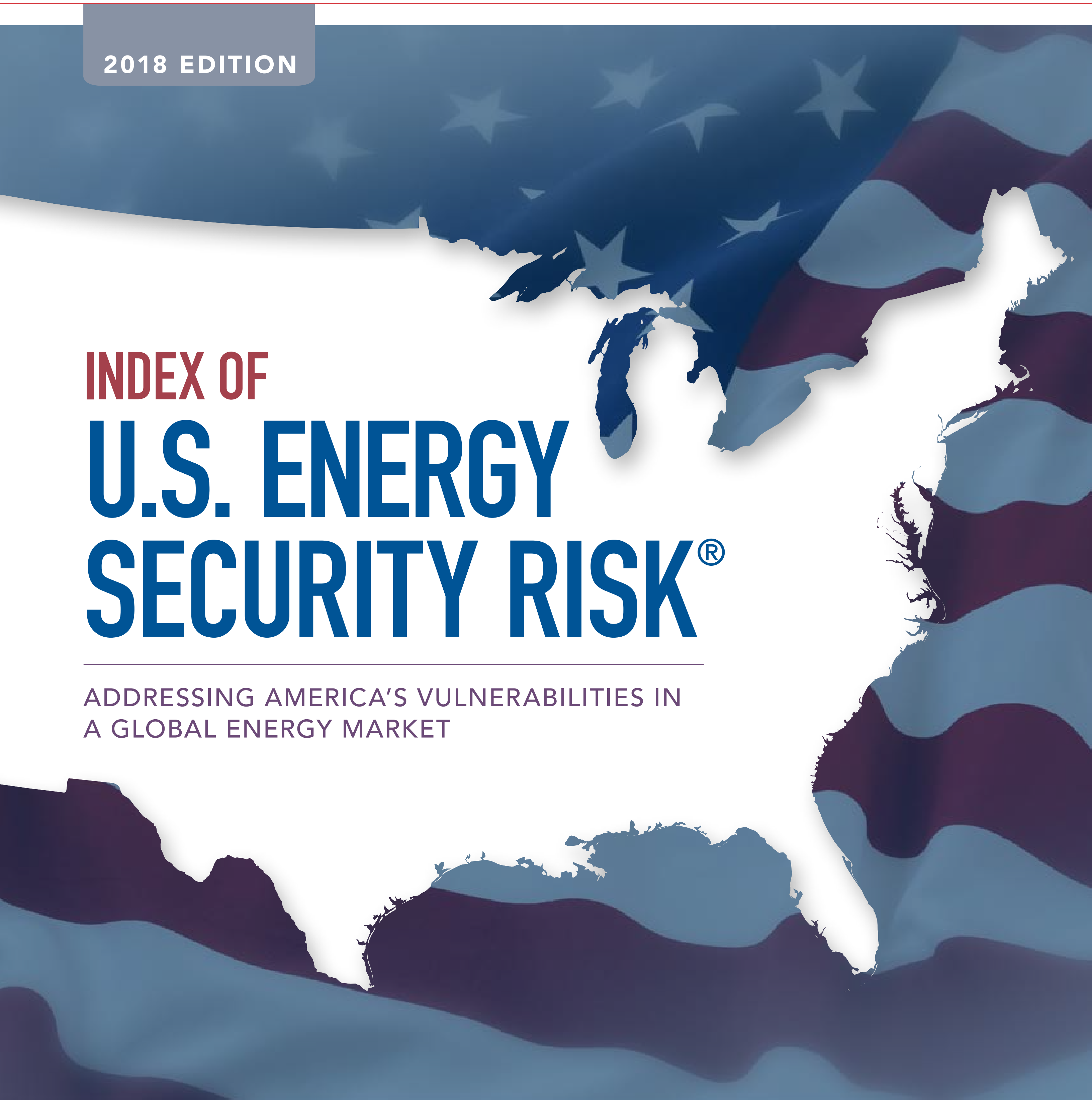

2018 EDITION

INDEX OF U.S. ENERGY SECURITY RISK®

ADDRESSING AMERICA'S VULNERABILITIES IN A GLOBAL ENERGY MARKET

GLOBAL ENERGY INSTITUTE
U.S. CHAMBER OF COMMERCE

2018 EDITION

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Contents

FOREWORD

The Global Energy Institute is pleased to present this 2018 edition of the U.S. Index of Energy Security Risk, our ninth edition. Since the U.S. risk hit it worst level in 2011, there has been lots of good news to report.

Back in 2014, we noted that total energy security risks declined for the second consecutive year following their record high in 2011. Pointing to certain emerging developments, especially in the oil and gas sector, we wondered if these results marked "the beginning of a durable trend of U.S. improved energy security." Four years later, it's clear the answer is a resounding "Yes," almost entirely due to the shale revolution.

It is hard to overestimate how profoundly the application of hydraulic fracturing, horizontal drilling, and advanced seismic imaging has so rapidly improved our energy security by unlocking vast quantities of "unconventional" oil and natural energy—which is getting more conventional by the day.

To put the impact of the shale revolution on U.S. energy security into perspective, consider that it takes a lot to move appreciably, either up (bad) or down (good), an index with 37 metrics over a short period of time. The period between 1970 and 1980 was an economically and geopolitically tumultuous time. We had the Arab Oil Embargo, the Iranian Revolution and hostage crisis, the invasion of Afghanistan by the Soviet Union, two U.S. recessions, and much else. These events of this decade had a large impact on U.S. energy security risk, which jumped up 22 points to a score of 100 in 1980.

In just the six years from 2012 to 2017, however, the U.S. energy security risk score plunged 24 points from its record high to 77.5 almost solely because of the shale revolution. In other words, the magnitude of the shale revolution on U.S. energy security (to the good) has been greater than the combined impact of seismic geopolitical events that shook world energy markets profoundly in the 1970s.

America's newfound status as a global energy superpower has created economic opportunities here at home and stability around the world. There is no compelling reason why this turnaround in America's energy fortunes cannot continue. Indeed, as this edition of the Index shows, the outlook for our future energy security is as bright as it has been since we started measuring it back in 2010. And while we may not be able to predict future geopolitical events with any confidence, we clearly are in a much better position to deal with the inevitable, if unpredictable, crises that will crop up so that they will be less disruptive to our economy and security. However, now is not the time for complacency, as history has shown an unpredictable or hostile policy and investment environment could derail the progress that has been made, increasing future energy security risks and making us more vulnerable in the process

To continue to harness our abundant natural resources and spur innovation, our energy infrastructure must keep pace with the demand placed on it, and that often means building out new infrastructure. The timely permitting of energy infrastructure projects is especially critical. "Keep It In The Ground" activists, however, are battling energy projects across the nation by filing countless lawsuits, organizing protests and even vandalizing private property with the goal of delaying or outright killing projects. While these efforts have been reported on over the years, their aggregate economic impact was never calculated.

GEI released a new analysis, "Infrastructure Lost: Why America Cannot Afford To 'Keep It In the Ground," quantifying the impacts of select delayed and cancelled energy infrastructure projects. The results are eye-opening and show the serious threat the movement has on our energy economy and security.

The 15 projects identified included pipelines, power plants, transmission lines and export facilities as well as the statewide hydraulic fracturing ban in New York (individual project profiles are included within the full report). The analysis indicates that the 'Keep it in the Ground' movement has prevented at least $91.9 billion in domestic economic activity and eliminated nearly 730,000 job opportunities. In addition, federal, state, and local governments have missed out on more than $20 billion in tax revenue.

It need not be this way. The report includes a discussion of reforms to our broken permitting process, which would assist the expansion and modernization of energy infrastructure, including proposals by the Administration and legislation. Today, many environmental reviews take an average of five years. The Empire State building was constructed in less than a year and half. You could build at least three Empire State buildings in the average time it takes to review paperwork today. As a general rule it should not take longer to approve a project than to build it.

Marshalling private sector investment requires confidence that investments will deliver an adequate, risk-adjusted rate of return, and that necessary permits, infrastructure, supply and value chains and human resources would be available in a timely fashion. Projects become seriously delayed or even canceled and their budgets skyrocket due to an uncertain and seemingly endless permitting process. It is long past time to reform and streamline the permitting process in a way that protects the environment and allows for infrastructure investment.

The United States has the world's most plentiful and diverse energy resources. When combined with innovation and an entrepreneurial culture, there is every reason to believe we can usher in a prolonged era of energy security. Instead of erecting barriers to domestic energy development, we should be looking for ways create an environment that welcomes investment, innovation, and job creation and so embrace a more secure energy future.

Given the continued focus on energy security, we hope this latest edition of the Index will provide the public, analysts, and policymakers with useful insights into how our energy security has improved—and why.

Developing and maintaining something as complex as the U.S. Index remains a 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 compiling much of the data used, and Christopher Russell. Special thanks also go to GEI intern Ian DeValliere from The George Washington University for reviewing the data and pulling together and analyzing the impact on energy security of the various Energy Information Administration side case forecast scenarios examined in this report. The entire production team here at the U.S. Chamber of Commerce did their usually fine job designing clean graphics that make sense of complex issues and producing a publication under a tight deadline.

Karen A. Harbert
President and CEO
Global Energy Institute
U.S. Chamber of Commerce

Introduction

The 2018 edition of the Global Energy Institute's (GEI) *Index of U.S. Energy Security Risk* (Index)—the eight in the series—incorporates the most recent historical and forecast data to assess the current and future state of U.S. energy security risk. The Index is made up of 37 different measures of energy security risk in the following nine categories: global fuels; fuel imports; energy expenditures; price and market volatility; energy use intensity; electric power sector; transportation sector; environmental; and basic science and energy research & development.[1] The Index covers the historical period from 1970 to 2017 and a forecast period out to 2040.

GEI'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) 2018.

The Index is designed to convey the notion of risk: a lower Index score indicates a lower risk to energy security and a higher score indicates a higher risk.

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

The average Index score for the 30-year period from 1970 to 1999, a period that includes times with relatively very high (100 in 1980) and very low (75.1 in 1994) scores, is 83.8. When reviewing this year's results, the 1980 baseline score and the 30-year averages, along with the historical high and low scores also provided, can be used as reference points against which to consider current and future risk scores. Unless noted otherwise, all dollar figures are in real 2017 dollars and "historic" or "record" high or low risk scores refer to scores since 1970, the beginning year of the GEI Index database.

This report 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. GEI also publishes an *International Index of Energy Security Risk* that puts the risks to the U.S. in an international context and provides comparisons with 24 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 GEI'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

- **Energy security risks fell for the sixth year in a row in 2017:** After achieving a record high risk score in 2011, the total U.S. energy security risk score fell for the sixth consecutive year in 2017—the longest streak of annual declines in the Index database—dropping to 77.5, its lowest level since 1995.

- **Total risk score has plunged 24 points since the 2011 record-high score:** In the six years since the U.S. risk score peaked in 2011, it has tumbled 24.1 points, a rapid rate of decline that is unprecedented. By comparison, it took twice as many years—from 1980 to 1992—for the risk score to fall 25 points to the historic low of 75.1. Barring unforeseen events, even further declines are anticipated.

- **Natural gas import risk fall to "0":** Natural gas imports risks fell to zero on the back of surging domestic production that in 2017 made the United States a net exporter of natural gas for the first time since 1957.

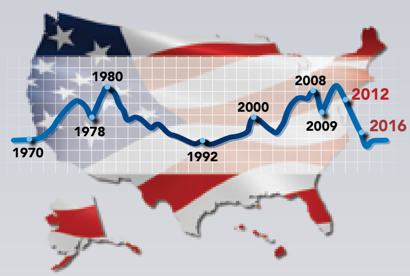
- **U.S. energy security risk score for 2018 is expected to achieve a record low:** The outlook suggests that the United States will have a record low risk score (between 74 and 75 points) in 2018 as the impact of the large crude oil price spike in 2015 dissipates, price volatility returns to a low level, and current trends in domestic energy production and energy efficiency proceed as expected.

- **Risks expected to stay very low out to 2040:** Based on EIA's *AEO2018*, we expect an average U.S. risk score of 74.4 from 2018 to 2040, ranging from 75.4 to 74 (which would be a new record low). There is nothing comparable to such prolonged period of risk scores below 80 points in the Index database going back to 1970. As we know from history, however, unexpected events are almost certain to occur that will impact future risk scores.

- **The forecast suggests three additional metric risks scores are expected fall to "0":** In addition to the metric for natural gas import risk, which reached a score of zero in 2017, the risk scores for three other import-related metric s also should reach zero sometime before 2030: petroleum import risk (in 2018); oil and natural gas import expenditures (in 2025); and oil and natural gas import expenditures per GDP (in 2025).

Total energy security risk in 2017 fell for the sixth year in a row, dropping 0.3 points from 2016 to

77.5



Of the 37 Index metrics,

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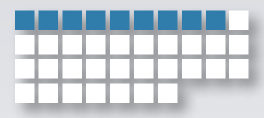

showed an increase in risk of 1% or more,

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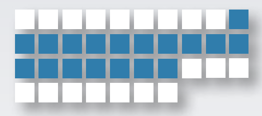
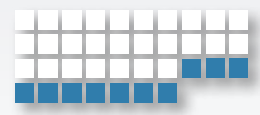


showed a decrease in risk of 1% or more, and

10



showed essentially no change in risk in 2017.

■ Figure 1

U.S. Energy Security Risk Index, 1970-2040

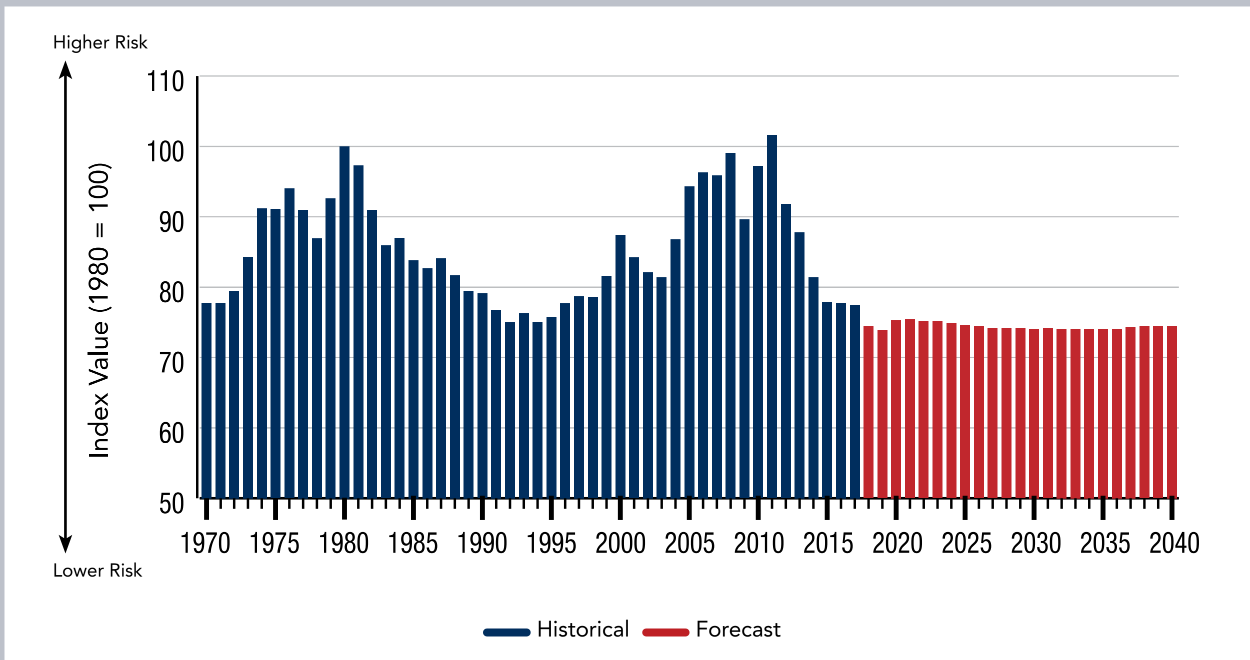


Table 1. U.S. Energy Security Risks from 1970 to 2017: Highest, Lowest and 30-Year (1970-1999) Average Index Scores

Indexes of U.S. Energy Security Risk	2017 Score	1980 Baseline Score	Highest Risk		Lowest Risk		30-Year Average (1970-1999)
			Year	Index Score	Year	Index Score	
Total Index	77.5	100	2011	101.6	1992	75.0	83.8
Sub-Indexes:							
Geopolitical	76.1	100	2011	101.4	1970	71.6	82.6
Economic	68.5	100	2011	102.0	1998	61.1	73.2
Reliability	90.3	100	2011	115.3	1994	76.0	85.9
Environmental	80.1	100	1973	110.7	2017	80.1	99.4

Overview

Total energy security risk in 2017 fell for the sixth year running, dropping 0.3 points from 2016 score to 77.5. Although this represents a modest annual change of 0.4% from the previous year, it is part of a longer trend of lower total risk scores now stretching into its sixth year, the longest period of decline in the record. Over this six-year period, the total energy security risk score has plunged 24.1 points (Figure 1). The direct and indirect impacts of the revolution in unconventional oil and natural gas production are largely responsible for this remarkable and unprecedented run of ever lower risks scores. Improvements in energy efficiency and environmental metrics also contributed.

More than twice the number of metrics show risk score declines of at least 1% compared to increases of 1%. Nineteen metrics showed a risk scores at least 1% lower, nine showed scores of at least 1% higher, and ten showed essentially no change (less than ±1%). Most of the 19 metrics showing improvement were in the Fuel Import, Price & Market Volatility, Energy Use Intensity, and Environmental metric categories. The most significant metrics showing higher risk were in the Energy Expenditure metric grouping.

Although decreasing risks were seen across a bit more than half of the 37 energy security measures, most of the total decrease in risk in 2017 can be attributed to changes in imports risks (Table 2).

The security of natural gas imports metric dropped almost 32 points to "0" in 2017, a change of -100%. This is the first of the 37 risk metrics to achieve a zero score.[3] (In calculating some metrics, such as those for measuring imports, it is possible to arrive at a "negative" risk score. For purposes of the Index, negative results are assigned a risk score of zero.) The score for the security of U.S. oil imports also showed a significant decline of nearly 13 points, a 23% improvement from 2016. The only metric with a risk score of at least 10% higher than in the previous year is the price of crude oil. The risk score for this metric rose 22%, reflecting an average rise in price of $9.70 per barrel (to $54 per barrel) in 2017.

The U.S. became a net exporter of natural gas in 2017, reducing the import risk for this fuel to zero. Since 2005, natural gas production in the United States has increased every year except 2016. (This was a year during which oil prices were unusually low because of an attempt by Saudi Arabia to increase market share by revving up crude oil output and sending prices lower. Low crude oil prices affect not only crude oil production, but natural gas production from oil wells.) Output has increased 49% over the 12 years from 2005 to 2017, a rate of increase of 3.4% per year. In 2017, natural gas production rose nearly 0.2 trillion cubic feet (tcf) to 26.9 tcf. Well more than half of all natural gas production is from shale formations in Arkansas, Colorado, Louisiana, Pennsylvania, and Texas.

Table 2. Movers and Shakers: Energy Security Metric Scores Changing at Least ±10% in 2017

Declining Risk		Rising Risk	
Metric	% Change	Metric	% Change
Security of U.S. Natural Gas Imports	-100%	Crude Oil Prices	22%
Security of U.S. Petroleum Imports	-23%		

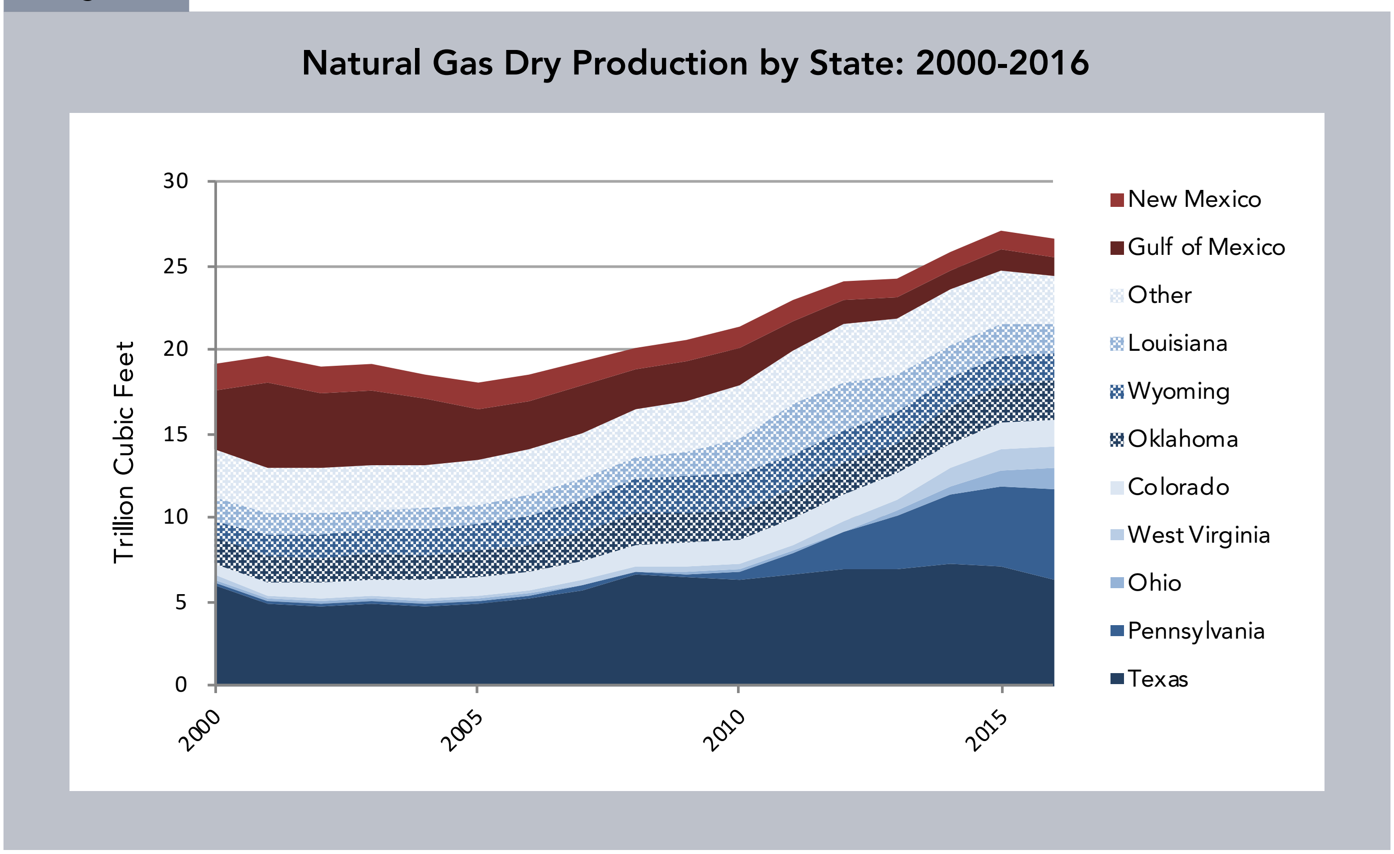
[3] It is certain, however, that scores of zero would be assigned to U.S. import metrics from well before 1970, the year our database begins.

What tipped the United States from a net importer to a net exporter in 2017 was less the small increase in production and more the large increase in gross exports, which went from 2.3 tcf in 2016 to 3.2 tcf in 2017, an increase of 0.9 tcf. While increased pipeline shipments contributed about 0.3 tcf of this increase (especially exports to Mexico from the Permian basin in Texas), shipment of liquefied natural gas (LNG) from the two terminals operating in 2017 contributed 0.5 tcf. Four more LNG terminals are expected to come on line by the end of next year raising the number to six. The International Energy Agency reports that within five to seven years the United States could overtake Qatar and Australia to become the world's largest exporter of LNG.

Once a small contributor to total U.S. natural gas production, the tri-state Pennsylvania, Ohio, and West Virginia area produces more natural gas than Texas, a completely unexpected turn of events a decade ago. These four states now produce well more than half of all the natural gas produced in the United States. Figure 2 shows that total amount of natural gas produced by the top nine states and the Gulf of Mexico Federal Offshore. (The remaining states have been lumped together and shown as "Other" for completeness, but this catch-all category is not considered in the following discussion of rankings.) The blue shaded areas show regions that have increased production since 2000, the red shaded areas regions that have decreased production. As the chart shows, Texas is the perennial top producer. Pennsylvania, ranked ninth out of these ten areas in 2000, increased its production from less than 0.2 tcf to more than 5 tcf to take over second place. Ohio increased its rank from 10th to seventh over the same period. Production from the Gulf of Mexico slipped from 3.6 tcf to a bit more than 1 tcf, moving from second place to 10th.

