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Abstract: How well are industrialized nations doing in terms of their energy security? Without a standardized set of metrics, it is difficult to determine the extent that countries are properly responding to the emerging energy security challenges related to climate change, growing dependence on fossil fuels, population growth and economic development. In response, we propose the creation of an Energy Security Index to inform policymakers, investors and analysts about the status of energy conditions. Using the United States and 21 other member countries of the Organization for Economic Cooperation and Development (OECD) as an example, and looking at energy security from 1970 to 2007, our index shows that only four countries—Belgium, Denmark, Japan, and the United Kingdom—have made progress on multiple dimensions of the energy security problem. The remaining 18 have either made no improvement or are less secure. To make this argument, the first section of the article surveys the scholarly literature on energy security from 2003 to 2008 and argues that an index should address accessibility, affordability, efficiency, and environmental stewardship. Because each of these four components is multidimensional, the second section discusses ten metrics that comprise an Energy Security Index: oil import dependence, percentage of alternative transport fuels, on-road fuel economy for passenger vehicles, energy intensity, natural gas import dependence, electricity prices, gasoline prices, sulfur dioxide emissions, and carbon dioxide emissions. The third section analyzes the relative performance of four countries: Denmark (the top performer), Japan (which performed well), the United States (which performed poorly), and Spain (the worst performer). The article concludes by offering implications for policy. Conflicts between energy security criteria mean that advancement along any one dimension can undermine progress on another dimension. By focusing on a 10-point index, public policy can better illuminate such tradeoffs and can identify compensating policies.

Competing Dimensions of Energy Security: An International Perspective

1. Introduction

On January 23, 1980, President Jimmy Carter issued a famous declaration that any effort by a hostile power to block the flow of oil from the Persian Gulf would be viewed by an assault on the "vital interests" of the United States, and would be repelled by "any means necessary, including military force."[1] In addition to proposing to Congress that the country establish an Energy Security Corporation to invest in alternative sources of fuel,[2] President Carter also created a Rapid Deployment Joint Task Force to perform the function of protecting the shipping lanes through which Middle Eastern oil flowed to American shores. In a policy later strengthened by the creation of the U.S. Central Command in the early 1980s and since termed the "Carter Doctrine," the Ronald Reagan, George H. Bush, Bill Clinton, and George W. Bush Administrations have each relied on the threat of military force to deter and prevent major disruption in world oil supply.[3] The price of these military activities in the Persian Gulf is expected to cost between $29 billion to $80 billion per year.[4] Every Presidential Administration since Carter, in other words, has viewed national security and energy supply as inexorably intertwined.

The deepening of the Carter Doctrine, however, does not inform us if such an approach to "energy security" is optimal and desirable. Nor does it tell us which countries have done the best at improving their energy security since the 1970s. This article measures and assesses energy security for 22 countries from 1970 to 2007. The first section surveys the scholarly literature on energy security from 2003 to 2008 and argues that it should be composed of accessibility, affordability, efficiency, and environmental stewardship. Because each of these four components is multidimensional, the second section discusses ten metrics that comprise an Energy Security Index. We then use our Energy Security Index to measure and track progress on energy security between the United States and 21 OECD countries. The third section analyzes the relative performance of four countries: Denmark (the top performer), Japan (which performed well), the United States (which performed poorly), and Spain (the worst performer). The article concludes by offering implications for policy.

In attempting to tackle a concept as complicated as energy security, we could have focused on almost any scale and any group of countries. Instead of emphasizing smaller scales (such as the individual and enterprises) or international organizations (such as the World Bank or Organization of Petroleum Exporting Countries), we have focused exclusively on nation states. And instead of looking at countries in a single region such as the European

Union[5], Asia[6], the Caspian Sea,[7] or the Black Sea,[8] we have investigated energy security for 22 geographically dispersed countries that belong to the OECD. The first reason for this focus is practical: data on patterns of energy production and use have been collected and compiled for OECD countries since the 1950s, and these countries are powerful members of a number of multilateral organizations dealing with energy issues such as the United Nations and the International Energy Agency. The next reason is more theoretical: OECD countries offer a representative sample of different types of energy markets and cultures. The United Kingdom and New Zealand are examples of liberalized and privatized energy markets while other countries such as Denmark and parts of the United States remain highly regulated. The OECD countries we selected also include cultures as diverse as Australia, Greece, Japan, and Turkey. The final reason is pragmatic: because OECD countries are the most industrialized, they also possess the technical and financial capacity to implement policy changes that can improve their energy security. The OECD countries include many of the world's largest consumers of energy, so their decisions affect the global energy marketplace

The importance of such an exploration is threefold. First, energy security is arguably one of the most important forms of human security. Energy services are a ubiquitous component of modern lifestyles, needed to power modes of transport, light factories and workplaces, cultivate food, manufacture and distribute products, and cool and warm residences. Economist E. F. Schumacher once noted that energy services in modern society are "not just another commodity, but the precondition of all commodities, a basic factor equal with air, water, and earth." They are used directly and indirectly by every living person, which means assessing how securely they are provided is crucial.

Second, perhaps because of its ubiquity, notions of energy security are either so narrow that they tell us little about comprehensive energy challenges, or so broad that they lack precision and coherence. Trying to measure energy security by using contemporary methods in isolation—such as energy intensity or electricity consumption—is akin to trying to drive a car with only a fuel gauge, or to seeing a doctor who only checks your cholesterol. Our study provides precision, breadth, and standardization to the oft-ambiguous concept. Without such criteria, it is difficult to determine the extent that policy decisions, private investments, new technologies, and research and development are keeping pace with the challenges facing the growing global economy in a carbon-constrained world. Though considerable effort has been dedicated by energy and environmental groups to the development of composite indicators of transportation productivity and environmental quality, there are no standard composite metrics to evaluate energy security. Thus, the enduring question—"Are our energy systems progressing or regressing?"—remains difficult to answer.

Third, international comparisons of energy security highlight the interdependence of countries, enmeshed in larger relationships between and within producers and consumers. Global trade in energy fuels and services amounted to $900 billion in 2006, and almost two-thirds of the oil produced in 2007 was traded on the global market.[9] Of hundreds of countries in the world, none are truly energy independent. Saudi Arabia exports crude oil but must import refined gasoline. Russia exports natural gas but must import uranium. The United States exports coal but imports oil and natural gas. This interdependence explains why our assessment of energy security examines the interactions between countries as much as within them, and serves as a useful reminder that energy security does not stand abstractly by itself; rather, it is most meaningful in a geographic context.

2. Conceptualizing Energy Security

Notions of energy security frequently differ by personal and institutional perspectives; national styles, geology, and geography; and time. Scientists and engineers characterize energy security as a function of strong energy research and development, innovation, and technology transfer systems.[10] The World Bank, in contrast, tells us that energy security is based on the three pillars of energy efficiency, diversification of supply, and minimization of price volatility.[11] Consumer advocates and users tend to view energy security as reasonably priced energy services without disruption. Major oil and gas producers focus on the "security" of their access to new reserves, while electric utility companies emphasize the integrity of the electricity grid. Finally, politicians dwell on securing energy resources and infrastructure from terrorism and war.[12]

Distinct national styles, geology, and geography also influence conceptions of energy security. In the United States, energy security has generally meant the availability of sufficient supplies at affordable prices, protecting Middle East suppliers and shipping lanes against piracy, maintaining a strategic petroleum reserve, and reducing physical threats to energy infrastructure.[13] Russia appears to pursue an energy security strategy of asserting state influence over strategic resources to gain primary control over the infrastructure through which it ships its hydrocarbons to international markets. Restricting foreign investment in domestic oil and gas fields is an important element of this strategy.[14] In the United Kingdom, energy security tends to be associated with promoting open and competitive energy markets which will provide fair access to energy supplies, foster investment, and deliver diverse and reliable supplies at competitive prices.[15] China has viewed energy security as an ability to rapidly adjust to their new dependence on global markets and engage in energy diplomacy, shifting from their former commitments to self-reliance and sufficiency ("*zili gensheng*") to a new desire to build a well-off society ("*Xiaokang Shehui*"). Buying stakes in foreign oil fields, militarily protecting vulnerable shipping lanes, and an all-out "energy scramble" for resources are key features of China's current approach to energy security.[16] Japan envisions energy security as offsetting its stark scarcity of domestic resources through diversification, trade, and investment, as well as selective engagement with neighboring Asian countries to jointly develop energy resources.[17] Saudi Arabia pursues energy security as maintaining a "security of demand" for their oil and gas exports,[18] while Australia cultivates a strong demand for uranium, natural gas, and coal exports.[19] Venezuela and Columbia, in contrast, focus on minimizing attacks on oil, gas, and electric infrastructure.[20]

Further complicating matters, conceptions of energy security change over time. The modern notion of energy security emerged in the early nineteenth century as the mechanization of warfare accelerated the energy requirements for coal-powered warships and vehicles. Global concerns about energy security became more prominent during the World Wars, the energy crises of the 1970s, and both invasions of Iraq.[21] In the United States, depending on the Administration, energy security has meant ending all oil imports, eliminating imports only from the Middle East, merely reducing dependence on foreign imports, and entirely weaning the country off oil.[22] Following the emergence of nuclear power in the 1970s, energy security has been expanded to include nuclear nonproliferation.

