2016 EDITION

INDEX OF U.S. ENERGY SECURITY RISK®

ASSESSING AMERICA'S VULNERABILITIES IN A GLOBAL ENERGY MARKET

Institute for 21st Century Energy • U.S. Chamber of Commerce | www.energyxxi.org

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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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INSTITUTE FOR 21ST CENTURY ENERGY
U.S. CHAMBER OF COMMERCE

Contents

Foreword

This year's edition of the Institute for 21st Century Energy's Index of U.S. Energy Security Risk (U.S. Index) shows yet another year of improvement in the country's energy security. As the report that follows shows, since energy security risks reached their highest level in 2011, we have seen a dramatic improvement that continued into 2015, when the risk index hit a score of 77.9, the lowest level since 1996.

That this lowering of risk occurred at the same time U.S. energy companies were using hydraulic fracturing, horizontal drilling, and advanced seismic imaging to coax unprecedented volumes of oil and natural gas from shale formations is hardly a coincidence. The beneficial effects of this energy revolution have rippled throughout the entire economy, lowering imports, improving our balance of trade, creating good-paying jobs, lowering energy prices and expenditures, and giving a still-ailing economy a much needed shot in the arm.

"The outlook for U.S. energy security is as bright as it has been since we started measuring it back in 2011. While it is never safe to bet against America's entrepreneurs, one should also never take a bright energy future for granted, either."

And this is just the beginning. U.S. industry has been put under tremendous pressure by the desire of Saudi Arabia—once thought the world's undeniable swing oil producer—to capture market share by creating a global glut. Far from weakening America's energy sector, what is emerging is an industry that is much stronger and efficient, and one that is poised to take advantage of tightening market conditions. The outlook for U.S. energy security is as bright as it has been since we started measuring it back in 2011. While it is never safe to bet against America's entrepreneurs, one should also never take a bright energy future for granted, either.

Given this bright outlook, it is mystery that some of our political leaders have campaigned on promises to nip this energy revolution in the bud. Granted, it is not unusual for candidates in an election year to say things that only appeal to certain constituencies, such as the "Keep it in the Ground" movement. It is disconcerting nonetheless.

So we decided to take them at their word and examine what it would mean for the U.S. if different aspects of their campaign rhetoric were actually implemented. That is the goal of the Energy Institute's "Energy Accountability Series." The series goes beyond the energy security aspects detailed in our Risk Index reports and takes a look at what might have happened in the past—or could happen in the future—if certain energy-related ideas and policy prescriptions put forth by prominent politicians and their supporters actually were adopted. One broad question we posed was: What if America's energy renaissance had not actually happened? To answer it, we took a look at the years 2009 through 2015 and analyzed what the American economy would look like had the energy revolution not occurred. The results are not pretty.

We found that without the energy renaissance, America would have had 4.3 million fewer jobs and $548 billion less in annual GDP. Consumers would be paying 31% more for electricity and 43% more for gasoline. Lower energy prices have spurred a comeback in manufacturing that alone is responsible for nearly 400,000 jobs.

Over the past year, a growing number of politicians and interest groups also have called to make federal lands and offshore waters off limits for oil, natural gas and coal extraction. Federal lands are the source of a significant, if declining, share of America's energy production. We found that if policies restricting access to these federally-controlled resources were to be enacted, about one-fourth of all U.S. oil, natural gas, and coal production would be halted at a cost of $11 billion in lost royalties, 380,000 jobs, and $70 billion in annual GDP.

The impacts would be felt disproportionately in a few states. Wyoming, for example, would lose $900 million in annual royalty collections—which represents 20% of the state's annual expenditures. New Mexico could lose $500 million—8% of the state's total General Fund Revenues. Colorado would see the loss of 50,000 jobs, while the Gulf States (Texas, Louisiana, Mississippi and Alabama) would see 110,000 fewer jobs

We have written at some length both in the U.S. Index and in our companion International Index of Energy Security Risk reports about the competitive edge low energy costs give U.S. industry vis-à-vis industry in other developed countries, particularly those in the European Union.

This hard-won competitive edge has not stopped some politicians and interest groups from heralding Europe's energy policies as a model for the United States to follow. So we took an in-depth look at the policies and regulations that have led to much higher prices for energy in the European Union (EU). We identified four key factors that make energy more costly in the EU: (1) restrictions that inhibit access to low-cost, existing electricity supply and oil and natural gas supplies; (2) more generous subsidies provided by EU members for

uneconomic technologies; (3) EU policies that place a tax on carbon emissions; and (4) much higher taxes on energy consumption. What we found was that if EU price levels were overlaid on the U.S. economy in 2014, the average American household would pay $4,800 more for their energy needs, and there would be 7.7 million fewer jobs.

Hydraulic fracturing, or "fracking," also has become something of a hot-button issue, especially with environmental groups who do not appreciate how the use of this technology has furthered their own goals.

Fracking has been used safely for decades as well stimulation technique in vertical wells, and its value increased tremendously when used in combination with horizontal (or "directional") drilling in shale formations.

"The decisions the next president will make will go a long way to determine whether the energy security momentum America has been able to build will dissipate or strengthen."

Despite claims to the contrary, there is no credible evidence that fracking has ever caused contamination of ground water, as even the Environmental Protection Agency concluded. That has not stopped environmental activists and their political allies from proposing to ban the practice that largely has been responsible for the huge increases in U.S. oil and gas production.

The impacts of a ban would be tremendously detrimental to the economy. We estimate that if a ban fracking ban were implemented, by 2022 natural gas, crude oil and wholesale electricity prices would increase by more than 400%. Many of the downstream industries that now rely on inexpensive natural gas would look elsewhere for supplies of feedstock and fuel, and some would close up shop and move operations overseas. New investment in chemical facilities also would dry up.

The impacts would extend beyond the economic to the geopolitical, as the high oil and natural gas prices that would result from a ban would stimulate production internationally from less reliable global suppliers. The Global Fuel metrics for oil, natural gas, and coal used in our U.S. and International Indexes measure the benefits, in terms of reduced risk, of increasing the reliability and the diversity of supplies for these fuels. Less U.S. output would increase the concentration of suppliers and give greater leverage in the energy space to countries like Russia and cartels like the Organization of Petroleum Exporting Countries.

These and other benefits of America's energy revolution, however, are contingent on the ability to move these resources to domestic and global markets. Construction of the infrastructure needed to sustain of the U.S. energy revolution, has become controversial. We have already seen how politics has for now stopped construction of the northern portion of the Keystone XL pipeline, which would have carried Canadian crude oil to refineries along the Gulf Coast.

Domestically, New England region could definitely benefit from greater access to inexpensive natural gas, and producers in Pennsylvania and Ohio would love to meet this demand. But doing so requires pipeline infrastructure that is in danger of being blocked or delayed, which would keep energy costs in New England needlessly high.

It is not just New England that is being impacted. The Dakota Access pipeline will link North Dakota's oil fields with refineries in the Midwest and Gulf Coast. The project has undergone extensive stakeholder consultation and environmental review, received its national permits, and would run along existing rights of way for a natural gas pipeline and transmissions line. As of this writing, Dakota Access is awaiting a final Army Corp of Engineers easement and is being held up by Keep it in the Ground activists, which means that most North Dakota crude oil will continue to travel by rail.

Our purpose in highlighting these issues is simple: The decisions the next president will make will go a long way to determine whether the energy security momentum America has been able to build will dissipate or strengthen. We think—indeed, we have shown—there is an unassailable case to make that America's energy revolution has been good for America's energy security, and in turn that the country's improving energy security picture has been good for the economy, consumers, and workers.

Now it is up to policymakers to ensure that we are prepared to capitalize on the type of economic and geopolitical opportunity that comes along only rarely. The energy industry is up to the job. Are our political leaders?

Karen A. Harbert
President and CEO
Institute for 21st Century Energy
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 City University of New York Hunter College intern Matthew LoCastro 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 usually fine job designing clean graphics that make sense of complex issues and producing a publication under a tight deadline.

Introduction

The 2016 edition of the Institute for 21st Century Energy's (Energy Institute) Index of U.S. Energy Security Risk (Index), the seventh in the series, provides an updated look at U.S. energy security incorporating the most recent historical data 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] It 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) 2016.

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's scale is necessarily open-ended. 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 Index scores, the 1980 baseline scores, the 30-year average scores, and the historical high and low scores provided in the report can be used as a frame of reference against which to assess current and future risks. Unless noted otherwise, all dollar figures are in real 2015 dollars.

This Index focuses 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.

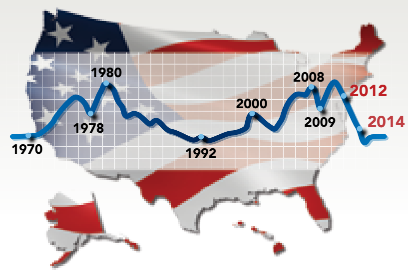
2 Appendix 1 contains more information on the methods used to develop the Index.

Highlights

This 2016 edition of the Index of U.S. Energy Security Risk (U.S. Index) includes the most recent energy data available, including AEO 2016 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 2015 fell for the fourth year in a row, dropping 3.1 points (4%) from 2012 to

78.0.

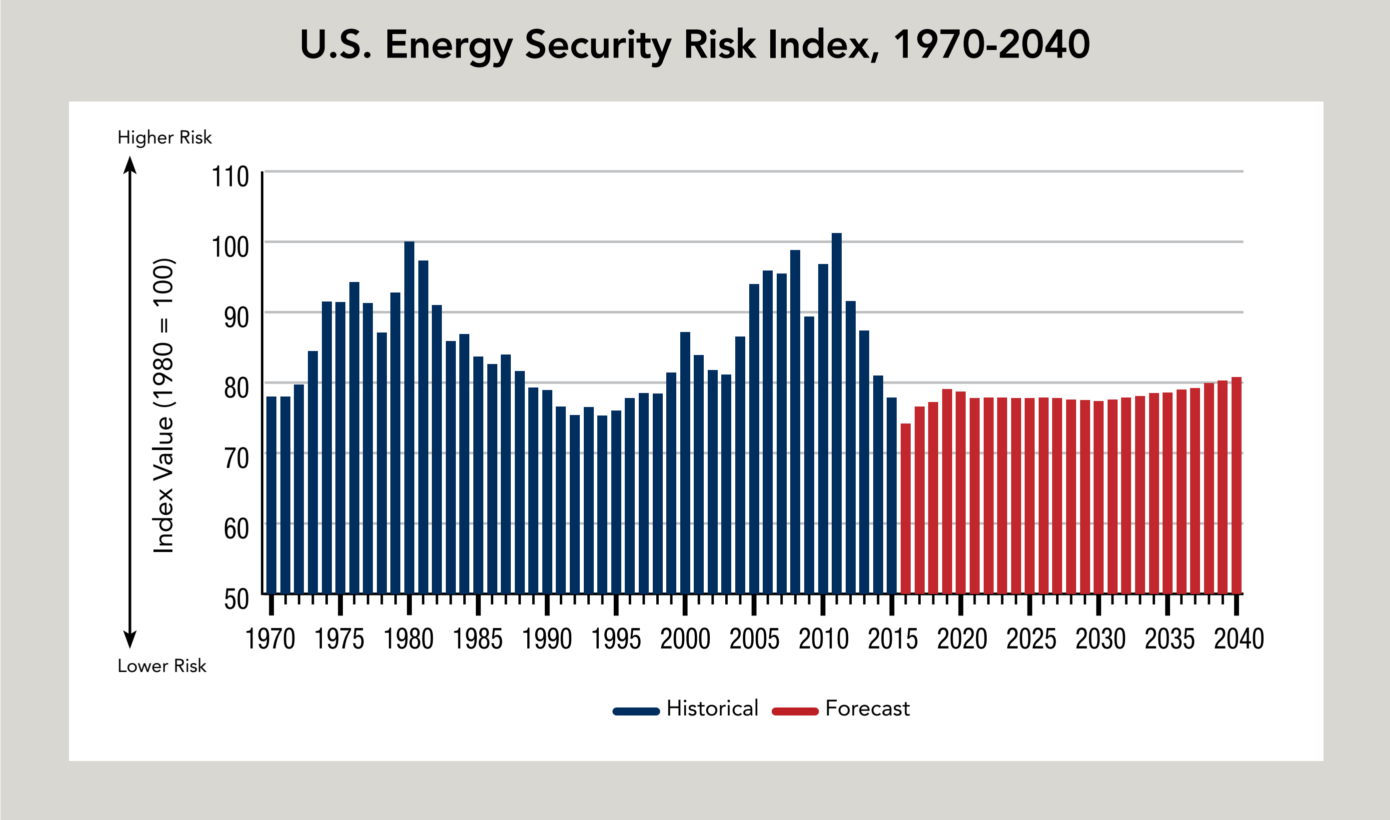


Overview

Total energy security risk in 2015 fell for the fourth year in a row, dropping 3.1 points (3.8%) to 78, its lowest level since 1996. This decline follows a 6.3 point drop in risk in 2014 and a 4.3 point drop in 2013, and 9.5 drop in 2012. This represents a total decline in risk of 23.2 points over the last four years (Figure 1).

The 2016 score dipped 7.0% below the 30-year (1970-1999) average. Like in the preceding couple of years, greater domestic

Figure 1



unconventional oil and natural gas production from shale formations was the biggest single factor contributing to the improved U.S. energy security picture in 2015.

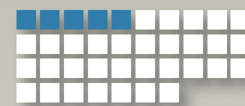
The decrease in risk was generally broad based. Of the 37 Index metrics, 19 showed a decrease in risk of 1% or more, 5 showed an increase in risk of 1% or more, and 13 showed essentially no change in risk in 2015. Most of the 19 metrics showing improvement were in the Fuel Import, Energy Expenditure, Energy Use Intensity, and Environmental metric categories. The most significant metrics showing higher risk were in the Market and Price Volatility metric grouping.

This year's declining risk could be part of an emerging and durable trend trend similar to that observed in the late 1980s to the mid-1990s. While oil and natural gas risk metrics linked and those related to them continue to decline, other risks related to volatility show worrisome increases. Although decreasing risks were seen across about half of the energy security measures, most of the risk decrease in 2015 can be attributed to six oil- and natural gas-related measures that changed by very large amounts (±10% or more). These included risk measures associated with oil and natural gas import expenditures and security, crude oil prices, overall energy expenditures, and carbon dioxide emissions (Table 2). On the higher-risk side of the ledger, the two metrics measuring volatility—one for energy expenditures and the other for crude oil prices—not unexpectedly show very large increases.

The unconventional oil and natural gas boom in the United States has increased supply security and reduced net imports, all of which to contributed to lower energy security risk. Sharp crude oil price volatility (on the down side), however, has raised questions about the ability of U.S. industry to maintain high levels of crude oil production.

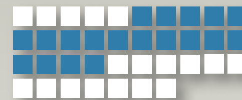
Of the 37 Index metrics,

5



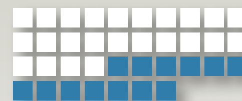
showed an increase in risk of 1% or more,

19



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

13



showed essentially no change in risk in 2014.

Table 1. U.S. Energy Security Risks from 1970 to 2015: Highest, Lowest and 30-Year (1970-1999) Average Index Scores

Indexes of U.S. Energy Security Risk	2015 Score	1980 Baseline Score	Highest Risk		Lowest Risk		30-Year Average (1970-1999)
			Year	Index Score	Year	Index Score	
Total Composite Index	77.9	100.0	2011	101.2	1994	75.3	83.9
Sub-Indexes:							
Geopolitical	75.6	100.0	2011	100.8	1970	71.9	82.9
Economic	69.2	100.0	2011	101.9	1998	61.1	73.2
Reliability	89.4	100.0	2011	114.8	1994	75.8	86.0
Environmental	83.0	100.0	1973	110.7	2015	83.0	99.2

Because natural gas is produced in association with crude oil in many areas of the country, there is also the potential for lower natural gas production. 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.

Despite slumping crude oil prices, domestic crude oil output still increased a healthy 7.4%, or 650,000 bbl/d, to 9.4 MM bbl/d. This is the seventh consecutive year of rising production. It is, however, well off the pace of the previous three years (2012-2014), when production rose at an astonishing average rate of nearly 16% annually. The largest production increases in 2015 were in Texas (290,000 bbl/d), the Gulf of Mexico (120,000 bbl/d), North Dakota (96,000 bbl/d), Colorado (84,000), and New Mexico (63,000).A portion of these gains were offset by lower output six areas—Louisiana, the West Coast, Alaska, Kansas, Utah, and California—each of which experienced declines of 16,000 bbl/d or less. EIA is forecasting that crude oil production will dip to 8.6 MMbbl/d by 2017 before climbing to more than 9.0 MMbbl/d in 2018 as prices recover.

Dry natural gas output rose for the 10th consecutive year in 2015 and achieved a record high of 27.0 trillion cubic feet (tcf). Output rose 1.3 tcf in 2015, or 5.1%. Since 2005, natural gas production has climbed by nearly 50%. In 2015, about half of all U.S. gas production was from shale formations. Pennsylvania's Marcellus Shale, in particular, has made an extraordinary difference. In 2006, Pennsylvania produced about 1% of the total U.S. natural gas supply in contrast to 2015, when its roughly 4 tcf of production accounted for 17% of domestic production, putting it second only to Texas (at 28% of the U.S. total). We are also seeing bigger contributions from Arkansas, Colorado, and Louisiana. (The share of production from federal areas in the Gulf of Mexico, however, slipped from about 11% in 2006 to less than 5% in 2015.) As a result of these trends, the normalized risk metric measuring the security of natural gas imports declined 24% in 2015, the second largest relative improvement in our record.

Total energy expenditures, expenditures as a share of GDP, and expenditures for imports of oil and gas all continued to decline in 2015 primarily as a result of greater domestic production.

- Energy Expenditures: The amount spent on energy—which as measured by EIA excludes most renewable expenditures—per household dropped nearly 22% in 2015, or almost $2,700. This is the second largest swing in this metric since 1970 (there was a nearly $3,500 decline in 2009, when oil prices plunged about $40 per barrel). As a result, energy expenditures as a share of GDP also fell 24%. In 2015, about 6% of GDP was spent on energy.

- Oil and Gas Import Expenditures: From $191 billion in 2014, it is estimated that U.S. expenditures on

Table 2. Movers and Shakers: Energy Security Metrics Changing ±10% or More in 2015

Declining Risk		Rising Risk	
Metric	% Change	Metric	% Change
Oil & Natural Gas Import Expenditures per GDP	-53%	Energy Expenditure Volatility	331%
Oil & Natural Gas Import Expenditures	-52%	Crude Oil Price Volatility	251%
Crude Oil Prices	-48%	Electricity Capacity Margins	19%
Energy Expenditures per GDP	-24%		
Security of U.S. Natural Gas Imports	-23%		
Energy Expenditures per Household	-22%		
Energy-Related CO_2 Emissions	-11%		

imports of petroleum and natural gas slipped 52% ($99 billion) in 2015 to $92 billion, sending the risk index for this metric down 46 points. 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 19 points (53%). This is the fourth 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 three-quarters since 2011.

Crude oil price volatility moved much higher in 2015, ending a trend of stable, if high, oil prices. 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 rose (worsened) a whopping 252% in 2015, moving to the highest level it has been since 2008. The spike in volatility risk is directly attributable to the effort by Saudi Arabia to capture greater market share by increasing production and driving down the price of crude oil from more than $100 per barrel to below than $50 per barrel in less than a year. Since 2015, oils prices have continued to gyrate, so we expect higher volatility risk at least for the next few years. If crude oil prices eventually settle at a lower level, but one that stills allows for a high level of U.S. output, it would help send future risks lower. (That is because stable but somewhat lower oil prices would be combined and higher domestic oil output compared to the recent situation of stable and high oil prices combined with increasing domestic output.)

It is likely that in the next few years, there will be upward pressure of energy security risks. The combination of lower oil output, higher levels of imports, and price volatility will put upward pressure on U.S. energy security risk in the next edition of the index.

Energy efficiency gains were realized in all of the metrics measuring energy use in 2015. The largest gain was measured in household energy efficiency (nearly 5%), reversing a two-year trend of slightly worsening efficiency in the residential sector. The scores for commercial and industrial energy efficiency improved about 2% each. Trends in energy consumption per capita, energy intensity, and petroleum intensity all improved in 2015.

Risks related to energy-related carbon dioxide emissions declined about 11% in 2015. Most of the decrease in risk for this metric was related to improvements in energy intensity. A Kaya analysis indicates that decrease in intensity accounted for two of every three tons of carbon dioxide reduced in 2015. Fuel switching from coal to natural gas and increased renewable output also played a role.

Based on EIA's latest AEO 2016, the U.S. Index is projected to average 78.3 points over the entire forecast period from 2016 to 2040, about a

2.4 point

improvement over last year's Index projection based on the AEO 2015 forecast.

The sharp increase in electricity capacity margin risk in 2015 may represent increased churn of generating capacity additions and closures. This metric measures the average amount of unused available capability of the U.S. electric power system at peak load as a percentage of total capability. It is an indication of power sector's ability to respond to the disruption or temporary loss of some production capacity without an uneconomic overhang of capacity.[3] The 19% increase in risk in 2015 comes one year after a 13% decrease in risk in 2014. These changes were due to a large decrease in peak load in 2014 and a large increase in

3 A related, though slightly different, term is "reserve margin." Whereas the capacity margin is defined as the net of capacity minus demand as a percentage of total capacity, the reserve margin measures this net as a percentage of total demand. Both terms are in common use, but as intermittent generating capacity grows over time, the two measures may increasingly diverge.

2015. Peak load can vary year-to-year for any number of reasons. Nevertheless, the 2015 number fits the pattern of generally increasing risk for this metric since 2000. In 2016, we may see another large jump in capacity margin risk as a number of coal plants are retired because of environmental regulations.

Outlook to 2040

Based on EIA's latest AEO 2015, the U.S. Index is projected to average 78.3 points from 2016 to 2040, a 2.4 point improvement over last year's Index projection based on the AEO 2015 Reference forecast. Risks are expected to stay below 80 points through 2037. By 2040, the total energy security risk is expected to reach 80.8, about 3 points lower than the 30-year 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 overall 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, 19 are expected to improve and six are expected to worsen. Metrics in the Fuel Imports, Energy Use Intensity, Transportation, and Environmental categories generally show, to one degree or another, lower risk over time while metrics in the Energy Expenditure, Price & Volatility, and Electric Power Sector categories general show higher risks.

The rising risk trend late in the forecast period is being driven primarily by a projected 160% increase in the price of crude oil by 2040 (to $151 per barrel), but much greater domestic production of oil and natural gas and energy efficiency mean that import expenditures for these fuels will be much lower in 2040 than anticipated in last year's forecast. This is a trend we have been seeing since the shale revolution began to take hold, with subsequent AEOs showing lower import expenditure risks despite high oil prices. Based on EIA's AEO 2016 forecast, in 2040 the U.S. will spend about $34 billion on imports of these fuels (expenditures for natural gas will be essentially "$0" because the United States is expected to become a net exporter of natural gas as early as 2018). Last year, the AEO 2015 forecast suggested a figure of about $130 billion in 2040. Greater production, 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 2015. As a result of this trend, the risk index for oil & natural gas import expenditures per GDP will fall below 5 points by 2035 (it was 100 points in 1980).

The future growth in U.S. crude oil and production in the AEO2016 forecast is expected to be lower than in the AEO2015 forecast through 2030 and much higher after 2030. Not surprisingly, the tumble in oil prices will slow domestic output in the near term, and it will take some time for production to recover. After 2030, output is expected to climb higher than last year's projection. By 2040, domestic crude oil production is forecast to be 11.3 MMbbl/d compared to the forecast of 9.4 MMbbl/d made in 2015 (a projection nearly one-fifth higher). New EPA rules that favor the use of natural gas over coal and an increasing market for exports mean that natural gas output in the AEO2016 runs ahead of the level in the AEO2015, and by 2040 also is about one-fifth higher.

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 forecast period out to 2040. The rate of change in these energy intensity and efficiency metrics has not changed appreciably from those reported in earlier editions of the U.S. Index. The economy-wide energy intensity and petroleum intensity—intensity being a measure of consumption per dollar of GDP produced—are expected to improve by more than 37% and 39%, respectively, from 2015 to 2040. Over the same period energy efficiency is expected to improve 20% in the residential sector, 14% in the commercial sector, and 18% in the industrial sector.

All transportation-related metrics show considerable improvement by 2040. Average fuel economy for the U.S. automobile fleet is expected to increase from 18 miles per gallon (mpg) in 2015 to 26.3 mpg in 2040, a 46% increase in efficiency. Over the same period, the number of vehicle miles being traveled as a share of GDP is anticipated to improve 27%. The lower this value is, the less that transportation mileage factors into the overall economy. The ratio can decline as a result of greater use of mass transit, carpooling and vanpooling, trip consolidation, smart growth planning, telecommuting, and a host of other actions and trends. (Transportation vehicle miles traveled per GDP was the subject of a special feature in the 2015 edition of the Index.) Non-petroleum also penetrate the transportation sector to a greater extent, and by 2040, 11.5% of energy use in this sector will come from non-petroleum fuels compared to 8.3 % in 2015. As a result of all of these trends, petroleum demand in the transportation sector is expected to be almost 9% lower in 2040 than in 2015.

