Ecological Economics 88 (2013) 148–158

Contents lists available at SciVerse ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

An international assessment of energy security performance

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ARTICLE INFO

Article history:
Received 20 August 2012
Received in revised form 22 January 2013
Accepted 23 January 2013
Available online 6 March 2013

Keywords:
Energy security indices
Energy security index
Energy sustainability

ABSTRACT

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.
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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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http://dx.doi.org/10.1016/j.ecolecon.2013.01.019

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

particular snapshot of a particular point, but do not compare performance over a series of years." Another noted that "these indexes and metrics presume that the classifications they model are constant and unchanged over time, leading to very problematic assessments."

To fill these gaps, and to develop an index capable of measuring energy security across a range of political systems and geopolitical priorities, as well as across differing levels of governance and energy markets, a five-phase process was utilized. The first phase involved breaking down energy security into its constituent parts, then devising an index based on these parts (correlating them with specific metrics), collecting and consolidating data on these metrics into an index, and finally scoring performance within the index for 1990 to 2010.

To define energy security, the author first relied on an extensive review of the academic literature, semi-structured research interviews, a survey instrument, and a workshop with global energy security experts. The author reviewed more than 90 studies in peer-reviewed journals published on the topic of energy security from 2000 to 2010, and then conducted 68 semi-structured research interviews over the course of February 2009 to November 2010 with senior energy security experts, including visits to the International Energy Agency, U.S. Department of Energy, United Nations Environment Program, Energy Information Administration, World Bank Group, Nuclear Energy Agency, and International Atomic Energy Agency. Participants were selected based on a critical stakeholder approach that sought to include a balance of perspectives from civil society members, academics, government officials, and private sector managers. Participants at these types of institutions were asked: (1) Which dimensions of energy security are most important? (2) What metrics best capture these dimensions? (3) How might these metrics be used to create a common index or scorecard to measure national performance on energy security? Responses were frequently captured with a digital audio recorder and always textually coded. To supplement qualitative research interviews that were difficult to code, a survey was administered to 74 energy experts working at 35 institutions in Asia, Europe, and North America. Lastly, the author hosted a three-day workshop in Singapore in November 2009, attended by 37 participants from 17 countries to discuss the same three questions as the interviews.[1]

Drawing from this voluminous amount of data, energy security was defined as how to equitably provide available, affordable, reliable, efficient, environmentally benign, proactively governed and socially acceptable energy services to end-users. This definition was then correlated with the dimensions, components, and metrics summarized in Table 1.

In presenting Table 1, it deserves to be mentioned that although a majority of the expert interviews and surveys supported this particular composition of an index, agreement was not unanimous (Cherp, 2012). Some participants (and even a small sample of the literature reviewed) suggested strongly that carbon dioxide emissions and climate change should *not* be part of the index, and also that certain aspects, such as security of supply, should be weighted more than aspects such as stewardship and governance. The index weights each of the 20 metrics as equal in importance, and it does not distinguish qualitatively between different energy sources; that is, oil and coal are treated as the "same" as nuclear power and renewables, even though each involves separate risks and benefits. The index investigates energy security at the national level, rather than the regional or global level. Some workshop participants even disagreed about what to *name* the index, with some arguing that it should be called a "scorecard" or "toolkit" (Sovacool, 2012).

[1] For more details about this process, see Sovacool and Brown (2010) and Sovacool et al. (2011).

Despite these disagreements, these 20 metrics in aggregate do demonstrate the necessity of having a multidimensional and comprehensive index. To some readers, such metrics may look disjointed and unrelated to each other, or too closely associated with energy or environmental sustainability. But as Table 1 shows, each metric ties to a particular dimension and component of energy security. It is also intuitive why one needs a broad set of indicators rather than a few utilized in isolation. Relying on total primary energy supply per capita by itself, for example, does nothing to measure how efficient energy is used within a country or how clean or equitably distributed it is. Electricity price volatility and the affordability of petroleum, furthermore, can be linked more to the introduction of new subsidies, or trends in international markets, than individual actions within a country; high prices can also be good if they reflect other things, like the inclusion of externalities into energy prices or the cross-subsidization of energy efficiency programs and mandates. The point is that utilizing our 20 metrics as part of a consolidated index is instrumental in ensuring as many of the dimensions and complexities of energy security are captured as possible.

With the metrics chosen, the author and his research team then selected eighteen countries to analyze—the United States and the European Union (as its own entity) were chosen because they are two of the world's most advanced energy producers and consumers; China, India, Japan, and South Korea because they are Asia's four largest energy consumers; and the ten countries comprising the Association of Southeast Asian Nations (ASEAN) (Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam) because they have rapidly developing economies along with Australia and New Zealand because they represent a diverse mix of energy importers and exporters and are also close in proximity to ASEAN.

The penultimate research phase involved collecting data for these 20 metrics for the period 1990 to 2010 in five year increments for these countries. The author and his team relied on energy databases and reports from the International Energy Agency, U.S. Energy Information Administration, World Health Organization, World Bank, and United Nations. As these sources did not provide complete coverage for all countries over the years in question, we reviewed academic articles and reports for missing pieces of data. Energy ministries in the relevant countries were contacted via email, fax, and telephone to fill remaining data gaps—though in truth many of these remain.

After collecting and coding raw data, the author made all 20 metrics unidirectional, so that higher values corresponded with better energy security scores (the idea being that it would be easier to identify common trends). The author thus inverted or transformed eight metrics: price stability,[2] households dependent on traditional fuels, retail gasoline prices,[3] energy intensity, grid inefficiency, per capita CO_2 and SO_2 emissions, and per capita energy subsidies.