None of this, however, tells us which institutional, national, or temporal form of energy security is preferable. Current conceptions of energy security, moreover, are so vague that it would be simultaneously possible to increase oil production to strengthen energy availability while weakening environmental stewardship, as is the case with the development of tar sands and oil shale. Such contradictions and tensions among the various national approaches and meanings of energy security, and their differentiation over time, reveals important dimensions to the concept, but they do not address the deeper question as to which is the preferred or most beneficial form. We argue, based on an extensive assessment of 91 peer-reviewed academic articles on energy security from September, 2003 to September, 2008,[23] that energy security should be based on the interconnected factors of availability, affordability, efficiency, and environmental stewardship.[24]

2.1 Energy Security as Availability

The classic conception of energy security addresses the relative safety and source diversification of energy fuels and services.[25] More than 80 percent of the academic literature we examined noted the importance of availability, a component often predicated on promoting independence and diversification.

Part of ensuring availability entails procuring “sufficient and uninterrupted supply” and minimizing foreign dependence on fuels.[26] Dependence can be costly, most recently illustrated with Russian efforts to negotiate natural gas prices in Europe. Russia was able to successfully triple the price of natural gas exported to Belarus and Ukraine because these countries were completely dependent on Russian supply. In more serious cases, growing dependence or perceived scarcity of domestic energy supply has precipitated international conflict. Energy supplies had a significant role to play in provoking the American Revolutionary War.[27] In World War I, both Entente and Central powers believed control of coal, oil, and gas resources were a key to victory.[28] During World War II, Japan, suffering from a dearth of available raw materials, invaded Manchuria in 1931 to acquire their coal reserves.[29] In response to Japan’s later invasion of China in 1937, the U.S. cut off oil exports in July 1941. Without domestic resources, Japan invaded the oil-rich Indonesian islands, and the resulting tensions were a direct contributor to the Japanese decision to attack Pearl Harbor. That same year, Adolf Hitler declared war on the Soviet Union in part to secure oil for his war machine, and he launched *Operation Blau* to protect German oilfields in Romania while securing new ones in the Central Caucuses. The Soviet Union attempted to invade northern Iran in 1945 and 1946 to acquire control of their oil resources precisely to reduce their own dependence.[30] During the Gulf War of 1990-1991, Iraq invaded Kuwait explicitly to enhance its control of energy reserves. Lessening dependence on foreign supplies of energy fuels, therefore, is an important component of ensuring availability and improving energy security.

A related aspect of availability is diversification, or preventing the sabotage and attack of critical infrastructure, such as power plants, pipelines, dams, and transmission and distribution networks so that the services they provide are uninteruptible. Diversification encompasses three dimensions: (1) Source diversification requires utilizing a mix of different energy sources, fuels, types, fuel cycles (i.e., relying not just on nuclear power or natural gas but also coal, oil, wind, biomass, geothermal, etc.); (2) Supplier diversification refers to developing multiple points of energy production so that no single company or provider has control over the market (i.e., purchasing oil from not just one or two companies but a diversified mix of dozens of energy firms); and (3) Spatial diversification means dispersing the locations of individual facilities so that they cannot be disrupted by a single attack, event, malfunction, or failure (i.e., building one oil refinery in every state instead of placing all of them in the Gulf Coast). The principle of diversification is rooted in ecology (natural ecosystems reveal that a diversity of flora and fauna are best able to prevent spread of disease and pests);[31] finance (a diversified investment strategy is the best way to guarantee highest overall return);[32] and politics (democracy can be viewed as a form of diversification of the idea of consensus building, decision-making, and accountability in governance).[33]

Multiplying one's supply sources by investing in multiple alternatives serves the interests both of consumers and producers because it ensures that the energy supply chain is not dependent on any single fuel source. As well, the geographical dispersion of energy facilities not only improves their overall reliability, it makes the entire distribution network more secure and resilient to accidental disruption, systems failure, or intentional attack. Geographical dispersion creates multiple targets, all of which would have to be disrupted at the same time to elicit total systems collapse.

Diversification, too, has historical importance, for a variety of actors, saboteurs, terrorists, and insurgents have targeted energy infrastructure. Starting with North America, in 1975 the New World Liberation Front bombed pipelines of the Pacific Gas and Electric Company in California more than 10 times, and members of the Ku Klux Klan and San Joaquin Militia have been convicted of attempting to attack natural gas infrastructure throughout Mexico and the United States.[34] In 1997 in Texas, police prevented the bombing of natural gas storage tanks at a processing plant by Ku Klux Klan members seeking to create a diversion for a robbery.[35] In 1999 Vancouver police arrested a man for planning to blow up the trans-Alaskan pipeline for personal profit in oil futures.[36] In 2001, an attack on the trans-Alaska pipeline with a high-powered rifle forced a two day shut down and caused extensive economic and environmental damage—all apparently part of a hunting trip gone awry.[37]

Focusing beyond North America, in the 1970s during the Russian invasion of Afghanistan, the Mujahedeen conducted so many attacks on Soviet oil and gas pipelines that the Russians lost more than 500 tons of petroleum every day. A few decades later in the midst of the Russian-Chechen conflict, both sides exploited pipelines as a way to intensify their military campaign, with the Chechens even tapping the Baku-Grozny-Novorossiysk pipeline more than 100 times to draw away oil to hidden refineries where it could be processed into cheap gasoline then sold in Grozny to purchase weapons.[38] The government of Saudi Arabia, which manages more than 11,000 miles of gas and oil pipelines, has repelled at least thirty attempts in the past four years to destroy or damage their pipelines by "insurgents" in nearby Iraq.[39] Next door, in Iraq, more than 150 attacks on the country's 4,000 mile pipeline system occurred over the course of 12 months.[40] Suicide bombers have attacked natural gas infrastructure in Nigeria, Sri Lanka, and Yemen,[41] and in Pakistan, gunmen have frequently stormed Pakistan Petroleum Limited natural gas facilities, fired rockets at pipelines, and kidnapped employees of the Water and Power Development Authority.[42] In Columbia, the 480-mile Cano Limon-Covenas pipeline has had so many holes blown in it that the locals jokingly refer to it as "the flute."[43] In the Sudan, Arakis Energy Corporation and Greater Nile Petroleum Company sometimes have to repel daily attacks on their oil and gas pipelines.[44] London Police also foiled a plot by the Irish Republican Army in 1996 to bomb gas pipelines and other utilities across the city with 36 explosive devices.[45] There is much precedence, in other words, for diversification becoming a more significant component of energy security.

2.2 Energy Security as Affordability

A second component of energy security extends beyond availability to include the basic affordability of energy services. Slightly more than 50 percent of the examined literature suggested affordability as an important principle. Less affluent families spend a larger proportion of their income on energy services (some as much as 40 percent), so ensuring that energy is affordable can be central to meeting their basic needs. Moreover, people living in poverty pay proportionally more for energy, hindering accumulate of the wealth needed to make investments to escape their poverty. The United Nations has warned that energy pollution has an often ignored class dimension: infant mortality rates are more than 5 times higher among the poor, the proportion of children below the age of five who are malnourished is 8 times higher, and maternal mortality rates are 14 times higher.[46] Indirectly, higher energy prices tend to inflate the price of almost all other goods and services, since energy can account for up to 15 percent of the total cost for food processing, textiles, lumber, paper processing, chemical manufacturing, and cement mixing.[47]

Energy fuels and services must not only be affordable, their prices should also be relatively stable. When energy prices swing wildly, suppliers find it difficult to plan prudent investments. The enormous price spikes for natural gas seen over the past few years in the United States, for example, have made natural gas–fired plants uneconomic to operate, and have resulted in significant increases in electricity prices in several areas, much to the consternation of utility executives.[48] At the same time, the energy affordability component of energy security can conflict with other energy security criteria. For instance, energy price controls in developing countries have resulted in artificially low prices, which thwart investments in energy-efficient and clean energy technologies.

