstitut-linz.at

Information according to the § 25 MedienG law / disclosure at http://www.energieinstitut-linz.at/p_impressum.asp

Contents

1 MOVE2 und MOVE2social

Since 2013, an update of the data base and an adaptation of the equation structures of the model MOVE (Model to simulate the (Upper) Austrian economy with a focus on energy), which was designed at the Energy Institute at the Johannes Kepler University of Linz, has been carried out. MOVE has already been applied in a variety of private and public studies to quantify economic impacts of energy, environmental and climate policies. Since 2008, the Energy Institute at the JKU Linz realized quantitative economic analysis with this time series-based macroeconomic simulation model. The update of the model, named MOVE2, is used for future research questions about the economy, energy policy and environmental policy issues since autumn 2014. For a full and transparent presentation of all model equations the reader is referred to Tichler, R. (2009) "*Optimal energy prices and the impact of energy price changes on the Upper Austrian Economy. An analysis using the newly developed simulation model MOVE* (in German)", Energy Institute at the Johannes Kepler University of Linz, Energy Studies, Volume 4.

The primary targets of energy and climate policies are the sustainable, competitive and secure energy supply and the reduction of greenhouse gas emissions. This leads regularly to cost burdens of the addressees of the regulation and may imply differences between climate / energy and distribution policy objectives. Thus, in addition to the economic efficiency and environmental effectiveness also socioeconomic preferred or non-regressive distributional effects have to be taken into account. On the basis of the module MOVE2social, the effects of energy and climate policies for (Upper) Austria can be displayed from a socioeconomic point of view.

This description of MOVE2 and its add-on module MOVE2social represents a compact summary of the model, its properties and structure, as well as the integration of socio-economic parameters age, income and gender.

The simulation model MOVE allows the estimation of various economic and structural changes within (Upper) Austria and the analysis of economic, ecologic and energetic effects due to political decisions. The main emphasis lies on energy which enables comprehensive and complex studies of all aspects of the (local) energy market. The model was principally designed for Upper Austria, but is suitable for the entire Austrian area accounting for special structural characteristics. MOVE was already applied in several regional and national projects (financed e.g. by the Austrian Climate and Energy Fund, regional institutions and energy providers) particularly for the economic analysis of energy and environment related research questions.[1] Within the level of Central Europe, no comparable simulation tool regarding the energy sector exists.

An update of MOVE was conducted due to the fact that a lot of new time series data points are available since the creation of the first model (2007) to refresh the old dataset and the estimations of the equations. Furthermore, a more detailed illustration of social structures is enabled by the socio-economic additional module MOVE2social.

The main differences between MOVE2 and its predecessor model are:

- MOVE2 includes additional data for the time from 2008.
- MOVE2 includes effects of the financial and economic crisis and the changes in the behavior and decisions of consumers and producers. For example, it was found that the variation in consumer behavior in such cases lasted slightly longer in the following years as in the model MOVE.
- After including new data points, all estimates were recalculated. This led to adjustments in the estimated coefficients and thus to slight changes in the model calculation based on the economic structure.
- The tool MOVE2social also recognizes socio-economic parameters via displaying the effects on the level of employment (or unemployment) broken down by sector, income groups, gender and age mapping

[1] For an overview about various research applications of the model for Upper Austria and Austria the reader is referred to Section 4.

2 Model structure

In the following, the general structure of the simulation model MOVE2 is outlined taking also into account the socio-economic module. In the last step, the functioning of simulation models (as opposed to forecasting models) and the used econometric methodology is explained.

2.1 Model components

Macroeconomic models use econometric methods to display economic relationships in specific structural equation systems. All endogenous variables are explained by stochastic equations. The economic relationships are revealed using time series, so that the model draws on the economic structures of the past to simulate certain changes. The specified theory-based equations are estimated using econometric methods and implemented in the model structure. In addition to the stochastic equations (or, in the economic context "behavioral equations") the model incorporates identities of equations, which specify the model additionally. MOVE2, MOVE2social and their predecessor models were designed to allow extensions of the model through identity equations and stochastic equations. Hence, additional modules can be inserted into the model framework. MOVE2 contains 330 equations and 476 variables to perform the simulations. The estimation horizon is modifiable.

