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Analysis

An international assessment of energy security performance

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A B S T R A C T

Energy security has in recent years grown as a salient policy and political issue. To better understand energy security and sustainability concerns, this study's main objective is to present an energy security index which measures national performance on energy security over time. Based on three years of research involving interviews, surveys, and an international workshop, this study conceptualizes energy security as consisting of the interconnected factors of availability, affordability, efficiency, sustainability, and governance. It then matches these factors with 20 metrics comprising an energy security index, measuring international performance across 18 countries from 1990 to 2010. It offers three case studies of Japan (top performer), Laos (middle performer), and Myanmar (w]orst performer) to provide context to the index's results. It then presents four conclusions. First, a majority of countries analyzed have regressed in terms of their energy security. Second, despite the near total deterioration of energy security, a great disparity exists between countries, with some clear leaders such as Japan. Third, tradeoffs exist within different components of energy security. Fourth, creating energy security is as much a matter of domestic policy from within as it is from foreign policy without.

1. Introduction

The global energy system faces a number of distinct governance and policy challenges. Analysts expect world energy demand to expand by 45% between now and 2030, and by more than 300% by the end of the century, necessitating a *tripling* in the amount of needed investment in infrastructure (Brown and Sovacool, 2011). The twelve largest oil companies control roughly 80% of petroleum reserves and are all state owned; and prices of oil, coal, uranium, and natural gas have been exceedingly volatile over the past decade (Florini and Sovacool, 2009, 2011; Goldthau and Witte, 2009). As a result of "electricity deprivation" or "energy poverty," millions of women and children spend significant amounts of time searching for firewood, and then burning either it or charcoal indoors to heat their homes and prepare their meals, contributing to more global morbidity and mortality than malaria and tuberculosis (International Energy Agency, 2010). The impacts of climate change continue to exert considerable costs for the global economy, especially for least developed countries with little adaptive capacity and resilience (Claussen and Peace, 2007; Stern, 2006). Adding to the list, theories about peak oil, rising prices, and energy poverty have also become prominent concerns among policymakers and investors, as is energy security's close relationship with sustainable development and economic growth (Sovacool and Brown, 2010).

The perceived global energy security challenges facing the countries around the world have become so pronounced that some have called for military action. Writing from Hungary, one government official proposed militarizing energy security as part of the North Atlantic Treaty Organization (NATO), desiring to assign NATO with the task of formally ensuring a secure supply of energy fuels, surveying maritime transportation corridors, securing pipelines, and interdicting energy terrorists (Nagy, 2009). One officer from the US military went so far as to claim that "responsible access to energy could be the single largest US strategic security issue short of full-scale nuclear war" (Triola, 2008). Others have argued that new institutions, such as a global Energy Stability Board, are required to coordinate energy investments and minimize energy security risks (Victor and Yueh, 2010).

Indeed, with such a diverse set of geographic, economic, social, and political challenges, how ought energy security in the modern world be conceptualized? How can national performance on it be measured and tracked? How can best practices at improving energy security be identified? How can countries strengthen their energy security relative to others?

This study tackles these questions directly. It explores the dimensions to energy security, attempts at measuring it on a national and international scale, and particular case studies and complications related to energy security in practice. Many studies rely on incomplete or inconsistent definitions of energy security, centered on technical and economic aspects such as security of fossil fuel supply or end-user prices but not social and political elements such as sound governance. In addition, as this article documents below, many energy security studies focus only on a particular sector (e.g. industrial energy intensity), an individual state, (e.g. Russia), or a specific technology (e.g. "nuclear security" or "oil security"). Little effort to date has occurred trying to measure, track, or quantify energy security,

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and few attempts have been made to compare energy security dimensions, or the relative strength and weaknesses of different approaches to energy security. Presumably, this is due to a lack of consensus on how best to capture these elements (Sovacool and Brown, 2010; Sovacool et al., 2011).

To fill this void, this study develops a comprehensive energy security index for use by scholars and national planners. After breaking energy security down into five interrelated concepts associated with 20 metrics, it measures the energy security performance of 18 countries from 1990 to 2010. It then describes case studies for three countries: the best performer (Japan), a middle performer (Laos), and a worst performer (Myanmar), before concluding with implications for energy and global policy more generally.

The value of such an approach is fourfold. First, focusing on energy security as a multidimensional concept helps to move away from narrow depictions of energy security as merely security of fuel supplies or appropriately priced energy services. Second, proposing a systematic method of measuring energy security performance can inform energy policy and build institutional capacity. Analytical tools, such as indicators and empirically measurable metrics, can be helpful in enabling analysts and regulators to find the best energy solutions in a menu of available options. Third, an energy security index enables the identification of individual energy security performance over time and makes it possible to correlate that performance with major events such as military conflicts, embargoes, or the introduction of new, transformational energy policies or technologies. Fourth, an energy security index helps identify tradeoffs within the different dimensions of energy security and also areas needed for improvement. It enables the understanding of complementarities between the identified dimensions such as availability and affordability or energy efficiency and environmental quality. The index can also reveal energy security vulnerabilities and problems that can motivate regional cooperation by creating an incentive for countries to work together to address common energy security threats.

