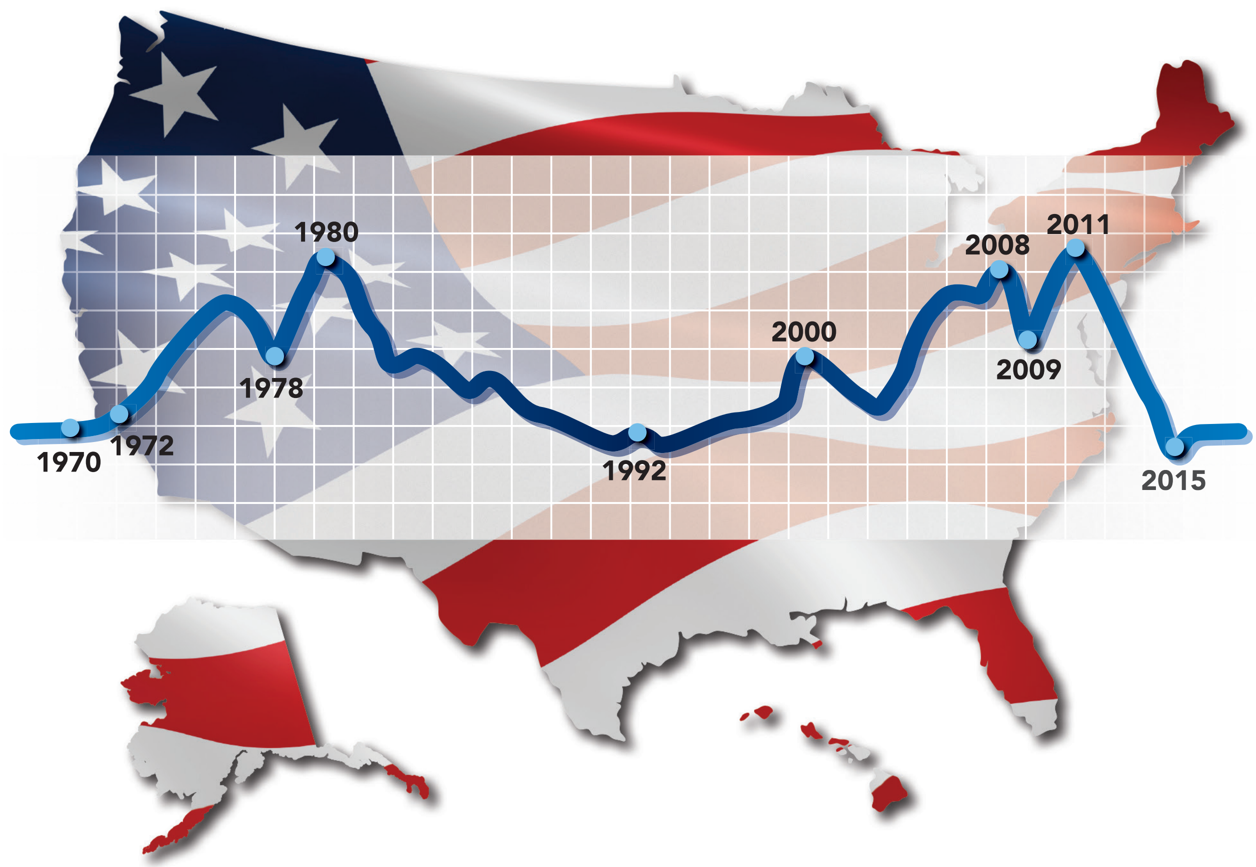
INDEX OF U.S. ENERGY SECURITY RISK®

2015 EDITION

ASSESSING AMERICA'S VULNERABILITIES IN A GLOBAL ENERGY MARKET



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OUR MISSION

The mission of the U.S. Chamber of Commerce's Institute for 21st Century Energy is to unify policymakers, regulators, business leaders, and the American public behind a common sense energy strategy to help keep America secure, prosperous, and clean. Through policy development, education, and advocacy, the Institute is building support for meaningful action at the local, state, national, and international levels.

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Contents

Foreword

There is a lot of good news in this 2015 edition of the Institute for 21st Century Energy's Index of U.S. Energy Security Risk (U.S. Index), not least of which is a decline in overall risk for the third year in a row. We noted in last year's edition how, after rising steadily since the mid-1990s, the country's overall energy security risk appeared to be embarking on a durable downward trend. While the data in this year's edition continues to support that conclusion, it is also clear that the geopolitical response to America's new-found influence in global energy markets, especially from Saudi Arabia, will create challenges over the next few years. More on that later.

One special feature of this year's report is a look at how, using Energy Information Administration (EIA) data, our forecasts of energy security risk have changed over time. It is fair to say that over the last three years, our expectations of future risk have improved substantially, as you will read about in the report.

Greater domestic energy production and improved energy efficiency have created the real possibility that U.S. energy self-sufficiency is within reach.

The shale revolution has been unquestionably the single biggest factor in the more favorable view of future risk. It is now expected that by 2017, the United States will become a net exporter of natural gas instead of perennial net importer.

The change in the outlook for oil production has been no less profound. Since 2008, when crude oil production reached its lowest level since the 1950s, crude oil production has surged an incredible 74%, or 3.7 million barrels per day, through 2014. Over this period, output in Texas jumped 185% to 2.1 million barrels per day while output in North Dakota rose a staggering 530% to 915,000 barrels per day. If these states were countries, in 2014 they would have ranked as the 8th and 19th largest crude oil producers in the world. All of this means lower volumes of imported crude oil. The U.S. also became a net exporter of refined petroleum products in 2011, a trend that is expected to grow in the coming years.

Also, despite a concerted effort by the federal government to regulate coal out of existence, the U.S. is still the world's second largest producer. It is one of the main reasons U.S. electricity prices are among the lowest in the developed world, which along with inexpensive natural gas and nuclear energy, affords us a huge competitive advantage. Throwing this advantage away would be incredibly short-sighted.

These supply-side trends overlay some longer-term trends in improved energy efficiency. This is especially evident in the transportation sector, where a combination of better automobile gasoline mileage and declining miles traveled for each dollar of GDP—the subject of another special feature in this year's report—has flattened the once rising trend in gasoline consumption.

The combination of these and other factors have created the real possibility that U.S. energy self-sufficiency, something unimaginable as little as eight years ago, is within reach.

The term "energy self-sufficiency" is purposely chosen rather than the commonly-used term "energy independence." Many invoke the term energy independence, which is an imprecise term used usually in the context of the security of petroleum supplies, a strategic concern that goes back 40 plus years. Moreover, the phrase conjures up an America that produces all of the energy it uses, with no need for imports. As attractive as the prospect of complete independence from foreign sources of energy might sound, there is no realistic way for the U.S. to achieve this goal. In fact, in today's globalized economy, complete energy independence may not even be desirable, particularly where it forces reliance on high-cost fuels and strategies that could be better provided by a reliable and diversified global market. Energy autarky is not a sound energy security strategy, and for these reasons this Index focuses instead on the reliability and diversity of supplies.

Nevertheless, the goal of energy independence is still one that has tremendous resonance both with the public and policymakers. So putting these caveats to the side, is it possible that America is nearing the day when it produces more energy that it consumes? Yes.

The rate at which net imports have been needed to meet demand has plummeted since about 2009, and EIA is forecasting that this will continue well into the 2020s.The stunning chart nearby shows that if the future unfolds as EIA expects (blue dashed line), by the mid-2020s the share of total U.S. energy consumption satisfied by net imports will hover near 1% and slip into negative territory by 2029, making the United States a net energy exporter for the first time since the 1950s. At that point, the United States will be a net exporter of every type of fuel except crude oil, but this will be imported in much smaller volumes than today.

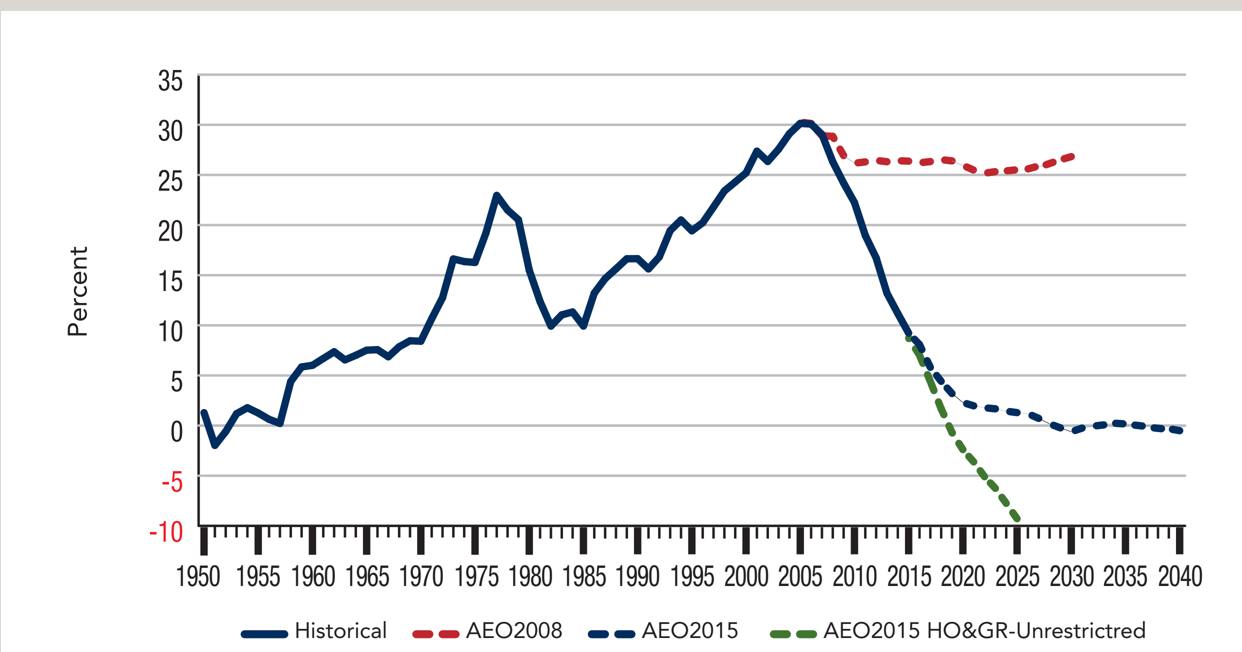
This is much different than the EIA forecast in 2008, when the Shale Gale was just a breeze. As the red dashed line shows, back then EIA was predicting that net imports would account for between 25% and 30% of total energy demand for as far as the eye could see.

Just as interesting is the green dashed line showing what would happen if oil and gas resources are larger than EIA currently expects, production per well improves, and the ban on crude oil exports is lifted. Under this scenario, which is entirely within the realm of possibility, the United States would gain energy self-sufficiency four years from now, in 2019.

Forecasting is an admittedly hard thing to do, and forecasters can be forgiven for not recognizing earlier how revolutionary the combination of hydraulic fracturing, horizontal drilling, and advance seismic imaging would be. As difficult as it is to anticipate technology innovation, predicting the response to other actors in global energy markets to these developments also is a tricky business.

The decision by Saudi Arabia to sustain a high production level despite depressed global crude oil prices to capture greater market share has resulted

Net Energy Imports as Share of Total U.S. Energy Demand: 1950-2040



in tremendous price volatility during 2014 and 2015. Oil prices dropped sharply from more than $100 per barrel to below $50 per barrel (something that will be captured more fully in next year's U.S. Index). This strategy was aimed in large part at taking out high-cost production, including U.S. production. Under a prolonged, period of low oil prices, it was believed, U.S. oil and natural gas production would be constrained, increasing the need for imported oil.

While Saudi Arabia's decision caught many by surprise, it probably should not have, as we have been through something similar before. The dizzying changes in global oil markets we are experiencing today harken back to the 1980s, a decade when the U.S. risk Index score dropped steadily from its 1980 high.

There was a lot going on back then that contributed to the decline in risk—the shutting down of oil-fired power stations and the construction of coal and nuclear stations, greater energy efficiency, price deregulation, etc.—but two things stand out. The first was the construction of the Trans-Alaska Pipeline System, which carried crude oil from Prudhoe to Valdez on the southern coast of Alaska. Alaskan oil production, which by 1985 was nearly 1.8 million barrels per day, was responsible for reversing five years of declining U.S. crude oil production. The second was North Sea oil coming online. By the mid-1980s, production from Norway and the United Kingdom reached about 3.6 million barrels per day (on its way to more than 6.0 million barrels per day in 1999). All of this occurred in a global oil market that was at least one-third smaller than today's market.

These two factors had a big impact on oil markets and put tremendous downward pressure on prices, and that in turn weakened the resolve of many "price taking" Organization of Petroleum Exporting Countries (OPEC) to limit production to defend a target global price for crude oil. Maintaining market share at any price became the priority for many cash-strapped OPEC members.

It is unfortunate that increases in energy production have come in spite of U.S. energy policy, not because of it.

Fed up with the lack of discipline within OPEC, Saudi Arabia decided that it, too, would seek to boost market share, and it opened the spigots, raising output 1.6 million barrels per day in 1986 to 5.2 million barrels per day. The result was a nearly 50% drop in the price of crude oil in a single year. Sound familiar?

But the U.S. oil market is in an entirely different place than it was back in the 1980s, and the current bear market is not likely to run U.S. oil producers off the field over the longer term. Indeed, the ability of U.S. producers to innovate and lower the price point at which production from shale formation remains profitable has been nothing short of spectacular, and it is why more than a year after prices began their plunge, U.S. oil production is, as of this writing, still above 9 million barrels per day.

Nimble producers are using new techniques to increase production per rig and lower drilling and fracking costs. Producers also are returning to vertical wells that don't require a lot of cash to tap again and can be drilled quickly—some can be revisited for as little as $1 million per well. Drilling service companies are providing discounts. Wells also are being drilled, fracked, and capped until prices rise, which means that even as U.S. output slows, once prices recover, U.S. producers will be back in the game quickly. So while there are signs that U.S. production will slow, the decline will not be anywhere near what analysts expected.

The resilience of the U.S. oil and natural gas sector must have come as something of a shock to Saudi Arabia and OPEC. This experience shows that it is never a good idea to bet against the ingenuity of U.S. industry.

So what can be done to make sure the U.S. energy revolution continues? A lighter regulatory touch would certainly be welcome. It is unfortunate that increases in energy production have come in spite of U.S. energy policy, not because of it.

Heavy-handed regulation of hydraulic fracturing, which has been done safely for decades, threatens to raise costs unnecessarily at a time when producers already are facing daunting market conditions.

Lifting the ban on crude oil exports that has been in place since 1975 also would encourage greater oil production. Groups as varied as IHS, the Brookings Institution, and EIA have all concluded that free trade in crude oil could boost U.S. production, generate billions of dollars of investment, create jobs, and reduce the nation's oil import bill by tens of billions of dollars per year. More importantly for consumers, these analyses also conclude that removing exports restriction would lower U.S. gasoline prices. It is well past time we allowed free trade in U.S. crude oil.

The Environmental Protection Agency's (EPA) new climate change regulations governing carbon dioxide emissions from new and existing power plants also threaten to disrupt electricity markets by shutting down prematurely coal-fired base load power plants, raising electricity costs to consumers and industry, jeopardizing grid reliability, and reducing jobs and economic growth—and all for no discernible climate benefit.

Setting aside its very real legal vulnerabilities, EPA's plan will be ineffective largely because any emissions reductions achieved will be more than offset by increases in emissions from other countries, in particular developing countries. Despite rhetoric, addressing climate change is of considerably less importance to these countries, where the main priority is poverty eradication.

It is well understood that America's abundance of affordable, reliable energy provides businesses a critical operating advantage in today's intensely competitive global economy. Affordable and reliable fuel and electricity, supplied by a diverse mix of coal, nuclear, and increasingly natural gas, give American industry an enormous economic edge.

Unfortunately, EPA's Clean Power Plan and other burdensome EPA regulations threaten to throw away this national energy advantage. Instead of attracting foreign investment to the United States, EPA rules could repel this investment away from the United States. Because U.S. businesses compete on a global scale, the electricity and related price increases resulting from EPA's rule will severely disadvantage energy intensive, trade-exposed industries such as chemicals, manufacturing, steel, and pulp and paper. As a result, GHG emissions would not be reduced in the global sense, but simply moved to other countries that have not implemented similar restrictions.

An energy policy that is behind the times and environmental policies that endanger our manufacturing and industrial revival pose significant challenges moving forward. The energy prospects before America are unprecedented in their scale and scope. Given the freedom to innovate and produce in a sensible regulatory environment, U.S. industry can continue to lead the way to a more energy self-reliant and competitive America.

K Harbert

Karen A. Harbert
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U.S. Chamber of Commerce

Acknowledgements

Developing and maintaining something as complex as the U.S. Index remains very challenging task that could not happen without the remarkable efforts of many people. In particular, our thanks go to Daniel E. Klein, President of Twenty-First Strategies of Santa Fe, New Mexico for designing and compiling much of the data used, and Christopher Russell. Special thanks also go to Rice University intern Michael Robinson for reviewing the data and pulling together and analyzing the various forecast side cases examined in this report. The entire production team here at the U.S. Chamber of Commerce, led by Brian Miller did their usual fine job designing clean graphics that make sense of complex issues and producing a publication under a tight deadline.

Introduction

This 2015 edition of the Institute for 21st Century Energy's (Energy Institute) Index of U.S. Energy Security Risk (Index), the sixth in the annual series, provides an updated look at U.S. energy security incorporating the most recent historical data and reflecting the latest and updated forecasts. The Index employs 37 different measures of energy security risk that include: global fuels; fuel imports; energy expenditures; price and market volatility; energy use intensity; electric power sector; transportation sector; environmental; and basic science and energy research & development.[1] The Index covers the period from 1970 to 2040.

The Energy Institute's Index includes four Sub-Indexes that identify the major areas of risk to U.S. energy security: geopolitical, economic, reliability, and environmental. Each of the 37 metrics is mapped to one or more of these four sub-indexes. These four sub-indexes are then combined into an overall Index, where the weighted average of the four sub-indexes constitutes the overall Index of U.S. Energy Security Risk.[2]

This year's edition reflects revisions to the historical data and the new forecast in the Energy Information Administration's (EIA) Annual Energy Outlook (AEO) 2015.

The Index is designed to convey the notion of risk: a lower Index score indicates a lower risk to energy security and a higher score indicates a higher risk. When evaluating the results, it is important to recognize that the Index necessarily moves along an open-ended scale. To provide a relative sense of potential hazard, the Index score for 1980, a particularly bad year for U.S. (and global) energy security risks, was set at 100. Index scores approaching or surpassing 100, therefore, suggest a very high degree of risk.

The average Index score for the 30-year period 1970 to 1999, a period that includes times with relatively very high (100 in 1980) and very low (75.3 in 1994) scores, is 83.9. When reviewing this year's results, the 1980 baseline score and the 30-year averages, along with the historical high and low scores also provided can be used as reference points against which to assess current and future risk scores. Unless noted otherwise, all dollar figures are in real 2010 dollars.

The Index discussed in this report is focused exclusively on the United States and how its energy security risks have moved over time and where they might be headed in the future. The Energy Institute also has developed an International Index of Energy Security Risk that puts the risks to the U.S. in an international context and provides comparisons with other large energy producing countries. Readers interested in how U.S. risks compare to those faced by other countries should consult the International Index, which is available on the Energy Institute's website.

1 Each of the 37 metrics is presented and discussed in Appendix 2.

2 Appendix 1 contains more information on the methods used to develop the Index.

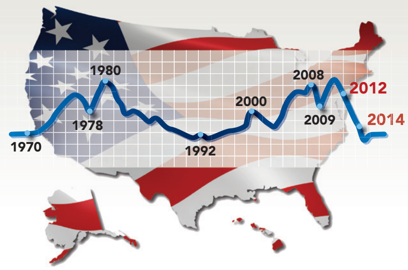
Highlights

The total U.S. energy security risk in 2014 fell for the third consecutive year, dropping 5.3 points to 82. The long-term outlook suggests declining risks through the mid-2020s and gradually rising risk thereafter. Nevertheless, this outlook is considerably better than in previous years, which had total U.S. risk rising to a score of nearly 100.

This 2015 edition of the Index of U.S. Energy Security Risk (U.S. Index) includes the most recent energy data available, including *AEO 2015* projections, to provide an up-to-date assessment of those energy supply and energy use metrics having the greatest impact on energy security over the past year. The U.S. Index is based on a combination of 37 different energy security metrics beginning in 1970 and ending in 2040.

Total energy security risk in 2014 fell for the third year in a row, dropping 5.3 points (6%) from 2012 to

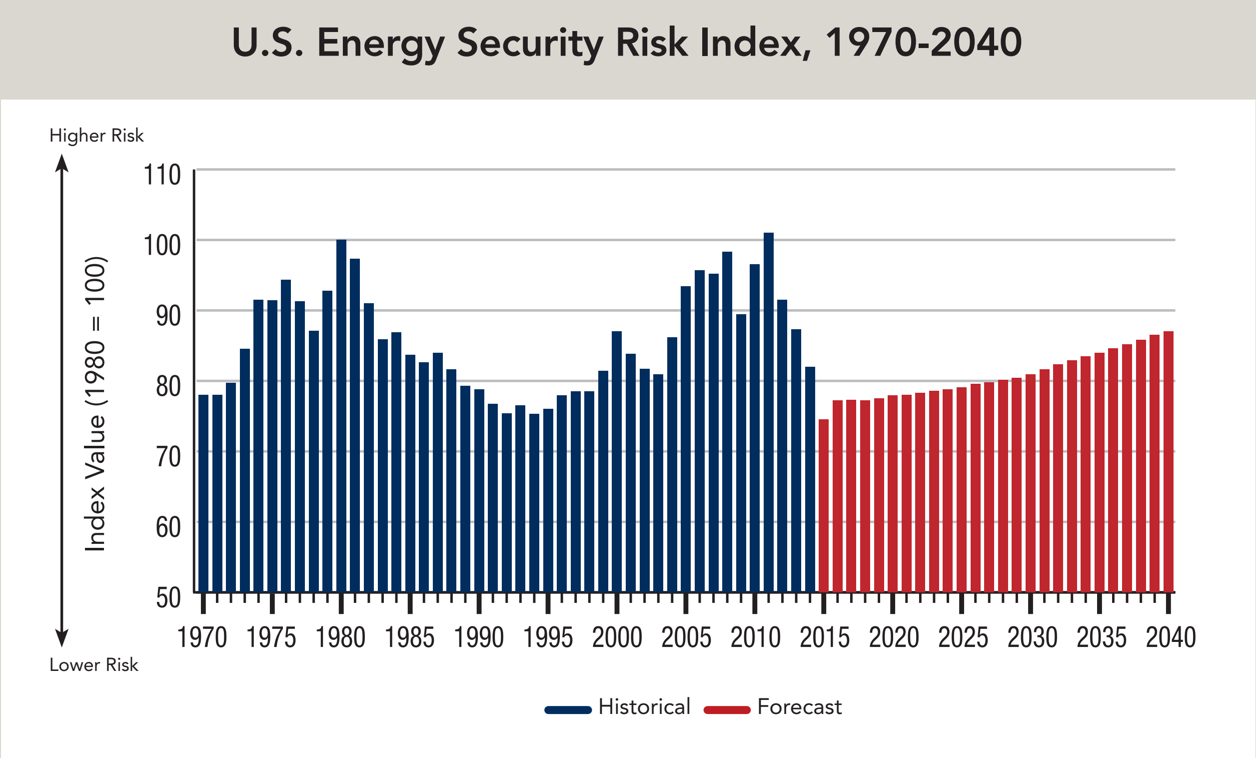
82.0.



Overview

Total energy security risk in 2014 fell for the third year in a row, dropping 5.3 points (6%) from 2013 score to 82.0. This decline follows a 4.2 point drop in risk in 2013 and a 9.5 point drop in 2012.

Figure 1



Over the past three years, the total U.S risk has dropped 19 points of its 2011 high of 101.0 (Figure 1).

The 2014 score dipped below the 30-year (1970-1999) average, the first time it has done so since 2003 (Table 1). Like in 2013, greater domestic unconventional oil and natural gas production on private and state lands was the biggest single factor contributing to the improved U.S. energy security picture in 2014.

This year's declining risk is part of what is emerging as a potentially robust and durable trend similar to that observed in the late 1980s to the mid-1990s—but for different reasons. During that earlier period, there was a broad-based reaction to the Arab Oil Embargo and the Iranian Revolution. The construction of the Trans-Alaska Pipeline System opened up production on Alaska's North Slope, which gave a needed boost to domestic crude oil output. The switch to coal and nuclear power in the electricity sector increased the diversity of the U.S. electricity and lowered electricity prices. High oil prices in the 1970s and early 1980s drove tremendous investment in energy efficiency that began to pay off. Lastly, the diversity and reliability of global fuel supplies both improved greatly. Today, the main drivers of the improvement in the energy picture are related in one way or another to greater unconventional oil and natural gas output, such as risks related to oil and natural gas imports and import expenditures.

Of the 37 Index metrics, 18 showed a decrease in risk of 1% or more, 9 showed an increase in risk of 1% or more, and 10 showed essentially no change in risk in 2014. Four of the 10 metrics showing an increase in risk were in the Global Fuel Metrics category. In general, these increases were related to: (1) rising reliability risks (using Freedom House political and civil liberties index as a proxy) in some large

Of the 37 Index metrics,

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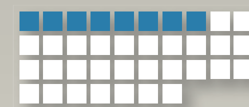

showed an increase in risk of 1% or more,

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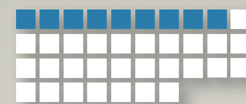

showed a decrease in risk of 1% or more, and

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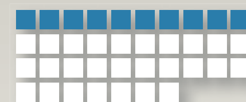


showed essentially no change in risk in 2014.

Table 1. U.S. Energy Security Risks from 1970 to 2014: Highest, Lowest and 30-Year (1970-1999) Average Index Scores

Indexes of U.S. Energy Security Risk	2014 Score	1980 Baseline Score	Highest Risk		Lowest Risk		30-Year Average (1970-1999)
			Year	Index Score	Year	Index Score	
Total Composite Index	82.0	100.0	2011	101.0	1994	75.3	83.9
Sub-Indexes:							
Geopolitical	81.9	100.0	2011	100.7	1998	72.5	82.9
Economic	79.9	100.0	2011	101.7	1998	61.2	73.2
Reliability	82.1	100.0	2011	114.5	1994	75.7	86.0
Environmental	85.0	100.0	1973	110.7	2012	83.3	99.2

producing countries; and (2) increasing output from countries with high reliability risks (e.g., China, Libya, Iraq, and Russia).

Although decreasing risks were seen across nearly half of the energy security measures, most of the risk decrease in 2014 can be attributed to a half dozen oil and natural gas related measures that changed by very large amounts (±10% or more). These included risk measures associated with imports of oil and natural gas, import expenditures, and energy price volatility, factors that were the biggest drivers of the 5.3-point drop in overall energy security risks in 2014 (Table 2). No metric showed an increase in risk of greater than 10% (the largest being Energy Expenditure Volatility at 5.3%).

As in 2012 and 1213, the unconventional oil and natural gas boom in the United States increased supply security, reduced net imports, and put downward pressure on energy costs and expenditures, all of which to contributed to lower energy security risk. The growing impacts of increasing unconventional oil and natural gas production have been noted in previous years of the U.S. Index.

Crude oil production rose an astonishing 1.3 million in 2014, a 17% increase—the highest single annual increase of any year since before the Second World War. This is part of a longer-term trend in growing domestic production that took off after 2008, when domestic crude oil output reached its lowest level since the 1950s. By 2014, crude oil production surged an incredible 74%, or 3.7 million bbl/d. Over this period, Texas saw its production grow by 2.1 million bbl/d (up 186%) while North Dakota saw its production grow by 915,000 bbl/d (up 532%). If these states were countries, in 2014 they would have ranked as the 8th and 19th largest crude oil producers in the world. The only major exception to this upward trend in oil output is Alaska, which saw its production dip by 185,000 bbl/day since 2008 (down 27%).

Natural gas output rose for the eighth consecutive year in 2014 and achieved a record high of 25.7 trillion cubic feet (tcf). Since 2008, natural gas production has climbed 28%. Today, slightly more than 40% of U.S. gas production in 2014 was from shale formations. Pennsylvania's Marcellus Shale, in particular, has made an extraordinary difference. In 2008, Pennsylvania produced about 1% of the total U.S. natural gas supply in contrast to 2014, when its roughly 3.3 tcf of production accounted for 11% of domestic production, putting it second only to Texas.

Rapidly rising domestic production of crude oil and natural gas on private and state lands reduced import exposure risks for these fuels. Because of increased production of crude oil, only about 45% the crude oil input to U.S. refineries in 2014 was imported, well below the record high level of 65% set in 2005. Moreover, since 2011, the U.S. has been a net exporter of refined petroleum products. For natural gas, imports

Table 2. Movers and Shakers: Energy Security Metrics Changing ±10% or More in 2014

Declining Risk		Rising Risk	
Metric	% Change	Metric	% Change
Crude Oil Price Volatility	-46%	None	
Oil & Natural Gas Import Expenditures per GDP	-30%		
Oil & Natural Gas Import Expenditures	-29%		
Security of U.S. Petroleum Imports	-20%		
Security of U.S. Natural Gas Imports	-14%		
Crude Oil Prices	-13%		

accounted for just below 10% of supply in 2014, well off the 19% peak in 2007. As a result, the risk metrics for petroleum and natural gas imports declined 20% and 14%, respectively, in 2013.

Declining imports of both oil and natural gas also have benefited the United States by lowering import expenditures. From $239 billion in 2013, it is estimated that U.S. expenditures on imports of petroleum and natural gas slipped 29% ($69 billion) in 2014 to $170 billion, sending the risk index for this metric down 35 points (29%). The index measuring these expenditures as a share of GDP, a gauge of the exposure of the United States to price shocks, also improved about 15 points (30%). This is the third year in a row of large declines in these two metrics. As a result, the amount spent on imports of oil and natural gas, both nominally and as a share of GDP, has decreased by nearly one-half since 2011.The United States produces all the coal it needs, and in recent years has increased its export volumes, primarily to Asia but also to Europe and South America.

Crude oil price volatility moved much lower in 2014 for the third year running. Energy costs are a significant portion of our overall economy, and extreme price volatility can slow economic growth. The Crude Oil Price Volatility risk index improved by about 46% in 2014. This is a dramatic turnaround for this measure, which reached a record high in 2011. Since then, crude oil volatility risks have been lowered by 77%. Rising domestic production of crude oil coupled with greater output from Canada and Iraq over the period has contributed to lower price volatility by offsetting declines in supply stemming from large suppliers such as Iran, Libya, Mexico, Nigeria, Norway, and the United Kingdom. Without these added U.S. supplies, it is likely that volatility would have been much greater over the past couple of years.

Energy efficiency gains were uneven in 2014. While the overall risk index score for the Energy Intensity metric showed improvement, the indexes for House Energy Efficiency and Commercial Energy Efficiency showed small upticks in risk for the second consecutive year. Industrial Energy Efficiency, however, achieved the largest decline in risk (4%) since 2005.

Risks related to energy-related carbon dioxide emissions increased slightly in 2014 but still remain well below the historical average. Slow but steady trends towards greater energy efficiency in the industrial sector, fuel switching from coal to cheap natural gas in the power sector, and still sluggish economic growth all contributed to the decline in total emissions.

Based on EIA's latest AEO 2015, the U.S. Index is projected to average 80.7 points over the entire forecast period from 2015 to 2040, about a

7.4 point

improvement over last year's Index projection based on the AEO 2014 forecast.

Outlook to 2040

Based on EIA's latest *AEO 2015*, the U.S. Index is projected to average 80.7 points over the entire forecast period from 2015 to 2040, about a 7.4 point improvement over last year's Index projection based on the *AEO 2014* forecast. Risks are expected to stay below the 2014 level through 2032. By 2040, the total energy security risk is expected to reach 87, about 3 points higher than the historical average. Greater U.S. oil and gas production is the primary cause of the improved outlook in risk compared to last year.

Even though the risk level in 2040 is expected to be higher, most metrics are expected to improve from 2015 to 2040. Of the 25 metrics for which forecast data are available, 16 are expected to improve and eight are expected to worsen.

The rising risk trend late in the forecast period is being driven primarily by a projected 49% increase in the price of crude oil by 2040 (to $134 per barrel), but much greater domestic production of oil and natural gas and energy efficiency mean that import expenditures for these fuels will be considerably

lower in 2040 compared to last year's 2040 estimate. Based on EIA's *AEO 2015* forecast, in 2040 the U.S. will spend about $120 billion on imports of these products (expenditures for natural gas will be essentially "$0" because the United States is becoming a net exporter of natural gas). Last year, the *AEO 2014* forecast suggested a figure of about $325 billion in 2040. Flattening oil demand, especially in the transportation sector, and continued exports of refined products are the primary factors in decreasing expenditures compared to the level calculated using *AEO 2014*.

The future growth in U.S. crude oil and production is expected to proceed much more rapidly than predicted last year. EIA's *AEO 2015* predicts even greater crude oil production than in last year's *AEO*, with an average production rate over the forecast period of nearly 10 million bbl/d. How the downward oil price shock in 2015 affects future output is something that bears watching and could affect subsequent EIA forecasts. Natural gas output in the *AEO 2015* runs only slightly below the level in the *AEO 2014*.

Unprecedented levels of regulation covering fossil fuel-fired power plants and changing market dynamics are expected to increase energy security risks in the electric power sector by decreasing generation diversity. The generation diversity metric captures the flexibility of the power sector's ability to dispatch electricity from a diverse range of sources. Since there are inherent differences in availability among different generating technologies, the generating capacities are weighted by an availability factor. Risks related to electricity generation capacity diversity are forecast to rise by 13%, reaching 100 points in 2040, a level higher than at any time since the early 1980s and much higher than the historical average of 94. Federal environmental regulations targeting coal plants and to a lesser extent greater competition between natural gas and coal in the power sector are primarily responsible for the loss of generation diversity. BY 2040, retail electricity prices also are expected to increase 15%, raising the risk index for this metric.

Along with nuclear power plants, coal-fired plants provide base-load power and are critical to the smooth functioning of the electric grid, but over the short term (out to 2017), electricity capacity margins are expected to decline because of the coal plant closures of nearly 34 gigawatts in capacity from 2014 to 2017 related to the Environmental Protection Agency's (EPA) Mercury and Air Toxics rule. Capacity margin risk over this period is expected to jump from an index score of 92 in 2014 to 107 in 2017. Forecast data beyond 2017 are not available. Nevertheless, should this short-term be extended, the lack of adequate capacity margins in the future could pose serious reliability risks. Indeed, utility companies and independent organizations like the North American Electric Reliability Corporation (NERC), with primary responsibility for the reliability of the electric grid, noted that these and other unbalanced rules could cause disruptions to the stability and reliability of the grid. The Supreme Court ruled in 2015 that EPA's rule violated the Clean Air Act because the agency should have considered costs, which even in EPA's reckoning exceeded benefits by a very wide margin, when promulgating the rule. While this case was winding its way through the courts, many power producers closed coal-fired power stations, contributing to the shrinking capacity margins.

The long-term trend towards greater energy efficiency across most sectors continues to moderate future U.S. energy risks. Metrics measuring energy and petroleum intensity and sector-specific energy efficiency all show considerable improvement over the 2015 to 2040 forecast period. The rate of change in these energy intensity and efficiency metrics out to 2040 has not changed appreciably from those reported in earlier editions of the U.S. Index. Both the economy-wide energy intensity and petroleum intensity—intensity being a measure of consumption per dollar of GDP produced—are both expected to improve by more than 40% by 2040 while over the same period energy efficiency in the residential, commercial, and industrial sectors is expected to improve 21%, 13%, and 24%, respectively.

