The trajectories of new energy technologies in carbon constraint cases with the POLES world energy model

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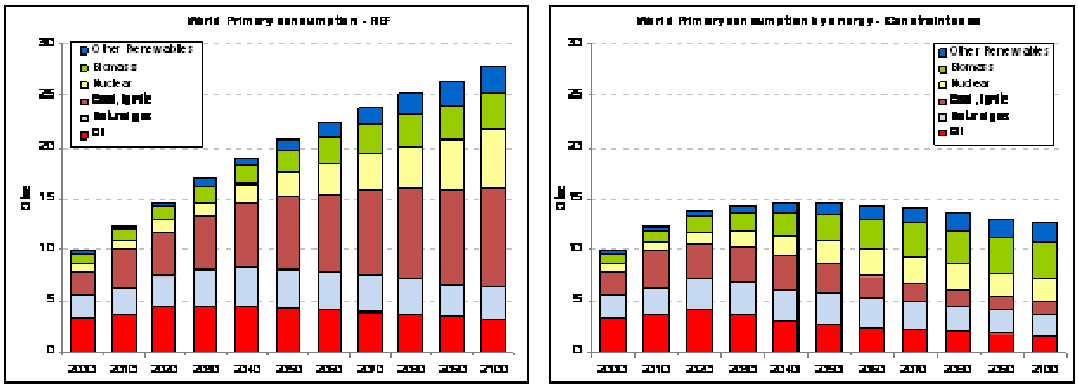
The MENGHTECH study (Modelling of Energy Technologies Prospective in a General and Partial Equilibrium Framework, under EU-FP6) has aimed at introducing a more detailed treatment of technological change in the general and partial equilibrium large scale models used for the design of climate policies. In this context, the modelling of endogenous technical change in the POLES model (a 46 regions, world long term energy model) has been improved, with the introduction, in addition to the existing "learning-by-doing" and "learning-by-searching" features, of social network effects and the simulation of breakthroughs in certain clusters of technologies. With this new version of the model, a Reference and a Carbon Constraint projection of the world energy system to 2100 have been developed, in order to test different scenarios for technology and climate policies in the next century. These projections adopt exogenous forecasts for population and economic growth in the different world regions and make consistent assumptions for the availability of fossil energy resources and for the features and performances of future technologies. On the contrary, the mechanisms of different nature introduced in the model – according to the literature on technical change – allow for an endogenous treatment of technology and for complex dynamics and development paths. The POLES model is used in order to describe the development to 2100 of a set of key technologies among the fifty identified in the model, in this exercise especially concerning the transport sector. Such simulations performed under constraints on fossil energy resources and GHG emissions take into account the impacts on national and regional energy systems and their interactions through international energy markets, The Carbon Constraint case reflects a state of the world with ambitious climate targets, aiming at an emission profile that is compatible in the long-term with concentration levels below 550 ppmv CO2 equivalent, i.e. a profile that is consistent with those analysed in the Stern report. Taken together, the Reference projection and the Carbon Constraint case indicate the major changes to be expected in the structure and development of the world energy system in different policy contexts. The present POLES projections, with the horizon of 2100, clearly show the consequences of the twin constraints of finite fossil fuel resources and restrictions on greenhouse gas emissions. The images of the world provided in the MENGHTECH runs of POLES clearly illustrate the impact of technological breakthroughs and radical changes in the world energy system. Three sets of scenarios are considered in the paper: a Carbon Constraint case, with "social network effects" and "breakthrough effects" focused either: i. on the electricity sector or, ii. on the hydrogen technology cluster and, iii. on both of these energy carriers. They describe alternative technological and socio-economic pathways that illustrate the consequences of disruptions in the diffusion of electricity or hydrogen energy carriers. After an introduction, the paper first presents (section 2) the main features of the POLES model with details on the treatment of endogenous technical change, as well as the common sets of assumptions used in the model's databases. The third section presents and compares the results of the Reference projection and of the Carbon Constraint case for the World and for Europe (EU27). The fourth section analyses the differentiated impacts of technological breakthroughs in the Carbon Constraint case in the presence of social network effects applied to the adoption of key technologies in the electricity or/and hydrogen developments. The fifth section concludes with the analysis of the combined effects of social network effects and learning-by-doing that creates increasing returns to adoption and snowballing effects. The key results correspond to significant reductions in the cost of the low-carbon technologies but also to very contrasted energy technology paradigms in the next century.

Figures: World Primary energy consumption by energy, Reference and Carbon Constraint case



Source : POLES-LEPII MENGTECH