Modelling Energy Supply Security in the Power Sector: notes on generic policy options

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Extended Abstract

Energy security is becoming an increasingly pressing concern for many countries, especially those that find domestic energy supply inadequate (either in terms of quantity or cost) to meet growing energy needs.

Today, there are several definitions of what constitutes energy (supply) security, depending on national or regional circumstances. They generally include one or more of the following elements:

- adequate energy supply to meet basic needs and development aspirations
- energy self sufficiency
- protection against energy supply disruptions
- protection against energy price volatility
- physical plant and infrastructure reliability
- diversity of technologies and sources
- threats to/from energy supplier states or energy transit countries
- well-functioning energy markets
- economic sustainability of energy supply
- stable environmental integrity

Disrupting energy supply (either physical or in price) can lead to direct economic impacts, such as, losses of GDP, negative balance of payments, rise of inflation and interest rates, while indirect economic impacts include reduction in tax revenue and welfare expenditure, higher unemployment, reduced real incomes of consumers and weaker consumer confidence (Markandya, et al 2007).

For example, the high level of world oil prices between 2004 and 2007 has caused particular hardship to low-income oil-importing countries. First, because they are more energy-intensive, and second since they tend to use energy less efficiently in comparison to industrialised nations. In this regard the World Bank (2006) concluded that, on average, the rise in oil prices between 2003 and 2005 have reduced real incomes in oil-importing economies by 3.6% and by as much as 10% for some low-income oil importers.

Figure 1: Energy import dependence of selected countries and regions

Source: World Bank 2005 (left), IEA 2005 (right)

Since an increasing number of countries have become more reliant on imported energy over the past decades improving energy supply security[1] is increasingly relevant, which can be addressed in part by diversifying supply. Figure 1 illustrates the increasing trend in energy import dependency. While the left graph indicates that more countries are becoming more dependent on energy imports, the graph on the right depicts a similar trend showing energy imports as a share of total primary energy supply (TPES) for OECD countries.

The objective of this study is two-fold. First, to quantify the change in cost for countries that are responding to energy security concerns through the implementation of generic policy measures. Second, to determine the effectiveness of these policies to improve energy security by using a mathematical indicator. This research presents a generic approach to monetize and index the effects of specific policies aimed at addressing energy security, and can thus provide useful guidance to policymakers in formulating energy supply strategies.

In this study we focus on the electricity sectors of three different types of countries to demonstrate how the quantification of cost and policy effectiveness can be applied. The optimization model OSeMOSYS[2] is used to determine the least-cost capacity expansion scheme in the power sector until 2030. The resultant reference cases are then tested against generic policy measures that are aimed at improving energy security.

Key to improving energy security - amongst others - is to diversify supply. In this study, the degree of supply diversity in a country is taken as a measure to assess energy security. The Shannon-Wiener index, which provides a simplified measure of diversity, is used to assess whether some specific policy measures, such as mandating renewable

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1 Supply security is also a concern for energy exporting countries. Supplier countries seek assured and sustained energy sales and hence sale revenues to finance further investment in energy producing and transmission facilities as well as in their own economic and social development. Uncertainty over future demand may translate into uncertainty about needed levels of long-term investment, and may ultimately affect long-term oil market stability (OPEC, 2006). Similarly, reducing the domestic consumption of indigenous depletable energy resources in favour of their export may lead to additional export revenues that can support the development of a more diversified energy infrastructure.

2 OSeMOSYS (Howells et al (Accepted) was designed to fill a gap in the analytical toolbox available to the energy research community. At present there exists a useful, but limited set of accessible energy systems models. These tools often require significant investment in terms of human resources,
training and software purchases in order to apply or further develop them. Their structure is such that integration with other tools, when
possible, can be difficult. OSMOSYS is a fully fledged energy systems optimisation model, with no associated upfront financial requirements
to extend the availability of energy modelling further to the communities of students, business analysts, government specialists, and developing country energy researchers (Strachan et al. 2010).

energy contribution or limiting foreign energy imports, actually lead to greater diversification of generation in the electricity system - and at what cost.

This study begins by providing an overview of the principal aspects that govern many of the energy security debates today to help frame the research scope of this exploratory modelling exercise. We appreciate that energy security is a multi-dimensional concept, which can not be covered in its complex interaction with all involved actors in one model alone, but aids clarifying the discussion points to which the modelling approach can provide useful input.

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