Domestic crude oil output rose a healthy 5.9%, or 520,000 barrels per day (bbl/d), to nearly 9.4 million bbl/d in 2017, lowering oil import risks by 23%. About 87% of the 600,000 bbl/d loss in production in 2016 was made up for in 2017, an extraordinary comeback in such a short amount of time. Crude oil output has increased in eight of the last nine years. The volume produced in 2017 was exceeded only four times in U.S. history, and

Figure 2

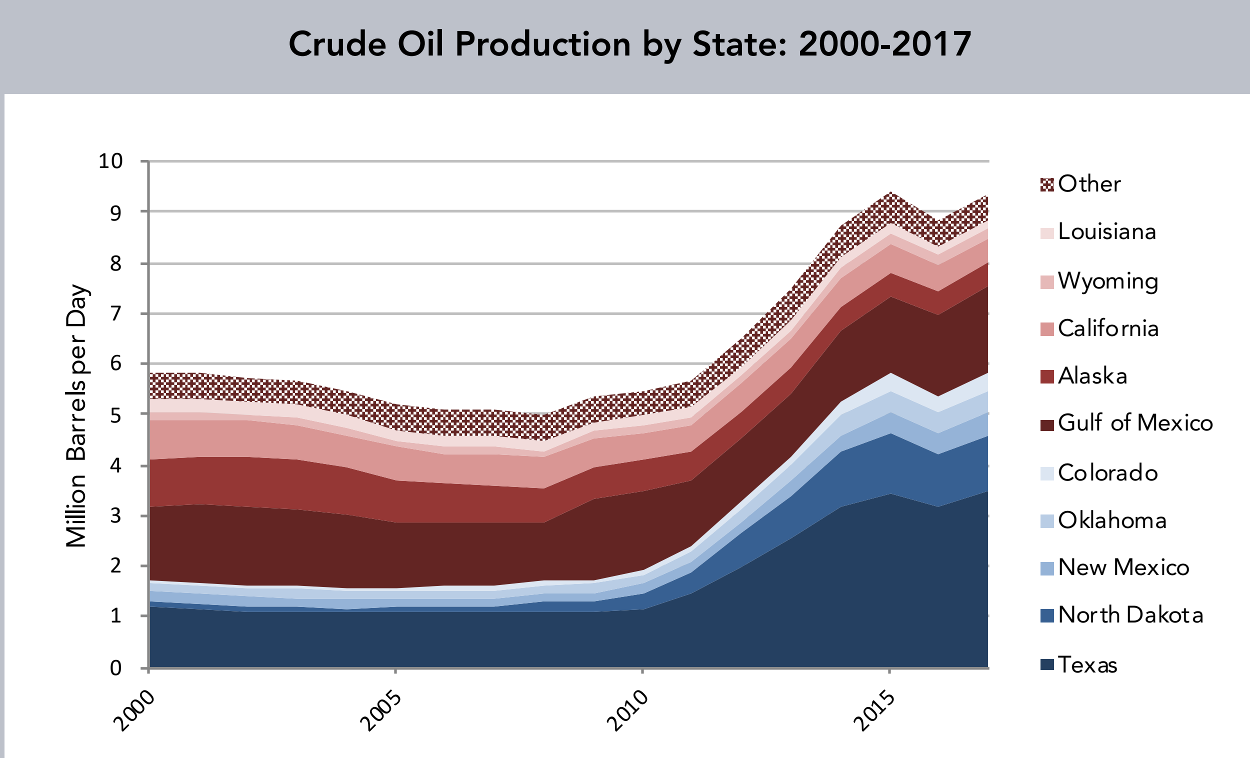


forecasts suggest even larger volumes in the future. Texas had by far the largest volumetric increase of any state in 2017 (306,000 bbl/d) followed by the Gulf of Mexico (80,000 bbl/d), New Mexico (70,000 bbl/d), North Dakota (42,000 bbl/d), Colorado (40,000 bbl/d), Oklahoma (30,000 bbl/d), and Utah (11,000 bbl/d). A portion of these gains were offset by lower output in California (-31,000 bbl/d) and Louisiana (-12,000 bbl/d). Even greater production levels are being forecast, which bodes well for future risks.

Since 2000, the sources of U.S. crude oil supplies have shifted substantially, with some formerly low-producing states emerging as major contributors to total U.S. output. Figure 3 shows total amount of crude oil produced by the top nine states and the Gulf of Mexico Federal Offshore. (Again, the remaining states have been lumped together and shown as "Other" for completeness, but this catch-all category is not considered in the following discussion of rankings.) The blue shaded areas show regions that have increased production since 2000, the red shaded areas regions that have decreased production. Texas has been either the first or second (after the Gulf of Mexico) largest producing area for many years, and solely first since 2011. It is now far and away the largest, producing twice as much as the Gulf. North Dakota, which in 2000 was the ninth largest producing state, was the third largest in 2017. Colorado and New Mexico also have climbed the rankings (to eighth and sixth, respectively), while Alaska, California, and Louisiana have seen their production, and their rankings, drop (to fourth, fifth, and 10th, respectively). The states that have experienced greatest output have benefited economically from increased production activity and the investment that goes along with it.

Crude oil prices rose 22% in 2017, from $44.43 to $54.13 per barrel. The firming of crude oil prices and greater production efficiency helped to stimulate increased production of crude oil and natural gas. Output of both fuels fell in 2016 after the world price of crude oil tumbled from more than $100 per barrel in 2015 to less than $50 in 2016. A modest global increase in

Figure 3



crude oil production of 0.4% in 2017 was well below global growth, putting upward pressure on prices. Large (greater than 100,000 bbl/d) production declines in Saudi Arabia, Venezuela, Mexico, Kuwait, China, and Angola were offset by large production rises in the United States, Libya, Iran, Canada, and Kazakhstan. Greater volatility could be in store in future years, with further declines in Venezuela and possibly a sanction-related reversal of production in Iran. The presidential change in Mexico also could lead to less foreign investment in that country's hydrocarbon sector and a continued decline in output.

Price volatility, both upward and downward, can play havoc with oil output and economies. The relatively high risk score for crude oil price volatility in 2017 reflects the swift drop in prices during 2015, when the price for a barrel of oil went from more than $100 to nearly $50. The Index's oil price volatility metric measures for each specific year the absolute average change in price for that year and the previous two years. Thus the plunge in price in 2015 will no longer impact the volatility index score in 2018. Crude oil prices are expected to rise in late 2018 to $90 or even more as less Iranian and Libyan oil is expected to come onto the market and OPEC and Russia may not increase output to compensate. Nevertheless, the crude oil volatility risk score in 2018 should be considerably less (about half) than the 2017 level. Such a drop in the risk score for this metric would be enough to propel the total U.S. risk score to its lowest level in our record.

Despite a 22% increase in the price of crude oil, the risk metrics measuring oil and gas import expenditures and oil and gas import expenditures as a share of GDP declined a healthy 7.8% and 9.8%, respectively. The rising price of crude oil was more than offset by increased exports for both oil and gas. Total import expenditures dipped $2.8 billion dollars in 2017, the sixth consecutive year of declining imports costs. Since 2011, import expenditures have declined from a record high of $175 billion to $33 billion, a drop of $142 billion (or 81%). The greater volumes of exports combined with greater energy efficiency means that the amount spent on imports as a share of GDP has decreased from 2.3% of GDP in 2011 to 0.4% in 2017, a drop of 83%.

All metrics measuring energy use efficiency or intensity risks showed improvement in 2017 ranging from 0.6% (energy use per capita) to 4.3% (motor vehicle average miles per gallon). These include the six metrics in the Energy Use Intensity category and the average MPG for the light vehicle fleet, and improvements in all of these metrics have been steady over the decades since 1970. Of the seven metrics in this group, six have the lowest risks score in the record in 2017 while industrial efficiency had its third lowest in 2017 (the best score for this metric was in 2015).

Risks related to all metrics in the Environmental group declined in 2017, and three of the four achieved record low scores. Total carbon dioxide emissions is the only one of the four Environmental metrics to have a lower score in an earlier year (1970). Total emissions, however, have fallen 865 million metric tons, or 14%, from its 2007 apex. Reductions in power sector emissions have been the main, but by no means only, driver of lower emissions in recent years. Reductions in this sector have been led by decarbonization and greater efficiency of electricity use. Decarbonization of the power supply accompanied the build-out of nuclear facilities in the 1980s and since around 2007 has been the result of coal plant closures dues to a combination of regulation, competition from inexpensive shale gas, and greater generation from renewables. These trends are shown in Figure 4, which charts the cumulative impact of annul changes in power sector emissions broken down into their Kaya Identity[4] elements.

Electric Power Sector metric scores generally declined in 2017 and are below their historical averages. After falling for many years, the share of total net generation from coal-fired power plants appears to have stabilized somewhat at about 31%, about the same share as

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4 The Kaya Identity is a calculation whereby total emissions of energy-related carbon dioxide emissions can be expressed as the product of four factors: population, GDP per capita, the energy intensity of the economy, and the carbon intensity of the energy supply (emissions per unit of energy consumed). For this analysis, electricity intensity and the carbon intensity of electricity generation are used instead of overall energy intensity and carbon intensity of the energy supply. An analysis such as this that uses cumulative changes is sensitive to the starting point. Because the Index begins in 1970, that was the year selected as the starting point to calculate cumulative emissions changes.

natural gas. Nuclear continues to supply about one-fifth of the U.S. electricity supply. Both wind and solar generation have grown rapidly, with wind reaching about 6.6% and solar 1.4% of total generation. The Production Tax Credit for wind is scheduled to phase out at the end of 2019 and the Investment Tax Credit for solar at the end of 2021. As a result, after 2022 EIA forecasts very little growth in wind power, and while solar power capacity additions shrink, by 2030 they recover and grow rapidly as solar PV costs continue to decrease. With the Clean Power Plan being replaced by the Environmental Protection Agency, coal-fired plants are expected to maintain a higher share of generation (from 20% to 30%) than they would have otherwise for the foreseeable future.

Looking at the scores for individual metrics, 12 of the 37 had their lowest risk score in 2017 (Table 3). These twelve metrics are clustered in four metric categories: Energy Use, Transportation, Environmental, and Fuel Imports. The low scores for metrics in the Energy Use Intensity and Transportation groups track long-term and consistent trends of improving energy efficiency in industry, commercial buildings, residences, and transportation. The trends towards lower risks in the metrics found in the Environmental group are more recent (since around 2005) and reflect the confluence of many factors, but better efficiency, fuel switching, regulations, and subsidies have all played a role. The metrics measuring risks associated with natural gas and petroleum imports also reached their lowest level in 2017, an achievement wholly related to the rapid and steep rise in domestic output for these two fuels. The lowest score for six other metrics occurs at the other end on our database in 1970. Four of these are related to energy prices or expenditures, as energy prices in were 1970 historically quite low. Total U.S. greenhouse gas emissions on 1970 also were at the lowest point in the database, a time when the economy was about three-and-a-half times smaller than it is today. The highest individual risk scores tend to occur in two periods: (1) the mid to late 1970s, a period of tumult in world energy markets caused by the Arab Oil Embargo and the Iran revolution and hostage situation; and (2) 2010-2011, a period of spiking crude oil prices creating tremendous volatility in oil markets.

Figure 4

Cumulative Kaya Identity Components of Power Sector CO_2 Emissions: 1970-2017

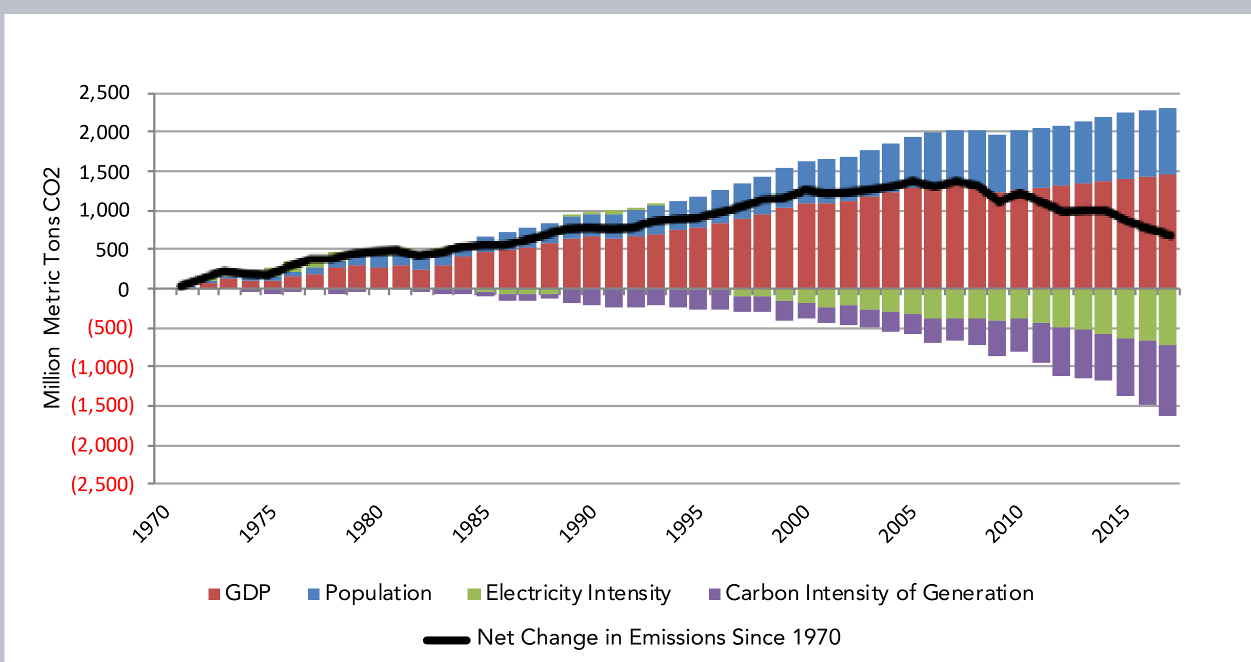


Table 3. Highest and Lowest Energy Security Risks by Metric: 1970-2017				
Metric	**Highest Risk**		**Lowest Risk**	
	Year	**Index Score**	**Year**	**Index Score**
Global Fuels Metrics				
Security of World Oil Reserves	1993	133.6	2007	86.3
Security of World Oil Production	1976	111.1	2002	67.1
Security of World Natural Gas Reserves	1984	141.6	1970	57.4
Security of World Natural Gas Production	1986	155.8	1997	61.1
Security of World Coal Reserves	1976	108.6	1998	49.8
Security of World Coal Production	2016	201.8	1998	74.3
Fuel Import Metrics				
Security of U.S. Petroleum Imports	1977	130.3	2017	41.5
Security of U.S. Natural Gas Imports	2007	181.9	2017	0.0
Oil & Natural Gas Import Expenditures	2008	218.4	1970	7.4
Oil & Natural Gas Import Expenditures per GDP	1980	100.0	1970	10.1
Energy Expenditure Metrics				
Energy Expenditures per GDP	1981	101.9	2016	42.6
Energy Expenditures per Household	2008	120.3	1970	54.0
Retail Electricity Prices	1982	111.8	1970	70.4
Crude Oil Price	2011	131.4	1972	14.4
Price & Market Volatility Metrics				
Crude Oil Price Volatility	2011	182.5	1972	1.3
Energy Expenditure Volatility per GDP	2010	128.8	1995	2.8
World Oil Refinery Utilization	1970	159.3	1982	89.8
Petroleum Stock Levels	1973	140.1	2016	79.4
Energy Use Intensity Metrics				
Energy Consumption per Capita	1979	104.6	2017	87.3
Energy Intensity	1970	118.7	2017	47.2
Petroleum Intensity	1973	121.1	2017	40.0
Household Energy Efficiency	1972	112.2	2017	84.6
Commercial Energy Efficiency	1972	113.1	2017	66.8
Industrial Energy Efficiency	1970	124.2	2015	48.9
Electric Power Sector Metrics				
Electricity Capacity Diversity	1971	110.2	2000	77.0
Electricity Capacity Margins	1999	266.4	1982	81.1
Electricity Transmission Line Mileage	2006	134.3	1982	90.8
Transportation Sector Metrics				
Motor Vehicle Average MPG	1973	111.8	2017	71.1
Transportation VMT per $ GDP	1977	104.4	2017	78.6
Transportation Non-Petroleum Fuels	1978	101.4	2013	90.5
Environmental Metrics				
Energy-Related CO_2 Emissions	2007	267.4	1970	34.8
Energy-Related CO_2 Emissions per Capita	1973	113.3	2017	57.0
Energy-Related CO_2 Emissions Intensity	1970	122.5	2017	40.8
Electricity Non-CO_2 Generation Share	1970	131.3	2017	62.1
Research and Development Metrics				
Industrial Energy R&D Expenditures	1999	323.3	1980	100.0
Federal Energy & Science R&D Expenditures	2000	290.9	1978	95.2
Science & Engineering Degrees	2000	144.0	1971	79.0

Shifts in Sources of Energy Security Risk Over Time

A new feature of the 2018 edition of the Index shows how much the nine metric groups contribute to the total energy security risk score over time.

The input weighting for each metric group does not change from year to year. The "output weight" of each group—how much of the total risk score accounts for—can change greatly over time.

Table 4 provides a list of the nine metric categories and the total input weighting of the metrics that make up that group. It also shows the output for 2017 for each group, that is, the share of the total energy security risk score of each group.

In years where the output score for a particular metric group is higher than the input score, it means that metric group is a relatively more significant contributor to the total energy security score. That does not mean necessarily that the score for this metric group is getting worse. It could also mean that its score is improving more slowly than the scores for the other metric groups. The same dynamic in reverse applies to a metric group score below its corresponding input value.

The data in Table 4 show that in 2017, the Fuel imports, Energy Expenditures, and Energy Use Intensity group scores were all below the assigned input weighting for that group, indicating that these groups have over time become smaller contributors to the total Index score for the United States.

Figure 5 shows the contribution of each metric group by nominal group score and Figure 6 the relative contribution of each metric group from 1970 to 2017.

- **Fuel Imports:** Both charts clearly show how Fuel Imports risks have fluctuated over the years. As recently as 2007, combined Fuel Imports risks accounted for 16.0% of the total U.S. risk score. In 2017 it was just 4.3%.

- **Global Fuels:** Risk scores for the Global Fuels group have been inching up since around 2005, one result of which is that its share of total risk is 20.4% compared to an input weighting of 15.1%. So while risks have been increasing globally, the recent increase in domestic production of oil and natural gas combined with the already high domestic production of coal suggests the United States is insulating itself from these Global Fuel risks. Because the price of crude oil and increasingly coal and natural gas are set in world markets, the United States is still susceptible to the economic impacts of supply disruptions overseas.

- **Price and Volatility:** The contribution of the Price and Volatility metric group has jumped around over the years. This reflects the wild swings in the price of crude oil and natural gas, many of which had their origins in geopolitical crises or attempted, and sometimes successful, market manipulation by OPEC (e.g., to garner greater global market share).

- **Energy Expenditures**: The contribution of the Energy Expenditures group has moved up and down since 1970. In 1970, this group contributed 9% to the total U.S. Index score. In 2017, it was just about 15%. Energy costs in the early 1970s were very low. The Energy Expenditure group score in 2017 was not quite as low as it was in 1970, but its share of the total U.S. score was still considerably

Table 4. Input and Output by Metric Group

Metric Category	Input Weighting	2017 Output
Global Fuels	15.1	20.4
Fuel Import	11.8	4.2
Energy Expenditure	18.3	14.9
Price & Volatility	12.6	16.4
Energy Use Intensity	15.3	11.5
Power Sector	6.2	7.8
Transportation Sector	9.8	9.9
Environmental	7.6	7.9
R&D	3.3	6.9

Figure 5

Risk Scores by Metric Group

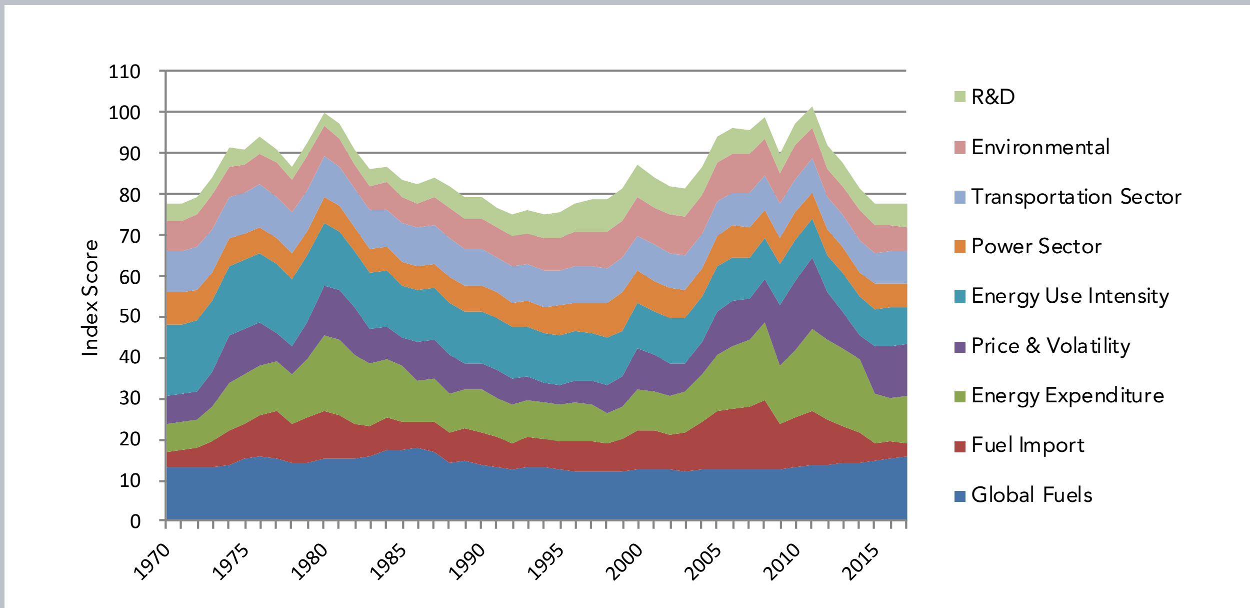
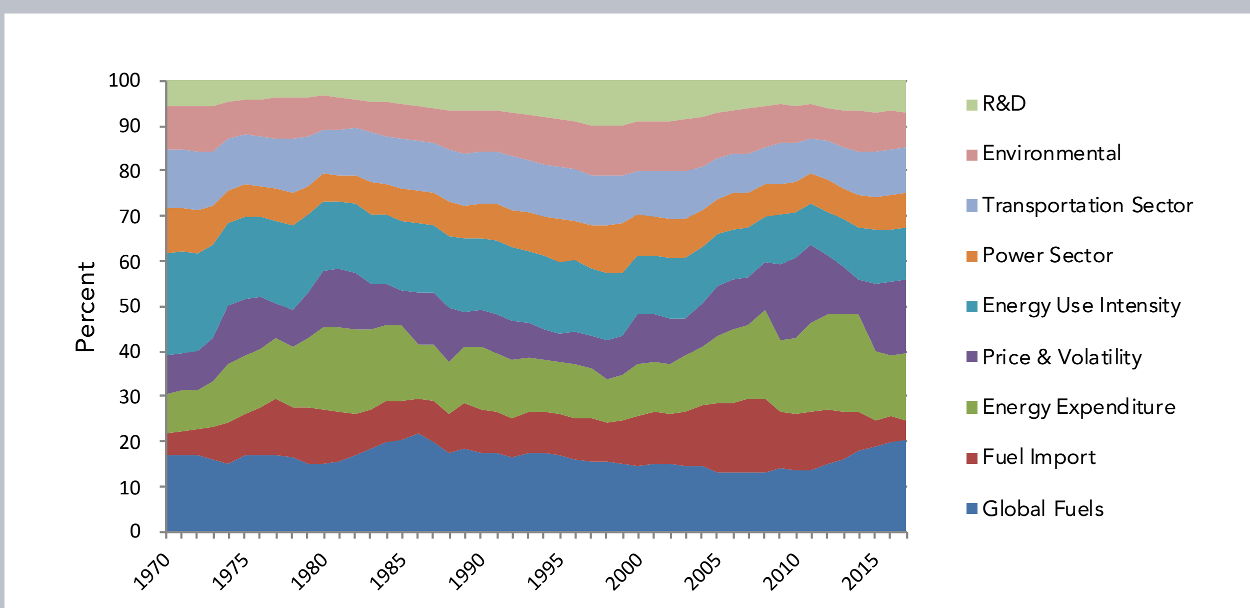


Figure 6

Share of Total Risk by Metric Group



lower than the 18.3% input weighting for two reasons: greater supply leading to declining prices (especially for crude oil and natural gas) and greater energy efficiency leading to lower consumption.

- **Energy Use:** The scores for the Energy Use group since 1970 have declined at a rate of about 0.6% per year, about the same rate as the decline in its share of the total U.S. score over the same period. The contribution of this group is now below the input weighting, meaning that, among other things, the United States has made quite a bit of progress in making its economy less energy intensive and more efficient.

- **Transport and Environmental:** The input and output weighting for the Environmental and Transportation metric groups are about the same. The absolute contribution of both, however, has generally been trending down, if at a slower rate than for other metric groups (e.g., imports).

- **R&D:** Energy R&D metric group was at its lowest point shortly after the energy crises of 1973 and 1979/80. Since around 2010, risk scores for this group have increased both nominally and as a share of total risk.

Outlook to 2040

Based on EIA's latest *AEO2018*, the U.S. Index is projected to average 74.4 points from 2018 to 2040, ranging between 73.9 and 75.4. All but four years in this 23-year period have total risks below the current record low score, 75.0, set back in 1992, and after 2024 all of the scores are below the 1992 record low (Figure 1). The major drivers of lower risks scores are by now familiar: comparatively lower import and price risks because of high domestic crude oil and natural gas output; a much more gradual increase in the future price of crude oil; improvements in energy efficiency across the entire economy, including in transportation; and lower environmental risks related to greater efficiency and the growth of natural gas and renewables.

This would greatly exceed the most extended period of very low Index scores in the record. From 1970 to 2017, the longest stretch of scores below 80 points was 10 years, from 1989 to 1998. Scores based on the *AEO2018* forecast suggest a period of 26 years (from 2015 to 2040) with scores below 80 (indeed, below 76). It is important to recognize that these figures are based on EIA forecasts, which, as all forecasts do, have a high degree of uncertainty. Moreover, forecast data are not available for some of the metrics used in the Index. In these situations, we are forced to make assumptions about future risk scores (usually by taking the score for the most recent years and projecting it into the future). Despite the shortcomings inherent in forecasts, and accepting that world events could at any time intervene to increase risks sharply, this would represent a remarkable period of U.S. energy security.

The forecast of future U.S. energy is brighter than ever before. Figure 7 shows how forecasts of U.S. energy security risk have changed for the better over time. The 2013 edition of the Index was the first with forecast data going out to 2040. It indicates a score just shy of 100 for that year. As it became ever more obvious over the years that the shale revolution was here to stay and that domestic energy production was set to achieve record highs, forecast risk scores have steadily declined, with 2040 scores dropping from 99.9 in the 2013 edition to 74.5 in this edition.

EIA expects crude oil output will be sustained at a rate 2 million barrels per day higher than the previous U.S. record of 9.6 million barrels per day set in 1970. EIA is forecasting that crude oil production will rise steadily to between 11 MMbbl/d and 12 MMbbl/d by the early 2020s and maintain that level out to 2040 and beyond. The United States already is a net exporter of refined petroleum products, and this anticipated increase in crude oil production coupled with anticipated flat demand for oil means that by 2030 the country could be a net exporter of oil (crude + refined products) as well as natural gas and coal, which would reduce risks for this import metric to zero.