2.3 Energy Security as Energy and Economic Efficiency

A third component, mentioned by about one-third of the literature, relates to energy efficiency, or the improved performance and increased deployment of more efficient equipment and conservation.[49] Energy efficiency enables the most economically efficient use of energy to perform a certain task (such as light, torque, or heat) by minimizing unit of resources per unit of output. Energy efficiency can include substituting resource inputs or fuels, changing habits and preferences, or altering the mix of goods and services to demand less energy.[50] A key part of improving the efficiency of energy technologies and services relates to innovation and research and development. Energy technology innovation is the process of leading to new or improved energy technologies that enhance the quality of energy services and reduce the negative externalities and costs associated with energy supply and use.[51]

2.4 Energy Security as Environmental Stewardship

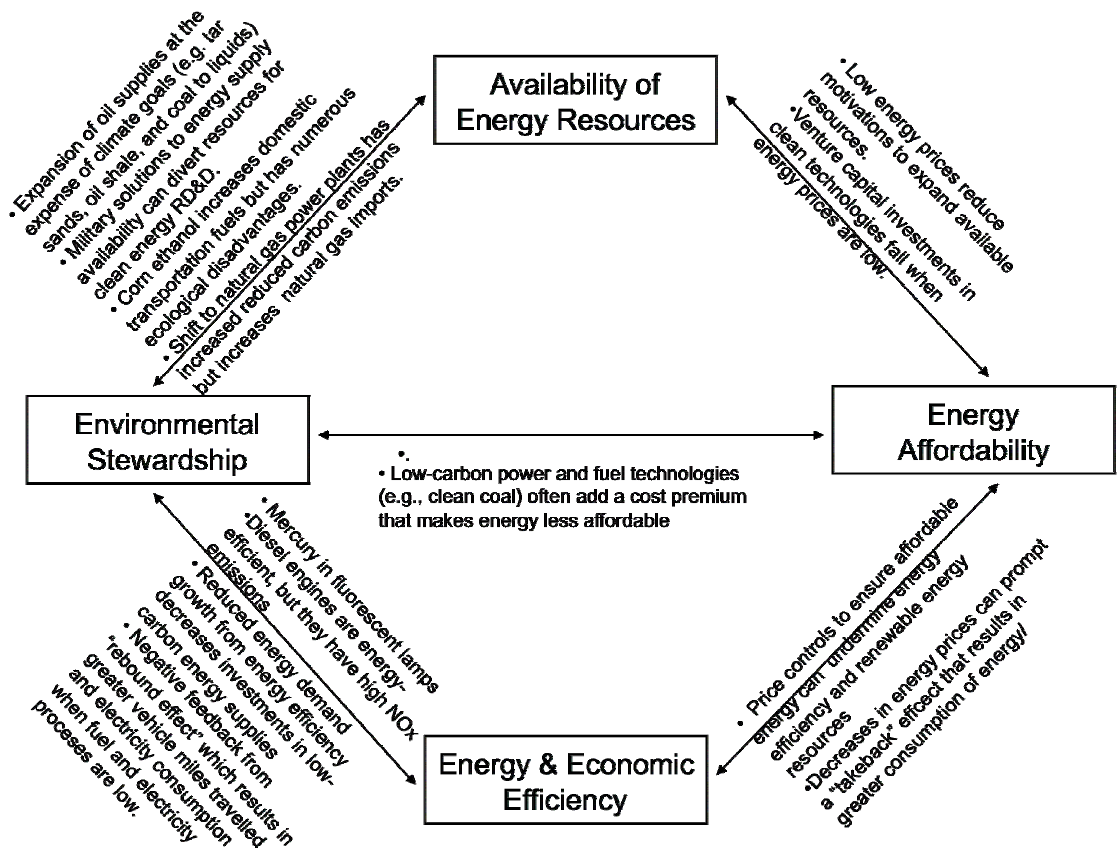
The final component, promoted by about one-fourth of the examined articles, relates to environmental stewardship, and it emphasizes the importance of sustainability. In its classic sense, the concept encompasses the notion of balancing current resource consumption with the resource requirements of future generations. For example, the landmark 1987 Brundtland Report of the World Commission on Environment and Development (published under the title *Our Common Future*) defined sustainable development as meeting "the needs of the present without compromising the ability of future generations to meet their own needs."[52] When applied to energy policy, sustainability has meant pursuing one of three rules: ensuring that the harvest rates of renewable resources do not exceed regeneration rates; making sure that waste emissions do not exceed relevant assimilative capacities of ecosystems; and guaranteeing that non-renewable resources are only depleted at a rate equal to the creation of renewable ones. Even groups such as the International Energy Agency[53] and former American Defense Secretaries John Deutch and James Schlesinger[54] have noted that mitigating and adapting to climate change must be considered a part of any attempt to create energy security

2.5 All Together Now

These four criteria—availability, affordability, efficiency, and stewardship—must be promoted holistically.[55] A number of examples illustrate the necessity of needing all four criteria simultaneously. Protecting the shipping lanes used by oil tankers with military force protects supply, meeting the criterion of availability, but diverts attention and resources from pursuing alternatives to petroleum, failing to meet the criterion of stewardship.[56] Increasing production of corn-based ethanol would reduce petroleum dependence in the transport sector, but would mitigate environmental stewardship through the widespread use of fertilizers and destructive farming practices.[57] Stockpiling petroleum and natural gas through strategic reserves can serve as a buffer against price shocks, but also offer just the kind of centralized targets that terrorists and saboteurs find attractive.[58]

Unfortunately, many countries continue to adhere to particularly narrow views of energy security, pursuing one of the four criteria even at the expense of each of the other three. A study of large-scale energy projects in Thailand, Myanmar, and Laos found that while the construction of regional interstate natural gas pipelines and hydroelectric projects enhanced the availability of energy supply, such projects have exacerbated social tension, worsened the gap between rich and poor, hastened environmental degradation, and intensified various manifestations of human insecurity, ultimately making electricity and energy more expensive.[59] International funding by the European Union on coal-to-liquids has helped some countries reduce dependence on foreign sources of oil, but this strategy conflicts with efforts to fight climate change.[60] The United States has started shifting from the use of coal to natural gas in the power sector to reduce greenhouse gas emissions, but this has exacerbated dependence on foreign sources of liquefied natural gas.[61] Figure 1 illustrates some of the many conflicts between components of energy security. Tradeoffs often occur between options that are effective along one dimension, but which adversely impact other aspects of security. Given the abundant illustrations of such conflicts, it would appear that most countries have overtly or inadvertently pursued technologies and policies that involve swapping progress in one energy security domain with retreat in another.

Figure 1: Conflicts Between Components of Energy Security



3. Quantifying Energy Security and Evaluating Performance

These examples, and the countless more that we have not mentioned, underscore the importance of pursuing a comprehensive notion of energy security, one that does not achieve secure supply and affordable prices at the expense of stewardship and efficiency, or vice versa. Recognizing that each criterion does not exist in a vacuum, and that each is of comparable importance, we have developed 10 metrics that comprise an Energy Security Index. (See Table 1).

Table 1: Defining and Measuring Energy Security

Criteria	Underlying Values	Explanation	Metrics
Availability	Independence, diversification, reliability	Diversifying the fuels used to provide energy services as well as the location of facilities using those fuels, promoting energy systems that can recover quickly from attack or disruption, and minimizing dependence on foreign suppliers	Oil import dependence; Natural gas import dependence; Availability of alternative fuels
Affordability	Equity	Providing energy services that are affordable for consumers and minimizing price volatility	Retail electricity prices; Retail gasoline/petrol prices
Energy and Economic Efficiency	Innovation, resource custodianship, minimization of waste	Improving the performance of energy equipment and altering consumer attitudes	Energy intensity; Per capita electricity use; Average fuel economy for passenger vehicles
Environmental Stewardship	Sustainability	Protecting the natural environment and future generations	Sulfur dioxide emissions; Carbon dioxide emissions

To reflect *availability*, oil import dependence, natural gas import dependence, and availability of alternative fuels serve as useful indicators. Oil import dependence and natural gas import dependence reflect how dependent a country is on foreign supplies of petroleum (mostly used in transport) and natural gas (a feedstock for industrial activity and power generation), and also document changes in the supply mix for the world's first and third most used fuels (the second being coal). The presence of alternative fuels such as ethanol and bio-diesel also reveal how far countries have moved away from dependence on petroleum. To reflect *affordability*, the price of electricity and gasoline at the retail level serve as important metrics. We have decided to track residential prices for electricity and gasoline consumption rather than diesel or jet fuel because homes and passenger vehicles account for a majority of the energy used by ordinary people.[62] To reflect *energy and economic efficiency*, metrics such as energy intensity, per capita electricity use, and fuel economy show different but important dimensions. Perhaps the most important of these three is energy intensity, a measure that indicates the amount of energy used to produce a unit of GDP. By correlating energy use with economic output, the measure thus encompasses patterns of consumption and use for industries, government facilities, consumers, and multiple sectors all at once. Per capita electricity consumption and on-road fuel economy for passenger vehicles also show how efficient individual technologies have become at the end-user level. To reflect *environmental stewardship*, aggregate sulfur dioxide emissions and carbon dioxide emissions reveal how far countries have gone towards mitigating greenhouse gas emissions, acid rain, and noxious air pollution. These indicators also help show relative progress in how governments have implemented national climate change programs.