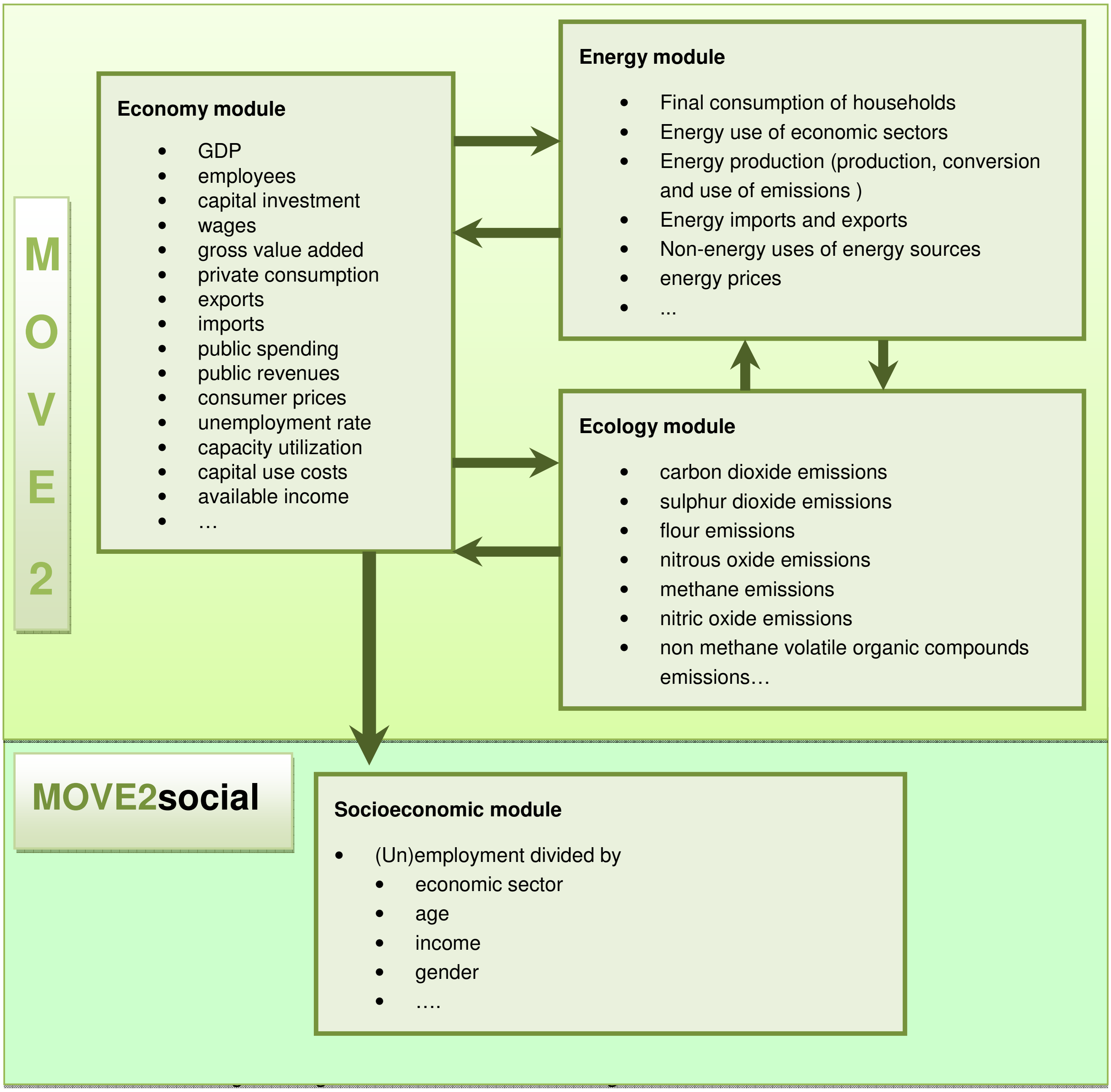
Table 1: Model components

	#
Equations	330
Stochastic equations	162
Identities	168
Variables	476
Endogenous variables	330
Exogenous variables	146
Modeled sectors	13
Modeled energy sources	24

Note: Extensions of the individual modules are possible, so that the respective number of variables, equations and model components can change over time. The extensions by mapping social structures have been neglected here.

In Figure 1, the different modules of MOVE2 are presented. The economic module covers 13 economic sectors. Since the use of energy implicates the generation of (greenhouse gas) emissions, MOVE2 also contains an emissions tool which calculates the emissions changes due to the energetic use in (Upper) Austria. Within the module MOVE2social, the effects on unemployment or employment can be diversified by industry sector, income, gender and age.

Figure 1: Modules overview



Within the energy module 24 energy sources are modeled whose emissions can finally be displayed in the ecologic module. Via this tool the quantity changes of carbon dioxide emissions, sulphur dioxide emissions, fluor emissions, nitrous oxide emissions, methane emissions, nitric oxide emissions and nonmethane volatile organic compounds emissions can be displayed. Hence, MOVE offers a broad scope of application: Exemplary analysis features the increase of fuel prices, deviations in investment activities in certain economic sectors or changes of the (Upper) Austrian interest rate.

The focus on energy is not constrained to the final private consumption of households as well as the energy consumption of different economic sectors. Various energy flows in (Upper) Austria, for example the production of secondary energy carriers, the fabrication of primary energy carriers and imports and exports of energy are covered by the simulation model. Table 2 provides an overview of the covered energy sources in the model.

Table 2: Covered energy sources

ambient heat	diesel	liquefied gas
bio fuel	district heat	natural gas
brown coal	electric power	other refinery inputs
coal briquets	fire wood	petrol
coke	fuel oil (heavy)	solar and wind power
coke oven gas	fuel oil (light)	stack gas
combustible turf	hydro power	stone coal
crude oil	kerosene	waste

Note: The selection of energy sources is based on the energy balances of Statistics Austria.

Within the energy module, 24 different energy sources are modeled whose emissions can finally be displayed in the ecologic module. Via this tool the quantity changes of carbon dioxide emissions, sulphur dioxide emissions, fluor emissions, nitrous oxide emissions, methane emissions, nitric oxide emissions and nonmethane volatile organic compounds emissions can be displayed.

In order to provide differentiated and detailed simulations, the following 12 different economic sectors are modeled next to the aggregation of the private households:

Table 3: Covered economic sectors

forestry and fishery
mining industry
real assets production
energy and water supply
building industry
commerce and repair of automobiles and durable goods
accommodation and restaurant
transport and communication and information transmission
credit and insurance industry
real estate and business services
public services
other services

2.2 Additional socio-economic module

The objective of the socio-economic science is to analyze the connection between economic activities and processes in the society in order to explain the social reality. In order to detect these interactions between the economy and society within the simulation analyzes in greater detail, the MOVE2social tool was created. Hence, the outputs of this tool allow to value energy-, environmental- and climate policy issues not only from an "economic" point of view (eg, efficiency, utility maximizing actors) but also taking into account social structures.

The model extension is based on data of the Public Employment Services of Austria (AMS) and Eurostat (EU-SILC surveys 2009-2011). Any increase in employment leads to a reduction in unemployment in the same order, and vice versa. Thus, the determinants of employment changes are identical to those for unemployment, but in the reverse direction of action. Determinants that lead to employment changes are for example changes in the real wage and/or productivity, qualification-requirements as well as changes in aggregate demand. With regard to the variables "employment" and "unemployment" MOVE2social detects the subdivisions and socio-economic parameters:

- economic sector
- income class
- age
- gender

Figure 2 through Figure 5 provide an overview of the employment distribution by industry, income distribution and the gender and age distribution by income groups for Austria in 2011.

Figure 2: Employment distribution by sector in Austria (2011)