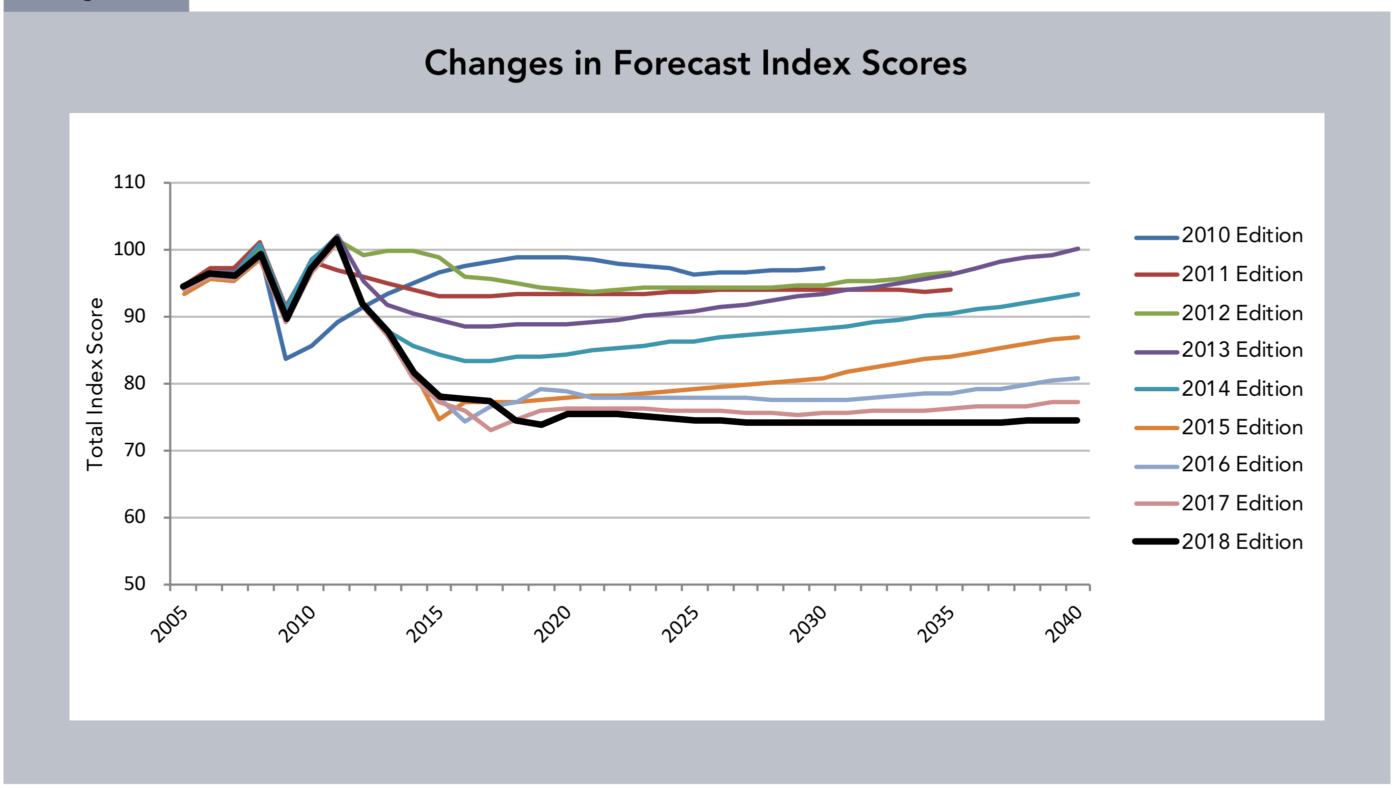
EIA expects production of natural gas to jump an astonishing 50% from 2017 to 2040, from 27 to almost 41 trillion cubic feet, which should keep the U.S. as the world's largest producer. The pull from greater demand for gas in the power and industrial sectors drive the vast majority of the increase in production. Importantly, increased demand is not expected to materially impact prices. In fact, over the next decade, EIA projects natural gas prices will go no higher than $4.20 per million Btu—significantly below a corresponding projection of $4.75 in last year's forecast. EIA also forecasts that U.S. natural gas net exports will range between 7 tcf and 8 tcf, with shipment volumes from LNG terminals exceeding shipments by pipeline by roughly two to one.

With the United States becoming both a net oil and natural gas exporter by 2030, and thus register risks scores of zero for these metrics, the risk scores for the metrics measuring oil and gas import expenditures and oil and gas import expenditures as a share of GDP also will go to zero. The U.S. already is a net natural gas exporter and is expected to become a net oil (crude oil plus refined products) exporter in 2029. At that time, the balance of trade in oil and gas will favor the United States. The U.S. also is expected to become and even larger exporter of coal, which will contribute to a positive balance of trade in energy as well.

The world price of crude oil is forecast to rise 96% by 2040, a bit lower than EIA was forecasting last year. From about $54 per barrel in 2017, the price is anticipated to rise to $106 in 2040, a rate of increase of about 3% a year. Normally, an increase in price like this would lead to increasing risks. But with oil and natural gas import expenditure risks falling to zero by 2030 and oil demand flattening, especially in the transportation sector (see below), the increase in crude prices should not be as consequential as it once was.

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 out to 2040 has not changed appreciably from those reported in earlier editions of the U.S. Index. Both the economy-wide energy intensity and petroleum intensity—intensity being a measure of consumption per dollar of GDP produced—are expected to improve by more than 34% and 38%, respectively, from 2017 to 2040. Over the same period energy efficiency is expected to improve 16% in the residential sector, 17% in the commercial sector, and 15% in the industrial sector.

Figure 7



Average fuel economy for the U.S. automobile fleet is expected to increase almost 10 miles per gallon, from 18.7 miles per gallon (mpg) in 2017 to 28.0 mpg in 2040, a 50% increase in efficiency. Over the same period, the number of vehicle miles being traveled as a share of GDP is anticipated to improve 30%. 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. Non-petroleum also penetrate the transportation sector to a greater extent, and by 2040, 11% of energy use in this sector will come from non-petroleum fuels compared to not quite 8% in 2017. As a result of all of these trends, motor gasoline demand is expected to be almost 30% lower in 2040 than in 2017.

All environmental-related metrics show considerable improvement by 2040. Carbon dioxide emissions per capita and emissions intensity show the largest relative improvement, with risks declining 28% and 32%, respectively, from 2017 to 2040. Most of the emissions decrease comes about because of decarbonization in the power sector, as natural gas replaces coal, and increasing renewables, especially solar, generation.

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 fractionally (0.4%) in 2017 to 76.1 points. This is the sixth consecutive year of lower risk since the record high score of 101.4 points was recorded for this sub-index in 2011 (Figure 8). Growing unconventional domestic oil and natural gas production—which led to import risks and import expenditure risks–and less volatility in the price of crude oil were the main factors contributing to lower geopolitical risks in 2017. While trends in the risk score for these factors have improved, however, all of the metrics in the Global Fuels metric group—which measures the diversity and reliability of global crude oil, natural gas, and coal reserves and production—have shown increased risk since 2011. The recent rapid rise in domestic oil and gas output and the resulting plunge in imports have limited U.S. exposure to rising global supply risks.

EIA's 2018 forecast suggests that geopolitical risks in the next couple of years will approach the historic low score for this Sub-Index set in 1970. The Geopolitical Sub-Index has the most number of metrics with no forecast component. The metrics that make up the Global Fuels group, for example, incorporate Freedom House scores for civil and political liberties that are not forecast. If the risk trends in Global Fuels do not change, then it is expected that the Geopolitical Sub-Index risk score will average about 73.4, ranging from 71.9 to 74.4. These scores are well below the 30-year average of 82.6 points. There are many market and non-market (e.g., political) factors that could lower or increase Global Fuel risks in this Sub-Index going forward. While these are difficult to predict, there is every expectation that unconventional crude oil and natural gas production in North America will continue to rise and lessen the influence of the Middle East and Russia in global markets. Nevertheless, increasing demand in the large emerging economies like China, India, Brazil, South Africa, Indonesia, and others will keep upward pressure on global fuel prices, but not nearly to the extent expected in forecasts from a few years ago.

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

Energy costs are a significant portion of our overall economy. In 2017, roughly $1.1 trillion were spent for end-use energy in the residential, commercial, industrial, and transportation sectors, amounting to roughly 5.8% of GDP, the second lowest level since 1970. 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 climbed for the second year running, rising 1.4 points (2.4%) in 2017 to 68.5 (Figure 9). This is, however, a very low score by historical standards, much lower than the 30-year average of 73.2.

Figure 8

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

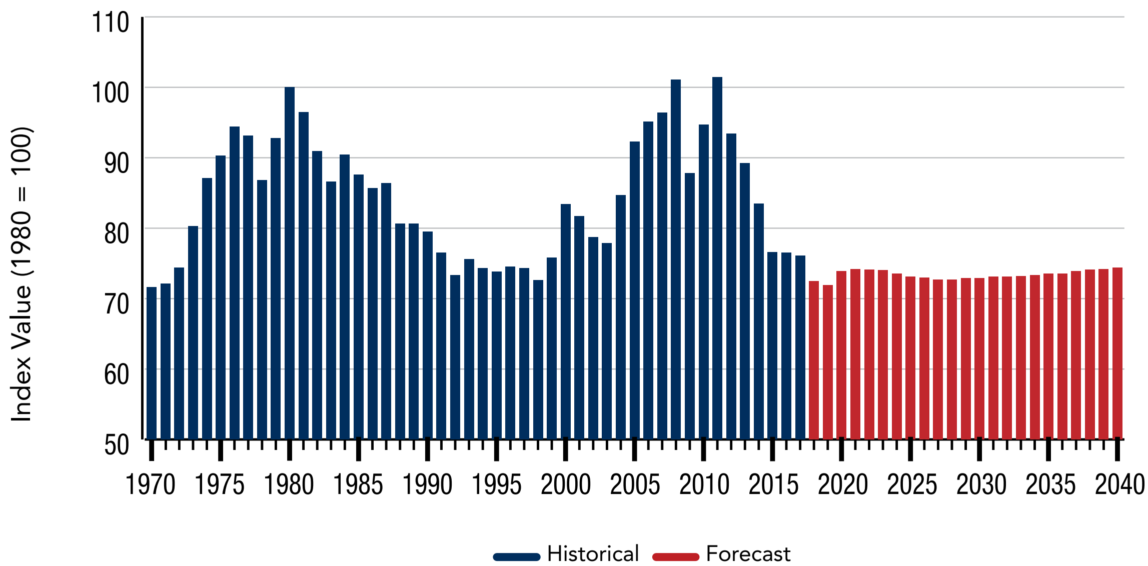
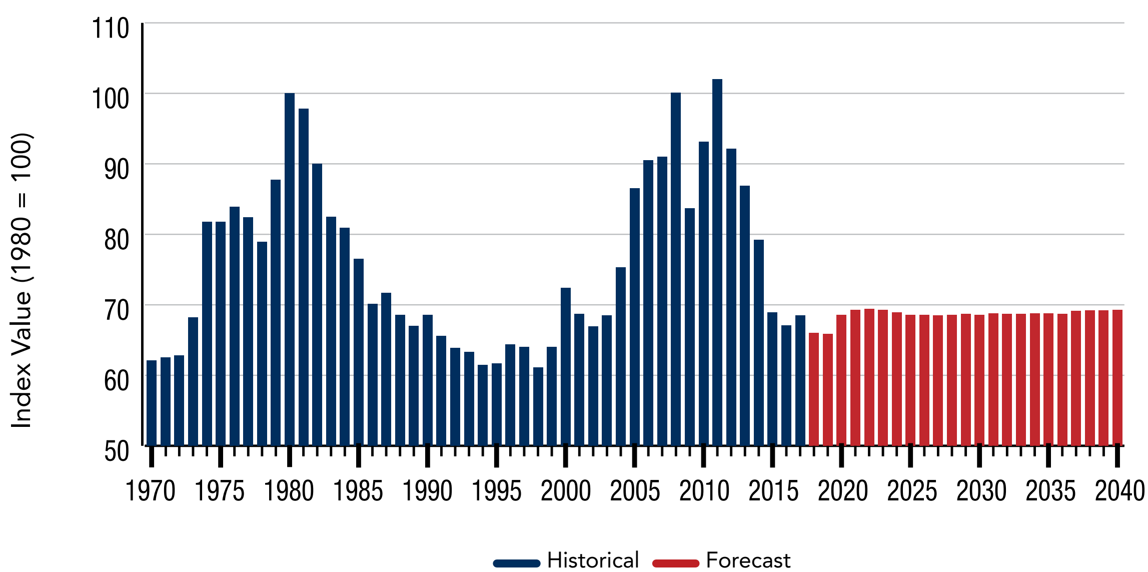


Figure 9

Energy Security Risk: Economic Sub-Index, 1970-2040



The biggest improvements were noted in the metrics covering energy expenditures, and oil and gas import. These reductions in risk were offset by a 22% increase in the world price of crude oil and a relatively high score in crude oil price volatility, a remnant from the 2015-2016 price collapse. In the 2016 edition we wrote about how moves by Saudi Arabia in 2015 to defend market share and drive down the global price for crude oil cold have an impact on crude oil price volatility scores for the next few years. We expect volatility risks to be much lower in 2018.

Volatility in energy markets can lead to sudden and large shifts in international trade. Greater expenditures on imported fuels represent lost economic investment opportunities closer to home, and this risk is captured in metrics measuring how much the U.S. spends on imported oil and natural gas, both in total and as a share of GDP. Risks associated with oil and gas import total expenditures fell 7.8% and those associated with those expenditures as a share of GDP fell 9.8%. Both metrics now score well below their 30-year average.

Economic risks are expected to stay essentially flat out to 2040. We expect risks for this Sub-Index to average about 68.6 points out to 2040, a level quite a bit below it 30-year average of 73.2. This is despite an anticipated rise in the price of crude oil of 96% by 2040. A much improved petroleum intensity risk (down 38%), however, and the U.S. becoming a net exporter of oil soften the impact of this price rise.

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

The metrics that make up the Reliability Sub-Index measure things such 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.

Since its peak of 115.3 in 2011, the risk score for this Sub-Index has jumped around a bit, settling on 90.3 in 2017, down 1.5 points from 2016 (Figure 10). This is about 4.4 points above the baseline average score of 85.9, mostly due to lingering high scores in crude oil volatility and energy expenditure volatility risk, discussed above. Reliability risks related to the power sector, however, were better than in 2017 while higher risks were estimated for refinery utilization and petroleum stock levels.

Forecast scores based on the *AEO2018* suggest Reliability risks will dip in 2018, after which it will rise steadily if modestly out to 2040, reaching 88.5. This is still below 2017 level. 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 margin risks are expected to rise 8.4 percent between 2017 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.

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

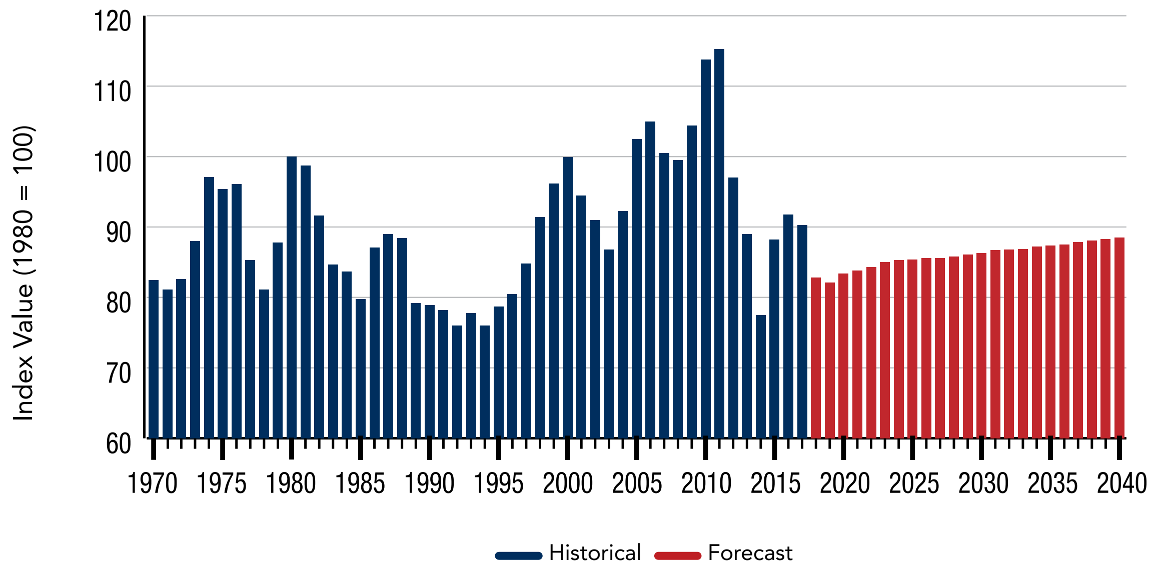
The Environmental Sub-Index includes metrics of energy intensity and efficiency, transportation, power, carbon dioxide emissions, and research and development.

With a score of 80.1, the Environmental Sub-Index risk score fell in 2017 to its lowest level since 1970, 80.1 points. This is 1932 points below the historical average (Figure 11). Metrics in this sub-index tend to move more slowly than in others as improvements occur incrementally. In 2017, all of the metrics measuring energy use and carbon dioxide emissions improved. Most of the decrease in risk for carbon dioxide emissions in 2017 was related to improvements in energy intensity, with fuel switching from coal to natural gas and increased renewables also contributing.

The Environmental Sub-Index is the only one of the four sub-indexes to show steadily declining risk out to 2040. All of the intensity measures—i.e., for energy, petroleum, and carbon dioxide emissions—show declines of between 30% and 40% between 2017 and 2040, and emissions per capita decline by 28%. 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 5.3% between 2017 and 2040.

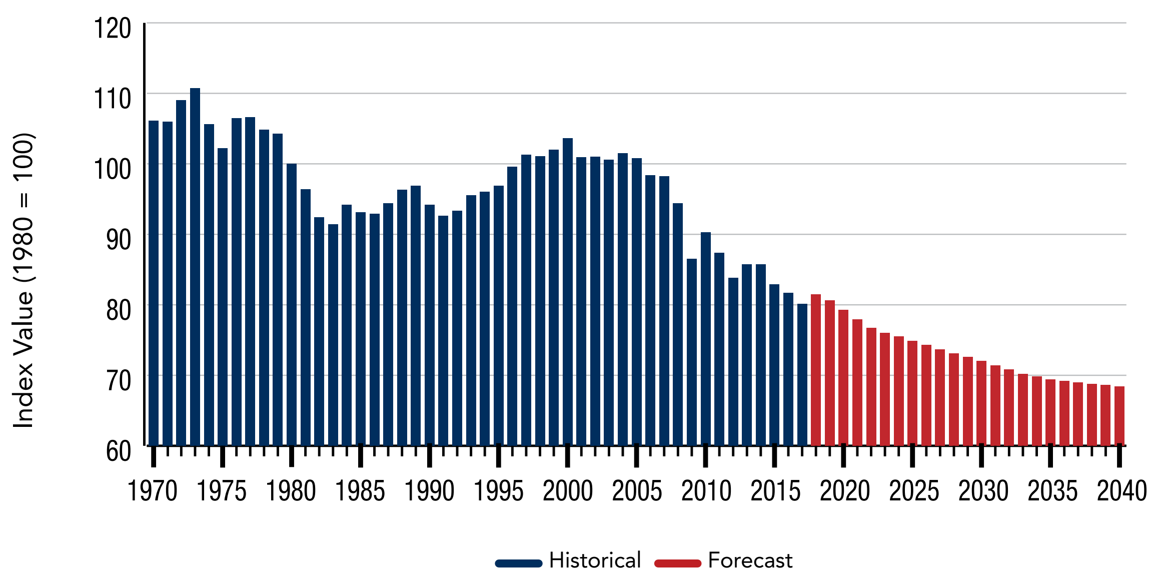
■ Figure 10

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



■ Figure 11

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



Special Feature:
Energy Security Risks under Alternate Future Scenarios

In addition to its reference case, EIA also models a number of scenarios featuring alternate policies and other important factors—prices, technologies, resources, and the like—that potentially can change appreciably the country's energy economy and energy security. For its *AEO2018*, EIA ran and made forecast data available for more than 20 side cases, many of which (like the reference case) include versions with and without the Clean Power Plan (CPP), which was suspended by the Supreme Court and is at any event being replaced by the Trump Administration.[5]

Twenty seven 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 *AEO2018* reference case. For each side case examined, Table 5 presents the differences in energy security risk score and cumulative GDP between it and the reference case for the years 2030 and 2040. Each of these side cases is described Table 6.

The low oil price scenarios result in the greatest decreases (5 to 6 points) in security compared to the reference case, and each shows a modest increase in GDP. The various high oil & gas resource and technology and carbon price cases also show lower energy security risk scores with the major difference being that the high resource cases lead to considerably higher GDP vis-à-vis the reference case while the carbon price cases lead to a reduction in GDP. As we have seen in previous editions of the Index, of the side cases that result in lower energy security risk, only the carbon fee and reference case with CPP side cases led to lower GDP as well.

The high oil & gas resource and technology cases lead to much higher U.S. production of crude oil and natural gas. Over the period from 2018 to 2040, crude oil production averages 11.5 in the reference case versus 14.6 million barrels per day in the high resource case while natural gas production averages 36.6 tcf versus 42.3 cubic feet. Such large rises in domestic output ripple through many other metrics (e.g., those related to imports).

Those scenarios that show increasing energy security risks scores tend to be the mirror image of those that result in lower risk scores. The high oil price scenarios with and without CPP show very large increases in risk (16 points) out to 2040 even as they show (counterintuitively) modest increases in GDP, which appear to be related to much greater domestic crude oil production that nears 15 million barrels per day in the late 2020s and early 2030s.

While average crude oil production in the reference case average about 11.5 million barrels per day out to 2040, production in the high oil price side case averages 14.0 million barrels, a difference of about 2.5 million barrels. Whereas the large increase in domestic oil and natural gas production noted for the high oil and gas resource and technology side cases were driven both by an increase in available resources and by dramatic technology improvements lowering the cost of developing a producing well, the increases in production observed for the high oil price cases were driven entirely by high prices.

The various iterations of the low oil and gas resource and technology side cases also show higher risk (about 6 points) compared to the reference case. These scenarios also tend to show the biggest declines in GDP, much of which is related to less domestic production of crude oil and natural gas and greater costs to produce it compared to the reference case.

These results demonstrate policy and technology development both matter greatly. In general, policies that encourage greater domestic production, promote greater efficiency, and encourage the commercial use of advanced cost-effective technologies offer a way to lower energy security while increasing employment and GDP.

[5] EIA's *AEO2018* side case data are available at: https://www.eia.gov/outlooks/aeo/tables_side.php.

Table 5. Energy Security Risk Measures: Differences Between EIA *AEO2018* Side Cases and Reference Case

	Change In:			
EIA *AEO2018* Side Case	**2030 Energy Risk Index Score**	**Cumulative GDP: 2019-2030 (Billion 2017$)**	**2040 Energy Risk Index Score**	**Cumulative GDP: 2019-2040 (Billion 2017$)**
Reference Case	NA	NA	NA	NA
Reference Case (CPP)	-1	-309	-1	-561
Low Oil Price	-6	565	-5	972
Low Oil Price (CPP)	-6	241	-6	318
High Oil Price	15	460	16	1,183
High Oil Price (CPP)	14	95	16	466
High Oil & Gas Resource & Technology	-2	1,414	-2	3,318
High Oil & Gas Resource & Technology (CPP)	-2	1,122	-3	2,794
Low Oil & Gas Resource & Technology	5	-1,895	7	-4,821
Low Oil & Gas Resource & Technology (CPP)	4	-2,485	6	-5,702
Nuclear costs 20% Higher, Reference case	0	-14	0	-34
Nuclear costs 20% Lower, Reference case	0	16	0	32
Nuclear costs 20% Higher, High Resource & Technology Case	-1	1,355	-1	3,162
Nuclear costs 20% Lower, High Resource & Technology Case	-2	1,454	-2	3,397
Nuclear costs 20% Higher, Low Resource & Technology Case	5	-1,944	7	-4,890
Nuclear costs 20% Lower, Low Resource & Technology Case	5	-1,918	7	-4,813
$15 Carbon Allowance Fee	-2	-366	-3	-846
$25 Carbon Allowance Fee	-3	-551	-3	-1,085
No PTC/ITC Sunset, Reference case	0	-46	0	-64
Early PTC/ITC Sunset, Reference case	1	-68	1	-115
Solar PV Tariff, Reference case	0	-5	0	7
No New Efficiency Requirements, Reference case	1	48	1	296
New Efficiency Requirements, Reference case	0	-73	-1	-233
High ANWR Resource Base	0	2	-1	399
Mean ANWR Resource Base	0	-7	0	337
Low ANWR Resource Base	0	-6	0	268
Autonomous Battery Electric Vehicle	0	18	0	110
Autonomous Hybrid Electric Vehicle	0	18	0	91

Table 6. Summary of Side Cases

EIA *AEO2018* Case	Description
Reference case	Baseline assumptions for economic growth (2.0% from 2017 to 2050), oil prices, technology, and demographic trends. Brent spot prices rise to about $114 per barrel (2017 dollars) in 2050. Assumes the Clean Power Plan is not implemented.
Reference case (CPP)	Baseline assumptions for economic growth (2.0% from 2017 to 2050), oil prices, technology, and demographic trends. Brent spot prices rise to about $114 per barrel (2017 dollars) in 2050. Assumes compliance with the Clean Power Plan through mass-based standards modeled with cooperation across states at the regional level, with all allowance revenues rebated to taxpayers.
Low Oil Price	Low oil prices result from a combination of lower demand for petroleum and other liquids in the non-OECD nations and higher global supply. Producers face lower costs of production for both crude oil and other liquids production technologies. OPEC increases its market share to 53 percent in 2040, and the costs of other liquid production technologies are lower than in the Reference case. Brent spot price falls below $27 per barrel (2017 dollars) in 2018 and rises slowly to almost $52 per barrel in 2050.
Low Oil Price (CPP)	Low oil prices result from a combination of lower demand for petroleum and other liquids in the non-OECD nations and higher global supply. Producers face lower costs of production for both crude oil and other liquids production technologies. OPEC increases its market share to 53 percent in 2040, and the costs of other liquid production technologies are lower than in the Reference case. Brent spot price falls below $27 per barrel (2017 dollars) in 2018 and rises slowly to almost $52 per barrel in 2050. Assumes compliance with the Clean Power Plan through mass-based standards modeled with cooperation across states at the regional level, with all allowance revenues rebated to taxpayers.
High Oil Price	High oil prices result from a lack of global investment in the oil sector, eventually inducing higher production from non-OPEC producers. Higher economic growth relative to the Reference case leads to increased demand, particularly in non-OECD countries. Brent spot price rises to $229 per barrel (2017 dollars) in 2050.
High Oil Price (CPP)	High oil prices result from a lack of global investment in the oil sector, eventually inducing higher production from non-OPEC producers. Higher economic growth relative to the Reference case leads to increased demand, particularly in non-OECD countries. Brent spot price rises to $229 per barrel (2017 dollars) in 2050. Assumes compliance with the Clean Power Plan through mass-based standards modeled with cooperation across states at the regional level, with all allowance revenues rebated to taxpayers.
High 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% 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.