We collected data on these ten indicators and metrics for 22 OECD countries from 1970 to 2007, with a few exceptions and caveats. First, reliable data for energy intensity was only available for 1980 and 2005; fuel economy data for 2005 instead of 2007; and sulfur dioxide emissions data for 2000 instead of 2007. Second, our index is not meant to imply that quantitative measures of energy security are perfect, or that reducing complex situations to numbers is without problems. Numerical indices often highlight not what is most significant or meaningful, but merely what is measurable. Quantitative measurements, especially those taken out of context, can also conceal important nuances and variability. Does a reduction in the energy intensity of a given country mean that its economy is becoming more energy efficient, or that instead more energy-intense products are being imported from elsewhere and energy-intensive jobs outsourced?[63] Third, collecting the data for this study was tedious and difficult. Most of it was not available online and the data for 1970 involved much digging through libraries. Historical data from International Energy Agency publications and archives are inconsistent, and discrepancies found in data and reports published by different agencies (e.g., the Energy Information Administration, World Resources Institute, United Nations, and the World Bank) are even more difficult and troubling.

That said, we do believe that these ten metrics still provide a reasonable sense for how well countries have provided energy services and promoted energy security, and the results may be surprising to some. Tables 2 and 3 show the data for each of the 10 metrics for the 22 selected countries in 1970 and 2007. We then assessed the relative progress for each country for each metric, assigning a value of -1 if the metric worsened over time; 0 if it stayed the same; and +1 if it improved. All metrics were weighed equally, with the results presented in Table 4 and Figure 2.

Table 2: Energy Security Performance Index for 22 OECD Countries, 1970 (in $2007)[64]

	Oil import dependence (%)	Alternative fuels (%)	On-road fuel economy (passenger vehicles mpg-e)	Energy intensity (thousand BTU/US$GDP)*	Electricity use (kWh/capita)	Natural gas import dependence (%)	Nominal electricity retail prices (US¢/kWh)	Nominal gasoline prices (US$/liter)	SO_2 emissions (million tons)	CO_2 emissions (million tons)
Australia	67%	3.9%	17	10.3	3,919	0%	3.7	0.26	1.6	143
Austria	57%	5.7%	21	8.5	3,302	34%	18	1.32	0.4	49
Belgium	100%	1.6%	22	12.2	3,399	99%	18.5	1.74	1.2	118
Canada	46%	2.7%	14	18.7	9,529	1%	3.7	0.37	4.1	340
Denmark	99%	1.9%	24	8.8	3,211	0%	9.5	0.42	0.3	56
Finland	100%	2.3%	22	12.6	4,885	100%	5.3	0.53	0.4	40
France	98%	3.7%	28	8.7	2,882	35%	7.9	0.74	3.5	435
Germany	92%	3.6%	24	9.8	2,962	24%	15.9	1.16	6.9	984
Greece	99%	1.7%	21	6.0	1,118	0%	2.1	0.58	0.3	25
Ireland	98%	2.8%	22	9.0	1,956	0%	6.9	0.58	0.2	22
Italy	97%	1.3%	28	7.1	2,262	0%	6.3	0.42	2.6	295
Japan	100%	1.8%	20	7.8	3,445	32%	48.6	1.27	5.1	743
Netherlands	97%	2.0%	25	12.9	3,110	0%	15.3	1.00	1.4	130
New Zealand	100%	4.4%	19	11.0	4,941	0%	3.17	0.48	0.1	14
Norway	100%	2.5%	23	16.4	14,785	0%	2.6	0.42	0.2	24
Portugal	99%	2.0%	23	4.4	830	0%	20.6	1.59	0.1	15
Spain	99%	2.7%	27	7.0	1,623	85%	5.8	0.37	1.1	121
Sweden	100%	2.5%	20	13.7	8,048	0%	3.2	0.32	0.9	831
Switzerland	100%	3.1%	23	7.6	4,693	100%	4.0	1.59	0.1	39
Turkey	53%	2.3%	15	5.0	241	0%	21.1	0.11	0.8	42
UK	100%	2.3%	21	9.9	4,489	7%	5.3	0.58	8.6	630
United States	22%	4.9%	13	14.7	8,022	4%	7.0	0.42	31.2	4,200
Median	99%	2.5%	22	9.0	3,302	1%	6.9	0.6	0.9	118
Mean	84%	2.6%	21	9.6	4,079	24%	10.5	0.7	3.2	416

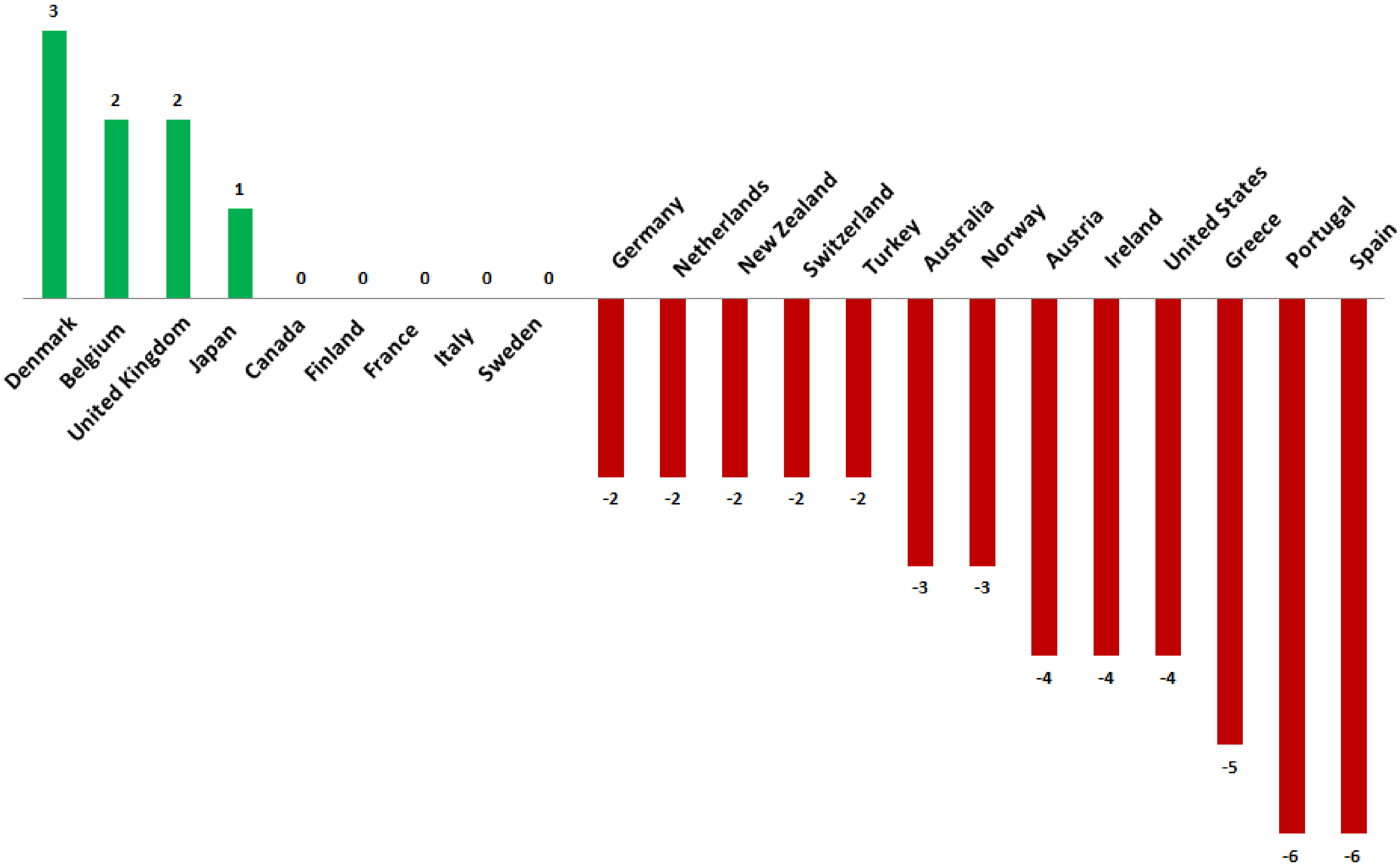
Table 3: Energy Security Performance Index for 22 OECD Countries, 2007[65]