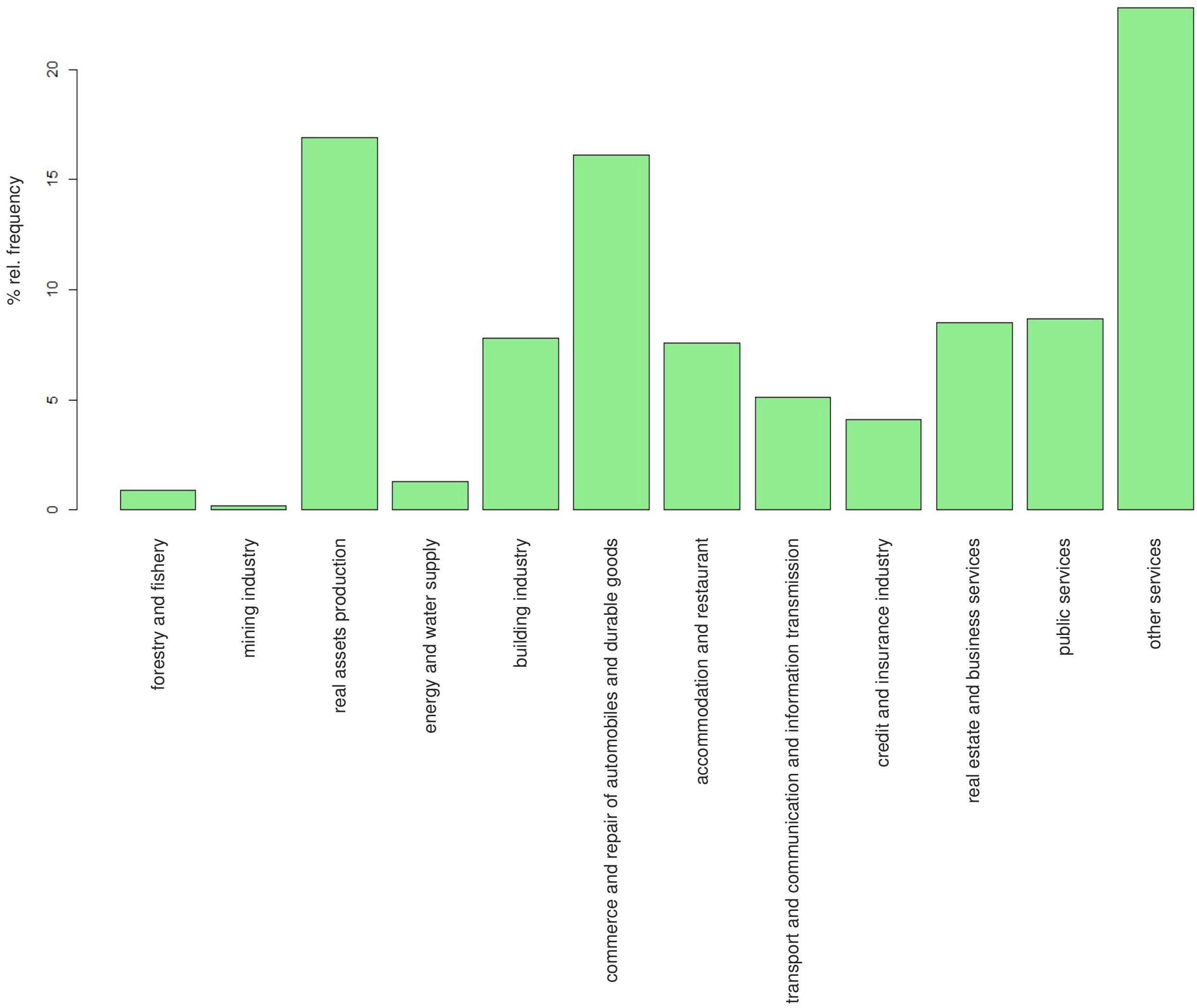


Figure 3: Box plots of net income by economic sector in Austria (2011)

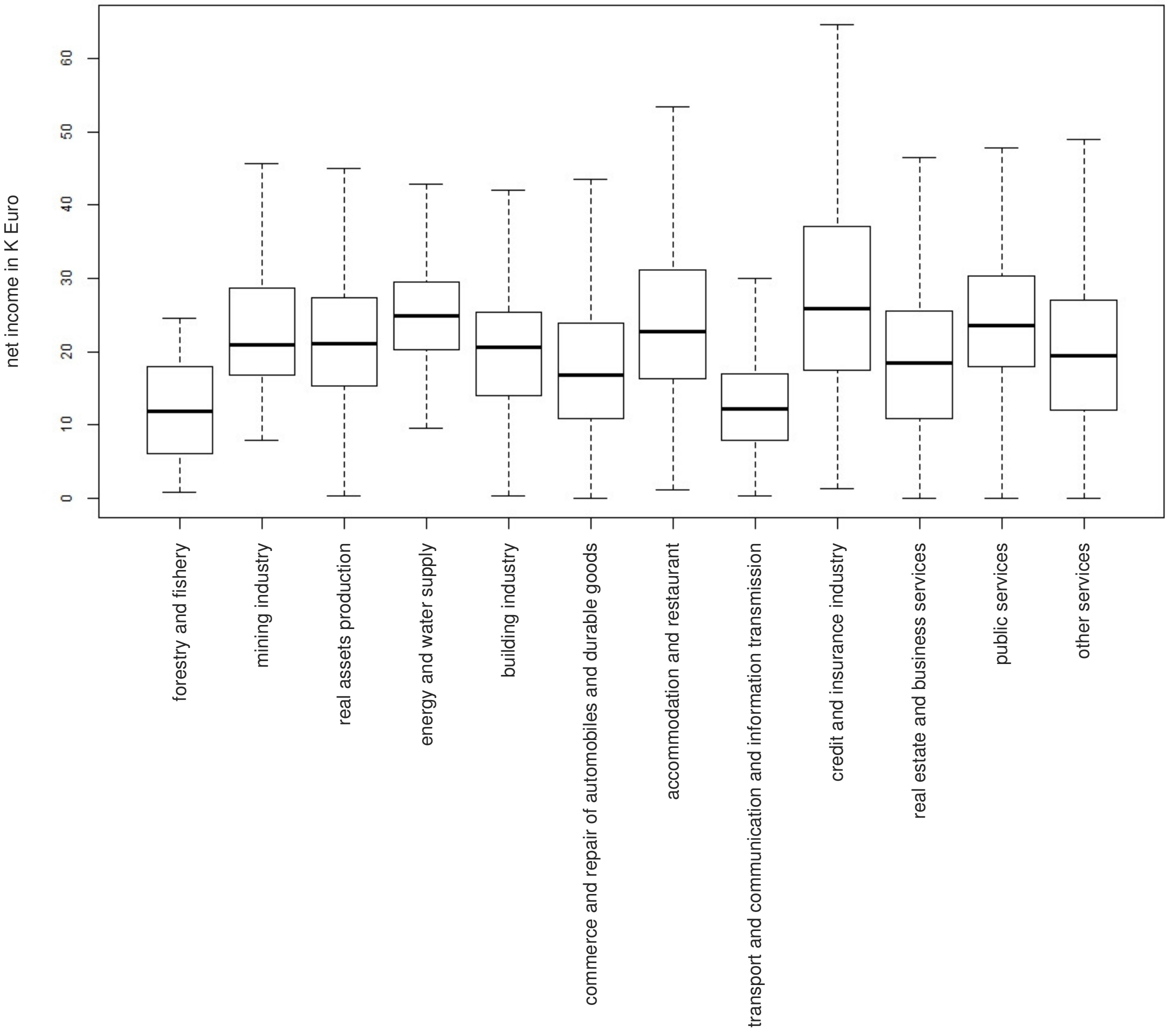
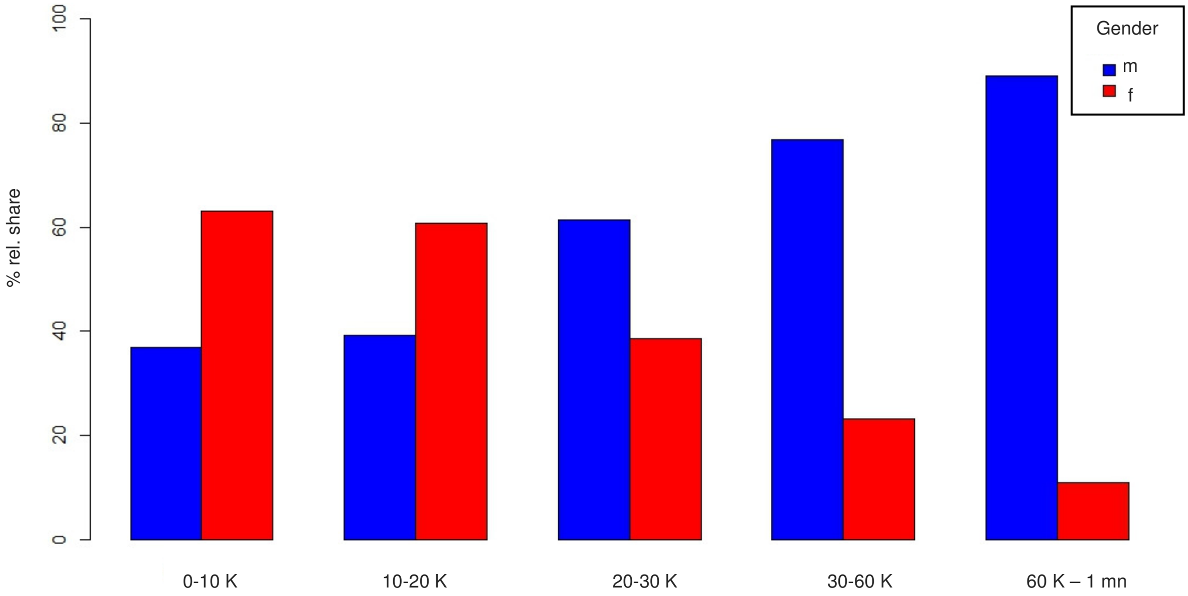
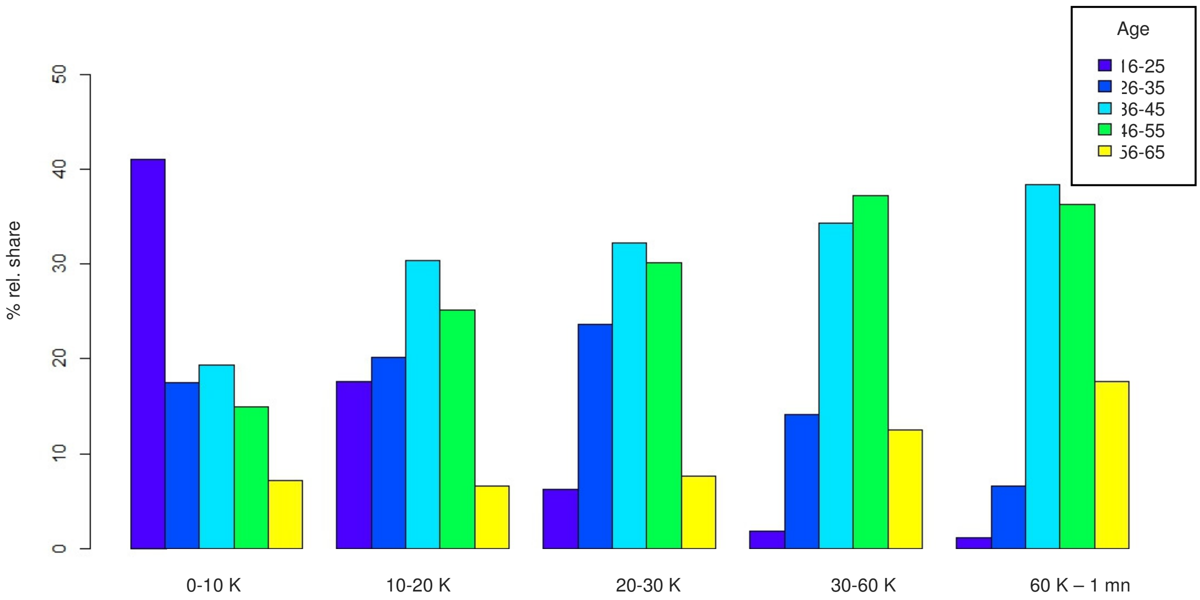