Table 6. Summary of Side Cases *(continued)*

EIA *AEO2018* Case	Description
High Oil & Gas Resource & Technology (CPP)	Assumes the Clean Power Plan is not implemented. 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% 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. Tight oil and shale gas resources are added to reflect new plays or the expansion of known plays. Assumes compliance with the Clean Power Plan through mass-based standards modeled with cooperation across states at the regional level, with all allowance revenues rebated to taxpayers.
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.
Low Oil & Gas Resource & Technology (CPP)	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. Assumes compliance with the Clean Power Plan through mass-based standards modeled with cooperation across states at the regional level, with all allowance revenues rebated to taxpayers.
Nuclear Costs 20% higher, reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Operating and capital costs for both new and existing nuclear units are increased by 20%.
Nuclear Costs 20% lower, reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Operating and capital costs for both new and existing nuclear units are decreased by 20%.
Nuclear Costs 20% Higher, High Resource & Technology Case	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States; undiscovered resources in Alaska and the offshore lower 48 states; and rates of technological improvement that reduce costs and increase productivity are 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. Operating and capital costs for both new and existing nuclear units are increased by 20%.
Nuclear Costs 20% lower, High resource and technology case	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States; undiscovered resources in Alaska and the offshore lower 48 states; and rates of technological improvement that reduce costs and increase productivity are 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. Operating and capital costs for both new and existing nuclear units are decreased by 20%.

Table 6. Summary of Side Cases *(continued)*

EIA *AEO2018* Case	Description
Nuclear Costs 20% higher, Low Resource & Technology Case	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States; undiscovered resources in Alaska and the offshore lower 48 states; and rates of technological improvement that reduce costs and increase productivity are 50% lower than in the Reference case. Operating and capital costs for both new and existing nuclear units are increased by 20%.
Nuclear Costs 20% Lower, Low Resource & Technology Case	Estimated ultimate recovery per shale gas, tight gas, and tight oil well in the United States; undiscovered resources in Alaska and the offshore lower 48 states; and rates of technological improvement that reduce costs and increase productivity are 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. Operating and capital costs for both new and existing nuclear units are decreased by 20%.
$15 Carbon Allowance Fee	A cost for carbon dioxide emissions from utility-scale electricity generators beginning at $15 (in 2017 dollars) in 2020 and increasing at 5% per year in real terms.
$25 Carbon Allowance Fee	A cost for carbon dioxide emissions from utility-scale electricity generators beginning at $25 (in 2017 dollars) in 2020 and increasing at 5% per year in real terms.
No PTC/ITC Sunset, reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Extends the production tax credit (for wind, geothermal, conventional hydropower, biomass, and other eligible technologies) and the investment tax credit (for solar and wind projects) through 2050 at full value.
Early PTC/ITC Sunset, Reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Eliminates the production tax credit (for wind, geothermal, conventional hydropower, biomass, and other eligible technologies) and the investment tax credit (for solar and wind projects) in 2019, prior to their currently scheduled phase outs and expirations.
Solar PV tariff, reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Imposes a tariff on photovoltaic system imports, declining over the 4 years from 2019 through 2022.
No New Efficiency Requirements, reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Removes federal efficiency standards slated to go into effect after 2018 for major residential and commercial end-use equipment and maintains light-duty vehicle fuel economy and greenhouse gas emissions standards at 2021 levels in the transportation sector.

Table 6. Summary of Side Cases *(continued)*

EIA *AEO2018* Case	Description
New Efficiency Requirements, reference case	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Includes additional updates to federal efficiency standards for major residential and commercial end-use equipment and increases light-duty vehicle fuel economy and greenhouse gas emissions standards beyond 2025 in the transportation sector.
High ANWR Resource Base	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Crude oil is produced from ANWR assuming high resources based the 1998 USGS assessment. First production occurs at least 10 years after the first least sale in 2021, with the largest fields are brought into production first. Economic fields are sequentially developed every two years. Fields take three to four years to reach peak production, maintain peak production for three to four years, and then decline until they are no longer profitable.
Mean ANWR Resource Base	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Crude oil is produced from ANWR assuming mean resources based the 1998 USGS assessment. First production occurs at least 10 years after the first least sale in 2021, with the largest fields are brought into production first. Economic fields are sequentially developed every two years. Fields take three to four years to reach peak production, maintain peak production for three to four years, and then decline until they are no longer profitable.
Low ANWR Resource Base	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. Crude oil is produced from ANWR assuming low resources based the 1998 USGS assessment. First production occurs at least 10 years after the first least sale in 2021, with the largest fields are brought into production first. Economic fields are sequentially developed every two years. Fields take three to four years to reach peak production, maintain peak production for three to four years, and then decline until they are no longer profitable.
Autonomous Battery Electric Vehicle	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. More widespread use of light-duty autonomous vehicles that increasingly switch from conventional gasoline internal combustion engines to battery electric vehicles by 2050.
Autonomous Hybrid Electric Vehicle	Baseline assumptions for economic growth, oil prices, technology, and demographic trends. More widespread use of light-duty autonomous vehicles that increasingly switch from conventional gasoline internal combustion engines to gasoline hybrid electric internal combustion engine vehicles by 2050.

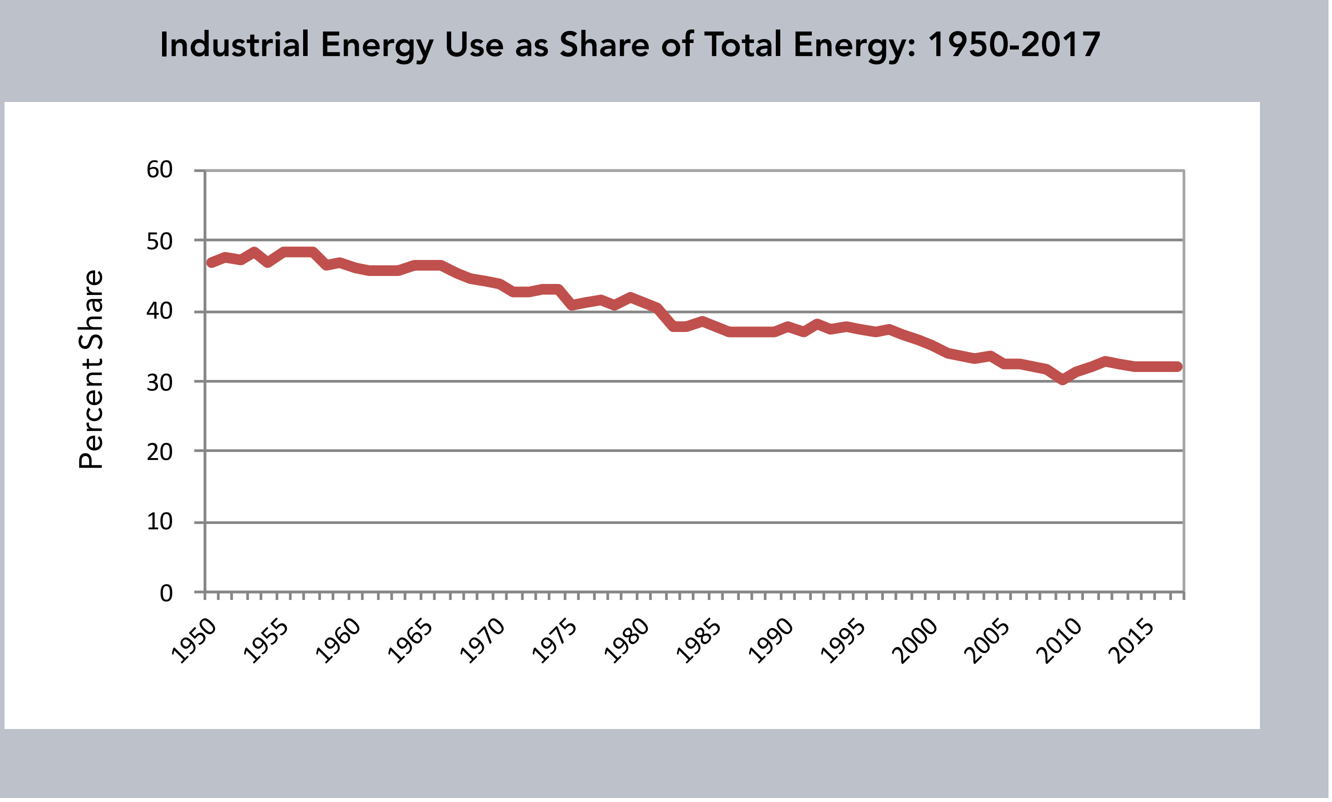
Special Feature: Industrial Energy Efficiency

Of the four economic sectors used by the Energy Information Administration (EIA)—residential, commercial, industry, and transportation—industry accounts for the biggest share of energy use. EIA estimates that in 2017, industry users consumed about 30.5 trillion Btus, or 32%, of all the energy consumed in the United States (including the energy used to generate the electricity purchased by industry). Large energy users include the petroleum, coal, paper, chemicals, metals, mining,cement, glass, and food industries. This makes industrial energy efficiency an important metric of energy security.

As Figure 12 shows, however, energy use by industry is shrinking relative to energy use in other sectors. Since the mid-1950s to the present, industry's share of energy use has fallen steadily, from over 48% in the mid-1950s to about 32% today. Similarly, industry's share of electricity use (including transmission-related losses) has fallen from more than half in the mid-1950s to about a quarter today.

The mix of energy sources consumed in the industrial sector also has changed. In 1950, coal was the dominant fuel (36%), followed by oil (24%), natural gas (22%),

Figure 12



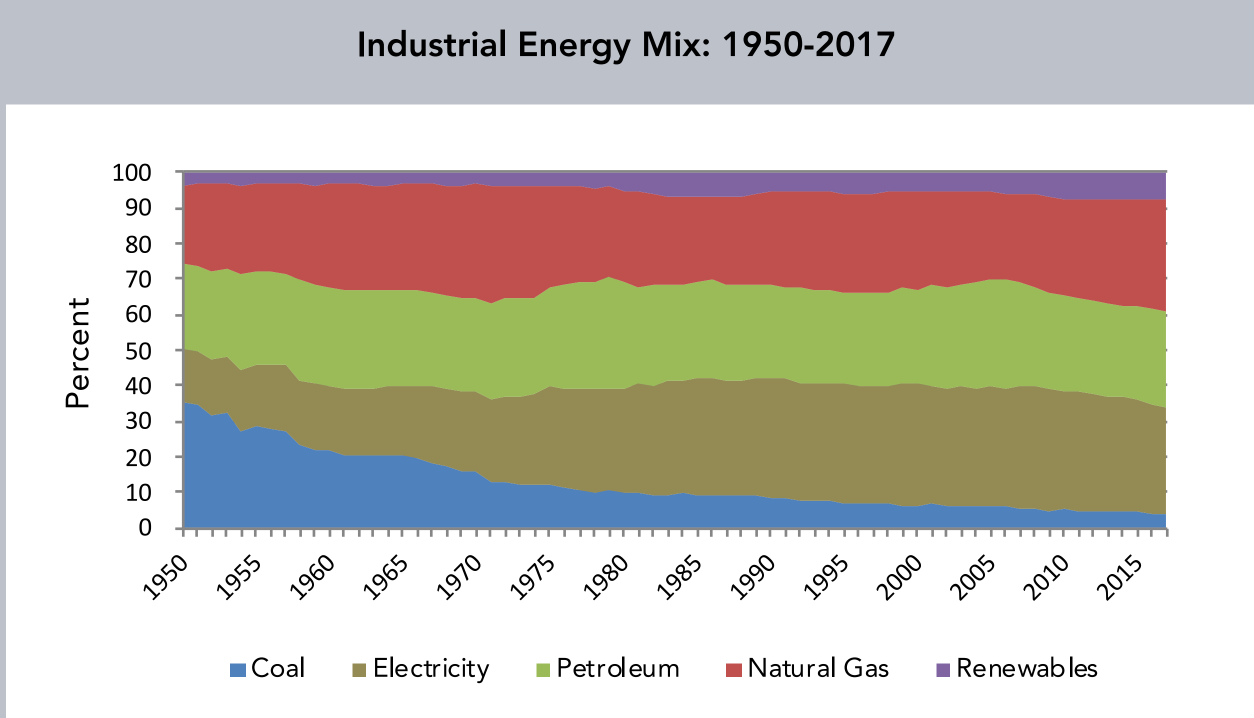
Source: EIA, ***Monthly Energy Review.***

electricity (14%), and renewables (biomass) (4%). Today, natural gas and electricity are the largest energy sources (31% and 30%, respectively) used by industry, followed close behind by (27%) and then renewables (8% and still predominately biomass) and coal (4%) (Figure 13). Of course, the mix of energy used to generate the electricity purchased by industry has changes a lot as well, with natural gas and to a lesser extent renewables assuming a larger share of generation at the expense of coal and petroleum.

For purposes of the Index, Industrial Energy Efficiency is defined as the total energy used (in trillions of Btu) in the industrial sector divided by the Federal Reserve Board's Index of Industrial Production (IP Index). The resulting metric indicates the degree to which the typical commercial enterprise uses energy efficiently.

The industrial energy efficiency metric measures energy usage compared to output. The Federal Reserve's monthly Industrial Production (IP) and the related capacity indexes and capacity utilization rates cover manufacturing, mining, and electric and gas utilities. They do not cover agriculture, construction, and some other activities that fall within EIA's definition of "industrial sector." These tend to be a relatively small portion of overall industrial sector energy consumption, however. So while not a perfect match, the industrial scope of the IP index is a reasonably close to the Industrial Sector defined in the EIA statistics.

Figure 13



Source: EIA, *Monthly Energy Review*.

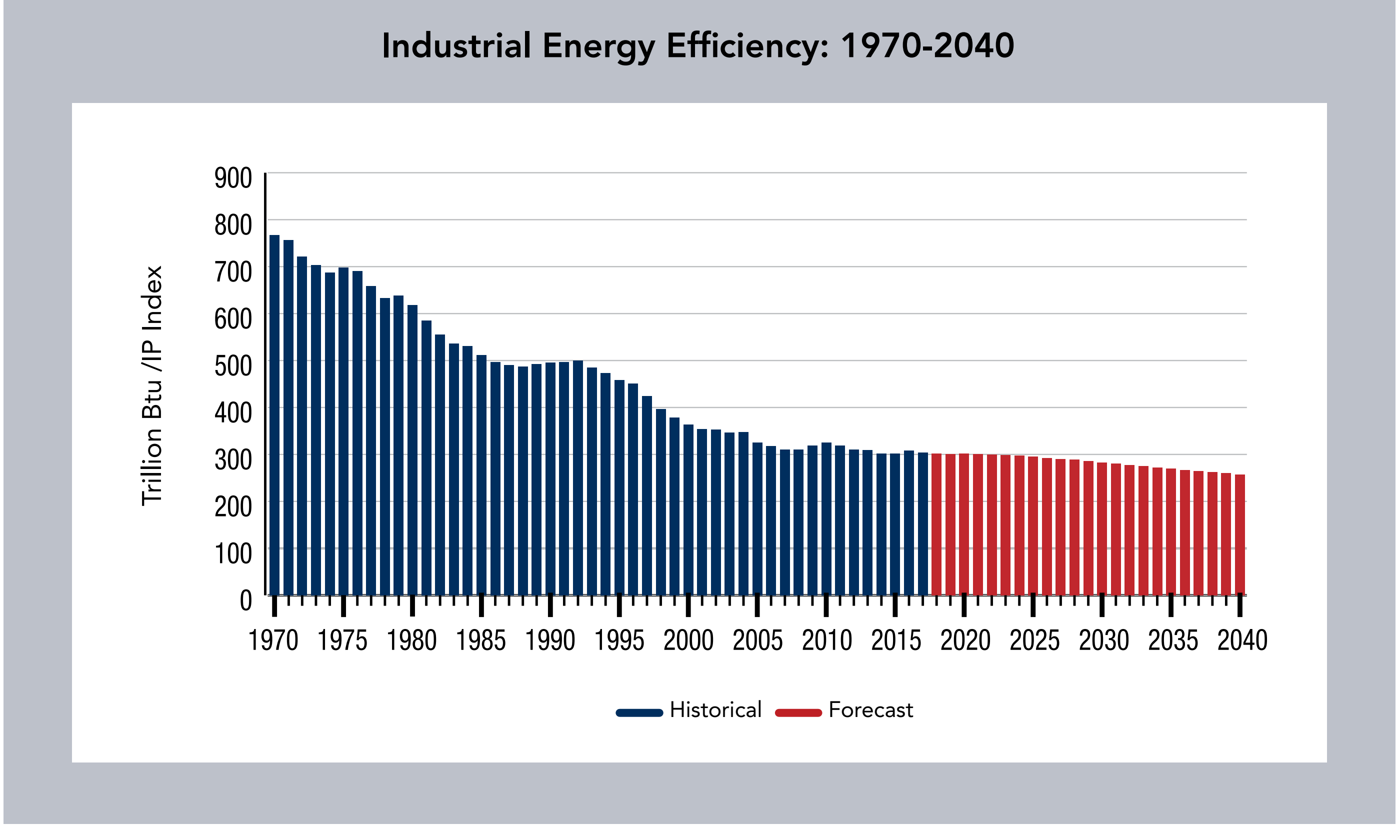
The Federal Reserve does not produce an IP forecast, but EIA produces a forecast of U.S. industrial energy consumption and output ("Total Value of Shipments") as part of it AEO. The industrial output data represent the sum of manufacturing and non-manufacturing activity. EIA's Value of Shipments data are expressed in terms of billions of year 2009 dollars. These values are linked to the IP Index by calculating annual percent changes and applying these ratios beginning with the most recent year of the historical IP Index. This process results in a proxy IP Index projection based on EIA's value of industrial shipments projections.

The results covering the period 1970-2040 are shown in Figure 14. The long-term trend shows a dramatic improvement in overall industrial energy efficiency.

Over the 30 years from 1970 to 2000, the amount of energy needed to produce overall energy efficiency in this sector improved by half. This reflects not only the greater efficiency of most industries and processes, but also the broader shifts in our economy towards services and less energy-intensive goods.

That improvement has come about unevenly over the years (Figure 15). From 1971 to 2017, industrial efficiency improved at an average rate of about 2% a year. From 1971 to the middle of the 1980s, annual efficiency improvements averaged about 2.7%. This trend began to stall and even reverse itself between 1986 and 1992, when rapidly falling energy prices made efficiency less of an imperative. The result was an average improvement of just 0.3% annually during these

Figure 14



Sources: EIA, *Annual Energy Review*; EIA, *Annual Energy Outlook*; Federal Reserve Board.

years. Since then efficiency has improved at an annual 1.6% rate.

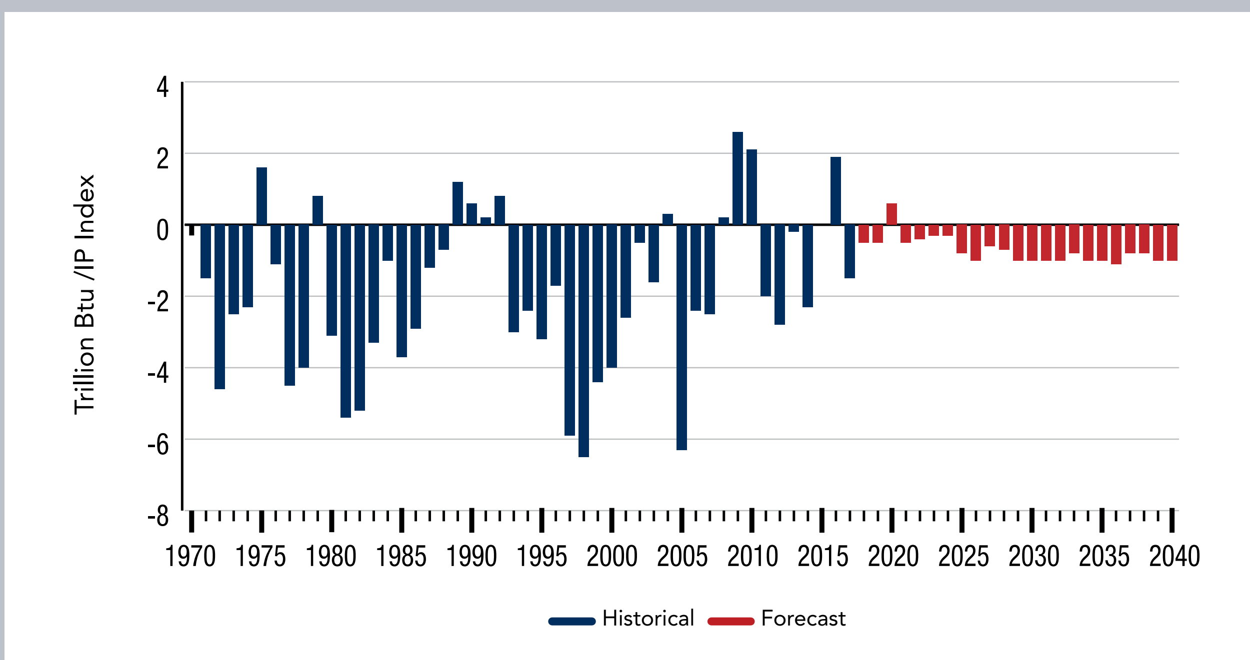
Looking ahead, EIA forecasts that industrial energy consumption is projected to grow 29% between 2017 and 2040. Even though overall consumption in the sector grows, it does so at a slower rate than economic growth because of efficiency gains.

Based on the estimates of future industrial output (described above), we estimate that industrial efficiency will improve at an annual rate of 0.7% out to 2040, a more leisurely pace than the historic average since 1970. Some of the difference could be attributed to the way future scores for this metric, described above, is estimated. Another reason could be the very large increase in energy consumption projected for chemicals, a very energy-intensive industry that makes up about 30% of total industrial energy consumption. The Shale Revolution has attracted greater investment in new chemical facilities as well as increased usage of current facilities. EIA forecasts that total energy demand for this sub-sector will soar 53% between now and 2040 while efficiency improves much more slowly.

If experience is any guide, however, it is likely that industrial efficiency will beat our forecast estimate of 0.7% per year.

Figure 15

Annual Change in Industrial Energy Efficiency: 1970-2040



Sources: EIA, *Annual Energy Review*; EIA, *Annual Energy Outlook*; Federal Reserve Board.

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

The Global Energy Institute's (GEI) 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.

GEI'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 GEI'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.

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[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 Most Recent Contribution of Each Metric to Energy Security Indexes:** Provides a table with: (1) the input 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 contribution of each metric to the resulting Sub-Index value for the most recent year. 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 most recent contribution 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.

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.

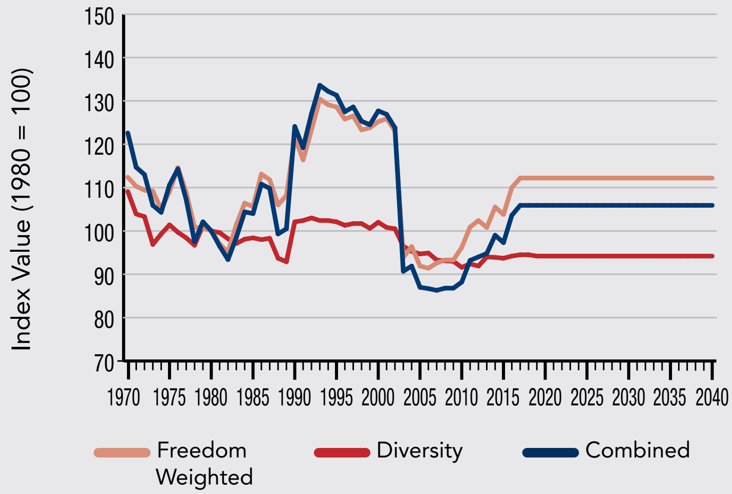
Importance

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.

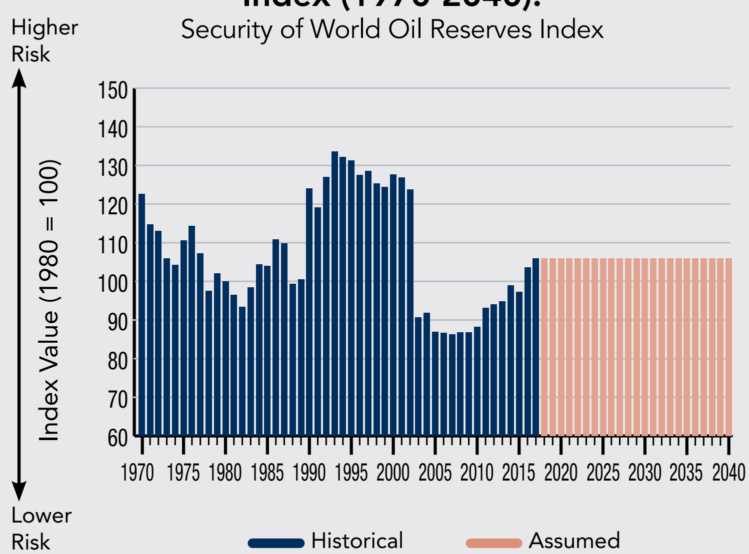
Category of Metric

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
Contribution in 2017	12.5	N/A	N/A	N/A	3.7

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.

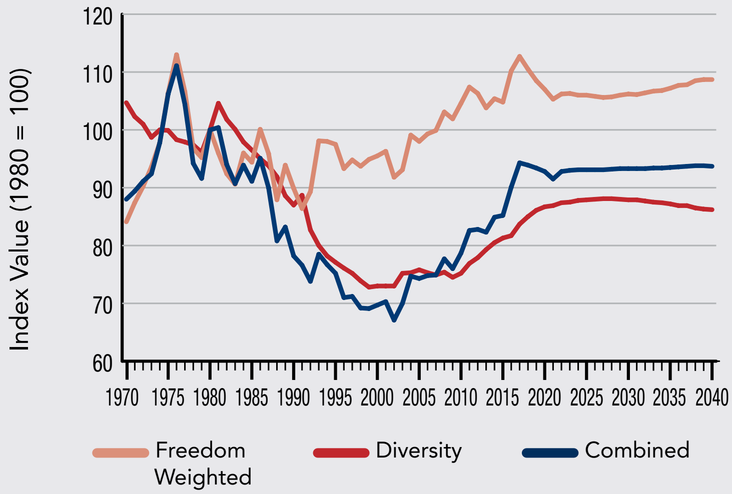
Importance

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

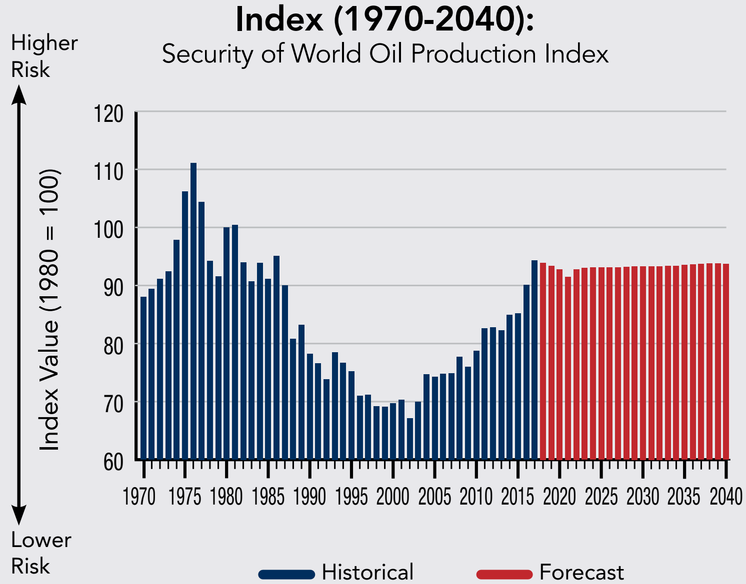
Category of Metric

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
Contribution in 2017	8.7	6.9	6.3	N/A	5.8

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.