	Oil import dependence (%)	Alternative fuels (%)	On-road fuel economy (passenger vehicles mpg-e)	Energy intensity (thousand BTU/US$GDP)*	Electricity use (kWh/capita)	Natural gas import dependence (%)	Real electricity retail prices (US¢/kWh)	Real gasoline prices ($/liter)	SO_2 emissions (million tons)*	CO_2 emissions (million tons)
Australia	37%	1.7%	26	9.0	11,309	0%	12.5	1.24	2.6	395
Austria	91%	3.7%	31	7.0	8,090	95%	22.6	1.81	0.2	73
Belgium	99%	1.9%	29	9.2	8,688	100%	16.5	2.20	1.3	117
Canada	0%	1.2%	23	13.8	16,766	0%	7.6	1.08	2.9	539
Denmark	0%	2.3%	30	5.2	6,864	0%	38.2	2.05	0.1	55
Finland	96%	1.9%	29	8.8	17,178	93%	17.1	2.12	0.3	67
France	96%	1.9%	32	7.2	7,585	97%	17.3	2.03	1.3	378
Germany	94%	1.9%	29	7.0	7,175	79%	23.1	2.10	2.4	823
Greece	99%	1.9%	29	6.8	5,372	99%	13.0	1.19	0.8	94
Ireland	100%	1.9%	29	4.9	6,500	86%	24.7	1.77	0.1	45
Italy	93%	2.5%	33	5.8	5,762	85%	27.2	2.06	1.5	448
Japan	97%	1.8%	22	6.5	8,220	93%	17.8	1.46	2.6	1,213
Netherlands	91%	1.9%	30	9.8	7,057	59%	24.2	2.28	1.0	178
New Zealand	69%	2.9%	29	9.1	9,746	0%	17.8	1.35	0.1	37
Norway	0%	1.9%	29	12.8	24,295	0%	17.5	2.32	0.6	37
Portugal	98%	1.9%	29	5.9	4,799	100%	23.3	2.07	0.2	56
Spain	98%	1.9%	31	7.1	6,213	100%	18.7	1.64	2.1	328
Sweden	99%	1.9%	28	9.1	15,230	100%	12.7	1.99	0.3	48
Switzerland	99%	1.9%	29	5.8	8,279	100%	15.6	1.65	0.1	44
Turkey	94%	3.7%	29	6.1	2,053	97%	15.8	2.60	2.1	240
UK	4%	3.7%	31	6.0	6,192	8%	22.7	2.07	1.6	536
United States	59%	2.9%	20	9.1	13,515	17%	10.3	0.82	17.8	5,697
Median	94%	1.9%	29	7.0	7,585	93%	17.8	2.0	1.0	117
Mean	72%	2.2%	27	7.4	8,890	64%	18.4	1.8	1.8	502

Table 4: Energy Security Performance Score, 1970 to 2007

	Oil import dependence (%)	Alternative fuels (%)	Fuel economy (new passenger vehicles mpg-e)	Energy intensity (thousand BTU/US$GDP)*	Electricity use (kWh/capita)	Natural gas import dependence (%)	Nominal electricity retail prices (US¢/kWh)	Nominal gasoline prices (US$/liter)	SO_2 emissions (million tons)	CO_2 emissions (million tons)	Final Score
Australia	+1	-1	+1	+1	-1	0	-1	-1	-1	-1	**-3**
Austria	-1	-1	+1	+1	-1	-1	-1	-1	+1	-1	**-4**
Belgium	+1	+1	+1	+1	-1	-1	+1	-1	-1	+1	**+2**
Canada	+1	-1	+1	+1	-1	+1	-1	-1	+1	-1	**0**
Denmark	+1	+1	+1	+1	-1	0	-1	-1	+1	+1	**+3**
Finland	+1	-1	+1	+1	-1	+1	-1	-1	+1	-1	**0**
France	+1	-1	+1	+1	-1	-1	-1	-1	+1	+1	**0**
Germany	-1	-1	+1	+1	-1	-1	-1	-1	+1	+1	**-2**
Greece	0	+1	+1	-1	-1	-1	-1	-1	-1	-1	**-5**
Ireland	-1	-1	+1	+1	-1	-1	-1	-1	+1	-1	**-4**
Italy	+1	+1	+1	+1	-1	-1	-1	-1	+1	-1	**0**
Japan	+1	0	+1	+1	-1	-1	+1	-1	+1	-1	**+1**
Netherlands	+1	-1	+1	+1	-1	-1	-1	-1	+1	-1	**-2**
New Zealand	+1	-1	+1	+1	-1	0	-1	-1	0	-1	**-2**
Norway	+1	-1	+1	+1	-1	0	-1	-1	-1	-1	**-3**
Portugal	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	**-6**
Spain	+1	-1	+1	-1	-1	-1	-1	-1	-1	-1	**-6**
Sweden	+1	-1	+1	+1	-1	-1	-1	-1	+1	+1	**0**
Switzerland	+1	-1	+1	+1	-1	0	-1	-1	0	-1	**-2**
Turkey	-1	+1	+1	+1	-1	-1	+1	-1	-1	-1	**-2**
UK	+1	+1	+1	+1	-1	-1	-1	-1	+1	+1	**2**
United States	-1	-1	+1	+1	-1	-1	-1	-1	+1	-1	**-4**
Mean	0.5	-0.4	1.0	0.7	-1.0	-0.6	-0.7	-1.0	0.3	-0.5	-1.7

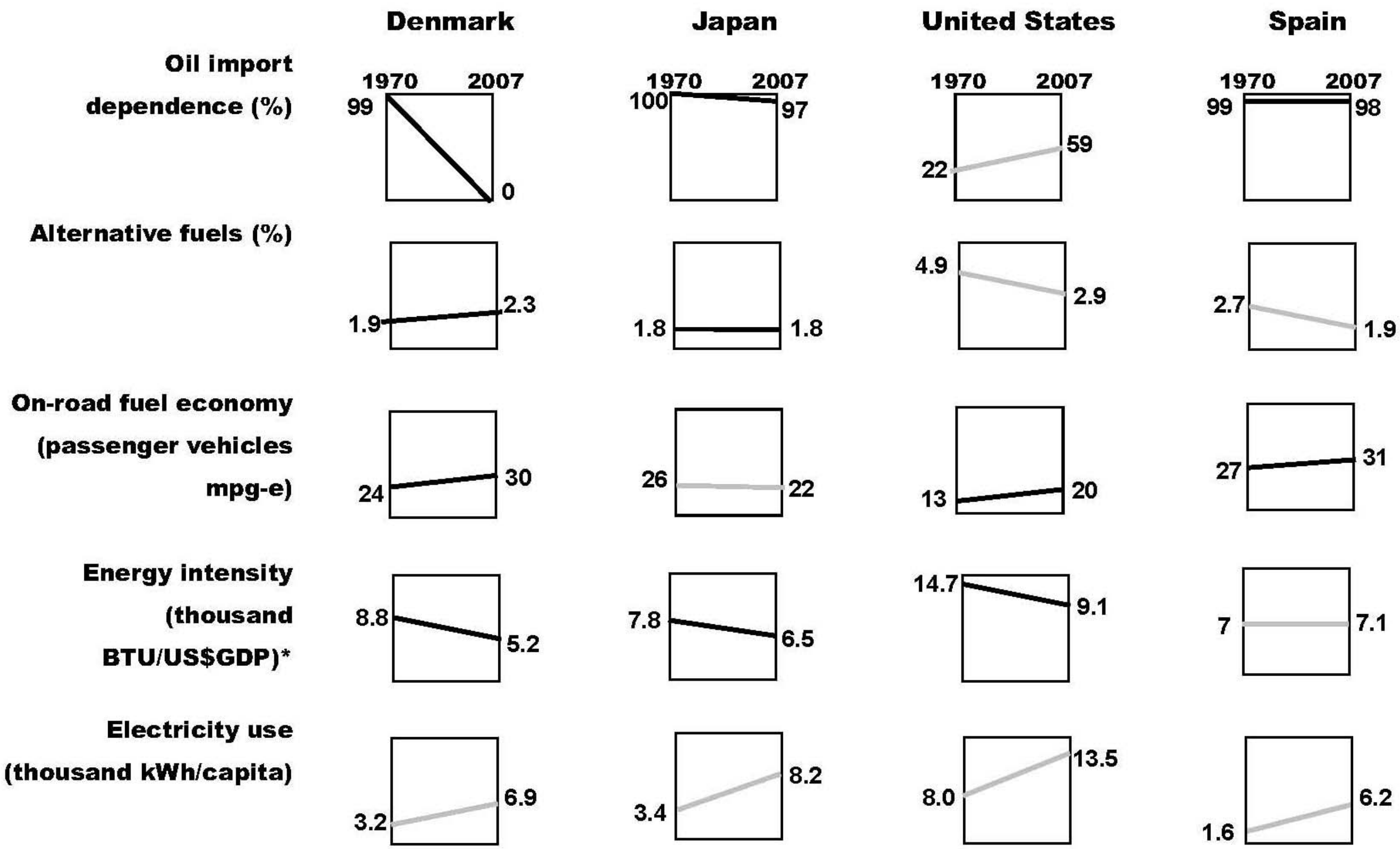
Figure 2: Most to Least Improved Energy Security Rankings, Based on 1970-2007 Trends