In combination, the mixed methods approach utilized by the author, the multidimensional nature of the resulting index, and the countries the index was applied to make it distinct from earlier indices and energy security research in multiple ways. Unlike indices investigating developed economies *or* developing economies, the index covers both members of the OECD and the emerging economies of Southeast Asia and Northeast Asia. Unlike indices focusing only on electricity, oil, fossil fuels, and/or trade, the index here has

[2] Negative price movements received a 100 regardless of magnitude, while the peak price gains for each period were scored as 0. Positive percentage values for the metric were converted to real numbers with their inverses used as the basis for assigning score values.

[3] Endpoints for the 0–100 range were then drawn from extreme transformed values in each period. Since GTZ uses black-market exchange rates for countries with parallel currency rates, Myanmar prices were converted from USD equivalents, as expressed in the GTZ fuel price reports, back to local currency using the black-market rate, while all other countries were converted using historical official exchange rates from Oanda or the Federal Reserve Economic Data (FRED) database.

Table 1
Dimensions, components, and metrics comprising an energy security index.

Dimension	Component	Metric	Unit	Definition
Availability	Security of supply	Total primary energy supply per capita	Thousand tons of oil equivalent (ktoe)	Total primary energy supply comprises the production of coal, crude oil, natural gas, nuclear fission, hydroelectric, and other renewable resources plus imports less exports, less international marine bunkers and corrected for net changes in energy stocks.
	Production	Average reserve to production ratio for the three primary energy fuels (coal, natural gas, and oil)	Remaining years of production	Ratio of proven recoverable reserves at the end of a given year to the production of those reserves in that year
	Dependency	Self sufficiency	% energy demand by domestic production	Percentage of total primary energy supply divided by total primary energy consumption
	Diversification	Share of renewable energy in total primary energy supply	% of supply	Share of geothermal, solar, wind, hydroelectric, tidal, wave, biomass, municipal waste, and biofuel based energy in total primary energy supply
Affordability	Stability	Stability of electricity prices	% change	Percentage that retail electricity prices have changed every five years
	Access	% Population with high quality connections to the electricity grid	% electrification	Combined percentage of urban and rural electricity customers with reliable grid connections compared to all people in the country
	Equity	Households dependent on traditional fuels	% of population using solid fuels	Percentage of the population that relies on solid fuels as the primary source of domestic energy for cooking and heating. Solid fuels include biomass, wood, charcoal, straw, crops, agricultural waste, dung, shrubs and coal
	Affordability	Retail price of gasoline/petrol	Average price in US$ PPP for 100 l of regular gasoline/petrol	Actual prices paid by final consumers for ordinary gasoline inclusive of all taxes and subsidies
Technology development and efficiency	Innovation and research	Research intensity	% government expenditures on research and development compared to all expenditures	Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development
	Energy efficiency	Energy intensity	Energy consumption per Dollar of GDP	Total primary energy consumption in British Thermal Units per Dollar of GDP (2005 US dollars PPP)
	Safety and reliability	Grid efficiency	% electricity transmission and distribution losses	Electric power transmission and distribution losses include losses in transmission between sources of supply and points of distribution and in the distribution to consumers, including pilferage
	Resilience	Energy resources and stockpiles	Years of energy reserves left	Reserves of coal, oil, gas and uranium divided by total final energy consumption
Environmental sustainability	Land use	Forest cover	Forest area as percent of land area	Forest area is land under natural or planted stands of trees of at least 5 m in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.
	Water	Water availability	% population with access to improved water	Improved sources include household connections, public standpipes, boreholes, protected wells, and/or spring and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 l a person a day within 1 km of dwelling
	Climate change	Per capita energy-related carbon dioxide emissions	Metric tons of CO_2 per person	Annual tons of carbon dioxide emissions from fuel combustion divided by total national population
	Pollution	Per capita sulfur dioxide emissions	Metric tons of SO_2 per person	Annual tons of sulfur dioxide emissions from fuel combustion divided by total national population
Regulation and governance	Governance	Worldwide governance rating	Worldwide governance score	Mean score given for the six categories of accountability, political stability, government effectiveness, regulatory quality, rule of law, and corruption
	Trade and connectivity	Energy exports	Annual value of energy exports in 2009 US$ PPP — (billions)	Total value in US$ of net exports of coal (including coke and briquettes), crude petroleum, and natural gas (including liquefied natural gas)
	Competition	Per capita energy subsidies	Cost of energy subsidies per person (2009 US$ PPP)	Total government expenditures on direct and indirect energy subsidies divided by the national population
	Information	Quality of energy information	% data complete	% of data points complete for this index out of all possible data points

dimensions encompassing each of them all in addition to “demand side” elements such as retail prices and information and “governance” elements such as subsidies and corruption. Unlike complicated indices relying on logarithmic functions, the index here is transparent in its assumptions and relatively simple to understand. Unlike indices that cover only static moments in time, the index here assesses performance over a timespan of twenty years.