Much greater efficiency in the transportation sector combined with fewer vehicle miles being traveled are the main factors contributing to lower petroleum demand. By 2040, the Motor Vehicle Average MPG metric is anticipated to improve 32% and the Transportation Vehicle Miles Traveled per GDP metric 27%. (VMT per GDP is the subject of a special feature in this year's edition that appears later in this report.) As a result, petroleum demand in the transportation sector, which peaked in 2007, is expected to dampen in the future. By 2040, demand for petroleum in the transportation sector is forecast to be 12.7 million bbl/d, slightly above the 1998 level. Together with greater domestic crude oil production, these trends will continue to dampen demand for foreign crude oil.

Sub-Index of U.S. Geopolitical Energy Security Risk

The Geopolitical Sub-Index measures the security of global oil, gas, and coal supplies and other factors that affect the ability of the U.S. economy to withstand supply disruptions from whatever causes.

Geopolitical energy security risks declined nearly 8% in 2014 to 81.9 points. This is the third consecutive year of lower risk since the record high score of 100.75 points was recorded for this sub-index in 2011 (Figure 3). Lower crude oil and natural gas import and lower total import expenditure risks stemming from growing unconventional domestic oil and natural gas production and less volatility in the price of crude oil were the main factors contributing to lower geopolitical risks in 2014.

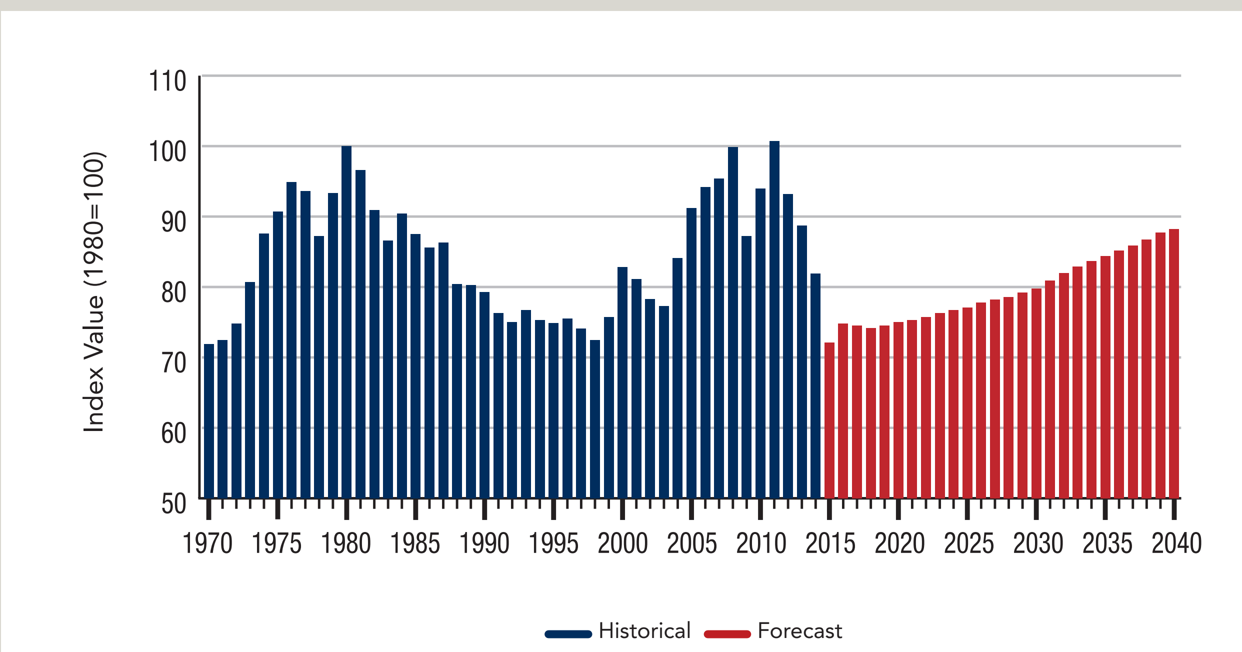
EIA's 2015 forecast suggests that geopolitical risks will rise six points by 2040, driven by increasing crude oil prices and volatility despite the strong trends in increasing production of U.S. crude oil and natural gas. Increasing unconventional crude oil gas production in North America, however, is expected to moderate the risks associated with the large concentration of crude oil supplies in the Middle East. Nevertheless, increasing demand in the large emerging economies like China, India, Brazil and others will keep upward pressure on global prices. Moreover, political turmoil like that being experienced in the Middle East today may lead to market instability and price volatility.

Sub-Index of U.S. Economic Energy Security Risk

Energy costs are a significant portion of our overall economy. In 2014, roughly $1.3 trillion was spent for

Figure 2

U.S. Energy Security Risk: Geopolitical Sub-Index, 1970-2040



end-use energy in the residential, commercial, industrial, and transportation sectors, amounting to roughly 7.8% of GDP, the lowest level since the early 1970s. The Economic Sub-Index includes metrics measuring trends in the costs associated with energy, the intensity and efficiency of energy use, and international supply risks. Energy price volatility and high energy prices can have large impacts on the economy, the competitiveness of U.S. industries, and U.S. balance of trade.

Economic energy security risk fell nearly 7 points in 2014 to 79.9, the lowest level since 2004 but still above the 30-year average of 73.2. The biggest improvements were noted in the metrics covering energy expenditure, crude oil volatility, and oil and gas import expenditures (Figure 3).

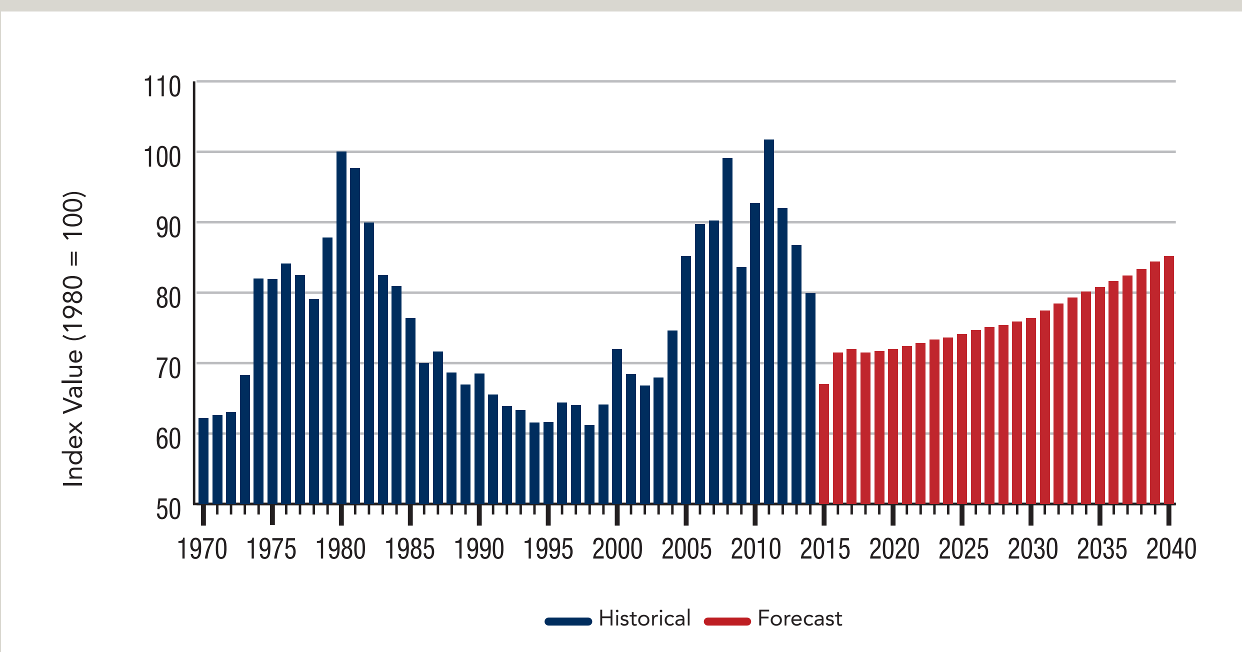
In 2014, the risk index for crude oil price volatility moved proportionally more than any other metric in the U.S. Index, 46%. Price spikes and market chaos peaked in 2010/11. Since then, the risk score for this metric has fallen by 77%, a remarkable decline over such a short period of time.

With a large part of our energy use still consisting of fuel imports, volatility in the markets can lead to sudden and large shifts in international trade. Greater expenditures on imported fuels represent lost economic investment opportunities closer to home, and this risk is captured in metrics measuring how much the U.S. spends on imported oil and natural gas, both in total and as a share of GDP. Both of these measures got significantly better in 2013, the former by 29% (to 86.7 points) and the latter by about 30% (to 34.8 points). Historically, however, while the score for expenditures remains well above their 30-year average of 42, the score for expenditures as a share of GDP has moved slightly below the average of 36.

Further declines in economic risks are expected through about 2020, after which they will rise steadily, increasing to 85.2 points in the late 2040 largely due to high crude oil prices. Nevertheless, this 2040 figure is about 9 points below last year's 2040 figure, suggesting a great deal of improvement in the outlook for this sub-index.

Figure 3

U.S. Energy Security Risk: Economic Sub-Index, 1970-2040



Sub-Index of U.S. Reliability Energy Security Risk

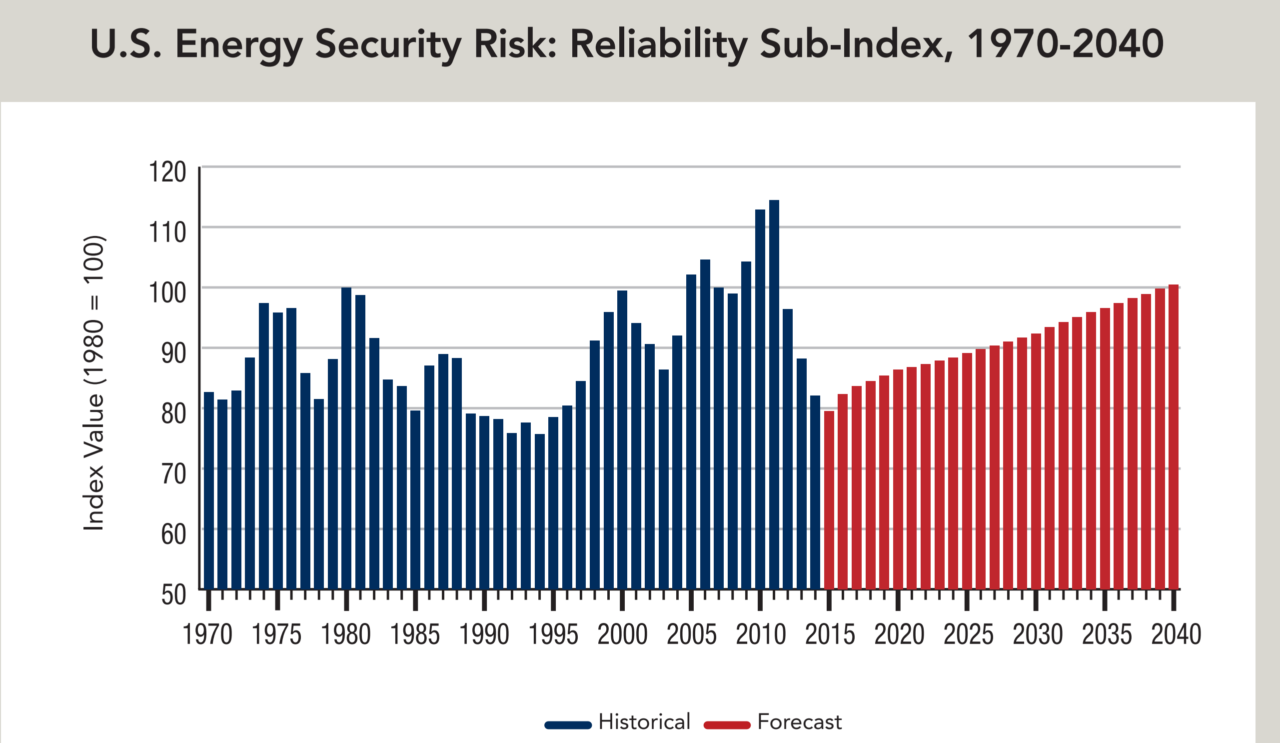
The metrics that make up the Reliability Sub-Index measure such things as global fossil fuel production and imports, crude oil price and volatility, oil refining and stock levels, the power sector, and energy research and development.

Reliability energy security risks fell 6.1 points (7%) to 82.1 points, about 4 points below its 1970-1999 baseline average score of 86 (Figure 4). The reduction in risk observed in 2014 was due chiefly to large drops in crude oil volatility and energy expenditure volatility, discussed above. Large and growing supplies of unconventional oil and gas in the United States continue to enhance the reliability of supplies both in the United States and globally, with oil import risks tumbling 20% and natural gas import risks 14% in 2014. Reliability risks related the power sector, world oil refining capacity utilization, however, remained little changed from 2013. The Petroleum Stock Levels metric showed a significant shift in 2014, seeing its risk score drop nearly 5%. Greater oil production in the U.S. coupled with market distortion created by the ban on crude oil exports is largely responsible for the improvement.

Reliability risks related the power sector remained basically unchanged from 2011, with only the risk index for generation capacity dropping appreciably (by nearly 8%). Measures for capacity diversity and transmission line mileage per peak demand showed little change in 2013. At 121.2, the risk index for capacity margins was 27 points higher than its 1970-1999 baseline average, while the indexes for capacity diversity and transmission, critical aspects of grid reliability, were not appreciably different from their historical averages.

Forecast scores based on the *AEO 2015* suggest steadily rising risks out to 2040, reaching 100.5. Rising crude oil prices and potential crude oil price volatility are factors going forward. Of equal significance are the growing risks related to lower generating capacity diversity and generating capacity margins

Figure 4



(discussed above), both of which are being driven by shrinking shares of base load coal and nuclear generating capacity in the generating mix. Between 2014 and 2040, risks connected to capacity diversity are expected to rise by 13%.

Sub-Index of U.S. Environmental Energy Security Risk

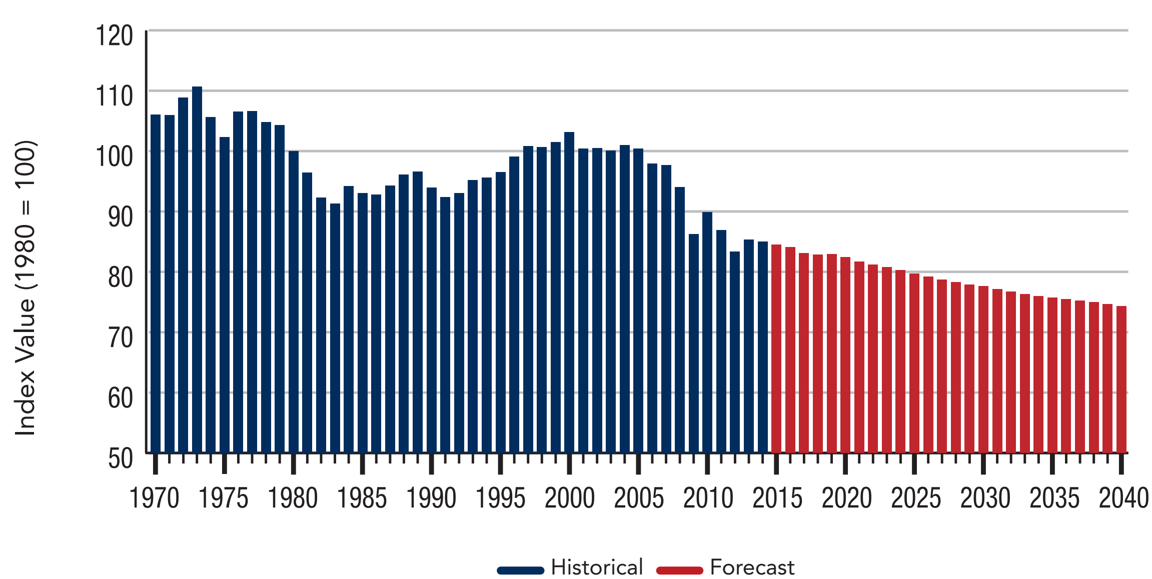
The Geopolitical Sub-Index measures the security of global oil, gas, and coal supplies and other factors that affect the ability of the U.S. economy to withstand supply disruptions from whatever causes.

With a score of 85.0, environmental energy security risks were little changed (-1%) in 2014. This is the second lowest score for this sub-index in the entire record going back to 1970 (only the 2012 score is lower), and it is nearly 14 points below the historical average (Figure 5). Metrics in this sub-index tend to move more slowly than in others, and no metric in this sub-index moved more than 5% in 2014. Of the 20 metrics in the sub-index, four saw risks rise in 2013 by 1% or more while 10 declined by 1% or more.

Of the four sub-indexes, the Environment is the only one showing steadily declining risk out to 2040. By 2025, the risk score for this sub-index could fall below 80 for the first time, and by 2040 reach 74.3. Large improvements in the metrics measuring energy and petroleum intensity (more than 40% for each) and energy efficiency in all sectors—residential (-21%), commercial (-13%), industrial (-24%), and transportation (-32%)—are responsible for the decline in environmental risks going forward. Each of these metrics shows constant future improvement, and by 2040, their scores are at the lowest level recorded by the index. Largely as a result of these trends, emissions of carbon dioxide are expected to rise only about 10% by 2040, while per capita emissions and emissions intensity fall sharply (26%).

Figure 5

U.S. Energy Security Risk: Environmental Sub-Index, 1970-2040



Special Feature: Changes in Energy Security Forecasts over the Years

Since the Energy Institute issued its first U.S. Index in 2010, covering historical data through 2009, the U.S. energy landscape has changed almost beyond recognition. So swift was the change in U.S. energy fortunes that it caught many analysts and policymakers by surprise.

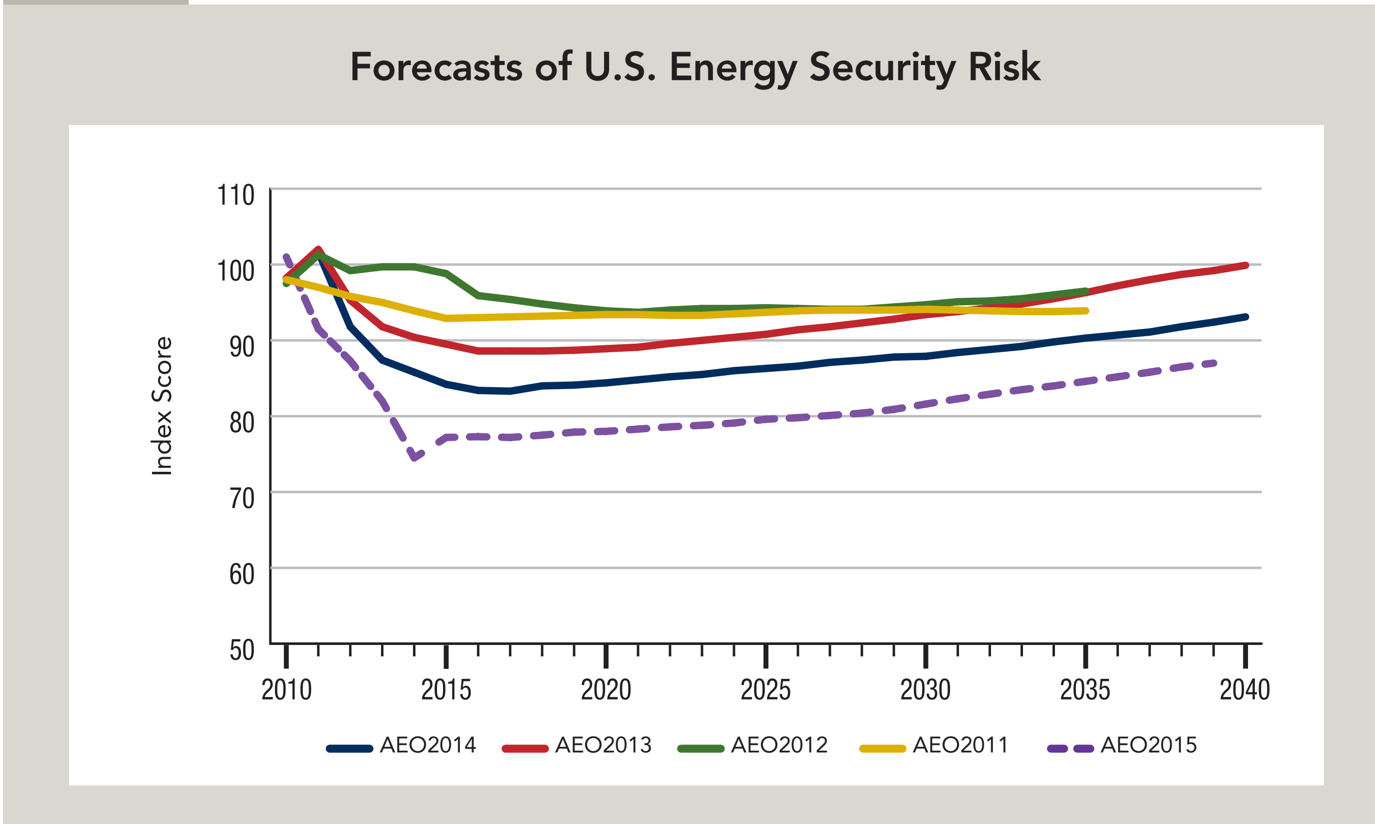
These revolutionary changes change not only how we view the present, but also how we view the future. The old aphorism that it is "tough to make an accurate prediction, especially about the future" certainly applies to something as complex as energy.

This special feature takes a look at the results of this year's U.S. Index forecasts and compares them to the forecast from previous editions based on previous EIA *AEO* forecasts staring with *AEO 2011*. The vast majority of the changes observed owe to different perceptions about the future trends, but it should also be recognized that revisions in the historical data and changes in the formulation of the metrics also will have a small impact. For consistency, we will look at forecast results for 2010 to 2040 or, for earlier editions, 2030. Note that index scores in the charts that follow are not produced as part of *AEO* model runs but rather derived from the output of these model runs.

We will begin with the overall Index, presented in Figure 6. In the past five years, the outlook has been getting progressively better, and this year's Index appears to be the biggest year-to-year improvement yet measured by the Index. The difference in outlook is evident especially in the short term, with sharply declining risk. The differential in risk expected to be established over the next few years is generally maintained out to 2040.

There are a number of inter-related factors that have contributed to this progressive lowering of future U.S.

Figure 6



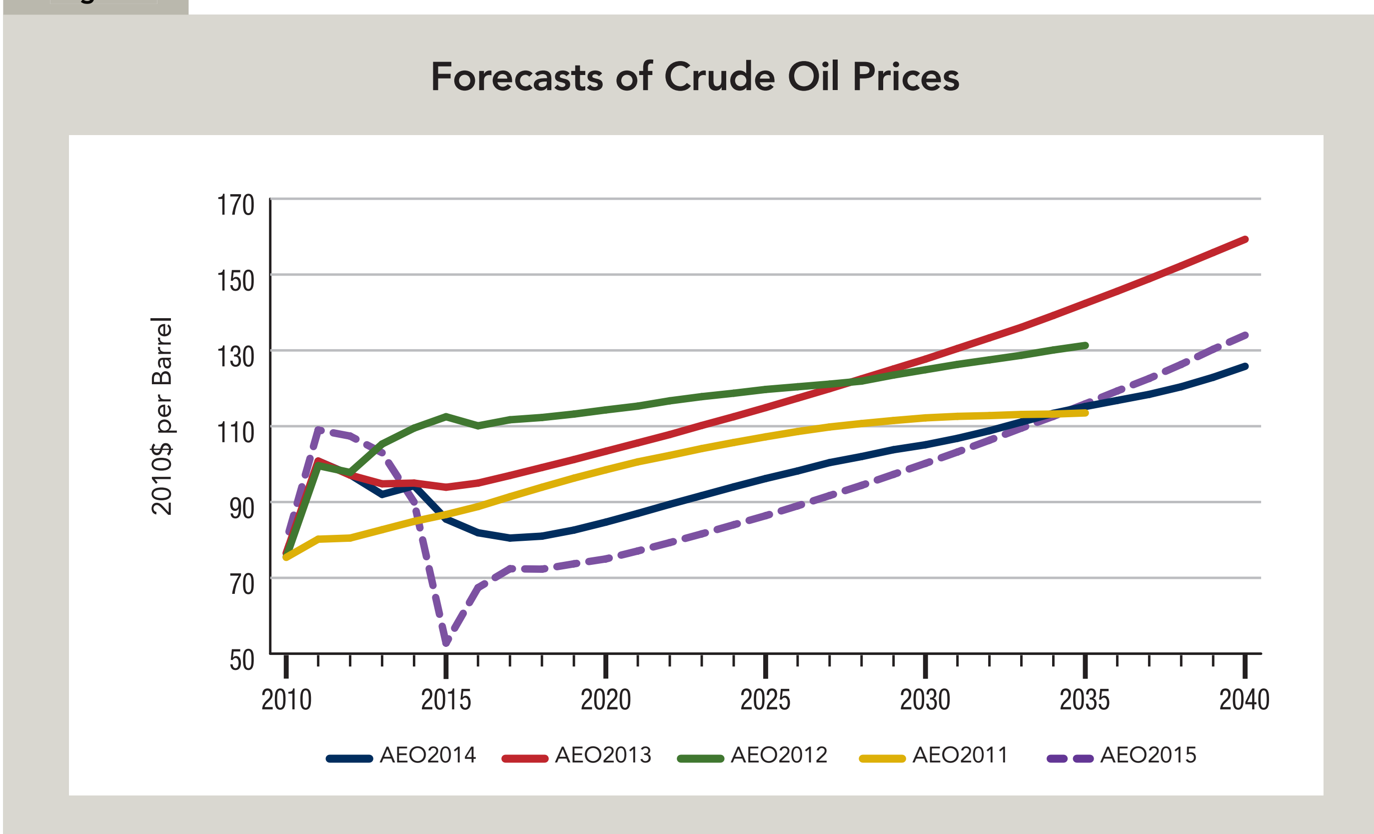
energy security risk. The biggest and most favorable changes are related from oil price and expenditure metrics. The *AEO 2015* shows a markedly lower oil price forecast (Figure 7) over the next several years, but in the later years rises at a faster rate, and by the mid-2030s is higher than the *AEO 2014* forecasts. Still, for the next decade or two, lower oil prices are projected for consumers.

Driving much of this drop in oil and natural gas prices is the rapid growth in US production, particularly in tight oil and shale formations. Significant production from these technologies began only about ten years ago, and has grown dramatically since then. The sharply higher US production is affecting markets worldwide, driving down prices and reducing U.S. imports. We noted in the 2013 edition of the U.S. Index how the trend in domestic crude oil output was a better match for EIA's *AEO 2013* High Oil and Gas case than its Reference, or business as usual, case because of surging production from tight oil from low-permeability shale and chalk formations such as the Bakken formation in North Dakota, and the Eagle Ford, and Three Forks formations in Texas. The following year, EIA's *AEO 2014* Reference case resembled more *AEO 2013*'s High Oil and Gas case, forecasting an average of about 8.6 million bbl/d from2015 to 2040. We also noted the likelihood that even this estimate was too low, and indeed, EIA's *AEO 2015* predicts even greater crude oil production averaging 10 million bbl/d over the forecast period (Figure 8).

Looking at net imports for oil and gas, we see the rapid drive towards self-sufficiency in the United States (Figures 9 and 10). Indeed, it is now expected that within the next couple of years, the U.S. will become a net exporter of natural gas, something not anticipated just a few years ago.

The tremendous growth in crude oil output has increased calls for lifting the 1970s-era ban on crude oil exports to reap the economic and trade benefits of such move and the geopolitical advantages free trade in crude oil could provide. Last year's edition pointed out the growing mismatch in the kind of crude oil we are producing and the kind most of our refineries are

Figure 7



designed to process—light sweet versus heavy sour. Lifting export restrictions on crude oil would stimulate greater domestic output and send a reassuring signal to global markets. As we have seen, greater U.S. participation in global markets on the supply side can help reduce price volatility and the use of energy as a geopolitical weapon. An energy export policy that adheres to free trade principles can only increase our influence. Granted, the United States is unlikely to become a price maker on world markets, but as a reliable supplier, it could be a price smoother.

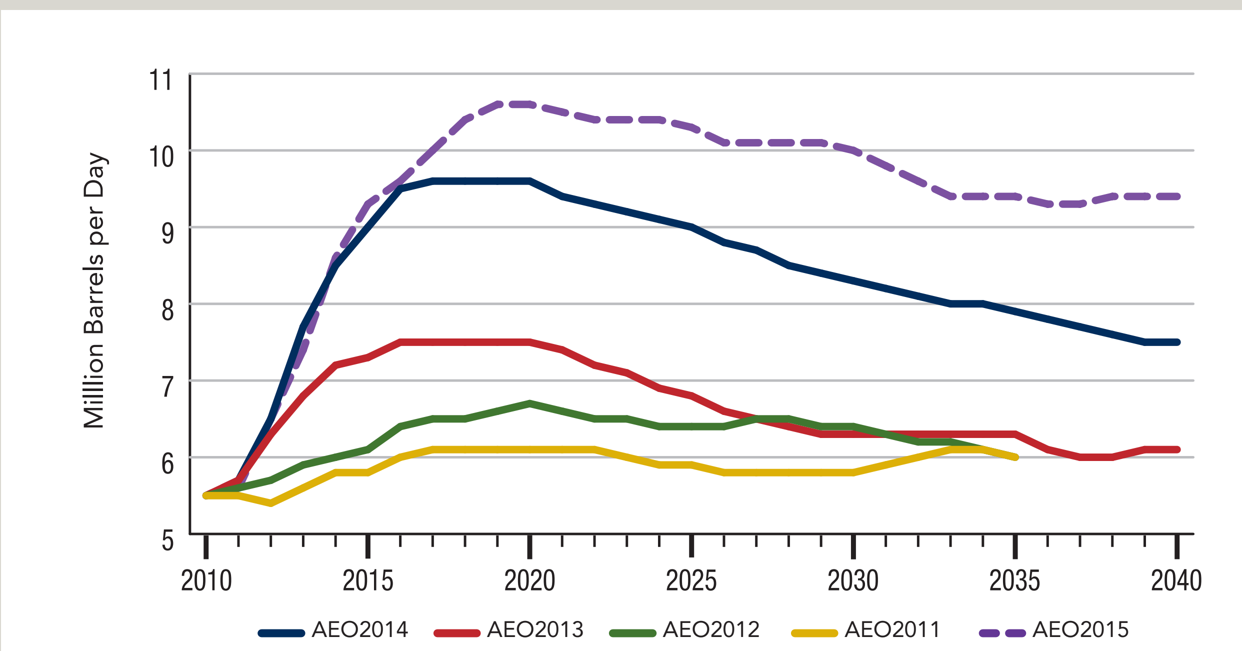
Saudi Arabia's stratagem to capture more of the global market share of crude oil by opening up the spigots and driving down the price to a level at which U.S. producers have to shut in production may have some short term impacts. U.S. producers, however, are the most nimble in the world, and new technology and drilling techniques are constantly being developed and deployed, lowering the price point at which these companies can produce oil at a profit. As prices rise, it is more than likely that U.S. producers will emerge all the stronger.

This combination is most obvious in the projections of net import expenditures for oil and gas, where the most recent projections show a drop of hundreds of billions of dollars in net import expenditures for U.S. oil and gas (Figure 11). It was noted earlier that the most recent *AEO* forecast estimates the United States will spend about $120 billion on oil and gas imports of these products in 2040, lower than the 2014 level. Last year, the *AEO 2014* forecast suggested a figure of about $325 billion in 2040. Flattening oil demand, especially in the transportation sector, and continued exports of refined products are the primary factors in decreasing expenditures compared to the level calculated using *AEO 2014*. As a result of these trends, the share of GDP devoted to oil and gas imports in 2040 is now projected to less than 0.5% compared to earlier estimates of between 1.0% and 1.5%

Indeed, U.S. industry has turned scarcity into abundance and boosted America's standing as a global energy powerhouse. These trends are expected to bring enormous future benefits to the U.S. economy and U.S. energy security that were almost entirely unimagined just a few years ago.

