Workshop “Energy Efficiency Policies and the Rebound Effect” – Information on Panel Discussion “Integration of Rebound Effects in Scenario Analysis”

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Introduction

Concerns about climate change, high oil prices as well as scarcity of fossil fuels are responsible for an increasing number of energy scenarios. The scenarios are created by using models. One important characteristic of models is the simplification of the real world. Therefore the appropriateness of the selected model for the objective of the analysis has to be checked before using the model. The realization that rebound effects can reduce the effectiveness of measures and instruments for climate protection it has to be checked how they are taken into account in the models and what the options are for improving / extending the approaches used in the models.

Energy System Models

Each year IEA publishes its “World Energy Outlook”. Together with “EU Energy Trends to 2030” it belongs to the most important outlooks among energy scenarios. On a national level the “Leitstudie 2010” and the “Policy Scenarios for Climate Protection” in particular can be used as examples for using energy models. [Energy, 2010, International Energy Agency, 2010, DLR et al., 2010, Matthes et al., 2009] The scenarios provided in these publications are created by using technology-based energy system models. These models allow analyzing physical energy flows and technological aspects on a very disaggregated level. GDP, the production activities of non-energy sectors, housing space, number of employees as well as passenger and freight transport capacities are assumed as given in these models. (see [Energy, 2010, p.13] [International Energy Agency, 2010, pp. 68], [Matthes et al., 2009, p. 22], [Forum für Energiemodelle und energiewirtschaftliche Systemanalysen in Deutschland, 2007])

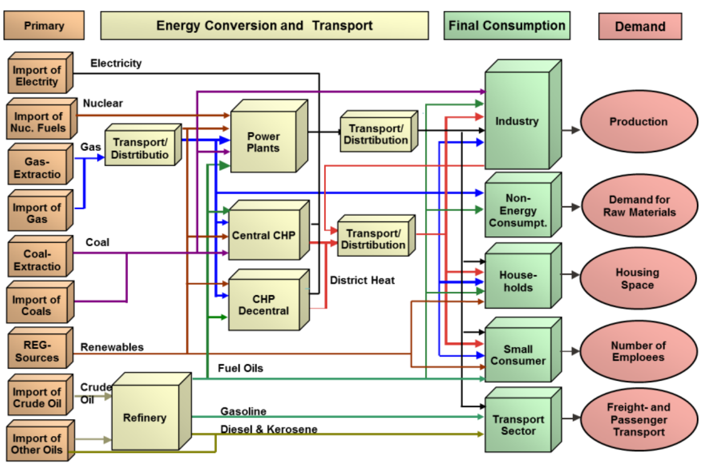

Figure 1: Basic structure of energy system models

With energy system models it is possible to identify different kinds of rebound effects. So it is possible to assess

- direct effects like an increase in the use of a technology induced by changes in the cost relation of the technologies and

- impacts of induced changes in fuel prices and resulting changes in the demand for different fuels in other sectors

The impacts of changes in prices/costs on production activities of non-energy sectors, on income and on expenditure patterns are more or less ignored.
Here are some examples which show how such models deal with rebound effects:
<u>Efficiency increases in coal-fired power plants</u>: Because of the increases in efficiency, the coal consumption of the coal-fired power plants in question will decrease. Instead of gas-fired plants more coal-fired power plants may be built because of lower generation costs. In this case coal demand will go up. Higher efficiency could result in lower electricity prices which leads to higher electricity demand and therefore to an increase in coal demand. On the other hand, the demand for other types of fuels will decrease. Energy system models take into account that changes in fuel demand may have an effect not only on the price for electricity but also on other fuel prices which influence the demand for these fuels.
However, the impacts of variation in the fuel prices (incl. the electricity price) on the production activities of non-energy sectors (incl. induced investment effects and changes in the income/expenditures of the private households) and the impacts on the growth of GDP are not been taken into account.
<u>Efficiency increases in diesel powered cars</u>: Specific diesel demand will decrease; more diesel cars will be used. So, the decrease in diesel demand will be partly compensated. In the scenarios created with energy system models the factors “miles per person” and “miles per tones” will stay unchanged though. In addition, income effects (incl. modification of the demand for other consumer goods) are not been taken into account.
All in all, despite limitations regarding economic feedback mechanism energy system models are suitable for evaluating a broad range of rebound effects.