Figure 4: Gender distribution by income classes in Austria (2011)



Note: m = male, f = female

Figure 5: Age group distribution by income classes in Austria (2011)



2.3 Functioning of simulation models

Analogous to MOVE, each simulation with MOVE2social involves the calculation of two different paths of (Upper) Austrian economy. The first development path calculates the future development of the endogenous variables in the model (below a certain definition of the future development of exogenous variables). This development path may be referred to as business-as-usual scenario. The second path of development, the simulation scenario, calculates the future development of all endogenous variables resulting from a change in a certain parameter (endogenous or exogenous) by the user of the simulation model.

Generally, it has to be noted that a large proportion of the exogenous variables in the overall model or a high absolute number of exogenous variables would decrease the actual forecast suitability of a model and therefore suggests the application of the model as a simulation model. Because of that, MOVE2social is defined as a simulation model and not as a forecasting model. This implies that the difference between the two paths of development - the difference of each endogenous variable between the business-as-usual and the simulation scenario – is the model's output.

The main difference between the two model types is particularly the degree of modeling the "foreign" region or economy. A detailed modeling of the "foreign" allows for the estimation of feedback effects. This means that certain changes in the "domestic" region and domestic economy influence in the "foreign" regions which in turn might have impacts on the domestic region and economy. The modeling of such feedback effects is essential for a forecast model. However, they cannot be carried out within the framework of the present model.

However, the results of a simulation model represented by the differences between the two development paths are not influenced crucially by exogenous effects of the foreign economy. Both scenarios, the simulation scenario and the business-as-usual scenario will be affected by the exogenous factors of the foreign economy to the same extent. Once the differences of both scenarios are reproduced there is no distortion in the result. This approach of a simulation model for reproducing the differences between a business-as-usual scenario as well as a simulation scenario is thus for MOVE2social and its predecessors the most appropriate form for the evaluation of changes in the (Upper) Austrian economy.

2.4 Econometric estimation methods

The construction of a macroeconomic model requires the careful selection of econometric methods for the estimation of individual equations and systems of equations. In principle, two central questions regarding the model design and the selection of the econometric estimation methods arise:

I. Does the estimation of the model's equations take place simultaneously or is a separate estimation of the individual equations reasonable?

II. Based on I), how can a consistent estimation be ensured?

An exclusive modeling of single equations can lead to inconsistent estimators when the residuals are correlated between the individual equations, particularly when large interdependencies of the different endogenous variables are existent. In contrast, the simultaneous estimation of all equations bears the risk that a particular equation can not only lead to biased estimates of the single equation, but also to biased estimators in all equations. For this reason, a completely simultaneous estimation of all stochastic equations is not carried out.