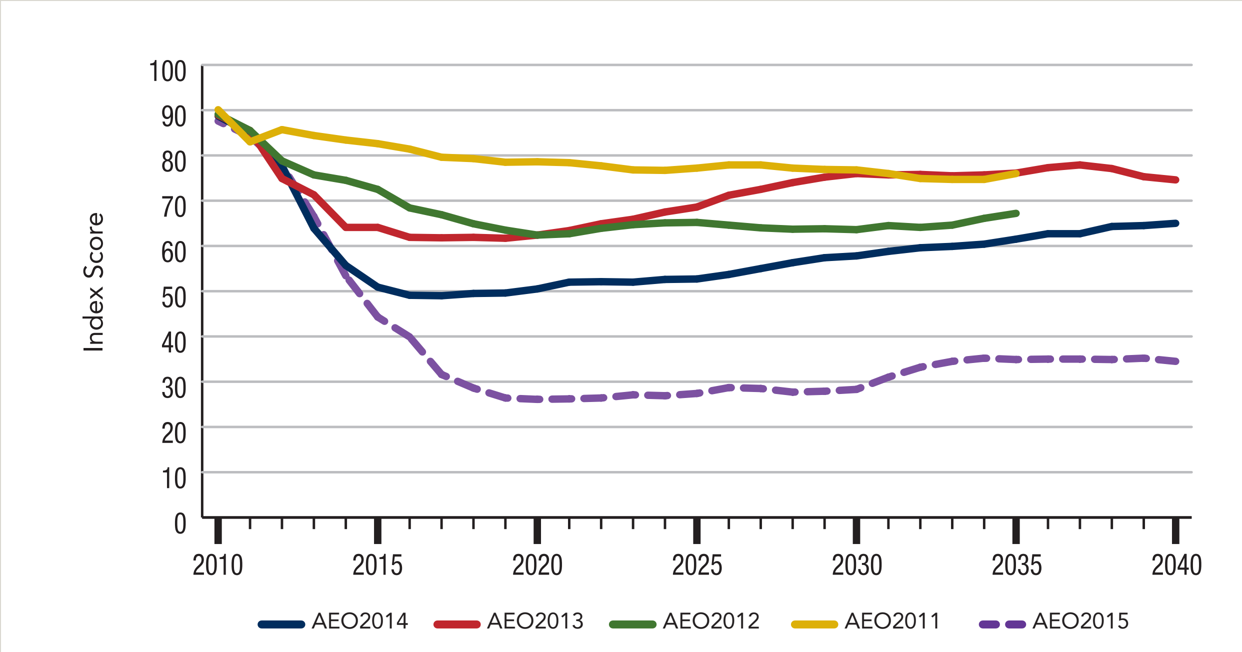
Figure 8

Forecasts of U.S. Crude Oil Production



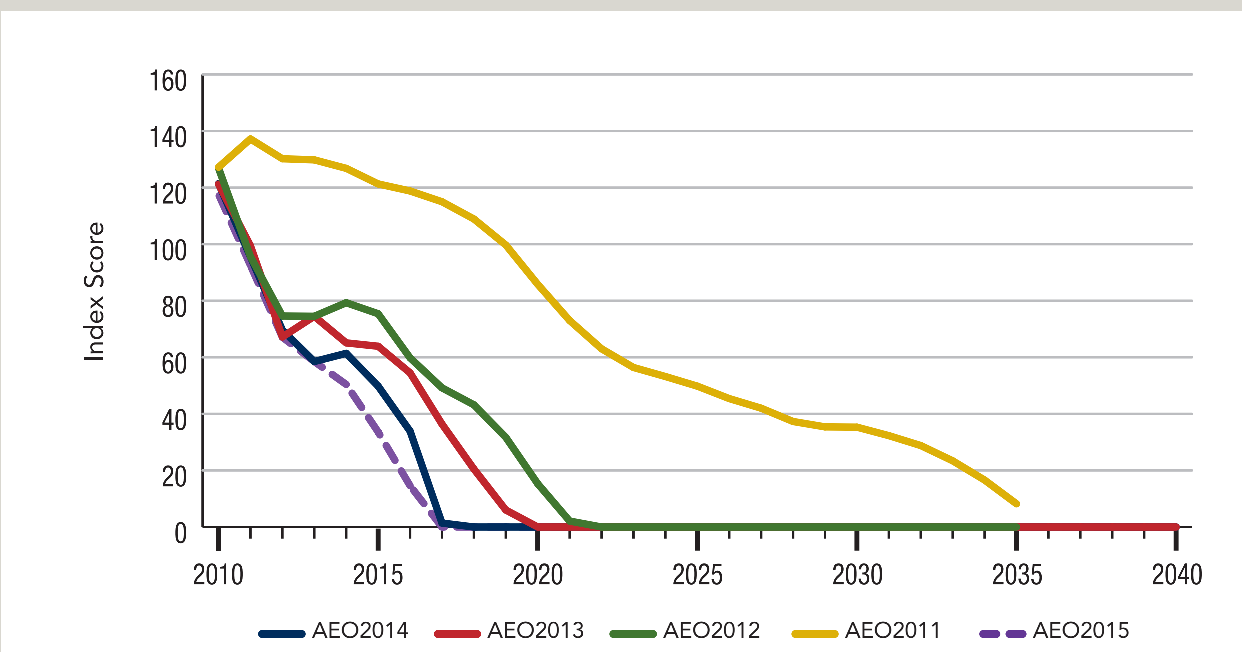
■ Figure 9

Forecasts of Security of Oil Imports



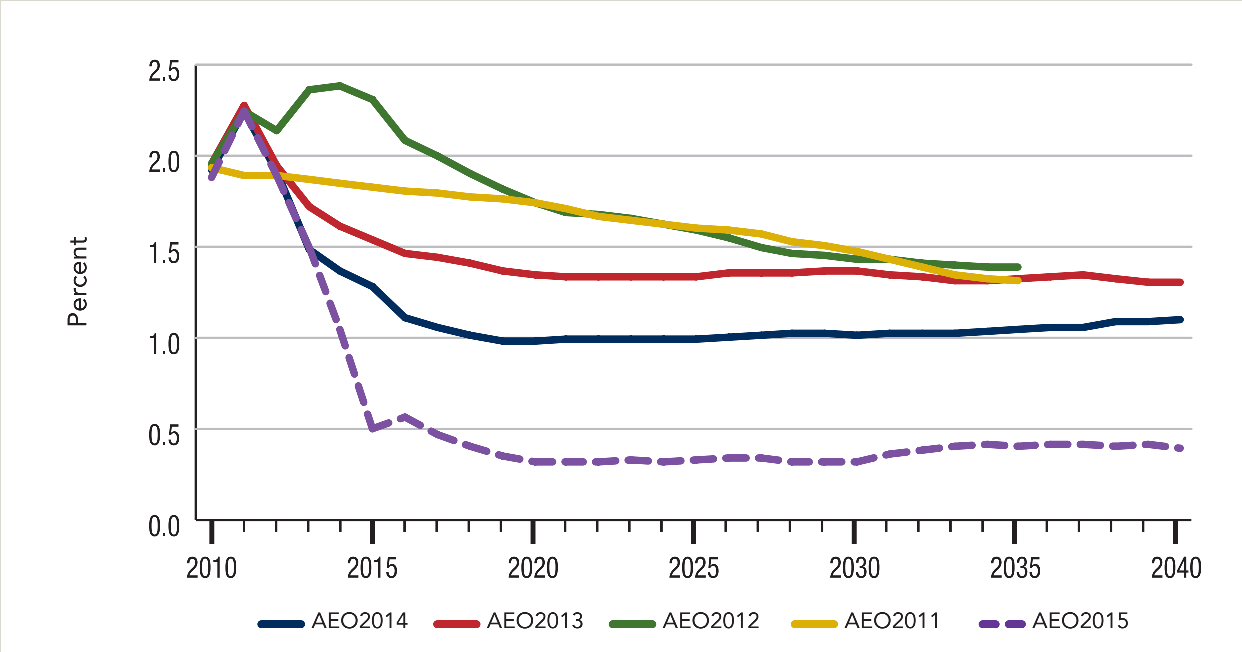
■ Figure 10

Forecasts of Security of Natural Gas Imports



■ Figure 11

Forecasts of Oil & Gas Import Expenditure as Share of GDP



Special Feature: Energy Security Risks under Alternate Future Scenarios

As part of its Annual Energy Outlook, EIA provides, in addition to it Reference case, a number of alternative cases that provide very different looks at what the future might hold. These can and do include quite different assumptions about many critical factors, including high oil price, low oil price, and high oil and gas resource. For its *AEO 2015*, EIA ran and made forecast data available for these five different side cases.[3] In addition to these side cases, EIA also was charged by Congress with performing analyses of two significant policy proposals: (1) EPA's proposed Clean Power Plan (CPP) regulating carbon dioxide emissions from existing fossil fuel-fired power plants under the Clean Air Act; and (2) lifting the restrictions on crude oil exports. While EPA's proposed rule has been superseded by its final rule, the results have been included here because they can provide insights into the impacts of regulations requiring deep emission reductions in the power sector.

These seven alternate scenarios were plugged into the U.S. Index model to see their impact on future energy security risk as compared to the *AEO 2015* Reference case. Note that the crude oil export scenarios run by EIA go out only to 2025.

The cases are ranked in Table 3 and described Table 4. In addition, the table contains the cumulative difference in GDP from 2016 to 2025 and from 2016 to 2040 for each case as a way to gauge the cost of the change in risk.

Energy Security Risk in 2025

The Low Oil Price & High Resource – Unrestricted and the High Resource – Unrestricted cases, which allow crude oil exports, have the best impact on energy security risk out to 2025. It comes as no surprise to note that these two side cases also show the greatest gains in cumulative GDP from 2016 to 2025 compared to the Reference case, with estimates of additional GDP as a result of lifting the export ban in the range of $739 billion to $752 billion. The "restricted' High Oil and Gas case—while it does not deliver as great an improvement in energy security—still produces about $722 billion in added GDP compared to the Reference case.

3 EIA. 2015. Annual Energy Outlook 2015 with Projections to 2040. DOE/EIA-0383(2015). Available at: http://www.eia.gov/forecasts/aeo/pdf/0383%282015%29.pdf.

Table 3. Energy Security Risk Measures: EIA AEO 2015 Side Cases vs. Reference Case

EIA AEO 2015 Side Case	Change in:			
	2025 Energy Risk Index Score	Cumulative GDP: 2016-2025 (Billion 2010$)	2040 Energy Risk Index Score	Cumulative GDP: 2016-2025 (Billion 2010$)
High Oil & Gas Resource	-4	722	-8	5,909
High Oil & Gas Resource - Unrestricted	-6	752	N/A	N/A
Low Oil Price	-3	84	-7	911
Low Oil Price - Unrestricted	-3	101	N/A	N/A
Low Oil Price & High Resource - Unrestricted	-7	739	N/A	N/A
CPP (Proposed)	-3	-708	-2	-1,006
High Oil Price	9	-137	14	-725

The High Oil Price case results in a big increase in energy security risk in 2025 of 9 points as well as a loss of roughly $137 billion in GDP. While the CPP side case results in a modest gain in energy security in 2025, it comes with an estimated GDP loss in excess of $700 billion.

Energy Security Risk in 2040

The High Resource and the Low Price cases provide the greatest energy security risk reduction in 2040 of the four side cases examined that go out this far into the future. The economic benefits of these cases, however, are much different. Whereas under the High Resource case, about $5.9 trillion are added to the U.S. economy over the forecast period, under the Low Price case, only about $925 billion are added (just 15% of the High Resource figure). Put another way, for every point of risk reduction in 2040, the economy gained about $135 billion under the Low Oil Price case versus about $700 billion under the High Oil & Gas Resource case.

The difference is because in the Low Oil Price case, most of the benefits of increased oil production are captured outside of the United States. In the High Oil & Gas Resource case, in contrast, production of domestic shale gas, tight gas, and tight oil is much higher, new tight oil resources are added reflecting new or expanded existing plays, technology improves rapidly, and higher offshore resources are discovered, among other factors. All of these factors contribute not only to significantly improved U.S. energy security but also to a huge boost in GDP and employment, with approximately 1.1 million additional non-farm jobs in 2040 compared to the Reference case. These results are similar to those obtained using the comparable High Resource and Low Oil Price scenarios in last year's *AEO 2014*.

At the bottom of the table is the High Oil Price case, which shows an increase in risk in 2040 of 14 points. This also is similar to last year's side cases using similar assumptions.

Although a side case using an economy-wide price on carbon was not included in this year's *AEO 2015*—two were included last year with initial prices of $10 and $25—EIA's CPP model run is included this year. It shows a modest decline in overall energy security risk in 2040 of 2 points vis-à-vis the Reference case. Those improvements, however, would come with a $1 trillion price tag, or a cost of about $485 billion for each point of risk reduction. (The $10 and $25 per ton carbon price scenarios also yielded similarly high costs per point of risk reduction.)

These results demonstrate that the types of policies employed can have a big impact on energy security and on the economy. Policies that encourage greater domestic production of unconventional and off-shore oil and natural gas resources, promote greater efficiency and the deployment of advanced, cost-effective technologies, and do not close prematurely existing coal and nuclear power stations and other valuable energy assets offer a way to lower energy security while increasing employment and GDP.

Table 4. Summary of Side Cases	
EIA AEO 2015 Case	Description
Reference	Real gross domestic product (GDP) grows at an average annual rate of 2.4% from 2013 to 2040, under the assumption that current laws and regulations remain generally unchanged throughout the projection period. North Sea Brent crude oil prices rise to $141/bbl (2013$) in 2040.
High Oil and Gas Resource	Estimated ultimate recovery (EUR) per shale gas, tight gas, and tight oil well is 50% higher and well spacing is 50% closer (i.e., the number of wells drilled is 100% higher) than in the Reference case. In addition, tight oil resources are added to reflect new plays or the expansion of known tight oil plays, and the EUR for tight and shale wells increases by 1%/year more than the annual increase in the Reference case to reflect additional technology improvements. This case also includes kerogen development; undiscovered resources in the offshore Lower 48 states and Alaska; and coalbed methane and shale gas resources in Canada that are 50% higher than in the Reference case. Other energy market assumptions are the same as in the Reference case.
High Oil & Gas Resource - Unrestricted	Same as High Oil & Gas Resource except with the ban on crude oil exports lifted.
Low Oil Price	Low oil prices result from a combination of low demand for petroleum and other liquids in nations outside the Organization for Economic Cooperation and Development (non-OECD nations) and higher global supply. On the supply side, the Organization of Petroleum Exporting Countries (OPEC) increases its liquids market share from 40% in 2013 to 51% in 2040, and the costs of other liquids production technologies are lower than in the Reference case. Light, sweet (Brent) crude oil prices remain around $52/bbl (2013$) through 2017, and then rise slowly to $76/bbl in 2040. Other energy market assumptions are the same as in the Reference case.
Low Oil Price - Unrestricted	Same as Low Oil Price except with the ban on crude oil exports lifted.
High Oil and Gas Resource	Estimated ultimate recovery (EUR) per shale gas, tight gas, and tight oil well is 50% higher and well spacing is 50% closer (i.e., the number of wells drilled is 100% higher) than in the Reference case. In addition, tight oil resources are added to reflect new plays or the expansion of known tight oil plays, and the EUR for tight and shale wells increases by 1%/year more than the annual increase in the Reference case to reflect additional technology improvements. This case also includes kerogen development; undiscovered resources in the offshore Lower 48 states and Alaska; and coalbed methane and shale gas resources in Canada that are 50% higher than in the Reference case. Other energy market assumptions are the same as in the Reference case.
Low Oil Price and High Oil and Gas Resource - Unrestricted	A combination of the Low Oil Price and High Resource scenarios with the ban on crude oil exports lifted.
Proposed Clean Power Plan	The Base Policy case models the proposed Clean Power Plan using the AEO2015 Reference case as the underlying baseline.
High Oil Price	High oil prices result from a combination of higher demand for liquid fuels in non-OECD nations and lower global crude oil supply. OPEC's liquids market share averages 32% throughout the projection. Non-OPEC crude oil production expands more slowly in short- to mid-term relative to the Reference case. Brent crude oil prices rise to $252/bbl (2013$) in 2040. Other energy market assumptions are the same as in the Reference case.

Special Feature: Trends in Vehicle Miles Traveled Intensity

Transportation has always been an important component of the U.S. economy, so risks to transportation have meant risks to the economy. January's 2011 Metric of the Month takes closer look at "Transportation Vehicle-Miles Traveled (VMT) per Real Gross Domestic Product" (VMT intensity[4]). The Energy Institute uses VMT Intensity in its U.S. Energy Security Risk Index to gauge the relative importance of travel to the U.S. economy. The lower its value is, the less that travel miles factor into the overall economy, which in turn contributes to a reduction in the energy security risk.

Trends in VMT intensity have changed markedly over the years (Figure 12). While U.S. Index data go back to 1970, for the purposes of this analysis, the range of historical data will be stretched back to 1945. Three distinct trends are evident in the VMT intensity data presented in Figure X. They are:

- **1945—1975:** Except for a short period in the mid-1960s, from 1945 to 1975, VMT rose at a generally faster rate than GDP. That means that over this period, for each percentage point increase in annual GDP, there was a larger relative increase in annual VMT.

- **1975—1995:** From about 1975 to the mid-1990s, VMT intensity was essentially constant, moving within a narrow band around 230 to 245 miles per $1,000 of GDP. This indicates that, overall, VMT grew proportionately with the economy so that each percentage change in economic growth was matched with roughly similar percentage change in VMT, a relationship that held more or less steady for 20 years.

- **1995—2040:** Beginning in the mid-1990s, VMT intensity began trending downward. This means that each percentage point increase in annual GDP growth was accompanied by a smaller increase in annual VMT. As a result, from 1995 through 2014, the VMT Intensity of the U.S. economy declined by about 1.3% per year. This trend is projected to continue, with the Energy Information Administration (EIA) forecasting improvement in VMT Intensity into the future at an average of nearly the same annual rate (1.2%).

The growth in VMT Intensity observed from 1945 to 1975 is most likely the result of a combination of inter-related factors, many of which began or accelerated after the Second World War. For example, during this period there were large and rapid shifts from low-VMT intensive transport modes—buses, commuter trains, and freight trains—to high-VMT intensive modes—cars, light trucks, and combination trucks. Growing suburbanization and the build-out of the interstate highway system also contributed to growing VMT.

From 1970 (the beginning year of our Index) to about 1995, the rapid pace of the modal shifts that occurred in earlier decades began to slow. Data from the U.S. Department of Transportation (DOT), for example, show that while these shifts continued throughout this period, they did so at a reduced rate than before 1975, leaving additional VMT growth more closely aligned with economic growth.

By the mid-1990s, the modals shifts that began in the late 1940s towards more VMT-intensive modes pretty much exhausted themselves, and auto ownership and vehicle occupancy have become more or less saturated. Greater use of mass transit and car and van pooling—which have seen a sharp uptick since 2003 —trip consolidation, and smart growth planning are other trends that begun to assert themselves since the mid-1990s. Moreover, the U.S. is now a mature automobile market, and many roads and highways also are reaching their design capacity.

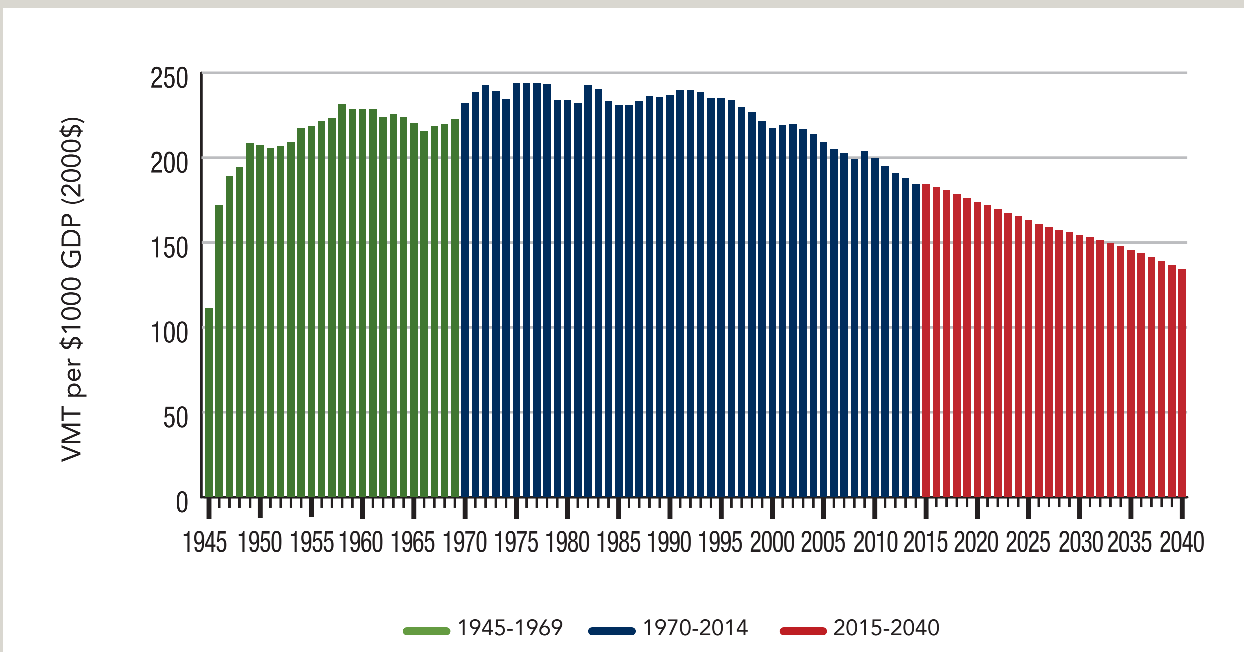
Additionally, since the mid-1990s there have been new kinds of "modal" shifts where increasing numbers of passenger car trips are being replaced by new communication and computing technologies that

4 "Vehicles" includes light-duty vehicles, commercial light trucks, and freight trucks. For historical data, we used VMT statistics from the U.S. Department of Transportation Federal Highway Administration's Highway Statistic 2013 (4.2.1. Public Road Mileage and VMT, 1920 – 2013) and real GDP data from the Current and Real Gross Domestic Product data series published by the Bureau of Economic Analysis, National Economic Accounts. Forecasts of VMT and GDP are from EIA's AEO 2015.

"compete" indirectly with cars. For example, DOT data indicate that since at least 1999, the number of people working from home has doubled since the mid-1990s to more than 6 million people. That trend, which has accelerated in recent years, should continue. The use of computers and Global Positioning System technologies to determine the most efficient shipping and delivery routes and also is growing and contributing to lower VMT.

The bottom line is that from about 1995 on, the United States has been producing more goods and services for each mile traveled. EIA forecasts suggest we can expect this positive trend towards greater productivity for each mile traveled to continue in the future, which will contribute to a lowering of U.S. energy security risks.

Figure 12



Appendix 1: Methodology Used to Develop the Index of U.S. Energy Security Risk

The Energy Institute's ultimate goal in developing the Index of U.S. Energy Security Risk was to use available data and forecasts to develop the metrics that collectively describe the geopolitical, economic, reliability, and environmental risks that in turn combine to measure the risk to overall U.S. energy security in a single Index.

Boiling down something as multifaceted as U.S. energy security into a single number posed a significant challenge. The Index was built from a foundation of just over three dozen individual metrics measuring energy security in a variety of aspects. The Index uses historical and forecast data covering the period 1970, before the time when energy security first became a large concern with the American public, to 2040 using "business-as-usual" forecasts from the Energy Information Administration (EIA).

The process used to develop the Index is described below, and it is represented schematically in figure A1-1.

Selecting and Developing the Metrics

Before selecting the measures, the first task was to establish some criteria that would ensure the data used possessed several important characteristics. The data for each metric had to be:

- Sensible—The data had to relate to common- sense expectations.
- Credible—The data source had to be well-recognized and authoritative.
- Accessible—The data had to be readily and publicly available.
- Transparent—Data derivations and manipulations had to be clear.
- Complete—The data record had to extend back in history for a reasonable amount of time, preferably back to 1970.
- Prospective—The historical data had to dovetail cleanly with forecast data that extend to 2040 where these are available.
- Updatable—The historical data had to be revised each year, with a new historical year added and new forecast outlooks prepared.

In many cases, data from government agencies—primarily the EIA, Department of Commerce, and Department of Transportation—were tapped, but this was not always possible, especially for certain types of data extending back to the 1970s and 1980s. Where historical data from government sources were not available, other widely used and respected sources were employed.

The metrics selected were organized around nine broad types of metrics that represent and balance some key and often competing aspects of energy security. These are found in table A1-1.
Using these categories as guides, 37 individual metrics were selected and developed covering a wide range of energy supplies, energy end-uses, operations, and environmental emissions. Anywhere from three to six metrics were selected for each metric category.

The Energy Institute's Index of U.S. Energy Security Risk and the various metrics that support it are designed to convey the notion of risk, in which a lower Index number equates to a lower risk to energy security and a higher Index number relates to a higher risk. This notion of risk is conceptually different from the notion of outcome. Periods of high risk do not necessarily lead to bad outcomes just as periods of low risk do not necessarily lead to good outcomes.

More often than was preferred, the available historical data measured what actually happened, not what might have happened. In other words, much of the available data measure history, not risk.

In choosing which metrics to use, it was necessary to strike a balance between the desired "ideal" measure and the available measure. Where data for the preferred metric existed, they were used, but in many cases, proxies for the risks that could not be measured directly had to be developed.

Several of the metrics use similar data in different ways

Figure A1-1. Building the Index of U.S. Energy Security Risk

	Table A1-1. Categories of Energy Security Metrics	
	Metric Category	General Description of the Metrics
1.	Global Fuels	Measure the reliability and diversity of global reserves and supplies of oil, natural gas, and coal. Higher reliability and diversity mean a lower risk to energy security.
2.	Fuel Imports	Measure the exposure of the U.S. economy to unreliable and concentrated supplies of oil and natural gas and import costs (not necessarily related to the amount of imports). Higher reliability and diversity and lower costs mean a lower risk to energy security.
3.	Energy Expenditures	Measure the magnitude of energy costs to the U.S. economy and the exposure of consumers to price shocks. Lower costs and exposure mean a lower risk to energy security.
4.	Price & Market Volatility	Measure the susceptibility of the U.S. economy and consumers to large swings in energy prices. Lower volatility means a lower risk to energy security.
5.	Energy Use Intensity	Measure energy use in relation to economic output and energy efficiency. Lower energy use by industry to produce goods and services and by commercial and residential consumers mean a lower risk to energy security.
6.	Electric Power Sector	Measure the diversity and reliability of electricity generating capacity. Higher diversity and reliability mean a lower risk to energy security.
7.	Transportation Sector	Measure efficiency of the vehicle fleet and diversity of fuels. Higher efficiency and diversity mean a lower risk to energy security.
8.	Environmental	Measure the exposure of the U.S. economy to national and international greenhouse gas emission reduction mandates. Lower emissions of carbon dioxide from energy mean a lower risk to energy security.
9.	Research & Development	Measure the prospects for new advanced energy technologies and development of intellectual capital. Higher R&D investments and technical graduates mean a lower risk to energy security.

and many of these related metrics rise and fall at the same times in the historic record, a situation that could introduce a bias in the Index. However, it is important to note that seemingly related metrics can often diverge at some point in the historical record or future. Furthermore, a procedure for weighting each metric avoided giving undue influence in the overall Index to metrics that on the surface appear similar.

Because the metrics are measured in many different units, it was necessary to transform them into comparable "building blocks" that could be assembled into the composite Geopolitical, Economic, Reliability, and Environmental Sub-Indexes and, ultimately, a single comprehensive Index of U.S. Energy Security Risk. To achieve this, the 1970 to 2040 time series for each metric was normalized into an index by setting the value for the year 1980 at 100 and setting the values for all other years in proportional relation to 1980 value, either higher or lower so that the trend lines remains the same. This normalizing procedure simply places all the metrics into a common unit that it preserves the trend as well as the relative movement up or down of each metric over time.

Setting each individual metric so that 1980 equals 100 also means that the Geopolitical, Economic, Reliability, and Environmental Sub-Indexes as well as the overall Index built from them will have a 1980 value of 100. The year 1980 was selected because an initial analysis of the metrics suggested that it reflected the worst year overall for U.S. energy security since 1970.[1]

1 This does not mean that 1980 necessarily represents the worst year for each individual metric or even for the Geopolitical, Economic, Reliability, and Environmental Sub-Indexes. Some metrics display

With some metrics, additional transformations were needed beyond this normalization procedure. The Index is designed so that a lower value represents an improvement in energy security while a higher value represents deterioration in energy security. This makes sense because for most of the metrics used, a declining trend is better for U.S. energy security than a rising trend. There are, however, some metrics where a rising trend signals a declining risk. When creating the normalized index for these metrics, various techniques were used to invert or "flip" the metric so that its index value moves in the opposite direction of its measured value, that is, increases became decreases and vice versa.[2] Additionally, some of the metrics required further transformations to reflect non-linearities in the scale.[3]

EIA's Annual Energy Outlook 2015 (AEO 2015) was the primary source for metric forecasts out to 2040. AEO 2015 projections, however, are not available for all of our metrics. In these cases, a neutral assumption was adopted and the last year of available data was extended over the forecast period.[4] All of these data transformations are discussed in detail in the documentation material available on the Energy Institute's web site.

Using the Metrics to Create Four Sub-Indexes of Energy Security Risk

Within our broad definition of energy security, four areas of concern were identified: (1) geopolitical; (2) economic; (3) reliability; and (4) environmental. While there are no "bright lines" delineating these categories, they nonetheless provided a reasonable framework around which to develop Sub-Indexes that when combined create the overall Index of U.S. Energy Security Risk.

higher (worse) values in years other than 1980, but in the composite Index for the United State, these are offset by lowers values for other metrics leading to an overall score of 100, the highest in the record for the composite Index.

2 For example, while a decline in energy use per unit of economic output would decrease energy security risks, a decline in energy R&D expenditures would increase risks.

3 For example, in cases where movement of a metric above or below a specific range of values does not change the risk in any meaningful way.

4 Similarly, on those few occasions where data for the metric did not extend all the way back to 1970, the last year of available data was "back cast" to 1970.

- **Geopolitical:** Petroleum is a globally-traded commodity with a supply that is concentrated in a relative handful of countries. Natural gas also is increasingly becoming a globally-traded commodity, and it too is fairly well concentrated, with about 70% of proven reserves located in the Middle East, Russia, and other former Soviet Union states. Trade in coal is more regional, but as China, India, and other large economies expand, it also may become a more international commodity. For both oil and gas, several of the top reserve-owning countries have uncertain political stability and are at best reluctant business partners with the United States. Dependence upon these fuel sources—for both the United States and the rest of the world—poses political and military risks. Because international disputes can quickly turn into energy problems, and vice versa, energy necessarily occupies a consequential role in U.S. foreign policy.

- **Economic:** With a large part of U.S. national income being spent on energy, price volatility and high prices can have large negative national impacts that crimp family budgets and idle factories. Over the longer-term, high energy prices can diminish our national wealth and provoke energy-intensive industries to migrate to other countries. Since much of U.S. petroleum consumption is supplied by imports, the Nation's trade balance is affected by hundreds of billions of dollars each year spent on imported oil.

- **Reliability:** Disruptions to energy supplies—whether natural or man-made, accidental or deliberate—entail high costs. Long-distance supply chains, including tankers and pipelines, are vulnerable to accidents and sabotage. Oil and gas fields located in weather-sensitive areas can be knocked out of service. Inadequate and outdated electrical grids can overload and fail. Lack of adequate electricity generation or refinery capacity can cause shortages and outages. These reliability considerations, in turn, have economic and even geopolitical consequences.

- **Environmental:** Fossil fuels—coal, oil, and gas—dominate the U.S. energy system. Combusting these fuels releases carbon dioxide, and these emissions comprise about four-fifths of total gross U.S. greenhouse gas emissions. Climate change poses risks related both to the actual impacts of climate change and to the economic and energy market impacts of taking actions to reduce GHG emissions. These risks and uncertainties are appropriately included as part of an assessment of energy security.

In determining the metrics that should be selected to build the Geopolitical, Economic, Reliability, and Environmental Sub-Indexes, the relevance of each metric to each of the four Sub-Indexes had to be established as well as the weight each metric should be accorded. In general, the aim was to develop a set of weightings that reflected not only each metric's intrinsic characteristics, but also provided a balance across sectors and within groups of metrics.

The weightings were applied as fixed values that remain unchanged over the 1970 to 2040 period. Both analysis and expert judgment were relied on in setting the appropriate weights. Those metrics considered of greater importance within a Sub-Index were given a greater weighting than those considered of lesser importance. It is also important to note that the importance of an individual metrics can differ across different Sub-Index categories, so when the same metric is used in two or more Sub-Indexes, its weighting might be different in one Sub-Index compared to another.

To arrive at the Sub-Indexes, the weightings were applied to each metric within each of the four areas to calculate essentially a weighted average of all the metrics selected for that group. The resulting weighted average is the energy security Sub-Index number.

As with the individual metric indexes, a lower Sub-Index number indicates a lower risk to U.S. energy security, a higher number a greater risk. Since each of the individual metrics has been normalized to a scale where its value for the year 1980 equals 100, all four Sub-Indexes also have a value for the year 1980 equaling 100.

Using the Four Sub-Indexes to Create an Index of U.S. Energy Security

The final step was to merge the four Sub-Indexes into an overall annual Index of U.S. Energy Security Risk for each year from 1970 to 2040. To do this, the input share of each of the four Sub-Indexes to the final overall Index was weighted and apportioned as follows:

- Geopolitical 30%
- Economic 30%
- Reliability 20%
- Environmental 20%

These values were used to arrive at a weighted average of the four Sub-Indexes.[5] The resulting number represents the overall Index of U.S. Energy Security Risk.

As with the weightings applied to the individual metrics in the Sub-Indexes, these weightings are unchanged over the entire 70-year period the Index covers. The weightings used to create the Energy Institute's Index are intended to give substantial weight to each of the four Sub-Indexes but to give slightly more weight to the geopolitical and economic risks that, for good reason, tend to dominate much of the public debate on energy security.

Like the individual metric indexes and the four Sub-Indexes, the year 1980 is set at 100. Although at 100, 1980 represents the worst year in historical record, this level is not a cap—the scale is open-ended. Whether future values approach or exceed this high point will be determined in large part by developments in U.S. policy, international politics, energy markets, technology, and many other factors.

Methodological and Data Revisions to the 2015 Edition

The Index includes 37 different metrics, each for the period of 1970 through 2040. In addition to being a meaningful element for reflecting risk, each metric needs to be based on data that were sensible, credible, accessible, transparent, complete, prospective, and updatable. Numerous data sets, from several different agencies and sources, were brought into this effort. Each year, we review the metric definitions, their weightings and contributions to the Index, and the data sources used in their implementation. From time to time, changes are made to the methodology to reflect changes to the data sources, as well as improved approaches for using the data.

5 To arrive at the Index, each Sub-Index was multiplied by its percentage weighting, and the products of these calculations were added together.

These changes are for the most part minor, and do not affect the findings presented here. However, they do have small effects on some of the specific values, so that a comparison of the 2015 Index may show small deviations from earlier editions. For the 2015 Index, these changes include the following.

- **Historical GDP Revision (several intensity metrics).** GDP is used in the formulation of several metrics, usually as the denominator. In 2014, the Department of Commerce's Bureau of Economic Analysis revised the historical GDP series going back several decades to reflect a different accounting for R&D. But since at that time, *AEO* 2014 used the older GDP series in the projections, we continued to use the pre-revision GDP for consistency. This year, both the historical data and the *AEO* 2015 use the new GDP series. The GDP differences are modest, but go up to 3.5% more than before, with the difference being more pronounced in recent years.

- **Security of World Production for Oil, Natural Gas, and Coal (Metrics 1, 3, and 5):** These metrics take into account the composite diversity and freedom of the world's production, weighted by each country's production. Previously, we had calculated these measures using each country's production in physical quantities such as barrels of oil, billion cubic feet of natural gas, and million tons of coal. We are now making these calculations using Btu production rather than physical quantities, as this provides a better measure of energy activity and is more consistent with measures for import dependence and metrics used in the International Index. The effect on oil and natural gas measures is modest, as the range of Btu per physical unit tends to be narrow. But for coal, there are larger differences in the average Btu per ton.

- **Net Import Expenditures for Oil and Natural Gas (Metrics 9 and 10):** The previous methodology used historical data from the Bureau of the Census on U.S. International Trade in Goods and Services, showing dollar values of imports and exports of crude oil, petroleum products, and natural gas. These historical data were matched to *AEO* dollar projections for Net Expenditures for Imported Crude Oil and Petroleum products, plus a natural gas estimate based on net import volumes and unit price. It has since been learned that the *AEO* dollar projections do not fully reflect some of the export values, which for the US have been growing rapidly. Accordingly, our new methodology has been changed to no longer rely on the historical Census data and *AEO* projections for net import expenditures, and instead develops dollar estimates for both imports and exports of oil and gas based on physical volumes and average unit prices. Historically, the revised values are still quite close to the historical Census data, while the projections capture more fully the growing US export role.

- **Crude Oil Prices (Metric 14):** For Crude oil prices, we had previously used an approach based on Refiner's Acquisition Costs (RAC). The approach used now is based primarily on the Brent price, which is more readily aligned with oil price projections presented in the *AEO*. Brent prices tend to average a little higher than average RAC in $/barrel terms, but when indexed to a 1980-100.0 basis show little difference. For 1970-1972, the new approach results in lower prices for those years, and a better reflection of the jump in prices seen in subsequent years.

- **Commercial Energy Efficiency (Metric 23):** The denominator of this metric is commercial square footage. Historical data and the basis for the AEO projections had been based on the 2003 Commercial Building Energy Consumption Survey (CBECS), last published by EIA for 2003. We now have CBECS survey data for 2012, and it shows an increase in commercial square footage (and hence a lower energy intensity) from what the earlier CBECS survey and the AEO showed. Since the AEO 2015 has not yet incorporated these new data, however, use of the 2012 CBECS would create a disconnect between historical and projected data. As such, this year's Index continues to be based on the earlier CBECS data. For the 2016 Index, when the AEO is updated to reflect the new data, we will similarly do so, with the likely effect that the commercial energy efficiency will be better than what we've been showing.