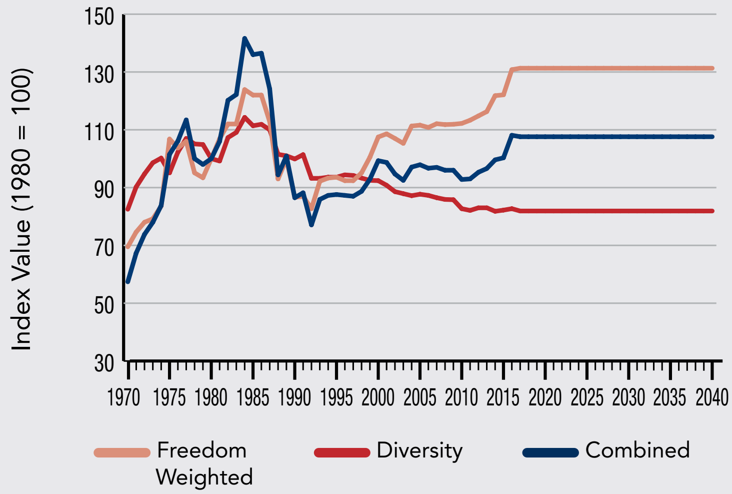
Importance

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.

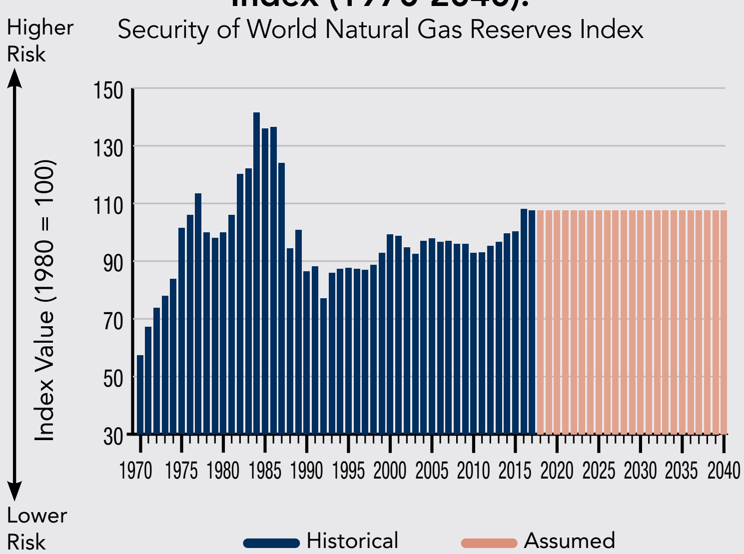
Category of Metric

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
Contribution in 2017	8.5	N/A	N/A	2.7	3.1

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

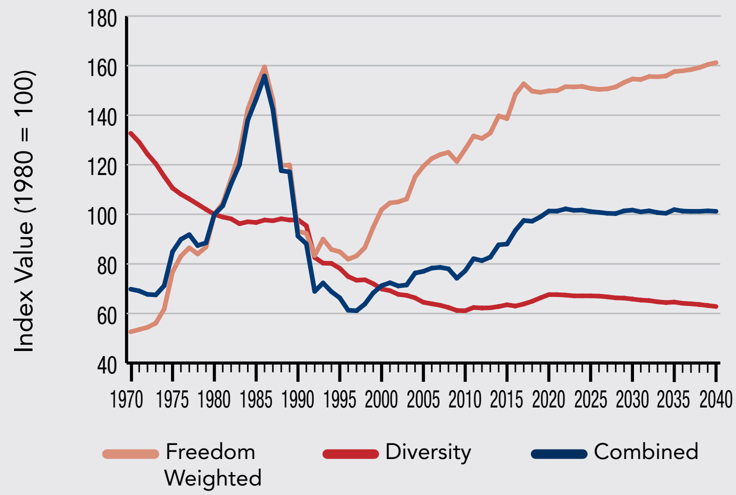
Indicates the level of risk attached to the average cubic foot of natural gas produced globally.

Category of Metric

Global Fuels

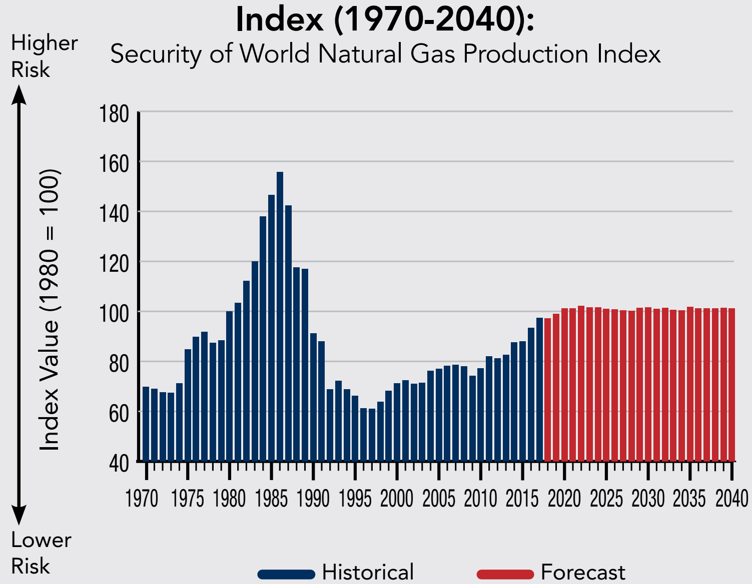
Historical and Forecast Values (1970-2040):

Security of World Natural Gas Production Trends

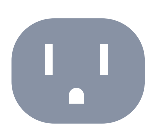


Index (1970-2040):

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
Contribution in 2017	6.4	2.8	3.2	2.4	3.9

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.

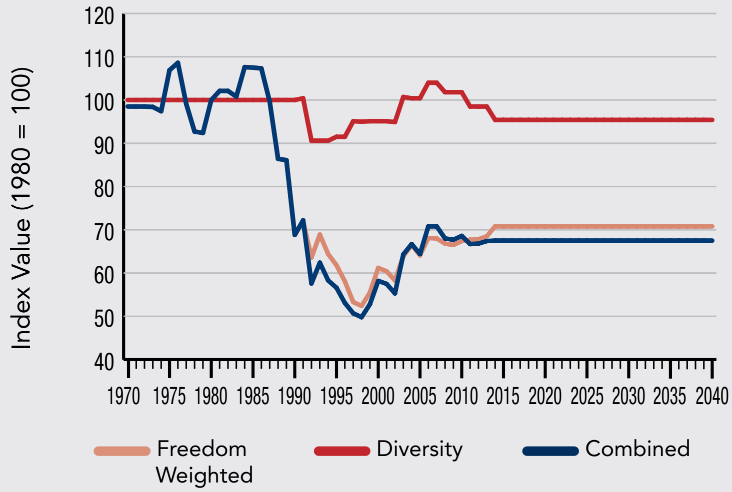
Importance

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

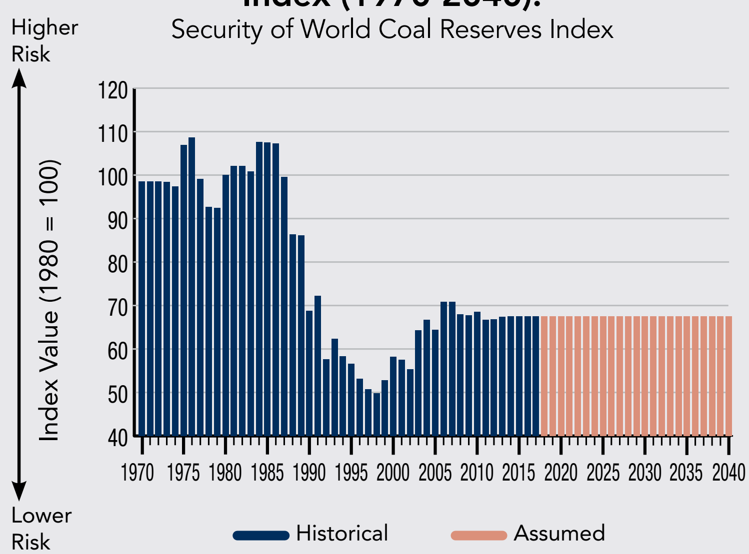
Category of Metric

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
Contribution in 2017	3.5	N/A	N/A	N/A	1.0

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.

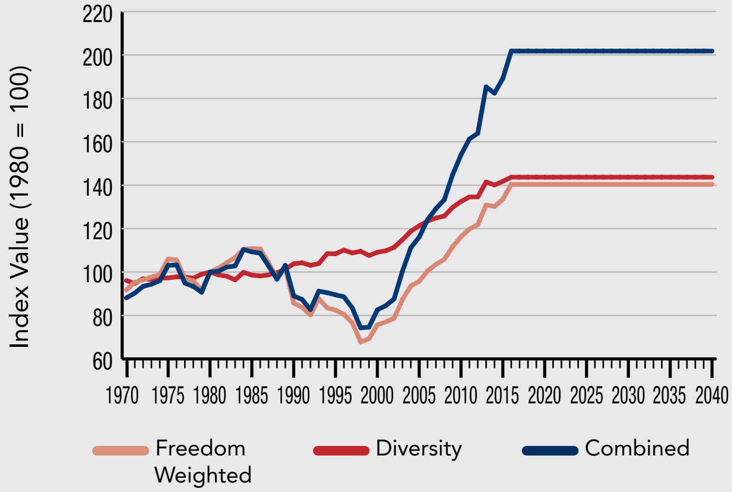
Importance

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

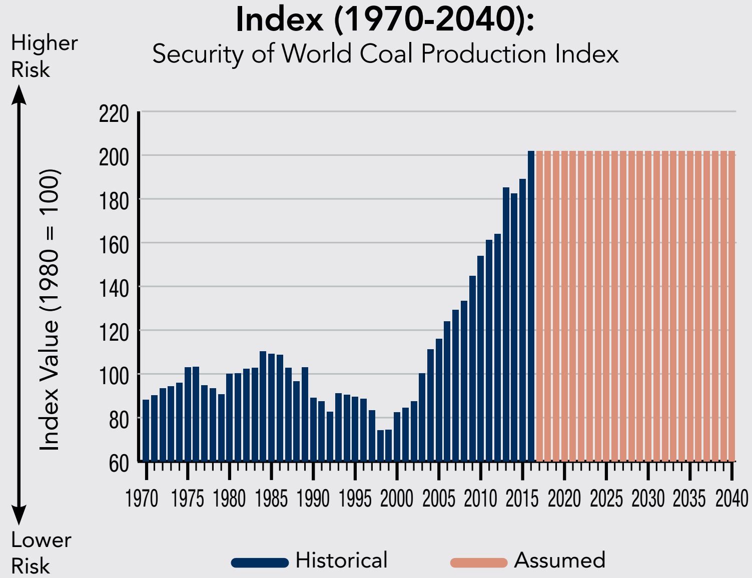
Category of Metric

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
Contribution in 2017	5.3	2.9	2.2	N/A	2.9

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.

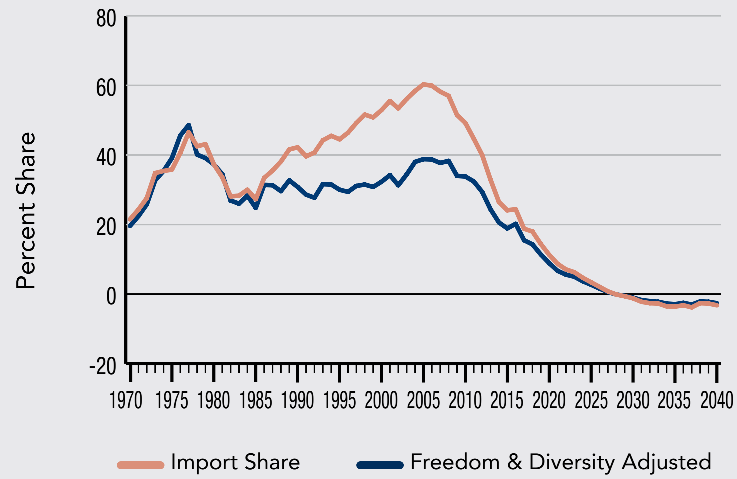
Importance

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.

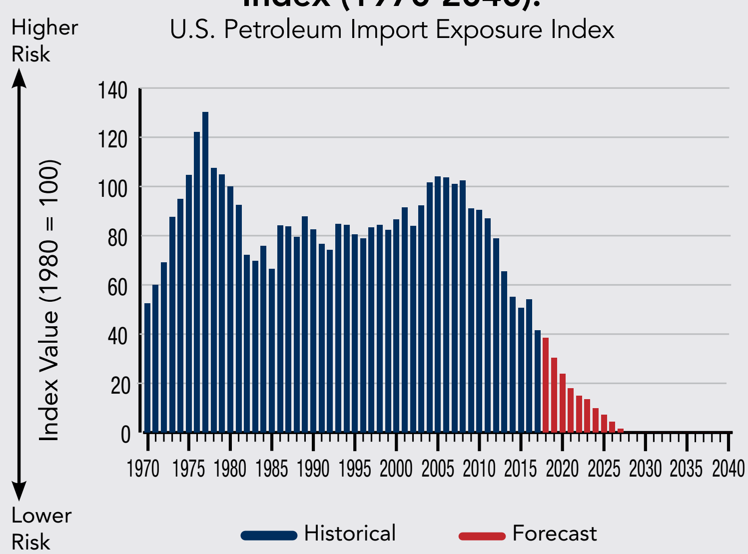
Category of Metric

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
Contribution in 2017	4.4	N/A	4.1	N/A	2.3

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

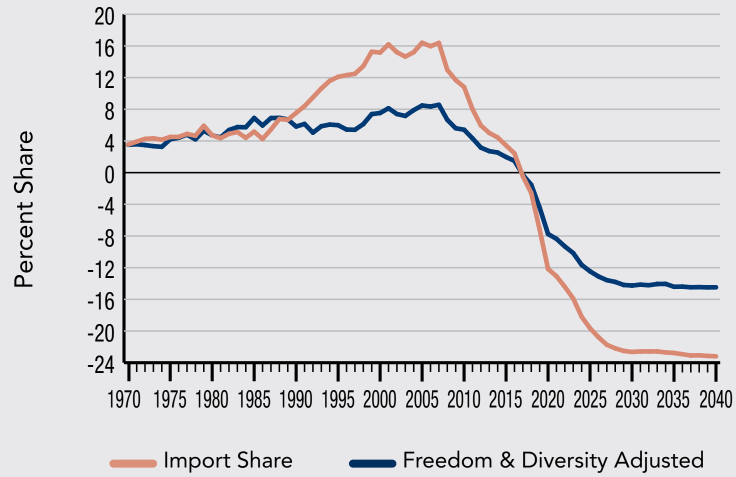
Indicates the degree to which changes in import levels expose the U.S. to potentially unreliable and/or concentrated supplies of natural gas.

Category of Metric

Fuel Imports

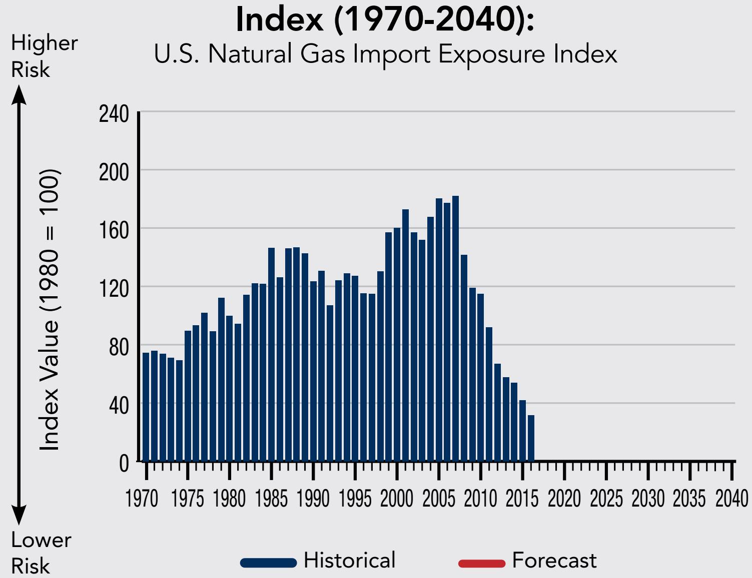
Historical and Forecast Values (1970-2040):

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
Contribution in 2017	0.0	N/A	0.0	N/A	0.0

Oil & Natural Gas Import Expenditures

Definition

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

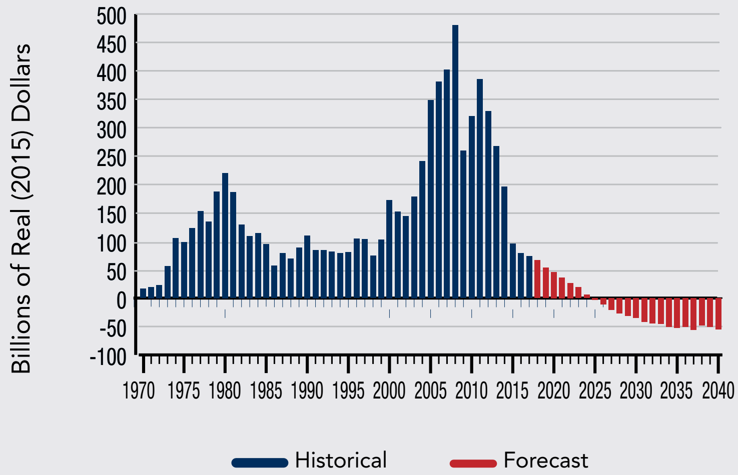
Importance

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

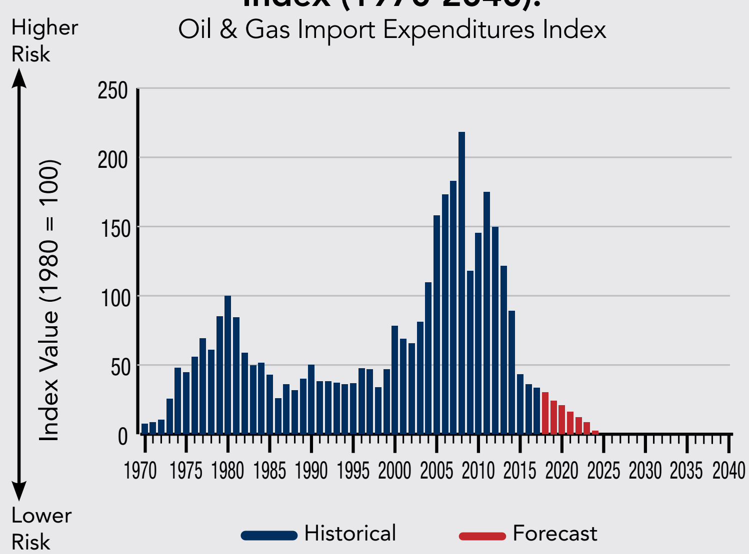
Category of Metric

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
Contribution in 2017	2.6	2.9	N/A	N/A	1.5

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.

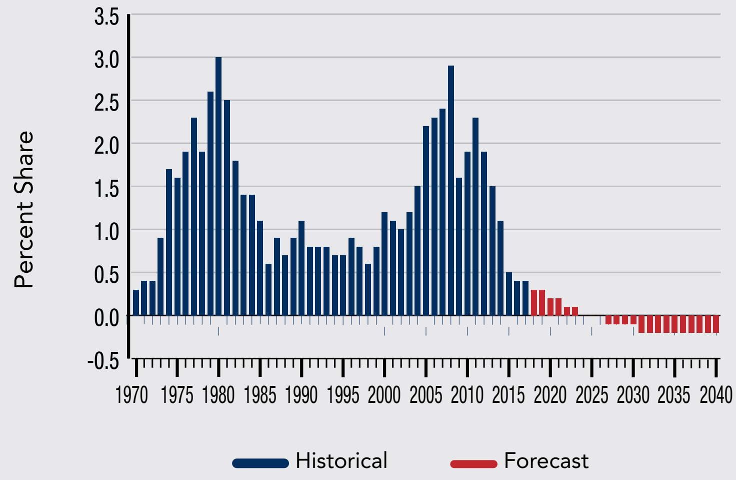
Importance

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

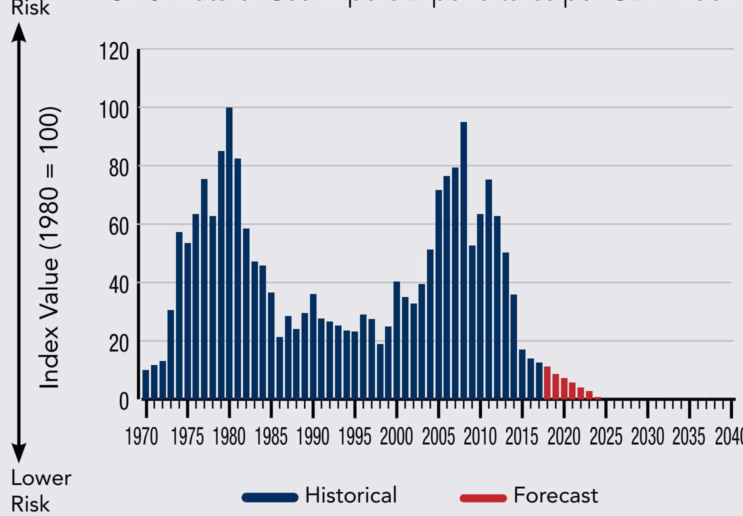
Category of Metric

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
Contribution in 2017	N/A	1.7	N/A	N/A	0.4

Energy Expenditures per dollar of GDP

Definition

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

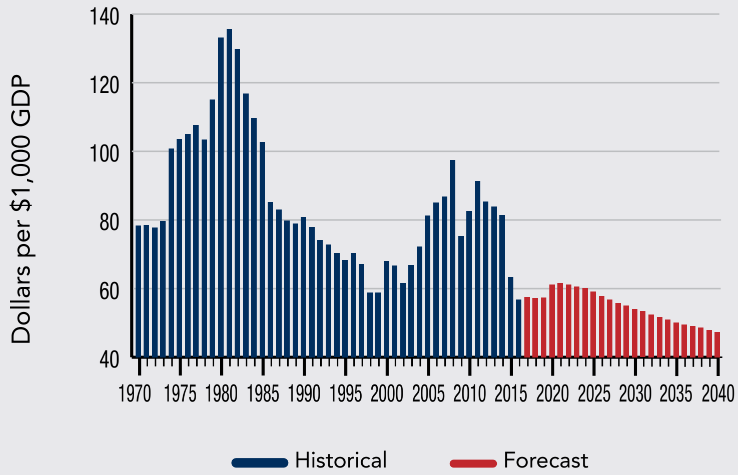
Importance

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

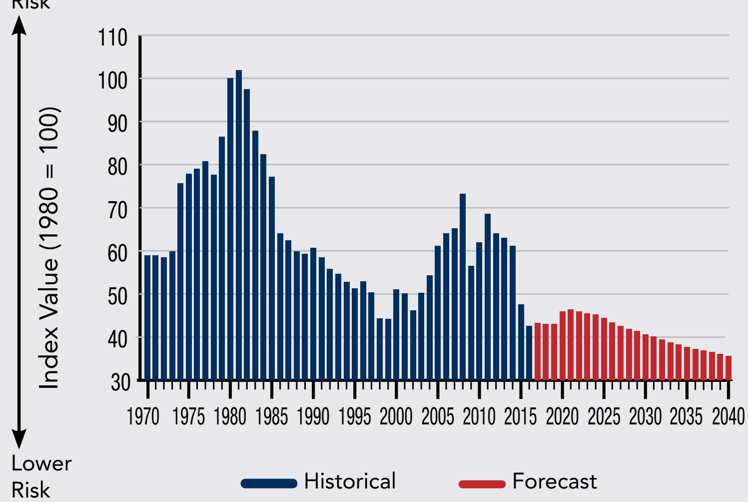
Energy Expenditures

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



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

Higher Risk



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
Contribution in 2017	2.8	4.4	N/A	N/A	2.0

Energy Expenditures per Household

Definition

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

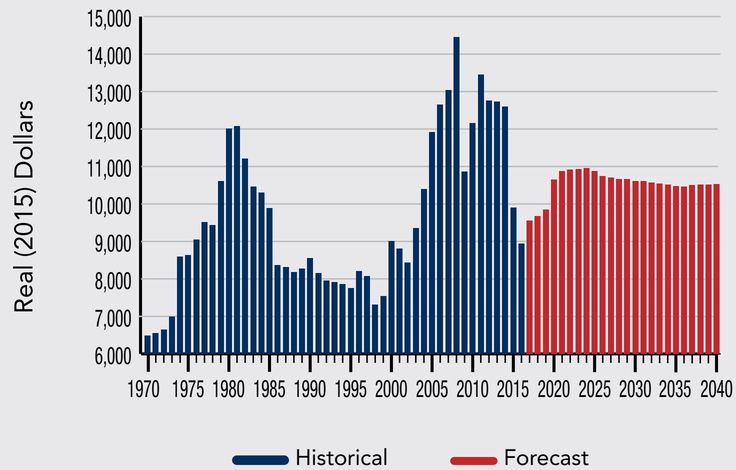
Importance

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

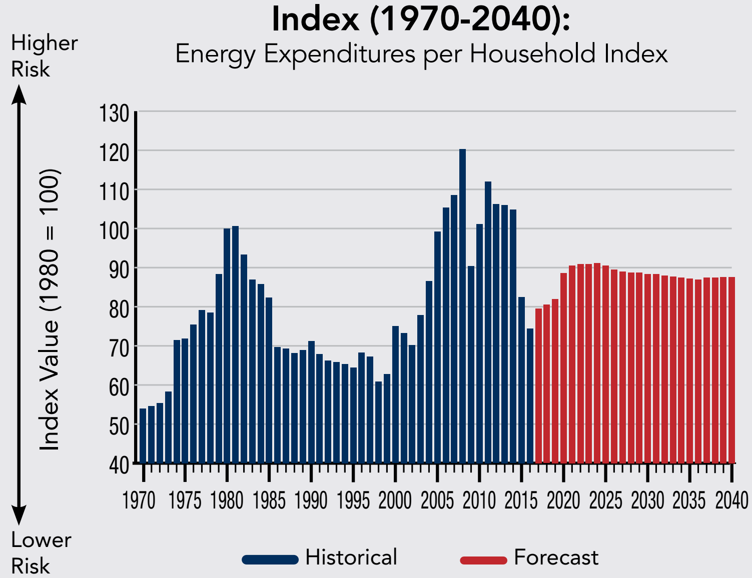
Category of Metric

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
Contribution in 2017	N/A	10.5	N/A	N/A	2.8

Retail Electricity Prices

Definition

Average electricity costs in the U.S. in cents per kWh in real (2015) dollars.