Regarding MOVE2, a hybrid version between a simultaneous estimate and the linking of individual equations is chosen as a consequence. Certain model segments are implemented in a simultaneous equation system, so that the simultaneous estimation of the specific unit does not result in distorted estimates in other parts of the model and potential errors to the specific system of equations can be reduced. The Seemingly Unrelated Regression (SUR) is best suited to deal with equations with relatively few data points. A great advantage of the estimation method SUR is the fact that the regression does not depend on the degrees of freedom of a single equation, but is based on the aggregate of all the individual degrees of freedom of all equations. For this reason, this procedure is appropriate for the present simulation model consisting of relatively short time series and thus relatively low degrees of freedom in the individual equations.

3 Verification of the model validity

The model validity of MOVE2 and MOVE2social is discussed via statistical measurements, visualizations and sample regressions. The coefficient of determination R^2 and the p-values will be used as measures of the model validity

The coefficient of determination R^2 is defined as the squared correlation coefficient between the observed and via regression inferred values of the declared variables and thus has values between zero and one. A coefficient of determination which is close to one is often interpreted as a quality feature of the applied regression approach. However, it must be noted that the consideration of further regressors also induce a higher coefficient of determination which supposedly leads to an increase of the model quality. Parallel to this, the estimation of further model parameters leads to a loss of degrees of freedom and thus to more imprecise estimates. In order to compare different approaches with different numbers of regressors and the same regressand, therefore an adjusted coefficient of determination R^{2*} is inserted, which takes into account the degrees of freedom. The following table provides information on the adjusted coefficient of determination of all the regression equations in MOVE2 and MOVE2social.

Table 4: Adjusted coefficient of determination

	R^{2*}			
# Regression equations	**> 0,9**	**> 0,8**	**> 0,7**	**> 0,5**
213	51%	65%	72%	85%

Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

The p-value is called the exceedance probability and represents an indicator for assessing statistical tests. The p-value represents the probability of obtaining the result obtained or a more extreme under the null hypothesis. Thus, the p-value shows how extreme the result is: the smaller the p-value, the more the result speaks against the null hypothesis. The rejection of the null hypothesis is made, if the p-values are less than pre-defined limits (for example, 10%, 5%, 1% or 0.1%).

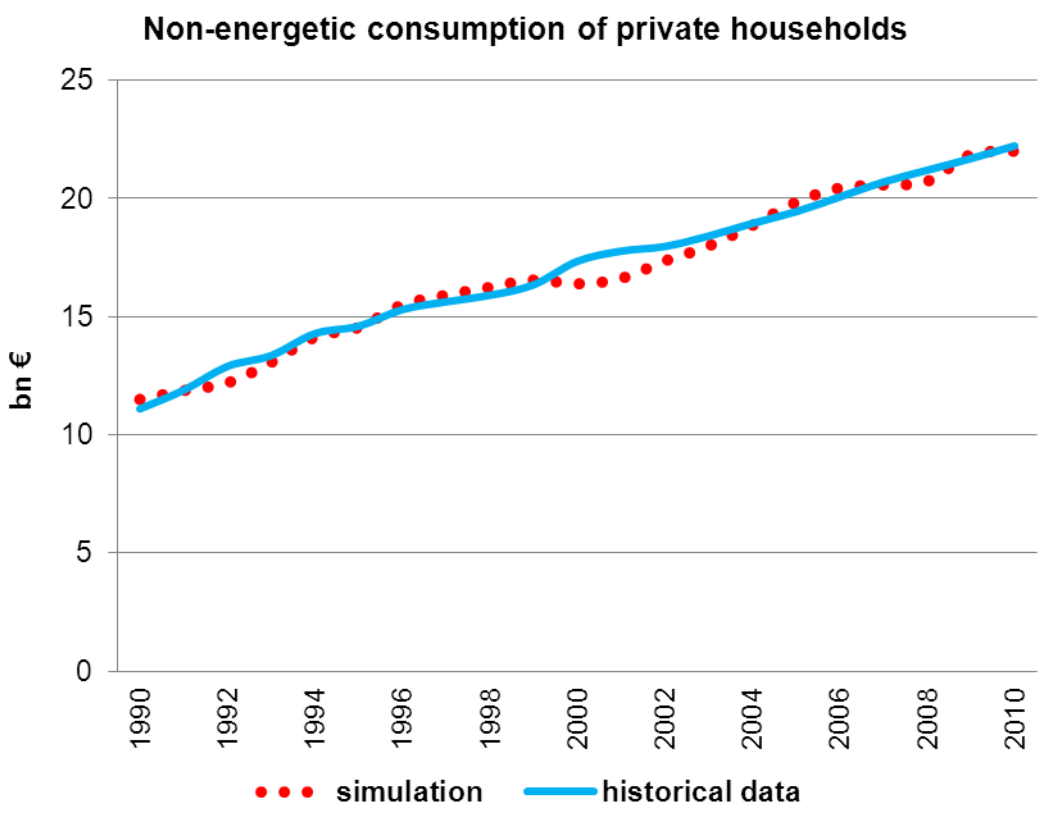
Table 5: p-values

Significance level	# p-values < significance level	Relative proportion
10%	486	66 %
5%	454	62 %
1%	374	51 %
0,1%	288	39 %

Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

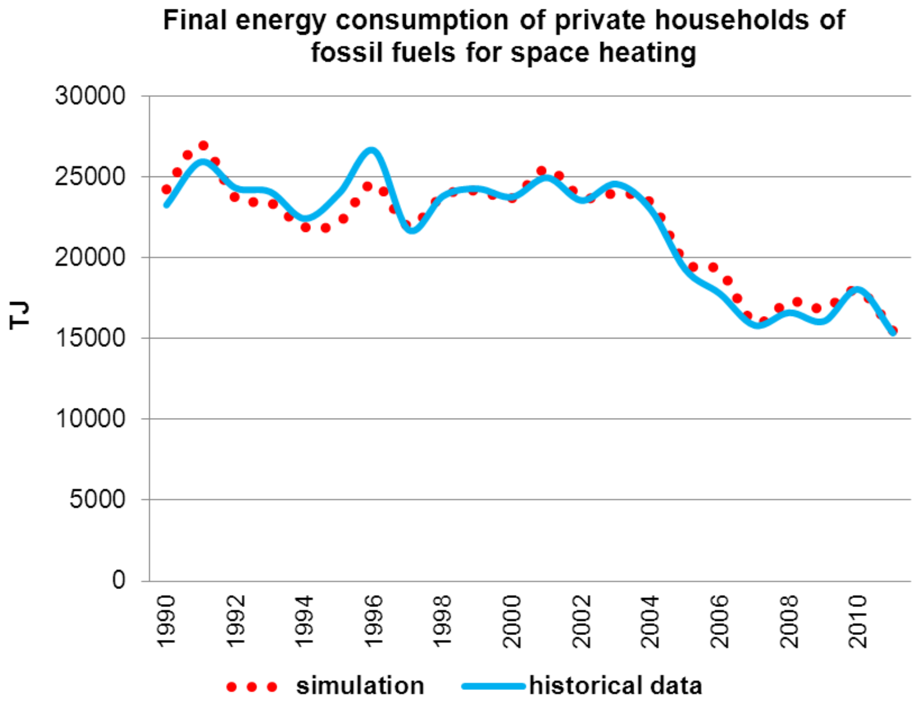
To classify the validity of MOVE2 and MOVE2social, the historical values are compared graphically with the estimated values of the business-as-usual scenario for significant model variables for the period from 1988 to 2010. The exemplary comparisons show a very high convergence between the initial data and the generated values of the business-as-usual scenario in the model.