Appendix 2: Metrics and Data Tables

Appendix 2 presents and describes the individual metrics used to define, quantify, and construct the Sub-Indexes and Index of U.S. Energy Security Risk. Nine types of metrics were selected covering a wide range of energy supplies, energy end-uses, operations, and environmental emissions covering the years 1970 to 2040. The nine types of metrics categories are as follows:

1. Global Fuels
2. Fuel Imports
3. Energy Expenditures
4. Price & Market Volatility
5. Energy Use Intensity
6. Electric Power Sector
7. Transportation Sector
8. Environmental
9. Research & Development

The following information is provided for each metric:

- **Definition:** Describes what is being measured and the units of measurement.
- **Importance:** Describes the potential impact and risks associated with each metric.
- **Category of Metric:** Identifies the metric as one of nine broad types of metrics.
- **Historical and Forecast Values:** Provides two charts: one that shows the metric in its units of measurement and another that shows the metric as a normalized index in which 1980 equals 100. Historical values are in blue and forecast values are in red. Lighter shades of blue or red indicate assumed data or combined forecast/assumed data.
- **Observations:** Provides a brief overview of major trends, policies, and events that contributed to the observe trends in the metric.
- **Weighting and Average Historical Contribution of Metric to Energy Security Indexes:** Provides a table with: (1) the weight each metric was assigned in creating each of the four Sub-Indexes and its average weight for the total U.S. Index and (2) the average historical contribution of each metric to the resulting Sub-Index value. These weights are given as percentages. The weight assigned to each metric is an input measure, and it remains the same for each year over the entire period (both historical and forecast). The average historical contribution (1970-2013) of each metric to the Sub-Index and Index values is an output measure. It can and does change from year-to-year as the metric moves up or down in relation to other metrics.
- **Primary Data Sources:** Lists government and other sources used to compile the metric.
- **Data Issues:** Describes briefly how the metric data were manipulated, where necessary, to arrive at the annual metric values and metric indexes and how gaps and discontinuities in the data were resolved.

Additionally, the annual data for each metric as well as the four Sub-Indexes and Index are provided in two sets of tables that follow the metric summaries. The first set lists the values for each of the metrics in the units in which it was measured. The second set of tables lists the values for each of the metrics as an index, with the value for the year 1980 pegged at 100 and the values for all other years set in relation to 1980 value, either higher or lower.

Data references used to develop the metrics are listed at the end of this appendix.

Acronyms

AEO	*Annual Energy Outlook*
AER	*Annual Energy Review*
API	American Petroleum Institute
ARRA	American Recovery and Reinvestment Act
BEA	Bureau of Economic Analysis
BP	British Petroleum
Btu	British thermal unit
CBECS	Commercial Buildings Energy Consumption Survey
CO2	carbon dioxide
EIA	Energy information Administration
EISA 2007	Energy Independence and Security Act of 2007
EPAct 2005	Energy Policy Act of 2005
FRB	Federal Reserve Board
FSU	Former Soviet Union
GDP	gross domestic product
HHI	Herfindahl-Hirschman Index
IEA	International Energy Agency
IEO	*International Energy Outlook*
IP Index	Industrial Production Index
IPEDS	Integrated Postsecondary Education Data System Completions Survey
kWh	kilowatt hour
MER	*Monthly Energy Review*
mpg	miles per gallon
NERC	North American Electric Reliability Council
NSF	National Science Foundation
O&G Journal	*Oil & Gas Journal*
SPR	Strategic Petroleum Reserve
UAE	United Arab Emirates
UK	United Kingdom
USSR	Union of Soviet Socialist Republics
VMT	vehicle-miles traveled

METRIC #1

Security of World Oil Reserves

Definition

Global proved oil reserves in billions of barrels weighted by (1) each country's Freedom House freedom ranking and (2) a diversity index applied to global oil reserves.

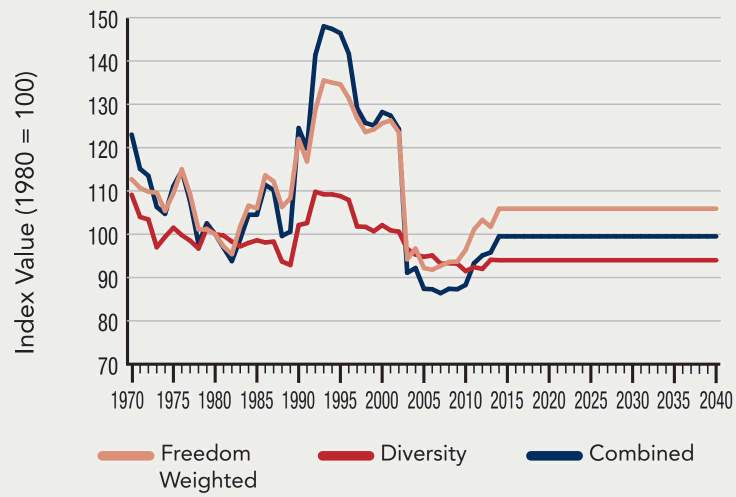
Importance

Indicates risk attached to the average barrel of global crude oil reserves. As a measure of reserves and not production, it largely reflects longer-term concerns.

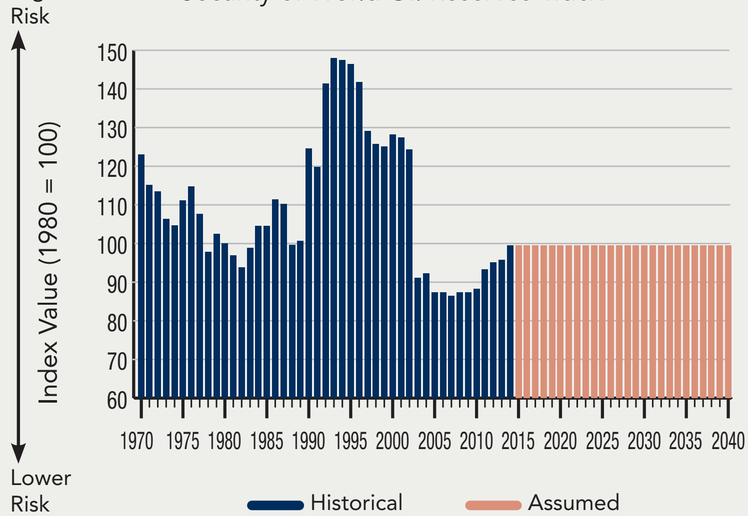
Category of Metric

Global Fuels

Historical and Forecast Values (1970-2040):
Security of World Oil Reserves Trends



Index (1970-2040):
Security of World Oil Reserves Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	9.0	N/A	N/A	N/A	2.7
Average Contribution	11.8	N/A	N/A	N/A	3.5

METRIC #2

Security of World Oil Production

Definition

Global oil production weighted by (1) each country's Freedom House freedom ranking and (2) a diversity index applied to global oil production.

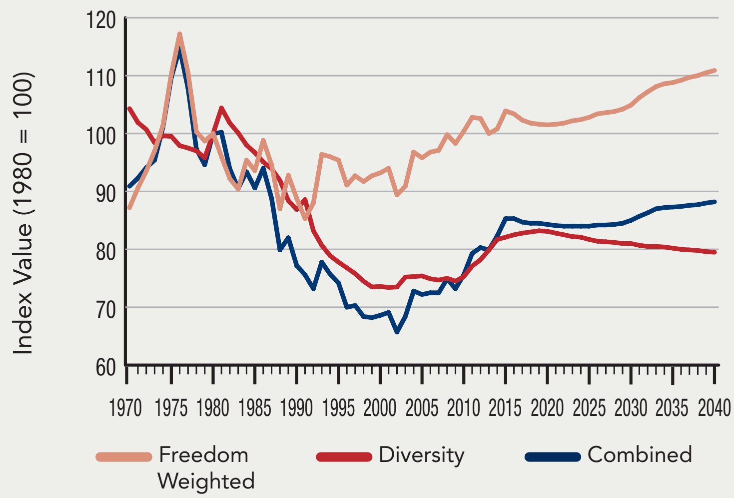
Importance

Indicates the level of risk attached to the average barrel of crude oil produced globally.

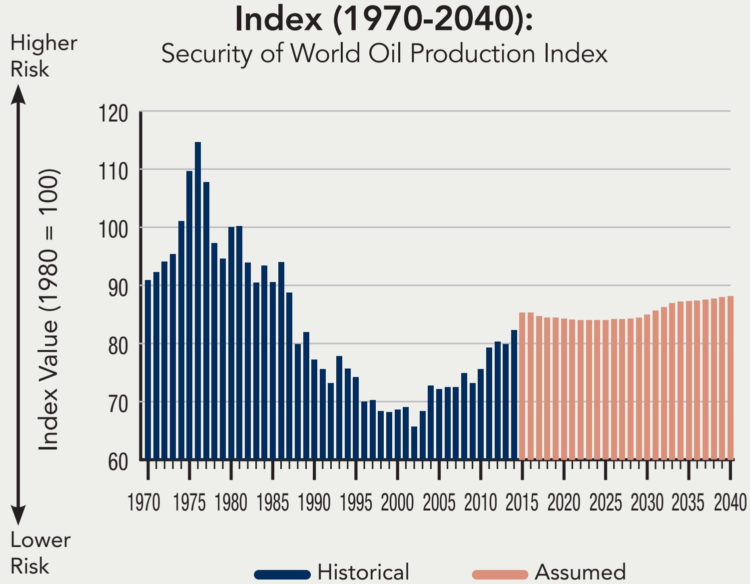
Category of Metric

Global Fuels

Historical and Forecast Values (1970-2040):
Security of World Oil Production Trends



Index (1970-2040):
Security of World Oil Production Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	7.0	5.0	6.0	N/A	4.8
Average Contribution	6.9	5.5	5.6	N/A	4.7

METRIC #3

Security of World Natural Gas Reserves

Definition

Global proved natural gas reserves weighted by (1) each country's Freedom House freedom ranking and (2) a diversity index applied to global gas reserves.

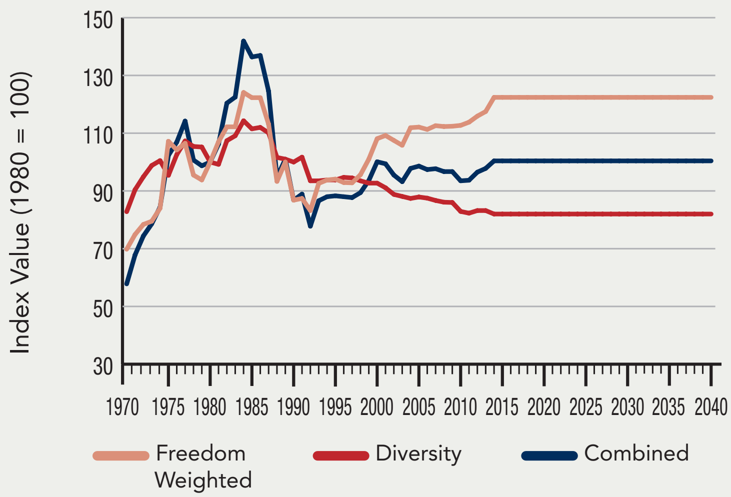
Importance

Indicates the risk attached to the average cubic foot of natural gas reserves globally. As a measure of reserves and not production, it largely reflects longer-term concerns.

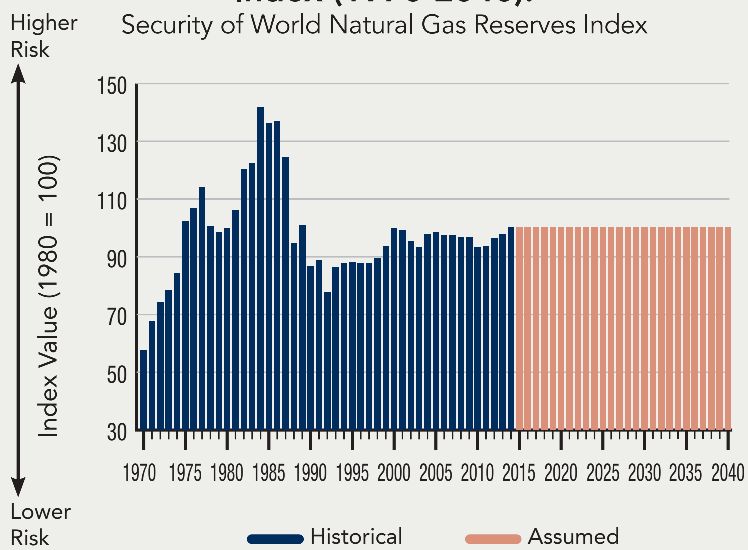
Category of Metric

Global Fuels

Historical and Forecast Values (1970-2040):
Security of World Natural Gas Reserves Trends



Index (1970-2040):
Security of World Natural Gas Reserves Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	6.0	N/A	N/A	2.0	2.2
Average Contribution	6.9	N/A	N/A	2.0	2.5

METRIC #4

Security of World Natural Gas Production

Definition

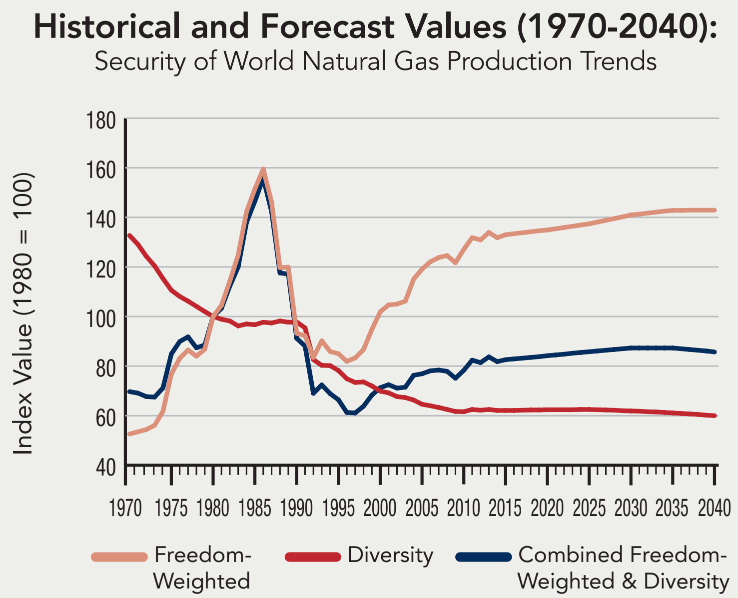
Global natural gas production weighted by (1) each country's Freedom House freedom ranking and (2) a diversity index applied to global natural gas production.

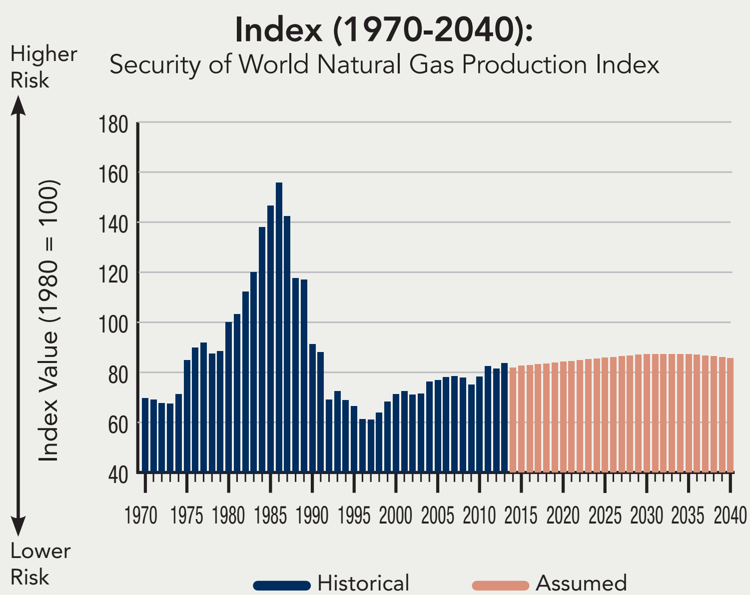
Importance

Indicates the level of risk attached to the average cubic foot of natural gas produced globally.

Category of Metric

Global Fuels





Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	5.0	2.0	3.0	2.0	3.1
Average Contribution	5.2	2.3	2.9	1.8	3.1

METRIC #5

Security of World Coal Reserves

Definition

Global proven coal reserves weighted by (1) each country's Freedom House freedom ranking and (2) a diversity index applied to global coal reserves.

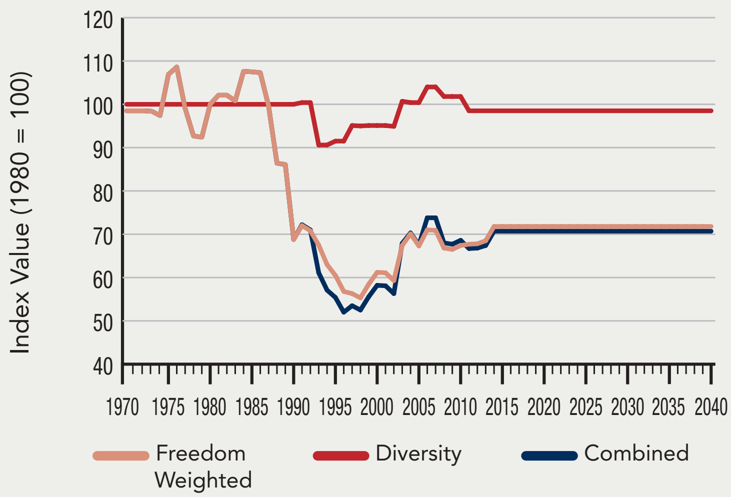
Importance

Indicates the risk attached to the average ton of coal reserves globally. As a measure of reserves, it largely reflects longer-term concerns.

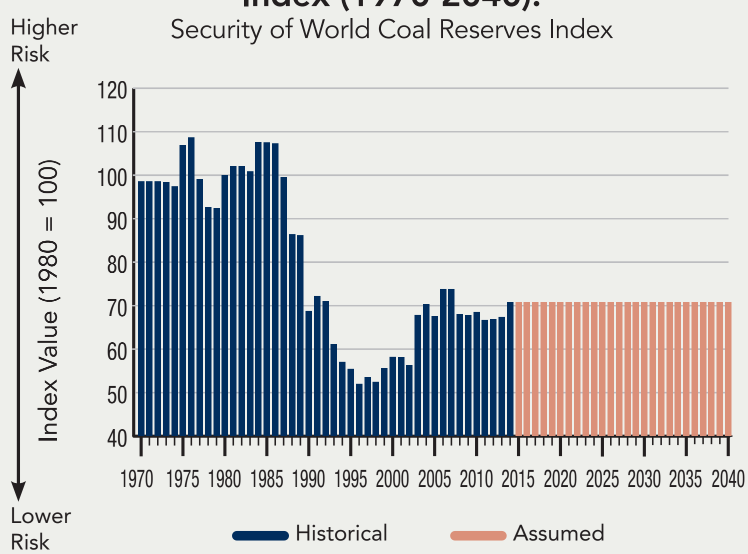
Category of Metric

Global Fuels

Historical and Forecast Values (1970-2040):
Security of World Coal Reserves Trends



Index (1970-2040):
Security of World Coal Reserves Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	4.0	N/A	N/A	N/A	1.2
Average Contribution	3.8	N/A	N/A	N/A	1.1

METRIC #6

Security of World Coal Production

Definition

Global coal production weighted by (1) each country's Freedom House freedom ranking and (2) a diversity index applied to global coal production.

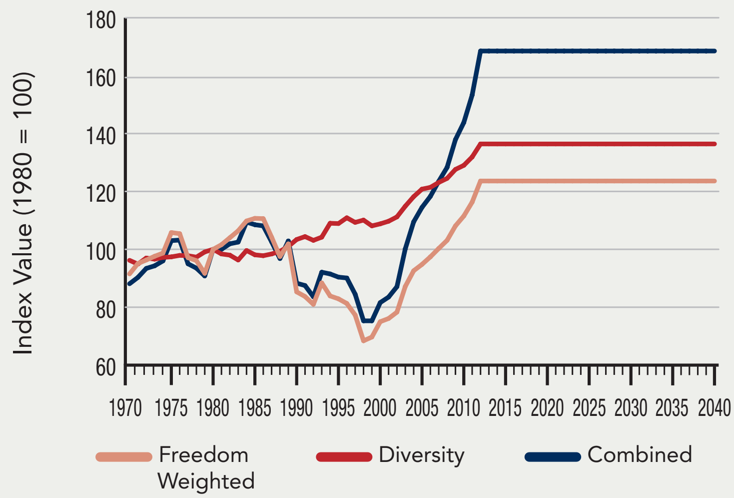
Importance

Indicates the level of risk attached to the average ton of coal production globally.

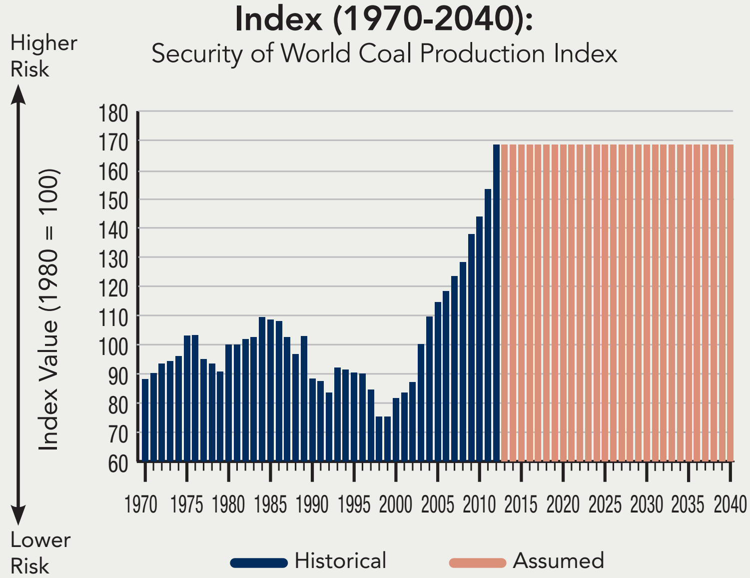
Category of Metric

Global Fuels

Historical and Forecast Values (1970-2040):
Security of World Coal Production Trends



Index (1970-2040):
Security of World Coal Production Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	2.0	1.0	1.0	N/A	1.1
Average Contribution	2.4	1.3	1.1	N/A	1.3

METRIC #7

Security of U.S. Petroleum Imports

Definition

Net petroleum imports as a percentage of total U.S. petroleum supply adjusted to reflect (1) each country's Freedom House freedom ranking and (2) a diversity index applied to non-U.S. oil producing countries.

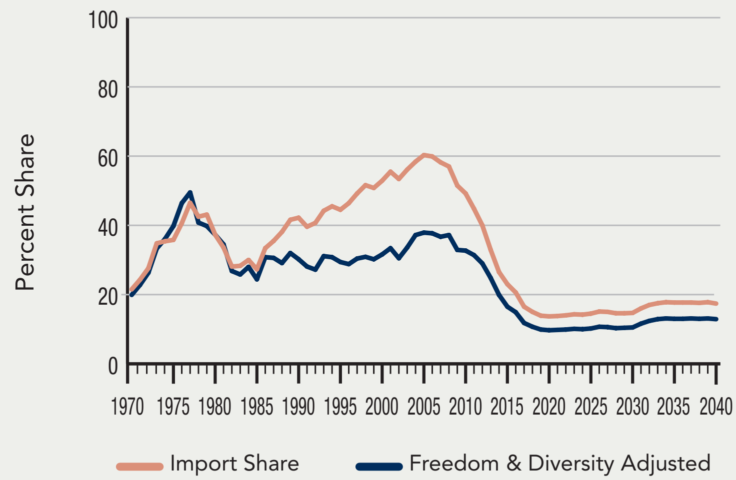
Importance

Indicates the degree to which changes in import levels expose the U.S. to potentially unreliable and/or concentrated supplies of crude and refined petroleum.

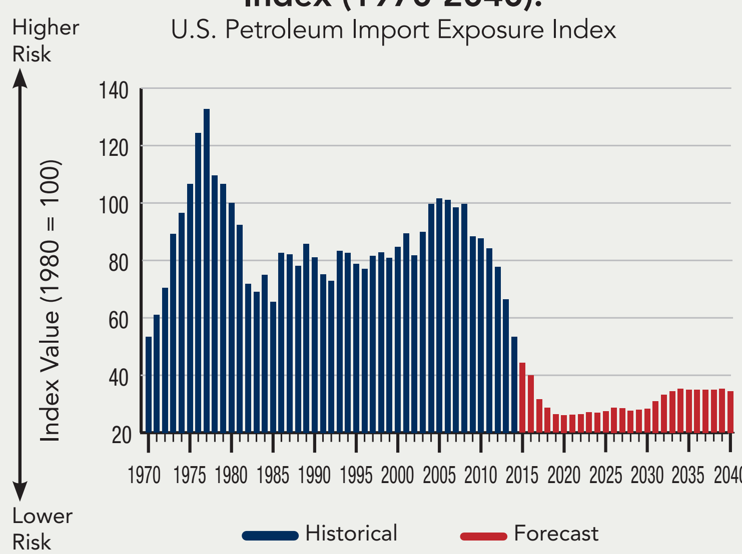
Category of Metric

Fuel Imports

Historical and Forecast Values (1970-2040):
U.S. Petroleum Import Exposure Trends



Index (1970-2040):
U.S. Petroleum Import Exposure Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	8.0	N/A	9.0	N/A	4.2
Average Contribution	8.2	N/A	8.7	N/A	4.3

METRIC #8

Security of U.S. Natural Gas Imports

Definition

Net natural gas imports as a percentage of total U.S. natural gas supply risk-adjusted to reflect (1) each country's Freedom House freedom ranking and (2) a diversity index applied to non-U.S. natural gas producing countries.

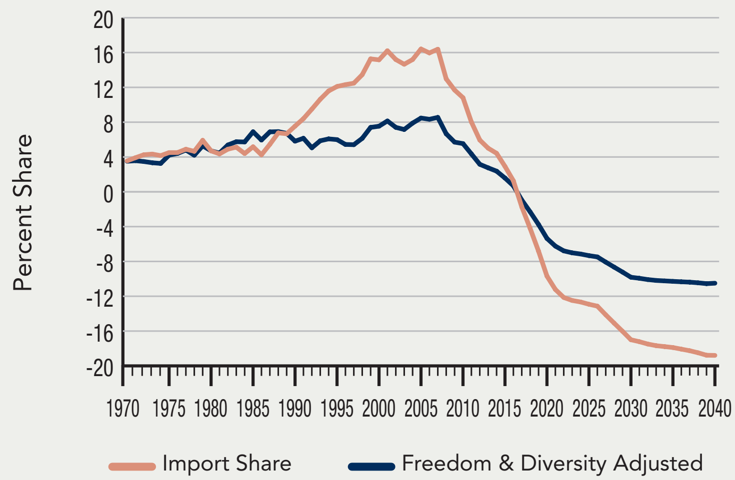
Importance

Indicates the degree to which changes in import levels expose the U.S. to potentially unreliable and/or concentrated supplies of natural gas.

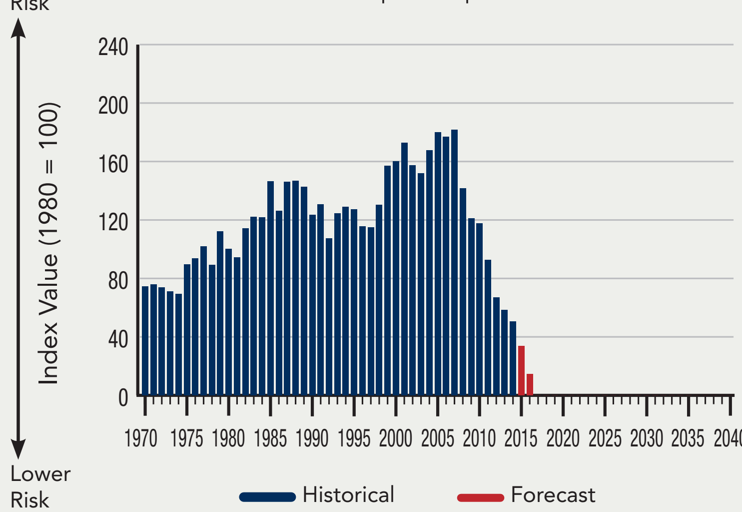
Category of Metric

Fuel Imports

Historical and Forecast Values (1970-2040):
U.S. Natural Gas Import Exposure Trends



Index (1970-2040):
U.S. Natural Gas Import Exposure Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	3.0	N/A	2.0	N/A	1.3
Average Contribution	4.4	N/A	2.7	N/A	1.9

METRIC #9

Oil & Natural Gas Import Expenditures

Definition

Value of net imports of crude oil, petroleum products, and natural gas in billions of real (2010) dollars.

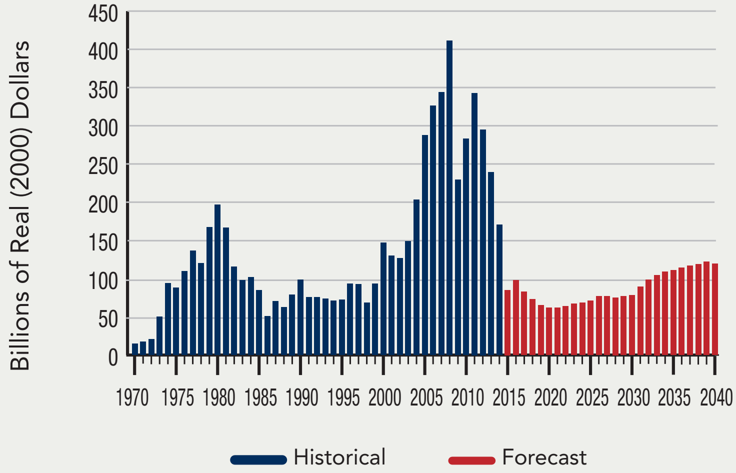
Importance

Indicates lost domestic economic investment and opportunity and the relative magnitude of revenues received by foreign suppliers.

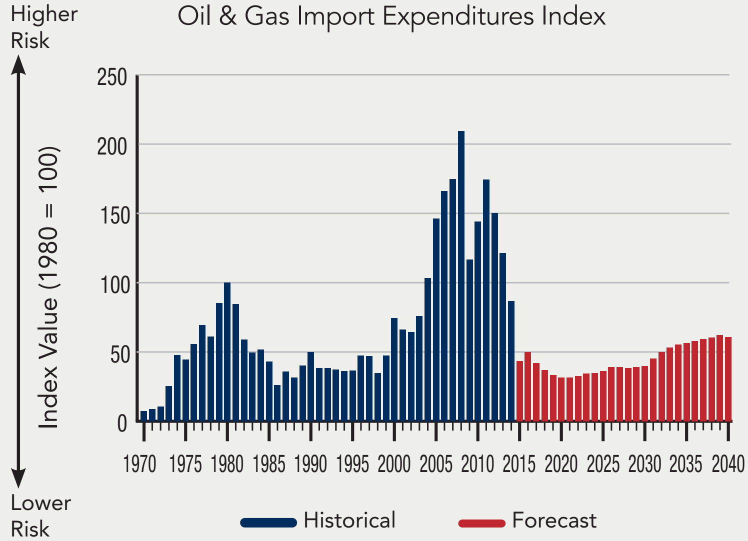
Category of Metric

Fuel Imports

Historical and Forecast Values (1970-2040):
Oil & Natural Gas Import Expenditures



Index (1970-2040):
Oil & Gas Import Expenditures Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	6.0	6.0	N/A	N/A	3.6
Average Contribution	4.8	5.4	N/A	N/A	2.9

METRIC #10

Oil & Natural Gas Import Expenditures per dollar of GDP

Definition

Value of net imports of crude oil, petroleum products, and natural gas as a percentage of GDP.

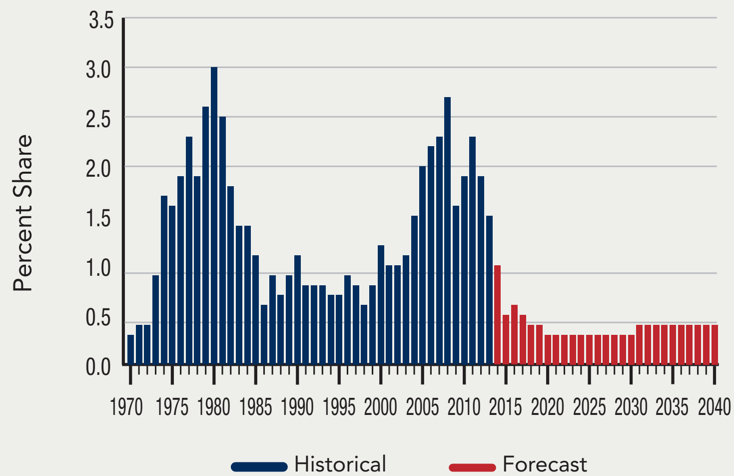
Importance

Indicates the susceptibility of the U.S. economy to imported oil and gas price shocks.

Category of Metric

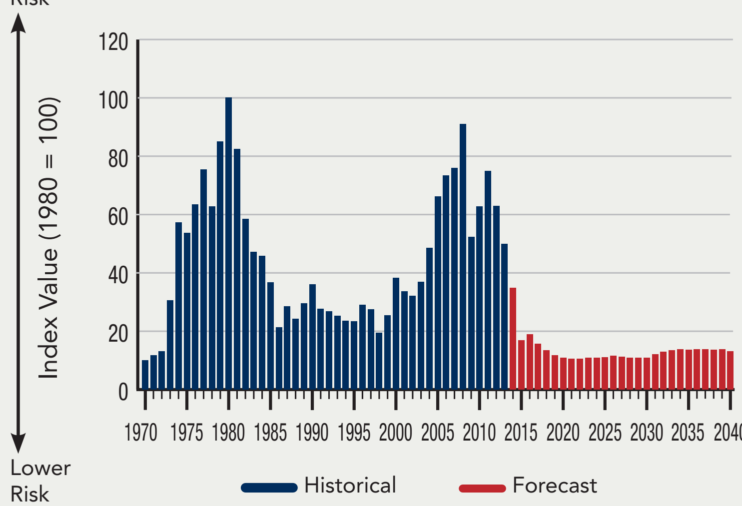
Fuel Imports

Historical and Forecast Values (1970-2040):
Oil & Natural Gas Import Expenditures per GDP



Index (1970-2040):
Oil & Natural Gas Import Expenditures per GDP Index

Higher Risk



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	9.0	N/A	N/A	2.7
Average Contribution	N/A	5.3	N/A	N/A	1.4

METRIC #11

Energy Expenditures per dollar of GDP

Definition

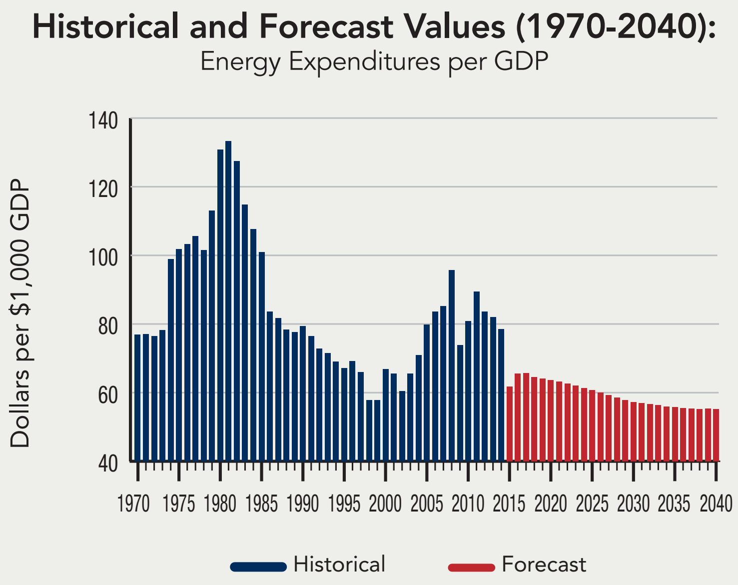
Total real (2010) dollar cost of energy consumed per $1,000 of GDP per year.