With the index firmly established, the final phase of the research process concerned scoring country performance among the 20 metrics over the 20-year period. Rather than measure performance using some type of abstract or absolute method, the author instead made scoring *empirical* and *relative*: empirical in that scores were based on real-world performance of countries observed within a particular metric for a given year, and relative in that we took the best and worst scores for those countries and used those to create our range of scoring points. This involved converting all of our raw data points to a score between zero and 100.[4] This means the scores for any given category shift year to year, and metric to metric, making them entirely dependent on the best and worst performance of actual

[4] More specifically, the author created a scoring range for a metric for a given year by subtracting the minimum value (the worst performer) from the maximum value (the best performer). Some values were negative, the author discarded these and converted them to zero. The author then took each data point, subtracted the minimum value, and divided by the range. What resulted was a score for each country anywhere between 0 and 100, the higher the score the better the performance. The idea was to avoid a scoring system based on arbitrary value judgments and instead rely on one that rooted in actual performance.

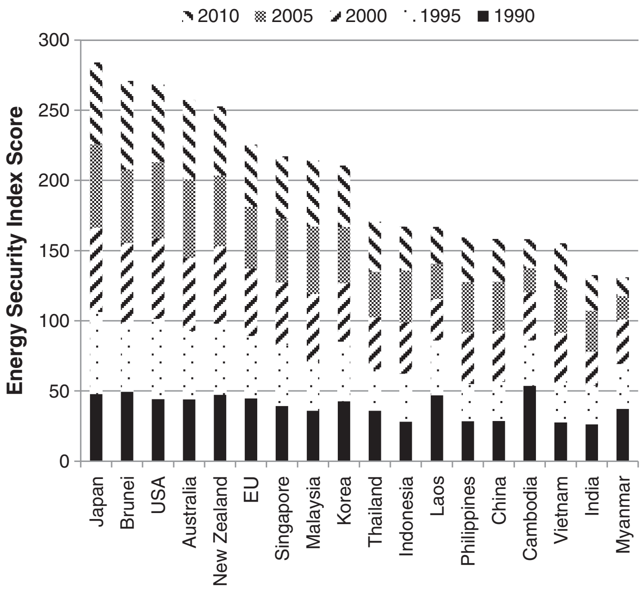

Fig. 1. Average energy security performance for eighteen countries.

countries. Appendices 1 and 2 present the raw data as well as the results of the scoring exercise for all eighteen countries.

3. Assessing International Performance

If one takes the mean score for each year and metric, and aggregates them, one gets a decent sense for who is most and worst energy secure among our sample of countries. The top three performers are Japan (284), Brunei (271), and the United States (168) whereas the worst three performers are Vietnam (155), India (132), and Myanmar (131). Fig. 1 presents these results disaggregated by year. The remainder of this section showcases three case studies, selected to represent a mix of different performs: Japan (the top performer), Laos (a middle performer), and Myanmar (the worst performer).

3.1. Japan

Japan boasts the world's third-largest economy in terms of purchasing power parity-adjusted Gross Domestic Product, ranks third in electricity consumption, third in oil consumption, and fourth in natural gas consumption globally. Lacking major deposits of fossil fuels, Japan must import most of the energy resources needed to fuel this consumption, and the country is also the second largest importer of energy fuels after the United States and the third largest importer of oil after the United States and Canada. With its few operating oil refineries and natural gas wells, less than 2% of the country's fossil fuel needs are met domestically. And despite being home to only 1.9% of the world's population, the country ranked seventh in global emissions of greenhouse gasses in 2008 (Takase and Suzuki, 2011). As Table 2 summarizes, however, despite these constraints Japan has done remarkably well providing its population with access to modern energy services, promoting energy efficiency, mitigating greenhouse gas emissions, and conducting research on new energy technologies—though these have resulted in slightly higher prices for electricity and gasoline, and relatively large amounts of subsidies distorting the energy marketplace.

In terms of availability, Japan's relatively poor resource endowment, historical experience, and current dependence on imported fuels combine to make security of supply a predominant concern. Japan does not have a single major oil field, is an archipelago, and its mountainous topography and seismic instability make transporting energy fuels and transmitting and distributing electricity difficult—as the Fukushima nuclear accident in March 2011 painfully demonstrated. Devastated after World War II, Japan's immediate problem was securing adequate supply of energy to fuel reconstruction and industrial growth, and the country's energy needs were met predominately by imported oil and domestic coal. By 1973, the time of the oil crisis, petroleum accounted for nearly 80% of total energy demand, and the crisis precipitated nothing less than sheer panic (Fukasaku, 1995). Japanese businesses had to streamline operations, electricity blackouts were widespread, and the government accrued massive amounts of debt from 1972 to 1976 caused in part by rapidly rising oil prices (Yokobori, 2005). Japan was a net importer of about 90% of its total energy fuels for most of the 1980s, and energy security was the “most important item” on a national 1980 report on Japan's *Comprehensive National Security* (Jain, 2007). Now, the country imports 97% of its natural gas, and 99% of coal, and meets only about 4% of energy demand met with local resources.

These trends have pushed Japan to engage more openly with energy producers and embark on a variety of large-scale collaborative projects. One would see an interconnected electricity network between Japan and South Korea (Kanagawa and Nakata, 2006). Another would involve the construction of an East Siberian Pipeline that would have Japan providing $5 billion for pipeline construction and support for oil development in East Siberia (Atsumi, 2007; Nakatani, 2004). Japan also helped finance and provided technical expertise for a network of natural gas pipelines in Southeast Asia that planners hope someday might extend to Northeast Asia (Sovacool, 2010). It invested in the Azadegan oil field in Southwest Iran, is competing with China to develop the Chunxiao gas fields in the East China Sea, and founded the Asia Energy Conservation Collaboration Center to enhance emergency responses to prevent disruption of energy supply in the region (Stewart, 2009; Toichi, 2003).