Figure 6: Historical and simulated (business-as-usual scenario) curves of the variable "non-energetic consumption of private households"



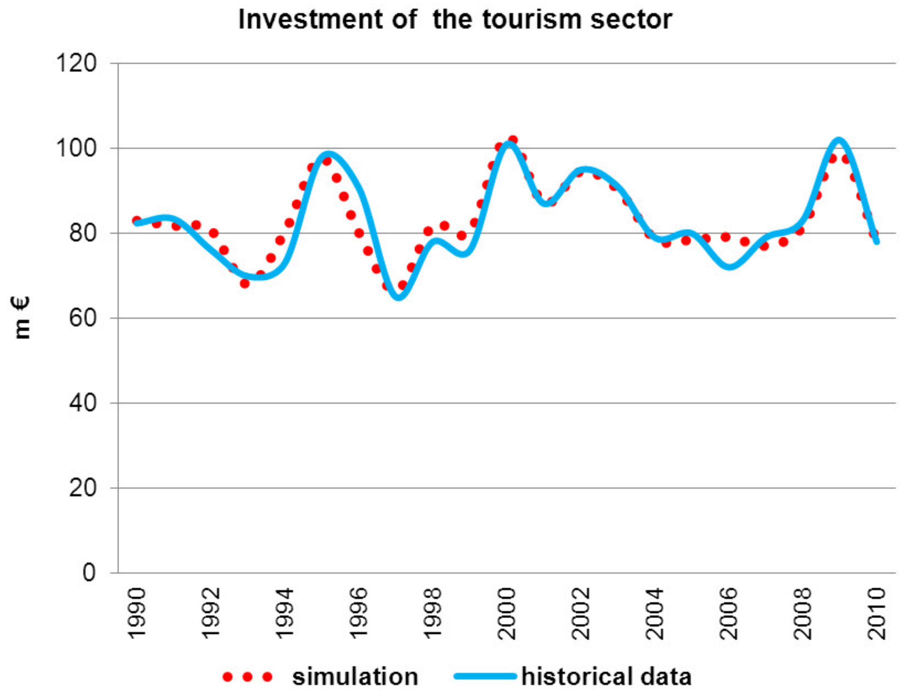
Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

Figure 7: Historical and simulated (business-as-usual scenario) curves of the variable "Total energy consumption of households by fossil fuels for space heating"



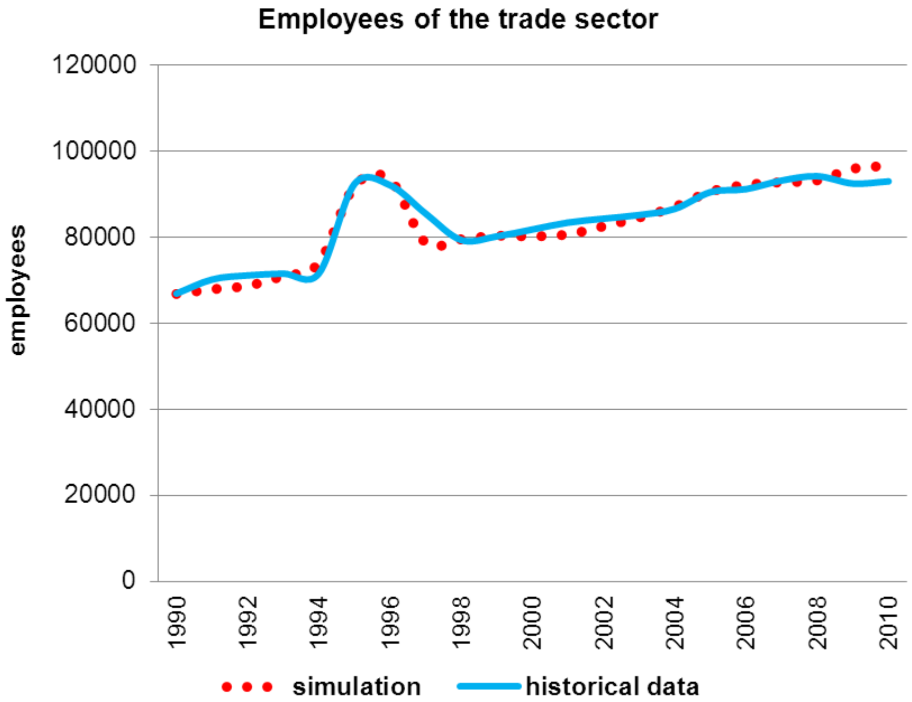
Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

Figure 8: Historical and simulated (business-as-usual scenario) curves of the variable „Investments in the sector tourism "



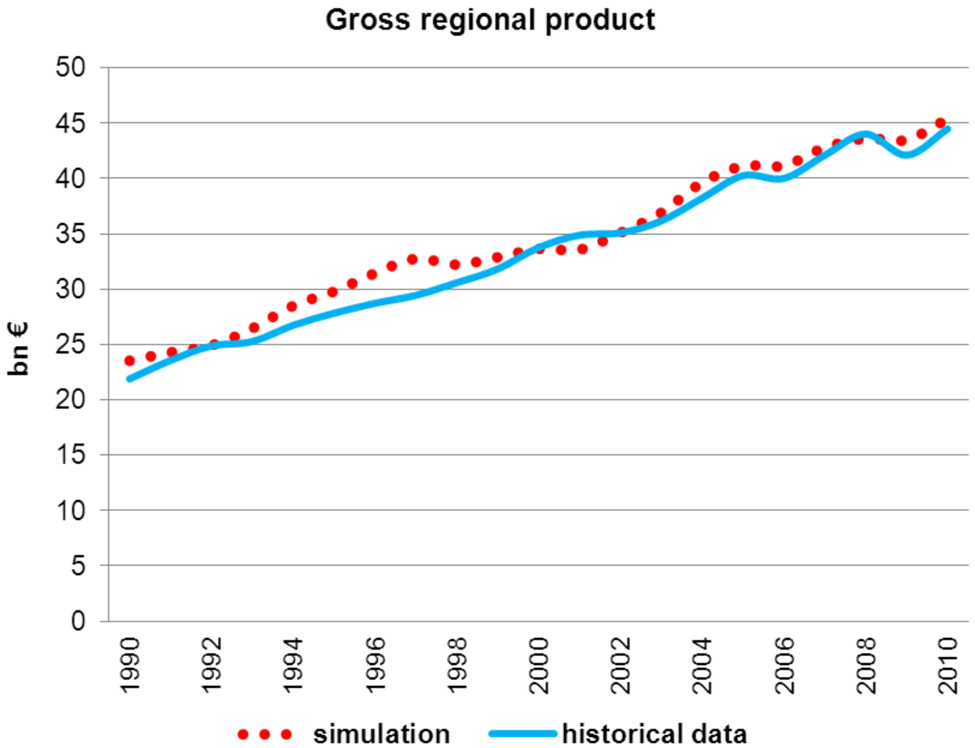
Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

Figure 9: Historical and simulated (business-as-usual scenario) curves of the variable „Employees in the sector trade“



Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

Figure 10: Historical and simulated (business-as-usual scenario) curves of the variable „Gross Regional Product“



Note: The values may change in case of model extensions.
Source: Own calculations based on MOVE2 and MOVE2social.