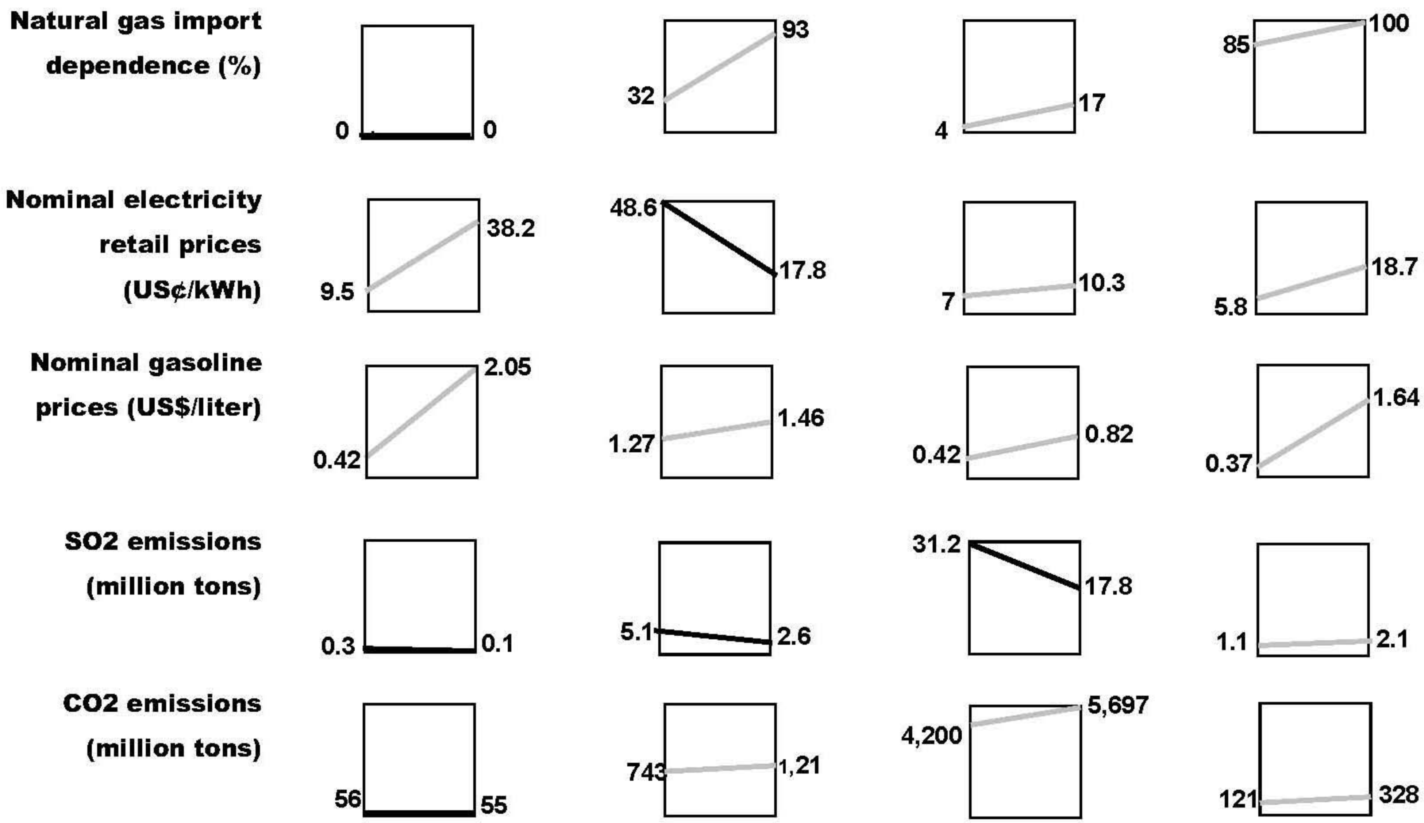


The results of our survey show that Denmark, Belgium, and the United Kingdom scored the highest; Japan, Canada, Finland, France, Italy, and Sweden did relatively well; Germany, the Netherlands, New Zealand, Switzerland, Turkey, Australia, Norway, Austria, Ireland, and the United States did poorly; and Greece, Portugal, and Spain did the worst. A few interesting trends are worth pointing out. First, scores are highly variable within the OECD, implying that the countries examined have taken diverse and divergent paths towards energy policy and security, and also reflecting different natural resource endowments. Second, no country scored perfectly, meaning that none improved in all categories. Denmark, with the best score, led the pack with “3” when their highest possible score was “10.” Third, a majority of countries did poorly, with thirteen countries scoring below zero, implying that their energy security has worsened from 1970 to 2007. Fourth, some metrics, such as energy intensity and fuel economy for passenger vehicles, have almost universally improved, while others, such as electricity consumption per capita, electricity prices, and gasoline prices have almost universally deteriorated.

Using the same statistical data, supplemented by a review of the published literature, we explore four countries in greater detail, focusing on their energy security scores and the strategic actions that have led to them. The four countries—Denmark, Japan, the United States, and Spain—represent two of the best and two of the worst countries in terms of their energy security trends over time (See Figure 3).

Figure 2: Energy Security Progress for Denmark, Japan, United States, and Spain, 1970 to 2007*





*Grey lines represent worsening trends.

3.1 Denmark

Denmark has exhibited considerable success in improving its energy security compared to the other countries analyzed. Since 1970, Denmark has transitioned from being 99 percent dependent on foreign energy sources such as oil and coal to becoming a net exporter of natural gas, oil and electricity today. Over the same period, Denmark has improved its reliance on non-petroleum transportation fuel, decreased its energy intensity by almost a factor of two, and lowered its aggregate carbon dioxide and sulfur dioxide emissions. The only areas where Denmark did not improve were in electricity use per capita, electricity prices, and gasoline prices, and these latter three were areas where almost no country improved.

Denmark is now the unchallenged world leader in terms of wind energy, exporting $8 billion in wind turbine technology and equipment per year, and Denmark also boasts the lowest energy consumption per capita in the European Union.[66] Primary energy consumption nationally grew just 4 percent from 1980 to 2004, even though the economy grew more than 64 percent in fixed prices. At the same time, more renewable energy replaced fossil fuels, and total CO_2 emissions decreased by 16 percent. Therefore, the carbon dioxide emission intensity—the amount of CO_2 emitted per unit of Gross Domestic Product—was 48 percent lower in 2004 than it was in 1980.

The most obvious factor responsible for such improvement is strong political leadership and well-designed, consistent policy mechanisms aimed at improving energy efficiency and promoting renewable energy. Denmark implemented energy taxes in 1974 as a response to the energy crises, and used the billions in dollars of revenue to invest in wind power, biomass, and small-scale combined heat and power units. The taxes furthermore sent price signals that encouraged voluntary energy efficiency measures. Denmark mandated energy efficiency standards for new buildings, and tightened them over a period of 30 years. Danish regulators also designed investment subsidies and feed-in tariffs forcing utilities to buy all power produced from renewable energy technologies at a rate equal to 70 to 85 percent the consumer retail price of electricity in a given distribution area, and they later regulated that all renewable power providers be given priority access to the grid.[67] The government levied a general carbon tax on all forms of energy and set strict vehicle fuel economy standards, and later adopted European standards pledging to decrease carbon dioxide emissions from automobiles to 140 grams of carbon dioxide emitted per kilometer driven by 2008, which help explain Denmark's lowered emissions of greenhouse gases.

While these efforts have improved many aspects of energy security, they have also made energy more expensive. Denmark's taxes do mean that electricity prices are the highest in the European Union at about 38 cents per kWh, and the price of petrol is more expensive than 13 other OECD countries. Denmark's experience does suggest that improving availability, efficiency, and stewardship can tradeoff with affordability, but overall the country appears to be the most energy secure in the OECD.

3.2 Japan

A similar pattern of strong government support for energy security exists in Japan, although with less focus on renewable energy and some other notable differences. Since 1970, Japan has lessened its dependence on oil and improved vehicle fuel economy slightly, but increased its dependence on natural gas and significantly increased its sulfur dioxide and carbon dioxide emissions despite its promises under the Kyoto Protocol. Electricity use per capita more than doubled and gasoline prices rose, but Japan was also one of only three countries where electricity prices decreased, and its energy intensity also improved.

Overall, Japan recorded unprecedented levels of economic growth between 1970 and 2007, closing the gap in per capita income, raising standards of living, and improving labor productivity compared to Western Europe and North America all while drastically improving energy efficiency.[68] 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. Population density in major cities such as Tokyo, however, made the mounting costs of air and water pollution visible, and environmental awareness was starting to rise at the same time the Arab oil embargo hit. By 1973, the time of the oil crisis, petroleum accounted for nearly 80 percent of total energy demand, and the crisis precipitated nothing less than panic.[69]

Energy security was given highest priority, and from 1973 to 1975 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. Japan's Ministry of International Trade and Industry (MITI) 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 3,500 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.