Japan scored moderately well in affordability. Japanese consumers are “sensitive to high prices” for energy because they already pay some of the highest in all of the OECD, in dollars per kWh, for electricity and the second highest among all Asian countries (Yokobori, 2005). Past energy and financial crises and electricity restructuring have made affordability a pressing energy security concern. The oil shocks of the 1970s saw a six-fold increase in gasoline and petrochemical feedstocks, and oil prices jumped again by a factor of six after the Asian financial crisis in July 1997 (Atsumi, 2007). This motivated Japanese regulators to restructure parts of the energy sector, including electricity, with the idea that regulatory reform would lower prices. Market mechanisms were introduced in the wholesale electricity sector with competitive bidding for additions to electricity generation in 1995, retail competition for large customers introduced in 2000, competitive electricity markets for the retail sector commenced in April 2005 with the formation of the Japan Electric Power Exchange (Goto and Yajima, 2006). This has meant increased scrutiny on affordability and lower costs for both industrial and retail energy consumers.

Japan has excelled in efficiency and innovation. World War II left Japan without many resources, and therefore post-war economic success depended on an ability to manufacture items of high quality more efficiently than competitors (Hayami and Ogasawara, 1999). Conservation and minimizing resource use are also part of the Shinto tradition of *mottainai*, or “don't waste,” dating back hundreds of years (Stewart, 2009: 185). Energy efficiency efforts certainly accelerated after the energy crises of the 1970s. Japan's Ministry of International Trade and Industry began their “Moonlight Project” in 1978 to develop more efficient power technologies and early fuel cells. In addition, the government offered free energy audits for smaller firms and issued standards for combustion and heating devices in industry to improve energy efficiency. These standards applied to more than 3500 factories in the manufacturing, mining, and energy supply sectors, and the government also required these facilities to hire a certified energy manager and to publicly disclose their energy consumption annually (Fukasaku, 1995).

The country's first minimum energy performance standards came in 1983 for refrigerators and air conditioners, and were later expanded to virtually all appliances, including the underrated electric toilet seat warmer (Yamamoto, 1986). The appliance standards were very successful at reducing electricity consumption. Average electricity use for refrigerators, for example, declined by 15% from 1979 to 1997 while average refrigerator size increased by 90%. Japanese regulators also applied their performance standards to imported technology ranging from automobiles and televisions to air conditioners and computers, and demanded that the efficiency level of new products had to meet the best performing product in the market, in some cases requiring energy efficiency improvements of more than 50% (Geller et al., 2006). These efforts appear to have paid dividends, with Japan having the most energy efficient baseline in the world for 1990 out of all Kyoto countries (causing some to joke that a further six percent reduction was equivalent to "wringing water out of a dry towel") (Stewart, 2009: 184).

In terms of innovation, Japan has long "promoted self-sufficiency" by developing new technologies (Jain, 2007), and for much of the 1990s it was the world leader in the manufacturing and use of solar photovoltaic panels. Recently it has diversified its research efforts into liquefied natural gas, coal liquefaction, ocean thermal energy conversion, and more efficient automobiles in addition to wind, solar, fuel cells, and nuclear fuel cycles (Stewart, 2009). A strong push in the industrial sector has also focused on energy-efficiency for manufacturing and production, including fusion reduction methods in iron and steel, fuel substitution in the chemical industry, fluidized bed kilns for the cement industry, and biopulping in the paper and pulp industry (Fukasaku, 1995).

In terms of stewardship, the population density in major cities such as Tokyo along with the large Japanese economy has made the mounting costs of air and water pollution highly visible, meaning that environmental pollution has high salience as an energy security issue. Japan was one of the first countries to pass acts barring industrial pollution and cleaner air and water in the 1960s (Fukasaku, 1995). Over the past decade, social concern over the natural environment has strengthened. Increasingly, Japanese citizens are less inclined to accept developments which impinge on environmental or esthetic enjoyment, and highly publicized cases of arsenic poisoning, mercury poisoning (Minamata disease), semi-acute spinal and optical nervous disorders and hexavalent chromium diseases inspired civil litigation and protest (Tsuru, 2000).

Japan has historically taken a strong stance on climate change, sponsoring the Kyoto Protocol and committing itself to reduce emissions by 6% compared to 1990 levels. Since about 90% of these emissions come from energy production and use, climate change mitigation and adaptation have become significant energy security problems (Yokobori, 2005). Japan ratified the Kyoto Protocol in 2002 and suggested post-Kyoto targets through its "Cool Earth 50" strategy to reduce emissions 50% by 2050 (Gasparatos and Gadda, 2009). Current policies for mitigation focus on voluntary measures including the Voluntary Action Plan (supported by the Japan Federation of Economic Organizations) suggesting that industry, transportation, and commercial sectors release emission records and reduction plans each year (Takase and Suzuki, 2011). Prime Minister Fukada also announced the "Fukada Vision" in 2008 suggesting an Emissions Trading Scheme without mandatory caps.