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

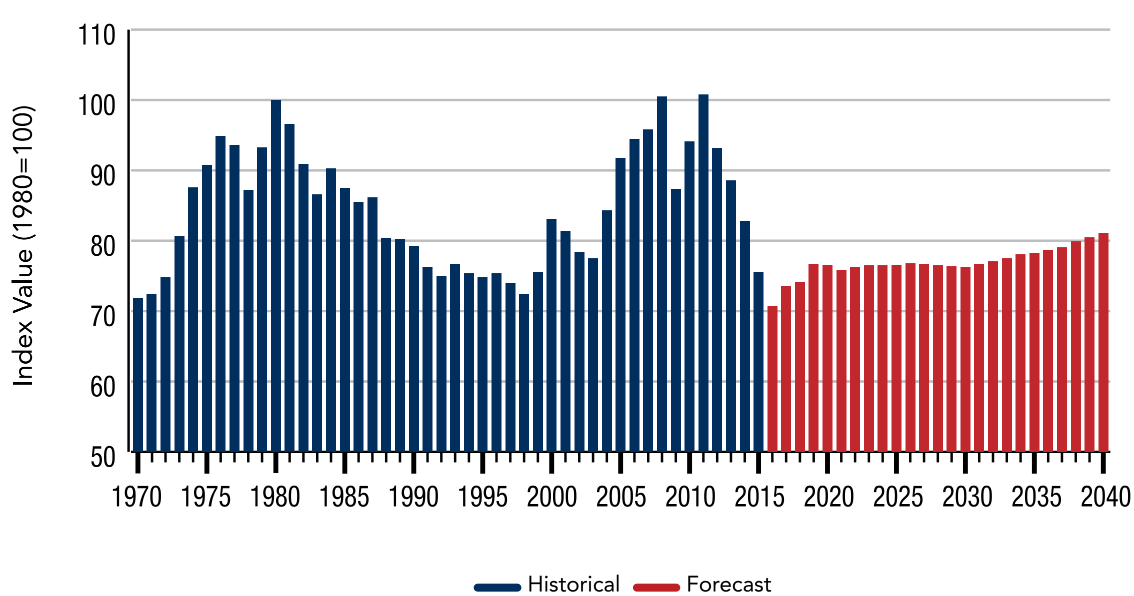
The Geopolitical Sub-Index measures the security of global oil, gas, and coal supplies and other factors that affect the ability of the U.S. economy to withstand supply disruptions from whatever causes.

Geopolitical energy security risks declined nearly 9% in 2015 to 75.6 points. This is the fourth consecutive year of lower risk since the highest score of 100.8 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 were the main factors contributing to lower geopolitical risks in 2015.

EIA's 2015 forecast suggests that geopolitical risks will rise between 5 and 6 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. Still, the trends in this year's forecast are better than in last year's. Based on AEO2015, we calculated a Geopolitical Index score of 88.2 in 2040. Using the AEO2016, that 2040 score falls 7 points to 81.1 points. Increasing unconventional crude oil 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

Figure 2

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



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

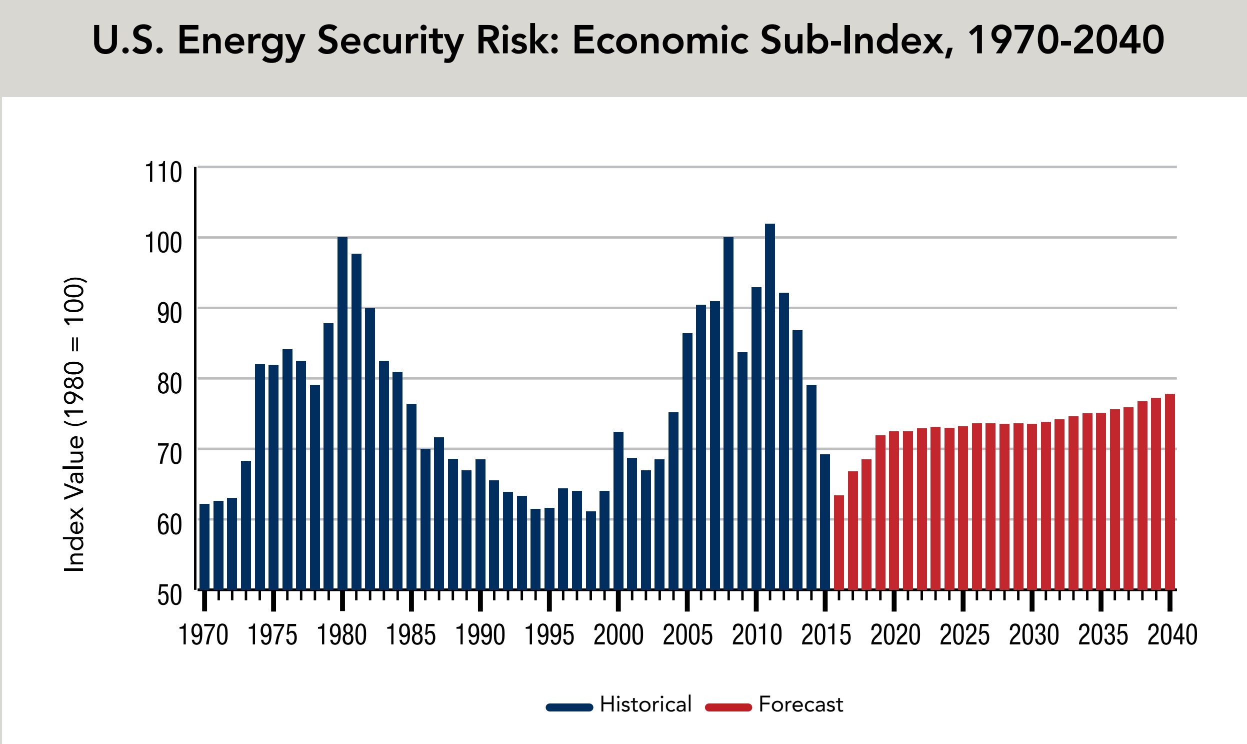
Energy costs are a significant portion of our overall economy. In 2015, roughly $1.1 trillion was spent for end-use energy in the residential, commercial, industrial, and transportation sectors, amounting to roughly 6.6% of GDP, the lowest level since the early 1970s. The Economic Sub-Index includes 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 10 points in 2015 to 69.2, the lowest level since 2004 and lower than the 30-year average of 73.2, the first time that has happened since 2003. The biggest improvements were noted in the metrics covering energy expenditure, and oil and gas import expenditures (Figure 3). These reductions in risk were offset somewhat by an increase, noted earlier, in crude oil price volatility.

In 2015, the risk index for energy expenditure volatility and crude oil price volatility moved proportionally more—up 331% and 251%—than any other metrics in the U.S. Index. We saw similar price spikes and market chaos in 2010 and 2011. Since then, the risk scores for these metrics have fallen sharply, but the recent moves by Saudi Arabia to defend market share and drive down the global price for crude oil had an impact in 2015 that may carry over for the next few years.

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.

Figure 3



spends on imported oil and natural gas, both in total and as a share of GDP. Both of these measures got significantly better in 2015 (between 50% and 55%), and both are below—in the case of import expenditures as a share of GDP, well below—their respective 30-year averages.

Economic risks are expected to climb steadily, if modestly, out to 2040, to 77.8 points. This 2040 figure is, however, 7.4 points below last year's 2040 figure, suggesting a great deal of improvement in the outlook for this sub-index.

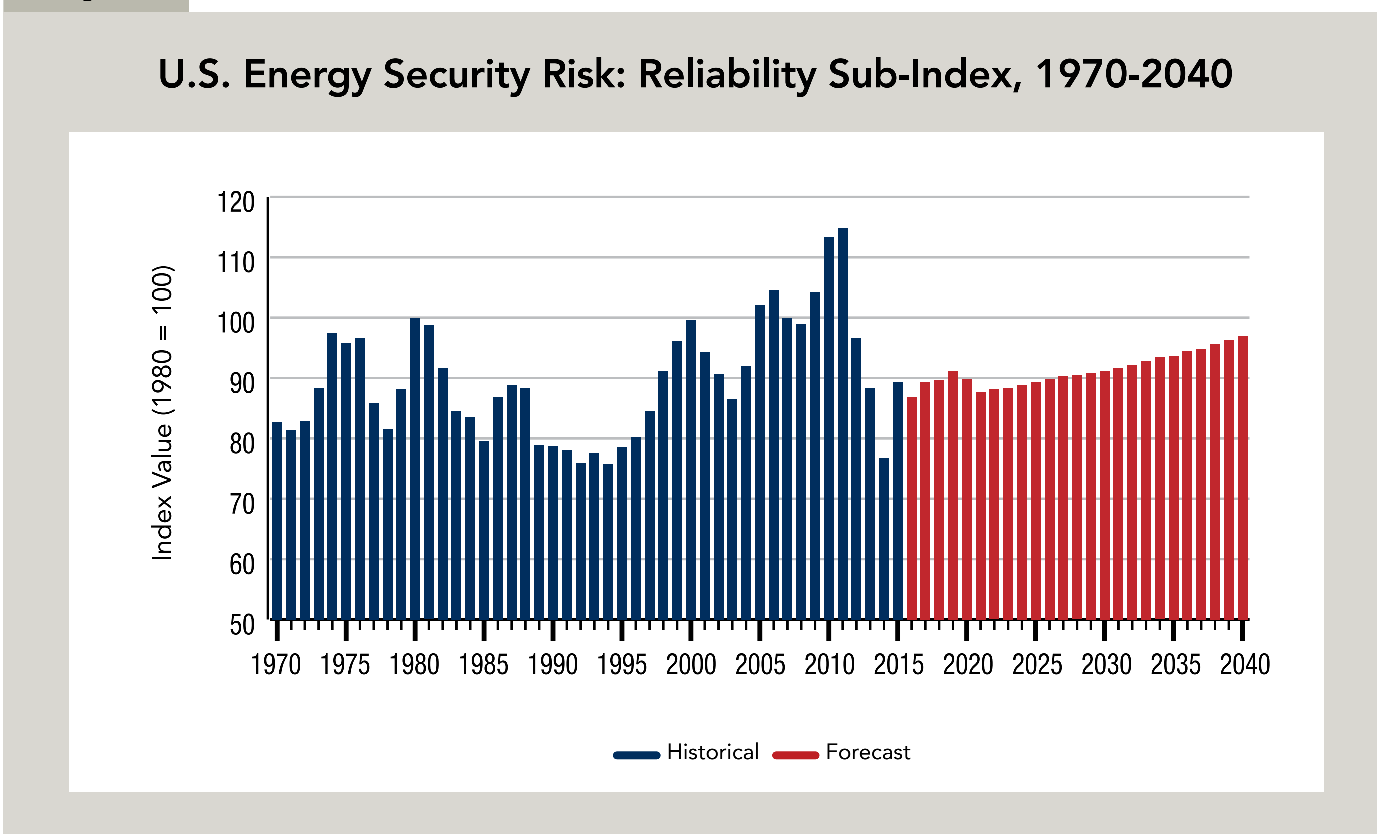
Sub-Index of U.S. Reliability Energy Security Risk

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.

After falling below the 1970-1999 average in 2014 for the first time since 1997, the Reliability Sub-Index jumped 12.6 points (16.4%) to 89.4 points (Figure 4). This is about 3.4 points above the baseline average score of 86. The rise in risk observed in 2015 was due chiefly to large upward moves in crude oil volatility and energy expenditure volatility risk, discussed above. Reliability risks related to power sector capacity margins and transmission and world oil refining capacity utilization, however, also worsen in 2015. The crude oil glut, however, contributed to lower risks related to petroleum stock levels.

Forecast scores based on the AEO 2016 suggest steadily rising risks out to 2040, reaching 97.0. Rising crude oil prices and potential crude oil price volatility are factors going forward. Also of significance are the potentially growing risks related to the power sector. Capacity diversity risks are expected to rise 5.5 points between 2015 and 2040, driven by shrinking shares of base load coal and nuclear generating capacity in the generating mix. There is also the potential for rising risks associated with capacity margins and transmission unless current trends change.

Figure 4



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

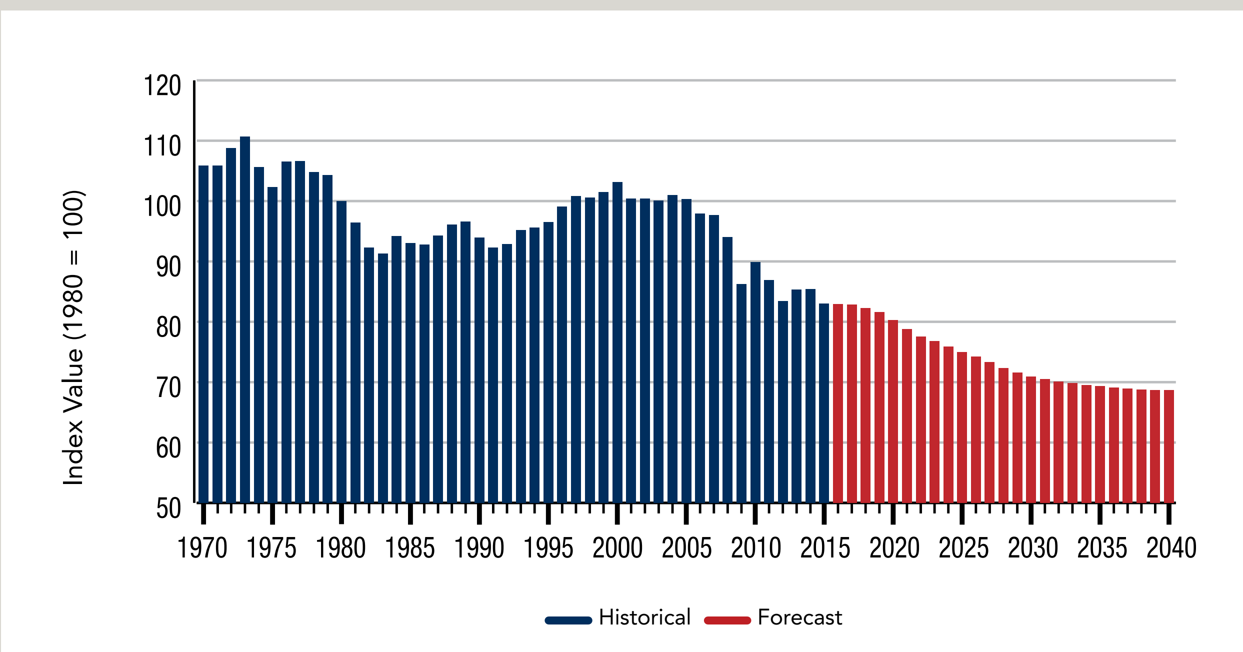
The Environmental Sub-Index includes metrics of energy intensity and efficiency, transportation, power, carbon dioxide emissions, and research and development.

With a score of 83.0, environmental energy security risks changed modestly (2.7%) in 2015. This is the lowest score for this sub-index in the entire record going back to 1970, and it is 16.2 points below the historical average (Figure 5). Metrics in this sub-index tend to move more slowly than in others, and only one metric in this sub-index moved more than 5% in 2015 (carbon dioxide emissions intensity).When viewed as normalized risk metrics, however, we see much larger moves in some cases, particularly in the three carbon dioxide emission metrics (total, per capita, and intensity), which declined between 5% and 11%. Most of the decrease in risk for carbon dioxide emissions in 2015 was related to improvements in energy intensity, with fuel switching from coal to natural gas also playing a role.

Of the four sub-indexes, the Environment is the only one showing steadily declining risk out to 2040. The inclusion of the Environmental Protection Agency's Clean Power Plan (CPP) in EIA's reference case means that we could see this sub-index declining much more steeply—to 68.7 points in 2040—than was forecast last year—74.3 points. A Kaya Identity analysis shows that improvements in energy intensity are the main drivers of lower emissions, with fuel switching being a significant additional factor, especially from 2020 to 2025. Large improvements in the metrics measuring energy and petroleum intensity of between 35% and 40% and energy efficiency in all sectors—residential (-20%), commercial (-14%), industrial (-18%), and transportation (-45%)—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 decline about 4% between 2015 and 2040, while per capita emissions and emissions intensity fall sharply (19% and 45%, respectively).

Figure 5

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



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 2016, EIA ran and made forecast data available for a number of side cases.[4] EIA also ran two reference cases, one with and one without the Environmental Protection Agency's CPP final rule (which as of this writing remains stayed by the U.S. Supreme Court).

Fifteen of these alternate scenarios were plugged into the U.S. Index model to see their impact on future energy security risk as compared to the AEO 2016 Reference case that includes CPP.

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

4 EIA. 2016. Annual Energy Outlook 2016 with Projections to 2040. DOE/EIA-0383(2016). Available at: http://www.eia.gov/forecasts/aeo/pdf/0383%282016%29.pdf.

Table 3. Energy Security Risk Measures: EIA AEO 2016 Side Cases vs. Reference Case

EIA AEO 2015 Side Case	Change in:			
	2025 Energy Risk Index Score	Cumulative GDP: 2016-2025 (Billion 2015$)	2040 Energy Risk Index Score	Cumulative GDP: 2016-2040 (Billion 2015$)
CPP Hybrid	0	40	0	367
CPP Rate Based	0	39	0	329
CPP Extended	0	-29	-1	-371
CPP Interregional Trading	0	72	0	201
CPP Allocation to Generators	0	-3	0	-4
Phase 2 Standards	-1	20	-2	-104
Extended Policies	-1	-78	-4	-586
High Industrial Efficiency Incentive	-3	-1,780	-4	-4,575
Low Industrial Efficiency Incentive	-1	-646	-2	-1,959
Manufacturing Industry Energy Efficiency	0	48	0	108
High Oil Price	12	-1,149	12	-2,998
Low Oil Price	-6	1,086	-6	1,631
High Oil & Gas Resource & Technology	-5	681	-7	3,878
Low Oil & Gas Resource & Technology	4	-704	11	-3,413
Reference Case without CPP	1	151	2	750

case as a way to gauge the cost of the change in risk.

The largest increases in risk are associated (unsurprisingly) with two scenarios—the High Oil Price and the Low Oil & Gas Resource & Technology. The High Oil Price case shows a large impact on energy security by 2025 (an increase of 12 points compared to the reference case). This scenario also leads to 12-point difference in 2040.

The impacts of the Low Oil and Gas Resource case are not as immediate (overall risks are four points higher in 2025, compared to the 12 point increase in 2025 in the High Oil Price scenario), but by 2040, it increases to 11 points greater risk. As significant, the cost in lost GDP also accelerates after 2025, and by 2040 the cumulative losses are higher than they are for the High Oil price case ($3.4 trillion versus $3.0 trillion).

The side case with the biggest negative economic impact is the High Industrial Efficiency Incentive scenarios. Of special note is an economy-wide price on carbon dioxide emissions from fossil fuels that phases in from 2018 to 2023 and ramps up 5% a year thereafter to $80 per ton by 2040. While energy security risk declines under this scenario compared to the Reference case (with CPP), it also costs $4.8 trillion in lost GDP, by far the most costly of the side cases examined.

Those side cases that show both large reduction in energy security risk and increases in GDP include the Low Oil Price case and the High Oil & Gas Resource & Technology. Both show similar improvements in risk in the near term to 2025 and the longer term to 2040. The major difference is in the impact on GDP. Both scenarios have oil prices that are lower than in the Reference case, but how those lower prices come about matters. In the High Oil & Gas Resource scenario—which is characterized by a high level of resources and a faster rate of technology improvement to get at them—we see a much bigger aggregate rise in GDP (nearly $3.9 trillion versus $1.6 trillion) between 2016 and 2040.

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, promotes greater efficiency and the deployment of advanced, cost-effective technologies, and does 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 2016 Case	**Description**
Reference	Baseline assumptions for economic growth (2.2 percent from 2015 to 2040), oil prices, technology, and demographic trends. Brent spot prices rise to about $136 per barrel (2015 dollars) in 2040. Assumes compliance with the Clean Power Plan through massed-based standards modeled with cooperation across states and at the regional level, with all allowance revenue rebated to taxpayers.
CPP Hybrid	Assumes that CPP regions can vary their CPP compliance method, with the Northeast and California regions choosing mass-based caps and the remaining regions using average rate-based standards.
CPP Rate Based	Assumes that CPP compliance is met through regional rate-based standards (pounds/megawatt hour) that, on average, affect all generation within the region.
CPP Extended	Assumes that the CPP CO_2 emission targets continue to decline after 2030, reaching a 45% reduction below 2005 levels in 2040.
CPP Interregional Trading	Assumes that the CPP compliance is met through regional mass-based caps and allows trading of carbon allowances between regions within the Eastern Interconnect and within the Western Interconnect.
CPP Allocation to Generators	Assumes the same CPP compliance as the Reference case, except that the carbon allowances are allocated to generators instead of being allocated to load entities, resulting in higher retail price impacts.
Phase 2 Standards	Assumes improvements to medium- and heavy-duty vehicle technologies while increasing the number of technologies from 37 to 70. Restructures the current 13 vehicle size classes and incorporates an additional size class, bringing the total to 14 size classes.
High Industrial Efficiency Incentive	Uses a price on carbon dioxide emissions as a proxy for higher energy costs as a way to increase energy efficiency in all industries except refining. The carbon dioxide price is phased in gradually, starting in 2018, reaching $35.00 in 2023 (2015 dollars per metric ton), and increasing by 5% per year thereafter.
Low Industrial Efficiency Incentive	Uses a price on carbon dioxide emissions as a proxy for higher energy costs as a way to increase energy efficiency in all industries except refining. The carbon dioxide price is phased in gradually, starting in 2018, reaching $12.50 in 2023 (2015 dollars per metric ton), and increasing by 5% per year thereafter.
Manufacturing Industry Energy Efficiency	Assuming Reference case prices and economic conditions, examines the effects of more aggressive adoption of energy-efficient technologies and rapid improvement in energy intensity on manufacturers in five industries (cement and lime, aluminum, glass, iron and steel, and paper).

High Oil Price	High prices result from a lack of global investment in the oil sector, eventually inducing higher production from non-OPEC producers relative to the Reference case. Higher prices stimulate increased supply from resource that are more expensive to produce—such as tight oil and bitumen, as well as increased production of renewable and synthetic fuels, compared with the Reference case. Increased non-OPEC production crowds out OPEC oil, and OPEC's share of world liquids production decreases, never exceeding the 41% reached in 2012 and dropping to 34% by the end of the projection. On the demand side, higher economic growth than in the Reference case, particularly in non-OECD countries, leads to increased demand: non-OECD consumers demand greater personal mobility and consumption of goods. There are also fewer efficiency gains throughout the industrial sector, and growing fuel needs in the nonmanufacturing sector continue to be met with liquid fuels, especially in response to policy shifts that force liquids to replace coal for chemical feedstock. Crude oil prices are about $230/b (2015 dollars) in 2040.
Low Oil Price	Low prices result from a combination of relatively low demand for petroleum and other liquids in the non-Organization for Economic Cooperative Development (non-OECD) nations and higher global supply. Lower demand occurs as a result of several factors: economic growth that is relatively slow compared with history; reduced consumption from the adoption of more efficient technologies, extension of the corporate average fuel economy (CAFE) standards, less travel demand, and increased natural gas or electricity use; efficiency improvement in nonmanufacturing in non-OECD countries; and industrial fuel switching from liquid to natural gas feedstocks for producing methanol and ammonia. On the supply side, both Organization of the Petroleum Exporting Countries (OPEC) and non-OPEC producers face lower costs of production for both crude oil and other liquids production technologies. However, lower-cost supply from OPEC producers eventually begins to crowd out supply from relatively more expensive non-OPEC sources.
High Oil & Gas Resource & Technology	OPEC's market share of liquids production rises steadily from 39% in 2015 to 43% in 2020 and 47% in 2040. Light, sweet crude oil prices fall to an average of $35/b (2015 dollars) in 2016, remain below $50/b through 2030, and stay below $75/b through 2040. United States, and undiscovered resources in Alaska and the offshore lower 48 states, are 50% higher than in the Reference case. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% higher than in the Reference case. In addition, tight oil and shale gas resources are added to reflect new plays or the expansion of known plays. All other assumptions remain the same as in the Reference case.
Low Oil & Gas Resource & Technology	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States and undiscovered resources in Alaska and the offshore lower 48 states are 50% lower than in the Reference case. Rates of technological improvement that reduce costs and increase productivity in the United States are also 50% lower than in the Reference case. All other assumptions remain the same as in the Reference case.
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.
Reference Case without Clean Power Plan	Baseline assumptions for economic growth (2.2 percent from 2015 to 2040), oil prices, technology, and demographic trends. Brent spot prices rise to about $136 per barrel (2015 dollars) in 2040. Assumes the Clean Power Plan is not implemented.

Special Feature: Trends in Security of World Crude Oil Production

Every president since Richard Nixon has made reducing oil imports—or even achieving total oil independence—a top priority of U.S. energy policy. Nearly four decades after the 1973 Arab Oil Embargo, and despite the recent jump in domestic crude oil output thanks to the shale revolution, the United States in 2015 imported about 43% of the crude oil processed in U.S. refineries.

The world we live in is increasingly defined by global trade. Petroleum, both crude oil and refined products, has long been a globally traded, fungible commodity. While this trade brings significant economic benefits, it also can introduce risks to energy security. For global commodities, events anywhere can affect supply and prices everywhere. Even if the United States were completely self-sufficient, we would remain vulnerable to some of these risks.

As enticing as the prospect of complete independence from foreign sources of oil may be, for the foreseeable future, it is an unrealistic goal. In today's globalized economy, it is not clear that complete oil independence would even be desirable. Nor is it realistic to assume that our appetite for oil will lessen dramatically. Projections from both government and industry still see oil as being the dominant transport fuel for decades into the future.

Realistically, then, our goals for oil security should capitalize on the benefits of global trade while minimizing its concurrent risks by increasing domestic production to reduce the amount we import and by encouraging the market availability, diversity, and reliability of world oil supplies.

Most of the world's crude oil reserves reside in the Middle East. Of the nearly 1.7 trillion barrels of global reserves, about 49% are found in the Middle East. North America holds reserves of about 220 billion barrels, which reflects the addition of about 175 billion barrels of proved reserves from Canada's oil sands in 2003.[5]

5 The addition of large amounts of oil from Canadian oil sands to worldwide reserves contributed to a sharp drop in risks to the security world oil reserves. See Metric #1 in Appendix 2 of this report.

When energy supplies are concentrated among a handful of countries, there are not only increased risks of supply interruptions, but also greater exposure to potential producer cartels. The 14 members of the Organization of Petroleum Exporting Countries (OPEC)[6] accounted for 73% of the world's reserves in 2009.

Global crude oil production is also concentrated, but not to the same degree. A little less than one third of output is produced in the Middle East, and about 19% was produced in North America. OPEC accounted for about 43% of world crude oil production.[7]

In addition, the regional distribution of production presents additional risks related to the transport of petroleum from wells to markets. Today, roughly a third of the global crude oil trade passes through just four navigable but narrow straits: Malacca between Indonesia and Malaysia; Hormuz in the Persian Gulf; Bab el-Mandab between Yemen and the eastern horn of Africa; and the Suez Canal in Egypt. A few years ago the International Energy Agency estimated that by 2030, these at-risk flows could increase to as much as 60%.[8]

With the bulk of world oil reserves and production concentrated in a few countries, many of which are not especially friendly to U.S. interests, this growing dependence poses both economic and national security risks. Considering also the fact that large oil consuming nations and regions (for example, Europe, Japan, China, and India) are not large oil producing nations, it is easy to appreciate how global competition for oil will continue to underlie international trade and security concerns.