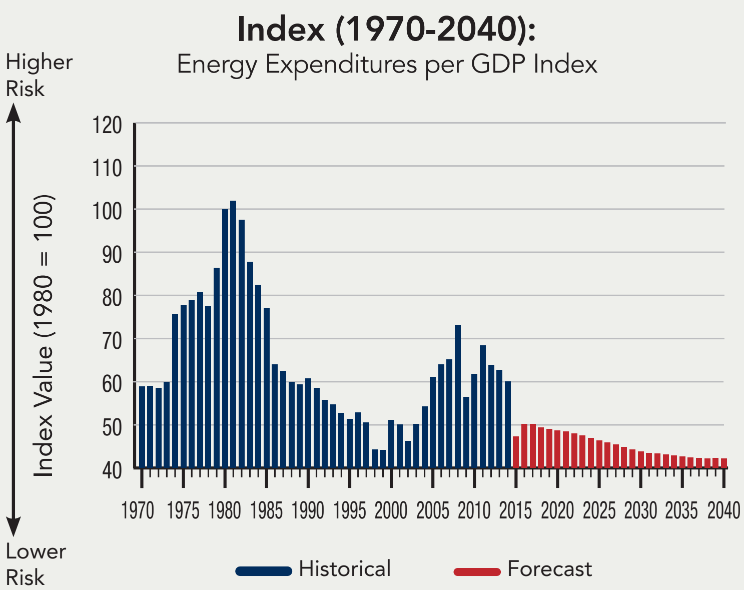
Importance

Indicates the magnitude of energy costs in the U.S. economy and its susceptibility to energy price shocks and exposure to price changes.

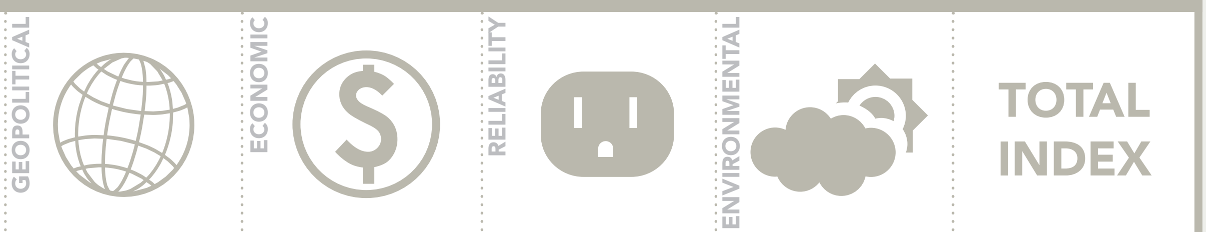
Category of Metric

Energy Expenditures





Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):



	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	5.0	7.0	N/A	N/A	3.6
Average Contribution	3.8	6.0	N/A	N/A	2.7

METRIC #12

Energy Expenditures per Household

Definition

Total real (2010) dollar cost of the energy consumed per household per year.

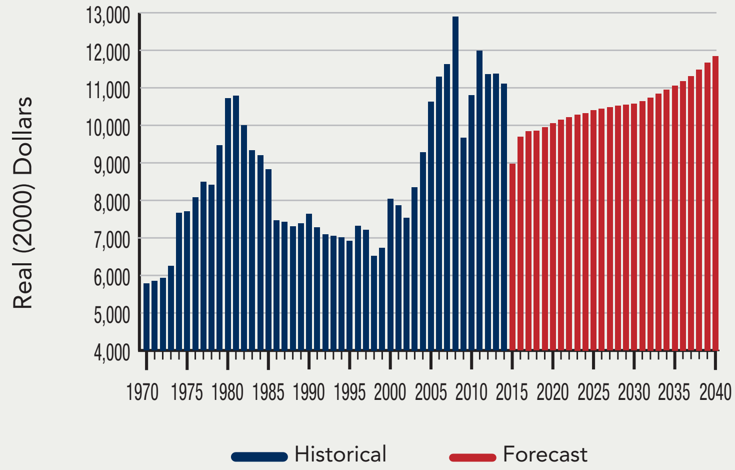
Importance

Indicates the importance of energy in household budgets and the susceptibility of U.S. households to energy price shocks.

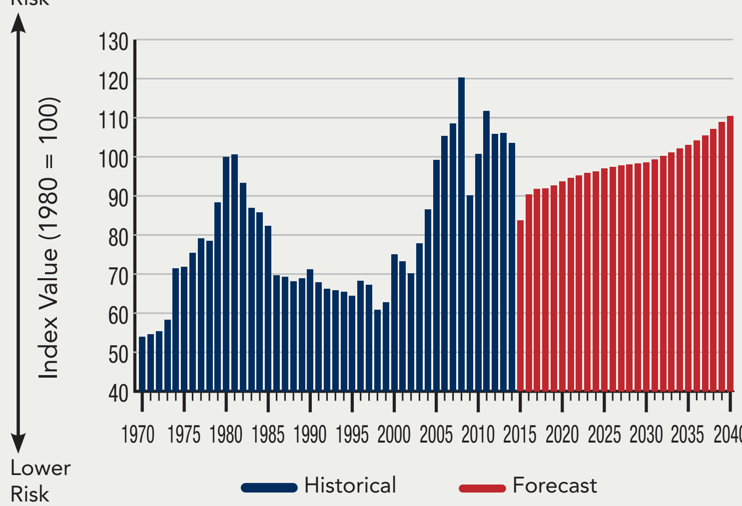
Category of Metric

Energy Expenditures

Historical and Forecast Values (1970-2040):
Energy Expenditures per Household



Index (1970-2040):
Energy Expenditures per Household Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	9.0	N/A	N/A	2.7
Average Contribution	N/A	9.3	N/A	N/A	2.5

METRIC #13

Retail Electricity Prices

Definition

Average electricity costs in the U.S. in cents per kWh in real (2010) dollars.

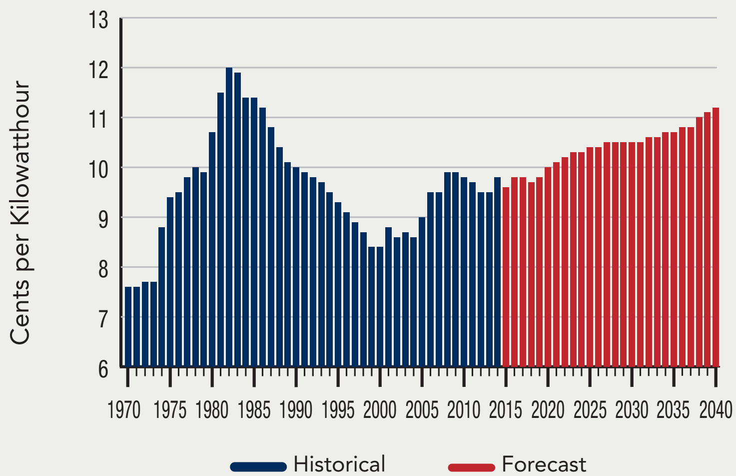
Importance

Indicates the availability of low-cost, reliable forms of power generation.

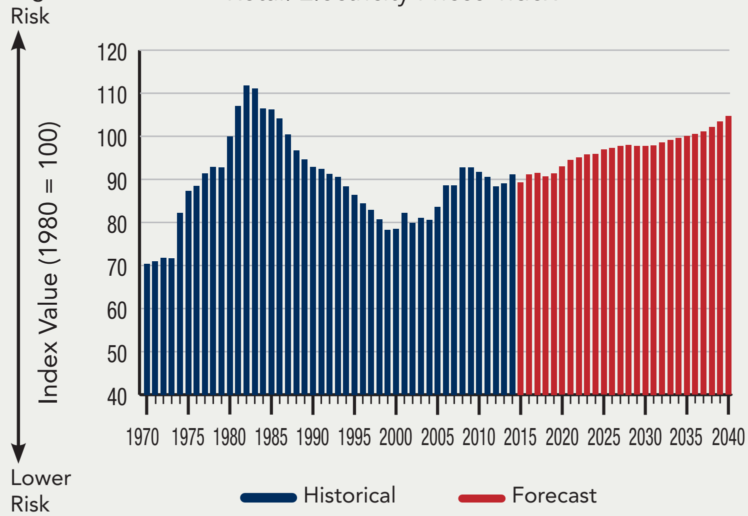
Category of Metric

Energy Expenditures

Historical and Forecast Values (1970-2040):
Retail Electricity Prices



Index (1970-2040):
Retail Electricity Prices Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	10.0	N/A	N/A	3.0
Average Contribution	N/A	11.8	N/A	N/A	3.1

METRIC #14

Crude Oil Prices

Definition

Cost per barrel of crude oil landed in the U.S. in real (2010) dollars.

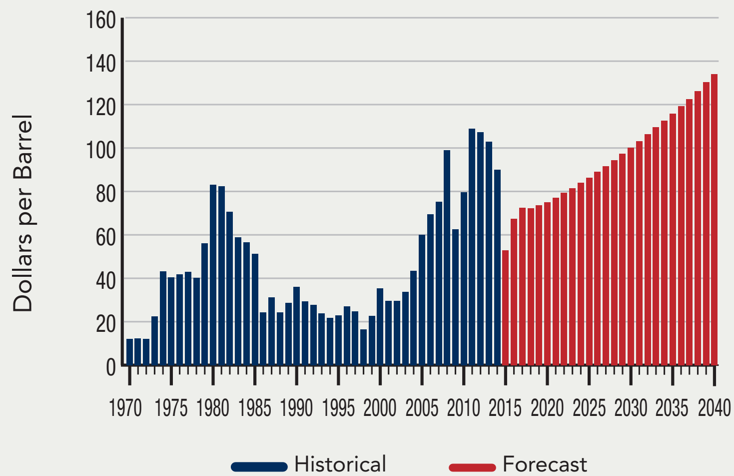
Importance

Indicates the susceptibility of the U.S. economy to high prices for petroleum, which supplies a significant portion of U.S. energy demand.

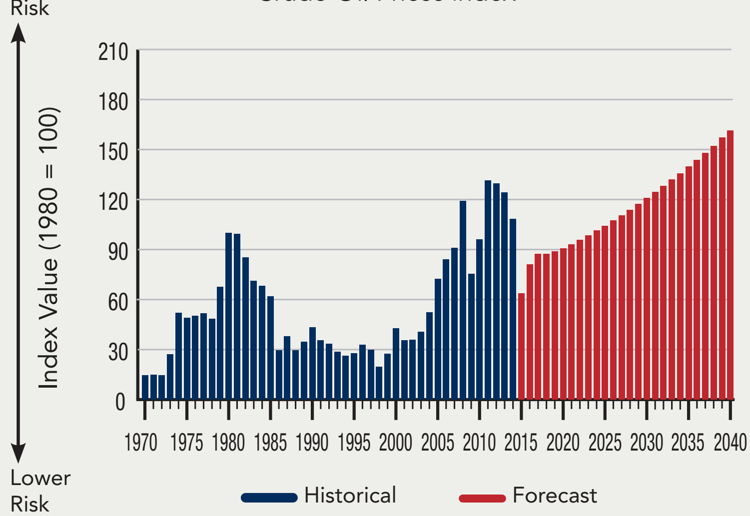
Category of Metric

Energy Expenditures

Historical and Forecast Values (1970-2040):
Crude Oil Prices



Index (1970-2040):
Crude Oil Prices Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	13.0	13.0	6.0	N/A	9.0
Average Contribution	8.0	8.9	3.5	N/A	5.5

METRIC #15

Crude Oil Price Volatility

Definition

Annual change in real (2010) crude oil prices averaged over a three-year period.

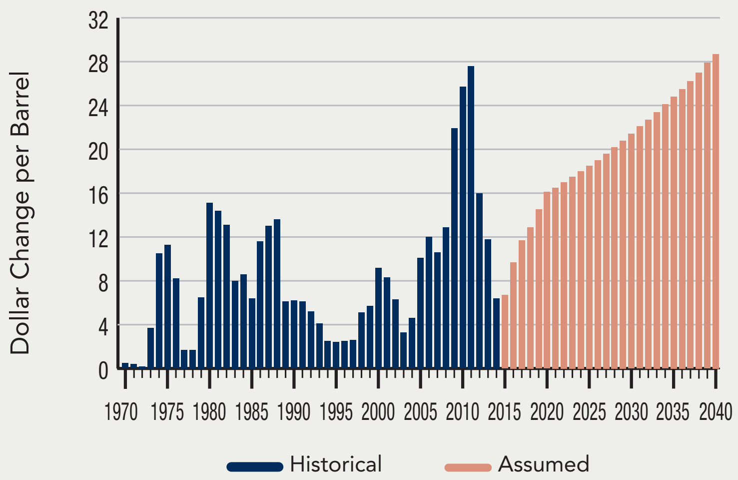
Importance

Indicates the susceptibility of the U.S. economy to large swings in the price of petroleum, which supplies a significant portion U.S. energy demand.

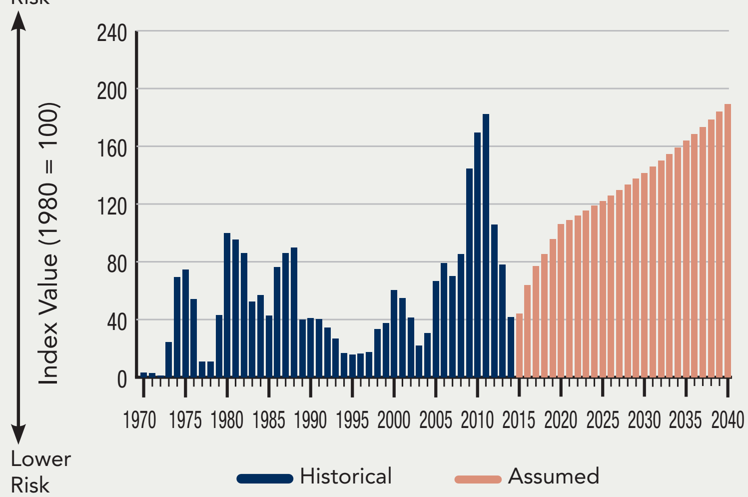
Category of Metric

Price Volatility

Historical and Forecast Values (1970-2040):
Crude Oil Price Volatility



Index (1970-2040):
Oil Price Volatility Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	5.0	3.0	10.0	N/A	4.4
Average Contribution	3.2	2.2	6.1	N/A	2.8

METRIC #16

Energy Expenditure Volatility

Definition

Average annual change in real (2010) U.S. energy expenditures per $1,000 of GDP.

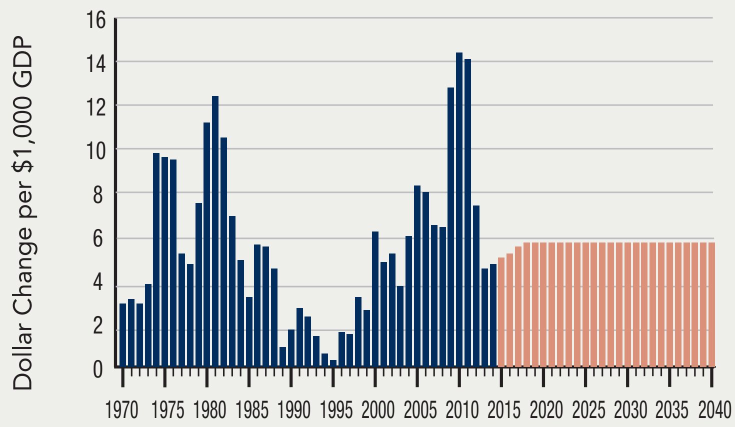
Importance

Indicates the susceptibility of the U.S. economy to large swings in expenditures for all forms of energy.

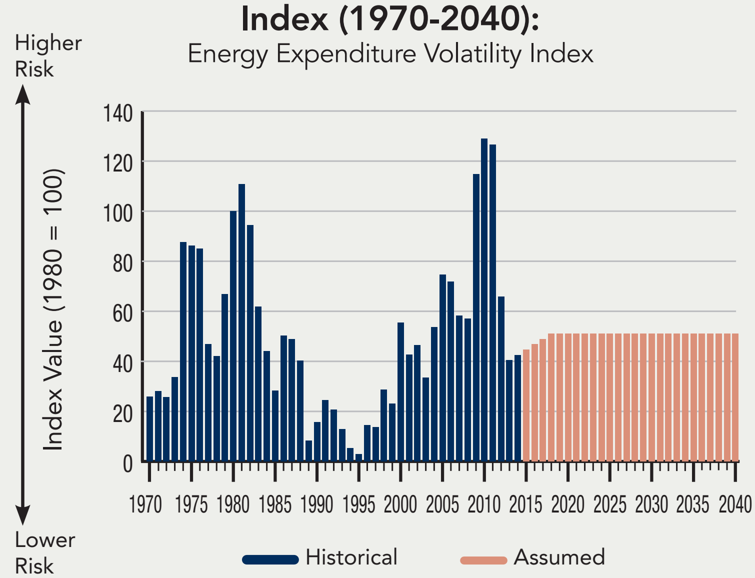
Category of Metric

Price Volatility

Historical and Forecast Values (1970-2040):
Energy Expenditure Volatility



Index (1970-2040):
Energy Expenditure Volatility Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	5.0	14.0	N/A	4.3
Average Contribution	N/A	3.4	7.9	N/A	2.6

METRIC #17

World Oil Refinery Utilization

Definition

Average percentage utilization of global petroleum refinery capacity.

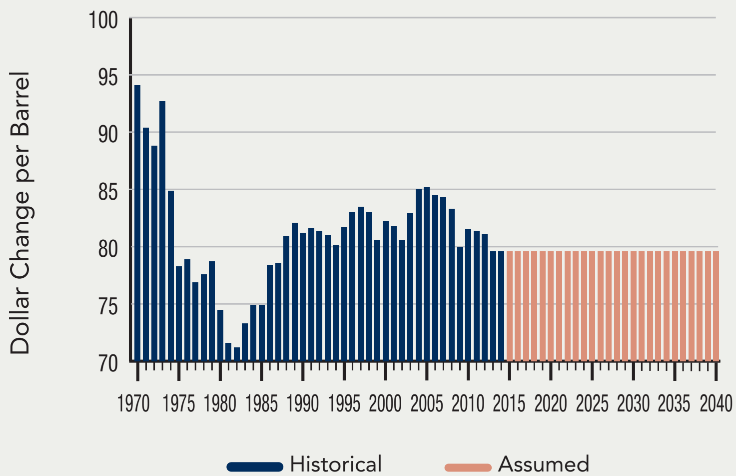
Importance

Indicates the likelihood of higher prices at high capacity utilization, and higher risk of supply limitations during refinery outages or disruptions.

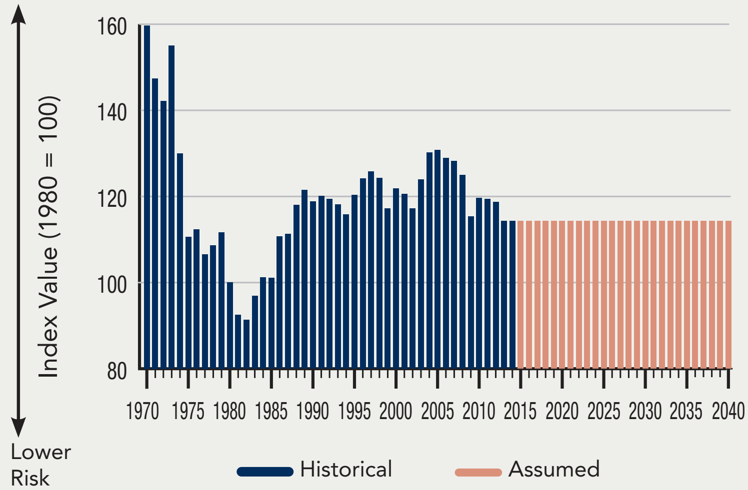
Category of Metric

Price Volatility

Historical and Forecast Values (1970-2040):
World Oil Refinery Utilization



Index (1970-2040):
World Oil Refinery Utilization Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	3.0	N/A	6.0	N/A	2.1
Average Contribution	4.2	N/A	8.0	N/A	2.9

METRIC #18

Petroleum Stock Levels

Definition

Average days supply of petroleum stocks, including strategic petroleum reserve (SPR), non-SPR crude, and petroleum products.

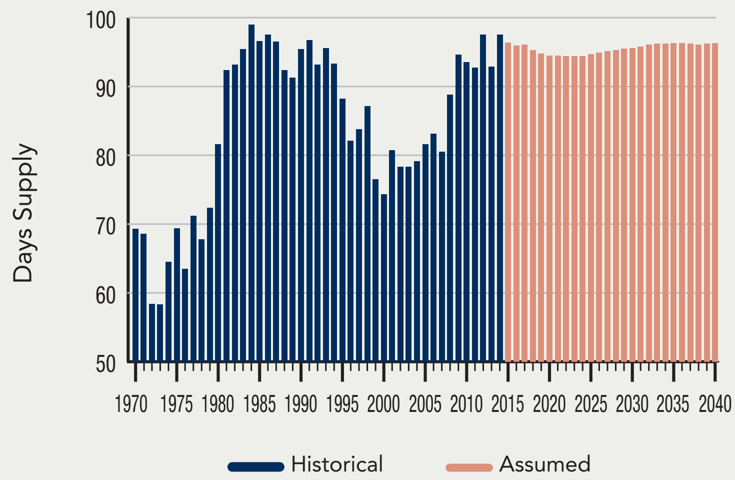
Importance

Indicates vulnerability of the U.S. to a supply disruption based on the quantity of oil stocks that are available domestically to be drawn down.

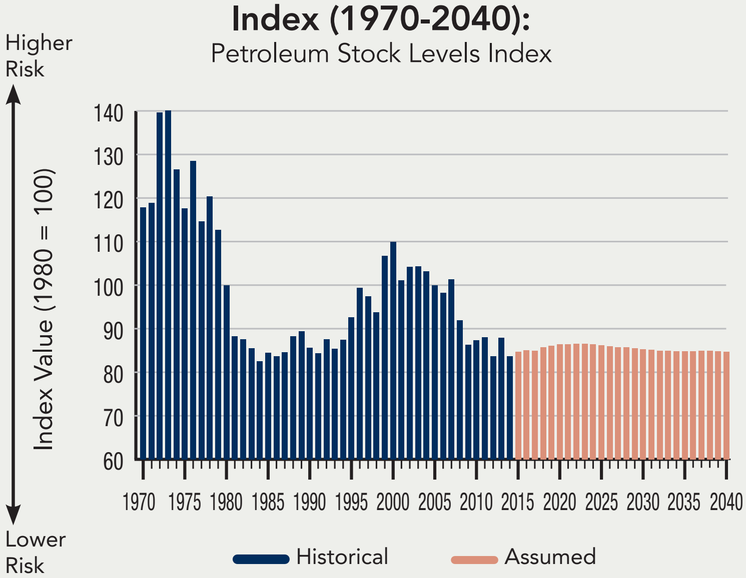
Category of Metric

Price Volatility

Historical and Forecast Values (1970-2040):
Petroleum Stock Levels



Index (1970-2040):
Petroleum Stock Levels Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	2.0	N/A	6.0	N/A	1.8
Average Contribution	2.4	N/A	6.7	N/A	2.1

METRIC #19

Energy Consumption per Capita

Definition

Million Btu consumed per person per year.

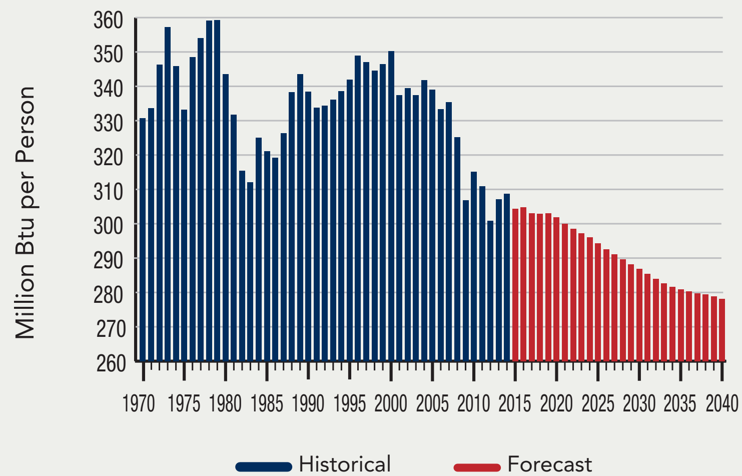
Importance

Indicates changes in both energy intensity and in per-capita GDP.

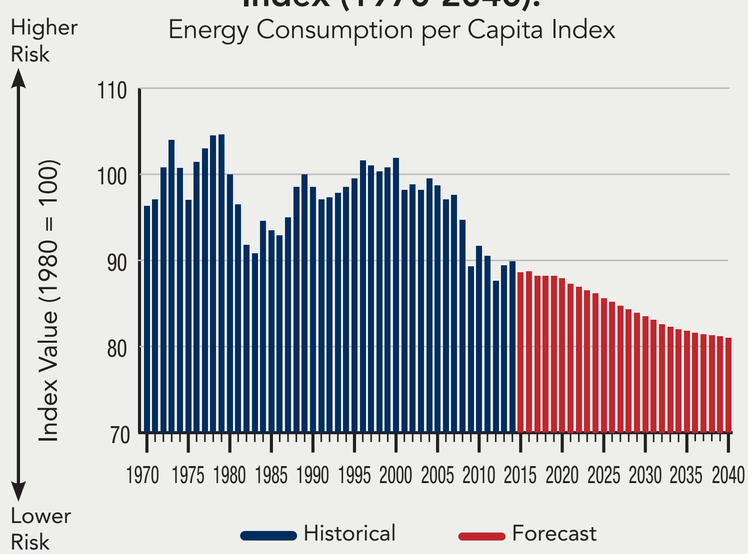
Category of Metric

Energy Use Intensity

Historical and Forecast Values (1970-2040):
Energy Consumption per Capita



Index (1970-2040):
Energy Consumption per Capita Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	3.0	N/A	8.0	2.5
Average Contribution	N/A	3.9	N/A	8.0	2.9

METRIC #20

Energy Intensity

Definition

Million Btu of primary energy used in the economy per $1,000 of real (2010) GDP.

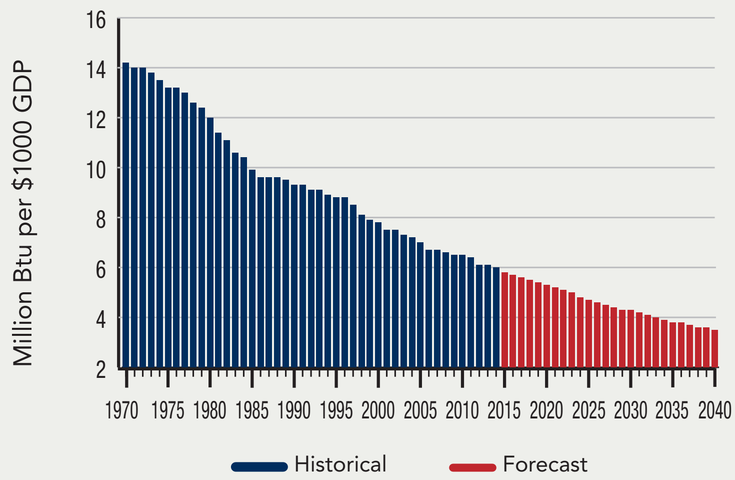
Importance

Indicates the importance of energy as a component of economic growth.

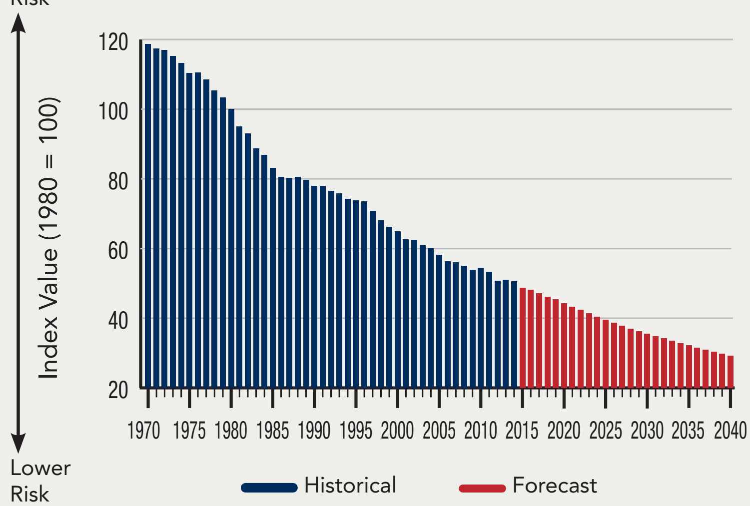
Category of Metric

Energy Use Intensity

Historical and Forecast Values (1970-2040):
Energy Intensity



Index (1970-2040):
Energy Intensity Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	4.0	N/A	10.0	3.2
Average Contribution	N/A	4.3	N/A	8.3	3.0

METRIC #21

Petroleum Intensity

Definition

Million Btu of petroleum consumed per $1,000 GDP in real (2010) dollars.

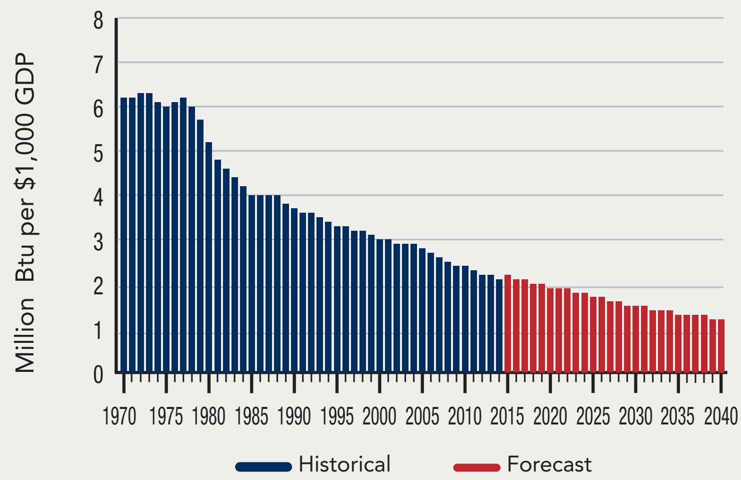
Importance

Indicates the importance of petroleum as a component of economic growth.

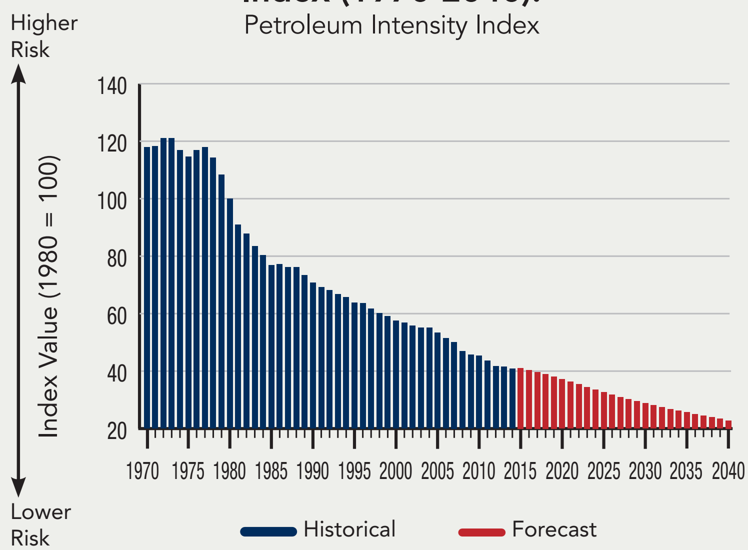
Category of Metric

Energy Use Intensity

Historical and Forecast Values (1970-2040):
Petroleum Intensity



Index (1970-2040):
Petroleum Intensity Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	8.0	3.0	N/A	6.0	4.5
Average Contribution	7.3	3.1	N/A	4.7	4.1

METRIC #22

Household Energy Efficiency

Definition

Million Btu of total energy consumed per household.

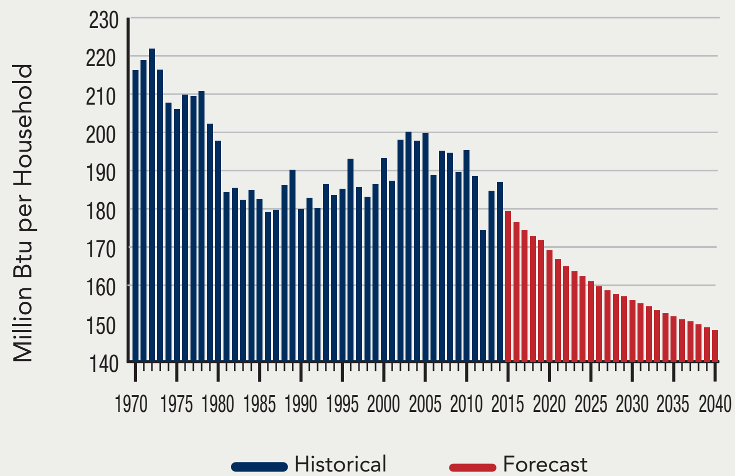
Importance

Indicates the degree to which the typical household uses energy efficiently.

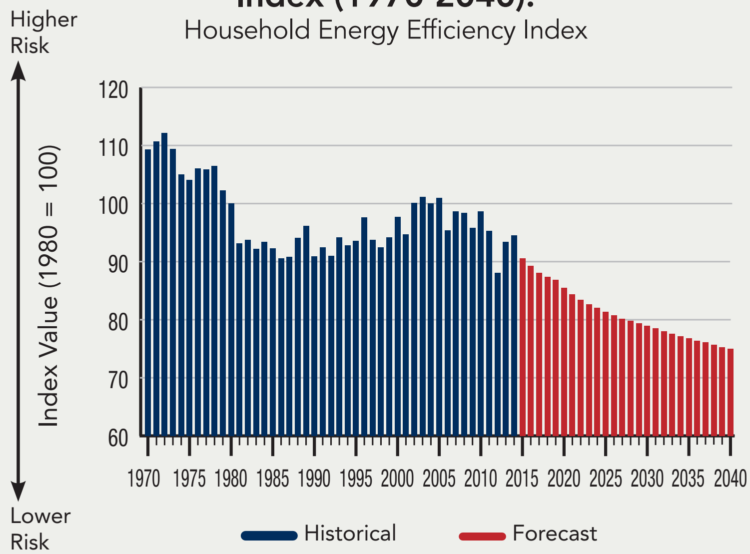
Category of Metric

Energy Use Intensity

Historical and Forecast Values (1970-2040):
Household Energy Efficiency



Index (1970-2040):
Household Energy Efficiency Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	3.0	N/A	4.0	1.7
Average Contribution	N/A	3.9	N/A	4.0	1.9

METRIC #23

Commercial Energy Efficiency

Definition

Million Btu of total commercial energy consumed per 1,000 square feet of commercial floor space.

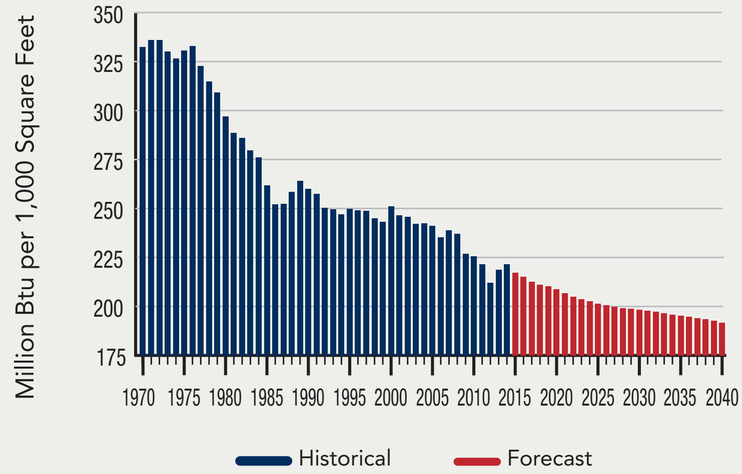
Importance

Indicates the degree to which commercial enterprises use energy efficiently.