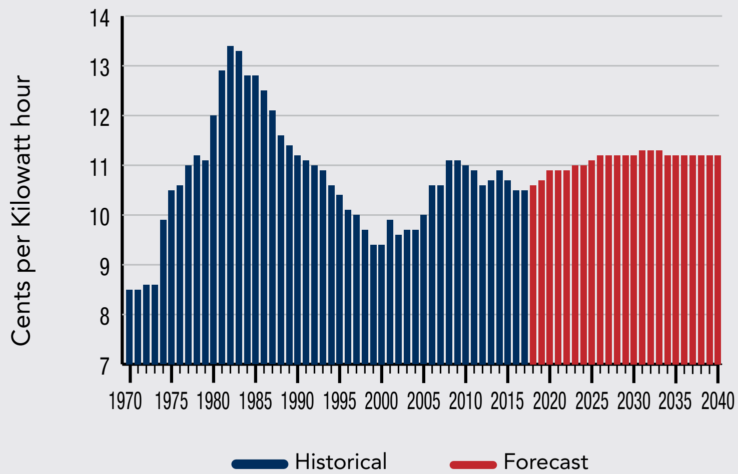
Importance

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

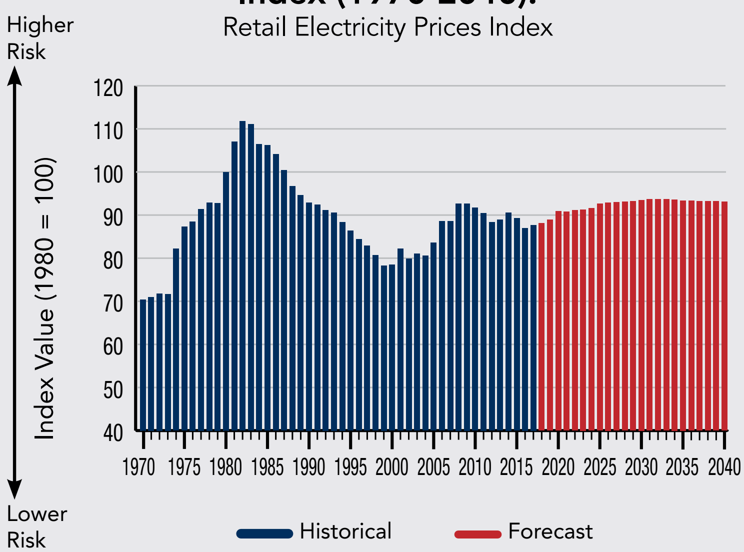
Category of Metric

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
Contribution in 2017	N/A	12.8	N/A	N/A	3.4

Crude Oil Prices

Definition

Cost per barrel of crude oil landed in the U.S. in real (2015) dollars.

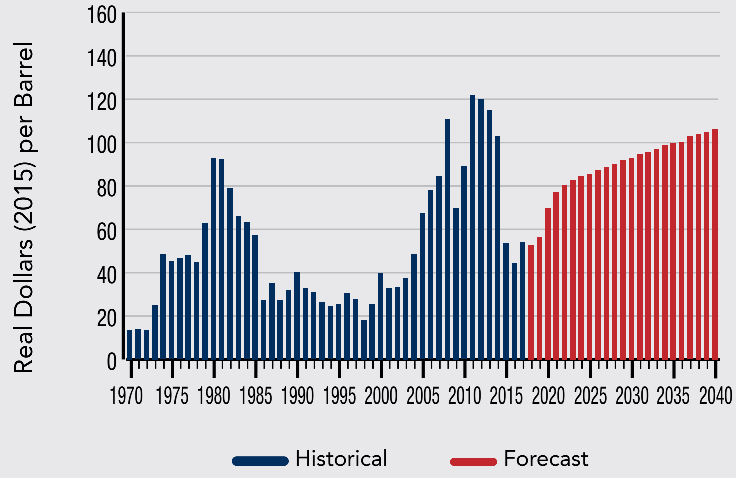
Importance

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

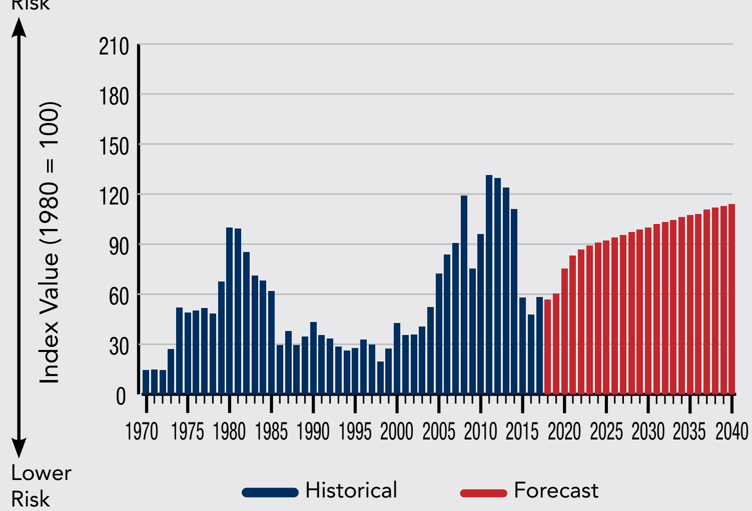
Category of Metric

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
Contribution in 2017	9.9	11.1	3.9	N/A	6.8

METRIC #15

Crude Oil Price Volatility

Definition

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

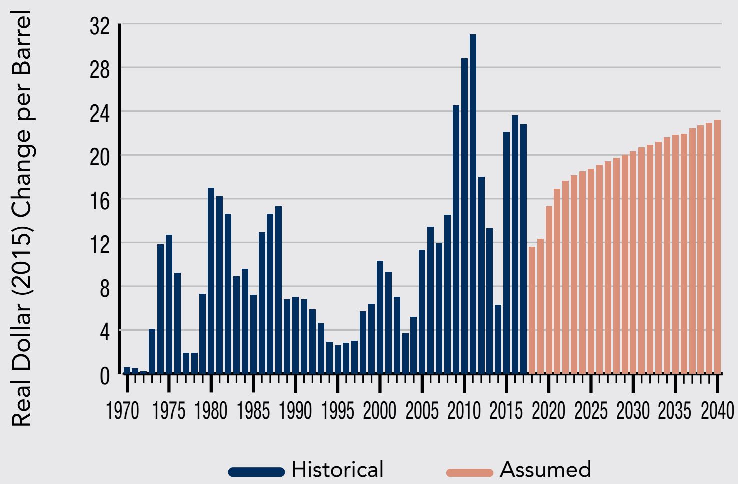
Importance

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.

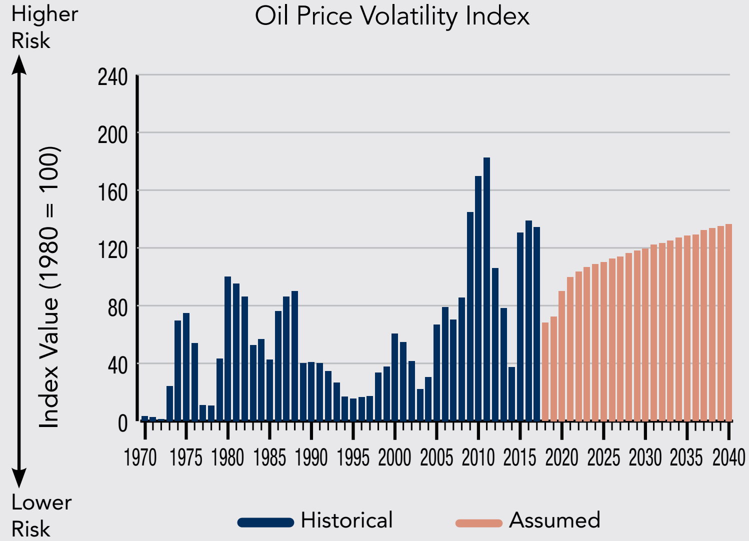
Category of Metric

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
Contribution in 2017	8.8	5.9	14.9	N/A	7.6

METRIC #16

Energy Expenditure Volatility

Definition

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

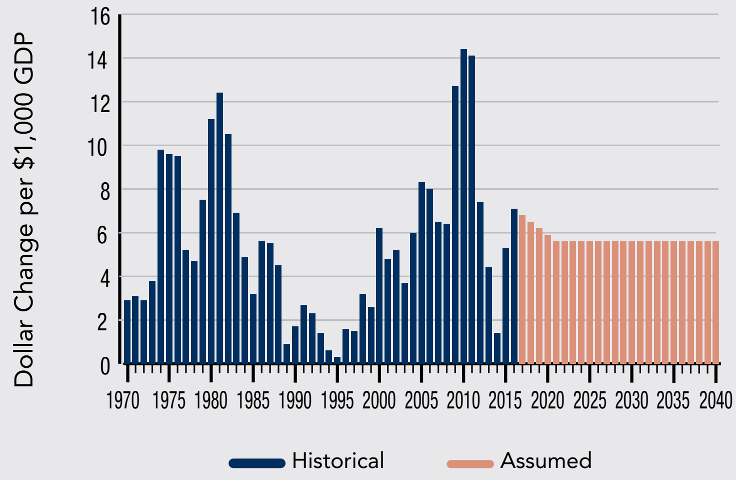
Importance

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

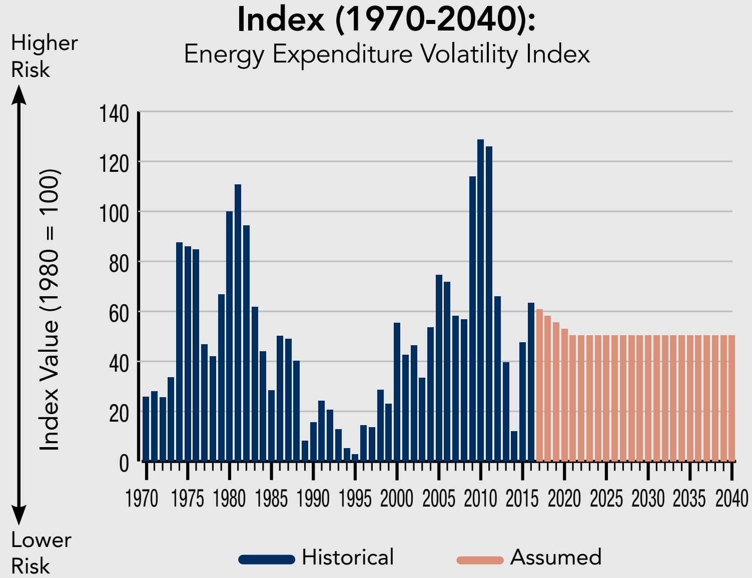
Category of Metric

Price Volatility

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



Index (1970-2040):
Energy Expenditure Volatility Index



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

	GEOPOLITICAL	ECONOMIC	RELIABILITY	ENVIRONMENTAL	TOTAL INDEX
Weight	N/A	5.0	14.0	N/A	4.3
Contribution in 2017	N/A	4.4	9.4	N/A	3.4

World Oil Refinery Utilization

Definition

Average percentage utilization of global petroleum refinery capacity.

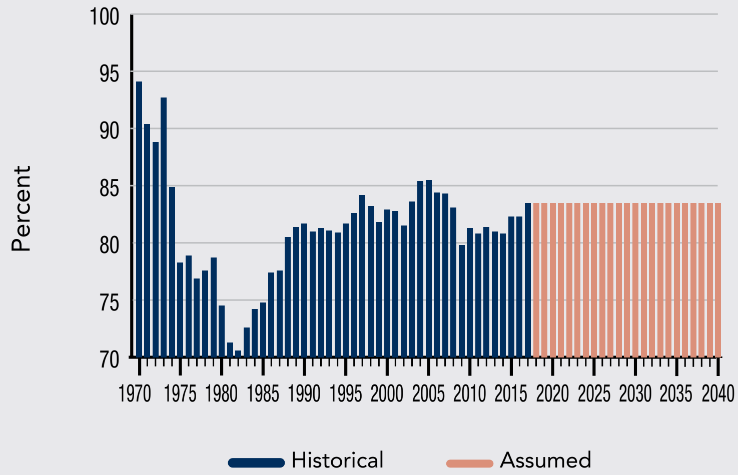
Importance

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

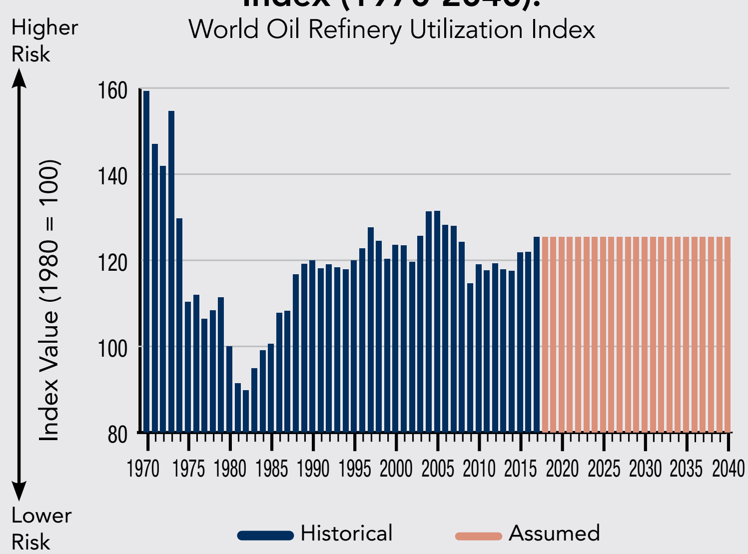
Category of Metric

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
Contribution in 2017	4.9	N/A	8.3	N/A	3.4

Petroleum Stock Levels

Definition

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

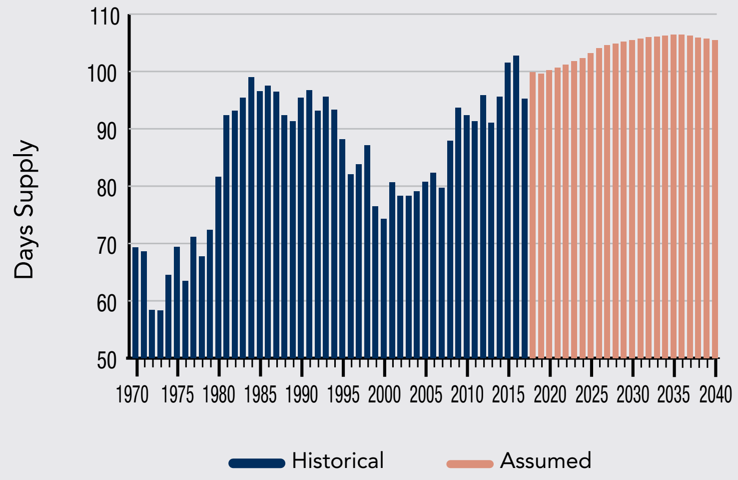
Importance

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.

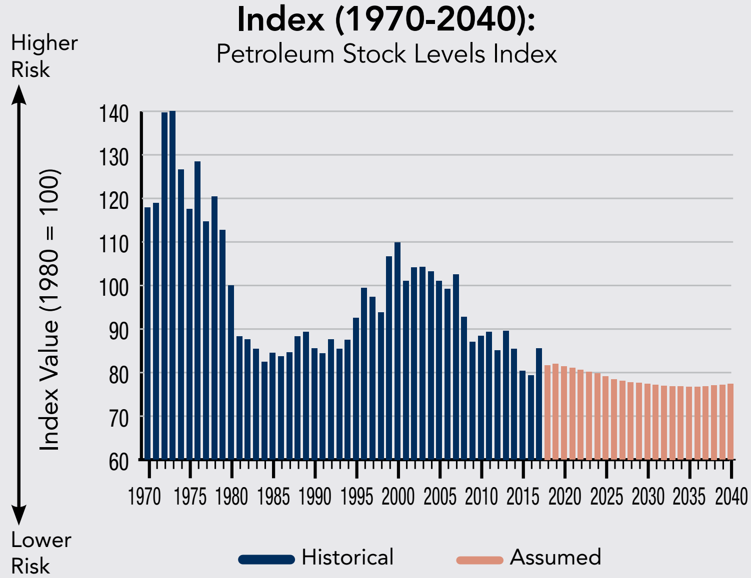
Category of Metric

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
Contribution in 2017	2.3	N/A	5.7	N/A	2.0

Energy Consumption per Capita

Definition

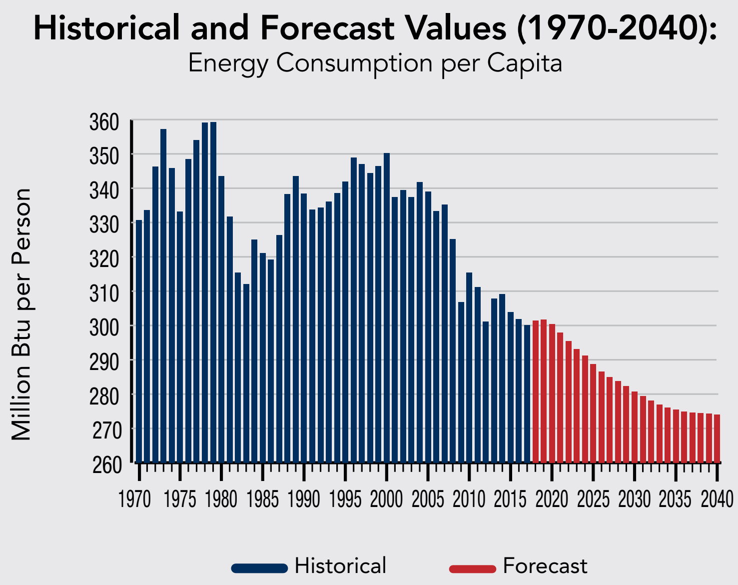
Million Btu consumed per person per year.

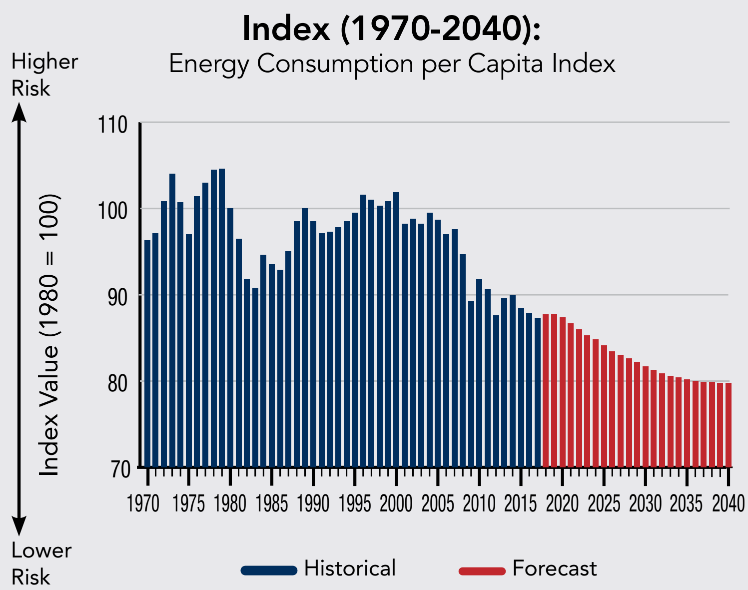
Importance

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

Category of Metric

Energy Use Intensity





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
Contribution in 2017	N/A	3.8	N/A	8.7	2.8

Energy Intensity

Definition

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

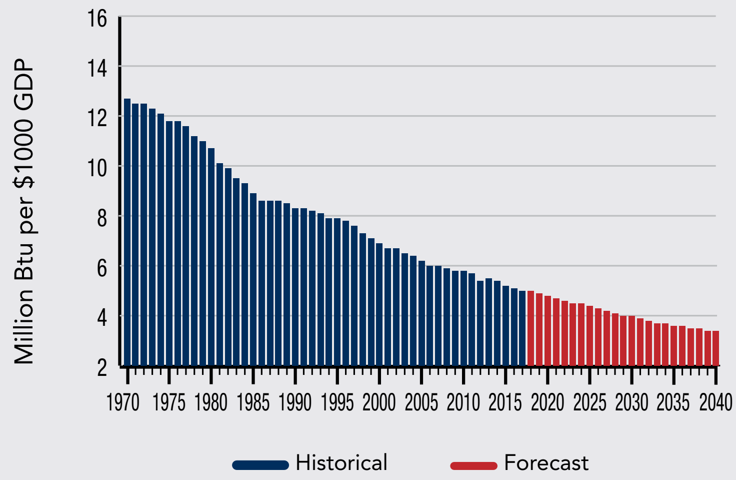
Importance

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

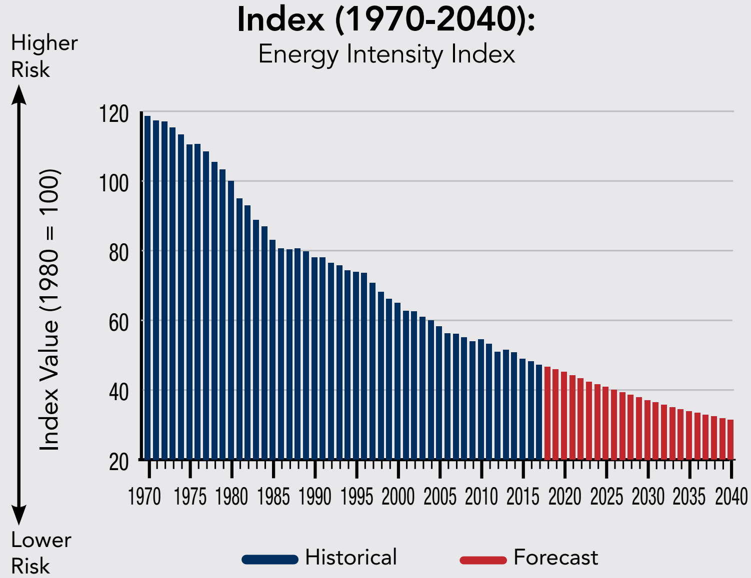
Category of Metric

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
Contribution in 2017	N/A	2.8	N/A	5.9	2.0

Petroleum Intensity

Definition

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

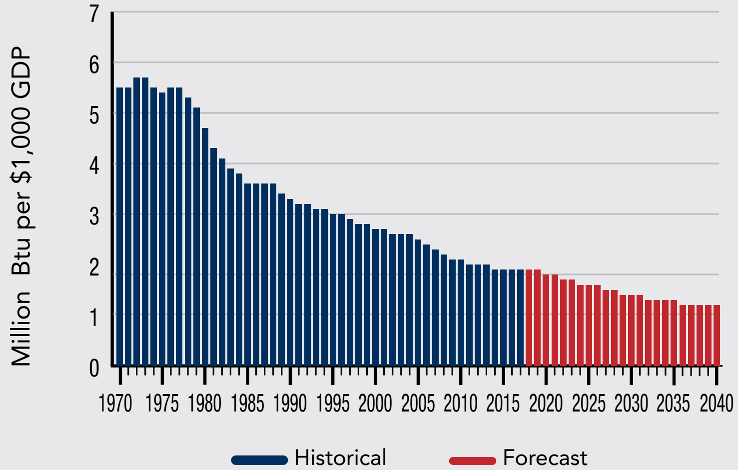
Importance

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

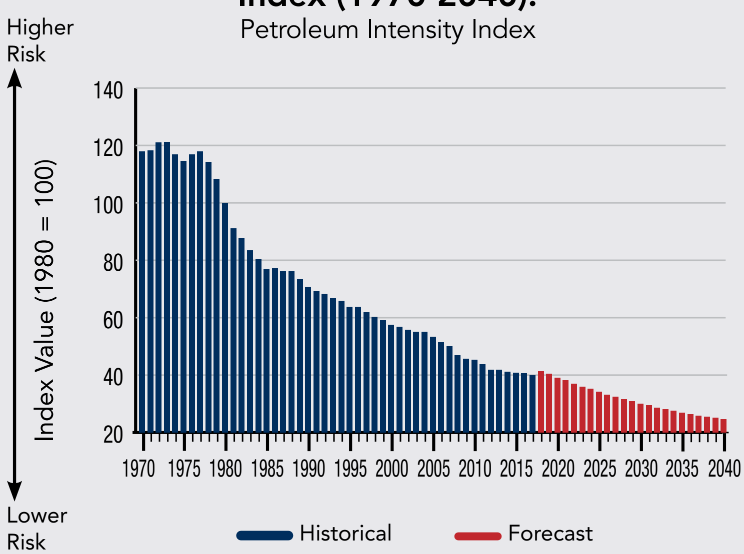
Category of Metric

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
Contribution in 2017	4.2	1.8	N/A	3.0	2.3

Household Energy Efficiency

Definition

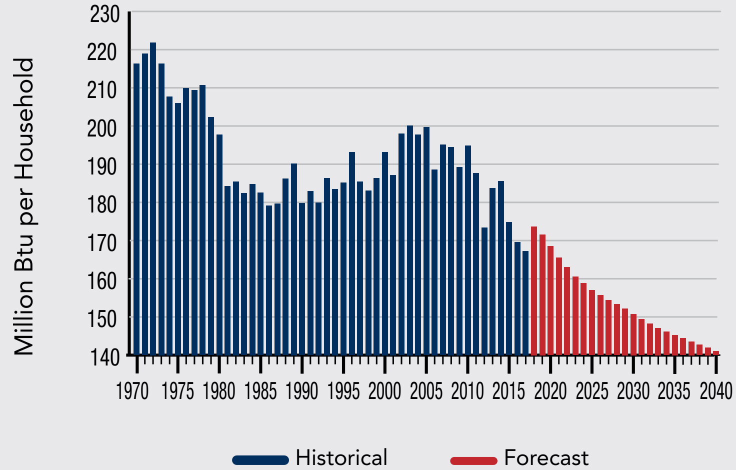
Million Btu of total energy consumed per household.