Factors such as these pose risks to the United States

6 They are: Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, and Venezuela.

7 EIA, International Energy Statistics, Crude Oil Production. Available at:http://www.eia.doe.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=53&aid=1.

8 International Energy Agency. 2007. World Energy Outlook 2007: China and India Insights. OECD/IEA, Paris.

that go well beyond the simple measurement of imports, which tell us little about the reliability and diversity of oil supplies, factors that affect all countries. These risks are not easy to quantify, but proxies for the reliability and the diversity of crude oil supplies are available and when combined provide reasonably good indication of the security of world oil production.

We begin with two propositions:

1. Countries exhibiting the greatest degree of political and civil liberties are more likely to be politically stable and reliable trading partners and are less likely to join cartels or use oil supplies to achieve geopolitical aims. The turmoil over the past few years in Algeria, Iraq, Iran, Libya, Nigeria and other oil-producing countries with limited freedoms provides confirmation of the inverse relationship between the degree of political and civil liberties and political stability.

2. Greater diversity of supply leads to enhanced competition and reduced volatility, both of which help lessen security risks. Even if a set of oil producing countries fares poorly on a measure of freedom, our energy security still is enhanced when supplies are more evenly spread among them.

By combining measures of freedom and diversity, we have created a "Security of Crude Oil Production" metric. The two elements of this metric are discussed below, and then we present the combined index.

Weighting World Crude Oil Production by Freedom

In an attempt to measure the risk attached to the average barrel of crude oil produced globally over time, we created a metric that expresses this risk in terms of a freedom index. For this, Freedom House's Freedom in the World rankings was used. These rankings provide a reliable comparative assessment of political and civil liberties among well over 100 nations and have been published annually since 1972. The country rankings move along a scale of 1 to 7, with lower scores reflecting greater freedom (and thus lower risk) and higher scores less freedom (and thus greater risk).

Using these country rankings together with annual country-level oil production data from EIA, we developed an index that measures the barrel-weighted average freedom—that is, the average freedom attached to the typical barrel of world crude oil production—for 1970 to 2015.[9]

Changes in the average freedom value of a barrel of crude oil over time can reflect two things:

(1) the effects of changes in oil production levels (so that, for example, greater production in relatively free countries would lower the average freedom-weighted score); and

(2) the effects of changes in the freedom rankings over time for different countries (so that, for example, the movement of former Soviet Union countries from the Not Free to the Partly Free category would lower risks).

Figure 6 shows the average freedom-weighted score of world crude oil production from 1970 to 2015. The first thing to note is that the weighted average ranges from 4 to 5, in the high end of Freedom House's "Partly Free" range (i.e., freedom scores of 3.0 to 5.0). As you can see, in the first half of the 1970s, freedom-weighted world crude oil production rose (worsened) steeply. This was followed by a period of improvement into the mid-1980s, after which the average freedom-weighted scores bumped along until about 2000, when they began to rise again (but not to earlier levels). Since about 2010, significantly greater output from the U.S. and Canada suggest a trend in better freedom-weighted scores.

A closer look at the share of production by different freedom rankings can help explain these trends. Freedom House groups countries into three broad categories:

1. Free (rankings from 1 to 2.5);
2. Partly Free (rankings from 3.0 to 5.0); and
3. Not Free (rankings from 5.5 to 7.0).

Using these three Freedom House categories, we can get an idea of how the share of crude oil production in each freedom category has changed over time. Figure 7 shows the historical trends in the share of global crude oil

9 Freedom House. Freedom in the World. Data and reports available at: https://freedomhouse.org/.

production from Free, Partly Free, and Not Free countries.

The first thing to notice is the decline in the share of crude oil that was being produced in Free countries in the early 1970s. It went from about 37% 1970 to about 26% 1976, reflecting in large part declining U.S. production.

From the late 1970s to the mid-1980s, the share of production in Free countries rebounded to 38% in 1985, primarily reflecting growing production from Alaska's North Slope (the Alaska Pipeline began operation in 1977) and the North Sea. Rising Mexican production also pushed up the relative contribution from Partly Free countries in the late 1970s, as did the brief move of Iran from the Not Free to the Partly Free category from 1978-1980. (After the 1979-80 revolution, Iran reverted to the Not Free category, where it remains.)

The chart also shows the sharp jump in share of oil production from Partly Free countries around 1990, linked directly to the collapse and break-up of the Soviet Union, the result of which moved former Soviet Republics from Not Free to Partly Free category. This was a significant development that lowered risks both by increasing the reliability (as measured by freedom) and the diversity of oil supplies.

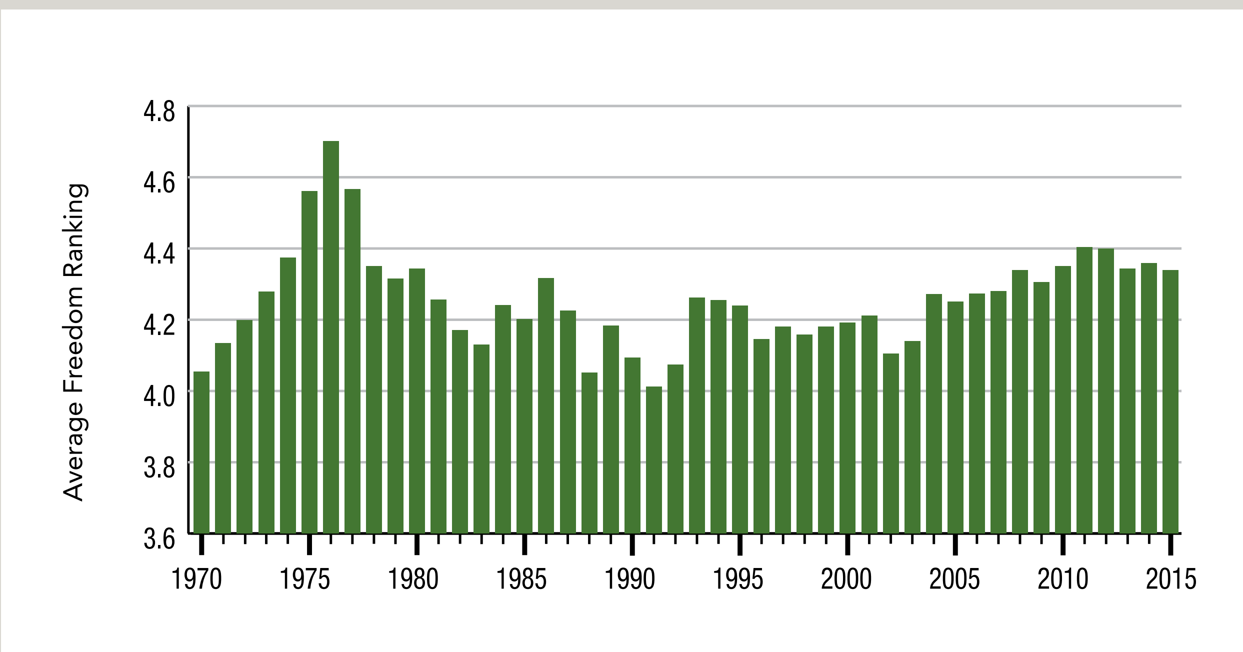
Much of this progress was reversed around 2005. This is the mainly the result of a shift in the Russian Federation from the Partly Free to Not Free category coupled with more Russian production (and thus a greater concentration of output). As a result, by 2010, Not Free countries accounted for 57% of total world output. As we noted earlier, since 2010, there are indications that greater production from the United States and Canada is improving the share of production from Free countries.

Measuring the Diversity of World Crude Oil Production

We start with the assumption that oil-producing countries with greater political and civil liberties are more reliable and tend to represent lower risk and therefore that overall energy security improves as

Figure 6

Freedom-Weighted World Crude Oil Production: 1970-2015



freedom expands. But other types of risks also exist and would be pose challenges even if all countries scored a "1" in the Freedom House rankings.

Long supply chains, for example, can pose risks, both man-made and natural, at each link in the chain. Concentration of supplies can make disruption in any one place more consequential and can tempt countries to join in cartels. (The Russian Federation's effort to set up a natural gas cartel with Qatar and Iran provides a good example.)

Production from a variety of physical and geological environments, however, promotes competition that leads to more innovation and technological advances. And importantly, a larger number of suppliers brings the economic benefit of market forces and reduces the likelihood and effectiveness of cartel behavior. A diverse of supply of crude oil is an important hedge against potential bad actors and against risks known and unknown.

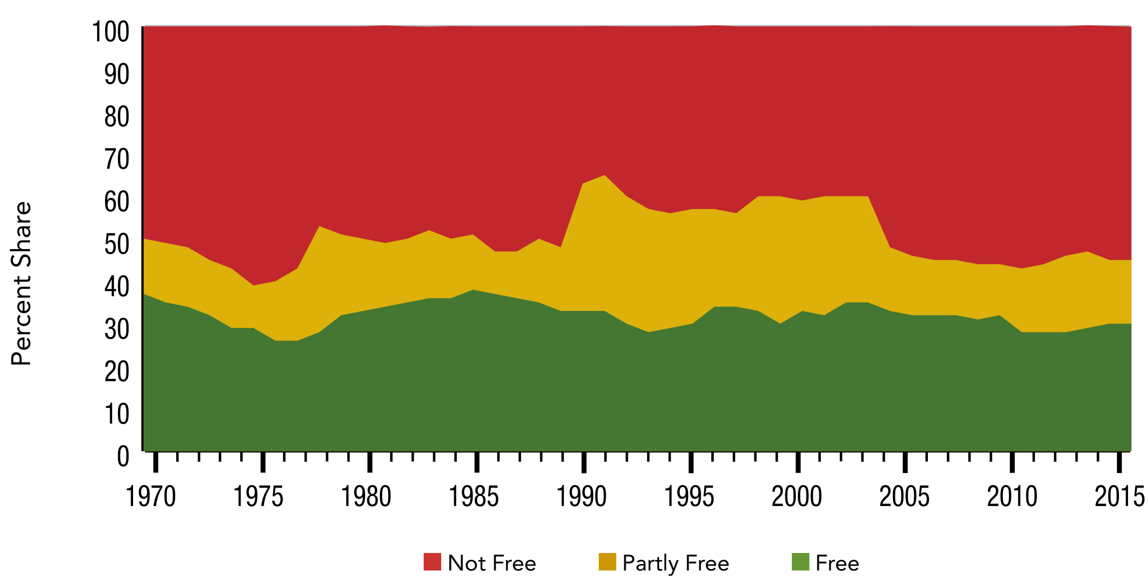
To measure supply diversity, a concept from competition law and antitrust analysis was adopted. The Herfindahl-Hirschman Index (HHI) is calculated by taking the market shares of each country's crude oil production (as a percentage from 0 to 100), then squaring each, and then summing across all suppliers. A market comprised of a single supplier would thus have an HHI of 10,000, whereas a market with a very large number of suppliers, each with a small share, would have an HHI closer to 1. This methodology was applied to each country's share of global production in each year.

The results are shown in Figure 8. As you look at the chart, remember that a high figure indicates greater supply concentration (or less diversity) while a low figure indicates less concentration (or greater diversity). For most of the 1970s, supplies were relatively highly concentrated among a few large producers located in the Middle East, North America, the Soviet Union, and a few other areas.

After 1980, diversity began to improve considerably, as more oil was brought on line from a broader range of countries, including Angola, Brazil, Mexico, Norway, the United Kingdom, and the United States. The split-up of the Soviet Union, meanwhile, created a greater number of crude oil suppliers, though most of the production remains

Figure 7

Share of World Crude Oil Production in Free, Partly Free & Not Free Countries: 1970-2015



concentrated in the Russian Federation. The chart shows steady improvement in the HHI until the year 2000 or so, after which the HHI began to level off and even rise slightly.

The improvement in supply diversity is seen in the number of countries producing at least 1 MMbbl/d of crude oil. Throughout the 1970s, 14 countries had averages exceeding 1 MMbbl/d. Since 2010, 22 countries had averages exceeding 1 MMbbl/d.

The numbers for smaller but still significant crude oil producers (i.e., between 500,000 bbl/d and 1 MMbbl/d) are perhaps even more telling. In the 1970s, only one country (Mexico) produced crude oil within this range; since 2010, there have been 11.

Composite Security of Crude Oil Production Index

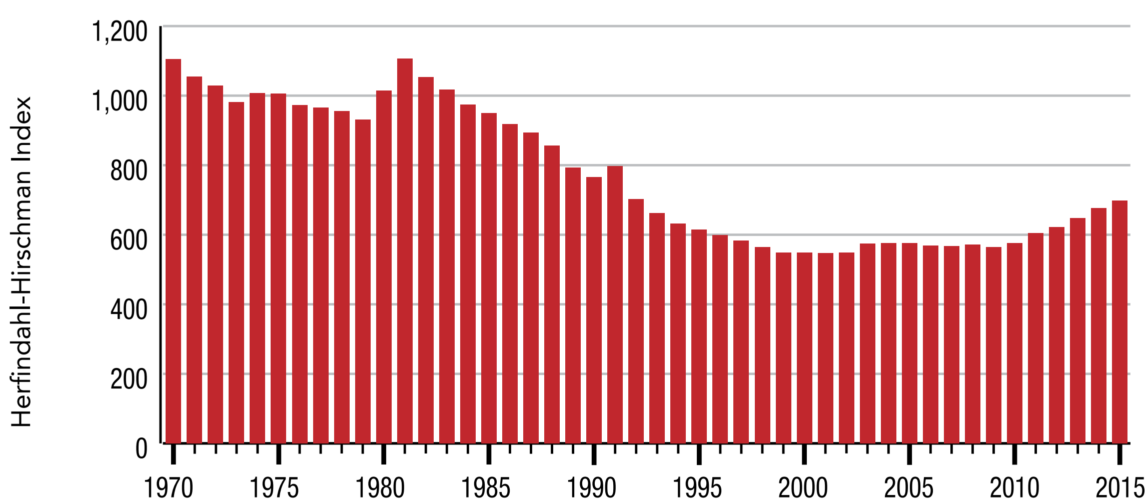
The HHI diversity index was combined with the freedom-weighted index for crude oil production to create a single "Security of World Oil Production" risk index.[10] Figure 9 shows the composite results. The ups and downs visible in the index reflect a variety of events around the world. For instance, since 1970, global oil production rose from about 44 MMbbl/d to about 80 MMbbl/d today. Also during this time, the world saw many changes in global freedom, for better and for worse.

In the mid-1970s, supply risks were very high. Large oil consumers responded in many ways—by improving energy efficiency; reducing demand through fuel switching (such as the moving from oil to coal in power generation); setting up petroleum reserves; and

10 The Index for the Security of World Oil Production was calculated by multiplying the freedom and diversity measures. In the development of each component, the data sources and methodology led to values that spanned a relatively narrow band of freedom values (a maximum spread of 1 to 7) and a relatively broad band of diversity values (a maximum spread of 1 to 10,000). To give both of these components roughly equal contribution to the Index, we used the square of the freedom-weighted score for global crude oil production, and the square root of the HHI diversity measure. The results were then transformed into an index, where the score for the year 1980 was set at 100 all of the others years set relative to that.

Figure 8

Diversity (Concentration) of World Crude Oil Production: 1970-2015



most importantly for this metric, increasing domestic production. As a result, from the mid-1970s to about 2000, overall supply risks declined.

Since 2000, supply risks have risen steadily. Oil production from less risky suppliers such as Mexico, Norway, and the United Kingdom has declined, while production from more risky supliers such as Iran, Iraq, Russia, and Saudi Arabia has generally been increasing. These shifts have led to a slight worsening in the combined freedom/diversity measures.

These trends highlight the importance of greater production from North America in general and the United States in particular. Increased output—whether from oil shale, oil sands, or the Outer Continental Shelf—can contribute to greater reliability and diversity of global supplies and increase our energy security. It is important, therefore, that producers be given access to resources on federal lands, which have seen declining production.

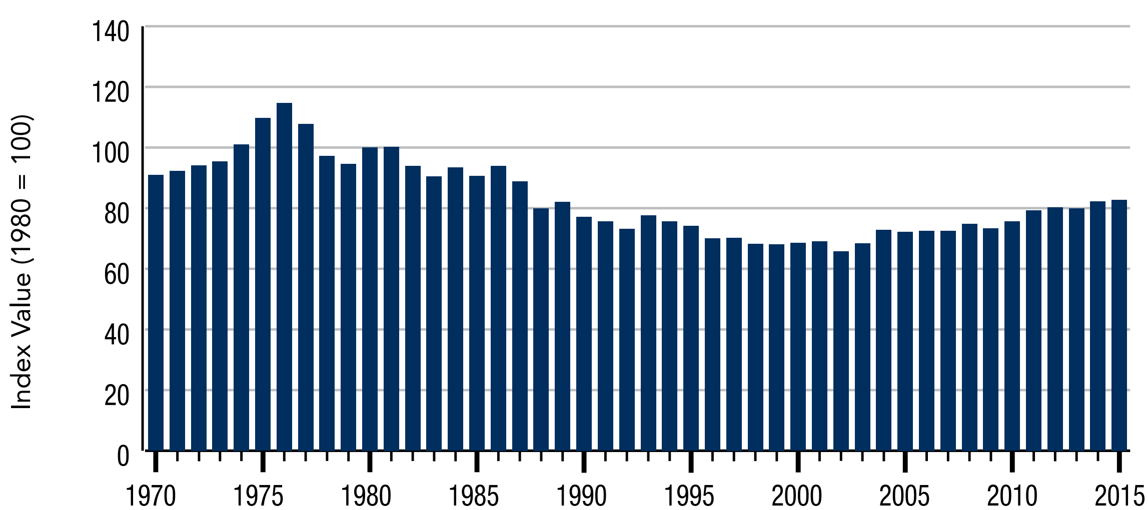
Over the past decade, and in particular the past five years, development of oil and natural gas resources in the United States has increased significantly, driven in large part by advances in drilling and completions technology and seismic imaging that have allowed producers to dramatically increase the available supply of crude oil and natural gas.

But because these developments have largely taken place on state and private-controlled lands, it is easy to lose sight of the still-significant role that federal lands play in contributing to the nation's overall production. Even as the United States continues to experience and benefit from the significant expansion of domestic energy production in the aggregate, the amount of energy produced on federal lands has declined both in terms of total volume and share of overall U.S. production.

U.S. producers have shown resilience in the face of recent attempts by Saudi Arabia to shut in U.S. shale production by deliberating driving down the price for a barrel of oil. What U.S. producers require now is policy certainty that they will continue to have access to the resources they need to continue to make America and energy powerhouse.

Figure 9

Security of World Crude Oil Production: 1970-2015



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.

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.

Several of the metrics use similar data in different ways 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]

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 (AEO) is the primary source for metric forecasts. AEO 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.

- **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.

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 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.

- **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.

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

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 (1970-2015) 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
CO_2	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.

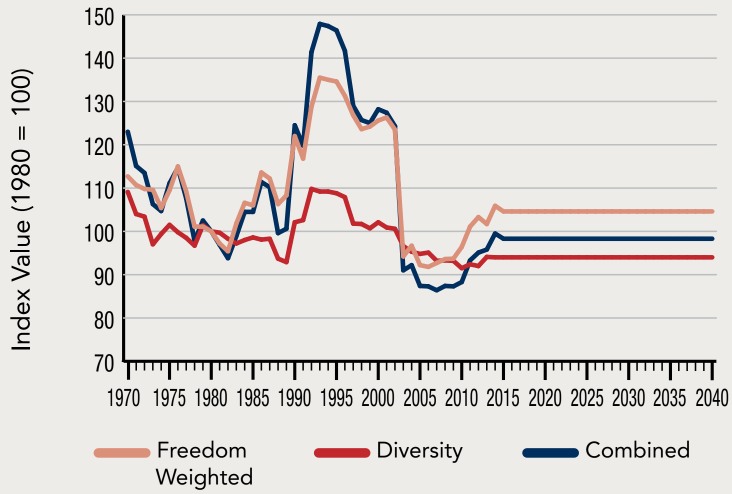
Importance

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.

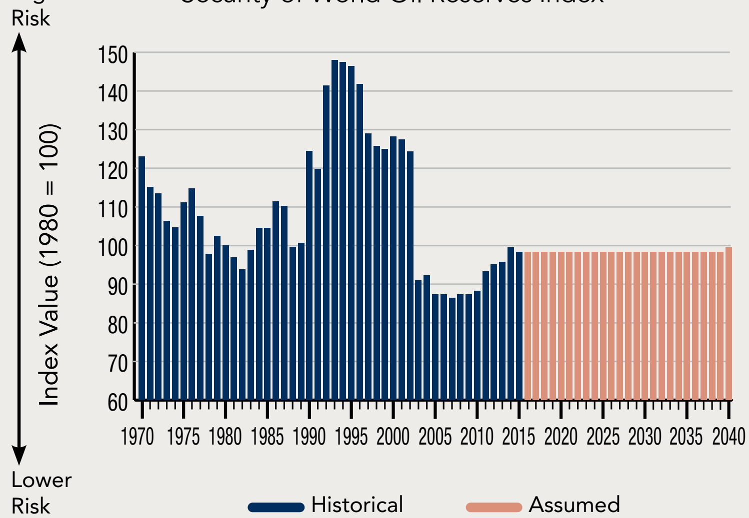
Category of Metric

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	11.6	N/A	N/A	N/A	3.4

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.

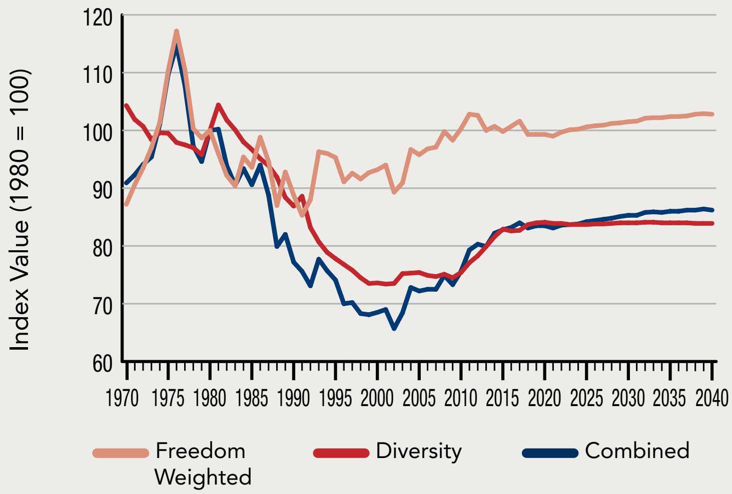
Importance

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

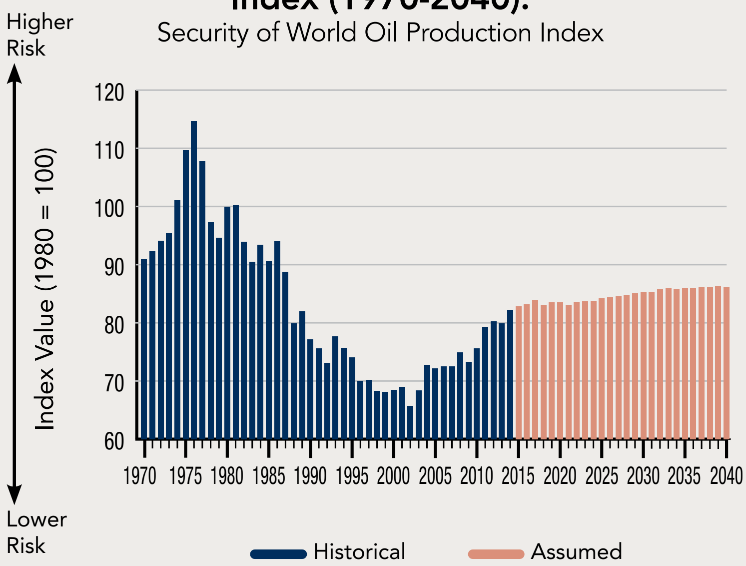
Category of Metric

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	5.4	5.6	N/A	4.7

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.

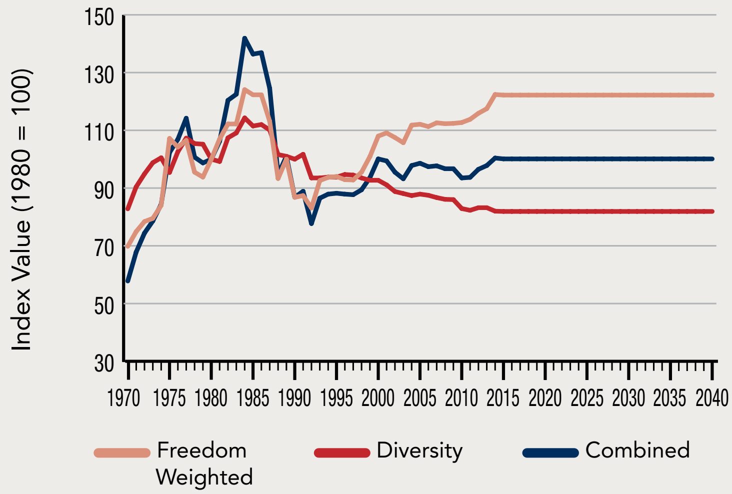
Importance

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.

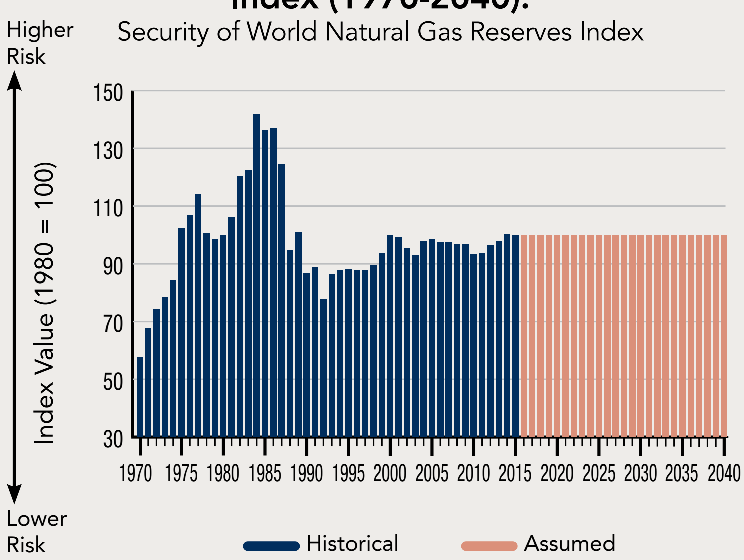
Category of Metric

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.