Possible Model Extensions

In the past, several approaches have been implemented to overcome the limitations of energy system models regarding the economic feedback mechanism. So-called hybrid models have been developed combining bottom-up and top-down models. Top-down models (e.g. PACE, NEWAGE, GEM-E3) are models which focus on economic interactions. In contrast to the bottom-up models, these models technologies use aggregated neoclassical production functions for the description of technological substitution possibilities instead of using data on specific technologies. [Forum für Energiemodelle und energiewirtschaftliche Systemanalysen in Deutschland, 2007, Löschel, 2002]
Examples of such linked models are MACRO-MARKAL, PRIMES and NEMS. In these examples energy system models are linked to aggregated CGE-models. In other approaches technology based models are linked to Input-Output models which allow a detailed analysis of the energy-economy system because of their low degree of aggregation (see e.g. [Forum für Energiemodelle und energiewirtschaftliche Systemanalysen in Deutschland, 2004]). With hybrid models it is possible to analyze rebound effects broadly (e.g. income effects, impacts of changes in the prices on non-energy goods as well as the impact of prices changes on production activities). On the other hand, the complexity of the model increases significantly. Also problems regarding the consistency of the approach arise. If a soft-link approach is selected, the models have to be used iteratively, which could be very time consuming. There are several examples showing the possibilities of analyzing rebound effects with hybrid models. However, currently such models are rarely used because of their complexity.
A lot of sector specific models exist (e.g. for the transport sector and models focusing on the energy demand for building heating) which can be used in addition to energy system models. In principle it is possible to extend the basic approach by adding modules which consider “weak” factors (e.g. behavior, quality of services and goods). However there will be a tradeoff between completeness and complexity.

All in all, it will not be possible to put the complex real world in a model. So, to limit complexity it should be discussed which factors have to be taken into account which should be taken into account and which factors are less important for the assessment of the effect of efficiency changes.

Reference

DLR, IWES & IFNE (2010) *Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global - „Leitstudie 2010".* Stuttgart.

ENERGY, E. C.-D.-G. F. (2010) *EU Energy Trends to 2030 - Update 2009.* Luxembourg, Publications Office of the European Union.

FORUM FÜR ENERGIEMODELLE UND ENERGIEWIRTSCHAFTLICHE SYSTEMANALYSEN IN DEUTSCHLAND (2004) *Energiemodelle zum Klimaschutz in liberalisierten Energiemärkten - Die Rolle erneuerbarer Energieträger.* Berlin-Münster-Wien-Zürich-London, Lit-Verlag.

FORUM FÜR ENERGIEMODELLE UND ENERGIEWIRTSCHAFTLICHE SYSTEMANALYSEN IN DEUTSCHLAND (2007) *Energiemodelle zu Innovation und moderner Energietechnik - Analyse exogenen und endogenen technischen Fortschritts in der Energiewirtschaft* Berlin-Münster-Wien-Zürich-London, Lit-Verlag.

INTERNATIONAL ENERGY AGENCY (2010) *World Energy Outlook.* Paris, OECD/IEA.

LÖSCHEL, A. (2002) Technological Change in Economic Models of Environmental Policy: A Survey. *Ecological Economics,* 43:2-3**,** 105-126.

MATTHES, F. C., et al. (2009) *Politikszenarien für den Klimaschutz V - auf dem Weg zum Strukturwandel - Treibhausgas-Emissionsszenarien bis zum Jahr 2030.* Dessau-Rosslau, Umweltbundesamt.