The 1980s saw Japan pass an Alternative Energy Law with provisions forcing suppliers to adopt natural gas and renewable power sources, along with the creation of tax incentives and low-interest loans for industrial energy efficiency measures, emphasizing the petrochemicals, refining, cement, and paper industries.[70] The 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. The appliance standards were very successful at reducing electricity consumption. Average electricity use for refrigerators, for example, declined by 15 percent from 1979 to 1997 while average refrigerator size increased by 90 percent. 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 percent.[71]

Japanese progress, however, has been more tempered than Denmark. Energy use per capita increased from 1973 to 2005 for both Japanese households and passenger travel. While the government promoted strict performance standards for appliances, they set only voluntary standards for buildings, and did not ramp up financial incentives until the late 1990s. Japan did require efficiency standards and efficiency labeling for automobiles, and these led to a 12 percent increase in fuel economy from 1979 to 1985 and another 8.5 percent increase from 1990 to 2000. Such improvement, however, was offset by a doubling of transport energy use between 1973 and 2001 due to the growth in vehicle ownership and increases in vehicle size. Private automobile travel rose in Japan from a modest 42.5 percent in 1970 to 55.9 percent in 1987.[72] Moreover, cheap oil prices in mid-1980s encouraged energy consumption. Energy demand growth as a whole averaged only 0.2 percent between 1973 and 1986, but jumped to 4 percent between 1987 and 1991.[73]

3.3 United States

The United States fared poorly compared to almost all other countries—with only Greece, Portugal, and Spain performing worse. The country has improved in only three of the indicators from 1970 to 2007—energy intensity, fuel economy, and sulfur dioxide emissions. In contrast, the country has become significantly more dependent on foreign supplies of natural gas and oil and remains the world's leading emitter of greenhouse gases.

While progress in the adoption of more energy-efficient technologies has saved billions of dollars throughout the economy, most other indicators of energy autonomy demonstrate that the country has become less less energy secure over time. Even though energy efficiency has taken root in some sectors of the economy, it has not compensated for the growth in energy consumption that has occurred since 1973, nor will it (if current trends continue) accommodate the growth that forecasters anticipate in coming decades. Moreover, America's dependence on oil from insecure and politically unstable countries has required extensive diplomatic and military efforts that incur huge costs borne by energy users and taxpayers. The country's information economy also remains inextricably tied to reliable power and to just-in-time manufacturing and distribution processes that depend on fleets of petroleum-guzzling trucks and airplanes.[74]

The United States remains more susceptible today to oil supply disruptions and price spikes than at any time in the recent past. It has grown to become the world's largest oil consumer by a considerable margin while, at the same time, its domestic oil production has plummeted. Oil imports have filled the expanding gap, accounting for 59 percent of total U.S. oil consumption in 2007—up from 22 percent in 1970. The United States has so many automobiles that the number of cars exceeds the number of people with drivers' licenses.[75]

The United States also continues to see increasing demand for electricity in a way that threatens its ability to meet customer load requirements. The country consumed about 170 percent more electricity in 2007 than it did in 1970, with power usage growing from 25 percent of the nation's total energy use in 1970 to 40 percent today. Efforts resulting from three decades of clean air legislation have decreased sulfur dioxide emissions from electric generators in the United States. Nevertheless, air pollution remains a serious threat to human and ecosystem health. Americans have experienced a rise in respiratory illnesses, and visibility continues to degrade in formerly pristine areas as a result of pollution from vehicles and coal-burning power plants. Beyond air pollution issues, current energy trends will lead to expanded emissions of greenhouse gases, which appear to be contributing to increased global temperatures, recession of glaciers, and more frequent and powerful weather events such as hurricanes.

Because of its huge dependence on imported oil to fuel a transportation sector that has seen little improvement in energy efficiency, the nation could be ravaged by disruptions to oil supplies due to weather, war, or terrorist attacks. At the same time, growing electricity consumption and reliance on power plants employing natural gas (which increasingly comes from foreign sources) make the electric utility infrastructure more vulnerable to service disruptions. And while efficiency efforts have successfully stemmed the growth rate of fuel consumption in the last few decades, population increases and economic expansion have forced up the nation's overall use of energy, exacerbating the country's environmental problems.

3.4 Spain

Tied for last in our energy security index, Spain has shown improvement in only two indicators: a meager reduction in dependence on foreign sources of oil from 99 percent to 98 percent, and a modest improvement in on-road fuel economy from 27 to 31 miles per gallon. Spain has worsened in every other metric, including energy intensity. Total primary energy use per unit of GDP has fallen for 19 other OECD countries (two other exceptions being Greece and Portugal), and overall major OECD economies used a third less primary energy to generate a unit of GDP in 2006 than in the 1970s.[76]

Spain has defied this trend. The country lacks sufficient supplies of domestic coal, oil, gas, and uranium, has experienced ongoing industrialization, but made little improvement in energy efficiency. Thus, the Spanish energy sector is currently suffering from difficulty in controlling greenhouse gas emissions, high prices, increasing reliance on imported fuels, high levels of growth in energy demand, and stagnating energy efficiency and energy intensity, culminating in a situation even Spanish analysts consider unsustainable.[77] Spain's gradual transition to democracy left intact the prevailing economic structures that had existed during the Franco regime. Unlike the comparatively progressive governments implementing energy reforms in other OECD countries during the 1970s, bankers and industrial managers continued to play the primary role in Spanish energy policymaking. Rather than promote energy efficiency or diversification, these stakeholders sought ways to ensure a smooth political transition, maintain economic growth, and retain their political power. From 1975 to 1982, alternative sources of policy such as left-wing parties, environmental groups, trade unions, and consumer advocates were able to exert little influence over Spanish energy policy. The country thus remained committed to developing conventional forms of supply and strengthening agreements to import energy fuels, but neglected energy efficiency and alternative energy.[78] When the Spanish Socialist Workers Party came to power in 1982, energy policy did not break significantly with past patterns.

Whereas energy intensity declined in almost every other OECD country, the late 1980s and most of the 1990s saw sustained growth in energy consumption per unit of GDP in Spain, which increased at an annual rate of 0.75 percent from 1990 to 1997. Per capita electricity consumption and carbon dioxide emissions also increased at rates between 2.3 and 2.8 percent annually over the same period.[79] Spanish regulators heavily focused on building nuclear plants in the early 1980s, but their plans were threatened by high costs and the Chernobyl disaster in 1986. Despite a few early policy documents and royal decrees, the country did not seriously consider energy efficiency and conservation until the early 1990s.[80] At this time, however, a significant number of mergers and acquisitions occurred in the energy sector, creating massive levels of concentration. The newly integrated energy companies, rather than focusing on the domestic Spanish market, initiated plans for international expansion, attempting to privatize and invest in emerging markets in Latin America.[81] Spanish companies established production, refining, and manufacturing centers in Argentina, Brazil, Columbia, and Mexico. The Spanish oil company REPSOL-YPF, the seventh largest in the world, expanded exploration and production to four Latin American countries. Endesa and Iberdrola, some of the world's largest electricity companies, became leading power suppliers for seven countries in South America and Central America. The Spanish company Gas Natural Group also became the largest single investor in Latin American gas markets.

The consolidation and concentration of Spanish energy companies, coupled with comparatively weak political oversight, lack of competition, and a focus on global markets left little space for consumer advocacy or environmental policy.[82] Throughout the late 1990s, Spanish customers had some of the highest electricity prices in all of Europe, and most consumers generally believed that such high prices reflected a pro-industry bias that allowed large cash flows to be funneled into the international expansion of Spanish firms. The consequence has been a deterioration of energy security in almost every metric. Spanish energy intensity increased from 1990 to 2000 by 5 percent while European intensity decreased by 10.4 percent.[83] The Spanish economy continues to be highly dependent on high-carbon fossil fuels such as oil and coal, which accounted for roughly 60 percent of energy use in 2007, and the situation is further compounded by the mismatch between state, territorial, and national energy policy, which has been very sporadic and irregular, with some regions aggressively pursuing renewables such as wind and solar while other regions have little penetration of renewable power supplies.

4. Conclusions

Contemporary notions of energy security are indeed diffuse. Our analysis of more than 90 academic articles on the topic revealed many dimensions, from the security of supply and the affordability of energy services to the efficiency of economic output and the well being of humans and the natural environment. While its multidimensional nature does create challenges for measurement and evaluation, energy security is too important a concept to be incoherently defined and poorly measured. In response, we have created an Energy Security Index, utilizing ten metrics that encompass economic, social, political, and environmental aspects of energy security, and analyzed the status of energy conditions in 22 OECD countries from 1970 to 2007. At least four interconnected conclusions can be drawn from our exercise.

First, our Energy Security Index shows that a majority of countries analyzed have regressed in terms of their energy security. This conclusion is discouraging, especially considering that the oil shocks of 1973 and 1974 culminated in the establishment of the International Energy Agency, the creation of strategic petroleum reserves among its members, and the diversification of the fuel base for electricity as most countries moved away from their use of oil to produce electricity. In the United States, the crisis forced sweeping energy legislation through Congress, resulted in the establishment of the Department of Energy, and even provoked President Jimmy Carter to cite the energy challenge as “the moral equivalent of war.” Since those times, the international community has seen advances in low-income energy services, efficiency and demand reduction programs, renewable resources initiatives, and market restructuring of the various energy industries. Many individual states in Europe and the United States have implemented aggressive renewable portfolio standards, feed-in tariffs, and systems benefits funds, started emissions trading schemes, and invested heavily in alternative fuels such as hydrogen, ethanol and biodiesel. Despite all of this effort, our Index reveals that most countries have backslid in their efforts to improve energy security.