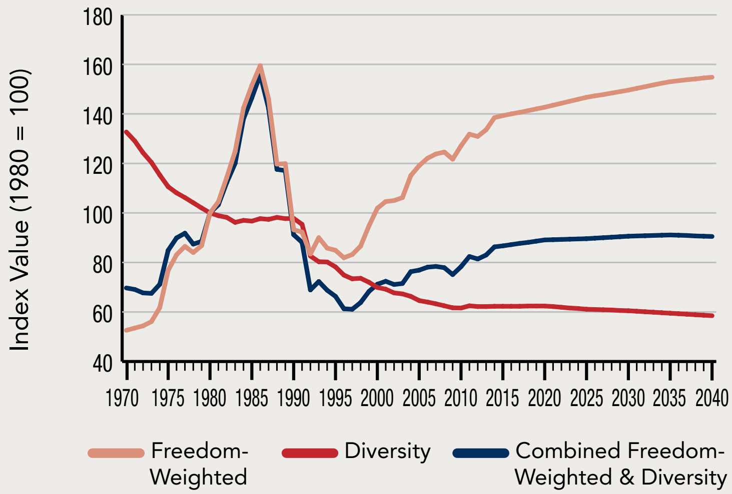
Importance

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

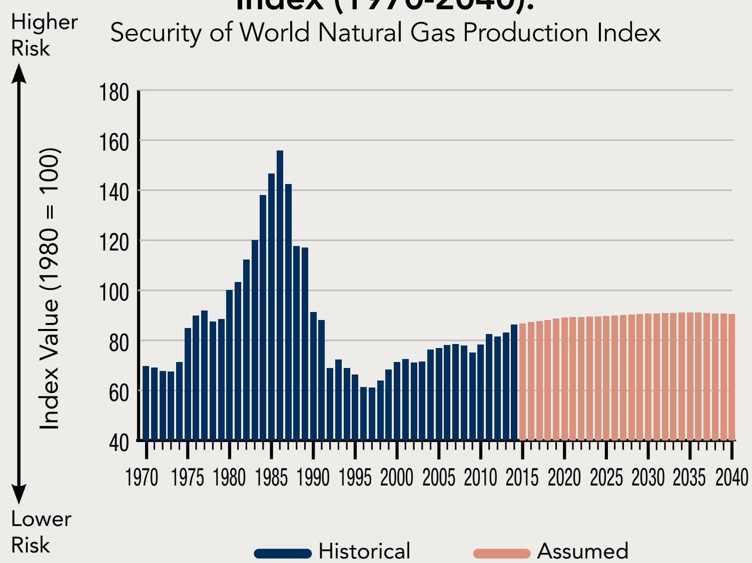
Category of Metric

Global Fuels

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



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



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	5.1	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.

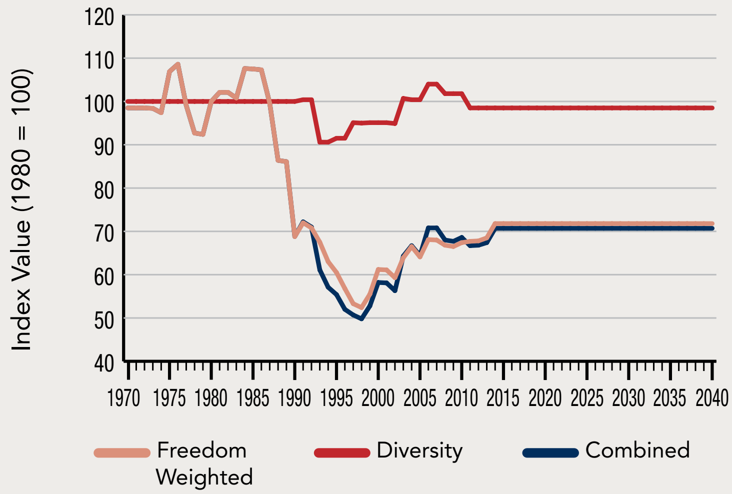
Importance

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

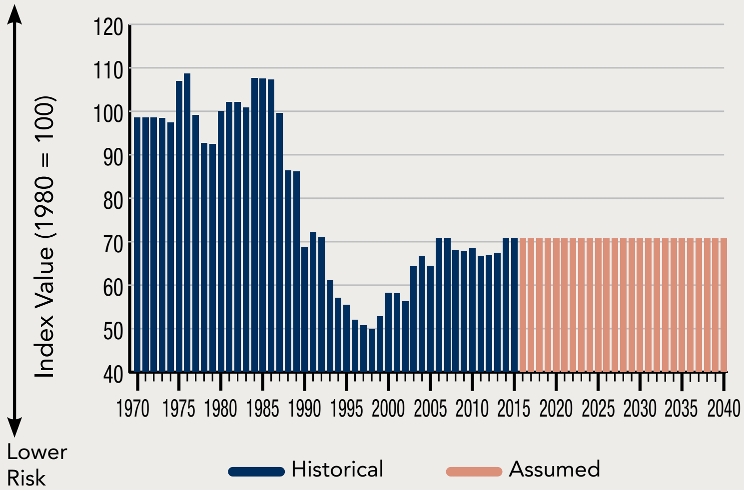
Category of Metric

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	3.7	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.

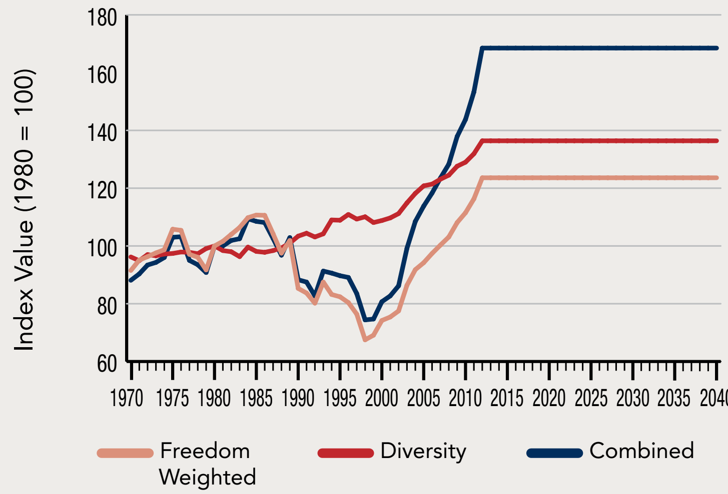
Importance

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

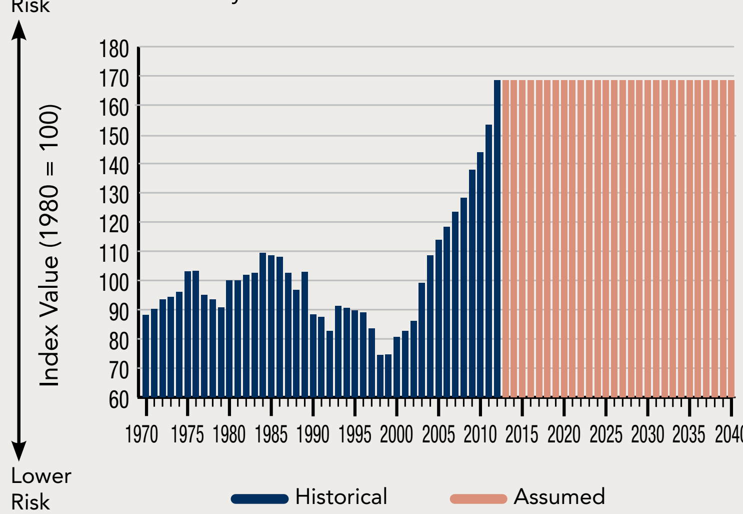
Category of Metric

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	2.5	1.4	1.2	N/A	1.4

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.

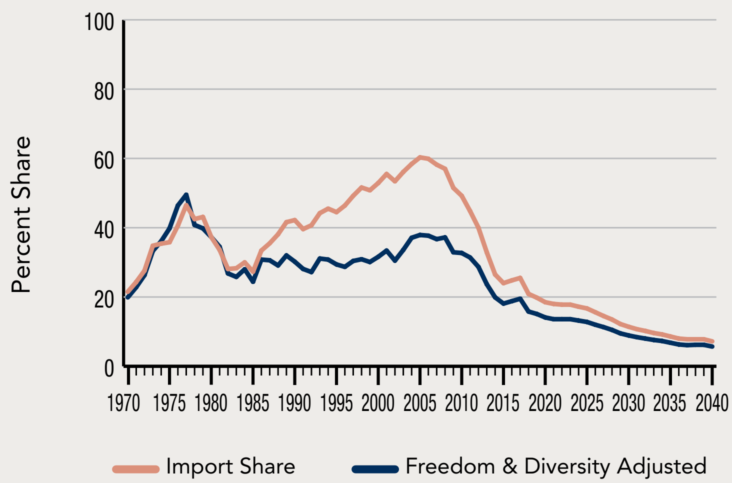
Importance

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.

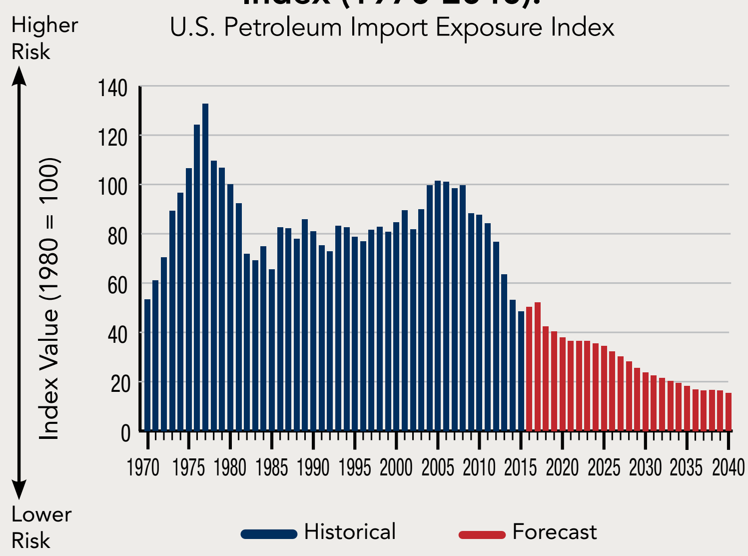
Category of Metric

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	8.0	N/A	8.5	N/A	4.1

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.

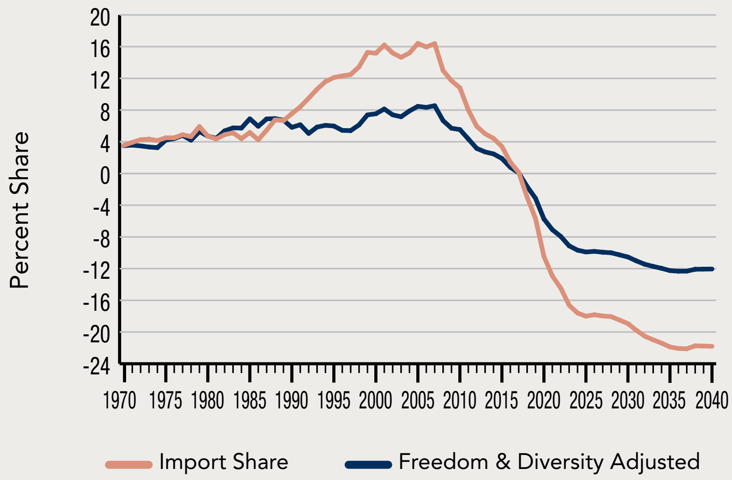
Importance

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

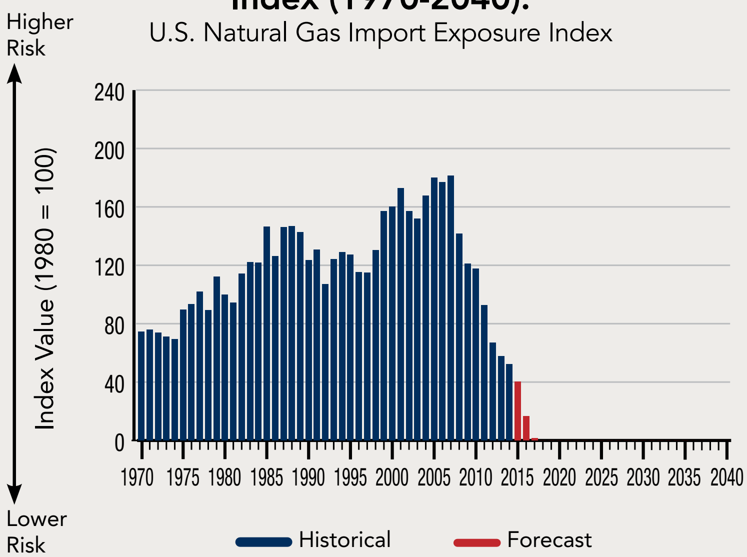
Category of Metric

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	4.2	N/A	2.6	N/A	1.8

METRIC #9

Oil & Natural Gas Import Expenditures

Definition

Value of net imports of crude oil, petroleum products, and natural gas in billions of real (2015) dollars.

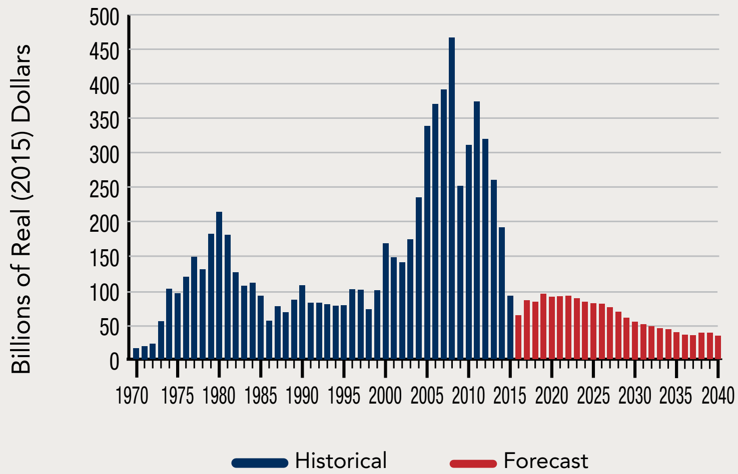
Importance

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

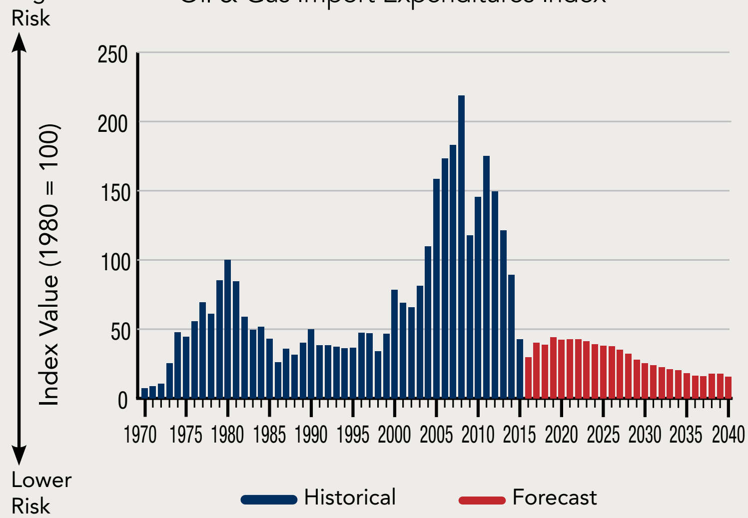
Category of Metric

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	5.1	5.7	N/A	N/A	3.0

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.

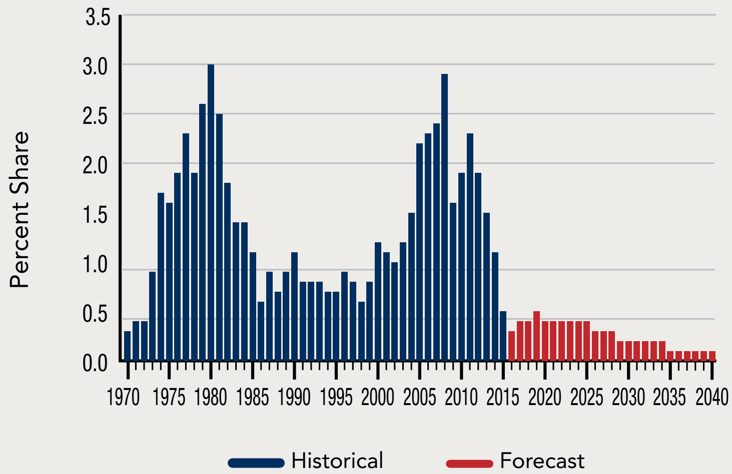
Importance

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

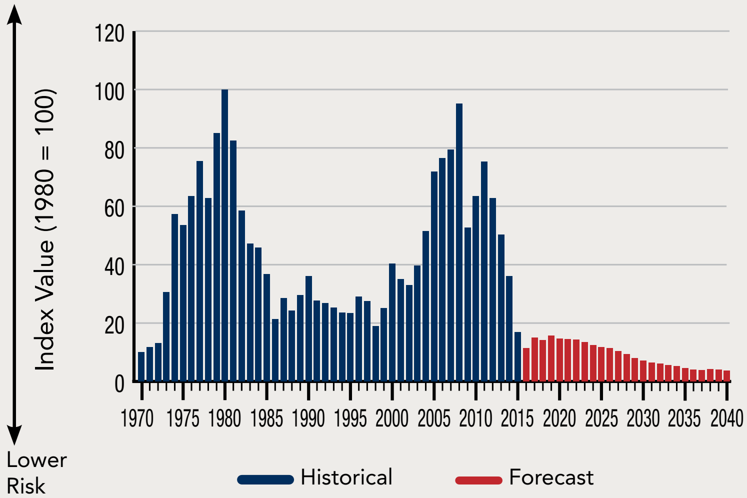
Category of Metric

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



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 (2015) dollar cost of energy consumed per $1,000 of GDP per year.

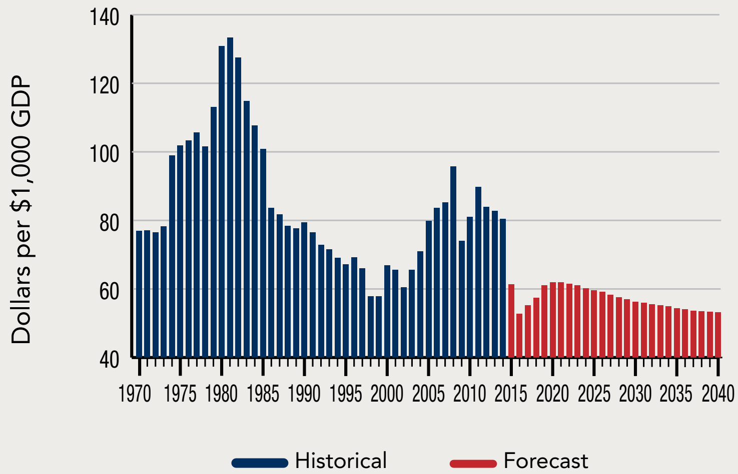
Importance

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

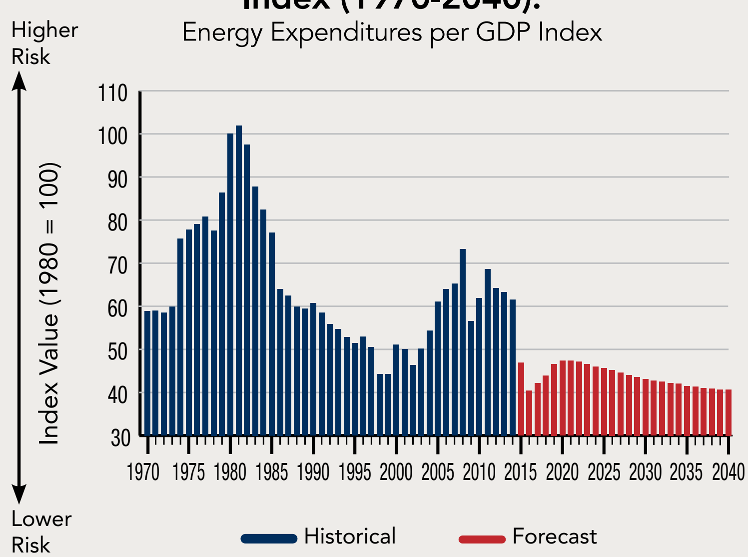
Category of Metric

Energy Expenditures

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



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



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	5.9	N/A	N/A	2.7

METRIC #12

Energy Expenditures per Household

Definition

Total real (2015) dollar cost of the energy consumed per household per year.

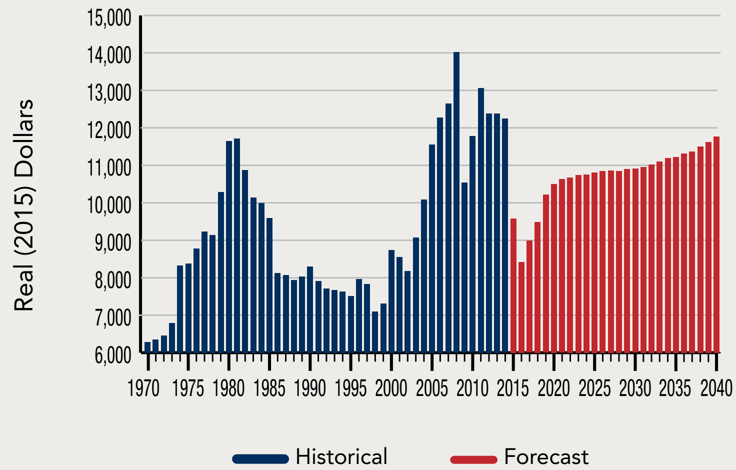
Importance

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

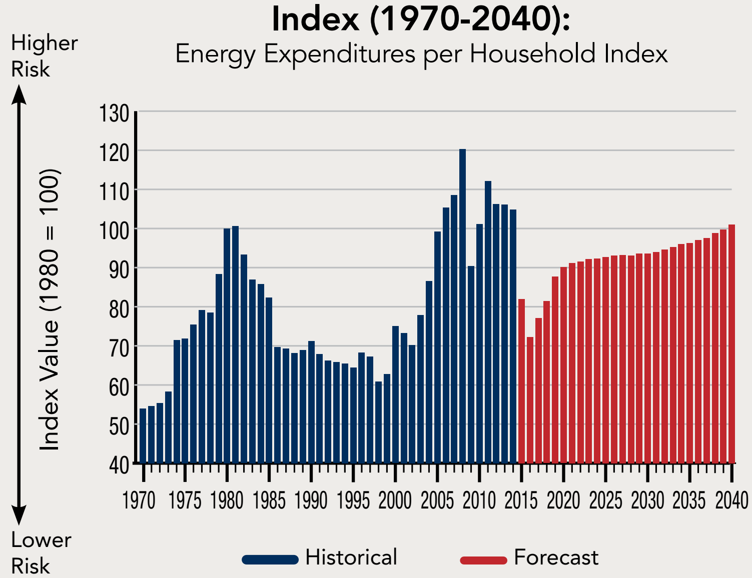
Category of Metric

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	9.4	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 (2015) dollars.

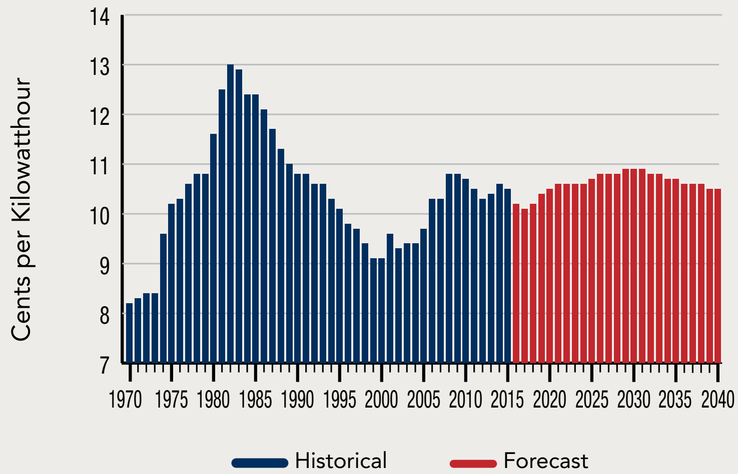
Importance

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

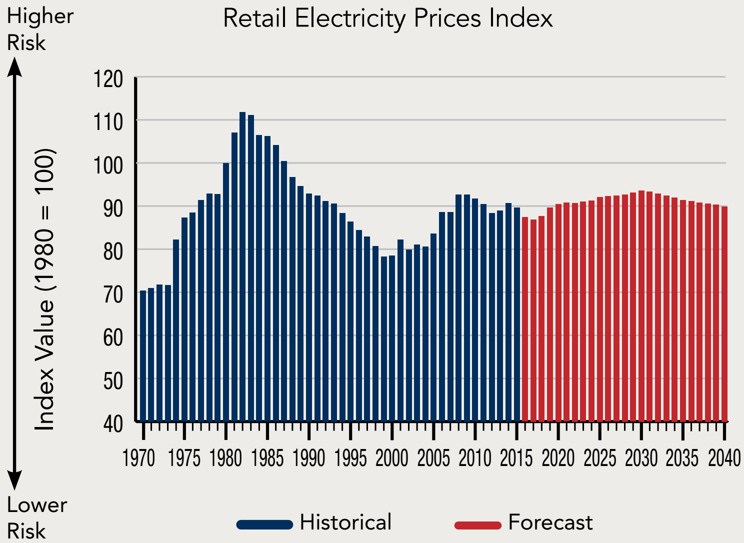
Category of Metric

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	11.7	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 (2015) dollars.