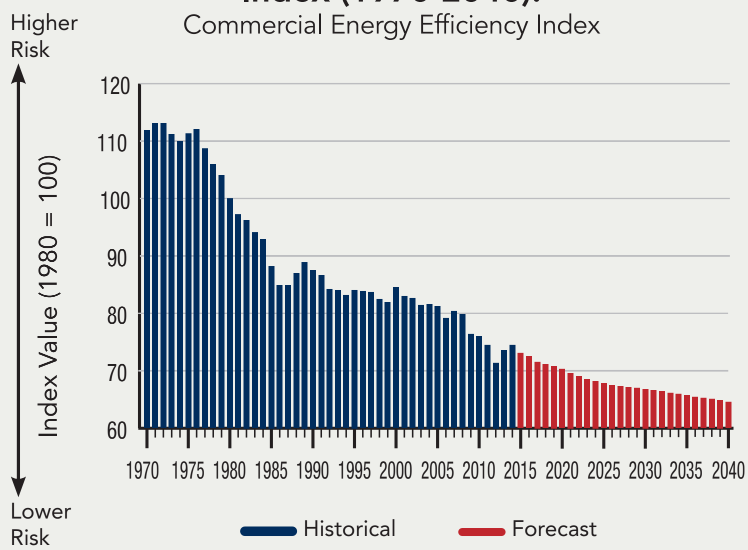
Category of Metric

Energy Use Intensity

Historical and Forecast Values (1970-2040):
Commercial Energy Efficiency



Index (1970-2040):
Commercial Energy Efficiency Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	3.0	N/A	4.0	1.7
Average Contribution	N/A	3.6	N/A	3.7	1.8

METRIC #24

Industrial Energy Efficiency

Definition

Trillion Btu of total Industrial energy consumed per unit of industrial production as measured by the Federal Reserve Bank's Industrial Production (IP) Index.

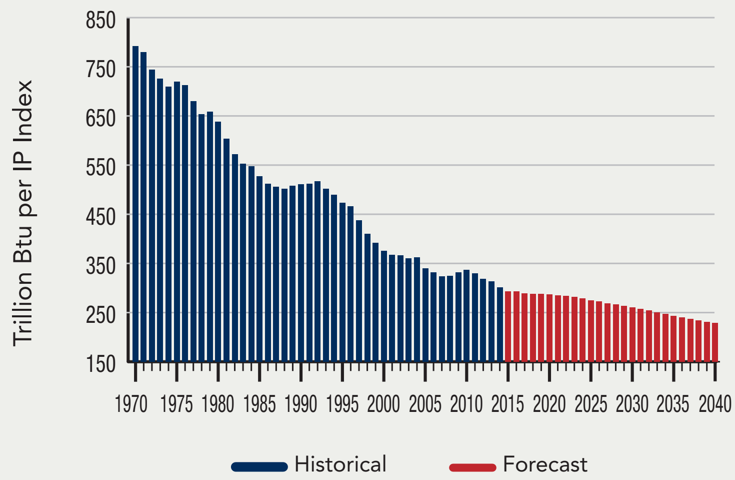
Importance

Indicates the degree to which the typical commercial enterprise uses energy efficiently.

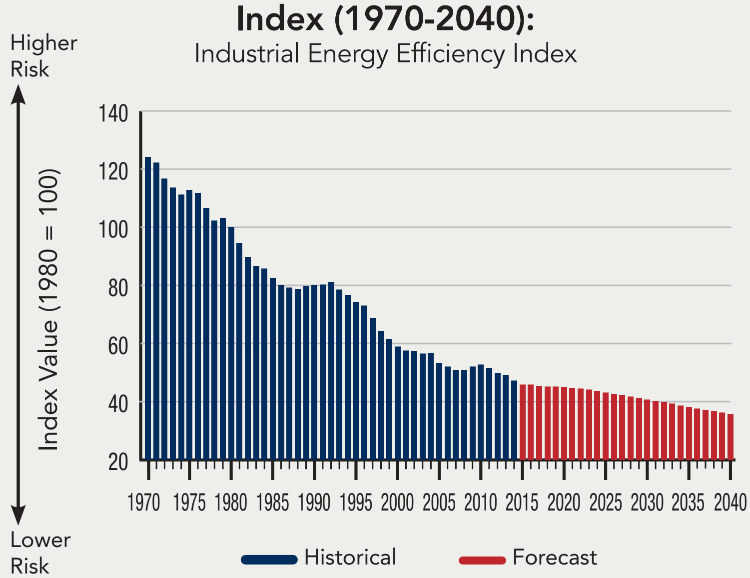
Category of Metric

Energy Use Intensity

Historical and Forecast Values (1970-2040):
Industrial Energy Efficiency



Index (1970-2040):
Industrial Energy Efficiency Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	3.0	N/A	4.0	1.7
Average Contribution	N/A	3.2	N/A	3.3	1.6

METRIC #25

Electricity Capacity Diversity

Definition

Market share concentration index (HHI) of the primary categories of electric power generating capacity, adjusted for availability.

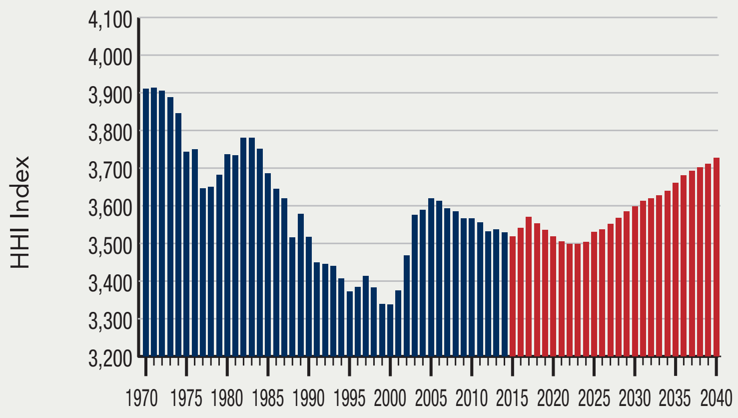
Importance

Indicates the flexibility of the power sector and its ability to dispatch electricity from a diverse range of sources.

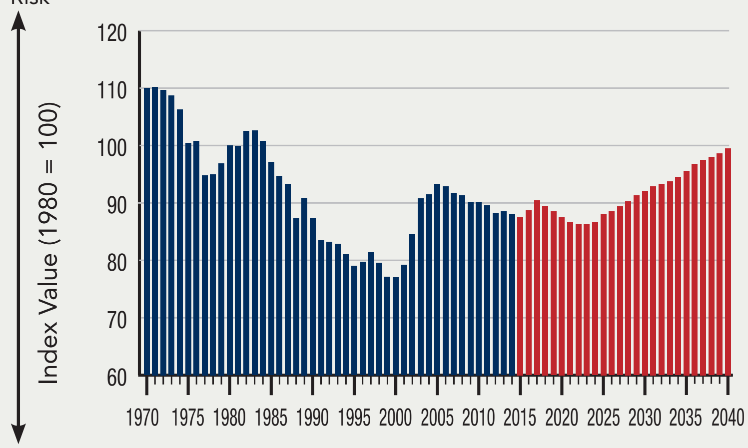
Category of Metric

Electric Power Sector

Historical and Forecast Values (1970-2040):
Electricity Capacity Diversity



Index (1970-2040):
Electricity Capacity Diversity Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	N/A	7.0	3.0	2.0
Average Contribution	N/A	N/A	7.2	2.8	2.2

METRIC #26

Electricity Capacity Margins

Definition

Unused available capability in the U.S. electric power system at peak load as a percentage of total peak capability.

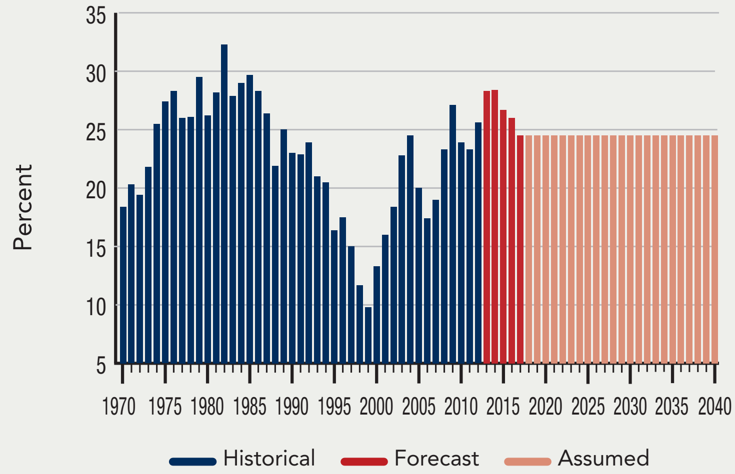
Importance

Indicates the ability of the power sector to respond to the disruption or temporary loss of some production capacity without an uneconomic overhang of excess capacity.

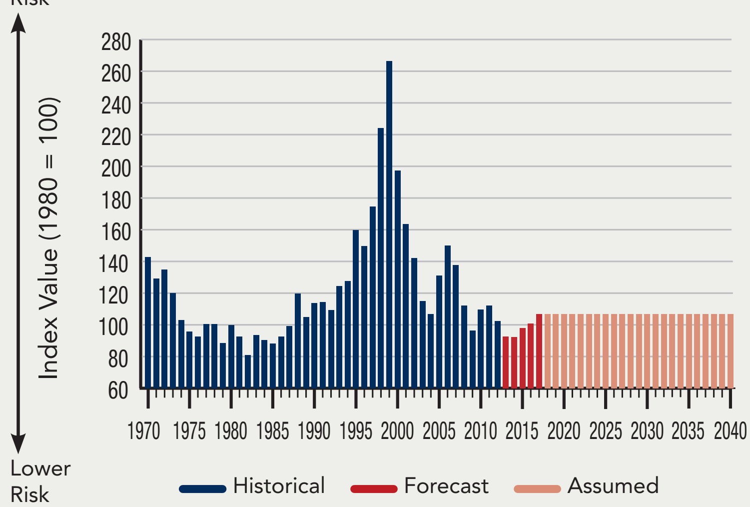
Category of Metric

Electric Power Sector

Historical and Forecast Values (1970-2040):
Electricity Capacity Margins



Index (1970-2040):
Electricity Capacity Margins Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	1.0	7.0	N/A	1.7
Average Contribution	N/A	1.6	9.7	N/A	2.5

METRIC #27

Electric Power Transmission Line Mileage

Definition

Circuit-miles of transmission lines per gigawatt of peak summer demand.

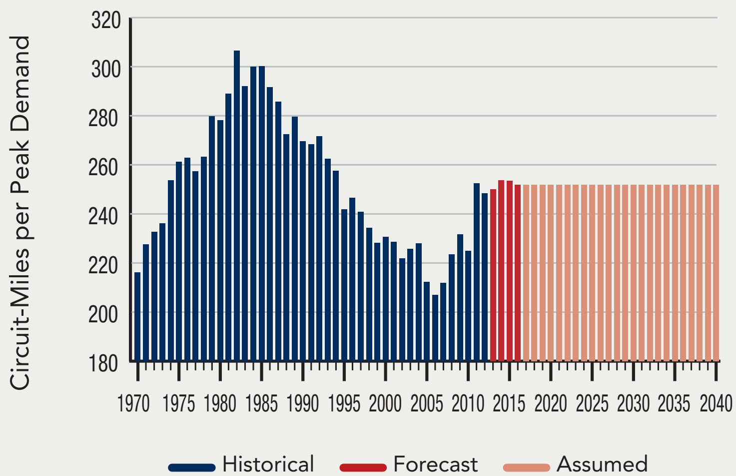
Importance

Indicates the integration of the transmission system and its ability to meet increasing demand reliably.

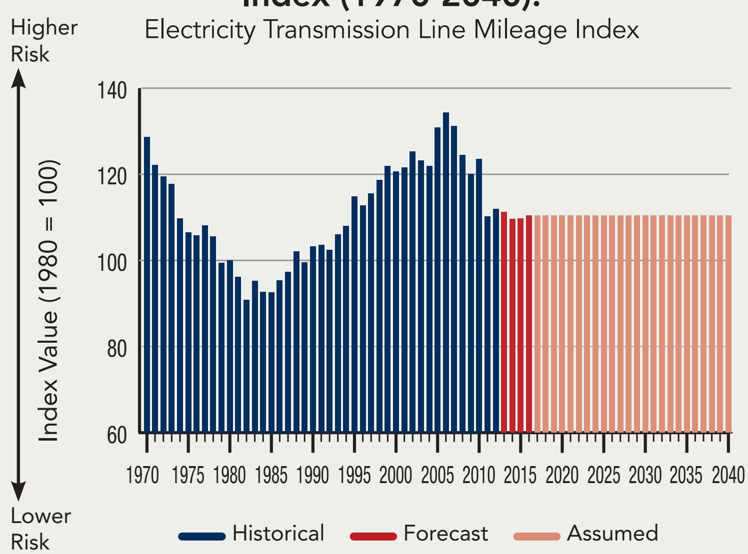
Category of Metric

Electric Power Sector

Historical and Forecast Values (1970-2040):
Electricity Transmission Line Mileage



Index (1970-2040):
Electricity Transmission Line Mileage Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	1.0	8.0	3.0	2.5
Average Contribution	N/A	1.5	9.9	3.4	3.2

METRIC #28

Motor Vehicle Average MPG

Definition

Average miles per gallon of passenger car fleet.

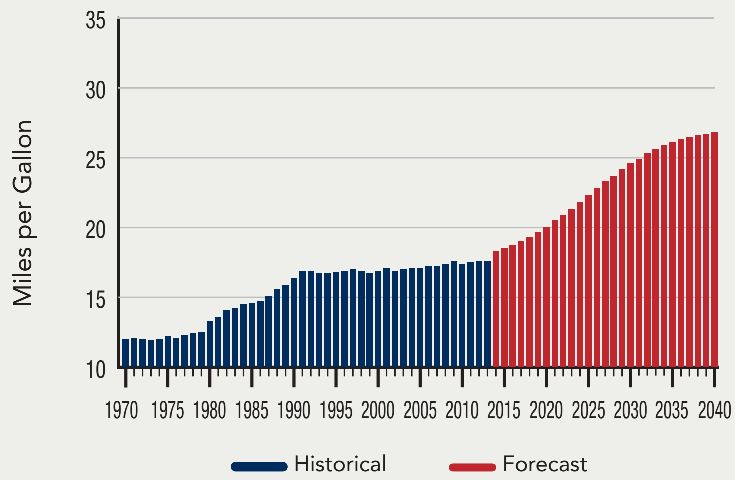
Importance

Indicates the degree to which the typical light vehicle uses energy efficiently (gasoline consumption accounts for about 16% of total U.S. energy demand).

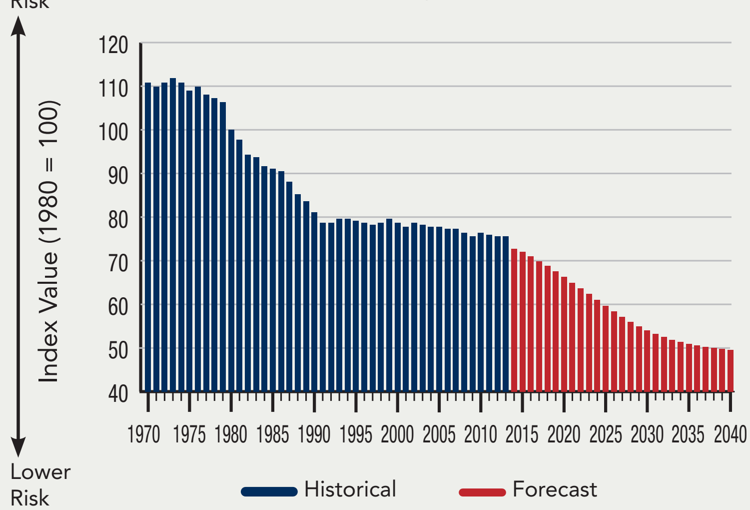
Category of Metric

Transportation Sector

Historical and Forecast Values (1970-2040):
Motor Vehicle Average MPG



Index (1970-2040):
Motor Vehicle Average MPG Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	3.0	4.0	N/A	12.0	4.5
Average Contribution	3.2	4.7	N/A	10.8	4.7

METRIC #29

Vehicle-Miles Traveled per GDP

Definition

Vehicle-miles traveled (VMT) per $1,000 of GDP in real (2010) dollars.

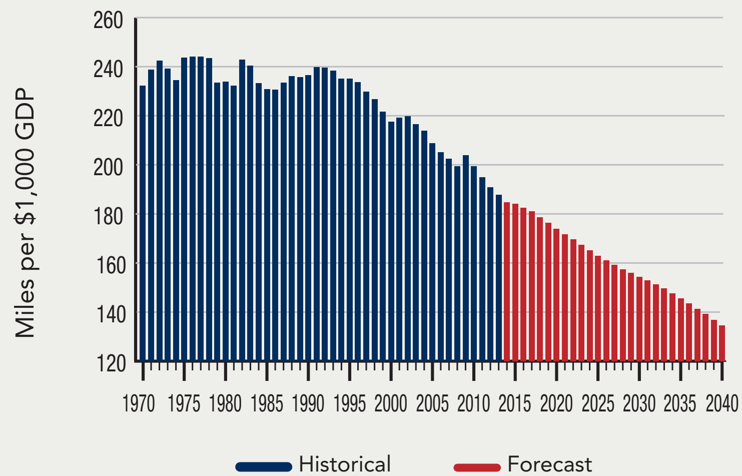
Importance

Indicates the importance of travel as a component of the economy.

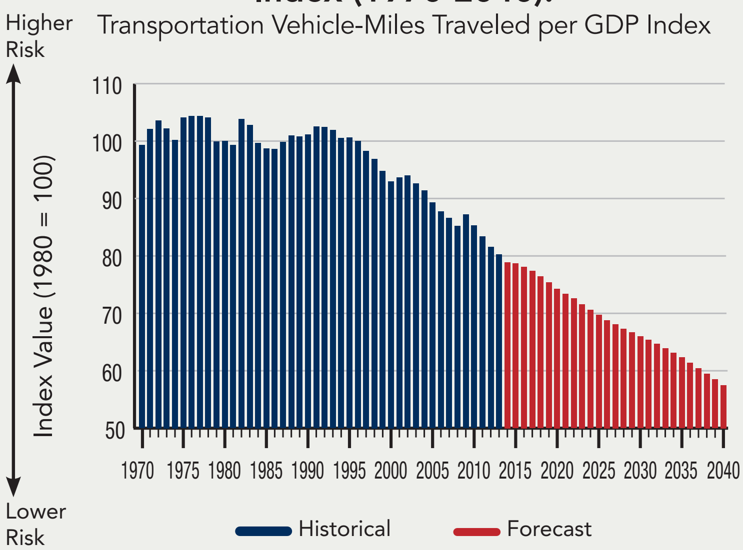
Category of Metric

Transportation Sector

Historical and Forecast Values (1970-2040):
Transportation Vehicle-Miles Traveled per GDP



Index (1970-2040):
Transportation Vehicle-Miles Traveled per GDP Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	2.0	2.0	N/A	8.0	2.8
Average Contribution	2.3	2.6	N/A	7.9	3.2

METRIC #30

Transportation Non-Petroleum Fuel Use

Definition

Non-petroleum fuels as a percentage of total U.S. transportation energy consumption.

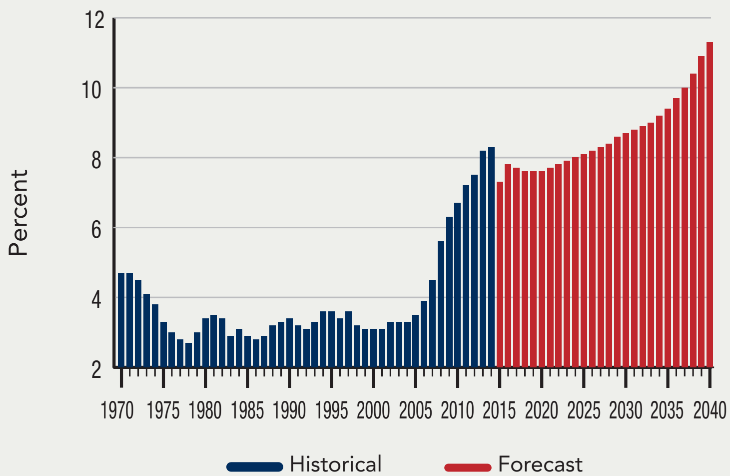
Importance

Indicates the diversity and flexibility of the fuel mix for transportation.

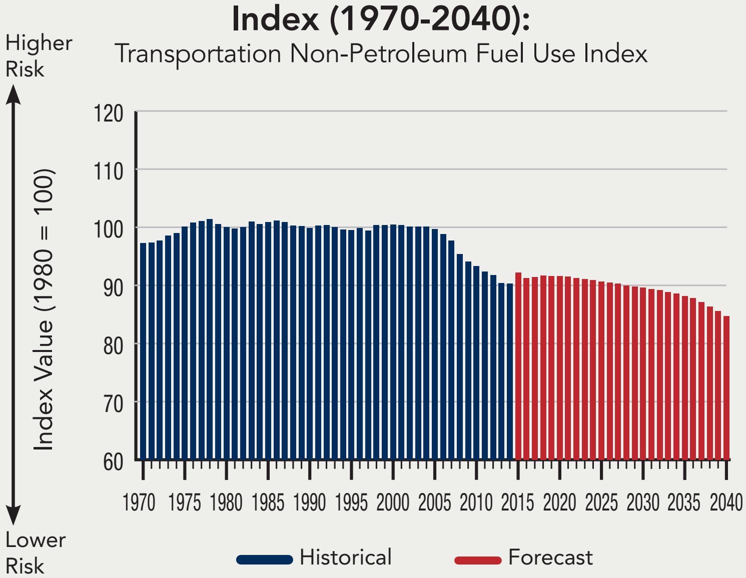
Category of Metric

Transportation Sector

Historical and Forecast Values (1970-2040):
Transportation Non-Petroleum Fuel Use



Index (1970-2040):
Transportation Non-Petroleum Fuel Use Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	3.0	N/A	4.0	4.0	2.5
Average Contribution	3.5	N/A	4.4	4.0	2.9

METRIC #31

Energy-Related Carbon Dioxide Emissions

Definition

Total U.S. energy-related CO_2 emissions in million metric tons.

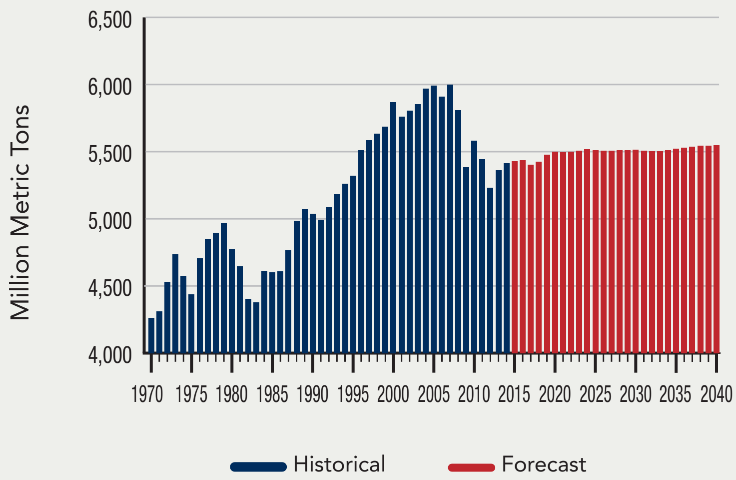
Importance

Indicates the exposure of the U.S. economy to domestic and international emissions reduction mandates.

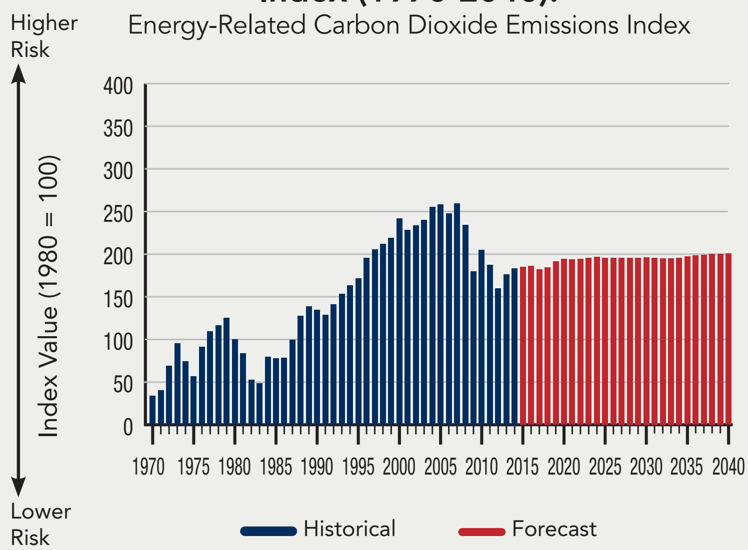
Category of Metric

Environmental

Historical and Forecast Values (1970-2040):
Energy-Related Carbon Dioxide Emissions



Index (1970-2040):
Energy-Related Carbon Dioxide Emissions Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	2.0	N/A	N/A	7.0	2.0
Average Contribution	3.5	N/A	N/A	10.5	3.4

METRIC #32

Energy-Related Carbon Dioxide Emissions per Capita

Definition

Million metric tons of CO_2 emissions from energy per capita.

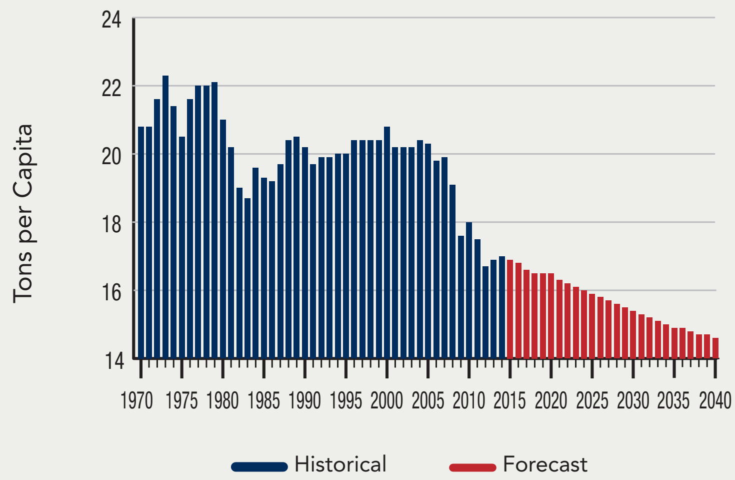
Importance

Indicates the joint effect of the amount of energy used per capita in the U.S. and the carbon intensity of that energy use.

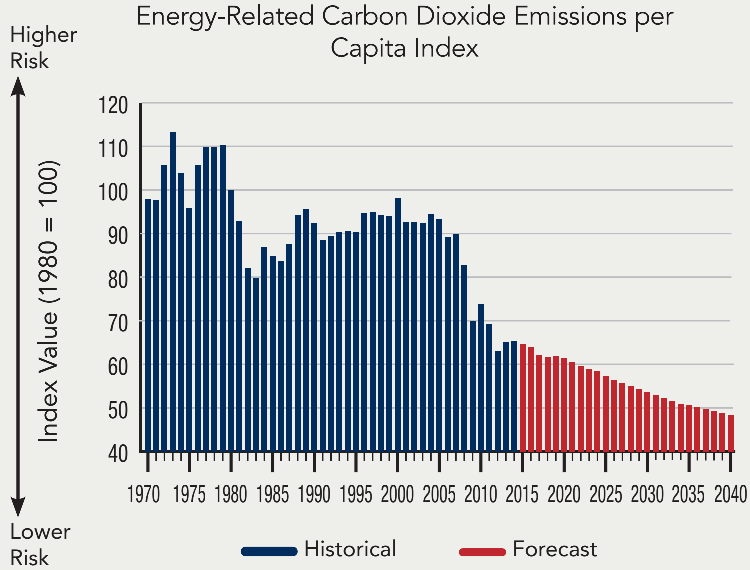
Category of Metric

Environmental

Historical and Forecast Values (1970-2040):
Energy-Related Carbon Dioxide Emissions per Capita



Index (1970-2040):
Energy-Related Carbon Dioxide Emissions per Capita Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	2.0	N/A	N/A	5.0	1.6
Average Contribution	2.2	N/A	N/A	4.7	1.7

METRIC #33

Energy-Related Carbon Dioxide Emissions Intensity

Definition

Metric tons of CO_2 from energy per $1,000 of GDP in real (2010) dollars.

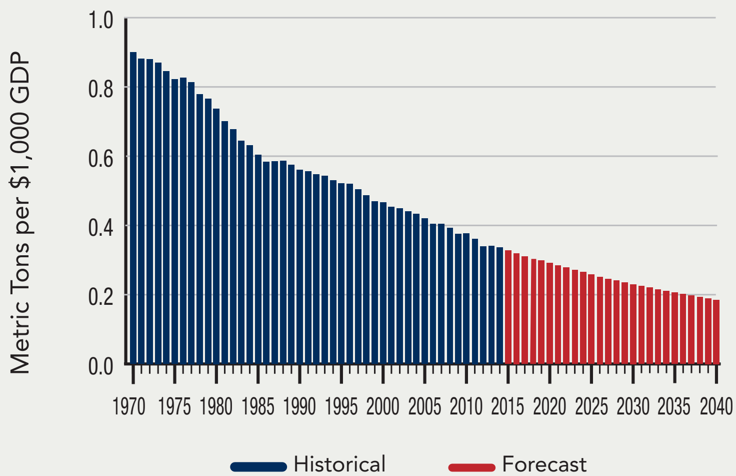
Importance

Indicates the importance of carbon-based fuels as a component of the economy.

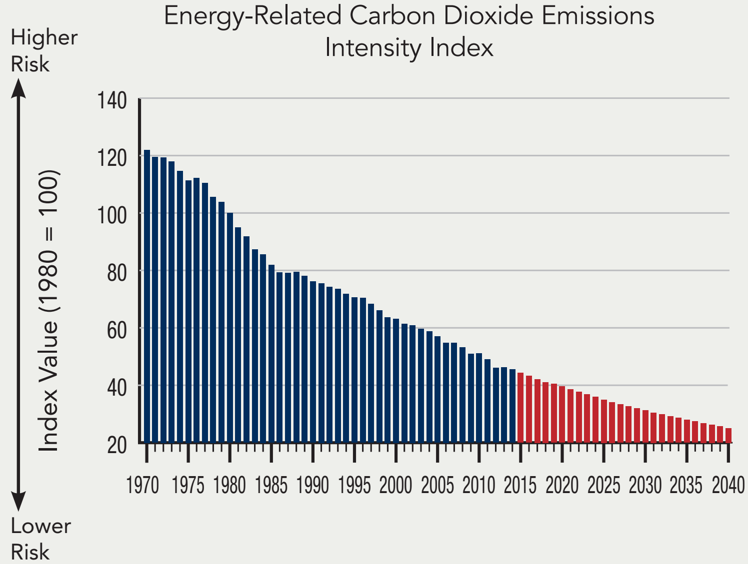
Category of Metric

Environmental

Historical and Forecast Values (1970-2040):
Energy-Related Carbon Dioxide Emissions Intensity



Index (1970-2040):
Energy-Related Carbon Dioxide Emissions Intensity Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	2.0	N/A	N/A	5.0	1.6
Average Contribution	1.9	N/A	N/A	4.1	1.5

METRIC #34

Electricity Non-CO_2 Generation Share

Definition

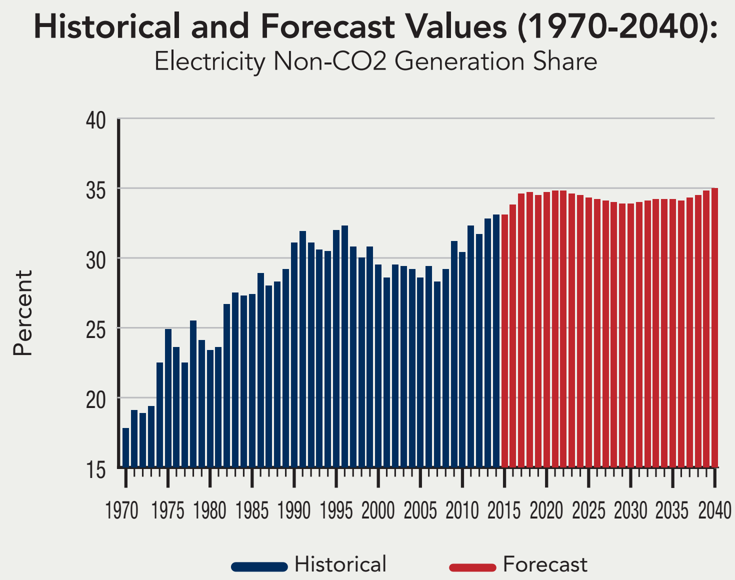
Percentage of total electric power generation contributed by renewables, hydroelectric, nuclear, and fossil-fired plants operating with carbon capture and storage (CCS) technology.

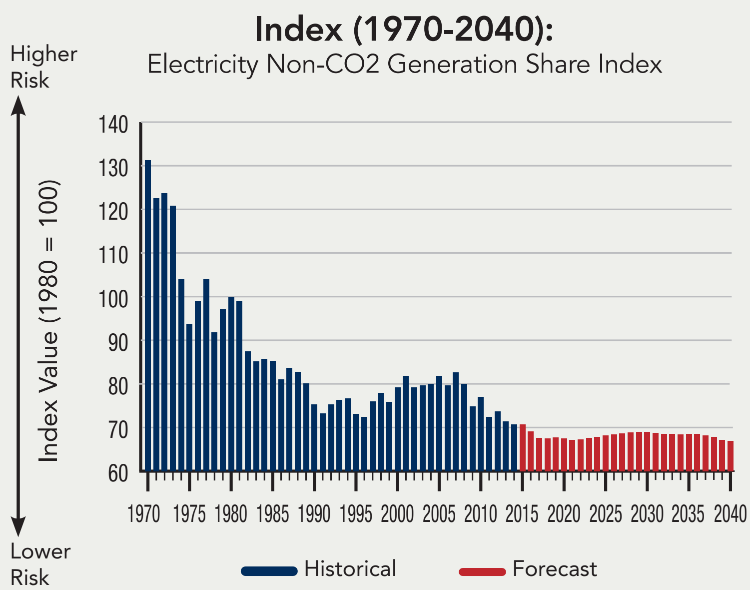
Importance

Indicates the degree to which the power sector is diversifying and employing non-CO_2 emitting generation.

Category of Metric

Environmental





Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	N/A	5.0	7.0	2.4
Average Contribution	N/A	N/A	4.8	6.2	2.4

METRIC #35

Industrial Energy R&D Expenditures

Definition

Dollars of industrial energy-related R&D (non-Federal) per $1,000 of GDP in real (2010) dollars.

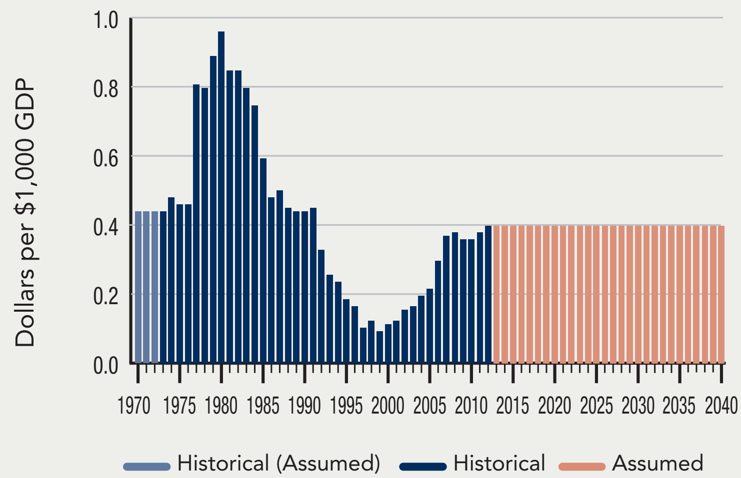
Importance

Indicates private industry engagement in improving performance and enabling new technological breakthroughs.