Second, despite the near universal deterioration of energy security, a great disparity exists between countries. Some clear leaders, such as Denmark and Japan, stand above the rest, and offer many lessons. Neither country left improving energy security to the marketplace, and their experience underscores the importance of government intervention through a progression of energy policy mechanisms. First came energy taxes, standards, and R&D, followed by mechanisms such as tariffs and quotas, demonstrating the necessity of using a variety of mechanisms at once to promote sound energy policy. The Danish strategy has promoted “triple diversification:” reliance on not just one type of technology, renewables, but also energy efficiency as well as combined heat and power and district heating to meet energy needs; not just one type of policy mechanism but a combination of taxes, subsidies, tariffs, and standards; and not just one type of renewable energy but a combination of biomass, wind, and biogas digestion. Diversification in all three forms—combining supply- and demand-side measures, utilizing a variety of policy mechanisms, and promoting a broad assortment of different types of renewable technologies—is essential. No one approach, no one technology, and no one policy is sufficient alone. Perhaps equally important, the overarching explanation for the success of Danish and Japanese energy policy lies in coordinated and consistent political support and policy. Unlike the United States and Spain, where lack of synchronization between state and federal policy, constant changes in authorization and appropriations, a focus on other priorities, and expiration of programs has impeded energy policy, Japan and Denmark stand as testaments to the importance of consistency.

Third, notwithstanding the progress made by Japan and Denmark (as well as Belgium and the United Kingdom), no nation scored perfectly. This is because efforts to promote energy security, even for the most successful nations, have tended to focus on energy efficiency or increased supply to meet consumer behavior. Strategies have involved increasing the energy efficiency of buildings, appliances, industrial operations, and vehicles, but not on changing consumer patterns, encouraging them to drive less, buy fewer vehicles, or own fewer appliances. Virtually none of the countries examined tax urban sprawl, heavily promote mass transit and limited personal vehicle ownership, attempted to change consumer awareness, provided feedback on energy consumption in the form of real time prices, or changed underlying values by encouraging people to value nature, community involvement, and conservation.[84] Thus, no country has successfully promoted true availability and affordability alongside efficiency and stewardship. Tradeoffs have often been involved between them, and most countries have seemingly pursued one or two of the criteria at the expense of the others.

Fourth and finally, the relative success of Denmark and Japan and the relative failure of the United States and Spain 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 draft new contracts with Nigeria and Russia for oil and gas supply. It is not sufficient to build trade alliances and share intellectual property, send more troops to Iraq or Saudi Arabia, or bolster naval deployments throughout the world's shipping lanes. Equally effective and important can be coordinated and robust domestic energy policy aimed at changing consumer behavior, promoting energy efficiency, and lowering greenhouse gas emissions. Tools such as R&D

expenditures, subsidies, tariffs, and standards can be just as important, possibly more, for achieving available, affordable, efficient, and responsible forms of energy supply and use.

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[1] Michael T. Klare, "The Futile Pursuit of Energy Security by Military Force," *Brown Journal of World Affairs* 13(2) (Spring/Summer 2007), p. 139.

[2] Ronald C. Mo, "Government Corporations and the Erosion of Accountability: The Case of the Proposed Energy Security Corporation," *Public Administration Review*, 39(6) (1979), pp. 566-571.

[3] The Carter Doctrine has significantly expanded since the 1970s. When Iranian forces began to attack Kuwaiti oil tankers traveling through the Persian Gulf in an attempt discourage Kuwait from supplying loans to Iraq for arms procurement at the height of the Iran-Iraq war of 1980 to 1988, President Reagan authorized the reflagging of Kuwaiti tankers with US ensign to afford them naval protection. The Clinton Administration and both Bush Administrations have also funneled billions of dollars into protecting the Persian Gulf and other oil-based assets. U.S. Southern Command now promotes security cooperation activities to expand U.S. influence and dissuade potential adversaries in oil-producing regions of South America, especially Columbia, including training, equipping, and developing security forces to protect refineries and offshore oil and gas platforms. In Central Asia, the U.S. operates military and training programs to train and equip Georgian and Uzbek security forces to maintain the "free flow of oil" essential to the American and world economy. In Western Africa, military aid and training has flowed to Nigeria to help bolster the "security" of their oil infrastructure. See Pierre Noel, "The New US Middle East Policy and Energy Security Challenges," *International Journal* 62 (2006-2007), pp. 43-54; Michael T. Klare, "The Futile Pursuit of Energy Security by Military Force," *Brown Journal of World Affairs* 13(2) (Spring/Summer 2007), p. 144; Doug Stokes, "Blood for Oil? Global Capital, Counter-Insurgency and the Dual Logic of American Energy Security," *Review of International Studies* 33 (2007), pp. 245-264; Jan H. Kalicki, "Prescription for Oil Addition: The Middle East and Energy Security," *Middle East Policy* 14(1) (2007), pp. 76-83.

[4] Mark A. Delucchi and James J. Murphy, ''US Military Expenditures to Protect the Use of Persian Gulf Oil for Motor Vehicles,'' *Energy Policy* 36 (2008): 2253–2264. To those that may express dismay at such a number, researchers at the Oak Ridge National Laboratory estimated that from 1970 to 2004 American dependence on foreign supplies of oil has cost the country $5.6 to $14.6 trillion. See David Greene and Sanjana Ahmad, Costs of U.S. Oil Dependence: 2005 Update (January 2005), Report to the U.S. DOE, ORNL/TM-2005/45. Numbers have been adjusted to $2007.

[5] Regional assessments of energy security for the European Union abound. For a thorough summary of the European Commission's energy security strategy, which seems centered on encouraging solidarity among member states, diversifying the fuel mix, supporting an integrated approach to tackling climate change, and counterbalancing a resurgent Russia, see Gawdat Bahgat, "Europe's Energy Security: Challenges and Opportunities," *International Affairs* 82(5) (2006), pp. 961-975; and Sanam S. Haghighi, "Energy Security and the Division of Competences between the European Community and its Member States," *European Law Journal* 14(4) (July, 2008), pp. 461-482. Aurelia Mane-Estrada proposes that the EU promote cooperation with Turkey and Russia to create a pan-European "geo-energy space" to enhance mutual security and interconnectedness in "European Energy Security: Towards the Creation of the Geo-Energy Space," *Energy Policy* 34 (2006), pp. 3773-3786. On how the European Union should handle a resurgent Russia, see Zeyno Baran, "EU Energy Security: Time to End Russian Leverage, *Washington Quarterly* 30(4) (2007), pp. 131–144. On how tension exists within and between EU Member States concerning energy security, see Onno Kuik, "Climate Change Policies, Energy Security, and Carbon Dependency: Trade-offs for the European Union in the Longer Term," *Politics, Law, & Economics* 3 (2003), pp. 221-242.

[6] Much work has already been done on regional energy security in Asia. For an exploration of the strategy being pursued by the Association of Southeast Asian Nations (ASEAN), which seems centered on harmonized action mediated by their principle of non-interference and inter-linkage through cooperation, see Andrew Symon, "Southeast Asia's Nuclear Power Thrust: Putting ASEAN's Effectiveness to the Test." *Contemporary Southeast Asia* 30(1) (2008), pp. 118-139; Elspeth Thomson, "ASEAN and Northeast Asian Energy Security: Cooperation or Competition?" *East Asia* 23(3) (2006), pp. 67-90. For the region as a whole (and in addition to the specific national styles mentioned above), see Dave Ernsberger, "The Future of East Asian Energy Security: An Introduction," *East Asia* 23(3) (2006), pp. 46-48;
Girijesh Pant, "Energy Security in Asia: The Necessity of Interdependence," *Strategic Analysis* 31(3) (2007), pp. 523-542; and Janet Xuanli Liao, "Sino-Japanese Energy Security and Regional Stability: The Case of East China Sea Gas Exploration," *East Asia* 25 (2008), pp. 57–78.

[7] For an introduction to the energy security challenges facing the Caspian Sea, see Robert A. Manning, *The Asian Energy Factor: Myths and Dilemmas of Energy, Security, and the Pacific Future* (espousing the merits of

regional cooperation in the Caspian Basin) and Adam N. Stulberg, " Fuelling Transatlantic Entente in the Caspian Basin: energy security and
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[27] In 1654, England turned to the colonies in America to harvest the great forests of White Pine as a way to reduce reliance on timber imports, especially after the Dutch cut off English access to the Baltic forests that very year. The old English sign of naval property, the Broad Arrow, appeared on trees more than 24 inches in diameter and by 1691, tensions over timber supply escalated as American demand increased. By the turn of the century, disputes over timber were already arising and timber was a major factor leading to the outbreak of the Independence Movement that later spurred the Revolutionary War.

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