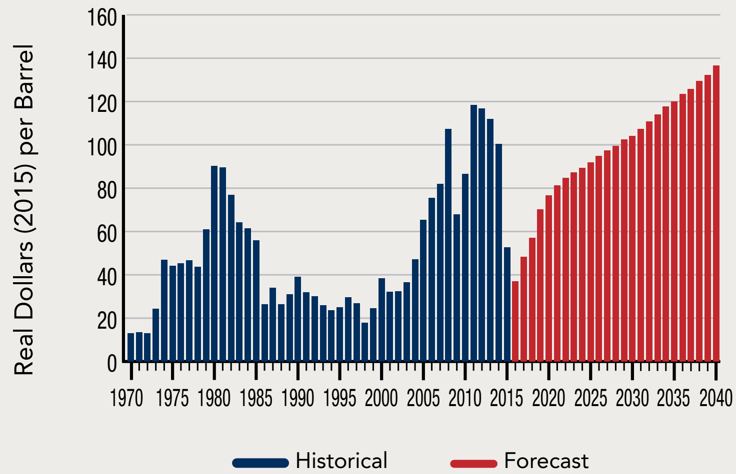
Importance

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

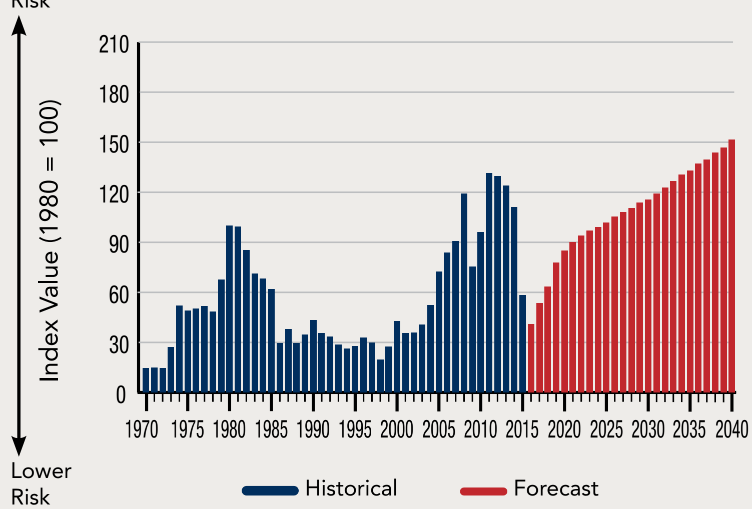
Category of Metric

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	8.7	9.6	3.8	N/A	6.0

METRIC #15

Crude Oil Price Volatility

Definition

Annual change in real (2015) crude oil prices averaged over a three-year period.

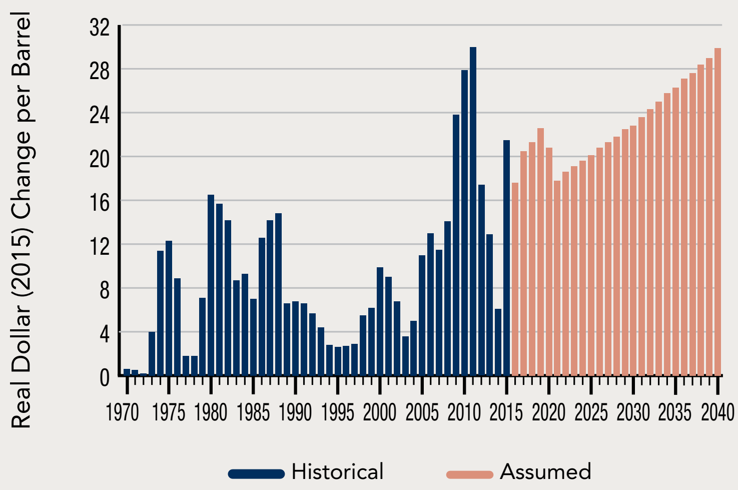
Importance

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.

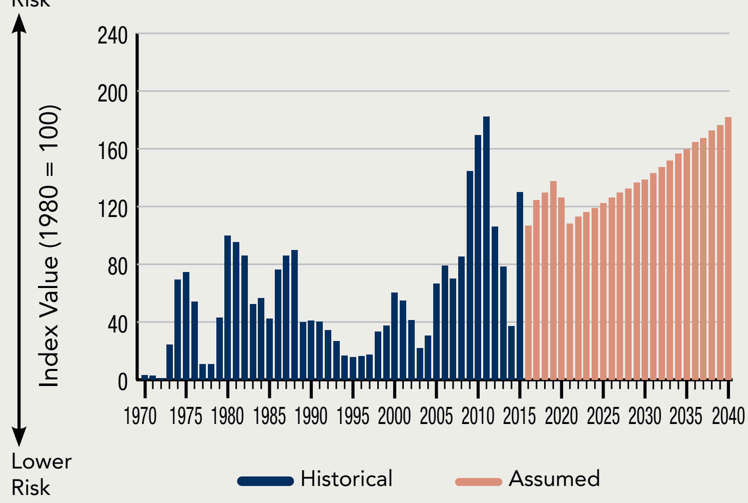
Category of Metric

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	3.4	2.3	6.4	N/A	3.0

METRIC #16

Energy Expenditure Volatility

Definition

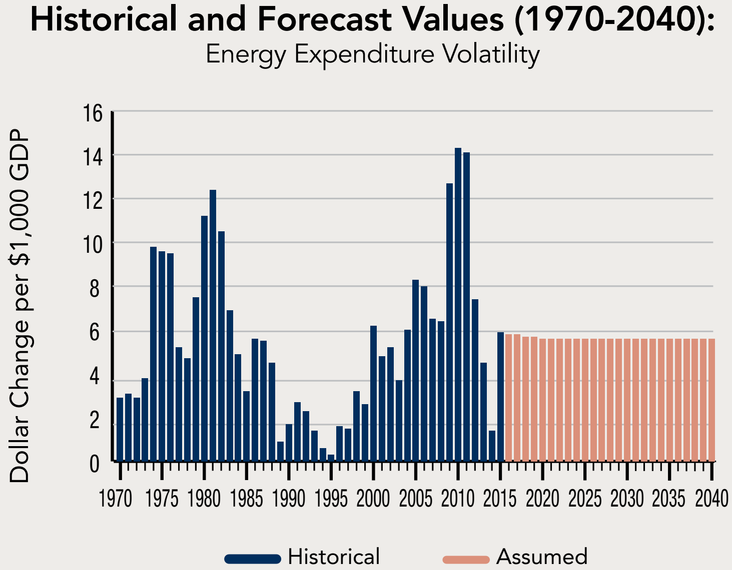
Average annual change in real (2015) U.S. energy expenditures per $1,000 of GDP.

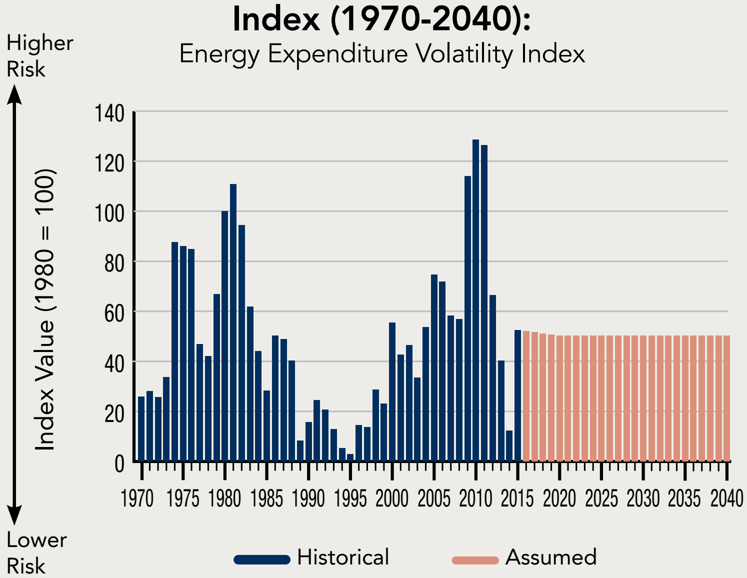
Importance

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

Category of Metric

Price Volatility





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	3.3	7.8	N/A	2.5

METRIC #17

World Oil Refinery Utilization

Definition

Average percentage utilization of global petroleum refinery capacity.

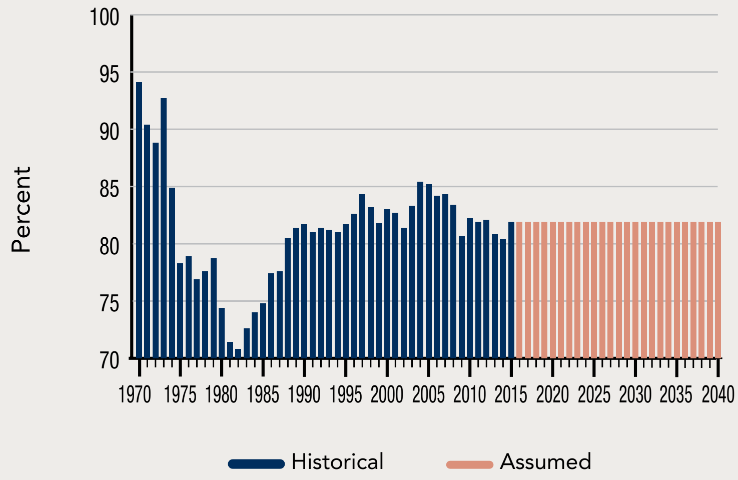
Importance

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

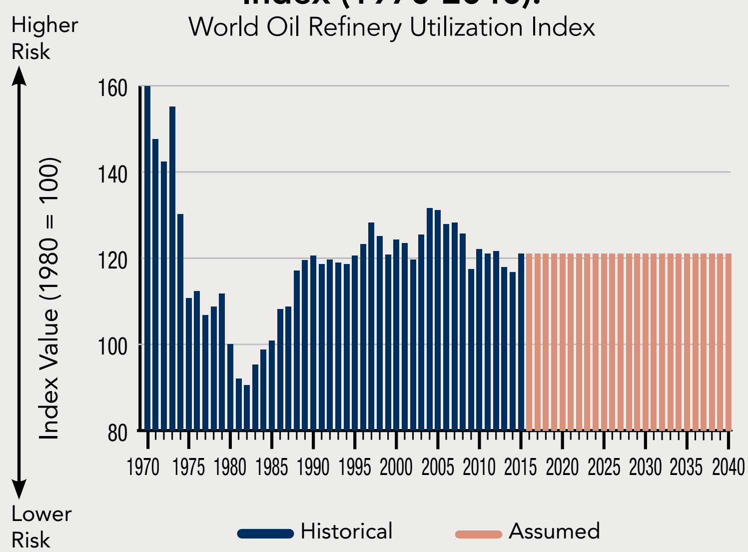
Category of Metric

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.

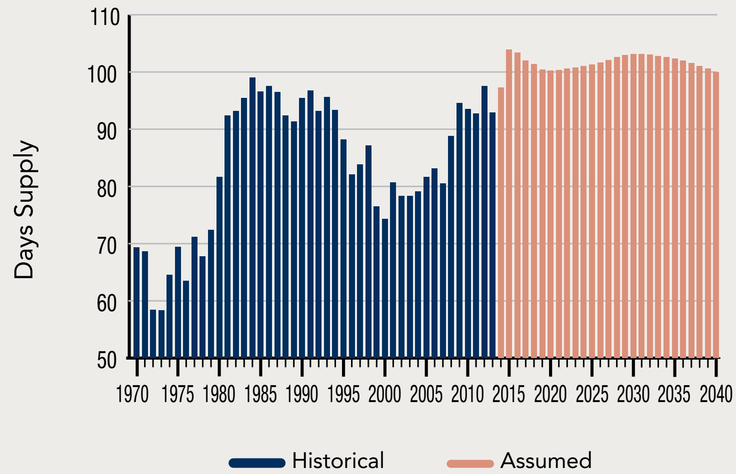
Importance

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.

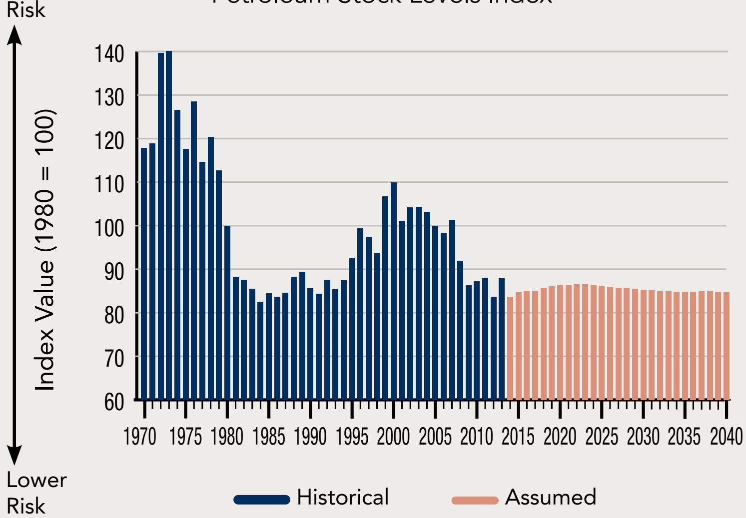
Category of Metric

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	2.3	N/A	6.6	N/A	2.1

METRIC #19

Energy Consumption per Capita

Definition

Million Btu consumed per person per year.

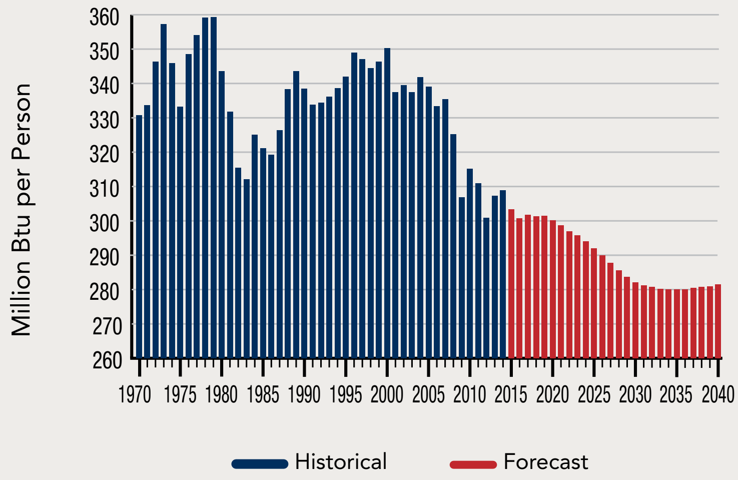
Importance

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

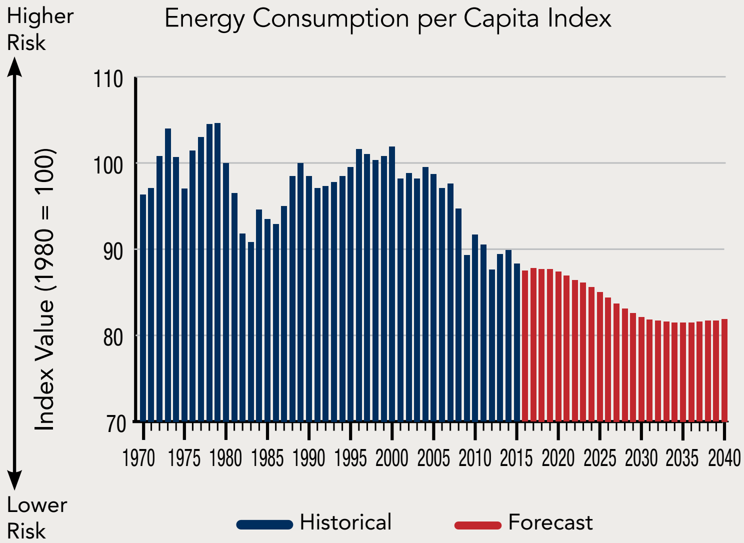
Category of Metric

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	3.8	N/A	8.0	2.8

METRIC #20

Energy Intensity

Definition

Million Btu of primary energy used in the economy per $1,000 of real (2015) GDP.

Importance

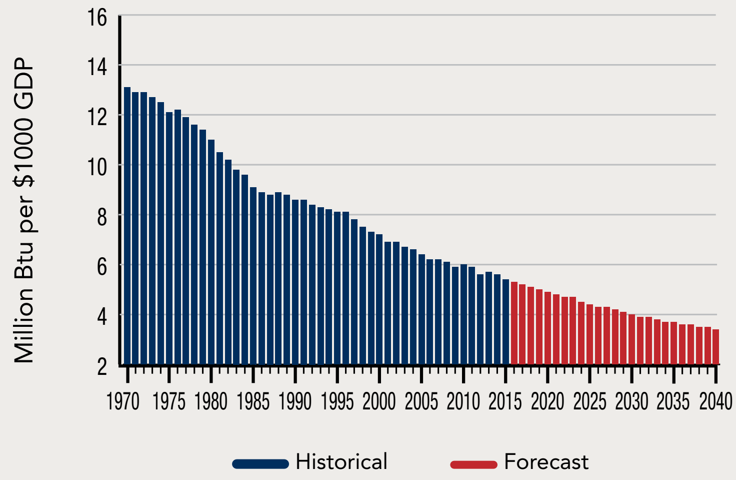
Indicates the importance of energy as a component of economic growth.

Category of Metric

Energy Use Intensity

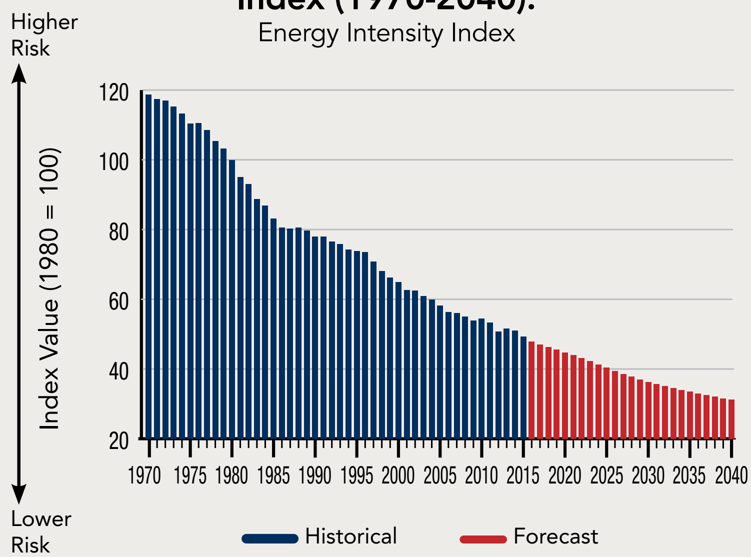
Historical and Forecast Values (1970-2040):

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	4.1	N/A	8.1	2.9

METRIC #21

Petroleum Intensity

Definition

Million Btu of petroleum consumed per $1,000 GDP in real (2015) dollars.

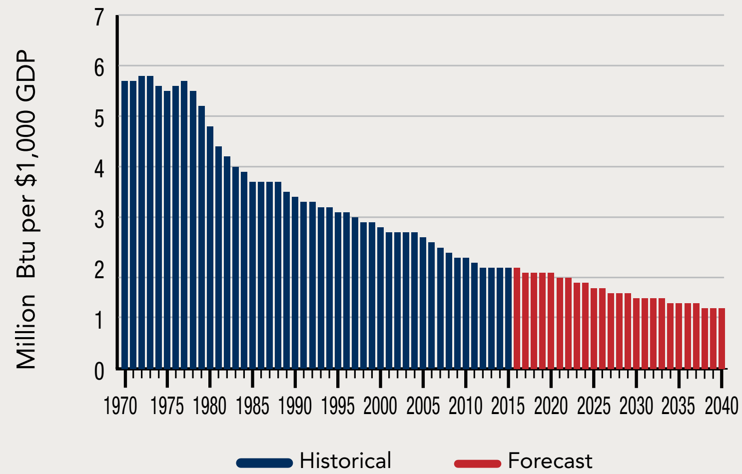
Importance

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

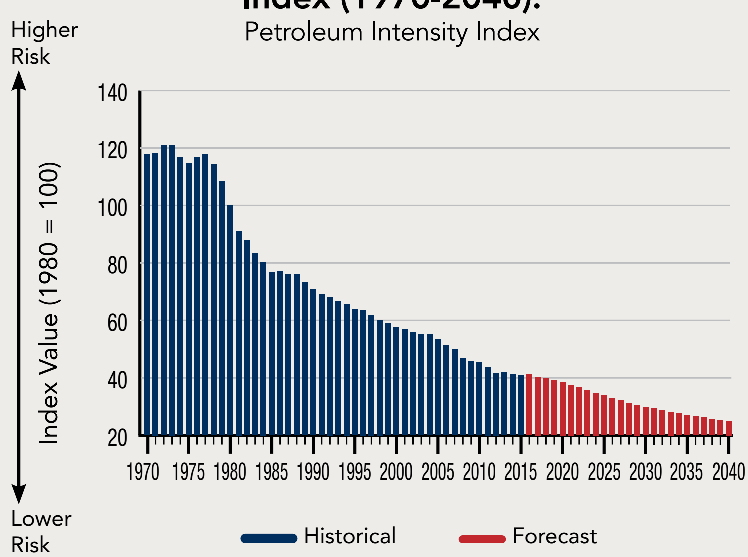
Category of Metric

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	7.0	2.9	N/A	4.6	3.9

METRIC #22

Household Energy Efficiency

Definition

Million Btu of total energy consumed per household.

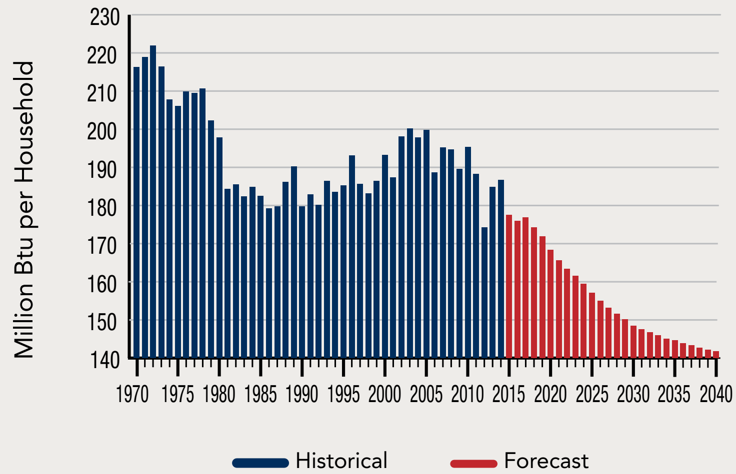
Importance

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

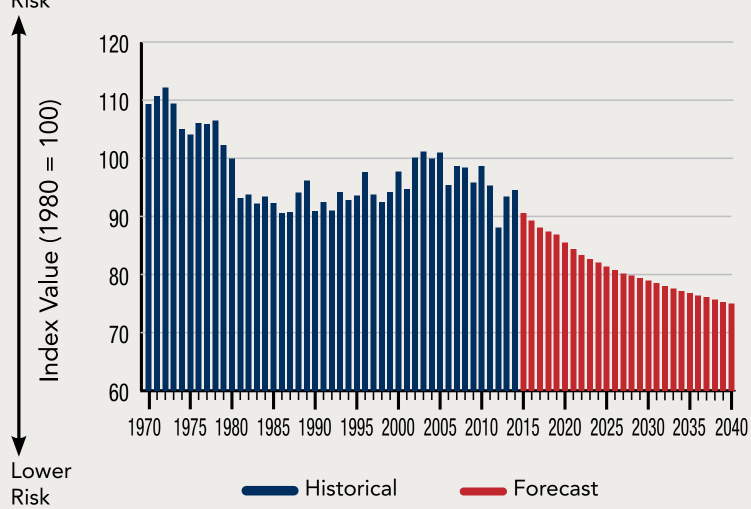
Category of Metric

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	3.8	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.

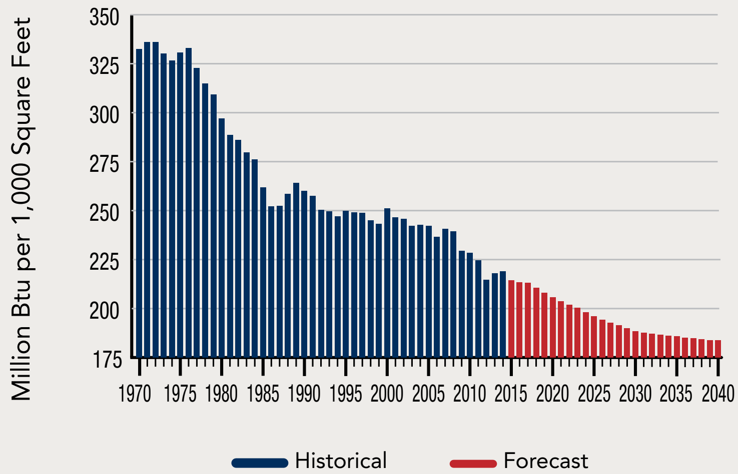
Importance

Indicates the degree to which commercial enterprises use energy efficiently.

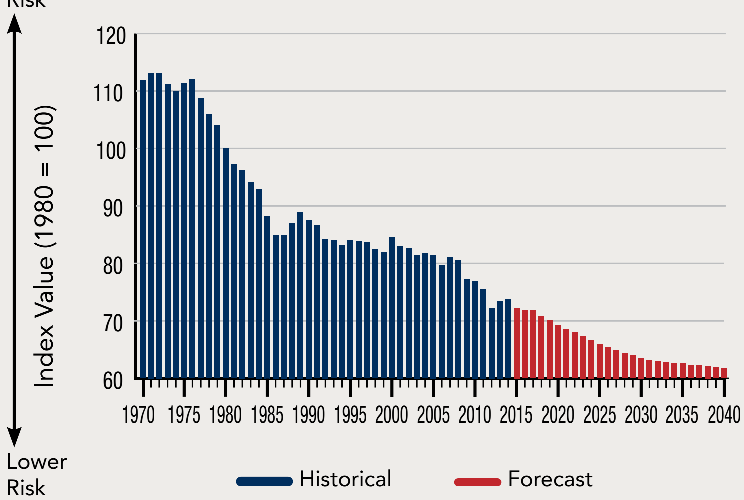
Category of Metric

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	3.5	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.

