Tackling Energy Security in Europe: the Role of the Electricity Sector

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(1) Overview

Energy security is together with the liberalization of energy markets and climate change one of the key drivers of European energy policy. Over the last decade, the share of energy imports in the total fossil primary energy consumption in Europe[2] has risen from 54 % in 1990 to 68% in 2005. The power sector is with a share of 27% in fossil primary energy use one of the main consumer of coal and gas. Dependency on fossil fuel imports for power generation varies in Europe. For some of the larger economies as Germany, the UK or Italy 25 %, 28 % or 60 %, respectively, of the electricity generation are based on fossil energy imports.
Against this background, this paper analyzes the role of the European power sector in policy strategies aiming at increasing security of supply in Europe until the year 2050. In a scenario analysis with the global energy system model TIAM (TIMES Integrated Analysis Model) different energy security targets with respect to the share of fossil fuels in the total primary energy supply are being studied.

(2) Methods

The scenario analysis is carried out with the global energy system model ETSAP-TIAM (TIMES Integrated Analysis Model), which is a technology-rich bottom-up model depicting the global energy system using the model generator TIMES. The model covers the time horizon from 2000 to 2050 divided in 5 year periods. In TIAM, the world is divided in 15 world regions, which are USA, Canada, Mexico, Latin America, Western Europe, Eastern Europe, the Former Soviet Union, Africa, the Middle East, India, China, Japan, South Korea, Other Developing Asia and Australia/New Zealand. The primary energy resources and the petroleum processing sector are further divided in OPEC and non-OPEC regions. The world regions are linked through the trade in the energy carriers crude oil, hard coal, pipeline gas, LNG (liquefied natural gas), petroleum products (diesel, gasoline, naphtha, heavy fuel oil) and ethanol. Therefore, the energy transport infrastructure between the world regions is described in the model by technologies, as pipelines, tankers or LNG terminals, taking into account the existing capacities and their technical and economic characteristics as well as the option to invest in new trade links.

On the resource side, for hard coal, lignite, conventional and unconventional oil and gas, the reserves and resources as well as their supply costs are differentiated by world region. In addition, renewable energy sources and their potentials as well as alternative technologies for synthetic fuels (e.g. CTL, GTL) and different pathways for the hydrogen production are considered in the supply side of the model. In each region, the TIAM model describes the entire energy system by all essential current and future energy technologies from the primary energy supply over the conversion and electricity sectors to the end-use sectors and the useful energy demand.

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[2] EU-27 plus Iceland, Norway and Switzerland.

TIAM minimizes the total discounted energy system costs over the entire model horizon until 2050. Results of the optimization are the structure of the energy system, i.e. type and capacity of the energy technologies, the energy consumption by fuel, the development of emissions, the energy trade flows between the regions as well as the therefore required transport capacities and the detailed energy system costs plus the information on the marginal costs of environmental measures as GHG reduction targets.

In the analysis, the share of indigenous fossil fuels (coal, natural gas, oil) in the total primary energy supply are used as indicators to measure security of supply. To identify strategies to strengthen energy security and to evaluate the role and impacts on the European power sector three scenarios are analyzed with the TIAM model. The reference scenario (REF) contains no explicit policy measures concerning energy security. In the fossil energy security scenario (FESC Fossil Energy Security Combined), the maximum share of the sum of imported fossil fuels (coal, natural gas, petroleum) in the total primary energy supply (TPES) in the Western and Eastern Europe regions is limited to a value of 45 % in 2050. While the FESC scenario allows flexibility in the mix of imported fossil fuels, i.e. a higher dependency on one fuel can be compensated by a reduced dependency on another fuel, the third scenario, FESI (Fossil Energy Security Individually), is more stringent by enforcing that the supply security targets have to be reached for each fossil energy carrier individually.

(3) Results

The analysis of the scenario results focuses on the effects of the energy security targets on the long-term decisions in the power sector and, especially, the impact on the natural gas and coal use for electricity generation. Security targets for the fossil fuel imports in the FESC scenario favor in the end-use sectors energy efficiency improvements and saving measures and the use of renewables, especially biofuels substituting petroleum in transport. This reduction of import dependency on oil allows higher coal and gas import quotas and, thus, also a higher fossil fuel use for power generation compared to the FESI scenario. In the latter scenario, individual targets remove this flexibility. Limited or expensive domestic fossil energy sources yield in this scenario a reduction in electricity generation from coal and natural gas, which can only partially be balanced by production from renewable sources (wind, biomass). Overall reductions in the final electricity demand by switching to renewables and increasing end-use efficiency are necessary to fulfill the energy security targets.

(4) Conclusions

Without policy measures, European dependency on fossil energy imports is expected to increase over the next decades. Policies aiming at ensuring energy security targets for fossil fuels individually, as in the FESI scenario, increase due to limited alternative options the electricity generation costs resulting in a reduced electricity demand in the end-use sectors. Renewables and indigenous coal resources are either limited by their potential or not cost-effective. Increased nuclear power generation can reduce the dependency on fossil fuels (directly in power generation and indirectly by a substitution of fossil fuels in end-use sectors), but lacks the political and societal support in several countries. A combined energy security strategy, as studied in the FESC scenario, opens the possibility to accept a higher dependency compared to the FESI scenario for natural gas, when in return this is compensated by a lower import share for oil due to increased use of biofuels in transport. The diversity of oil supply regions is, however, critical under such a strategy.