Lastly, in terms of regulation and governance, Japan was one of the earliest countries to formally pursue efforts to improve its energy security. Energy fuels played a part in why Japan colonized other Asian countries and went to war. Access to oil, for example, played a prominent role in the Japanese attack on Pearl Harbor, as it was intended to secure the Imperial Navy's real flank, ensuring that Japan could get oil from the newly invaded Southeast Asian countries (Stewart, 2009). Energy security was given high priority again from 1973 to 1975 when the government announced a formal energy security strategy that consisted of reducing dependence on petroleum, diversifying domestic energy supply, aggressively promoting energy conservation, and pushing research and development (Sovacool and Brown, 2010). Energy security has again taken "center stage" in Japan following September 11, with Iraq pushing up oil prices, a rising China and India, and global economic trends.[5] As one study recently argued, "concern for the security of its energy supply will dominate Japan's energy policy debates for the foreseeable future" (Yokobori, 2005) and another iterated that "energy security is seen as sacrosanct in Japan—it is not questioned" (Stewart, 2009: 184). Japan's New Energy Strategy, issued in 2006, explicitly mentions the importance of security of supply and the goal of diversifying energy use away from oil and fossil fuels (Takase and Suzuki, 2011).

3.2. Laos

The Democratic Republic of Laos is blessed with an abundance of resources and low per capita levels of energy-related pollution. It possesses large intact rainforests and the largest hydropower potential of any of the four lower Mekong Basin countries at 13,000 megawatts (MW) (Cruz-del Rosario and Souksavath, 2011). Yet as a least developed landlocked country, its government institutions and policies are in a nascent stage of development, and it lacks infrastructure such as power plants, transmission towers, and roads (Bambawale et al., 2011). As Table 3 summarizes, Laos led performance across all countries for its share of renewable energy (mostly hydroelectricity) and forest cover. It also has low per capita CO_2 emissions, and most recently, very high reserve to production ratios due to newly started gas production and expanded coal mining. However, Laos lags behind other countries in our sample in primary energy supply per capita, access to electricity and modern energy fuels, stable prices, and the availability of information.

In terms of energy availability, Laos has limited access to electricity and motorized transport, and it only started producing natural gas in 2009 (and has limited capability to mine its slightly larger coal reserves). It lacks refining capacity, has no national railway, energy consumption levels remain low, and wood accounts for the biggest total share of energy supply followed by imported petroleum and hydropower (Mustonen, 2010; Watcharejyothin and Shrestha, 2009). Planners have seemingly pursued energy exports and the foreign revenue they bring rather than expanding domestic access. As one sign of this export oriented strategy, Laotian planners intend to increase their number of dams from 14 to 55, making the country the "battery of Southeast Asia" (Case, 2011). In 2010, for example, the Nam Then 2 Dam was completed and the government signed agreements with China and Malaysia to build two more large-scale dams. It also has memorandums of understanding and contracts to supply 7000 MW of power to Thailand in addition to 5000 MW of electricity to Vietnam and 1500 MW to Cambodia by 2020 (Smits, 2011). It has a staggering 2520 MW of hydroelectric dams currently under construction compared to the 662 MW in current operation—essentially meaning the country has committed to quadrupling the size of their entire electricity sector (Cruz-del Rosario and Souksavath, 2011).

In terms of affordability and access, Laos has intended for some of this electricity to serve local populations. The government has the official target of 90% electrification by 2020 and from 1995 to 2009, had the fastest rate of electrification in the region (a rate that jumped from 16% to 63%) (Bambawale et al., 2011). It has also been implementing a unique "Power to the Poor" project which aims to provide households with subsidized ampere meters and interest-free

[5] Jain, 2007; Lesbirel, S. Hayden. 2004. "Diversification and energy security risks: the Japanese case," Japanese Journal of Political Science 5 (1): 1–22.

Table 2
Raw energy security data and adjusted energy security scores for Japan, 1990 to 2010.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio (years)	Self-sufficiency (%)	Share of renewable energy (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)
Raw data									
1990	3.6	–	0.2	12	–	100	0	–	–
1995	4.0	–	0.2	10	−2	100	0	63	2.8
2000	4.1	–	0.2	11	−2%	100	0	67	3.0
2005	4.1	9	0.2	10	3%	100	0	92	3.3
2010	3.7	5	0.2	10	7.2%	100	0	120	3.4
Scores (100 = best performance)									
1990	44.5	–	1.9	12.9	–	100.0	100.0	–	–
1995	48.6	–	2.5	10.6	100.0	100.0	100.0	71.0	100.0
2000	49.1	–	2.5	11.7	100.0	100.0	100.0	86.7	100.0
2005	52.0	3.5	2.3	11.0	100.0	100.0	100.0	59.7	100.0
2010	40.7	0.6	3.4	10.9	46.1	100.0	100.0	41.4	97.0

loans so they can afford electricity connections. Yet these efforts are not entirely effective, especially since they must compete with the capital costs for export-oriented dam construction, and since per capita incomes are slightly less than $1000 per year. The 1080 MW Nam Then 2 project, for example, cost about 80% of the country's annual gross domestic product (Smits and Bush, 2010). Donor dependency makes it close to impossible to finance future projects, and the country's debt was estimated at $5.8 billion in 2010 (U.S. Department of State, 2010). The result is what one independent study called a “contradiction,” for if Laos truly wanted to expand energy access it could have done so more cost-effectively using decentralized pico-hydropower (Smits and Bush, 2010). Debt levels within the government remain high—making it difficult to finance infrastructure investments—and inflation and the growth of imports have contributed to energy prices rising 5% per annum (Case, 2011).