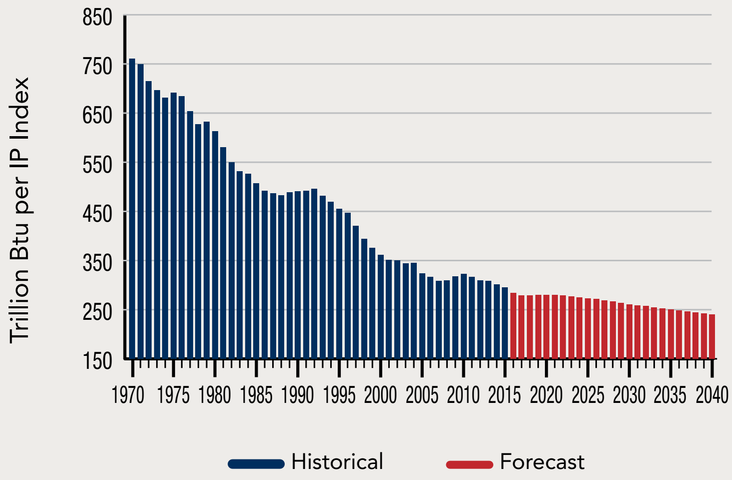
Importance

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

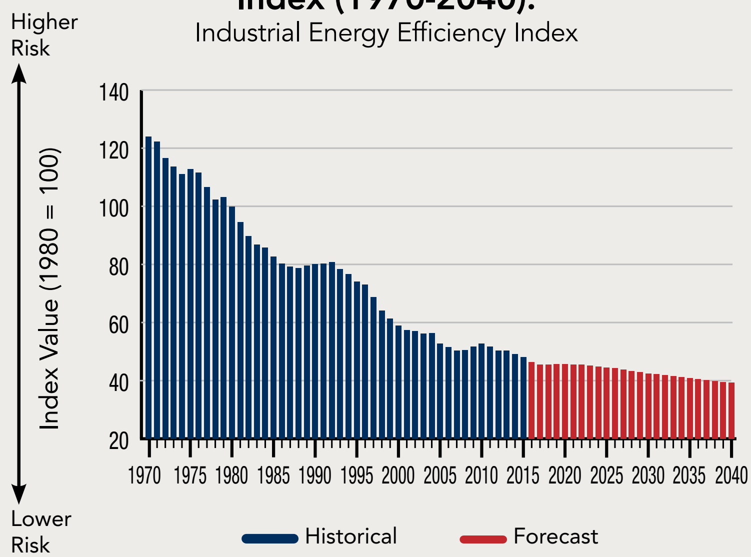
Category of Metric

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	3.0	N/A	3.2	1.5

METRIC #25

Electricity Capacity Diversity

Definition

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

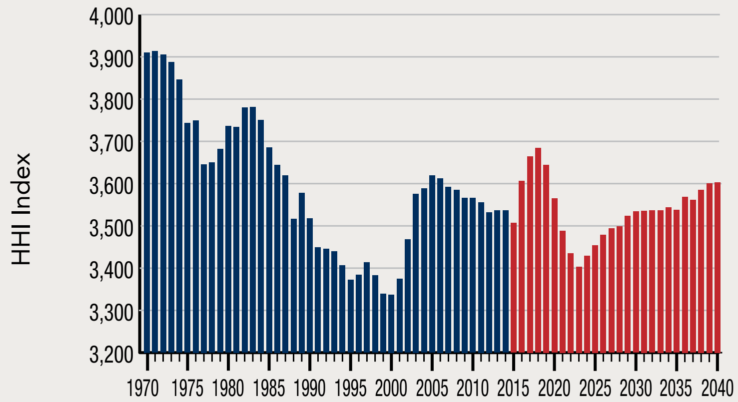
Importance

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

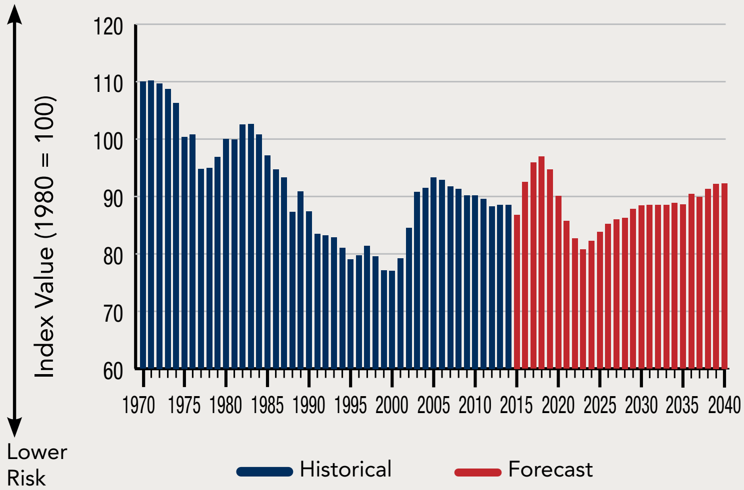
Category of Metric

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	2.1

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.

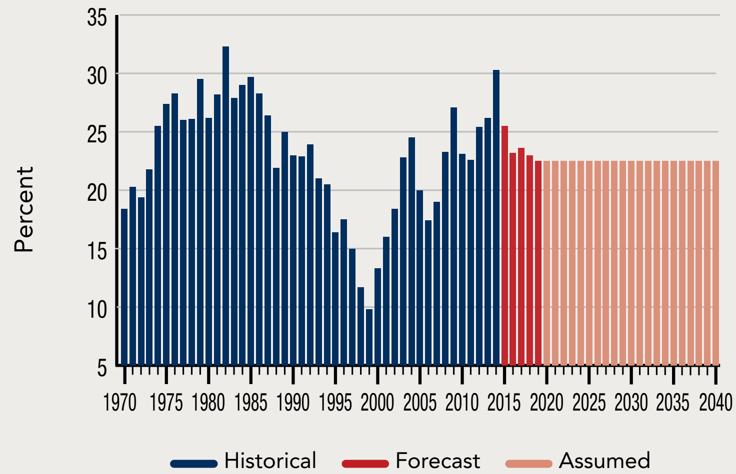
Importance

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.

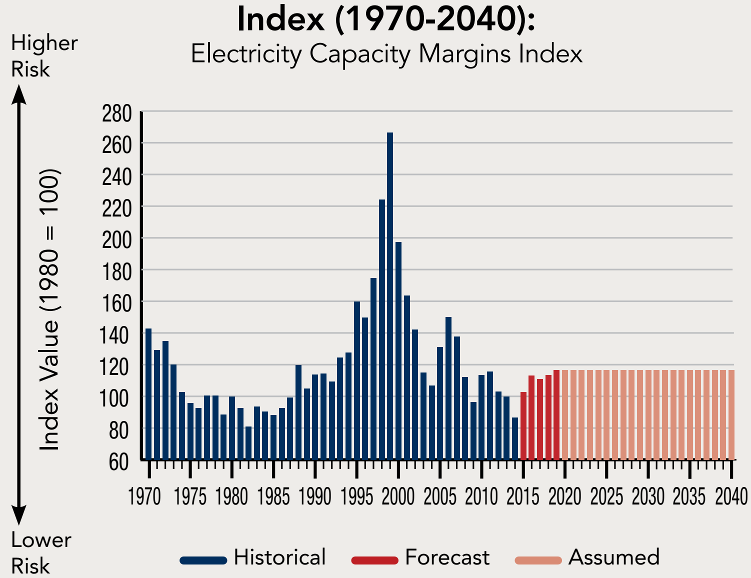
Category of Metric

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	9.5	N/A	2.4

METRIC #27

Electric Power Transmission Line Mileage

Definition

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

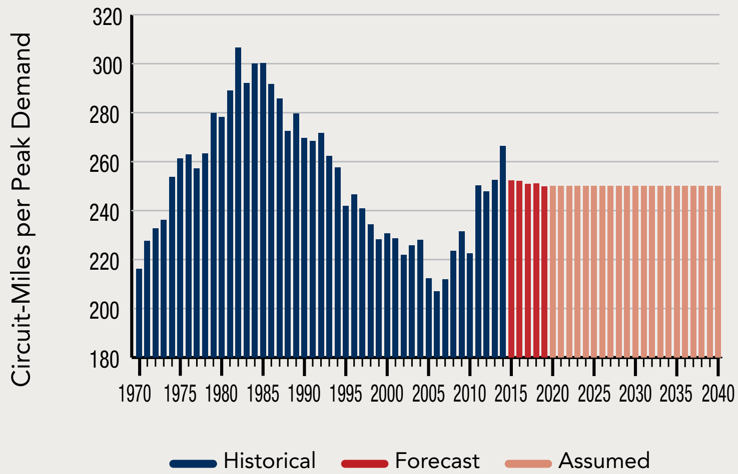
Importance

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

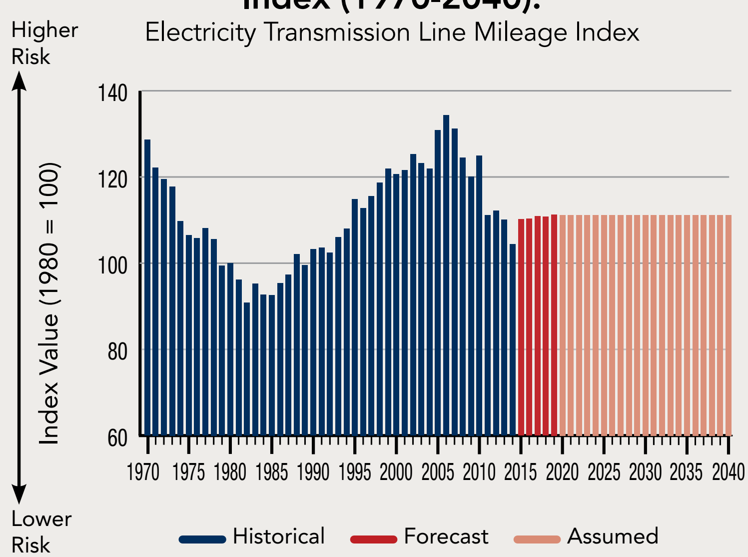
Category of Metric

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.

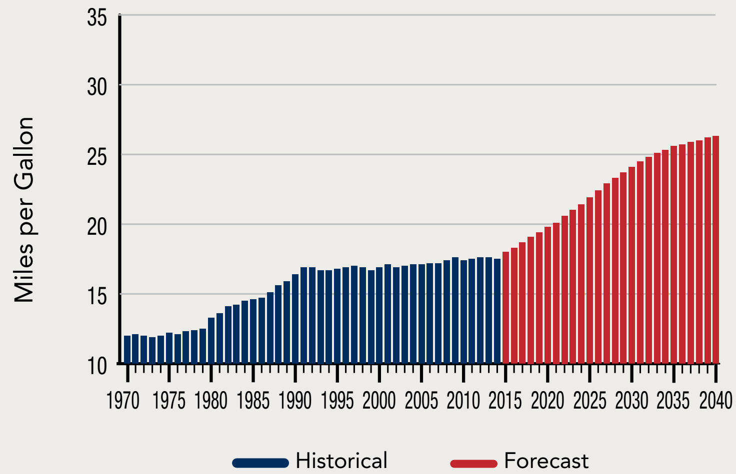
Importance

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

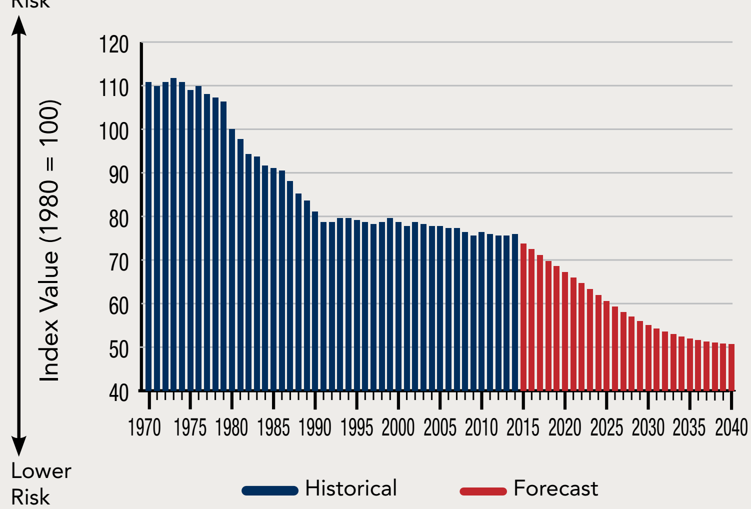
Category of Metric

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	3.1	4.6	N/A	10.8	4.6

METRIC #29

Vehicle-Miles Traveled per GDP

Definition

Vehicle-miles traveled (VMT) per $1,000 of GDP in real (2015) dollars.

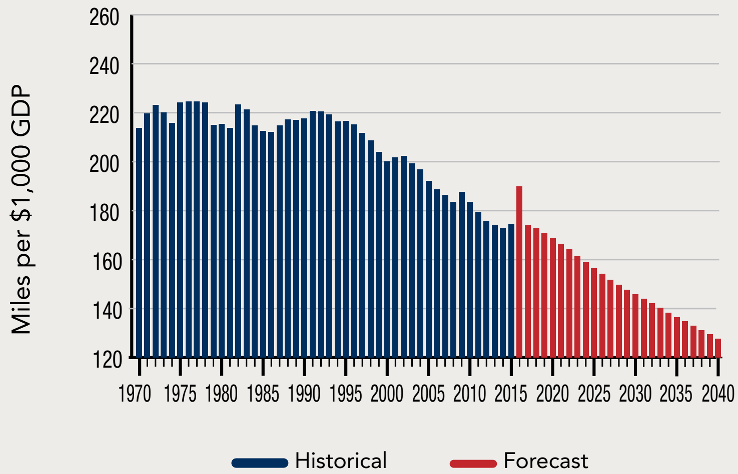
Importance

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

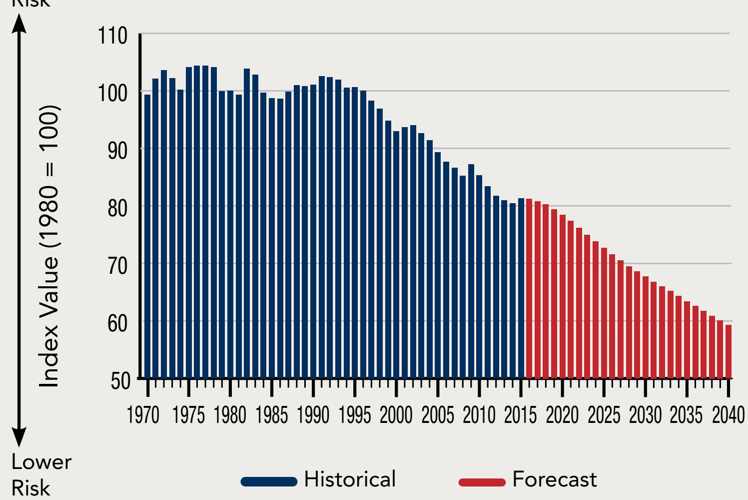
Category of Metric

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	2.5	N/A	7.9	3.1

METRIC #30

Transportation Non-Petroleum Fuel Use

Definition

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

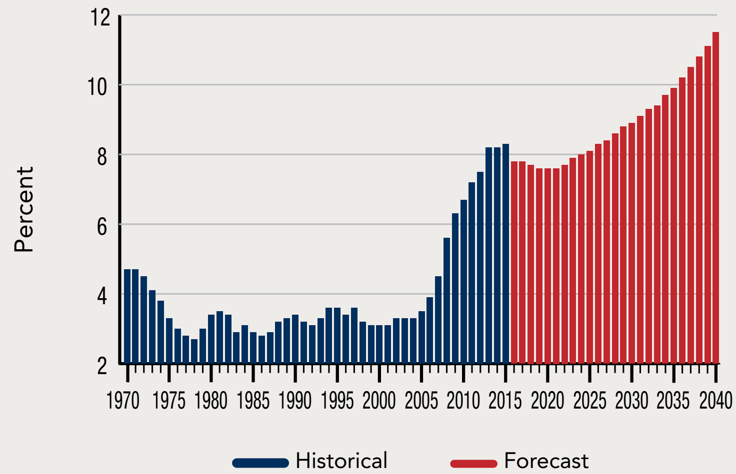
Importance

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

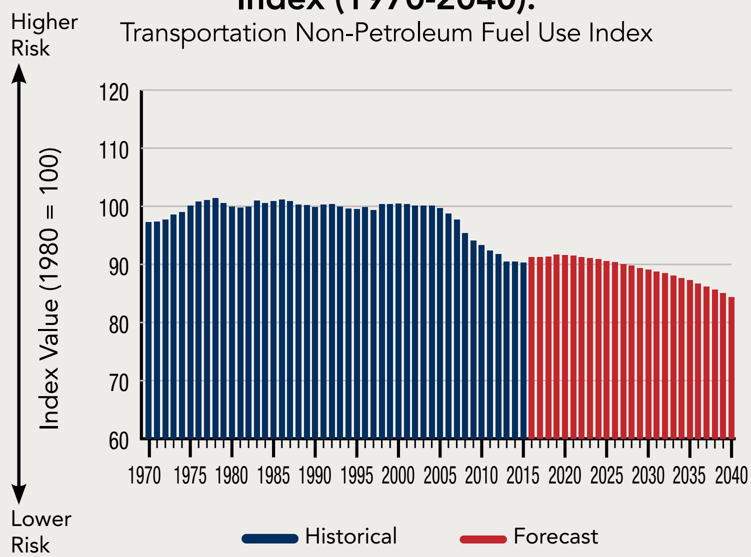
Category of Metric

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	4.1	2.9

METRIC #31

Energy-Related Carbon Dioxide Emissions

Definition

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

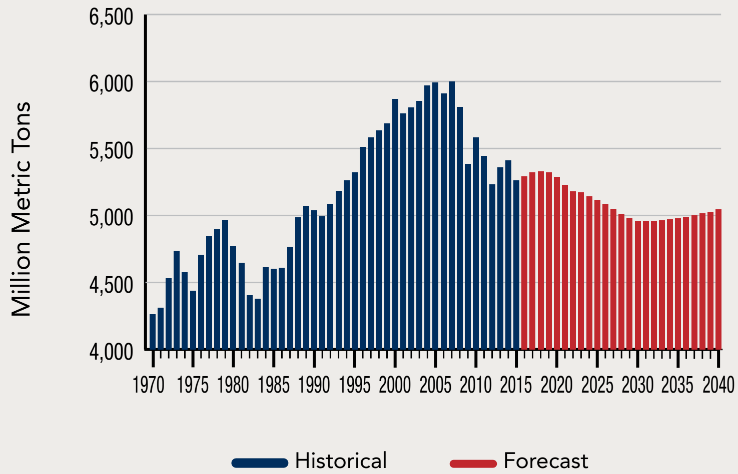
Importance

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

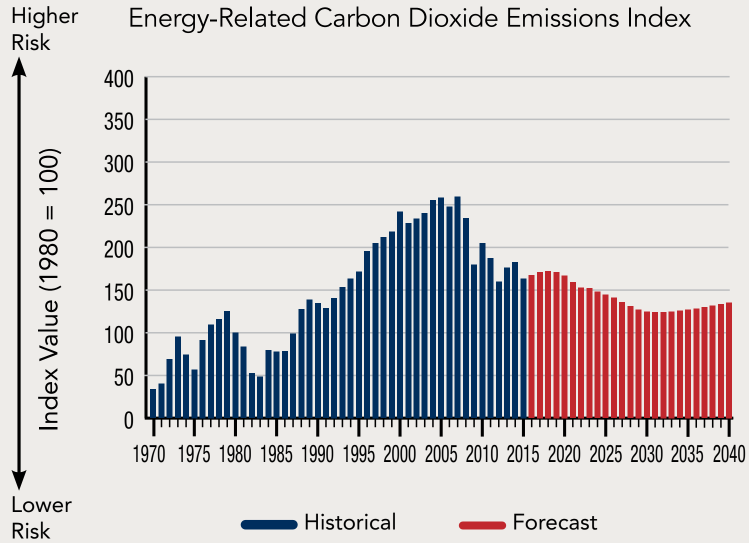
Category of Metric

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	10.8	3.5

METRIC #32

Energy-Related Carbon Dioxide Emissions per Capita

Definition

Million metric tons of CO_2 emissions from energy per capita.

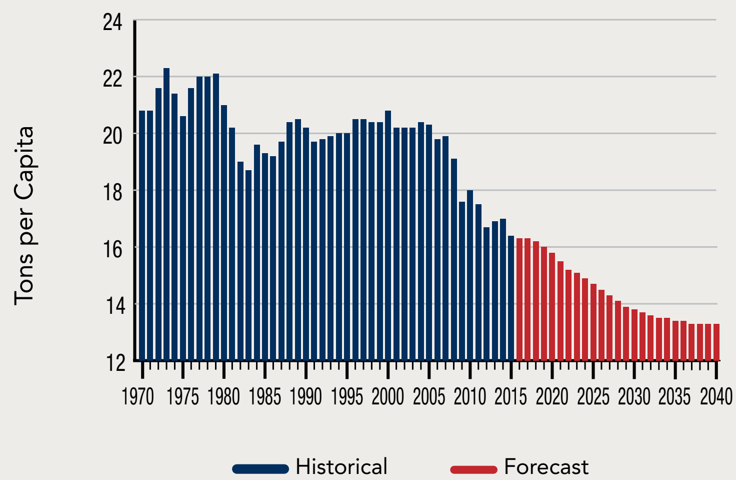
Importance

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

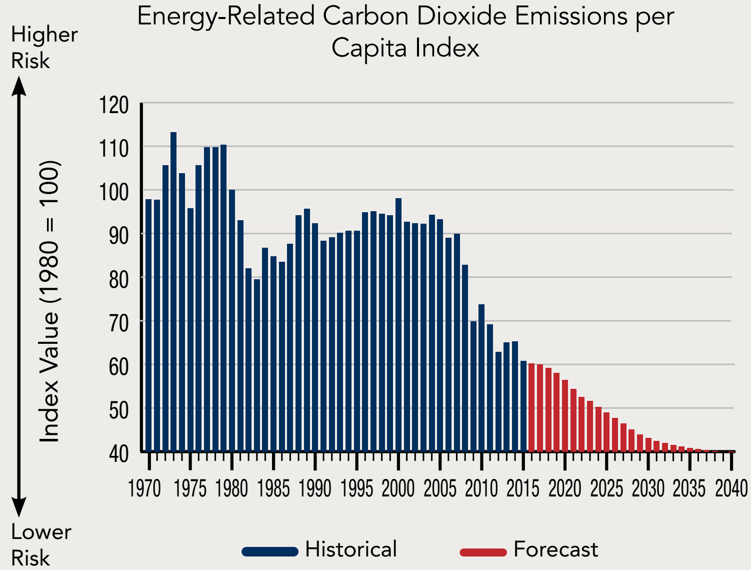
Category of Metric

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	2.1	N/A	N/A	4.6	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 (2015) dollars.

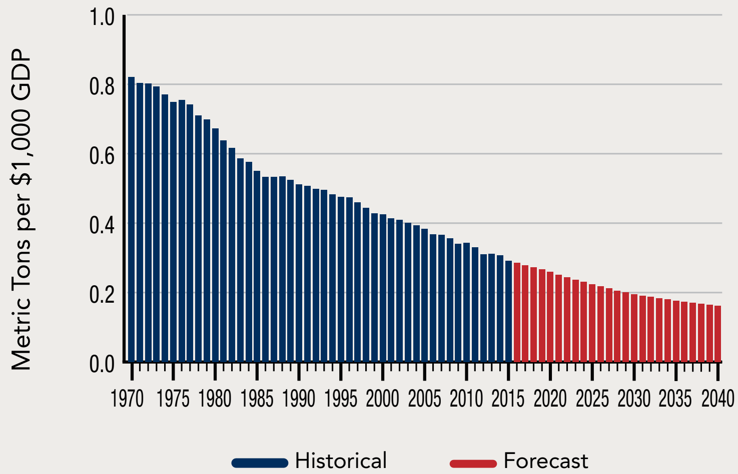
Importance

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

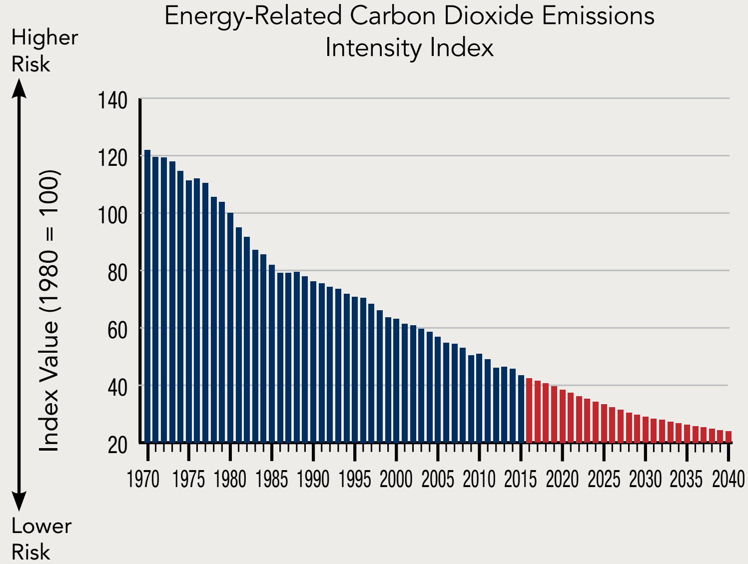
Category of Metric

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	1.8	N/A	N/A	4.0	1.4

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.

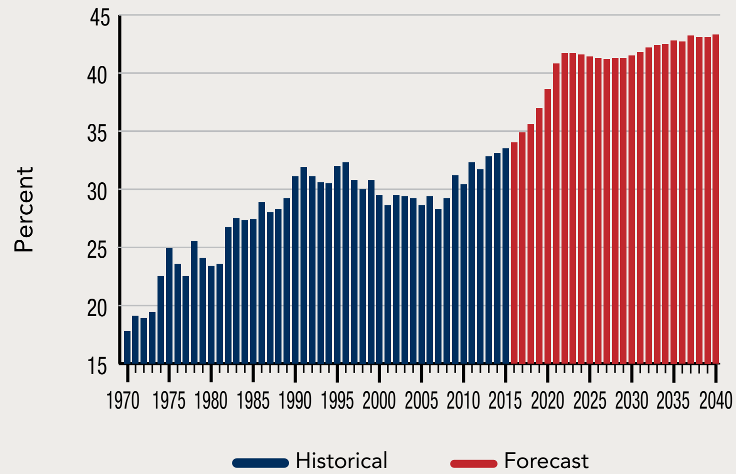
Importance

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

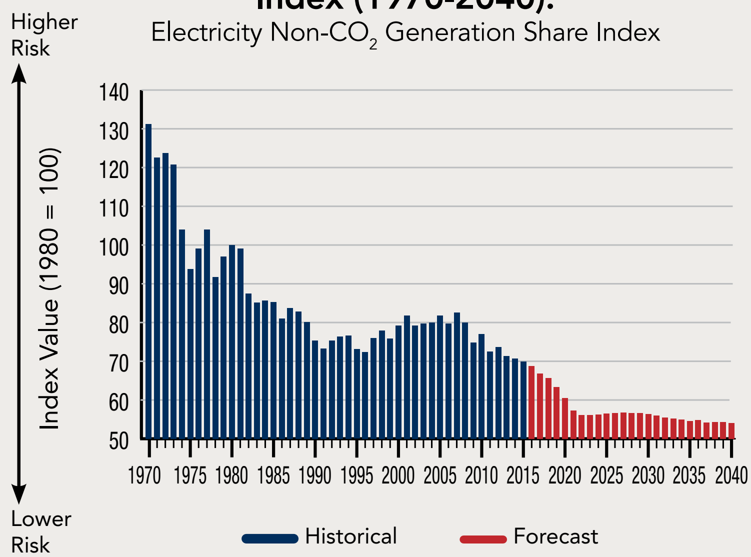
Category of Metric

Environmental

Historical and Forecast Values (1970-2040):
Electricity Non-CO_2 Generation Share



Index (1970-2040):
Electricity Non-CO_2 Generation Share Index



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 (2015) dollars.

