Energy security indicators: Are they helpful in assessing policies addressing energy security?

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Overview

Due to growing dependency on primary energy imports coming from only a small number of foremost insecure suppliers (e.g. Russia, Middle East), energy security nowadays gains increasing importance in EU energy policy making. In particular, it is argued that, for the proper functioning of the economy, a long-term energy security strategy must be geared to ensure uninterrupted physical supply of energy on the market at affordable prices (EU, 2000). Policies reducing carbon emissions, increasing the use of renewables, and increasing energy efficiency are commonly ascribed beneficial effects on security of primary energy supply since they induce either energy savings, fuel switches away from insecure fossil primary energy carriers, or both. However, detailed impact assessments providing a complete picture of the policies' energy security implications are nonetheless necessary in order to quantify these effects as well as to identify potential unintended consequences.

Due to the multidimensional nature of the concept, energy security assessments are generally conducted by the means of energy security indicator frameworks, whereby each indicator serves as a proxy for the state of certain characteristics of the economy's energy supply (Cherp and Jewell 2013). Nevertheless it is questionable whether these indicators are necessarily good policy indicators. In particular, since they have no direct link to economic welfare it is by no means clear how the society values changes in these energy security indicators. Hence, any standard cost-benefit analysis of the proposed energy security policies is hampered.

Nonetheless, despite these caveats quantitative energy security impact assessments based on these indicators can give at least some hints on the implications of EU regulation on different aspects of energy security. Hereby, we are particularly interested in the cost effectiveness of these policies in improving energy security indicators. Given a politically defined target value for some indicators, this would provide information on least cost market regulation addressing energy security.

Methods

In doing our quantitative energy security assessment we apply a static, hybrid, multi-sector, and multi-region computable general equilibrium model of energy and global trade. The model includes four commonly used energy security indicators (i.e. energy intensity, fuel mix diversity, net-import dependency, and supplier mix diversity) and is calibrated to the latest GTAP data set (i.e. version 8, base year 2007). We compute a reference business-as-usual scenario (i.e. the BaU-scenario) and three counterfactual policy scenarios at various levels of stringency. In particular, we apply a scenario *CO2* picking up carbon emission reductions (0% to 30% reductions in CO_2 emissions) via an endogenous carbon tax, a scenario *REN* mimicking the promotion of renewables in electricity generation (+0%-pt. to +30%pt. renewables in electricity generation) via endogenous subsidies on renewables, and a scenario *EFF* taking up energy efficiency improvements (0% to 30% reduction in primary energy consumption) via an endogenous tax on fossil primary energy.

Based on the simulation results we first assess the sensitivity of welfare and the applied energy security indicators to the policies' stringency to draw some conclusions on the policies' impact on welfare and the different energy security indicators. Thereafter, we derive for each policy scenario a cost function for improvements in each of the applied energy security indicators. By assessing these cost functions we draw some conclusions on the cost-effectiveness of the three policy options with respect to improvements of each of the applied energy security indicators.

Results

Reducing carbon emissions and increasing the use of renewables has an ambiguous impact on overall energy security. Reducing carbon emissions (i.e. scenario *CO2*) on the one hand improves energy intensity and net-import dependency while on the other hand makes fuel mix diversity and supplier mix diversity worse. This is mainly due to energy savings and fuel switches. Most notably, fossil fuels are substituted for renewables and coal is substituted for gas. This implies a more concentrated fuel mix towards gas and a more concentrated supplier mix towards gas suppliers. Promotion of renewables in electricity generation (i.e. scenario *REN*) as well has diverse effects on the four energy security indicators. In particular, while net-import dependency and fuel mix diversity improve, energy intensity and supplier mix diversity get worse. This is mainly due to the fact that consumption of renewables increase at the expense of fossil fuel consumption most notably coal while the impact on total primary energy consumption is negligible. Hence, the supplier mix of the economy is more concentrated towards crude oil and gas suppliers. Energy efficiency improvements (i.e. scenario *EFF*), in contrast, do only result in decreasing fossil primary energy consumption without having large fuel switching effects and, therefore, unambiguously improve each of the four energy security indicators. However, with respect to welfare effects it turns out that improving energy efficiency is the most expensive policy option while increasing the use of renewables in electricity generation is the cheapest policy options. Reducing carbon emissions assumes an intermediate position.

With respect to cost-effectiveness the picture is less clear. Improving energy efficiency is always the most cost-effective policy option for improving energy intensity and supplier mix diversity while increasing the use of renewables is the most cost-effective policy option for improving fuel-mix diversity. With respect to net-import dependency it depends on the how much the indicator increases. While for small increases (smaller 5% against BaU levels) increasing the use of renewables has a higher cost effectiveness than improving energy efficiency, for larger increases it is the other way around.

Conclusions

Although the application of a framework of traditional energy security indicators offers some hints on the implications of EU regulation on different aspects of energy security, it is not necessarily possible to draw economic conclusions of the policies' impact on overall energy security. This is mainly because a dominant policy option having the highest cost effectiveness for improving each of the applied energy security indicators does not exist. Hence, identifying the optimal policy option would require trade-offs between different indicators. However, due to the missing direct link to welfare, this is seriously hampered.

All in all, this study highlights the need for more advanced energy security indicators allowing conclusive energy security assessments. The aggregation of different energy security indicators into one single aggregated energy indicator would be a straightforward approach approach solving the indicated problem. Having only one energy security indicator eliminates the need for trade-offs. However, aggregating different energy security indicators is a highly problematic process since this includes a high degree of subjectivity with respect to the weighting of the different indicators included into the aggregation. Moreover, aggregating these indicators does not address the core of the problem. An aggregated indicator based on a set of simple indicators which do not have direct links to economic welfare necessarily would not have a direct link to welfare as well. Hence, the development of more advanced energy security indicators should forgo the use of these traditional energy security indicators. Instead, it should be based on a rigorous welfare foundation. Only with such indicators at hand it is possible to assess the impacts of policies addressing energy security in a for economists meaningful manner.

Literature

Cherp, Aleh, and Jessica Jewell. 2013. "Energy Security Assessment Framework and Three Case Studies." In *International Handbook of Energy Security*, edited by Hugh Dyer and Maria Julia Trombetta, 146–73. Cheltenham: Edward Elgar.

EU. 2000. "Green Paper: Towards a European Strategy for the Security of Energy Supply". European Commission.