Laos has struggled to promote energy efficiency and to invest in innovative energy systems. It underwent a massive economic transition in the 1980s from a socialist to a market-oriented economy (Krongkaew, 2004), and it has grown so fast that energy consumption and economic development have far outpaced efficiency efforts. For example, the Laotian economy has grown by double digits from 2000 to 2010 (its average annual growth from 2000 to 2008 was 10.9%) (Marks, 2011) and demand for electricity has grown 18% from 2006 to 2010; planners expect future growth to be 48% from 2006 to 2015 (Case, 2011). Thus, energy intensity remains high and research expenditures on new technologies low.

Laotian performance on sustainability is similarly mixed. The country has a low carbon footprint and relies almost exclusively on renewable energy for electricity, but must import practically all of its petroleum and its continued reliance on large-scale dams has involved the destruction of land and fisheries (Case, 2011). As one study recently summarized:

> In Laos, hydropower development impacts on fisheries resources, the flood regime and the availability of fertile lands local people often depend on. Large scale hydropower for export also requires new high voltage transmission lines, which also adversely affects local communities and environments. By producing much more electricity than the country needs, Laos will generate large amounts of foreign currency, but does so at the expense of its own environment and well-being of its people in dammed areas (Smits, 2011).

Also, the country's recent trend of investment in coal to diversify away from hydroelectricity threatens to reverse its progress on low per capita emissions of greenhouse gases and atmospheric pollutants (Watcharejyothin and Shrestha, 2009).

Regulation, governance, and institutional capacity remain constrained in Laos as well. The government in general, and Ministry of Energy and Mines in particular, has the sensible plan of expanding the grid and access to energy, promoting power exports with Cambodia, Thailand, and others along the Mekong, facilitating investment in the power sector, mostly through public private partnerships, and gaining technical capacity (Dimanivong, 2009). But the country is still managed by a single-party government with little input or involvement from the private sector and civil society in official affairs, including energy planning (Case, 2011). It remains dependent on international assistance to meet its electrification targets, with the World Bank pumping no less than $200 million into such programs over the past decade, and the government requiring overseas consultants to help prepare national energy plans and collect basic data about energy consumption and use (Bambawale et al., 2011). Indeed, in 2010, 90% of the government's capital budget came from donor-funded programs (U.S. Department of State, 2010).

3.3. Myanmar

Myanmar (Burma), notwithstanding its rich cache of oil and natural gas, is the least developed economy in Southeast Asia and also the “worst performer” in most indicators of economic and social progress—so it is perhaps unsurprising it performed poorly on the energy security index (Turnell, 2011). Less than 1% of the country's population reportedly use or have reliable access to electricity, and a majority of households (88%) depend on solid fuels such as wood and rice husks for cooking and heating (MercyCorps, 2011). Most rural villagers spend 233 h a year (about 20 h a month) collecting fuelwood, contributing to national deforestation and also inhibiting household productivity; more than two-thirds (70%) of households depend on diesel lamps, batteries, or candles for lighting. Indeed, the International Energy Agency has calculated that Myanmar has perhaps the poorest level of energy access in all of the Asia-Pacific, and percentages lower than a host of countries in Sub-Saharan Africa (International Energy Agency, 2011). As Table 4 summarizes, it scored moderately well in only five areas: share of renewable energy, forest cover, carbon dioxide emissions from energy, sulfur dioxide emissions, and information.

Myanmar has strikingly low levels of energy availability. Though it has improved slightly since, in 1997 Myanmar had the lowest per capita primary energy supply in the world (Black, 2009). Myanmar remains a biomass-centered energy system, with wood meeting 62% of all primary energy consumption in 2008—more than five *times* the second most significant source, crude oil and petroleum products (Kyaw et al., 2011). Blackouts and brownouts remain frequent in urban areas, and difficulty earning foreign exchange and lack of parts and labor has complicated

Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related CO_2 (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP)	Quality of energy information (completed data points)
5794	5	0	68	100	8.6	0.017	–	–	–	12
6077	5	0	68	100	9.1	0.017	78	–	–	16
6180	4	0	68	100	9.3	0.020	83	–	–	16
5032	5	0	68	100	9.6	0.007	85	0.2	43	19
4741	5	0	68	100	9.0	0.006	85	0.2	47	19
8.1	81.8	0.0	90.8	100.0	0.3	7.3	–	–	–	71.4
14.7	88.3	0.0	92.9	100.0	0.4	6.4	77.9	–	–	83.3
12.1	85.9	0.0	95.0	100.0	1.0	10.8	86.5	–	–	80.0
100.0	86.9	0.0	97.4	100.0	1.1	67.3	88.1	0.2	16.1	100.0
100.0	84.5	0.0	98.4	100.0	47.3	100.0	87.4	0.4	10.6	100.0

attempts to repair and maintain existing power plants and the transmission network (Tin, 2005).

In terms of affordability and access, even though only a small fraction of Burmese citizens have access to electricity, the government's official goal is to expand electrification rates to 60% by 2010. Nonetheless, the World Bank projected that Myanmar would need a staggering $444 million every year – almost 10% of its GDP, the highest of any country in Asia – to achieve universal access to electricity by 2030, making it unlikely.[6] And, in an understandable effort to reduce government deficits, the Burmese regime removed state subsidies on natural gas and diesel in 2007, leading to a doubling of domestic prices for bus fares and automobile fuel and spilling over into an increase in the price of basic commodities such as rice, beef, fish, milk, and eggs—hitting rural and poor households the hardest, and eventually leading to popular protest and a reactive state crackdown involving an "unknown" number of killings (Smith and Htoo, 2008).