4 Application of MOVE and MOVE2 on the Upper Austrian and Austrian level

4.1 Upper Austrian level (selection)

<u>Economic Analysis of the Program 'Energy Future 2030' of the Upper Austrian Provincial Government</u>

Funding body: Upper Austrian Government

Project Partners:

- Energy Economics Group, Technical University Vienna
- University of Natural Resources and Life Sciences Vienna

The Upper Austrian Provincial Government mandated the Energy Institute at the Johannes Kepler University Linz GmbH to conduct an economic analysis of the measures program „Energy Future 2030". The project analyzed 30 single measures that were designed to ensure the implementation of the program Energy Future 2030. The research project looked at different scenarios regarding the evaluation of economic implications, in order to synthesize single aspects and present a comprehensive perspective. The following three specific analyses were included:

1.) a "purely" comparative statistical analysis of the total potential savings effects of the program Energy Future 2030 (especially through the realization of savings potentials but also due to the switch to other energy carriers),

2.) a comparative statistical analysis of investment costs and the generated energetic changes of the single measures,

3.) a dynamic analysis of the economic effects on the value chain in Upper Austria generated by the single measures.

The dynamic simulation analyses of the single measures shows that the implementation of all measures in the segments electricity and heating (including the measures on refurbishing old buildings) entail positive macroeconomic effects for the Upper Austrian economy due to secondary effects. These effects are based on investment impulses that are supported by public subsidies. Investments are necessary because of the installation of new technologies and new infrastructure on the one hand and shifting reduced energy costs to an increased consumption of non-energetic goods as well as an increase of investments in non-energetic goods and services on the other hand. However, it has to be mentioned that these positive macroeconomic effects are the result of the share of public spending in financing these measures (electricity and heating – 35 %, traffic – 70 %). As a result, public debt increases as no additional revenues are gained and no other expenditures are cut.

The relevance of telework in the light of ongoing challenges in the structure of Upper Austria's mobility sector

Funding body: Austrian Climate and Energy Fund

Project Partners:

- University of Natural Resources and Life Sciences Vienna
- Institute for Environmental Management in Companies and Regions, Johannes Kepler University of Linz

The aim of the project is the evaluation of the economic, energetic and ecological effects of traffic reduction due to an intensification of telework for commuters using the relation Mühlviertel-Linz in Upper Austria. The quantitative and qualitative outcomes of this approach of telework can be useful with regard to traffic planning and management. It is shown that economic, ecological and energetic impacts are given by a sufficient intensity of implementation.

Effects on economic growth and employment due to building flood protection infrastructure in Upper Austria

Funding body: Upper Austrian Government

Starting in 2002, a continuous building of flood protection infrastructure aiming at preventing high monetary damages has been taking place in Upper Austria. As a result of investments in these flood protections measures between 2002-2015 significant positive effects on the gross regional product as well as on the employment level have been generated. However, the macroeconomic effects are found to depend substantially on the import quota for required materials.

Macroeconomic effects of healthy and regional nutrition in Upper Austria

Funding body: Upper Austrian Government

Within the study, the effects on the Gross Regional Product, the employment and the trade balance of Upper Austria resulting from a dietary change are quantified. The actual nutritional behavior of the Upper Austrian population is compared to an altered nutritional behavior in accordance with the recommendations of the Austrian food pyramid, taking into account the agricultural production potential of Upper Austria.

4.2 Austrian level (selection)

Economic and financial impacts in Austria of a new GHG target in Europe for 2030

Funding body: Federal Ministry of Science, Research and Economy, the Economic Chamber of Austria, the Federation of Austria's Industries and the Interest Group Austria's Energy

Within the study, the economic impacts in Austria resulting from newly-defined GHG reduction targets at EU level are analyzed. The study comprises two levels: (1) Economic and financial impacts in Austria and (2) Consequences for the Austrian energy-intensive industries and the electricity and heat sector. On the basis of different GHG target paths until 2030 - GHG reduction at EU level by 35%, 40%, 45% (base year: 1990) - different scenarios (accounting for necessary measures and technologies at the sector level) are developed and additional impacts on economic welfare are compared to a reference scenario, which is represented by the GHG emission paths of the Austrian Federal Environmental Agency. The effects of free allocation of CO2 allowances in the EU ETS, as well as the partial leakage of Austria's energy-intensive industries due to high mitigation costs, are analyzed in order to highlight the implications of Austria's energy-intensive industries and the electricity and heat sector. Methodologically, the analysis is performed in two steps: The comparative static analysis quantifies the annual cost burden (investment and operating costs) for the period 2010 to 2030 of Austria's ETS and non-ETS sectors. The dynamic simulation analysis calculates the macroeconomic effects in Austria including secondary and multiple-round effects of the implemented measures to reach the selected GHG targets.

Economic strength of renewable energy in Austria

Funding body: Austrian Climate and Energy Fund

Project Partner:

- Energy Economics Group, Technical University Vienna

The aim of this study is the detection of the Status Quo of renewable energy in Austria. The macroeconometric simulation analysis shows an increase in the gross domestic product to € 1,647 million in 2011 compared to a situation without the extension of renewable energy sources in the Austrian energy system since the year 2000. Between 2000 and 2011, an increase of GDP by an average of € 398 million was generated per year, representing an average share of 0.1% of the Austrian GDP. In addition, the promotion of renewable energy sources created an average of 3,300 jobs per year. The triggers of these effects are investment impulses stemming from the generation of electricity, heat and fuel production based on renewables, the installation of room heat-heating technologies and positive current account effects due to the reduction of (fossil) energy imports. Secondary effects by economic growth and employment growth lead to the increase of the general investment activities and the overall wage bill. Considering the tax revenues, it becomes clear that the stronger integration of renewables in the Austrian energy system led to a reduction in energy tax revenues by € 186 million per year.