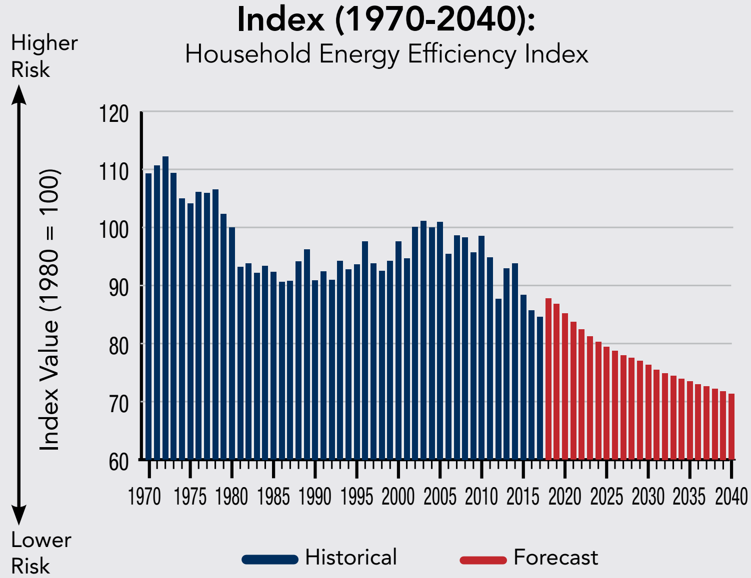
Importance

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

Category of Metric

Energy Use Intensity





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
Contribution in 2017	N/A	3.7	N/A	4.2	1.9

Commercial Energy Efficiency

Definition

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

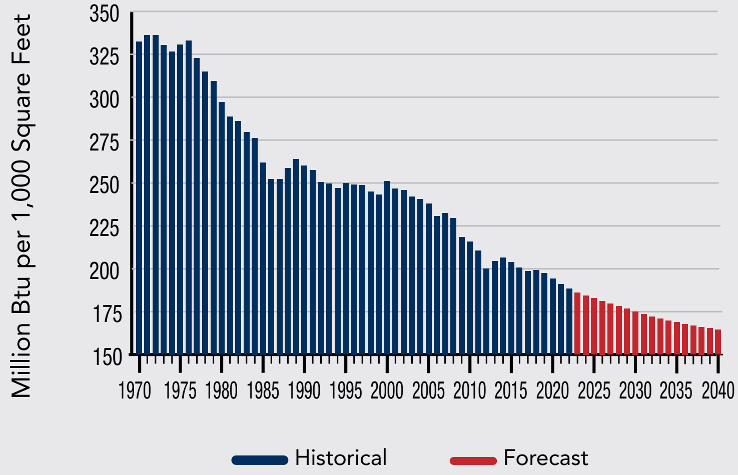
Importance

Indicates the degree to which commercial enterprises use energy efficiently.

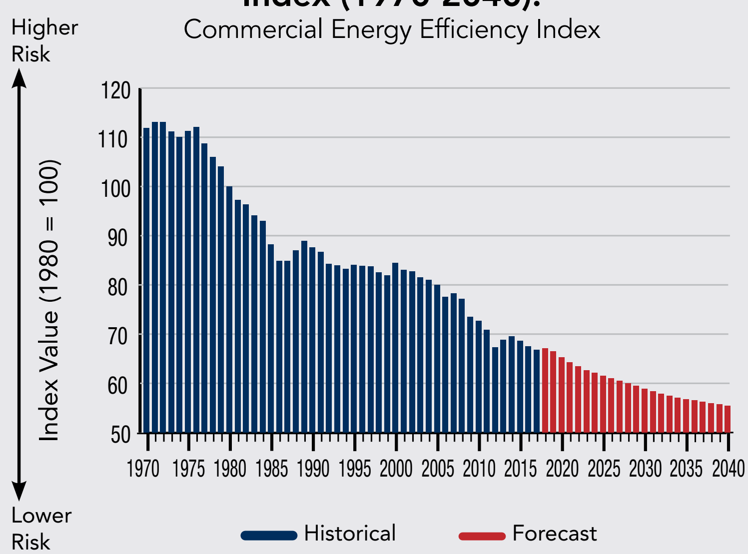
Category of Metric

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
Contribution in 2017	N/A	2.9	N/A	3.3	1.5

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.

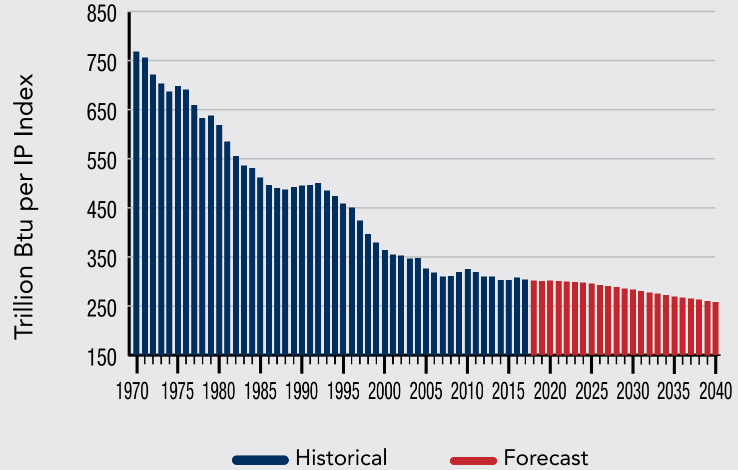
Importance

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

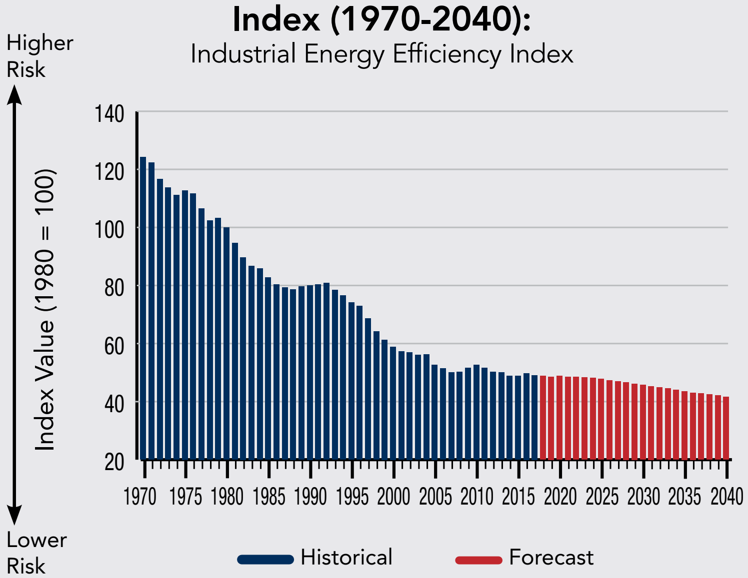
Category of Metric

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
Contribution in 2017	N/A	2.2	N/A	2.5	1.1

Electricity Capacity Diversity

Definition

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

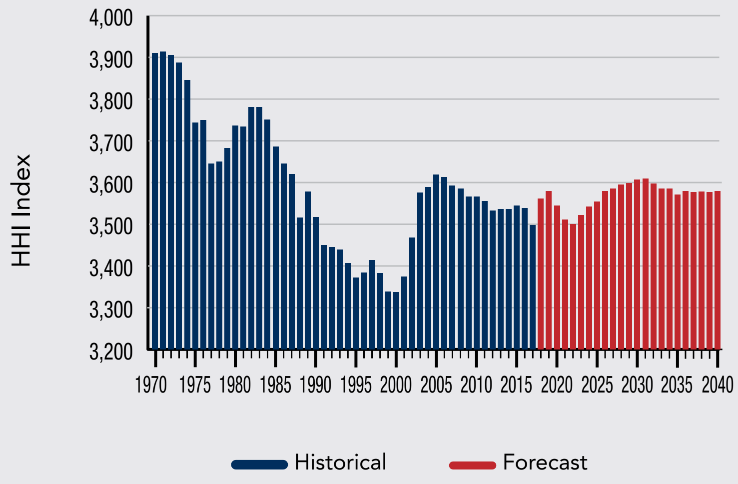
Importance

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

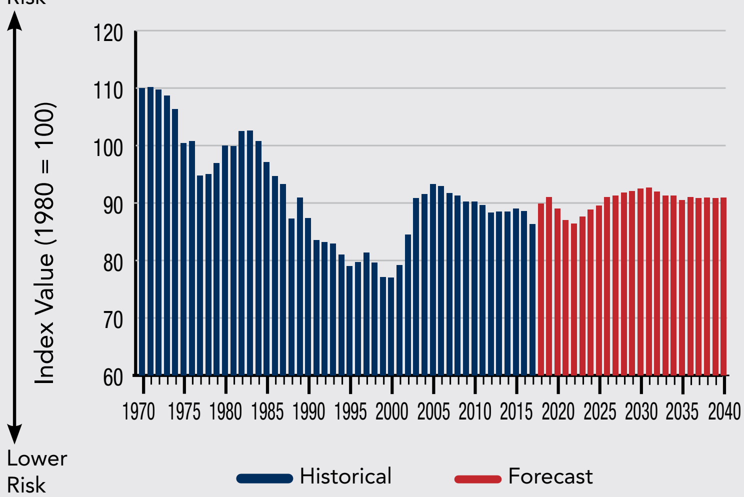
Category of Metric

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
Contribution in 2017	N/A	N/A	6.7	3.2	2.2

Electricity Capacity Margins

Definition

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

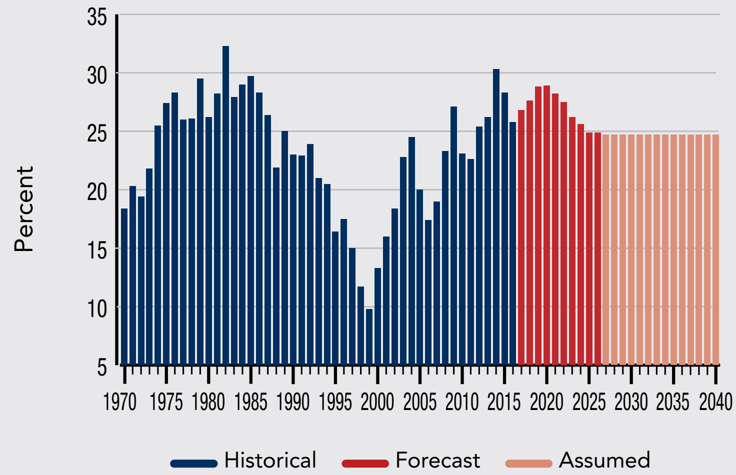
Importance

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.

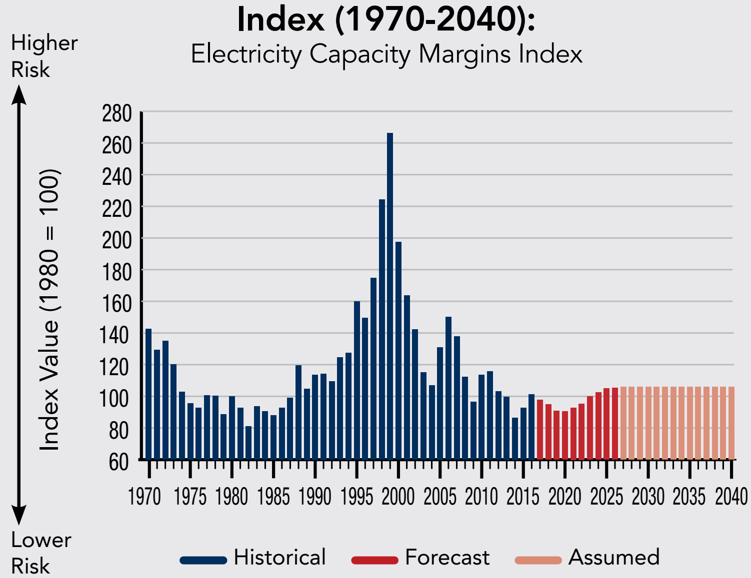
Category of Metric

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
Contribution in 2017	N/A	1.4	7.6	N/A	2.1

METRIC #27

Electric Power Transmission Line Mileage

Definition

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

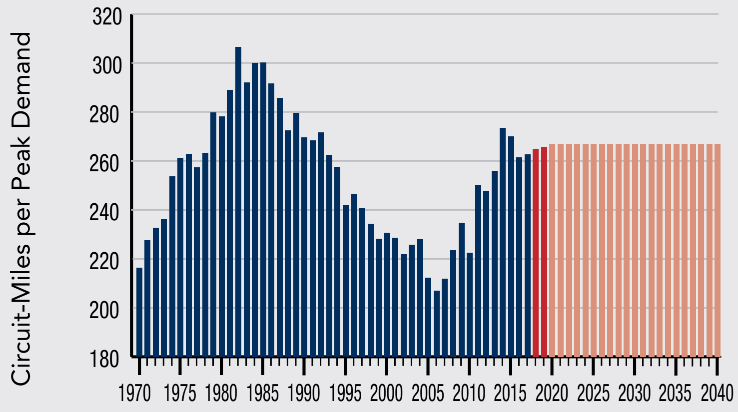
Importance

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

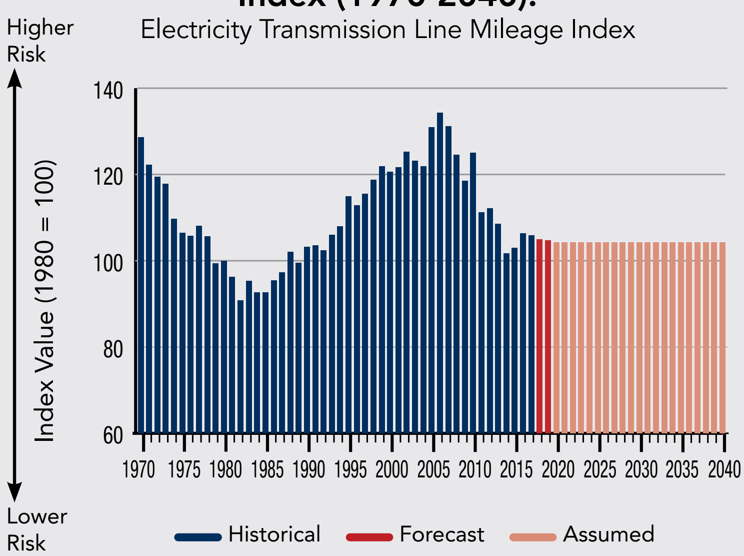
Category of Metric

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
Contribution in 2017	N/A	1.5	9.4	4.0	3.4

Motor Vehicle Average MPG

Definition

Average miles per gallon of passenger car fleet.

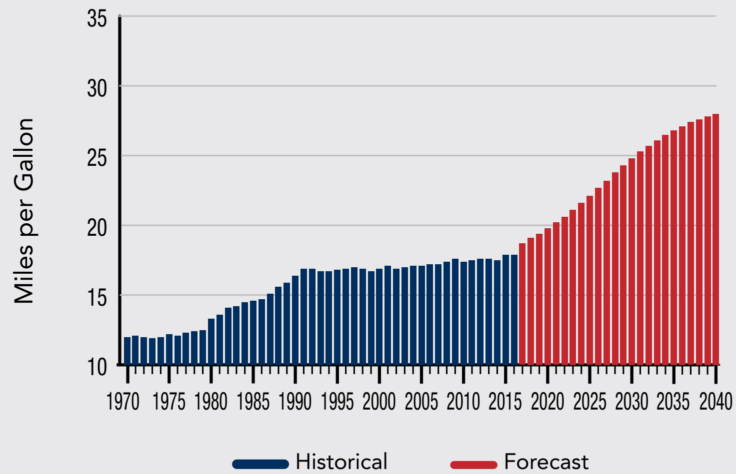
Importance

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

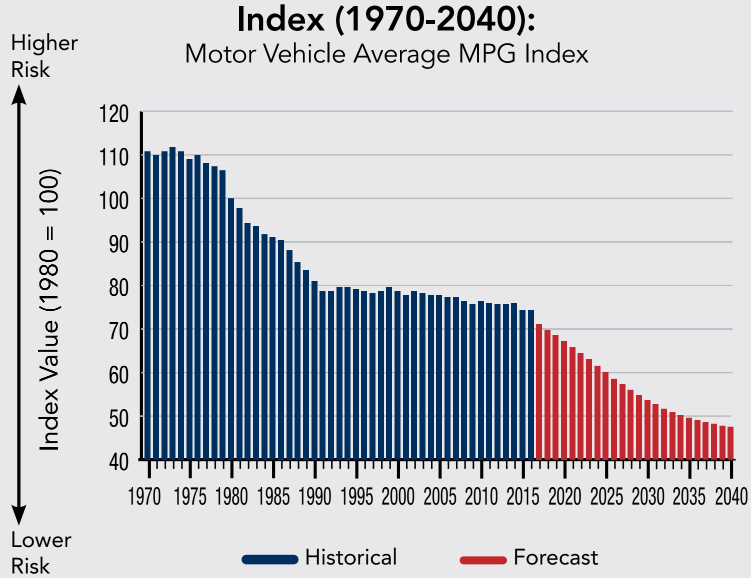
Category of Metric

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
Contribution in 2017	2.8	4.2	N/A	10.7	4.1

Vehicle-Miles Traveled per GDP

Definition

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

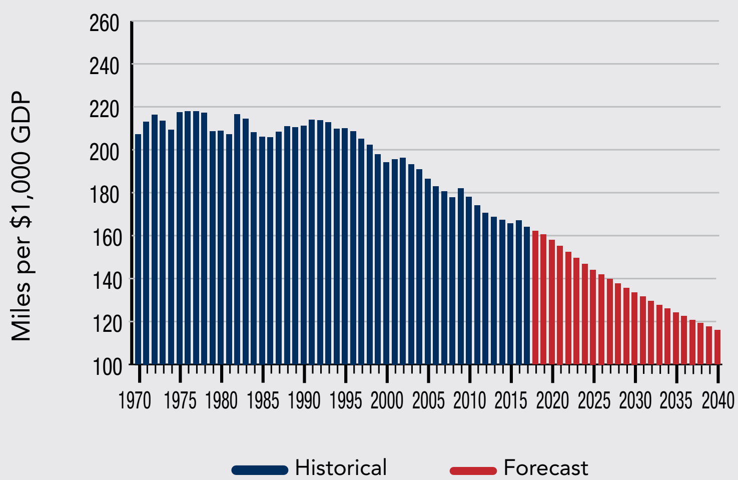
Importance

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

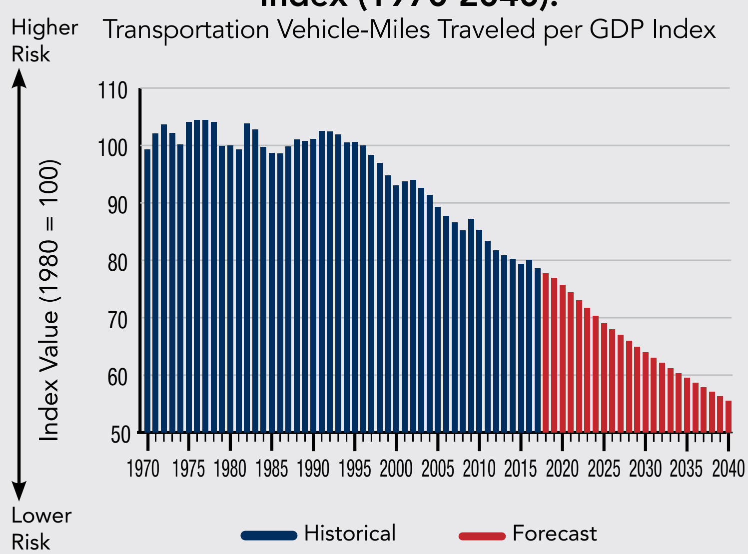
Category of Metric

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
Contribution in 2017	2.1	2.3	N/A	7.9	2.8

Transportation Non-Petroleum Fuel Use

Definition

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

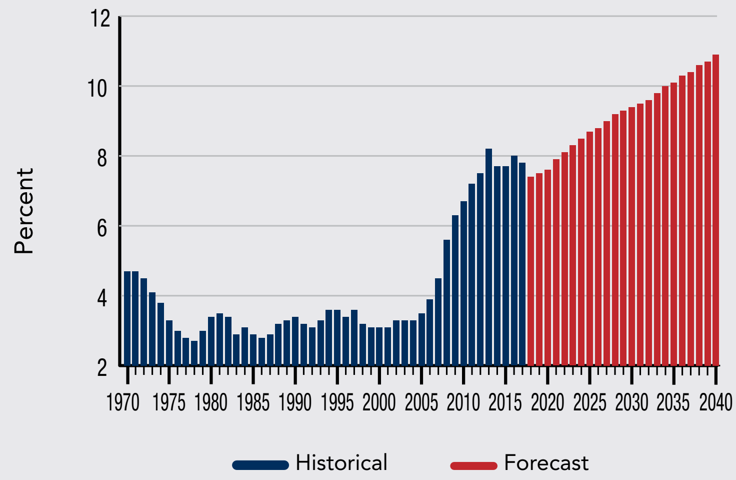
Importance

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

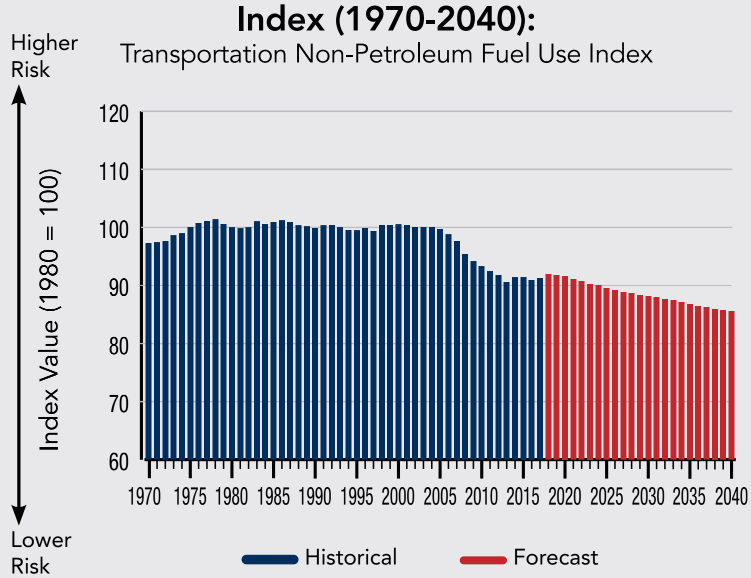
Category of Metric

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
Contribution in 2017	3.6	N/A	4.0	4.6	2.9

METRIC #31

Energy-Related Carbon Dioxide Emissions

Definition

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

Importance

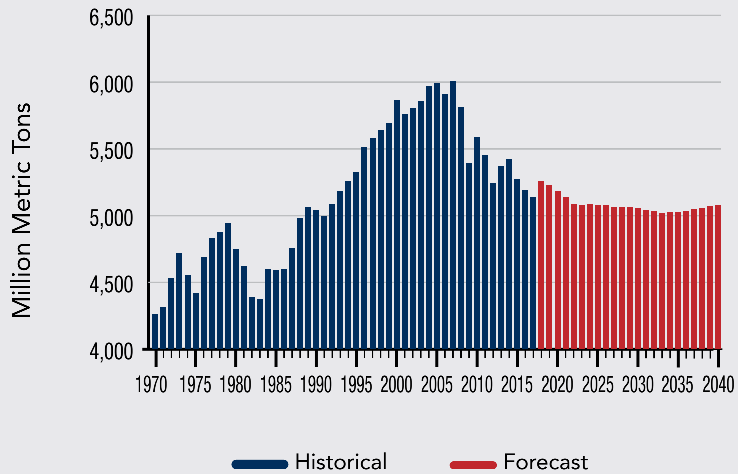
Indicates the exposure of the U.S. economy to domestic and international emissions reduction mandates.

Category of Metric

Environmental

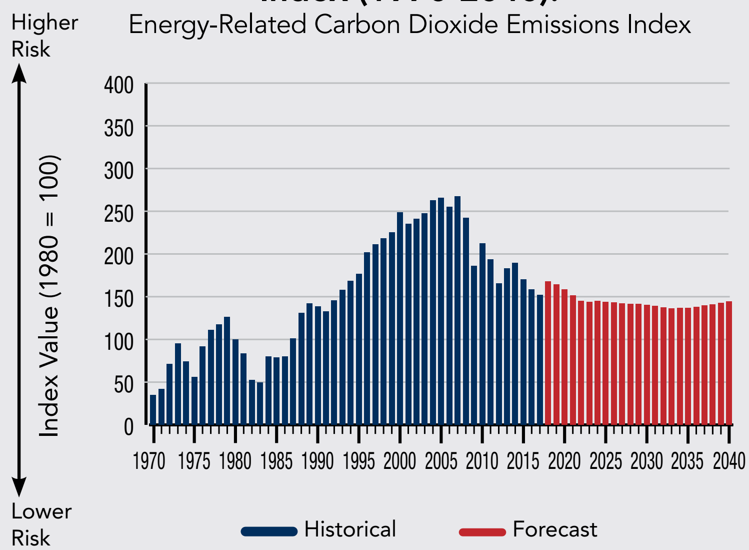
Historical and Forecast Values (1970-2040):

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
Contribution in 2017	4.0	N/A	N/A	13.3	3.9

METRIC #32

Energy-Related Carbon Dioxide Emissions per Capita

Definition

Million metric tons of CO_2 emissions from energy per capita.

Importance

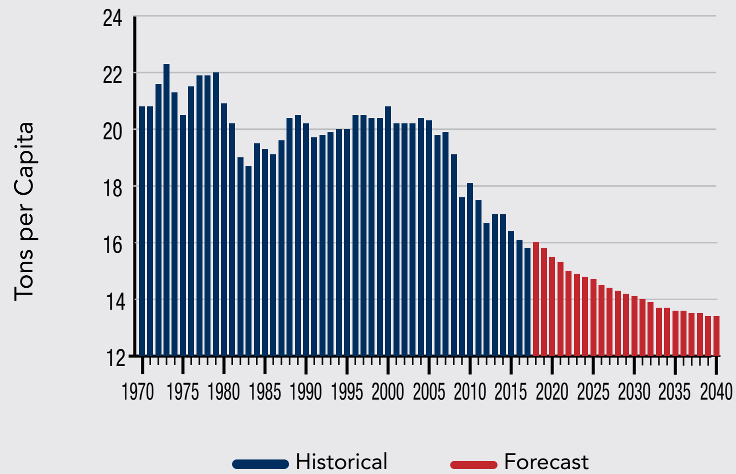
Indicates the joint effect of the amount of energy used per capita in the U.S. and the carbon intensity of that energy use.