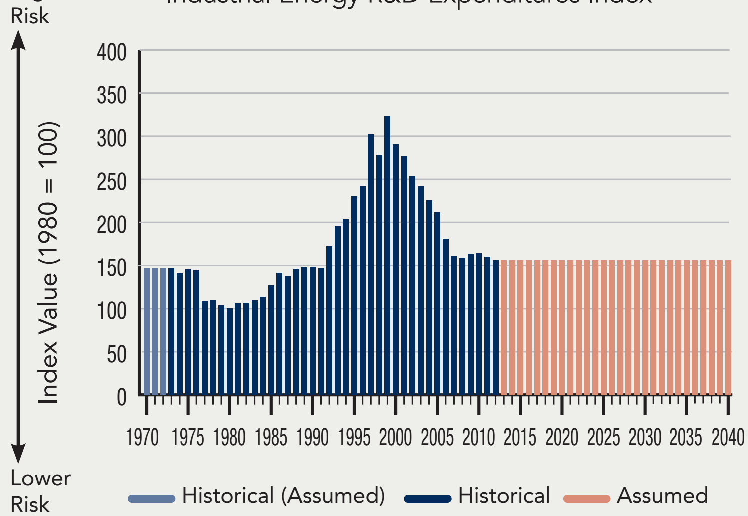
Category of Metric

Research & Development

Historical and Forecast Values (1970-2040):
Industrial Energy R&D Expenditures



Index (1970-2040):
Industrial Energy R&D Expenditures Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	1.0	2.0	2.0	1.1
Average Contribution	N/A	2.3	3.9	3.5	2.2

METRIC #36

Federal Energy & Science R&D Expenditures

Definition

Dollars of federal energy and science R&D per $1,000 of GDP in real (2010) dollars.

Importance

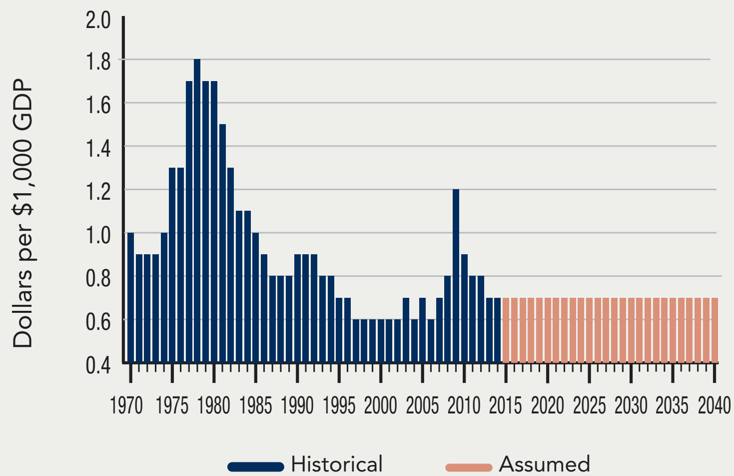
Indicates prospects for new scientific and technological breakthroughs through federally-supported public-private research.

Category of Metric

Research & Development

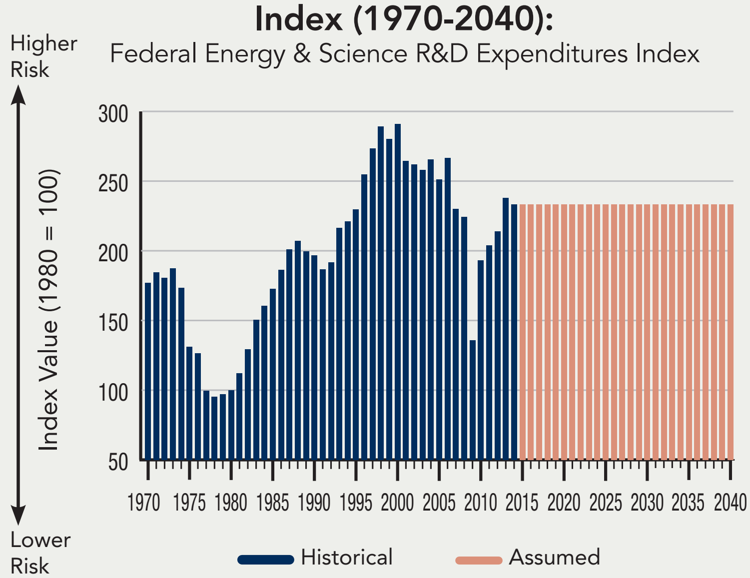
Historical and Forecast Values (1970-2040):

Federal Energy & Science R&D Expenditures



Index (1970-2040):

Federal Energy & Science R&D Expenditures Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	1.0	2.0	2.0	1.1
Average Contribution	N/A	2.6	4.4	4.0	2.5

METRIC #37

Science & Engineering Degrees

Definition

Number of science and engineering degrees, per billion dollars of GDP in real (2010) dollars.

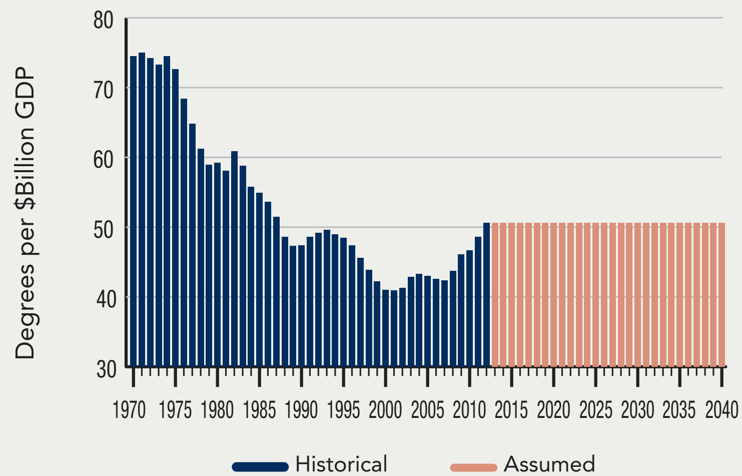
Importance

Indicates the degree to which human capital in high-tech science, technology, engineering, and mathematics fields will be available to the economy.

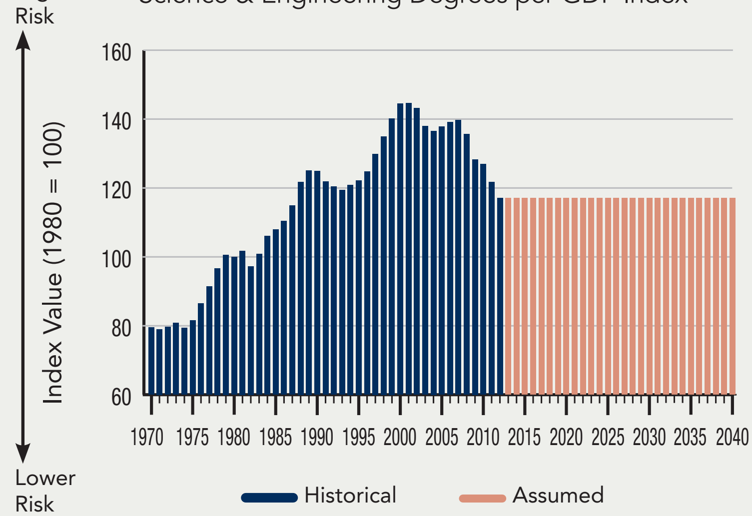
Category of Metric

Research & Development

Historical and Forecast Values (1970-2040):
Science & Engineering Degrees per GDP



Index (1970-2040):
Science & Engineering Degrees per GDP Index



Weighting and Average Historical Contribution of Metric to Energy Security Indexes (Percent):

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	1.0	2.0	2.0	1.1
Average Contribution	N/A	1.5	2.6	2.3	1.5

Summary Table 1: Energy Security Metrics (Values)

1970-1976

#	Metric	Units of Measurement	1970	1971	1972	1973	1974	1975	1976
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	123.0	115.1	113.5	106.3	104.7	111.1	114.7
2	Security of World Oil Production	production, freedom & diversity-weighted	90.9	92.3	94.1	95.4	101.1	109.7	114.7
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	57.8	67.8	74.4	78.6	84.4	102.3	106.9
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	69.7	69.1	67.7	67.5	71.2	84.9	89.9
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	98.5	98.5	98.5	98.4	97.4	106.9	108.6
6	Security of World Coal Production	production, freedom & diversity-weighted	88.1	90.3	93.4	94.3	96.0	103.0	103.2
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	19.9	22.8	26.3	33.3	36.1	39.8	46.4
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	3.5	3.6	3.5	3.3	3.3	4.2	4.4
9	Oil & Natural Gas Import Expenditures	billions of 2010$	$14.6	$17.4	$20.6	$50.4	$94.0	$87.9	$109.9
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.3%	0.4%	0.4%	0.9%	1.7%	1.6%	1.9%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$77.03	$77.10	$76.47	$78.33	$99.02	$101.75	$103.28
12	Energy Expenditures per Household	2010$/Household	$5,785	$5,849	$5,937	$6,246	$7,665	$7,712	$8,081
13	Retail Electricity Prices	cents/kWh (2010$)	7.6¢	7.6¢	7.7¢	7.7¢	8.8¢	9.4¢	9.5¢
14	Crude Oil Price	2010$/bbl	$12.06	$12.30	$11.97	$22.50	$43.23	$40.54	$41.77
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$0.52	$0.44	$0.20	$3.69	$10.53	$11.31	$8.21
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2010$)	$2.89	$3.12	$2.86	$3.76	$9.78	$9.62	$9.47
17	World Oil Refinery Utilization	percent utilization	94.1%	90.4%	88.8%	92.7%	84.9%	78.3%	78.9%
18	Petroleum Stock Levels	average days supply	69	69	58	58	64	69	63
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	330.8	333.6	346.3	357.2	345.9	333.2	348.5
20	Energy Intensity	million Btu/$1,000 GDP (2010$)	14.2	14.0	14.0	13.8	13.5	13.2	13.2
21	Petroleum Intensity	million Btu/real $1,000 GDP (2010$)	6.18	6.19	6.34	6.35	6.12	6.00	6.12
22	Household Energy Efficiency	million Btu/household	216.3	218.9	221.9	216.4	207.7	206.0	209.9
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	332.4	336.0	336.0	330.2	326.6	330.7	332.9
24	Industrial Energy Efficiency	trillion Btu/IP Index	792	780	744	725	709	720	712
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,910	3,913	3,905	3,887	3,846	3,743	3,750
26	Electricity Capacity Margins	percent	18.4%	20.3%	19.4%	21.8%	25.5%	27.4%	28.3%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	216	228	233	236	254	261	263
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	12.0	12.1	12.0	11.9	12.0	12.2	12.1
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2010$)	232	239	242	239	234	244	244
30	Transportation Non-Petroleum Fuels	percent	4.7%	4.7%	4.5%	4.1%	3.8%	3.3%	3.0%
Environmental Metrics									
31	Energy-Related CO2 Emissions	MMTCO2	4,261	4,312	4,532	4,735	4,575	4,439	4,707
32	Energy-Related CO2 Emissions per Capita	metric tons CO2/Person	20.8	20.8	21.6	22.3	21.4	20.5	21.6
33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.89	0.87	0.87	0.86	0.84	0.81	0.82
34	Electricity Non-CO2 Generation Share	percent of total generation	17.8%	19.1%	18.9%	19.4%	22.5%	24.9%	23.6%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.43	$0.43	$0.43	$0.43	$0.47	$0.45	$0.45
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.95	$0.92	$0.93	$0.90	$0.97	$1.29	$1.34
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	74.5	75.0	74.2	73.3	74.5	72.6	68.4

Summary Table 1: Energy Security Metrics (Values)

1977-1983

#	Metric	Units of Measurement	1977	1978	1979	1980	1981	1982	1983
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	123.0	115.1	113.5	106.3	104.7	111.1	114.7
2	Security of World Oil Production	production, freedom & diversity-weighted	90.9	92.3	94.1	95.4	101.1	109.7	114.7
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9	Oil & Natural Gas Import Expenditures	billions of 2010$	$14.6	$17.4	$20.6	$50.4	$94.0	$87.9	$109.9
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.3%	0.4%	0.4%	0.9%	1.7%	1.6%	1.9%
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11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$77.03	$77.10	$76.47	$78.33	$99.02	$101.75	$103.28
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13	Retail Electricity Prices	cents/kWh (2010$)	7.6¢	7.6¢	7.7¢	7.7¢	8.8¢	9.4¢	9.5¢
14	Crude Oil Price	2010$/bbl	$12.06	$12.30	$11.97	$22.50	$43.23	$40.54	$41.77
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30	Transportation Non-Petroleum Fuels	percent	4.7%	4.7%	4.5%	4.1%	3.8%	3.3%	3.0%
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33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.89	0.87	0.87	0.86	0.84	0.81	0.82
34	Electricity Non-CO2 Generation Share	percent of total generation	17.8%	19.1%	18.9%	19.4%	22.5%	24.9%	23.6%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.43	$0.43	$0.43	$0.43	$0.47	$0.45	$0.45
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.95	$0.92	$0.93	$0.90	$0.97	$1.29	$1.34
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	74.5	75.0	74.2	73.3	74.5	72.6	68.4

Summary Table 1: Energy Security Metrics (Values)

1984-2001

1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
104.5	104.5	111.4	110.2	99.6	100.6	124.5	119.8	141.4	148.0	147.4	146.4	141.7	129.1	125.7	125.1	128.2	127.4
93.4	90.6	94.0	88.8	79.9	82.0	77.2	75.6	73.2	77.8	75.7	74.2	70.0	70.3	68.4	68.2	68.6	69.1
141.9	136.4	136.9	124.5	94.7	101.0	86.8	88.9	77.8	86.6	88.0	88.3	88.0	87.7	89.4	93.6	100.1	99.4
138.0	146.5	155.8	142.3	117.6	117.1	91.2	88.1	69.0	72.4	68.9	66.4	61.3	61.1	63.8	68.3	71.3	72.5
107.6	107.5	107.3	99.6	86.4	86.1	68.8	72.2	71.0	61.1	57.1	55.4	52.0	53.5	52.5	55.6	58.2	58.1
109.4	108.5	108.1	102.6	96.8	102.9	88.3	87.5	83.6	92.1	91.5	90.4	90.1	84.5	75.3	75.3	81.6	83.5
28.0	24.4	30.8	30.6	29.1	32.0	30.2	28.1	27.2	31.1	30.8	29.4	28.8	30.4	30.9	30.2	31.6	33.4
5.7	6.9	5.9	6.9	6.9	6.7	5.8	6.1	5.1	5.9	6.1	6.0	5.4	5.4	6.1	7.4	7.5	8.1
$101.8	$84.9	$51.0	$70.6	$62.4	$79.2	$98.4	$75.6	$75.6	$73.4	$71.1	$72.2	$93.5	$92.5	$68.6	$93.5	$146.7	$129.9
1.4%	1.1%	0.6%	0.9%	0.7%	0.9%	1.1%	0.8%	0.8%	0.8%	0.7%	0.7%	0.9%	0.8%	0.6%	0.8%	1.2%	1.0%
$107.75	$100.89	$83.72	$81.68	$78.39	$77.63	$79.41	$76.54	$72.95	$71.58	$69.09	$67.16	$69.18	$65.99	$57.91	$57.84	$66.88	$65.56
$9,202	$8,824	$7,472	$7,429	$7,307	$7,385	$7,639	$7,278	$7,098	$7,060	$7,019	$6,918	$7,324	$7,212	$6,526	$6,732	$8,042	$7,864
11.4¢	11.4¢	11.2¢	10.8¢	10.4¢	10.1¢	10.0¢	9.9¢	9.8¢	9.7¢	9.5¢	9.3¢	9.1¢	8.9¢	8.7¢	8.4¢	8.4¢	8.8¢
$56.59	$51.34	$24.38	$31.32	$24.35	$28.66	$36.02	$29.40	$27.71	$23.83	$21.76	$22.87	$27.24	$24.80	$16.38	$22.63	$35.43	$29.56
$8.60	$6.44	$11.55	$13.05	$13.62	$6.07	$6.21	$6.10	$5.22	$4.06	$2.55	$2.36	$2.52	$2.64	$5.08	$5.70	$9.16	$8.30
$4.92	$3.16	$5.60	$5.45	$4.50	$0.91	$1.74	$2.72	$2.31	$1.42	$0.58	$0.31	$1.62	$1.53	$3.19	$2.58	$6.19	$4.76
74.9%	74.9%	78.4%	78.6%	80.9%	82.1%	81.2%	81.6%	81.4%	81.0%	80.1%	81.7%	83.0%	83.5%	83.0%	80.6%	82.2%	81.8%
99	97	98	96	92	91	95	97	93	96	93	88	82	84	87	76	74	81
325.0	321.1	319.2	326.3	338.3	343.5	338.5	333.8	334.4	336.1	338.6	341.9	349.0	347.0	344.5	346.4	350.2	337.5
10.4	9.9	9.6	9.6	9.6	9.5	9.3	9.3	9.1	9.1	8.9	8.8	8.8	8.5	8.1	7.9	7.8	7.5
4.21	4.02	4.05	3.99	3.99	3.85	3.70	3.63	3.57	3.50	3.45	3.34	3.34	3.24	3.16	3.10	3.01	2.97
184.8	182.5	179.2	179.7	186.2	190.2	179.8	182.9	180.1	186.4	183.5	185.2	193.1	185.6	183.1	186.4	193.2	187.3
276.2	261.9	252.1	252.3	258.5	264.0	260.1	257.4	250.4	249.5	247.0	249.9	249.1	248.7	244.9	243.2	251.0	246.6
547	527	512	506	502	508	511	512	517	501	489	473	466	438	410	392	376	367
3,751	3,686	3,645	3,620	3,516	3,578	3,518	3,449	3,445	3,440	3,406	3,372	3,384	3,414	3,383	3,339	3,337	3,374
29.0%	29.7%	28.3%	26.4%	21.9%	25.0%	23.0%	22.9%	23.9%	21.0%	20.5%	16.4%	17.5%	15.0%	11.7%	9.8%	13.3%	16.0%
300	300	292	286	273	280	270	269	272	262	258	242	247	241	234	228	231	229
14.5	14.6	14.7	15.1	15.6	15.9	16.4	16.9	16.9	16.7	16.7	16.8	16.9	17.0	16.9	16.7	16.9	17.1
233	231	231	233	236	236	237	240	240	238	235	235	234	230	227	222	217	219
3.1%	2.9%	2.8%	2.9%	3.2%	3.3%	3.4%	3.2%	3.1%	3.3%	3.6%	3.6%	3.4%	3.6%	3.2%	3.1%	3.1%	3.1%
4,614	4,600	4,608	4,766	4,984	5,070	5,039	4,993	5,087	5,185	5,261	5,323	5,510	5,584	5,636	5,688	5,868	5,761
19.6	19.3	19.2	19.7	20.4	20.5	20.2	19.7	19.9	19.9	20.0	20.0	20.4	20.4	20.4	20.4	20.8	20.2
0.63	0.60	0.58	0.58	0.58	0.57	0.56	0.55	0.54	0.54	0.52	0.52	0.51	0.50	0.48	0.47	0.46	0.45
27.3%	27.4%	28.9%	28.0%	28.3%	29.2%	31.1%	31.9%	31.1%	30.6%	30.5%	32.0%	32.3%	30.8%	30.0%	30.8%	29.5%	28.6%
$0.73	$0.58	$0.47	$0.49	$0.44	$0.43	$0.43	$0.44	$0.32	$0.25	$0.23	$0.18	$0.16	$0.10	$0.12	$0.09	$0.11	$0.12
$1.05	$0.98	$0.91	$0.84	$0.82	$0.85	$0.86	$0.91	$0.88	$0.78	$0.76	$0.74	$0.66	$0.62	$0.58	$0.60	$0.58	$0.64
55.8	54.9	53.6	51.5	48.6	47.3	47.4	48.6	49.2	49.6	49.0	48.5	47.4	45.6	43.9	42.2	41.0	40.9

Summary Table 1: Energy Security Metrics (Values)

2002-2008

#	Metric	Units of Measurement	2002	2003	2004	2005	2006	2007	2008
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	124.3	91.1	92.2	87.4	87.3	86.4	87.4
2	Security of World Oil Production	production, freedom & diversity-weighted	65.7	68.4	72.8	72.2	72.5	72.5	74.9
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	95.5	93.2	97.8	98.6	97.4	97.7	96.7
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	71.1	71.5	76.3	76.9	78.1	78.4	77.9
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	56.3	67.9	70.3	67.5	73.8	73.8	68.0
6	Security of World Coal Production	production, freedom & diversity-weighted	87.1	100.2	109.5	114.5	118.3	123.5	128.3
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	30.5	33.6	37.2	37.9	37.7	36.7	37.2
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	7.4	7.2	7.9	8.5	8.3	8.5	6.7
9	Oil & Natural Gas Import Expenditures	billions of 2010$	$126.4	$149.2	$203.4	$287.4	$326.4	$343.8	$411.4
10	Oil & Natural Gas Import Expenditures per GDP	percent	1.0%	1.1%	1.5%	2.0%	2.2%	2.3%	2.7%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$60.49	$65.61	$70.98	$79.88	$83.65	$85.24	$95.75
12	Energy Expenditures per Household	2010$/Household	$7,530	$8,349	$9,285	$10,634	$11,292	$11,634	$12,901
13	Retail Electricity Prices	cents/kWh (2010$)	8.6¢	8.7¢	8.6¢	9.0¢	9.5¢	9.5¢	9.9¢
14	Crude Oil Price	2010$/bbl	$29.75	$33.67	$43.46	$60.05	$69.56	$75.33	$98.87
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$6.28	$3.32	$4.63	$10.10	$11.96	$10.63	$12.94
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2010$)	$5.19	$3.74	$5.99	$8.34	$8.02	$6.50	$6.36
17	World Oil Refinery Utilization	percent utilization	80.6%	82.9%	85.0%	85.2%	84.5%	84.3%	83.3%
18	Petroleum Stock Levels	average days supply	78	78	79	82	83	81	89
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	339.5	337.5	341.8	339.0	333.4	335.4	325.2
20	Energy Intensity	million Btu/$1,000 GDP (2010$)	7.5	7.3	7.2	7.0	6.7	6.7	6.6
21	Petroleum Intensity	million Btu/real $1,000 GDP (2010$)	2.93	2.89	2.89	2.80	2.69	2.62	2.46
22	Household Energy Efficiency	million Btu/household	198.1	200.1	197.8	199.8	188.7	195.2	194.7
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	245.8	242.1	242.4	241.1	235.4	238.9	237.1
24	Industrial Energy Efficiency	trillion Btu/IP Index	366	360	362	340	332	324	324
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,468	3,576	3,588	3,619	3,613	3,593	3,585
26	Electricity Capacity Margins	percent	18.4%	22.8%	24.5%	20.0%	17.4%	19.0%	23.3%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	222	226	228	212	207	212	223
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	16.9	17.0	17.1	17.1	17.2	17.2	17.4
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2010$)	220	217	214	209	205	203	199
30	Transportation Non-Petroleum Fuels	percent	3.3%	3.3%	3.3%	3.5%	3.9%	4.5%	5.6%
Environmental Metrics									
31	Energy-Related CO2 Emissions	MMTCO2	5,804	5,853	5,970	5,993	5,910	6,001	5,809
32	Energy-Related CO2 Emissions per Capita	metric tons CO2/Person	20.2	20.2	20.4	20.3	19.8	19.9	19.1
33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.44	0.44	0.43	0.42	0.40	0.40	0.39
34	Electricity Non-CO2 Generation Share	percent of total generation	29.5%	29.4%	29.2%	28.6%	29.4%	28.3%	29.2%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.15	$0.16	$0.19	$0.21	$0.29	$0.36	$0.37
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.64	$0.65	$0.64	$0.67	$0.63	$0.73	$0.75
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	41.3	42.9	43.3	43.0	42.6	42.4	43.7

Summary Table 1: Energy Security Metrics (Values)

2009-2026

2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
87.3	88.3	93.3	95.1	95.8	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
73.2	75.6	79.3	80.3	79.9	82.3	85.3	85.3	84.7	84.5	84.5	84.3	84.1	84.0	84.0	84.0	84.0	84.2
96.7	93.5	93.7	96.5	97.8	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4
75.1	78.3	82.4	81.4	83.7	81.8	82.6	82.9	83.2	83.5	83.8	84.2	84.5	84.8	85.2	85.5	85.8	86.1
67.7	68.6	66.7	66.8	67.4	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7
137.9	143.8	153.3	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5
32.9	32.7	31.4	29.0	24.8	19.9	16.5	14.9	11.8	10.7	9.9	9.7	9.8	9.9	10.1	10.0	10.2	10.7
5.7	5.5	4.4	3.2	2.8	2.4	1.6	0.7	-0.9	-2.3	-3.8	-5.4	-6.2	-6.8	-7.0	-7.1	-7.3	-7.5
$229.6	$283.1	$342.8	$295.1	$238.9	$170.3	$85.1	$97.8	$82.9	$72.7	$65.3	$62.0	$62.1	$64.0	$67.3	$68.3	$71.3	$76.7
1.6%	1.9%	2.3%	1.9%	1.5%	1.0%	0.5%	0.6%	0.5%	0.4%	0.4%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
$73.79	$80.76	$89.48	$83.62	$82.02	$78.50	$61.83	$65.64	$65.68	$64.59	$64.11	$63.65	$63.26	$62.72	$62.12	$61.32	$60.69	$60.04
$9,672	$10,803	$11,983	$11,360	$11,374	$11,113	$8,969	$9,693	$9,846	$9,853	$9,944	$10,051	$10,146	$10,212	$10,284	$10,328	$10,397	$10,448
9.9¢	9.8¢	9.7¢	9.5¢	9.5¢	9.8¢	9.6¢	9.8¢	9.8¢	9.7¢	9.8¢	10.0¢	10.1¢	10.2¢	10.3¢	10.3¢	10.4¢	10.4¢
$62.49	$79.61	$109.01	$107.44	$102.95	$89.95	$52.75	$67.40	$72.41	$72.31	$73.68	$75.05	$77.09	$79.32	$81.64	$84.03	$86.42	$89.02
$21.89	$25.68	$27.63	$16.03	$11.82	$6.35	$6.66	$9.69	$11.68	$12.94	$14.47	$16.06	$16.50	$16.97	$17.47	$17.98	$18.49	$19.05
$12.80	$14.39	$14.12	$7.36	$4.51	$4.75	$4.99	$5.22	$5.46	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70
80.0%	81.5%	81.4%	81.1%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%
95	94	93	98	93	98	96	96	96	95	95	94	95	94	94	94	95	95
306.9	315.1	310.9	300.8	307.2	308.7	304.3	304.8	303.1	302.9	303.0	301.9	300.0	298.5	297.2	296.0	294.3	292.6
6.5	6.5	6.4	6.1	6.1	6.0	5.8	5.7	5.6	5.5	5.4	5.3	5.2	5.1	5.0	4.8	4.7	4.6
2.40	2.37	2.29	2.19	2.18	2.14	2.15	2.12	2.08	2.04	2.00	1.95	1.90	1.86	1.81	1.76	1.71	1.67
189.6	195.3	188.5	174.3	184.7	186.9	179.3	176.6	174.3	172.8	171.8	169.1	166.9	165.0	163.6	162.5	161.0	159.7
227.0	225.7	221.4	212.1	218.6	221.4	217.2	215.2	212.6	211.2	210.3	208.7	206.7	204.9	203.6	202.6	201.4	200.5
332	337	329	318	314	301	293	293	289	288	288	287	285	284	282	279	275	272
3,566	3,566	3,556	3,532	3,537	3,529	3,519	3,541	3,570	3,554	3,536	3,519	3,505	3,499	3,498	3,503	3,530	3,537
27.1%	23.9%	23.3%	25.6%	28.3%	28.4%	26.7%	26.0%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%
232	225	252	248	250	254	254	252	252	252	252	252	252	252	252	252	252	252
17.6	17.4	17.5	17.6	17.6	18.3	18.5	18.7	19.0	19.3	19.7	20.0	20.5	20.9	21.3	21.8	22.3	22.8
204	199	195	191	188	185	184	183	181	179	176	174	172	170	168	165	163	161
6.3%	6.7%	7.2%	7.5%	8.2%	8.3%	7.3%	7.8%	7.7%	7.6%	7.6%	7.6%	7.7%	7.8%	7.9%	8.0%	8.1%	8.2%
5,386	5,582	5,445	5,232	5,362	5,415	5,428	5,436	5,405	5,425	5,477	5,499	5,495	5,499	5,508	5,517	5,511	5,508
17.6	18.0	17.5	16.7	16.9	17.0	16.9	16.8	16.6	16.5	16.5	16.5	16.3	16.2	16.1	16.0	15.9	15.8
0.37	0.37	0.36	0.34	0.34	0.33	0.32	0.32	0.31	0.30	0.30	0.29	0.28	0.28	0.27	0.26	0.26	0.25
31.2%	30.4%	32.3%	31.7%	32.8%	33.1%	33.1%	33.8%	34.6%	34.7%	34.5%	34.7%	34.8%	34.8%	34.6%	34.5%	34.3%	34.2%
$0.35	$0.35	$0.37	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
$1.24	$0.87	$0.83	$0.79	$0.71	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72
46.1	46.7	48.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6	50.6

Summary Table 1: Energy Security Metrics (Values)

2027-2033

#	Metric	Units of Measurement	2027	2028	2029	2030	2031	2032	2033
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	99.5	99.5	99.5	99.5	99.5	99.5	99.5
2	Security of World Oil Production	production, freedom & diversity-weighted	84.2	84.3	84.5	85.0	85.7	86.3	87.0
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	100.4	100.4	100.4	100.4	100.4	100.4	100.4
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	86.4	86.7	87.0	87.3	87.3	87.3	87.3
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	70.7	70.7	70.7	70.7	70.7	70.7	70.7
6	Security of World Coal Production	production, freedom & diversity-weighted	168.5	168.5	168.5	168.5	168.5	168.5	168.5
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	10.6	10.3	10.4	10.5	11.6	12.4	12.9
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	-8.1	-8.7	-9.2	-9.8	-9.9	-10.1	-10.2
9	Oil & Natural Gas Import Expenditures	billions of 2010$	$76.7	$75.3	$76.7	$78.4	$89.3	$98.4	$104.7
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$59.32	$58.63	$57.94	$57.33	$56.94	$56.66	$56.37
12	Energy Expenditures per Household	2010$/Household	$10,483	$10,517	$10,542	$10,577	$10,647	$10,739	$10,844
13	Retail Electricity Prices	cents/kWh (2010$)	10.5¢	10.5¢	10.5¢	10.5¢	10.5¢	10.6¢	10.6¢
14	Crude Oil Price	2010$/bbl	$91.69	$94.44	$97.27	$100.19	$103.19	$106.29	$109.47
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$19.62	$20.21	$20.81	$21.44	$22.08	$22.74	$23.43
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2010$)	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70
17	World Oil Refinery Utilization	percent utilization	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%
18	Petroleum Stock Levels	average days supply	95	95	95	96	96	96	96
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	291.1	289.6	288.2	286.9	285.4	283.9	282.7
20	Energy Intensity	million Btu/$1,000 GDP (2010$)	4.5	4.4	4.3	4.3	4.2	4.1	4.0
21	Petroleum Intensity	million Btu/real $1,000 GDP (2010$)	1.62	1.58	1.54	1.51	1.47	1.44	1.41
22	Household Energy Efficiency	million Btu/household	158.7	157.8	157.1	156.2	155.3	154.4	153.5
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	199.8	199.2	198.9	198.4	197.8	197.2	196.6
24	Industrial Energy Efficiency	trillion Btu/IP Index	269	266	264	260	257	254	251
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,552	3,567	3,585	3,598	3,613	3,620	3,627
26	Electricity Capacity Margins	percent	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	252	252	252	252	252	252	252
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	23.3	23.7	24.2	24.6	24.9	25.3	25.6
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2010$)	159	158	156	154	153	151	150
30	Transportation Non-Petroleum Fuels	percent	8.3%	8.4%	8.6%	8.7%	8.8%	8.9%	9.0%
Environmental Metrics									
31	Energy-Related CO2 Emissions	MMTCO2	5,509	5,510	5,511	5,514	5,509	5,505	5,505
32	Energy-Related CO2 Emissions per Capita	metric tons CO2/Person	15.7	15.6	15.5	15.4	15.3	15.2	15.1
33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.24	0.24	0.23	0.23	0.22	0.22	0.21
34	Electricity Non-CO2 Generation Share	percent of total generation	34.1%	34.0%	33.9%	33.9%	34.0%	34.1%	34.2%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	50.6	50.6	50.6	50.6	50.6	50.6	50.6

Summary Table 1: Energy Security Metrics (Values)

2034-2040

2034	2035	2036	2037	2038	2039	2040
99.5	99.5	99.5	99.5	99.5	99.5	99.5
87.2	87.3	87.4	87.6	87.7	88.0	88.2
100.4	100.4	100.4	100.4	100.4	100.4	100.4
87.3	87.3	87.0	86.7	86.4	86.1	85.7
70.7	70.7	70.7	70.7	70.7	70.7	70.7
168.5	168.5	168.5	168.5	168.5	168.5	168.5
13.1	13.0	13.0	13.1	13.0	13.1	12.9
-10.2	-10.3	-10.3	-10.4	-10.5	-10.6	-10.5
$109.1	$110.9	$114.0	$116.7	$118.7	$122.0	$119.7
0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
$56.04	$55.76	$55.47	$55.26	$55.24	$55.26	$55.19
$10,946	$11,059	$11,177	$11,310	$11,485	$11,672	$11,848
10.7¢	10.7¢	10.8¢	10.8¢	11.0¢	11.1¢	11.2¢
$112.58	$115.89	$119.32	$122.65	$126.30	$130.32	$133.98
$24.09	$24.80	$25.53	$26.25	$27.03	$27.89	$28.67
$5.70	$5.70	$5.70	$5.70	$5.70	$5.70	$5.70
79.6%	79.6%	79.6%	79.6%	79.6%	79.6%	79.6%
96	96	96	96	96	96	96
281.7	280.9	280.3	279.7	279.5	278.9	278.2
3.9	3.8	3.8	3.7	3.6	3.6	3.5
1.37	1.34	1.31	1.28	1.26	1.23	1.20
152.7	151.9	151.1	150.5	149.8	149.0	148.3
195.9	195.3	194.7	194.1	193.5	192.7	191.8
247	243	240	237	234	231	228
3,640	3,660	3,681	3,693	3,702	3,711	3,728
24.5%	24.5%	24.5%	24.5%	24.5%	24.5%	24.5%
252	252	252	252	252	252	252
25.9	26.1	26.3	26.5	26.6	26.7	26.8
148	146	144	141	139	137	135
9.2%	9.4%	9.7%	10.0%	10.4%	10.9%	11.3%
5,510	5,521	5,531	5,536	5,545	5,546	5,549
15.0	14.9	14.9	14.8	14.7	14.7	14.6
0.21	0.20	0.20	0.20	0.19	0.19	0.18
34.2%	34.2%	34.1%	34.3%	34.5%	34.8%	35.0%
$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
$0.72	$0.72	$0.72	$0.72	$0.72	$0.72	$0.72
50.6	50.6	50.6	50.6	50.6	50.6	50.6