Integrated Assessment of Financial Policy Instruments for the Reduction of GHG-Emissions in Road Transport

Funding body: Austrian Climate and Energy Fund

Project Partners:

- University of Natural Resources and Life Sciences Vienna
- Federal Environment Agency
- Herry Consult

Several financial policies such as fuel taxes, vehicle purchase taxes and road-pricing schemes exist with each of it having different design options in terms of fee or tax level, the spatial implementation area or the use of revenues. The economic analysis shows that the effects of fiscal policy instruments crucially depend on the use of revenues. Negative economic effects (decrease in GDP and employment) are generated, if revenues are purely used for deficit cover. In the scenario of an increase in fuel prices of 2.0 €/l at EU level, these negative effects are displayed by reduction of GDP of approximately € 5.0 billion per year and employment of about 40,000 persons per year compared to the reference scenario. The most positive effects (increase in GDP of around € 4.8 billion per year and annual employment of about 20,000 compared to the reference scenario) take place in the case of an increase in car purchase tax in combination with a truck toll where revenues are reinvested via a transport based compensation particularly causing strong investment impulses.

5 Selective variable overview

Table 6: Selective overview of variables of *MOVE2social*

Types of variables
Economic variables
Gross Regional Product
Gross Domestic Product
Number of employees of specific economic sectors
Gross value added of specific economic sectors
Investment of specific economic sectors
Wages of specific economic sectors
Private consumption
Net exports
Disposable income
Net transfers
Unemployment rate
Number of unemployed person
Output gap
Interest rates
User cost of capital
Consumer Price Index
Import price deflator
World price index
Specific public revenue
Specific public spending
Net migration
Population between 15 and 64 years of age
Socio-economic variables
Number of employees / unemployed persons by income
Number of employees / unemployed persons by age
Number of employees / unemployed persons by gender
Energy module
Final energy consumption of specific energy sources by economic sectors
Final energy consumption of specific energy sources by households
Expenditure on final consumption of energy by economic sectors
Expenditure on final consumption of energy by households
Energy Price Index
Consumer prices of specific energy sources
Price of crude oil
Domestic production of specific energy sources
Imports of specific energy sources
Exports of specific energy sources
Net exports of energy

Inventory change of specific energy sources
Non-energy consumption of specific energy sources
Conversion use of specific energy sources
Conversion emissions of specific energy sources
Annual precipitation
Change of heating degree days (index change)
Vehicle inventory statistics
Ecology module
Specific air pollutant emissions resulting from the use of energy
Damage costs of specific emission types resulting from the use of energy
Specific greenhouse gas emissions resulting from the use of energy

Appendix: Data sources

Data sets from the following sources are used:

- Statistics Austria www.statistik.at
- Austrian Institute of Economic Research www.wifo.ac.at
- Public Employment Service Austria www.ams.at
- GEMIS - Global Emissions Model for integrated Systems www.iinas.org
- Zentralanstalt für Meteorologie und Geodynamik www.zamg.ac.at
- Eurostat www.eurostat.at

MOVE2 – Simulation model of the (Upper) Austrian economy with a special focus on energy

incl. the socio-economic module MOVE2social: integration of income, age and gender

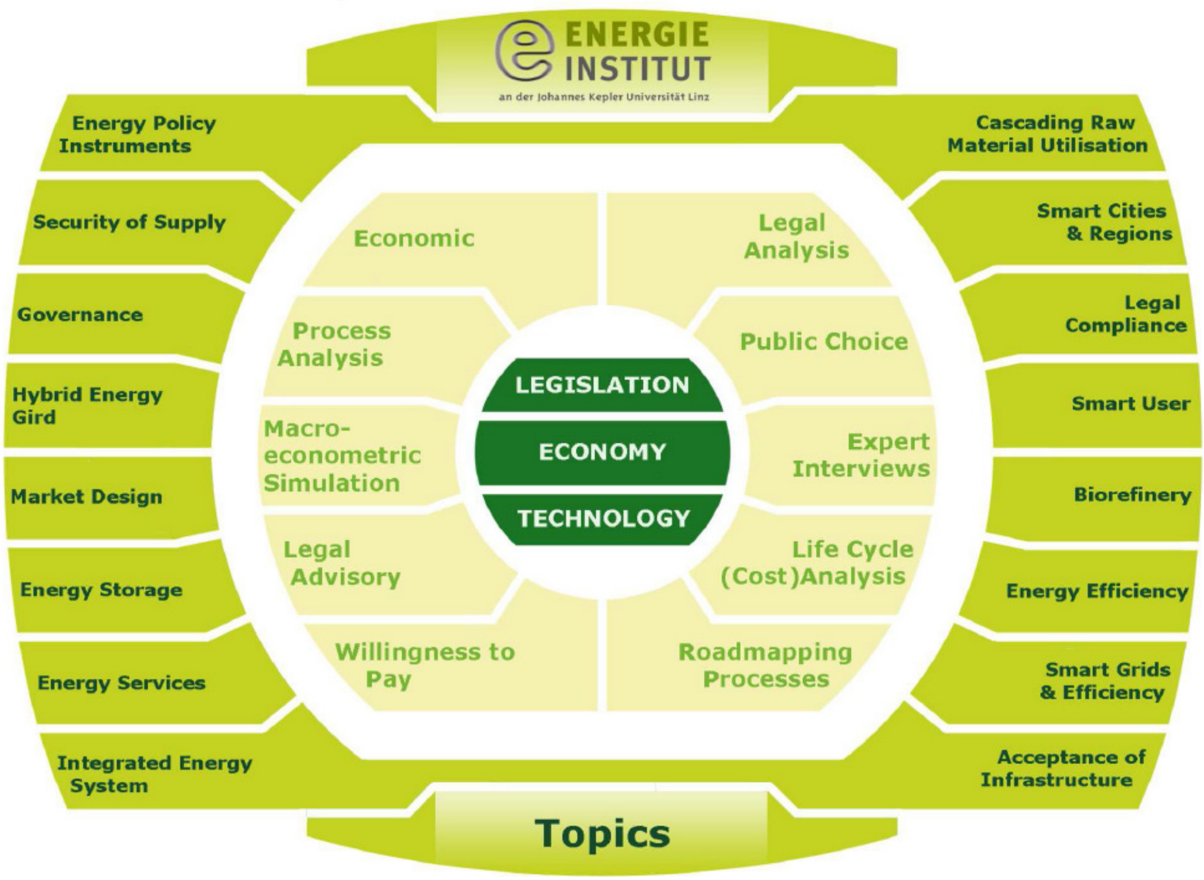
Authors:

Sebastian Goers and Martin Baresch are researchers at the Department of Energy Economics. Robert Tichler is the deputy director of the Energy Institute and project manager at the Department of Energy Economics. Friedrich Schneider is the head of the Department of Energy Economics.

Contact:

Phone: +43 (0)732 2468 5656
E-Mail: office@energieinstitut-linz.at

New challenges need new approaches, often with various instruments:



Visit us on our website and inform yourself about the latest projects:

www.energieinstitut-linz.at