To encourage energy efficiency, the government launched an "Energy Thrift" campaign in 2002 following the establishment of a Supervisory Committee for Utilization of Power and Fuel (Tin, 2005). But this pales in comparison to the government's efforts to rapidly increase energy supply—the formal national target is to grow the electricity grid at 8.5% per year, reaching 15,000 MW of capacity by 2020. Soe Myint, Director-General of the Myanmar Ministry of Energy, has explained that the country's true "overall objective" is to "increase the indigenous production of crude oil and natural gas to fulfill domestic demand and to export the excess to gain hard currency," rather than to invest in energy efficiency or domestic innovation (Black, 2009). Indeed, all indications point to a strong national strategy towards exports of oil, gas, and electricity rather than domestic use (Lall, 2006). At present, more than two dozen firms from Australia, Canada, China, France, India, Indonesia, Japan, Malaysia, Singapore, Thailand, the United Kingdom, and United States are involved in oil and gas extraction within Myanmar (Tin, 2005).

In the realm of sustainability, Myanmar has performed modestly due in part to its low levels of access—reflecting, in turn, smaller pollution footprints. However, in urban areas, charcoal production in inefficient locally-manufactured kilns need about eight times their weight in firewood as a feedstock; most of this wood comes from rural forests or mangroves (Tin, 2005). Its greenhouse gas emissions associated with energy production and use are dwarfed by those from the agricultural and forestry sectors, excluded from our index, but which still amounted to about 7.8 million metric tons of carbon dioxide equivalent, when traditional biomass fuel combustion is excluded (Swe, 2011).

Lastly, in terms of regulation and governance, Myanmar's long rule under a military junta from 1962 to 2011 created a reputation for authoritarianism, earning it the nickname "the bamboo curtain." (Kaplan, 2008) Many perceive Myanmar as having an "isolationist" and "non-liberal" economy, which complicates efforts at attracting private financing for infrastructure projects (Alamgir, 2008). The 2012 Index of Economic Freedom ranked Myanmar among the ten most "repressive" economies in the world out of 180 (Heritage Foundation, 2012) and Transparency International's "Corruption Perceptions Index" ranked them 180th out of 183 countries (Transparency International, 2011). One study went so far as to call the country a "gigantic, often grotesque bureaucracy" (Matthews, 2006). The government has reputedly viewed communities and rural villages not as partners in energy development, but obstacles to it. In the extreme, some have accused the Burmese regime of committing human rights violations such as forced labor, murder, interrupted livelihoods, and the covert transfer of weapons in their construction of energy projects such as the Yedana Gas Pipeline, Yetagun Pipeline, and Shwe Gas Project (Smith and Htoo, 2008).

4. Conclusion

Energy security is too important a concept to be incoherently defined and poorly measured. In response, this article has created an energy security index, utilizing twenty indicators that encompass economic, social, political, and environmental aspects of energy security, and analyzed the status of energy conditions in eighteen countries from 1990 to 2010. The central lesson from Japan's top performance is that a country need not possess large reserves of fossil fuels or uranium to rapidly improve its energy security. Laos implies that a country with a developing, agrarian, and overwhelmingly rural economy can still perform tolerably on energy security if it commits to using widely available domestic resources (such as hydroelectricity) and partners with international institutions such as the World Bank to expand energy access. Myanmar reminds us that poor capacity and governance can overwhelm the inherent potential of having a large endowment of energy resources. Readers can draw at least four broader conclusions from this exercise.

First, the energy security index utilized here suggests that a majority of countries regressed in terms of their energy security. Interestingly, the best possible score a country could have gotten—if it excelled in every category, for every year—was 500, indicating clearly that even the "best" performers still had aspects of their energy security that were unfavorable. Japan and Brunei scored favorably on slightly more than only 50% of the metrics and the third best performer, the United States, scored favorably only for one-third of its metrics. This conclusion is discouraging, given all that has happened

[6] World Bank and Australian Government 2011.

Table 3
Raw energy security data and adjusted energy security scores for Laos, 1990 to 2010.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio (years)	Self-sufficiency (%)	Share of renewable energy (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)
Raw data									
1990	–	–	–	95	–	–	–	–	–
1995	–	–	–	97	43	15	98	–	–
2000	–	–	–	90	1002%	–	95	315	0.0
2005	0.0	0	0.3	91	160%	44	95	171	–
2010	0.0	806	0.3	92	33.3%	55	95	292	–
Scores (100 = best performance)									
1990	–	–	–	100.0	–	–	–	–	0.0
1995	–	–	–	100.0	0.7	0.0	0.0	–	–
2000	–	–	–	100.0	0.0	–	1.2	12.0	0.0
2005	0.0	0.0	3.6	100.0	0.3	36.9	0.0	22.3	
2010	0.0	100.0	5.1	100.0	7.7	48.3	0.0	6.5	–

Table 4
Raw energy security data and adjusted energy security scores for Myanmar, 1990 to 2010.