2. Creating an Energy Security Index

As many readers of this journal will already know, the literature on energy security metrics and indicators is voluminous and growing by the day. As a brief sample of some of the best studies arising from this burgeoning field, Vivoda (2010) recently sought to create a “novel methodological” approach to energy security and proposed 11 broad dimensions and 44 attributes that could be utilized to assess national performance on energy issues. Sovacool and Mukherjee similarly devised 5 dimensions consisting of 20 components and 300 simple indicators along with 52 complex indicators (Sovacool, 2011). Kruyt et al. (2009) proposed 24 simple and complex indicators for energy security, Von Hippel et al. (2011) argued in favor of six dimensions and more than 60 separate attributes, issues, and strategies. Even the U.S. Department of Commerce created an “index of U.S. security risk” comprising 4 sub-indexes, 9 categories, and 37 metrics (U.S. Department of Commerce, 2010). Gupta (2008) and Volkan et al. (2007) have both looked at the energy security risks and indicators surrounding oil and fossil fuels. Others have employed diversity indices such as the Herfindahl–Hirschman Index to investigate vulnerability and diversification (Costantini et al., 2007; Lefevre, 2010; Lesbriel, 2004; Loschel et al., 2010; Neff, 1997).

Major energy institutions have also expressed interest in measuring energy security. The International Atomic Energy Agency proposed a comprehensive set of 30 indicators spanning social, economic, and environmental dimensions (International Atomic Energy Agency, 2005). Their work was extended by Vera et al. (2005) into four dimensions—the quality and price of energy services, impact on social wellbeing, environmental impacts, and availability and adequacy of regulators and regulations—and 41 indicators that they then applied to Brazil, Cuba, Lithuania, Mexico, Russia, the Slovak Republic, and Thailand. The International Energy Agency (2004) designed an “Energy Development Index” to provide a “simple composite measure of a country's or region's progress in its transition to modern fuels and of the degree of maturity of its energy end-use.” They later devised a different set of metrics to evaluate the risk of system disruptions, imbalances between supply and demand, regulatory failures, and diversification among a subset of OECD countries (International Energy Agency, 2007). The Energy Research Center of The Netherlands (ECN) has also developed a comprehensive “Supply and Demand Index” to better assess diversification of energy sources, diversification of imports and suppliers, the long-term political stability in origins of supply, and rates of resource depletion (Jansen, 2009; Jansen and Seebregts, 2010; Jansen et al., 2004; Kessels et al., 2008; Scheepers et al., 2006). Gnansounou (2008) built from this work to create a composite index of supply and demand investigating reductions in energy intensity, oil and gas import dependency, the carbon content of primary fuels, electricity weaknesses, and diversification of transport fuels.

These works are excellent, and essential for any serious scholar, analyst, or regulator with an interest in energy security. However, almost all of them suffer from a few common shortcomings:

- *Topical focus*. A vast majority of studies are designed exclusively for industrialized countries, mostly those belonging to the OECD or in Europe and North America. Frondel et al. (2009), as one example, look only at the G7. These studies thus center on pressing concerns related to electricity supply, nuclear power, and automobiles, but are not applicable to developing or least developed countries that have patchy and incomplete electricity networks, limited nuclear power units, and non-motorized forms of transport. Others, such as those from the IAEA and IEA mentioned above, go the opposite way and are geared toward sustainable development and energy poverty rather than energy security as a whole.
- *Scope and coverage*. Many indices are sector-specific, i.e. designed for electricity only (Scheepers et al., 2006 and Jansen et al.), oil (Gupta, 2008), or fossil fuels (Volkan et al., 2007), and many focus on energy supply rather than demand. Geopolitical relationships or trade flows are seldom included, and other dimensions such as sustainability or equity or efficiency are often ignored. Put another way, such tools underexpose or undervalue essential aspects of energy security on the demand side, involving behavior and consumer responses. Moreover, metrics are often frequently unbalanced. The IAEA, for instance, has sixteen metrics for “economics” but only 4 for “social” elements. Trade in energy carriers other than coal, oil, and natural gas is not modeled, yet it is fuelwood, charcoal, and dung that matters most in developing countries. Others rely on only a handful of metrics. The IEA's Energy Development Index is composed only of three metrics: per capita commercial energy consumption, share of commercial energy in total final energy use, and the share of population with access to electricity.
- *Transparency*. Most models and indices make hidden tradeoffs between aggregation and transparency. As models get more complex, they tend to hide underlying assumptions and dynamics that make it difficult to see the values and weights behind them. One respondent from our interviews called most energy security indices “Trojan horses” since they are “dressed a certain way get inside the gates of energy policymaking, so to speak, but no more reliable. They all have structural and problematic assumptions, but most of the time these are opaque.” Another respondent noted that “current energy security indices have hidden assumptions that are seldom apparent.” Stirling (2010) has cautioned that logarithmic functions, such as Shannon–Wiener, Simpson, and Herfindahl–Hirschman Indices require extensive modeling skill and econometrics training, meaning they are complicated and not intuitively understood by most policymakers.
- *Continuity*. Very few studies assess energy security performance over time. One respondent commented that they “often take a