Summary Table 2: Energy Security Indexes (1980 = 100)

1970-1981

#	Metric	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
	Index of U.S. Energy Security Risk	78.0	78.0	79.7	84.5	91.5	91.4	94.3	91.3	87.1	92.8	100.0	97.3
	Sub-Indexes												
	Geopolitical	71.9	72.5	74.8	80.7	87.6	90.7	94.9	93.6	87.2	93.3	100.0	96.6
	Economic	62.2	62.6	63.0	68.3	82.0	81.9	84.1	82.5	79.1	87.8	100.0	97.7
	Reliability	82.7	81.4	82.9	88.4	97.4	95.8	96.6	85.8	81.5	88.1	100.0	98.7
	Environmental	106.0	105.9	108.8	110.7	105.6	102.3	106.5	106.6	104.8	104.3	100.0	96.4
Global Fuels Metrics													
1	Security of World Oil Reserves	123.0	115.1	113.5	106.3	104.7	111.1	114.7	107.6	97.8	102.5	100.0	96.9
2	Security of World Oil Production	90.9	92.3	94.1	95.4	101.1	109.7	114.7	107.8	97.3	94.6	100.0	100.2
3	Security of World Natural Gas Reserves	57.8	67.8	74.4	78.6	84.4	102.3	106.9	114.2	100.7	98.7	100.0	106.2
4	Security of World Natural Gas Production	69.7	69.1	67.7	67.5	71.2	84.9	89.9	91.8	87.4	88.5	100.0	103.3
5	Security of World Coal Reserves	98.5	98.5	98.5	98.4	97.4	106.9	108.6	99.1	92.7	92.4	100.0	102.1
6	Security of World Coal Production	88.1	90.3	93.4	94.3	96.0	103.0	103.2	95.0	93.5	90.8	100.0	100.0
Fuel Import Metrics													
7	Security of U.S. Petroleum Imports	53.4	61.0	70.5	89.2	96.6	106.6	124.3	132.7	109.5	106.7	100.0	92.4
8	Security of U.S. Natural Gas Imports	74.5	75.9	73.8	70.9	69.2	89.4	93.5	101.9	89.3	112.2	100.0	94.4
9	Oil & Natural Gas Import Expenditures	7.4	8.8	10.5	25.6	47.8	44.7	55.9	69.4	61.0	85.2	100.0	84.6
10	Oil & Natural Gas Import Expenditures per GDP	10.1	11.7	13.1	30.5	57.2	53.6	63.5	75.4	62.8	85.0	100.0	82.5
Energy Expenditure Metrics													
11	Energy Expenditures per GDP	58.9	59.0	58.5	59.9	75.7	77.8	79.0	80.8	77.6	86.4	100.0	101.9
12	Energy Expenditures per Household	54.0	54.6	55.4	58.3	71.5	71.9	75.4	79.2	78.5	88.3	100.0	100.6
13	Retail Electricity Prices	70.4	71.0	71.8	71.7	82.2	87.3	88.5	91.4	92.9	92.8	100.0	107.0
14	Crude Oil Price	14.5	14.8	14.4	27.1	52.1	48.9	50.3	51.7	48.5	67.6	100.0	99.3
Price & Market Volatility Metrics													
15	Crude Oil Price Volatility	3.4	2.9	1.3	24.4	69.5	74.7	54.2	11.0	10.9	43.2	100.0	95.4
16	Energy Expenditure Volatility	25.9	28.0	25.6	33.6	87.6	86.1	84.9	46.9	42.1	66.9	100.0	110.8
17	World Oil Refinery Utilization	159.7	147.4	142.2	155.0	130.0	110.6	112.3	106.6	108.6	111.7	100.0	92.5
18	Petroleum Stock Levels	117.9	118.9	139.7	140.1	126.6	117.6	128.5	114.7	120.4	112.7	100.0	88.3
Energy Use Intensity Metrics													
19	Energy Consumption per Capita	96.3	97.1	100.8	104.0	100.7	97.0	101.4	103.0	104.5	104.6	100.0	96.5
20	Energy Intensity	118.7	117.4	117.0	115.3	113.3	110.4	110.6	108.5	105.4	103.3	100.0	95.0
21	Petroleum Intensity	117.9	118.2	121.0	121.1	116.9	114.6	116.9	117.9	114.2	108.3	100.0	91.0
22	Household Energy Efficiency	109.3	110.7	112.2	109.4	105.0	104.1	106.1	105.9	106.5	102.3	100.0	93.2
23	Commercial Energy Efficiency	111.9	113.1	113.1	111.2	110.0	111.3	112.1	108.7	106.0	104.1	100.0	97.2
24	Industrial Energy Efficiency	124.2	122.3	116.7	113.7	111.2	112.9	111.7	106.7	102.4	103.2	100.0	94.6
Electric Power Sector Metrics													
25	Electricity Capacity Diversity	110.0	110.2	109.7	108.7	106.3	100.4	100.8	94.8	95.0	96.9	100.0	99.9
26	Electricity Capacity Margins	142.7	129.2	135.0	120.1	102.9	95.7	92.6	100.6	100.4	88.6	100.0	92.7
27	Electricity Transmission Line Mileage	128.6	122.2	119.5	117.8	109.7	106.5	105.8	108.1	105.6	99.4	100.0	96.2
Transportation Sector Metrics													
28	Motor Vehicle Average MPG	110.8	109.9	110.8	111.8	110.8	109.0	109.9	108.1	107.3	106.4	100.0	97.8
29	Transportation VMT per $ GDP	99.3	102.1	103.6	102.2	100.2	104.1	104.4	104.4	104.1	99.9	100.0	99.3
30	Transportation Non-Petroleum Fuels	97.3	97.4	97.7	98.6	99.0	100.1	100.8	101.1	101.4	100.6	100.0	99.8
Environmental Metrics													
31	Energy-Related CO2 Emissions	33.8	40.4	69.0	95.3	74.5	56.9	91.6	109.8	116.3	125.2	100.0	83.7
32	Energy-Related CO2 Emissions per Capita	98.0	97.8	105.8	113.2	103.8	95.8	105.7	109.9	109.8	110.4	100.0	92.9
33	Energy-Related CO2 Emissions Intensity	122.0	119.5	119.4	118.0	114.6	111.4	112.1	110.4	105.6	103.8	100.0	94.9
34	Electricity non-CO2 Generation Share	131.3	122.6	123.7	120.8	104.0	93.8	99.1	104.0	91.8	97.1	100.0	99.1
Research and Development Metrics													
35	Industrial Energy R&D Expenditures	147.5	147.5	147.5	147.5	141.3	145.5	144.1	109.2	110.1	103.9	100.0	106.2
36	Federal Energy & Science R&D Expenditures	177.2	184.5	180.7	187.4	173.5	131.1	126.5	99.7	95.2	97.1	100.0	112.1
37	Science & Engineering Degrees	79.5	79.0	79.7	80.8	79.4	81.6	86.5	91.4	96.7	100.6	100.0	101.8

Summary Table 2: Energy Security Indexes (1980 = 100)

1982-2000

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
91.0	85.9	86.9	83.7	82.6	84.0	81.6	79.3	78.8	76.7	75.4	76.5	75.3	76.0	77.9	78.5	78.5	81.4	87.0
90.9	86.6	90.4	87.5	85.6	86.3	80.4	80.3	79.3	76.3	75.0	76.7	75.3	74.9	75.5	74.1	72.5	75.7	82.8
89.9	82.5	80.9	76.4	70.0	71.6	68.6	66.9	68.5	65.5	63.9	63.3	61.5	61.6	64.4	64.0	61.2	64.1	72.0
91.6	84.7	83.7	79.6	87.1	89.0	88.3	79.1	78.7	78.2	75.9	77.6	75.7	78.5	80.4	84.5	91.2	95.9	99.5
92.3	91.3	94.2	93.0	92.8	94.3	96.1	96.6	93.9	92.4	93.0	95.2	95.6	96.5	99.1	100.8	100.6	101.5	103.1
93.8	98.9	104.5	104.5	111.4	110.2	99.6	100.6	124.5	119.8	141.4	148.0	147.4	146.4	141.7	129.1	125.7	125.1	128.2
93.9	90.5	93.4	90.6	94.0	88.8	79.9	82.0	77.2	75.6	73.2	77.8	75.7	74.2	70.0	70.3	68.4	68.2	68.6
120.4	122.5	141.9	136.4	136.9	124.5	94.7	101.0	86.8	88.9	77.8	86.6	88.0	88.3	88.0	87.7	89.4	93.6	100.1
112.3	120.0	138.0	146.5	155.8	142.3	117.6	117.1	91.2	88.1	69.0	72.4	68.9	66.4	61.3	61.1	63.8	68.3	71.3
102.1	100.8	107.6	107.5	107.3	99.6	86.4	86.1	68.8	72.2	71.0	61.1	57.1	55.4	52.0	53.5	52.5	55.6	58.2
101.9	102.5	109.4	108.5	108.1	102.6	96.8	102.9	88.3	87.5	83.6	92.1	91.5	90.4	90.1	84.5	75.3	75.3	81.6
71.8	69.1	74.9	65.5	82.6	82.1	78.0	85.8	81.0	75.2	72.9	83.3	82.6	78.8	77.1	81.6	82.8	80.8	84.7
114.2	122.2	121.6	146.5	126.3	146.2	146.9	142.7	123.5	130.6	107.4	124.5	129.1	127.3	115.5	114.9	130.4	157.1	160.1
58.9	49.7	51.8	43.2	26.0	35.9	31.7	40.3	50.1	38.5	38.5	37.4	36.2	36.7	47.6	47.1	34.9	47.6	74.6
58.5	47.2	45.8	36.7	21.3	28.5	24.2	29.6	36.1	27.7	26.8	25.3	23.5	23.3	29.1	27.5	19.5	25.4	38.3
97.5	87.8	82.4	77.1	64.0	62.5	59.9	59.4	60.7	58.5	55.8	54.7	52.8	51.4	52.9	50.5	44.3	44.2	51.1
93.3	87.0	85.8	82.3	69.7	69.3	68.2	68.9	71.2	67.9	66.2	65.8	65.5	64.5	68.3	67.3	60.9	62.8	75.0
111.8	111.1	106.4	106.2	104.1	100.4	96.7	94.6	92.9	92.4	91.2	90.6	88.4	86.4	84.4	82.9	80.7	78.3	78.5
85.2	71.2	68.2	61.9	29.4	37.8	29.4	34.5	43.4	35.4	33.4	28.7	26.2	27.6	32.8	29.9	19.7	27.3	42.7
86.2	52.6	56.8	42.6	76.3	86.2	90.0	40.1	41.0	40.3	34.5	26.8	16.8	15.6	16.6	17.4	33.5	37.7	60.5
94.4	61.8	44.1	28.3	50.2	48.9	40.3	8.2	15.6	24.4	20.7	12.8	5.2	2.8	14.5	13.7	28.6	23.1	55.4
91.3	96.9	101.2	101.1	110.7	111.3	118.0	121.5	118.8	120.1	119.4	118.2	115.8	120.3	124.2	125.8	124.3	117.2	121.9
87.6	85.5	82.5	84.5	83.7	84.6	88.3	89.4	85.6	84.4	87.6	85.4	87.5	92.6	99.4	97.4	93.8	106.7	109.9
91.8	90.8	94.6	93.5	92.9	95.0	98.5	100.0	98.5	97.1	97.3	97.8	98.5	99.5	101.6	101.0	100.3	100.8	101.9
93.0	88.8	86.9	83.1	80.6	80.3	80.6	79.7	78.0	78.0	76.5	75.8	74.3	73.9	73.6	70.8	68.1	66.2	65.0
87.8	83.4	80.4	76.8	77.2	76.2	76.2	73.4	70.7	69.2	68.2	66.7	65.8	63.8	63.7	61.8	60.2	59.1	57.5
93.8	92.2	93.4	92.3	90.6	90.8	94.1	96.2	90.9	92.5	91.0	94.2	92.8	93.6	97.6	93.8	92.5	94.2	97.7
96.3	94.1	93.0	88.2	84.9	84.9	87.0	88.9	87.6	86.7	84.3	84.0	83.2	84.1	83.9	83.7	82.5	81.9	84.5
89.7	86.7	85.8	82.6	80.2	79.3	78.7	79.7	80.1	80.3	81.1	78.6	76.7	74.2	73.0	68.7	64.3	61.5	58.9
102.5	102.6	100.8	97.1	94.7	93.3	87.3	90.9	87.4	83.5	83.2	82.9	81.0	79.0	79.7	81.4	79.6	77.1	77.0
81.1	93.7	90.4	88.1	92.7	99.2	119.7	104.8	113.7	114.3	109.5	124.5	127.6	159.8	149.6	174.7	224.3	266.4	197.5
90.8	95.3	92.7	92.6	95.4	97.3	102.1	99.5	103.2	103.6	102.4	106.0	108.0	114.9	112.8	115.5	118.7	121.9	120.6
94.3	93.7	91.7	91.1	90.5	88.1	85.3	83.6	81.1	78.7	78.7	79.6	79.6	79.2	78.7	78.2	78.7	79.6	78.7
103.8	102.8	99.7	98.7	98.6	99.8	101.0	100.8	101.1	102.5	102.4	101.9	100.5	100.6	100.0	98.3	96.9	94.8	93.0
100.0	101.0	100.6	100.9	101.2	100.9	100.3	100.2	99.9	100.3	100.4	100.0	99.6	99.5	99.9	99.4	100.4	100.4	100.5
52.5	48.9	79.6	77.8	78.8	99.3	127.6	138.7	134.6	128.7	140.9	153.6	163.5	171.5	195.7	205.3	212.0	218.8	242.1
82.1	79.8	86.8	84.8	83.6	87.7	94.2	95.6	92.5	88.5	89.5	90.3	90.6	90.4	94.6	94.9	94.2	94.1	98.1
91.8	87.3	85.6	81.9	79.3	79.2	79.5	78.0	76.1	75.5	74.3	73.6	71.8	70.6	70.4	68.3	66.0	63.7	63.2
87.5	85.2	85.7	85.3	81.0	83.7	82.8	80.1	75.3	73.3	75.3	76.4	76.7	73.1	72.4	76.0	77.9	75.9	79.2
106.8	109.8	113.4	127.1	141.3	138.0	146.1	148.5	148.4	147.0	171.9	195.6	203.7	230.4	241.7	302.9	278.1	323.3	290.2
129.3	150.6	160.4	172.7	186.5	200.9	207.0	199.5	196.7	186.7	191.9	216.5	221.1	229.7	255.0	273.6	289.3	280.4	290.9
97.3	100.8	106.1	107.9	110.4	114.9	121.8	125.1	124.9	121.9	120.4	119.4	120.9	122.2	124.8	129.9	135.0	140.2	144.5

Summary Table 2: Energy Security Indexes (1980 = 100)

2001-2012

#	Metric	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	Index of U.S. Energy Security Risk	83.8	81.7	80.9	86.2	93.4	95.7	95.2	98.3	89.4	96.5	101.0	91.5
	Sub-Indexes												
	Geopolitical	81.1	78.3	77.3	84.1	91.2	94.2	95.4	99.9	87.2	94.0	100.7	93.2
	Economic	68.4	66.8	67.9	74.6	85.2	89.7	90.2	99.1	83.6	92.7	101.7	92.0
	Reliability	94.1	90.6	86.4	92.0	102.1	104.6	100.0	99.0	104.3	112.9	114.5	96.4
	Environmental	100.4	100.5	100.1	101.0	100.4	97.9	97.7	94.0	86.2	89.9	86.9	83.3
Global Fuels Metrics													
1	Security of World Oil Reserves	127.4	124.3	91.1	92.2	87.4	87.3	86.4	87.4	87.3	88.3	93.3	95.1
2	Security of World Oil Production	69.1	65.7	68.4	72.8	72.2	72.5	72.5	74.9	73.2	75.6	79.3	80.3
3	Security of World Natural Gas Reserves	99.4	95.5	93.2	97.8	98.6	97.4	97.7	96.7	96.7	93.5	93.7	96.5
4	Security of World Natural Gas Production	72.5	71.1	71.5	76.3	76.9	78.1	78.4	77.9	75.1	78.3	82.4	81.4
5	Security of World Coal Reserves	58.1	56.3	67.9	70.3	67.5	73.8	73.8	68.0	67.7	68.6	66.7	66.8
6	Security of World Coal Production	83.5	87.1	100.2	109.5	114.5	118.3	123.5	128.3	137.9	143.8	153.3	168.5
Fuel Import Metrics													
7	Security of U.S. Petroleum Imports	89.4	81.8	90.0	99.6	101.5	101.1	98.4	99.6	88.3	87.6	84.2	77.8
8	Security of U.S. Natural Gas Imports	172.8	157.2	152.0	167.6	180.0	177.0	181.5	141.5	121.2	117.6	92.5	67.1
9	Oil & Natural Gas Import Expenditures	66.1	64.3	75.9	103.5	146.2	166.1	174.9	209.3	116.8	144.0	174.4	150.1
10	Oil & Natural Gas Import Expenditures per GDP	33.6	32.1	36.9	48.5	66.2	73.3	75.9	91.0	52.3	62.8	74.9	63.0
Energy Expenditure Metrics													
11	Energy Expenditures per GDP	50.1	46.3	50.2	54.3	61.1	64.0	65.2	73.2	56.4	61.8	68.4	63.9
12	Energy Expenditures per Household	73.3	70.2	77.9	86.6	99.2	105.3	108.5	120.3	90.2	100.8	111.8	105.9
13	Retail Electricity Prices	82.2	79.9	81.0	80.6	83.6	88.6	88.6	92.7	92.7	91.7	90.5	88.3
14	Crude Oil Price	35.6	35.9	40.6	52.4	72.4	83.9	90.8	119.2	75.3	96.0	131.4	129.5
Price & Market Volatility Metrics													
15	Crude Oil Price Volatility	54.8	41.5	22.0	30.6	66.7	79.0	70.2	85.5	144.6	169.6	182.5	105.9
16	Energy Expenditure Volatility	42.6	46.5	33.5	53.6	74.7	71.9	58.2	57.0	114.7	128.9	126.5	65.9
17	World Oil Refinery Utilization	120.6	117.2	124.0	130.2	130.8	128.9	128.2	125.0	115.4	119.7	119.4	118.7
18	Petroleum Stock Levels	101.1	104.2	104.3	103.2	100.0	98.2	101.4	91.9	86.3	87.3	88.1	83.7
Energy Use Intensity Metrics													
19	Energy Consumption per Capita	98.2	98.8	98.2	99.5	98.7	97.1	97.6	94.7	89.3	91.7	90.5	87.6
20	Energy Intensity	62.7	62.5	61.0	60.0	58.2	56.3	56.1	55.1	53.9	54.5	53.3	50.8
21	Petroleum Intensity	56.8	55.8	55.1	55.1	53.4	51.4	50.1	46.9	45.7	45.3	43.7	41.7
22	Household Energy Efficiency	94.7	100.1	101.2	100.0	101.0	95.4	98.7	98.4	95.8	98.7	95.3	88.1
23	Commercial Energy Efficiency	83.0	82.7	81.5	81.6	81.2	79.2	80.4	79.8	76.4	76.0	74.5	71.4
24	Industrial Energy Efficiency	57.6	57.4	56.5	56.8	53.3	52.1	50.8	50.8	52.1	52.8	51.6	49.9
Electric Power Sector Metrics													
25	Electricity Capacity Diversity	79.2	84.5	90.8	91.5	93.3	92.9	91.7	91.3	90.2	90.2	89.6	88.3
26	Electricity Capacity Margins	163.7	142.3	115.0	106.8	131.0	150.2	137.8	112.3	96.5	109.6	112.3	102.3
27	Electricity Transmission Line Mileage	121.6	125.3	123.2	121.9	130.9	134.3	131.2	124.5	120.1	123.6	110.2	111.9
Transportation Sector Metrics													
28	Motor Vehicle Average MPG	77.8	78.7	78.2	77.8	77.8	77.3	77.3	76.4	75.6	76.4	76.0	75.6
29	Transportation VMT per $ GDP	93.7	94.0	92.6	91.4	89.3	87.7	86.6	85.2	87.2	85.3	83.4	81.6
30	Transportation Non-Petroleum Fuels	100.4	100.1	100.1	100.1	99.7	98.8	97.7	95.4	94.1	93.3	92.4	91.8
Environmental Metrics													
31	Energy-Related CO2 Emissions	228.3	233.9	240.3	255.4	258.4	247.6	259.3	234.5	179.6	205.1	187.3	159.7
32	Energy-Related CO2 Emissions per Capita	92.7	92.6	92.5	94.5	93.4	89.3	90.0	82.8	69.9	73.9	69.2	63.0
33	Energy-Related CO2 Emissions Intensity	61.4	60.9	59.7	58.7	57.0	54.8	54.7	53.2	50.9	51.1	49.0	46.0
34	Electricity non-CO2 Generation Share	81.8	79.2	79.7	80.0	81.8	79.7	82.6	80.0	74.9	77.0	72.5	73.7
Research and Development Metrics													
35	Industrial Energy R&D Expenditures	277.2	254.0	242.3	225.3	211.4	180.6	161.0	159.0	163.3	163.8	159.8	156.2
36	Federal Energy & Science R&D Expenditures	264.6	261.9	258.2	265.6	251.3	266.5	230.0	224.4	135.9	193.3	204.1	213.9
37	Science & Engineering Degrees	144.6	143.2	138.0	136.6	137.8	139.1	139.7	135.6	128.3	126.9	121.7	117.1

Summary Table 2: Energy Security Indexes (1980 = 100)

2013-2031

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
87.3	82.0	74.5	77.2	77.3	77.2	77.5	77.9	78.0	78.3	78.6	78.8	79.1	79.6	79.8	80.1	80.4	80.9	81.6
88.7	81.9	72.1	74.8	74.5	74.2	74.5	75.0	75.3	75.7	76.3	76.7	77.1	77.8	78.2	78.6	79.2	79.8	80.9
86.7	79.9	67.0	71.5	72.0	71.5	71.7	72.0	72.4	72.8	73.3	73.6	74.1	74.7	75.1	75.4	75.9	76.4	77.4
88.2	82.1	79.5	82.3	83.7	84.5	85.4	86.4	86.8	87.3	87.9	88.4	89.1	89.8	90.4	91.0	91.7	92.4	93.4
85.3	85.0	84.5	84.1	83.1	82.8	82.9	82.4	81.7	81.2	80.8	80.3	79.7	79.2	78.7	78.3	77.9	77.6	77.1
95.8	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
79.9	82.3	85.3	85.3	84.7	84.5	84.5	84.3	84.1	84.0	84.0	84.0	84.0	84.2	84.2	84.3	84.5	85.0	85.7
97.8	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4
83.7	81.8	82.6	82.9	83.2	83.5	83.8	84.2	84.5	84.8	85.2	85.5	85.8	86.1	86.4	86.7	87.0	87.3	87.3
67.4	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7
168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5
66.5	53.4	44.3	39.9	31.6	28.6	26.4	26.1	26.2	26.4	27.1	26.9	27.4	28.7	28.5	27.7	27.9	28.3	31.0
58.5	50.4	33.6	14.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121.5	86.7	43.3	49.8	42.2	37.0	33.2	31.6	31.6	32.6	34.3	34.7	36.3	39.0	39.0	38.3	39.0	39.9	45.4
49.9	34.8	16.9	18.9	15.7	13.4	11.7	10.8	10.6	10.6	10.9	10.8	11.0	11.5	11.3	10.8	10.8	10.8	12.0
62.7	60.0	47.3	50.2	50.2	49.4	49.0	48.7	48.4	48.0	47.5	46.9	46.4	45.9	45.4	44.8	44.3	43.8	43.5
106.1	103.6	83.7	90.4	91.8	91.9	92.7	93.7	94.6	95.2	95.9	96.3	97.0	97.4	97.8	98.1	98.3	98.6	99.3
89.1	91.1	89.3	91.1	91.5	90.7	91.4	93.0	94.5	95.1	95.8	95.9	96.9	97.3	97.7	98.0	97.7	97.8	97.9
124.1	108.4	63.6	81.2	87.3	87.2	88.8	90.5	92.9	95.6	98.4	101.3	104.2	107.3	110.5	113.8	117.2	120.8	124.4
78.1	41.9	44.0	64.0	77.2	85.4	95.6	106.1	109.0	112.1	115.4	118.8	122.1	125.8	129.6	133.5	137.5	141.6	145.8
40.4	42.5	44.7	46.8	48.9	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3
87.9	83.7	84.7	85.1	84.9	85.7	86.1	86.4	86.4	86.5	86.5	86.4	86.2	86.0	85.8	85.7	85.5	85.3	85.2
89.4	89.9	88.6	88.7	88.2	88.2	88.2	87.9	87.3	86.9	86.5	86.2	85.6	85.2	84.7	84.3	83.9	83.5	83.1
51.1	50.6	48.8	48.1	47.1	46.2	45.4	44.3	43.3	42.4	41.5	40.5	39.6	38.7	37.8	37.0	36.3	35.6	34.9
41.5	40.8	41.1	40.4	39.7	39.0	38.1	37.2	36.3	35.4	34.5	33.6	32.7	31.8	31.0	30.2	29.5	28.8	28.1
93.4	94.5	90.6	89.3	88.1	87.4	86.9	85.5	84.4	83.4	82.7	82.1	81.4	80.8	80.2	79.8	79.4	79.0	78.5
73.6	74.5	73.1	72.5	71.6	71.1	70.8	70.3	69.6	69.0	68.5	68.2	67.8	67.5	67.3	67.1	67.0	66.8	66.6
49.2	47.2	45.9	45.9	45.4	45.2	45.2	45.0	44.7	44.5	44.1	43.7	43.1	42.7	42.2	41.8	41.3	40.8	40.3
88.5	88.1	87.5	88.7	90.4	89.5	88.5	87.5	86.7	86.3	86.3	86.6	88.1	88.5	89.4	90.3	91.3	92.1	92.9
92.5	92.3	98.0	100.8	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9
111.2	109.6	109.7	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4
75.6	72.7	72.0	71.0	69.9	68.9	67.6	66.3	65.0	63.7	62.4	61.0	59.7	58.4	57.1	56.0	55.0	54.1	53.3
80.3	78.9	78.7	78.1	77.4	76.4	75.4	74.3	73.4	72.6	71.6	70.6	69.7	68.8	68.1	67.3	66.7	66.0	65.4
90.4	90.3	92.2	91.3	91.4	91.7	91.6	91.6	91.5	91.3	91.1	90.9	90.7	90.5	90.3	90.0	89.8	89.6	89.4
176.5	183.4	185.1	186.2	182.1	184.8	191.4	194.3	193.8	194.3	195.5	196.7	195.9	195.4	195.6	195.7	195.9	196.2	195.6
65.1	65.4	64.7	63.9	62.2	61.7	61.9	61.5	60.5	59.7	59.0	58.4	57.4	56.5	55.8	55.0	54.3	53.7	52.9
46.2	45.5	44.3	43.3	42.1	41.1	40.5	39.6	38.6	37.7	36.8	36.0	35.0	34.1	33.3	32.6	31.9	31.2	30.5
71.4	70.7	70.7	69.1	67.6	67.5	67.7	67.5	67.2	67.3	67.6	67.9	68.2	68.4	68.7	68.9	69.0	69.0	68.8
156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2
237.9	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4
117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1

Summary Table 2: Energy Security Indexes (1980 = 100)

2032-2040

#	Metric	2032	2033	2034	2035	2036	2037	2038	2039	2040
	Index of U.S. Energy Security Risk	82.3	82.9	83.5	84.0	84.6	85.2	85.8	86.5	87.0
	Sub-Indexes									
	Geopolitical	82.0	82.9	83.7	84.4	85.2	85.9	86.7	87.7	88.2
	Economic	78.4	79.3	80.1	80.8	81.6	82.4	83.3	84.4	85.2
	Reliability	94.3	95.1	95.9	96.6	97.4	98.2	98.9	99.8	100.5
	Environmental	76.7	76.3	76.0	75.7	75.5	75.2	75.0	74.6	74.3
Global Fuels Metrics										
1	Security of World Oil Reserves	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
2	Security of World Oil Production	86.3	87.0	87.2	87.3	87.4	87.6	87.7	88.0	88.2
3	Security of World Natural Gas Reserves	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4	100.4
4	Security of World Natural Gas Production	87.3	87.3	87.3	87.3	87.0	86.7	86.4	86.1	85.7
5	Security of World Coal Reserves	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7	70.7
6	Security of World Coal Production	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5
Fuel Import Metrics										
7	Security of U.S. Petroleum Imports	33.2	34.5	35.2	34.9	35.0	35.0	34.9	35.2	34.5
8	Security of U.S. Natural Gas Imports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	Oil & Natural Gas Import Expenditures	50.0	53.3	55.5	56.4	58.0	59.4	60.4	62.1	60.9
10	Oil & Natural Gas Import Expenditures per GDP	13.0	13.5	13.7	13.6	13.7	13.7	13.6	13.7	13.1
Energy Expenditure Metrics										
11	Energy Expenditures per GDP	43.3	43.1	42.9	42.6	42.4	42.3	42.2	42.3	42.2
12	Energy Expenditures per Household	100.2	101.1	102.1	103.1	104.2	105.5	107.1	108.9	110.5
13	Retail Electricity Prices	98.5	99.1	99.6	100.1	100.5	101.1	102.2	103.4	104.7
14	Crude Oil Price	128.1	132.0	135.7	139.7	143.8	147.8	152.2	157.1	161.5
Price & Market Volatility Metrics										
15	Crude Oil Price Volatility	150.2	154.7	159.1	163.8	168.6	173.3	178.5	184.2	189.4
16	Energy Expenditure Volatility	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0	51.0
17	World Oil Refinery Utilization	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3	114.3
18	Petroleum Stock Levels	85.0	84.9	84.8	84.8	84.8	84.9	84.9	84.8	84.7
Energy Use Intensity Metrics										
19	Energy Consumption per Capita	82.6	82.3	82.0	81.8	81.6	81.4	81.3	81.2	81.0
20	Energy Intensity	34.2	33.5	32.8	32.2	31.6	31.0	30.4	29.8	29.2
21	Petroleum Intensity	27.5	26.8	26.2	25.7	25.1	24.5	24.0	23.4	22.8
22	Household Energy Efficiency	78.0	77.6	77.2	76.8	76.4	76.1	75.7	75.3	75.0
23	Commercial Energy Efficiency	66.4	66.2	66.0	65.7	65.5	65.3	65.1	64.9	64.6
24	Industrial Energy Efficiency	39.9	39.3	38.7	38.1	37.6	37.1	36.7	36.3	35.8
Electric Power Sector Metrics										
25	Electricity Capacity Diversity	93.3	93.7	94.5	95.6	96.8	97.5	98.0	98.6	99.5
26	Electricity Capacity Margins	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9	106.9
27	Electricity Transmission Line Mileage	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4	110.4
Transportation Sector Metrics										
28	Motor Vehicle Average MPG	52.6	51.9	51.4	51.0	50.6	50.3	50.0	49.8	49.6
29	Transportation VMT per $ GDP	64.7	63.9	63.1	62.3	61.4	60.4	59.5	58.5	57.5
30	Transportation Non-Petroleum Fuels	89.2	88.9	88.6	88.2	87.8	87.1	86.4	85.6	84.7
Environmental Metrics										
31	Energy-Related CO2 Emissions	195.1	195.1	195.8	197.1	198.4	199.1	200.3	200.5	200.8
32	Energy-Related CO2 Emissions per Capita	52.2	51.5	51.0	50.6	50.2	49.7	49.4	48.9	48.4
33	Energy-Related CO2 Emissions Intensity	29.9	29.2	28.6	28.0	27.4	26.8	26.3	25.7	25.1
34	Electricity non-CO2 Generation Share	68.6	68.5	68.4	68.5	68.5	68.2	67.8	67.2	66.9
Research and Development Metrics										
35	Industrial Energy R&D Expenditures	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2	156.2
36	Federal Energy & Science R&D Expenditures	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4	233.4
37	Science & Engineering Degrees	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1	117.1

Primary Data Sources

The Energy Institute relied primarily on government data from the Energy Information Administration (EIA), Department of Commerce, and Department of Transportation to develop its Index of U.S. Energy Security. Where historical data from government sources were not available (largely data before 1990 or so), other widely-used and respected sources were employed. EIA's *Annual Energy Outlook 2015 (AEO 2015)* was the primary source for metric forecasts out to 2040.

The following provides a list of the main sources of the data used to compile the metrics. Detailed information on these sources also is available on the Energy Institute's Index of U.S. Energy Security website at http://www.energyxxi.org/energysecurityindex.

American Petroleum Institute:
For pre-1980 refinery utilization data.

BP: *BP Statistical Review of World Energy.* Available at: http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy.html. For pre-1980 international natural gas production and post-1980 refinery utilization data.

Department of Commerce:

- Bureau of the Census, Statistical Abstract. Available at: http://www.census.gov/compendia/statab/. For historical population data.

- Bureau of the Census, Housing Housing Vacancies and Homeownership (CPS/HVS) - Historical Tables, Table 7. Annual Estimates of the Housing Inventory: 1965 to Present. Available at: https://www.census.gov/housing/hvs/data/histtabs.html. For historical household data.

- Bureau of Economic Analysis, National Economic Accounts: Current-Dollar and "Real" Gross Domestic Product. Available at: http://www.bea.gov/national/xls/gdplev.xls. For historical nominal and real GDP data.

- Bureau of the Census, Statistical Abstract, Energy & Utilities, Electric Power Industry - Capability, Peak Load, and Capacity Margin. Available at http://www.census.gov/compendia/statab/cats/energy_utilities.html. For pre-1989 summer peak load aggregates.

Department of Transportation:
Federal Highway Administration, Highway Statistics. Available at: http://www.fhwa.dot.gov/policyinformation/statistics.cfm. For historical vehicle miles traveled data.

Energy Information Administration:

- Annual Energy Outlook 2013. Available at: http://www.eia.gov/forecasts/aeo/. For forecast import, expenditure, cost, electricity price, generating capacity, production, consumption, stock, miles per gallon, and energy-related carbon dioxide emissions data.

- Annual Energy Review. Available at: http://www.eia.gov/totalenergy/data/annual/. For historical import, expenditure, cost, electricity price, generating capacity, production, consumption, stock, miles per gallon, and energy-related carbon dioxide emissions data

- International Energy Outlook. Available at: http://www.eia.gov/forecasts/ieo/index.cfm. For forecast world oil and natural gas production data.

- International Energy Statistics. Available at: http://www.eia.gov/countries/data.cfm. For historical international reserves and production data.

- Monthly Energy Review. Available at: http://www.eia.gov/totalenergy/data/monthly/. For historical energy expenditure data and preliminary energy and emissions data.

Federal Reserve Board:
Industrial Production Index. Available at: http://www.federalreserve.gov/releases/G17/download.htm. For historical industrial production data.

Freedom House:
Freedom in the World: Comparative and Historical Data. Available at: http://www.freedomhouse.org/report-types/freedom-world#.U_JVsqO5KiA. For historical international political rights and civil liberties

historical international political rights and civil liberties data. Freedom House's annual index of political rights and civil liberties was used as a proxy for reliability of international trading partners.

International Energy Agency:
For pre-1980 international coal production data.

Oil & Gas Journal:
For pre-1980 international crude oil reserves and natural gas reserves data.

National Science Foundation:
Division of Science Resources Statistics, Science and Engineering Statistics. Available at: http://www.nsf.gov/statistics/. For historical industrial R&D expenditure, federal science and energy R&D expenditure, and science and engineering degree data.

North American Electric Reliability Council:
For historical transmission line mileage data.

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