	Total primary energy supply per capita (ktoe)	Average reserve to production ratio (years)	Self-sufficiency (%)	Share of renewable energy (%)	Stability of electricity prices (% change)	Population with high quality connections to the electricity grid (%)	Households dependent on traditional fuels (%)	Retail price of 100 l of unleaded gasoline (2009 U.S. Dollars PPP)	Research intensity (%)
Raw data									
1990	0.3	–	1.0	49	–	–	–	0.0	–
1995	0.3	–	0.9	41	–	–	–	0	0.1
2000	0.3	–	1.2	38	–	5	–	12	0.1
2005	0.3	29	1.5	45	186%	11	95	1	0.2
2010	0.3	32	1.5	62	120.9%	13	95	1	–
Scores (100 = best performance)									
1990	0.0	–	11.3	52.0	–	–	–	–	–
1995	0.0	–	11.8	42.5	–	–	–	–	0.0
2000	0.0	–	15.3	42.2	–	0.0	–	0.0	3.3
2005	4.2	11.5	17.6	45.8	0.0	0.0	0.0	22.1	6.1
2010	3.5	4.0	25.3	67.1	0.0	0.0	0.0	29.7	–

since the 1970s: the creation of the International Energy Agency, the rapid growth of renewable energy, the rise of energy efficiency and demand side management, and research on cutting edge technologies, to name a few. Despite all of this frenetic effort, the index suggests that most countries have regressed energy security relative to each other.

Second, despite the near total deterioration of energy security, a great disparity exists between countries. Some clear leaders, such as Japan, stand above the rest. Japan did not leave improving energy security to the marketplace, and their experience underscores the importance of government intervention through a progression of energy policy mechanisms. Perhaps equally important, the overarching explanation for the success of Japanese energy policy lies in coordinated and consistent political support and policy and aggressive investments and targets. We see degrees of the opposite—poor capacity and lack of coordination—partially in Laos and fully in Myanmar.

Third, and troublingly, is that the index reveals tradeoffs within different components of energy security. Japan achieved its low energy intensity, advanced technology, and mitigation of greenhouse gas emissions only with large subsidies and comparatively higher prices for energy services. Laos possesses a low carbon footprint and large penetration of hydroelectricity but has committed to exporting energy rather than domestic access, dam construction continues to erode environmental quality, and the country remains completely dependent on imported crude oil for its transport sector. Myanmar's extreme export oriented energy strategy leaves its population literally in the dark, and its limited capacity and low levels of access enable it to score favorably on environmental indicators. It appears that some elements of energy security, such as availability and affordability, can come only at the expense of others, such as sustainability and efficiency.

Fourth, finally, and most relevant for readers of this journal: the relative success of Japan, moderate success of Laos, and the relative failure of Myanmar serve as an important reminder that creating energy security is as much a matter of policy from within as it is from without. Policymakers need not focus only on geopolitical power structures in energy resource-producing states or on drafting new contracts with overseas partners. It is not sufficient to build trade alliances and share intellectual property, send troops abroad, or bolster naval deployments throughout the world's shipping lanes. Equally effective and important can be coordinated and robust domestic policy changes directed at diversification, promoting energy efficiency, and lowering greenhouse gas emissions. Tools such as research and development expenditures, subsidies, tariffs, and standards can be just as important, possibly more, for achieving truly available, dependable, affordable, efficient, and responsible forms of energy supply and use.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2013.01.019.

Acknowledgments

The author is appreciative to the MacArthur Foundation's Asia Security Initiative for grant 08-92777-000-GSS, which has supported elements of the work reported here. Any opinions, findings, and

Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related CO_2 (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP)	Quality of energy information (completed data points)
1911	–	–	75	29	0.1	0.003	–	–	–	6
1801	–	0	73	44	0.1	0.003	28	–	–	11
3756	–	0	72	48	0.2	0.010	19	–	–	12
12,730	21	0	70	54	0.2	–	15	0.0	82	17
11,815	13	0	69	57	0.2	–	18	0.0	80	17
30.5	0.0	–	100.0	–	94.3	49.6	–	–	–	0.0
72.4	–	0.0	100.0	11.1	100.0	47.4	20.6	–	–	16.7
30.7	–	0.0	100.0	3.7	100.0	23.7	14.5	–	–	0.0
27.5	39.9	0.0	100.0	0.0	100.0		12.1	0.0	7.8	0.0
27.2	55.2	0.0	100.0	0.0	0.0	–	16.3	0.0	5.9	0.0

Energy intensity (Btu per year 2005 U.S. Dollars PPP)	Grid inefficiency (%)	Energy resources and stockpiles (years)	Forest cover (%)	Water availability	Per capita energy-related CO_2 (metric tons)	Per capita sulfur dioxide emissions (metric tons)	Worldwide governance rating	Energy exports (billions of 2009 U.S. Dollars PPP)	Per capita energy subsidies (2009 U.S. Dollars PPP)	Quality of energy information (completed data points)
1791	26	9	60	57	0.1	0.001	–	–	–	10
1851	38	7	56	60	0.2	0.001	9	–	–	13
1751	31	4	53	66	0.2	0.003	6	–	–	14
23,208	35	3	49	71	0.3	–	4	0.0	245	18
16,884	29	4	48	71	0.2	–	2	0.0	255	17
32.8	0.0	1.8	79.0	39.4	49.9	100.0	–	–	–	42.9
70.2	4.5	2.2	75.8	36.5	38.6	100.0	0.0	–	–	33.3
85.0	0.0	1.2	72.5	37.0	93.8	88.0	0.0	–	–	40.0
6.0	0.0	1.2	69.0	37.0	77.7		0.0	0.0	1.7	50.0
12.6	0.0	2.0	67.6	32.6	0.3	–	0.0	0.0	1.4	0.0

conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the MacArthur Foundation. Anthony D'Agostino from Columbia University, as well as Ishani Mukherjee and Ira Martina Drupady from the National University of Singapore, also assisted greatly with data collection and coding.

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