MODELING ENDOGENOUS TECHNOLOGICAL CHANGE IN THE RENEWABLE POWER GENERATION SECTOR [Special session „Renewable Energy Technologies, Innovation, and Policy Mix – first results from the GRETCHEN project"]

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(1) Overview

Renewable energy deployment is growing rapidly on a global scale. China, Germany, Spain and the US are among the countries with highest capacity of renewables installed. In Germany, for example, the large growth in renewable power generation capacities in the past has been mainly due to demand supporting policy measures such as feed-in-tariffs (demand-pull). Globally, increasing deployment also is accelerated by strongly decreasing costs of these technologies. Deployment, in turn leads to cost decreases via scale effects and this interdependence can be captured in learning curves, which is a concept used to model technological change. Using this concept it is possible to – at least partly – endogenize technological change more adequately regarding renewable energy technologies in economic models. So far, technological change is either set exogenously (autonomous energy improving technological change) or price-induced in economic models. Introducing endogenous technological change is necessary to adequately analyze not only the direct effects of technological change, but also the indirect effects on important macro-economic indicators such as growth, employment, welfare and trade as well as their feedback to the electricity sector.

(2) Methods

In this paper a renewable power generation (RPG) module for the INFORUM type econometric input-output models (see Eurostat, 2008) such as GINFORS (Lutz & Wiebe, 2012) or PANTA RHEI (Lehr et al., 2012) is developed. To this end, the energy sector modeling, based on the energy balances of the IEA, is refined to include selected renewable energy carriers and the corresponding power generation technologies in more detail. The RPG technologies that we have selected for further analysis are wind (on- and off-shore), solar PV and concentrating solar power (CSP). The representation of their development in the model is based on global learning curves. These are estimated using data on specific costs, capacity installed and R&D. We test both one factor and two factor learning curves and compare our results to those of existing studies, see e.g. (Wiesenthal et al., 2012) for an overview. The learning curves reflect both learning-by-doing, indicated by capacity installed, and learning-by-searching, indicated by R&D spending.

(3) Results

The main result of this research is the endogenization of technological change in an empirical macro-economic model. The RPG module is implemented in a projection model that determines the development of the macro-economy of selected countries. The outcomes of the projection model include, next to the usual macro-economic indicators, sectoral demand for electricity. Electricity supply from RPG technologies is calculated from capacity installed (using the respective load hours of the year 2010, partly adapted if more information is available). Capacity installed is endogenous to the model, depending on electricity demand and on relative prices of the different energy carriers. The costs for the different RPG technologies are determined by the learning curves, thus depending on capacity installed, R&D spending and the learning rate. In addition, both costs and capacity installed may also be influenced by the RPG technology policy mix. The switch from fossil fuel power generation technologies to RPG technologies implies a changing structure of intermediate demand and, hence, a change in the composition of sectoral production. Thus, the transformation of the electricity sector feeds back into the economy. Important new model outcomes are exports and imports of RPG goods and services using assumptions regarding world market shares and trade shares, as well as the share of renewables in total electricity production and carbon emissions associated with electricity production.

(4) Conclusions

This RPG extension of the econometric input-output model will contribute to a better understanding of the interaction between the deployment of renewable energy technologies and macro-economic indicators such as employment, GDP and sectoral production. The implementation of endogenous technological change in the model considers the different approaches to modeling technological change (TC) as outlined by Löschel & Schymura (2013):

Learning-by-doing, R&D (learning-by-searching), price induced TC and directed TC. The learning curves capture both learning-by-doing and learning-by-searching. By including R&D spending in the learning curves, R&D support policies can be explicitly considered in the model. The demand for electricity from different energy carriers depends on relative prices, thus indicating price-induced TC, where ‘dirty’ power generation competes against ‘clean’ power generation. Prices for electricity from RPG technologies depend on costs, but are also often directly influenced by policy measures, e.g. through feed-in-tariffs.

The approach followed here is a first step to endogenously determine national investments in RPG technologies, electricity generation costs and global feedback loops of national policy measures (incl. export of policy measures) on RE investment and electricity production costs. The model will be used to analyze the impacts of the policy mix on technological change, welfare (economic development and employment), trade and structural change.

References

Eurostat (2008) “Eurostat Manual of Supply, Use and Input-Output Tables”, Luxembourg.

Lehr, U., Lutz, C. & Edler, D. (2012) “Green jobs? Economic impacts of renewable energy in Germany”, *Energy Policy*, 47(2012), 358-364.

Löschel, A. & Schymura, M. (2013) “Modeling technological change in economic models of climate change: A survey”, *ZEW Discussion Paper* No. 13-007.

Lutz, C. & Wiebe, K.S. (2012) “Economic impacts of different Post-Kyoto regimes”, *International Journal of Energy Science* 2(2012)4, 163-168.

Wiesenthal et al. (2012) “Technology Learning Curves for Energy Policy Support”, *EUR - Scientific and Technical Research Reports* JRC73231, doi:10.2790/59345.