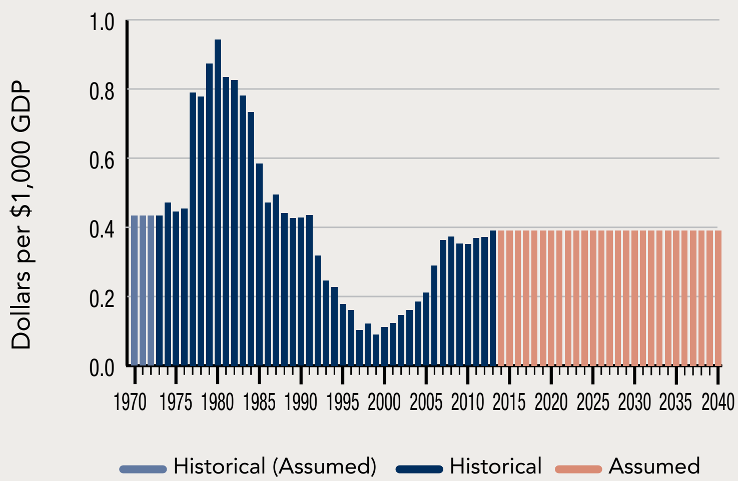
Importance

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

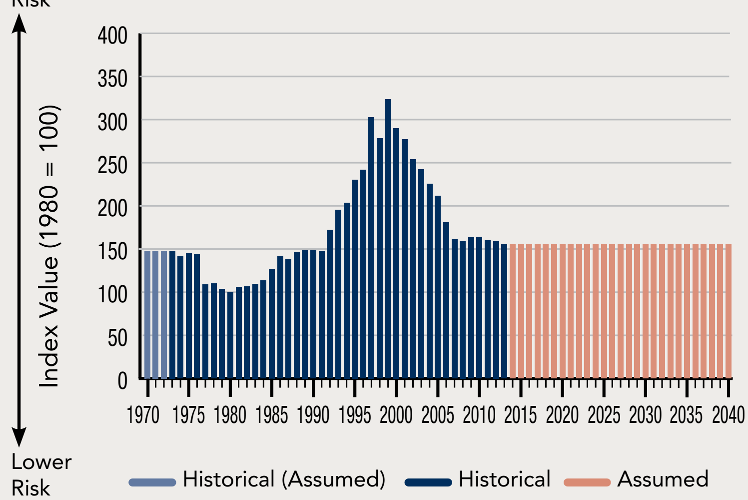
Category of Metric

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	3.8	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 (2015) dollars.

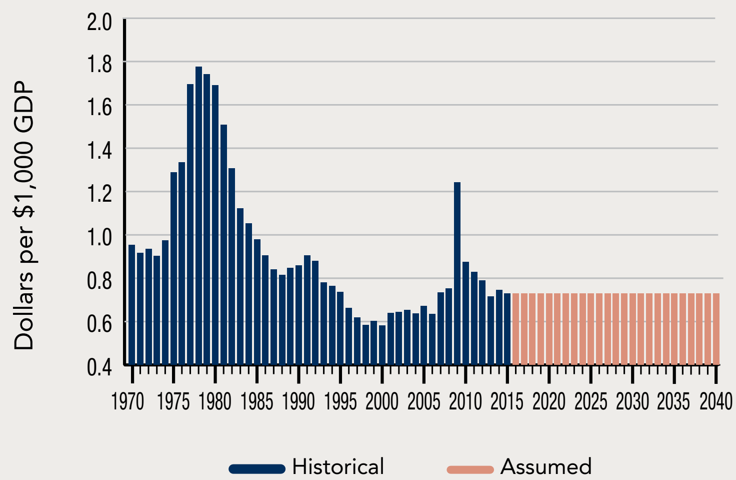
Importance

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

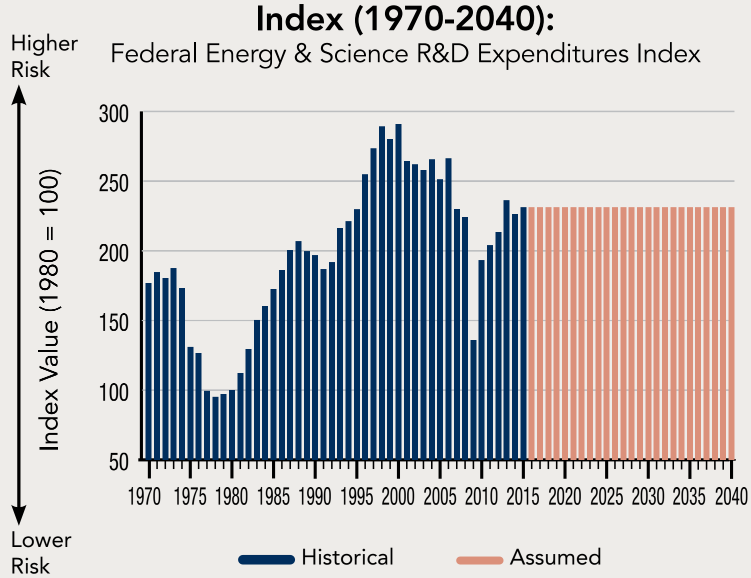
Category of Metric

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	4.1	2.6

METRIC #37

Science & Engineering Degrees

Definition

Number of science and engineering degrees, per billion dollars of GDP in real (2015) dollars.

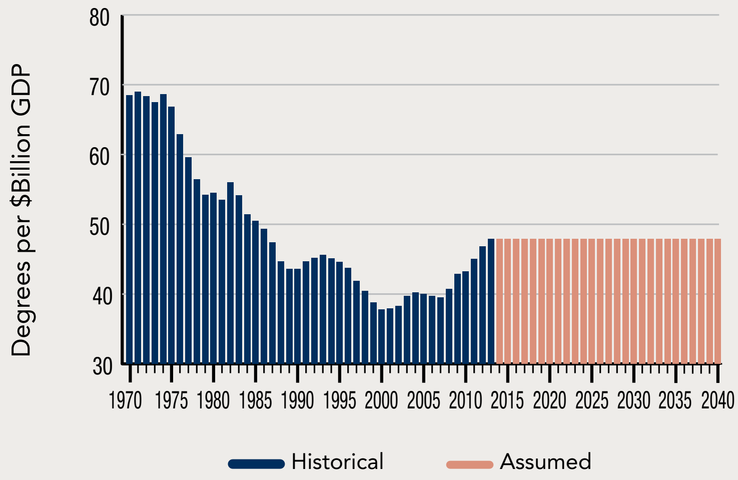
Importance

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

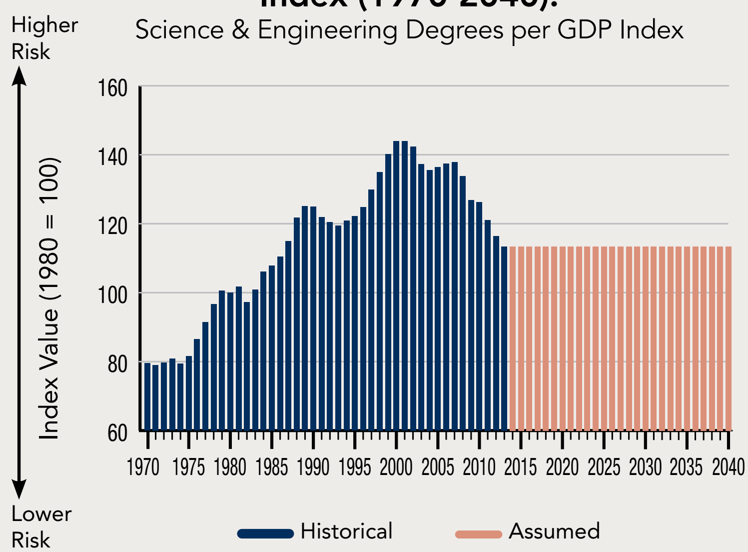
Category of Metric

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	2.4	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 2015$	$15.8	$18.9	$22.4	$54.8	$102.2	$95.6	$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 $1,000 GDP (2015$)	$77.03	$77.10	$76.47	$78.33	$99.02	$101.75	$103.28
12	Energy Expenditures per Household	2015$/Household	$6,287	$6,356	$6,451	$6,788	$8,330	$8,380	$8,081
13	Retail Electricity Prices	cents/kWh (2015$)	8.2¢	8.3¢	8.4¢	8.4¢	9.6¢	10.2¢	9.5¢
14	Crude Oil Price	2015$/bbl	$13.11	$13.36	$13.01	$24.45	$46.98	$44.06	$41.77
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$0.56	$0.48	$0.22	$4.01	$11.44	$12.30	$8.21
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2015$)	$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/$1,000 GDP (2015$)	13.1	12.9	12.9	12.7	12.5	12.1	12.2
21	Petroleum Intensity	million Btu/real $1,000 GDP (2015$)	5.68	5.70	5.83	5.84	5.64	5.53	5.63
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	761	749	715	697	681	691	684
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/$1,000 GDP (2015$)	214	220	223	220	216	224	225
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 CO_2 Emissions	$MMTCO_2$	4,261	4,312	4,532	4,735	4,575	4,439	4,707
32	Energy-Related CO_2 Emissions per Capita	metric tons CO_2/Person	20.8	20.8	21.6	22.3	21.4	20.6	21.6
33	Energy-Related CO_2 Emissions Intensity	metric tons CO_2/$1,000 GDP (2015$)	0.82	0.80	0.80	0.79	0.77	0.75	0.75
34	Electricity Non-CO_2 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 $/$1,000 GDP (2015$)	$0.43	$0.43	$0.43	$0.43	$0.47	$0.45	$0.45
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2015$)	$0.95	$0.92	$0.93	$0.90	$0.97	$1.29	$1.34
37	Science & Engineering Degrees	# degrees/$billion GDP (2015$)	68.5	69.0	68.3	67.5	68.6	66.8	62.9

Summary Table 1: Energy Security Metrics (Values)

1977-1994

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
107.6	97.8	102.5	100.0	96.9	93.8	98.9	104.5	104.5	111.4	110.2	99.6	100.6	124.5	119.8	141.4	147.9	147.4
107.8	97.3	94.6	100.0	100.2	93.9	90.5	93.4	90.6	94.0	88.8	79.9	82.0	77.2	75.6	73.1	77.7	75.7
114.2	100.7	98.7	100.0	106.2	120.4	122.5	141.9	136.4	136.9	124.5	94.7	101.0	86.8	88.9	77.7	86.5	87.9
91.8	87.4	88.5	100.0	103.3	112.3	120.0	138.0	146.5	155.8	142.3	117.6	117.1	91.2	88.1	68.9	72.3	68.8
99.1	92.7	92.4	100.0	102.1	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
95.0	93.5	90.8	100.0	100.0	101.9	102.5	109.4	108.5	108.1	102.6	96.8	102.9	88.3	87.5	82.7	91.3	90.6
49.5	40.8	39.8	37.3	34.5	26.8	25.8	28.0	24.4	30.8	30.6	29.1	32.0	30.2	28.1	27.2	31.1	30.8
4.8	4.2	5.3	4.7	4.4	5.4	5.8	5.7	6.9	5.9	6.9	6.9	6.7	5.8	6.1	5.0	5.9	6.1
$148.3	$130.3	$181.9	$213.6	$180.8	$125.7	$106.2	$110.6	$92.2	$55.5	$76.8	$67.8	$86.1	$106.9	$82.2	$82.2	$79.8	$77.2
2.3%	1.9%	2.6%	3.0%	2.5%	1.8%	1.4%	1.4%	1.1%	0.6%	0.9%	0.7%	0.9%	1.1%	0.8%	0.8%	0.8%	0.7%
$105.70	$101.54	$113.05	$130.78	$133.26	$127.50	$114.79	$107.75	$100.89	$83.72	$81.68	$78.39	$77.63	$79.41	$76.54	$72.95	$71.58	$69.09
$9,231	$9,144	$10,290	$11,651	$11,717	$10,873	$10,141	$9,999	$9,589	$8,120	$8,073	$7,941	$8,026	$8,302	$7,909	$7,714	$7,672	$7,628
10.6¢	10.8¢	10.8¢	11.6¢	12.5¢	13.0¢	12.9¢	12.4¢	12.4¢	12.1¢	11.7¢	11.3¢	11.0¢	10.8¢	10.8¢	10.6¢	10.6¢	10.3¢
$46.57	$43.68	$60.94	$90.15	$89.54	$76.80	$64.17	$61.50	$55.79	$26.50	$34.04	$26.46	$31.14	$39.14	$31.95	$30.11	$25.90	$23.64
$1.81	$1.80	$7.11	$16.45	$15.70	$14.19	$8.66	$9.35	$7.00	$12.56	$14.18	$14.80	$6.60	$6.75	$6.62	$5.68	$4.41	$2.77
$5.24	$4.70	$7.47	$11.16	$12.37	$10.53	$6.90	$4.92	$3.16	$5.60	$5.45	$4.50	$0.91	$1.74	$2.72	$2.31	$1.42	$0.58
76.9%	77.6%	78.7%	74.4%	71.4%	70.8%	72.6%	74.0%	74.8%	77.4%	77.6%	80.5%	81.4%	81.7%	81.0%	81.4%	81.2%	81.0%
71	68	72	82	92	93	95	99	97	98	96	92	91	95	97	93	96	93
354.0	359.2	359.3	343.6	331.7	315.5	312.1	325.0	321.1	319.2	326.3	338.3	343.5	338.5	333.8	334.4	336.1	338.6
11.9	11.6	11.4	11.0	10.5	10.2	9.8	9.6	9.1	8.9	8.8	8.9	8.8	8.6	8.6	8.4	8.3	8.2
5.68	5.51	5.22	4.82	4.39	4.23	4.02	3.88	3.70	3.72	3.67	3.67	3.54	3.41	3.34	3.29	3.22	3.17
209.4	210.7	202.3	197.8	184.3	185.5	182.4	184.8	182.5	179.2	179.7	186.2	190.2	179.8	182.9	180.1	186.4	183.5
322.8	314.8	309.2	297.0	288.6	286.1	279.6	276.2	261.9	252.1	252.3	258.5	264.0	260.1	257.4	250.4	249.5	247.0
653	627	632	613	580	550	532	526	507	492	486	482	488	491	492	496	481	470
3,646	3,650	3,682	3,736	3,734	3,780	3,781	3,751	3,686	3,645	3,620	3,516	3,578	3,518	3,449	3,445	3,440	3,406
26.0%	26.1%	29.5%	26.2%	28.2%	32.3%	27.9%	29.0%	29.7%	28.3%	26.4%	21.9%	25.0%	23.0%	22.9%	23.9%	21.0%	20.5%
257	263	280	278	289	307	292	300	300	292	286	273	280	270	269	272	262	258
12.3	12.4	12.5	13.3	13.6	14.1	14.2	14.5	14.6	14.7	15.1	15.6	15.9	16.4	16.9	16.9	16.7	16.7
225	224	215	215	214	223	221	215	212	212	215	217	217	218	221	220	219	216
2.8%	2.7%	3.0%	3.4%	3.5%	3.4%	2.9%	3.1%	2.9%	2.8%	2.9%	3.2%	3.3%	3.4%	3.2%	3.1%	3.3%	3.6%
4,847	4,897	4,966	4,771	4,646	4,405	4,377	4,614	4,600	4,608	4,766	4,984	5,070	5,039	4,993	5,087	5,185	5,261
22.0	22.0	22.1	21.0	20.2	19.0	18.7	19.6	19.3	19.2	19.7	20.4	20.5	20.2	19.7	19.8	19.9	20.0
0.74	0.71	0.70	0.67	0.64	0.62	0.59	0.58	0.55	0.53	0.53	0.53	0.52	0.51	0.51	0.50	0.50	0.48
22.5%	25.5%	24.1%	23.4%	23.6%	26.7%	27.5%	27.3%	27.4%	28.9%	28.0%	28.3%	29.2%	31.1%	31.9%	31.1%	30.6%	30.5%
$0.79	$0.78	$0.87	$0.94	$0.83	$0.83	$0.78	$0.73	$0.58	$0.47	$0.49	$0.44	$0.43	$0.43	$0.44	$0.32	$0.25	$0.23
$1.70	$1.78	$1.74	$1.69	$1.51	$1.31	$1.12	$1.05	$0.98	$0.91	$0.84	$0.82	$0.85	$0.86	$0.91	$0.88	$0.78	$0.76
59.6	56.4	54.2	54.5	53.5	56.0	54.1	51.4	50.5	49.3	47.4	44.7	43.6	43.6	44.7	45.2	45.6	45.1

Summary Table 1: Energy Security Metrics (Values)

1995-2001

#	Metric	Units of Measurement	1995	1996	1997	1998	1999	2000	2001
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	146.4	141.7	129.0	125.7	125.0	128.2	127.4
2	Security of World Oil Production	production, freedom & diversity-weighted	74.1	70.0	70.2	68.3	68.1	68.5	69.0
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	88.2	87.9	87.7	89.4	93.6	100.1	99.4
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	66.3	61.3	61.1	63.8	68.3	71.2	72.4
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	55.4	52.0	50.7	49.8	52.8	58.2	58.1
6	Security of World Coal Production	production, freedom & diversity-weighted	89.7	89.1	83.5	74.4	74.7	80.7	82.7
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	29.4	28.7	30.4	30.9	30.1	31.6	33.4
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	6.0	5.4	5.4	6.1	7.4	7.5	8.1
9	Oil & Natural Gas Import Expenditures	billions of 2015$	$78.4	$101.6	$100.6	$72.7	$100.2	$167.9	$147.6
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.7%	0.9%	0.8%	0.6%	0.8%	1.2%	1.1%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2015$)	$67.16	$69.18	$65.99	$57.91	$57.84	$66.88	$65.56
12	Energy Expenditures per Household	2015$/Household	$7,518	$7,959	$7,837	$7,092	$7,316	$8,740	$8,546
13	Retail Electricity Prices	cents/kWh (2015$)	10.1¢	9.8¢	9.7¢	9.4¢	9.1¢	9.1¢	9.6¢
14	Crude Oil Price	2015$/bbl	$24.85	$29.60	$26.95	$17.80	$24.59	$38.50	$32.12
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$2.56	$2.74	$2.87	$5.52	$6.20	$9.95	$9.02
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2015$)	$0.31	$1.62	$1.53	$3.19	$2.58	$6.19	$4.76
17	World Oil Refinery Utilization	percent utilization	81.7%	82.6%	84.3%	83.2%	81.8%	83.0%	82.7%
18	Petroleum Stock Levels	average days supply	88	82	84	87	76	74	81
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	341.9	349.0	347.0	344.5	346.4	350.2	337.5
20	Energy Intensity	million Btu/$1,000 GDP (2015$)	8.1	8.1	7.8	7.5	7.3	7.2	6.9
21	Petroleum Intensity	million Btu/real $1,000 GDP (2015$)	3.08	3.07	2.98	2.90	2.85	2.77	2.74
22	Household Energy Efficiency	million Btu/household	185.2	193.1	185.6	183.1	186.4	193.2	187.3
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	249.9	249.1	248.7	244.9	243.2	251.0	246.6
24	Industrial Energy Efficiency	trillion Btu/IP Index	455	447	421	393	376	361	351
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,372	3,384	3,414	3,383	3,339	3,337	3,374
26	Electricity Capacity Margins	percent	16.4%	17.5%	15.0%	11.7%	9.8%	13.3%	16.0%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	242	247	241	234	228	231	229
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	16.8	16.9	17.0	16.9	16.7	16.9	17.1
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2015$)	216	215	212	209	204	200	202
30	Transportation Non-Petroleum Fuels	percent	3.6%	3.4%	3.6%	3.2%	3.1%	3.1%	3.1%
Environmental Metrics									
31	Energy-Related CO_2 Emissions	$MMTCO_2$	5,323	5,510	5,584	5,635	5,688	5,868	5,761
32	Energy-Related CO_2 Emissions per Capita	metric tons CO_2/Person	20.0	20.5	20.5	20.4	20.4	20.8	20.2
33	Energy-Related CO_2 Emissions Intensity	metric tons CO_2/$1,000 GDP (2015$)	0.48	0.47	0.46	0.44	0.43	0.42	0.41
34	Electricity Non-CO_2 Generation Share	percent of total generation	32.0%	32.3%	30.8%	30.0%	30.8%	29.5%	28.6%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2015$)	$0.18	$0.16	$0.10	$0.12	$0.09	$0.11	$0.12
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2015$)	$0.74	$0.66	$0.62	$0.58	$0.60	$0.58	$0.64
37	Science & Engineering Degrees	# degrees/$billion GDP (2015$)	44.6	43.7	41.9	40.4	38.8	37.8	37.9

Summary Table 1: Energy Security Metrics (Values)

2002-2019

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
124.3	91.0	92.2	87.4	87.3	86.4	87.4	87.3	88.3	93.3	95.1	95.8	99.5	98.3	98.3	98.3	98.3	98.3
65.7	68.4	72.8	72.2	72.5	72.5	74.9	73.3	75.6	79.3	80.3	79.9	82.2	82.8	83.2	84.0	83.1	83.5
95.5	93.2	97.8	98.6	97.4	97.7	96.7	96.7	93.5	93.7	96.5	97.8	100.4	100.1	100.1	100.1	100.1	100.1
71.1	71.5	76.3	76.9	78.1	78.4	77.9	75.1	78.3	82.4	81.4	83.0	86.3	86.7	87.2	87.7	88.1	88.6
56.3	64.3	66.7	64.4	70.8	70.8	68.0	67.7	68.6	66.7	66.8	67.4	70.7	70.7	70.7	70.7	70.7	70.7
86.2	99.2	108.5	113.8	118.3	123.5	128.3	137.9	143.8	153.3	168.5	168.5	168.5	168.5	168.5	168.5	168.5	168.5
30.5	33.6	37.1	37.9	37.7	36.7	37.2	32.9	32.7	31.4	28.7	23.7	19.9	18.1	18.8	19.5	15.8	15.1
7.4	7.2	7.9	8.5	8.3	8.5	6.7	5.7	5.5	4.4	3.2	2.7	2.5	1.9	0.8	0.1	-1.6	-3.1
$140.5	$174.0	$234.6	$338.6	$370.4	$391.1	$467.1	$251.8	$311.1	$374.1	$319.5	$260.0	$191.0	$91.9	$63.7	$85.6	$83.1	$94.7
1.0%	1.2%	1.5%	2.2%	2.3%	2.4%	2.9%	1.6%	1.9%	2.3%	1.9%	1.5%	1.1%	0.5%	0.3%	0.4%	0.4%	0.5%
$60.49	$65.61	$70.99	$79.88	$83.65	$85.24	$95.73	$73.97	$81.00	$89.77	$83.94	$82.72	$80.41	$61.28	$52.83	$55.20	$57.44	$61.00
$8,183	$9,073	$10,090	$11,556	$12,271	$12,643	$14,017	$10,536	$11,775	$13,064	$12,381	$12,388	$12,243	$9,579	$8,424	$8,988	$9,485	$10,214
9.3¢	9.4¢	9.4¢	9.7¢	10.3¢	10.3¢	10.8¢	10.8¢	10.7¢	10.5¢	10.3¢	10.4¢	10.6¢	10.5¢	10.2¢	10.1¢	10.2¢	10.4¢
$32.32	$36.59	$47.22	$65.25	$75.60	$81.86	$107.44	$67.91	$86.51	$118.46	$116.71	$111.88	$100.29	$52.58	$36.91	$48.18	$57.13	$70.26
$6.83	$3.61	$5.03	$10.98	$13.00	$11.55	$14.06	$23.79	$27.90	$30.03	$17.43	$12.94	$6.11	$21.49	$17.59	$20.48	$21.35	$22.64
$5.19	$3.74	$5.99	$8.34	$8.02	$6.50	$6.35	$12.73	$14.34	$14.09	$7.41	$4.50	$1.36	$5.86	$5.81	$5.76	$5.71	$5.65
81.4%	83.3%	85.4%	85.2%	84.2%	84.3%	83.4%	80.7%	82.2%	81.9%	82.1%	80.8%	80.4%	81.9%	81.9%	81.9%	81.9%	81.9%
78	78	79	82	83	81	89	95	94	93	98	93	97	104	103	102	101	100
339.5	337.5	341.8	339.0	333.4	335.4	325.2	306.9	315.1	310.9	300.8	307.3	308.9	303.4	300.7	301.7	301.3	301.5
6.9	6.7	6.6	6.4	6.2	6.2	6.1	5.9	6.0	5.9	5.6	5.7	5.6	5.4	5.3	5.2	5.1	5.0
2.69	2.66	2.66	2.57	2.48	2.41	2.26	2.20	2.18	2.11	2.01	2.02	1.98	1.96	1.99	1.95	1.93	1.89
198.1	200.1	197.8	199.8	188.7	195.2	194.7	189.6	195.3	188.3	174.3	184.8	186.7	177.5	176.0	176.8	174.2	171.9
245.8	242.1	242.8	242.1	236.7	240.6	239.3	229.5	228.5	224.5	214.6	218.0	219.0	214.3	213.3	213.2	210.6	208.1
350	344	346	324	316	308	309	318	323	317	309	308	301	295	284	279	279	280
3,468	3,576	3,588	3,619	3,613	3,593	3,585	3,566	3,566	3,556	3,532	3,537	3,537	3,507	3,606	3,665	3,684	3,645
18.4%	22.8%	24.5%	20.0%	17.4%	19.0%	23.3%	27.1%	23.1%	22.6%	25.4%	26.2%	30.3%	25.5%	23.2%	23.6%	23.0%	22.5%
222	226	228	212	207	212	223	232	223	250	248	253	266	252	252	251	251	250
16.9	17.0	17.1	17.1	17.2	17.2	17.4	17.6	17.4	17.5	17.6	17.6	17.5	18.0	18.3	18.7	19.1	19.4
202	199	197	192	189	186	183	188	184	179	176	174	173	175	190	174	173	171
3.3%	3.3%	3.3%	3.5%	3.9%	4.5%	5.6%	6.3%	6.7%	7.2%	7.5%	8.2%	8.2%	8.3%	7.8%	7.8%	7.7%	7.6%
5,804	5,853	5,970	5,993	5,910	6,001	5,809	5,386	5,582	5,445	5,232	5,360	5,411	5,262	5,292	5,321	5,329	5,322
20.2	20.2	20.4	20.3	19.8	19.9	19.1	17.6	18.0	17.5	16.7	16.9	17.0	16.4	16.3	16.3	16.2	16.0
0.41	0.40	0.39	0.38	0.37	0.37	0.36	0.34	0.34	0.33	0.31	0.31	0.31	0.29	0.29	0.28	0.27	0.27
29.5%	29.4%	29.2%	28.6%	29.4%	28.3%	29.2%	31.2%	30.4%	32.3%	31.7%	32.8%	33.1%	33.5%	34.0%	34.9%	35.6%	37.0%
$0.15	$0.16	$0.19	$0.21	$0.29	$0.36	$0.37	$0.35	$0.35	$0.37	$0.37	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
$0.64	$0.65	$0.64	$0.67	$0.63	$0.73	$0.75	$1.24	$0.87	$0.83	$0.79	$0.71	$0.75	$0.73	$0.73	$0.73	$0.73	$0.73
38.3	39.7	40.2	40.0	39.7	39.5	40.7	42.9	43.2	45.0	46.8	47.9	47.9	47.9	47.9	47.9	47.9	47.9

Summary Table 1: Energy Security Metrics (Values)

2020-2026

#	Metric	Units of Measurement	2020	2021	2022	2023	2024	2025	2026
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	98.3	98.3	98.3	98.3	98.3	98.3	98.3
2	Security of World Oil Production	production, freedom & diversity-weighted	83.5	83.1	83.6	83.7	83.8	84.2	84.4
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	100.1	100.1	100.1	100.1	100.1	100.1	100.1
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	89.1	89.2	89.3	89.4	89.5	89.6	89.8
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	14.1	13.6	13.6	13.6	13.2	12.8	12.0
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	-5.7	-7.1	-7.9	-9.1	-9.7	-9.9	-9.8
9	Oil & Natural Gas Import Expenditures	billions of 2015$	$90.6	$90.9	$91.7	$88.4	$83.5	$81.4	$80.3
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.3%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2015$)	$61.94	$62.05	$61.54	$61.00	$60.22	$59.62	$59.05
12	Energy Expenditures per Household	2015$/Household	$10,498	$10,628	$10,670	$10,737	$10,757	$10,806	$10,847
13	Retail Electricity Prices	cents/kWh (2015$)	10.5¢	10.6¢	10.6¢	10.6¢	10.6¢	10.7¢	10.8¢
14	Crude Oil Price	2015$/bbl	$76.73	$81.32	$84.82	$87.28	$89.33	$91.78	$94.83
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$20.77	$17.83	$18.60	$19.14	$19.58	$20.12	$20.79
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2015$)	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60
17	World Oil Refinery Utilization	percent utilization	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%
18	Petroleum Stock Levels	average days supply	100	100	101	101	101	101	102
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	300.1	298.7	296.9	295.8	294.0	292.0	289.9
20	Energy Intensity	million Btu/$1,000 GDP (2015$)	4.9	4.8	4.7	4.7	4.5	4.4	4.3
21	Petroleum Intensity	million Btu/real $1,000 GDP (2015$)	1.85	1.81	1.77	1.72	1.68	1.63	1.59
22	Household Energy Efficiency	million Btu/household	168.3	165.6	163.4	161.5	159.4	157.1	155.0
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	205.8	203.8	201.9	200.3	198.1	196.0	194.2
24	Industrial Energy Efficiency	trillion Btu/IP Index	280	279	279	277	275	273	272
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,565	3,488	3,435	3,403	3,429	3,454	3,479
26	Electricity Capacity Margins	percent	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	250	250	250	250	250	250	250
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	19.8	20.1	20.6	21.0	21.4	21.9	22.4
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2015$)	169	167	164	161	159	156	154
30	Transportation Non-Petroleum Fuels	percent	7.6%	7.6%	7.7%	7.9%	8.0%	8.1%	8.3%
Environmental Metrics									
31	Energy-Related CO_2 Emissions	MMTCO_2	5,289	5,229	5,181	5,173	5,143	5,115	5,088
32	Energy-Related CO_2 Emissions per Capita	metric tons CO_2/Person	15.8	15.5	15.2	15.1	14.9	14.7	14.5
33	Energy-Related CO_2 Emissions Intensity	metric tons CO_2/$1,000 GDP (2015$)	0.26	0.25	0.24	0.24	0.23	0.22	0.22
34	Electricity Non-CO_2 Generation Share	percent of total generation	38.6%	40.8%	41.7%	41.7%	41.6%	41.4%	41.3%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2015$)	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2015$)	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73
37	Science & Engineering Degrees	# degrees/$billion GDP (2015$)	47.9	47.9	47.9	47.9	47.9	47.9	47.9

Summary Table 1: Energy Security Metrics (Values)

2027-2040

2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3
84.6	84.8	85.1	85.3	85.3	85.8	85.9	85.8	86.0	86.0	86.2	86.2	86.4	86.2
100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1
90.0	90.2	90.4	90.6	90.7	90.8	90.9	91.0	91.1	91.0	90.9	90.7	90.6	90.5
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
11.3	10.5	9.5	8.9	8.4	8.0	7.6	7.3	6.8	6.3	6.1	6.2	6.2	5.7
-9.9	-10.0	-10.3	-10.5	-11.0	-11.4	-11.7	-12.0	-12.3	-12.3	-12.3	-12.1	-12.1	-12.1
$75.1	$68.7	$60.1	$54.4	$51.0	$47.8	$45.1	$43.3	$38.9	$35.2	$34.5	$38.2	$38.0	$33.8
0.3%	0.3%	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
$58.32	$57.49	$57.03	$56.35	$55.87	$55.52	$55.20	$54.89	$54.30	$54.06	$53.59	$53.49	$53.29	$53.24
$10,857	$10,851	$10,900	$10,910	$10,953	$11,019	$11,101	$11,191	$11,217	$11,319	$11,371	$11,507	$11,619	$11,764
10.8¢	10.8¢	10.9¢	10.9¢	10.9¢	10.8¢	10.8¢	10.7¢	10.7¢	10.6¢	10.6¢	10.6¢	10.5¢	10.5¢
$97.38	$99.53	$102.43	$104.21	$107.44	$110.72	$114.08	$117.62	$119.89	$123.54	$125.76	$129.47	$132.35	$136.49
$21.35	$21.82	$22.46	$22.85	$23.56	$24.27	$25.01	$25.79	$26.28	$27.08	$27.57	$28.38	$29.02	$29.92
$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60	$5.60
81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%	81.9%
102	103	103	103	103	103	103	103	102	102	102	101	101	100
287.7	285.5	283.7	282.1	281.2	280.7	280.2	280.0	280.1	280.0	280.4	280.7	280.9	281.5
4.3	4.2	4.1	4.0	3.9	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4
1.55	1.51	1.47	1.44	1.41	1.38	1.36	1.33	1.31	1.28	1.26	1.24	1.22	1.20
153.2	151.6	150.1	148.5	147.5	146.7	145.9	145.1	144.6	143.8	143.4	142.7	142.2	141.8
192.6	191.4	190.0	188.5	187.7	187.2	186.6	186.0	185.8	185.1	184.9	184.3	183.8	183.7
269	266	264	261	258	257	255	253	250	248	246	244	243	241
3,494	3,498	3,524	3,534	3,536	3,536	3,537	3,544	3,538	3,569	3,561	3,586	3,601	3,603
22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%	22.5%
250	250	250	250	250	250	250	250	250	250	250	250	250	250
22.9	23.3	23.7	24.1	24.5	24.8	25.1	25.3	25.6	25.7	25.9	26.0	26.2	26.3
152	150	148	146	144	142	140	138	137	135	133	131	129	128
8.4%	8.6%	8.8%	8.9%	9.1%	9.3%	9.4%	9.7%	9.9%	10.2%	10.5%	10.8%	11.1%	11.5%
5,049	5,011	4,983	4,961	4,959	4,960	4,963	4,970	4,980	4,991	5,001	5,015	5,028	5,044
14.3	14.1	13.9	13.8	13.7	13.6	13.5	13.5	13.4	13.4	13.3	13.3	13.3	13.3
0.21	0.21	0.20	0.20	0.19	0.19	0.18	0.18	0.18	0.17	0.17	0.17	0.16	0.16
41.2%	41.3%	41.3%	41.5%	41.8%	42.2%	42.4%	42.5%	42.8%	42.7%	43.2%	43.1%	43.1%	43.3%
$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
$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73	$0.73
47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9	47.9

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	90.8	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	97.5	95.8	96.6	85.8	81.5	88.2	100.0	98.7
	Environmental	105.9	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	159.9	147.6	142.4	155.2	130.2	110.7	112.4	106.8	108.7	111.8	100.0	92.1
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	124.1	122.3	116.6	113.7	111.1	112.8	111.6	106.6	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 CO_2 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 CO_2 Emissions per Capita	97.9	97.8	105.7	113.2	103.8	95.8	105.7	109.8	109.8	110.4	100.0	93.0
33	Energy-Related CO_2 Emissions Intensity	122.0	119.5	119.3	118.0	114.6	111.4	112.1	110.4	105.6	103.8	100.0	94.9
34	Electricity non-CO_2 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	78.9	76.6	75.4	76.5	75.3	76.0	77.8	78.5	78.4	81.4	87.2
90.9	86.6	90.3	87.5	85.5	86.2	80.4	80.3	79.3	76.3	75.0	76.7	75.4	74.8	75.4	74.0	72.4	75.6	83.1
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	61.1	64.0	72.4
91.6	84.6	83.5	79.6	86.9	88.8	88.3	78.9	78.8	78.1	75.9	77.6	75.8	78.5	80.3	84.6	91.2	96.1	99.6
92.3	91.3	94.2	93.0	92.8	94.3	96.1	96.6	93.9	92.3	92.9	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	147.9	147.4	146.4	141.7	129.0	125.7	125.0	128.2
93.9	90.5	93.4	90.6	94.0	88.8	79.9	82.0	77.2	75.6	73.1	77.7	75.7	74.1	70.0	70.2	68.3	68.1	68.5
120.4	122.5	141.9	136.4	136.9	124.5	94.7	101.0	86.8	88.9	77.7	86.5	87.9	88.2	87.9	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	68.9	72.3	68.8	66.3	61.3	61.1	63.8	68.3	71.2
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	50.7	49.8	52.8	58.2
101.9	102.5	109.4	108.5	108.1	102.6	96.8	102.9	88.3	87.5	82.7	91.3	90.6	89.7	89.1	83.5	74.4	74.7	80.7
71.8	69.1	74.9	65.5	82.6	82.1	78.0	85.8	81.0	75.2	72.9	83.2	82.5	78.7	77.0	81.5	82.7	80.8	84.6
114.2	122.2	121.6	146.5	126.3	146.2	146.9	142.7	123.5	130.6	107.2	124.3	129.0	127.1	115.4	114.8	130.2	157.0	160.0
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	34.0	46.9	78.6
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	19.0	25.1	40.4
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
90.5	95.3	98.8	100.9	108.2	108.7	117.1	119.5	120.6	118.6	119.7	119.0	118.6	120.6	123.2	128.2	125.1	120.8	124.3
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	86.8	85.9	82.7	80.3	79.3	78.7	79.7	80.1	80.3	80.9	78.5	76.7	74.2	73.0	68.7	64.2	61.3	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	144.0

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	83.9	81.8	81.1	86.5	94.0	95.9	95.5	98.8	89.4	96.8	101.2	91.6
	Sub-Indexes												
	Geopolitical	81.4	78.4	77.5	84.3	91.8	94.5	95.8	100.5	87.4	94.1	100.8	93.2
	Economic	68.7	66.9	68.5	75.2	86.4	90.4	90.9	100.0	83.7	92.9	101.9	92.1
	Reliability	94.3	90.7	86.5	92.0	102.1	104.5	100.0	99.0	104.3	113.3	114.8	96.7
	Environmental	100.4	100.4	100.1	101.0	100.3	97.9	97.7	94.0	86.2	89.9	86.9	83.4
Global Fuels Metrics													
1	Security of World Oil Reserves	127.4	124.3	91.0	92.2	87.4	87.3	86.4	87.4	87.3	88.3	93.3	95.1
2	Security of World Oil Production	69.0	65.7	68.4	72.8	72.2	72.5	72.5	74.9	73.3	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	72.4	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	64.3	66.7	64.4	70.8	70.8	68.0	67.7	68.6	66.7	66.8
6	Security of World Coal Production	82.7	86.2	99.2	108.5	113.8	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	89.9	99.6	101.5	101.1	98.4	99.7	88.3	87.6	84.3	76.8
8	Security of U.S. Natural Gas Imports	172.7	157.1	152.0	167.6	179.9	177.0	181.5	141.5	121.2	117.6	92.5	67.1
9	Oil & Natural Gas Import Expenditures	69.1	65.8	81.5	109.8	158.5	173.4	183.1	218.7	117.9	145.6	175.1	149.6
10	Oil & Natural Gas Import Expenditures per GDP	35.1	32.9	39.6	51.4	71.8	76.5	79.4	95.1	52.7	63.5	75.2	62.8
Energy Expenditure Metrics													
11	Energy Expenditures per GDP	50.1	46.3	50.2	54.3	61.1	64.0	65.2	73.2	56.6	61.9	68.6	64.2
12	Energy Expenditures per Household	73.3	70.2	77.9	86.6	99.2	105.3	108.5	120.3	90.4	101.1	112.1	106.3
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	106.0
16	Energy Expenditure Volatility	42.6	46.5	33.5	53.6	74.7	71.9	58.2	56.9	114.0	128.5	126.3	66.4
17	World Oil Refinery Utilization	123.5	119.6	125.4	131.6	131.1	127.9	128.2	125.7	117.5	122.1	121.0	121.6
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	41.8
22	Household Energy Efficiency	94.7	100.1	101.2	100.0	101.0	95.4	98.7	98.4	95.8	98.7	95.2	88.1
23	Commercial Energy Efficiency	83.0	82.7	81.5	81.8	81.5	79.7	81.0	80.6	77.3	76.9	75.6	72.2
24	Industrial Energy Efficiency	57.4	57.1	56.2	56.4	52.8	51.6	50.3	50.5	51.8	52.7	51.7	50.4
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	113.6	115.7	103.1
27	Electricity Transmission Line Mileage	121.6	125.3	123.2	121.9	130.9	134.3	131.2	124.5	120.1	125.0	111.2	112.2
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	81.7
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 CO_2 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 CO_2 Emissions per Capita	92.7	92.4	92.3	94.3	93.3	89.0	90.0	82.8	69.9	73.8	69.2	62.9
33	Energy-Related CO_2 Emissions Intensity	61.4	60.8	59.6	58.6	56.9	54.7	54.5	53.0	50.5	51.0	49.0	46.1
34	Electricity non-CO_2 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	159.1
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	213.8
37	Science & Engineering Degrees	143.9	142.4	137.2	135.6	136.4	137.4	137.8	133.8	126.9	126.2	121.1	116.4

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
87.4	81.0	77.9	74.2	76.6	77.2	79.1	78.7	77.8	77.9	77.9	77.8	77.8	77.9	77.8	77.6	77.5	77.4	77.6
88.6	82.8	75.6	70.7	73.6	74.2	76.7	76.6	75.9	76.3	76.5	76.5	76.6	76.8	76.7	76.5	76.4	76.3	76.7
86.8	79.1	69.2	63.4	66.8	68.5	71.9	72.5	72.5	72.9	73.1	73.0	73.2	73.6	73.6	73.5	73.6	73.5	73.8
88.4	76.8	89.4	86.9	89.4	89.7	91.2	89.8	87.7	88.1	88.4	88.9	89.4	89.9	90.3	90.5	90.9	91.2	91.7
85.3	85.4	83.0	82.9	82.8	82.3	81.6	80.3	78.8	77.5	76.8	75.9	75.0	74.2	73.3	72.3	71.6	70.9	70.5
95.8	99.5	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3
79.9	82.2	82.8	83.2	84.0	83.1	83.5	83.5	83.1	83.6	83.7	83.8	84.2	84.4	84.6	84.8	85.1	85.3	85.3
97.8	100.4	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1
83.0	86.3	86.7	87.2	87.7	88.1	88.6	89.1	89.2	89.3	89.4	89.5	89.6	89.8	90.0	90.2	90.4	90.6	90.7
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
63.5	53.2	48.4	50.4	52.2	42.4	40.4	37.9	36.6	36.5	36.5	35.4	34.4	32.2	30.2	28.1	25.5	23.8	22.5
57.8	52.4	40.2	16.7	1.6	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
121.5	89.3	42.9	29.8	40.1	38.9	44.3	42.4	42.6	42.9	41.4	39.1	38.1	37.6	35.1	32.2	28.1	25.5	23.9
50.3	36.1	16.9	11.4	14.9	14.1	15.7	14.7	14.5	14.3	13.5	12.4	11.8	11.4	10.4	9.4	8.0	7.1	6.5
63.3	61.5	46.9	40.4	42.2	43.9	46.6	47.4	47.4	47.1	46.6	46.0	45.6	45.2	44.6	44.0	43.6	43.1	42.7
106.1	104.9	82.0	72.3	77.1	81.4	87.7	90.1	91.2	91.6	92.2	92.3	92.7	93.1	93.2	93.1	93.6	93.6	94.0
88.9	90.7	89.6	87.4	86.9	87.7	89.6	90.5	90.8	90.7	91.0	91.3	92.1	92.3	92.4	92.7	93.1	93.6	93.3
123.9	111.1	58.2	40.9	53.4	63.4	77.9	85.1	90.2	94.1	96.8	99.1	101.8	105.2	108.0	110.4	113.6	115.6	119.2
78.5	37.1	130.2	106.9	124.5	129.7	137.6	126.2	108.4	113.0	116.3	119.0	122.3	126.3	129.8	132.6	136.5	138.8	143.2
40.3	12.2	52.5	52.0	51.6	51.1	50.7	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
117.9	116.7	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1
87.9	83.9	78.6	79.0	80.0	80.5	81.3	81.5	81.4	81.1	81.0	80.8	80.6	80.3	79.9	79.5	79.3	79.2	79.2
89.4	89.9	88.3	87.5	87.8	87.7	87.7	87.4	86.9	86.4	86.1	85.6	85.0	84.4	83.7	83.1	82.6	82.1	81.8
51.6	51.0	49.3	47.9	47.0	46.3	45.6	44.8	44.0	43.2	42.3	41.3	40.4	39.5	38.6	37.8	37.0	36.3	35.7
41.9	41.2	40.8	41.2	40.4	39.9	39.3	38.5	37.6	36.7	35.7	34.8	33.9	33.0	32.1	31.3	30.5	29.9	29.3
93.4	94.4	89.7	88.9	89.4	88.1	86.9	85.1	83.7	82.6	81.7	80.6	79.4	78.4	77.4	76.7	75.9	75.1	74.5
73.4	73.7	72.2	71.8	71.8	70.9	70.1	69.3	68.6	68.0	67.4	66.7	66.0	65.4	64.9	64.4	64.0	63.5	63.2
50.3	49.1	48.1	46.4	45.5	45.5	45.7	45.7	45.6	45.5	45.2	44.8	44.6	44.3	43.9	43.4	43.0	42.5	42.2
88.5	88.5	86.8	92.5	95.9	97.0	94.7	90.1	85.7	82.7	80.8	82.3	83.8	85.2	86.0	86.3	87.8	88.4	88.5
99.8	86.5	102.6	113.1	110.9	113.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6
110.1	104.4	110.2	110.3	110.9	110.8	111.3	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2
75.6	76.0	73.8	72.5	71.1	69.8	68.6	67.3	66.0	64.7	63.4	62.0	60.6	59.3	58.1	57.0	56.0	55.1	54.3
81.0	80.4	81.3	81.2	80.8	80.3	79.4	78.4	77.4	76.2	75.0	73.8	72.7	71.6	70.5	69.5	68.6	67.7	66.8
90.5	90.5	90.3	91.3	91.3	91.4	91.7	91.6	91.5	91.3	91.1	90.9	90.6	90.4	90.1	89.8	89.4	89.1	88.8
176.4	182.9	163.6	167.4	171.3	172.3	171.3	167.1	159.3	153.1	152.1	148.1	144.5	141.0	135.9	131.1	127.4	124.6	124.3
65.1	65.3	60.8	60.3	60.0	59.2	58.1	56.5	54.4	52.6	51.7	50.3	49.0	47.8	46.5	45.1	44.0	43.1	42.5
46.5	45.8	43.5	42.5	41.5	40.6	39.6	38.5	37.3	36.2	35.3	34.3	33.3	32.4	31.5	30.5	29.8	29.0	28.4
71.4	70.7	69.9	68.8	66.9	65.7	63.3	60.5	57.3	56.1	56.1	56.3	56.5	56.7	56.8	56.7	56.6	56.4	56.0
155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3
236.4	226.7	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3
113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4

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	77.9	78.1	78.5	78.6	79.0	79.2	79.9	80.3	80.8
	Sub-Indexes									
	Geopolitical	77.1	77.5	78.1	78.3	78.7	79.1	79.9	80.5	81.1
	Economic	74.2	74.6	75.0	75.1	75.6	75.9	76.7	77.2	77.8
	Reliability	92.2	92.8	93.4	93.7	94.5	94.8	95.7	96.3	97.0
	Environmental	70.1	69.8	69.5	69.3	69.1	68.9	68.8	68.7	68.7
Global Fuels Metrics										
1	Security of World Oil Reserves	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3	98.3
2	Security of World Oil Production	85.8	85.9	85.8	86.0	86.0	86.2	86.2	86.4	86.2
3	Security of World Natural Gas Reserves	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1	100.1
4	Security of World Natural Gas Production	90.8	90.9	91.0	91.1	91.0	90.9	90.7	90.6	90.5
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	21.5	20.3	19.5	18.2	16.9	16.5	16.6	16.5	15.3
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	22.4	21.1	20.3	18.2	16.5	16.1	17.9	17.8	15.8
10	Oil & Natural Gas Import Expenditures per GDP	6.0	5.5	5.2	4.6	4.1	3.9	4.2	4.1	3.6
Energy Expenditure Metrics										
11	Energy Expenditures per GDP	42.5	42.2	42.0	41.5	41.3	41.0	40.9	40.7	40.7
12	Energy Expenditures per Household	94.6	95.3	96.0	96.3	97.1	97.6	98.8	99.7	101.0
13	Retail Electricity Prices	92.9	92.4	92.0	91.4	91.1	90.8	90.6	90.3	89.9
14	Crude Oil Price	122.8	126.5	130.5	133.0	137.0	139.5	143.6	146.8	151.4
Price & Market Volatility Metrics										
15	Crude Oil Price Volatility	147.5	152.0	156.7	159.7	164.6	167.6	172.5	176.3	181.9
16	Energy Expenditure Volatility	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
17	World Oil Refinery Utilization	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1	121.1
18	Petroleum Stock Levels	79.2	79.4	79.6	79.8	80.0	80.4	80.8	81.2	81.6
Energy Use Intensity Metrics										
19	Energy Consumption per Capita	81.7	81.6	81.5	81.5	81.5	81.6	81.7	81.7	81.9
20	Energy Intensity	35.1	34.6	34.0	33.5	33.0	32.5	32.1	31.6	31.2
21	Petroleum Intensity	28.7	28.2	27.6	27.1	26.6	26.2	25.7	25.3	24.9
22	Household Energy Efficiency	74.2	73.7	73.3	73.1	72.7	72.5	72.2	71.9	71.7
23	Commercial Energy Efficiency	63.0	62.8	62.6	62.6	62.3	62.3	62.1	61.9	61.8
24	Industrial Energy Efficiency	42.0	41.6	41.2	40.9	40.5	40.2	39.9	39.6	39.3
Electric Power Sector Metrics										
25	Electricity Capacity Diversity	88.5	88.5	88.9	88.6	90.4	89.9	91.3	92.2	92.3
26	Electricity Capacity Margins	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6	116.6
27	Electricity Transmission Line Mileage	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2	111.2
Transportation Sector Metrics										
28	Motor Vehicle Average MPG	53.6	53.0	52.5	52.0	51.7	51.3	51.1	50.8	50.7
29	Transportation VMT per $ GDP	66.0	65.2	64.3	63.4	62.6	61.7	60.9	60.1	59.3
30	Transportation Non-Petroleum Fuels	88.5	88.1	87.7	87.3	86.7	86.2	85.7	85.1	84.4
Environmental Metrics										
31	Energy-Related CO_2 Emissions	124.5	124.8	125.8	127.1	128.4	129.8	131.6	133.3	135.4
32	Energy-Related CO_2 Emissions per Capita	42.0	41.6	41.2	40.9	40.6	40.4	40.2	40.0	39.8
33	Energy-Related CO_2 Emissions Intensity	27.9	27.3	26.8	26.3	25.8	25.3	24.9	24.4	24.0
34	Electricity non-CO_2 Generation Share	55.5	55.2	55.0	54.6	54.8	54.2	54.3	54.3	54.1
Research and Development Metrics										
35	Industrial Energy R&D Expenditures	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3	155.3
36	Federal Energy & Science R&D Expenditures	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3	231.3
37	Science & Engineering Degrees	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4	113.4

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 2016 (AEO 2016) 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 2016. 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
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Institute for 21st Century Energy
U.S. Chamber of Commerce
1615 H Street, NW
Washington, DC 20062
Phone: (202) 463-5558 Fax: (202) 887-3457
energyinstitute@uschamber.com
www.energyxxi.org

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