Category of Metric

Environmental

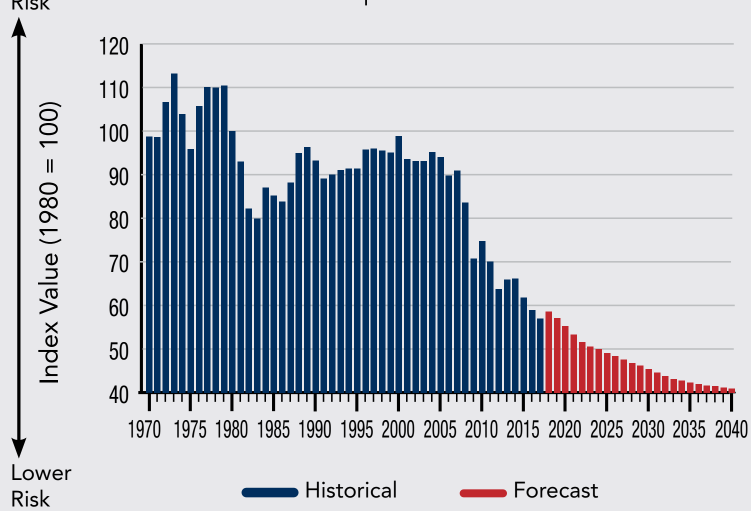
Historical and Forecast Values (1970-2040):

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
Contribution in 2017	1.5	N/A	N/A	3.6	1.2

Energy-Related Carbon Dioxide Emissions Intensity

Definition

Metric tons of CO_2 from energy per $1,000 of GDP in real (2015) dollars.

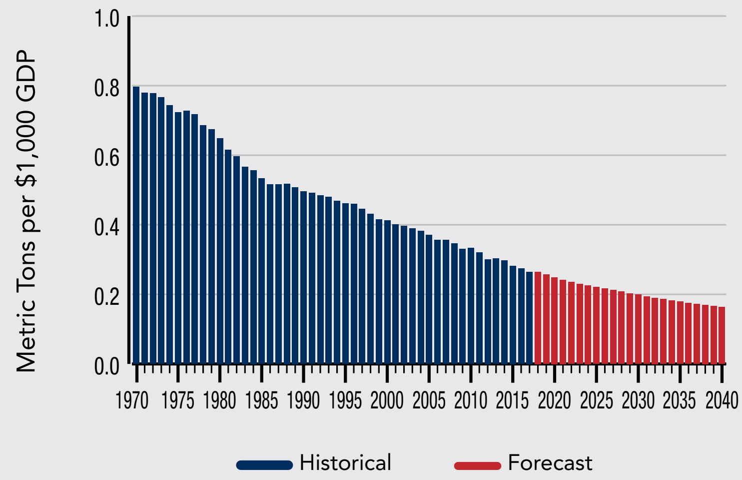
Importance

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

Category of Metric

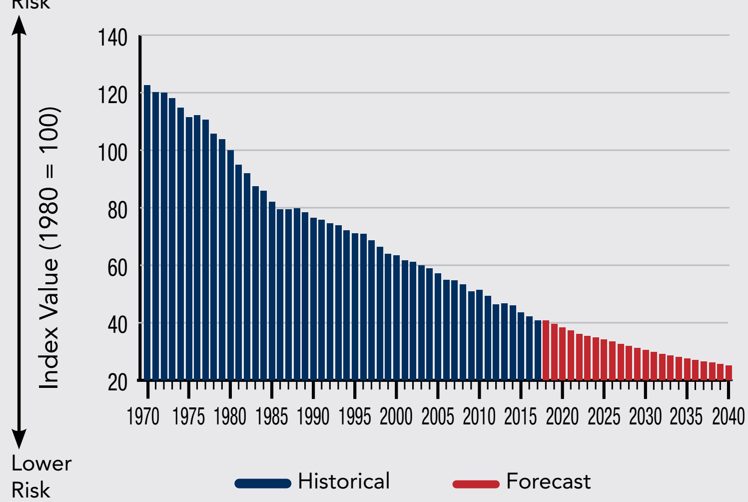
Environmental

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



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

Higher Risk



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
Contribution in 2017	1.1	N/A	N/A	2.5	0.8

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.

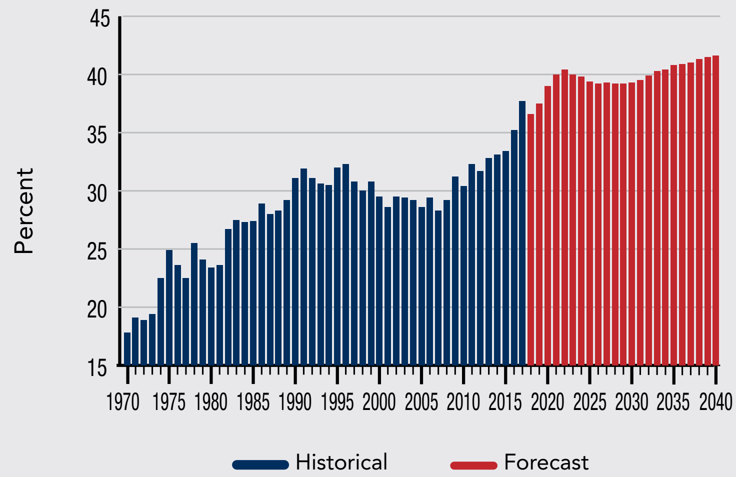
Importance

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

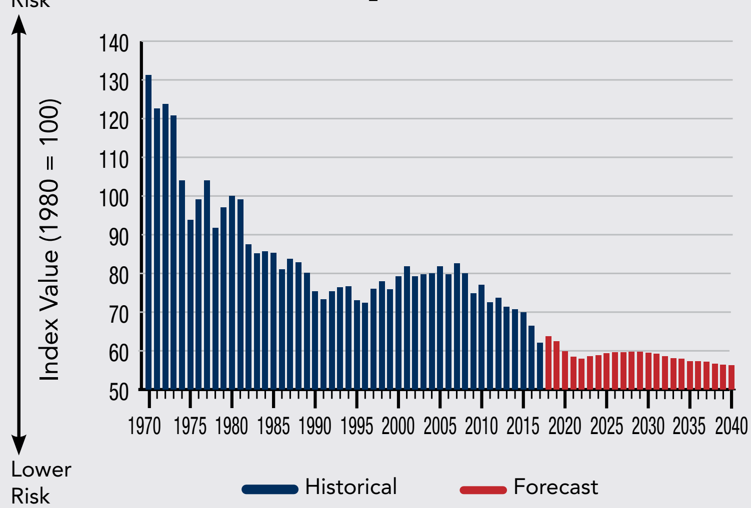
Category of Metric

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
Contribution in 2017	N/A	N/A	3.4	5.4	1.9

Industrial Energy R&D Expenditures

Definition

Dollars of industrial energy-related R&D (non-Federal) per $1,000 of GDP in real (2015) dollars.

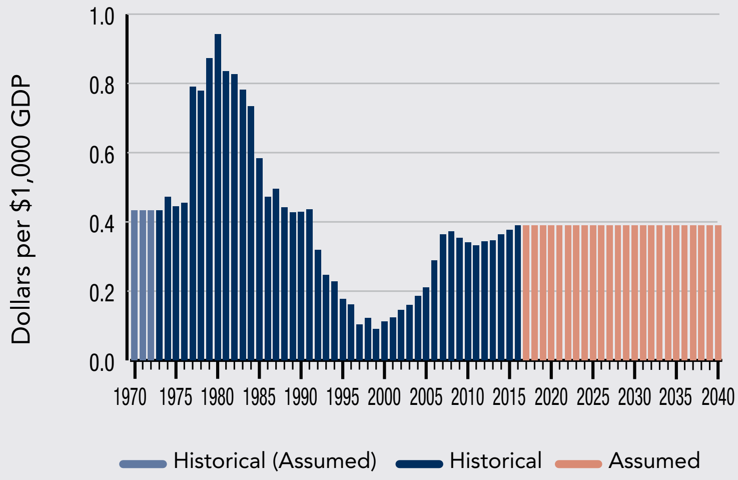
Importance

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

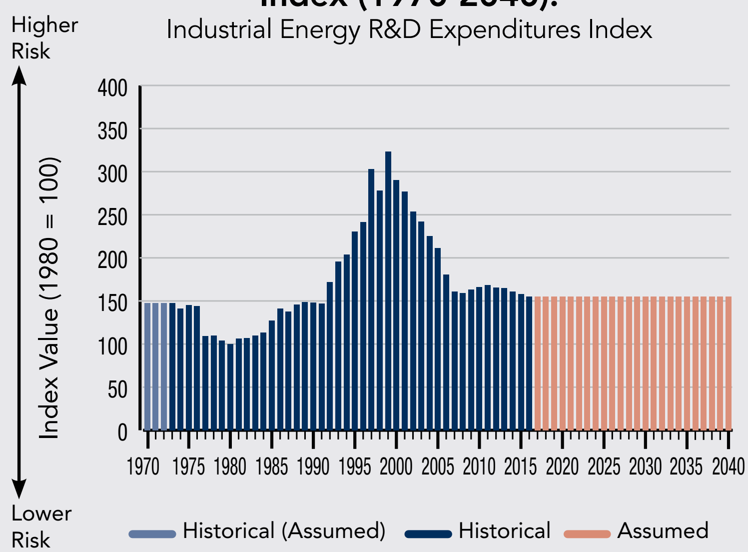
Category of Metric

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
Contribution in 2017	N/A	2.3	3.4	3.9	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

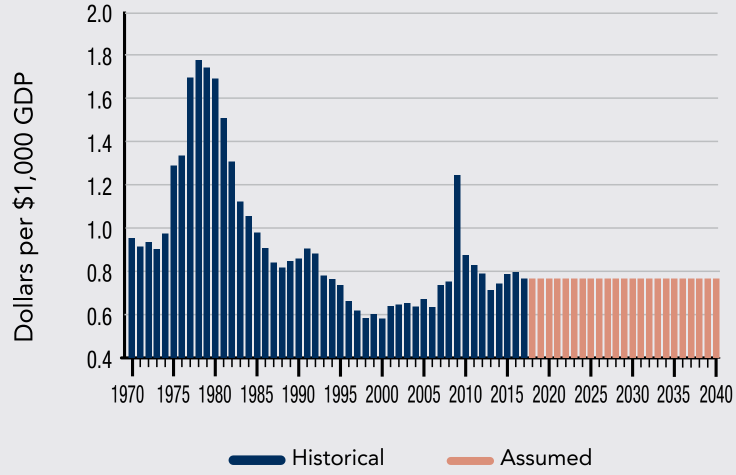
Indicates prospects for new scientific and technological breakthroughs through federally-supported public-private research.

Category of Metric

Research & Development

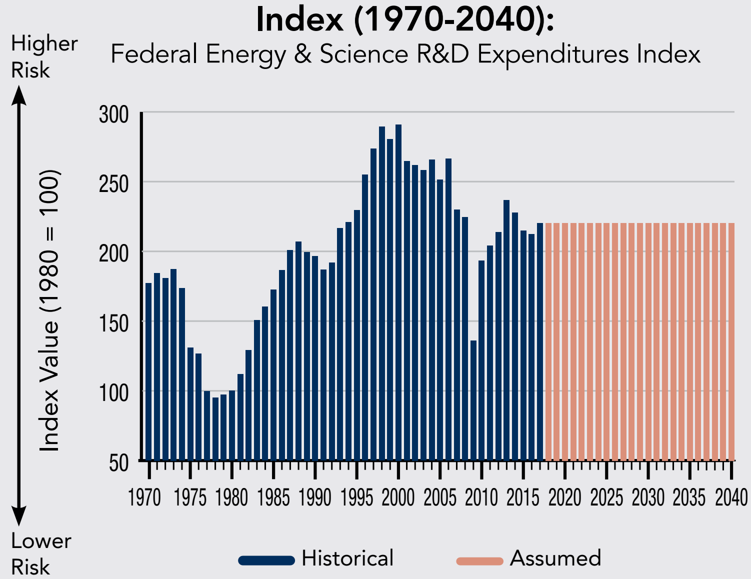
Historical and Forecast Values (1970-2040):

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
Contribution in 2017	N/A	3.2	4.9	5.5	3.1

Science & Engineering Degrees

Definition

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

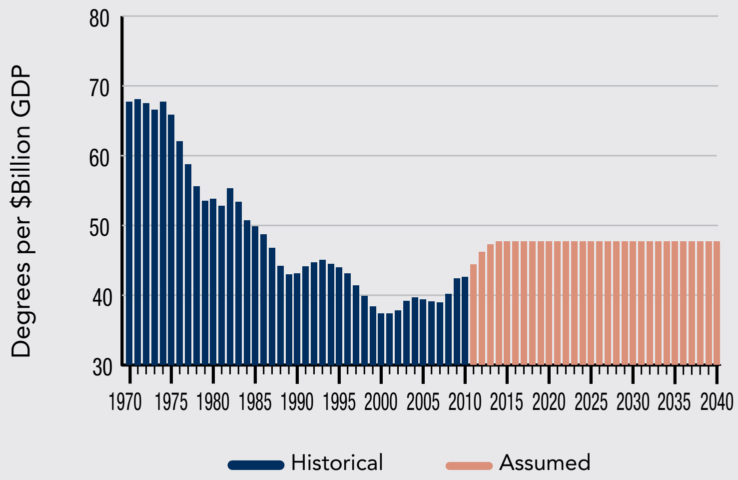
Importance

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

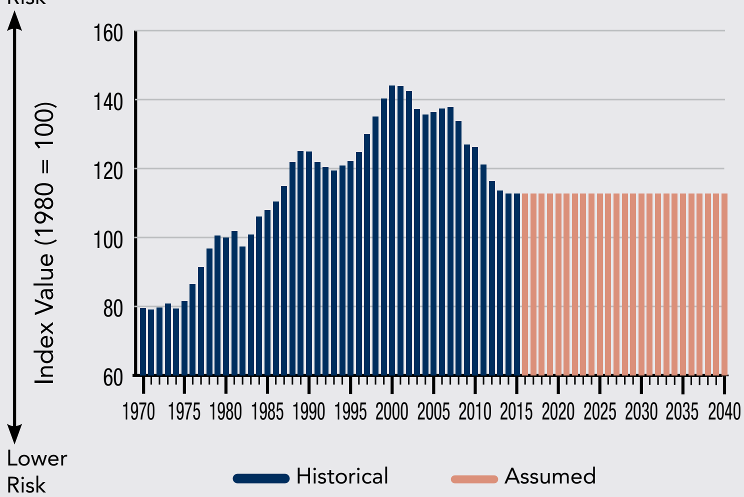
Category of Metric

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
Contribution in 2017	N/A	1.6	2.5	2.8	1.6

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	122.6	114.7	113.0	105.9	104.3	110.6	114.3
2	Security of World Oil Production	production, freedom & diversity-weighted	88.0	89.4	91.1	92.4	97.8	106.2	111.1
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	57.4	67.3	73.8	78.0	83.8	101.5	106.1
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	69.8	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	94.4	96.0	103.1	103.3
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	19.6	22.4	25.8	32.7	35.4	39.1	45.6
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$	$16.3	$19.4	$23.0	$56.4	$105.3	$98.5	$123.1
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 $1,000 GDP (2015$)	$78.42	$78.49	$77.85	$79.74	$100.80	$103.58	$105.14
12	Energy Expenditures per Household	2015$/Household	$6,483	$6,554	$6,652	$6,999	$8,589	$8,641	$9,055
13	Retail Electricity Prices	cents/kWh (2015$)	8.5¢	8.5¢	8.6¢	8.6¢	9.9¢	10.5¢	10.6¢
14	Crude Oil Price	2015$/bbl	$13.52	$13.78	$13.41	$25.21	$48.44	$45.43	$46.80
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$0.58	$0.49	$0.23	$4.14	$11.80	$12.68	$9.20
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/$1,000 GDP (2015$)	12.7	12.5	12.5	12.3	12.1	11.8	11.8
21	Petroleum Intensity	million Btu/real $1,000 GDP (2015$)	5.51	5.52	5.66	5.66	5.47	5.36	5.46
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	768	756	721	703	687	698	690
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/$1,000 GDP (2015$)	207	213	216	213	209	217	218
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	4,715	4,556	4,421	4,689
32	Energy-Related CO_2 Emissions per Capita	metric tons CO_2/Person	20.8	20.8	21.6	22.3	21.3	20.5	21.5
33	Energy-Related CO_2 Emissions Intensity	metric tons CO_2/$1,000 GDP (2015$)	0.80	0.78	0.78	0.77	0.74	0.72	0.73
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$)	67.7	68.1	67.5	66.6	67.7	65.9	62.1

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
107.2	97.5	102.1	100.0	96.5	93.4	98.5	104.4	104.0	110.8	109.8	99.3	100.5	124.1	119.2	127.0	133.6	132.2
104.4	94.2	91.6	100.0	100.4	94.0	90.7	93.9	91.1	95.1	90.0	80.8	83.2	78.2	76.6	73.8	78.5	76.7
113.4	100.0	98.0	100.0	106.0	120.2	122.2	141.6	136.0	136.5	124.1	94.4	100.9	86.5	88.2	77.1	85.9	87.3
91.8	87.4	88.5	100.0	103.4	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	57.6	62.4	58.3
94.9	93.4	90.7	100.0	100.4	102.3	102.8	110.4	109.3	108.7	102.8	96.7	103.1	89.0	87.4	82.7	91.2	90.5
48.6	40.1	39.1	37.3	34.5	26.9	26.0	28.3	24.8	31.4	31.3	29.6	32.7	30.8	28.6	27.7	31.6	31.5
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
$152.8	$134.3	$187.5	$220.2	$186.3	$129.5	$109.4	$113.9	$94.9	$57.1	$79.0	$69.8	$88.6	$110.1	$84.6	$84.6	$82.1	$79.4
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%
$107.61	$103.36	$115.09	$133.13	$135.66	$129.79	$116.85	$109.67	$102.66	$85.18	$83.11	$79.76	$79.00	$80.81	$77.90	$74.23	$72.85	$70.32
$9,518	$9,429	$10,610	$12,014	$12,081	$11,211	$10,457	$10,309	$9,883	$8,369	$8,320	$8,184	$8,272	$8,557	$8,153	$7,951	$7,909	$7,863
11.0¢	11.2¢	11.1¢	12.0¢	12.9¢	13.4¢	13.3¢	12.8¢	12.8¢	12.5¢	12.1¢	11.6¢	11.4¢	11.2¢	11.1¢	11.0¢	10.9¢	10.6¢
$48.02	$45.04	$62.83	$92.96	$92.32	$79.19	$66.16	$63.41	$57.53	$27.32	$35.10	$27.28	$32.11	$40.36	$32.94	$31.05	$26.70	$24.38
$1.87	$1.86	$7.33	$16.97	$16.18	$14.63	$8.93	$9.64	$7.22	$12.95	$14.62	$15.26	$6.80	$6.96	$6.83	$5.85	$4.55	$2.85
$5.24	$4.70	$7.47	$11.16	$12.37	$10.53	$6.90	$4.92	$3.17	$5.61	$5.46	$4.50	$0.91	$1.74	$2.72	$2.31	$1.43	$0.59
76.9%	77.6%	78.7%	74.5%	71.3%	70.6%	72.6%	74.2%	74.8%	77.4%	77.6%	80.5%	81.4%	81.7%	81.0%	81.3%	81.1%	80.9%
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	338.4	333.8	334.4	336.1	338.6
11.6	11.2	11.0	10.7	10.1	9.9	9.5	9.3	8.9	8.6	8.6	8.6	8.5	8.3	8.3	8.2	8.1	7.9
5.51	5.34	5.06	4.68	4.25	4.11	3.90	3.76	3.59	3.61	3.56	3.56	3.43	3.30	3.24	3.19	3.12	3.08
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	180.0	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
659	633	638	618	585	555	536	531	511	497	490	487	493	496	497	500	485	474
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
218	217	208	209	207	217	215	208	206	206	208	211	210	211	214	214	213	210
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%
4,830	4,879	4,945	4,750	4,625	4,393	4,371	4,600	4,593	4,598	4,757	4,982	5,065	5,039	4,993	5,090	5,184	5,261
21.9	21.9	22.0	20.9	20.2	19.0	18.7	19.5	19.3	19.1	19.6	20.4	20.5	20.2	19.7	19.8	19.9	20.0
0.72	0.69	0.67	0.65	0.62	0.60	0.57	0.56	0.53	0.52	0.52	0.52	0.51	0.50	0.49	0.48	0.48	0.47
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
58.8	55.6	53.5	53.8	52.8	55.3	53.4	50.7	49.9	48.7	46.8	44.2	43.0	43.1	44.1	44.7	45.1	44.5

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	131.3	127.5	128.6	125.3	124.5	127.7	126.9
2	Security of World Oil Production	production, freedom & diversity-weighted	75.2	71.0	71.2	69.2	69.1	69.7	70.3
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	87.6	87.3	87.0	88.7	92.9	99.3	98.7
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	56.6	53.1	50.7	49.8	52.8	58.2	57.5
6	Security of World Coal Production	production, freedom & diversity-weighted	89.5	88.6	83.5	74.3	74.6	82.6	84.5
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	30.0	29.4	31.1	31.5	30.8	32.3	34.2
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$	$80.7	$104.6	$103.4	$74.7	$103.0	$172.6	$151.7
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 $1,000 GDP (2015$)	$68.36	$70.42	$67.16	$58.94	$58.87	$68.07	$66.73
12	Energy Expenditures per Household	2015$/Household	$7,750	$8,205	$8,080	$7,311	$7,542	$9,010	$8,811
13	Retail Electricity Prices	cents/kWh (2015$)	10.4¢	10.1¢	10.0¢	9.7¢	9.4¢	9.4¢	9.9¢
14	Crude Oil Price	2015$/bbl	$25.63	$30.52	$27.78	$18.35	$25.36	$39.70	$33.12
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$2.64	$2.82	$2.96	$5.69	$6.39	$10.26	$9.31
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%	84.2%	83.2%	81.8%	82.9%	82.8%
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	344.4	346.4	350.2	337.5
20	Energy Intensity	million Btu/$1,000 GDP (2015$)	7.9	7.8	7.6	7.3	7.1	6.9	6.7
21	Petroleum Intensity	million Btu/real $1,000 GDP (2015$)	2.98	2.98	2.89	2.82	2.76	2.69	2.65
22	Household Energy Efficiency	million Btu/household	185.2	193.1	185.5	183.1	186.4	193.2	187.2
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	459	451	424	397	379	364	354
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/$1,000 GDP (2015$)	210	209	205	202	198	194	196
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	$MMTCO_2$	5,324	5,511	5,584	5,637	5,690	5,867	5,762
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/$1,000 GDP (2015$)	0.46	0.46	0.45	0.43	0.42	0.41	0.40
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$)	44.0	43.1	41.4	39.9	38.4	37.4	37.4

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
123.8	90.7	91.9	87.0	86.7	86.3	86.8	86.8	88.2	93.2	94.0	94.8	99.0	97.3	103.6	105.9	105.9	105.9
67.1	70.0	74.7	74.3	74.8	74.9	77.7	76.0	78.7	82.6	82.8	82.3	84.9	85.2	90.1	94.3	93.9	93.4
94.7	92.5	97.1	97.9	96.7	97.0	96.0	96.0	92.8	93.0	95.3	96.6	99.6	100.3	108.1	107.6	107.6	107.6
71.1	71.5	76.3	77.0	78.3	78.6	78.0	74.2	77.2	82.1	81.3	82.7	87.7	88.0	93.5	97.5	97.2	99.0
55.3	64.3	66.7	64.4	70.8	70.8	68.0	67.7	68.6	66.7	66.8	67.4	67.5	67.5	67.5	67.5	67.5	67.5
87.6	100.4	111.2	116.1	124.1	129.2	133.3	144.9	154.0	161.3	163.9	185.3	182.4	189.2	201.8	201.8	201.8	201.8
31.3	34.4	38.0	38.8	38.7	37.7	38.3	34.0	33.8	32.4	29.4	24.4	20.6	18.9	20.2	15.5	14.3	11.4
7.4	7.2	7.9	8.5	8.3	8.6	6.7	5.6	5.4	4.3	3.2	2.7	2.5	2.0	1.5	-0.3	-1.5	-4.4
$144.5	$178.7	$241.2	$348.0	$381.2	$402.4	$480.8	$259.3	$320.4	$385.6	$329.3	$267.5	$196.2	$95.4	$79.5	$73.5	$66.8	$53.3
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%	0.4%	0.4%	0.3%	0.3%
$61.57	$66.78	$72.25	$81.30	$85.14	$86.76	$97.43	$75.28	$82.56	$91.27	$85.38	$83.93	$81.48	$63.35	$56.76	$57.62	$57.32	$57.44
$8,437	$9,354	$10,402	$11,913	$12,651	$13,034	$14,451	$10,862	$12,157	$13,454	$12,755	$12,732	$12,591	$9,908	$8,938	$9,555	$9,673	$9,855
9.6¢	9.7¢	9.7¢	10.0¢	10.6¢	10.6¢	11.1¢	11.1¢	11.0¢	10.9¢	10.6¢	10.7¢	10.9¢	10.7¢	10.5¢	10.5¢	10.6¢	10.7¢
$33.33	$37.73	$48.69	$67.28	$77.95	$84.41	$110.79	$70.03	$89.21	$122.15	$120.34	$115.17	$103.14	$53.94	$44.43	$54.13	$52.89	$56.25
$7.04	$3.72	$5.19	$11.32	$13.41	$11.91	$14.50	$24.53	$28.77	$30.96	$17.98	$13.31	$6.33	$22.13	$23.58	$22.81	$11.55	$12.29
$5.19	$3.74	$5.99	$8.34	$8.02	$6.50	$6.35	$12.72	$14.38	$14.06	$7.37	$4.43	$1.35	$5.32	$7.08	$6.79	$6.50	$6.21
81.5%	83.6%	85.4%	85.5%	84.4%	84.3%	83.1%	79.8%	81.3%	80.8%	81.4%	81.0%	80.8%	82.3%	82.3%	83.5%	83.5%	83.5%
78	78	79	81	82	80	88	94	92	91	96	91	96	101	103	95	100	100
339.5	337.5	341.8	339.0	333.4	335.3	325.2	306.8	315.4	311.2	301.1	307.8	309.2	303.9	301.9	300.1	301.4	301.7
6.7	6.5	6.4	6.2	6.0	6.0	5.9	5.8	5.8	5.7	5.4	5.5	5.4	5.2	5.1	5.0	5.0	4.9
2.61	2.58	2.57	2.50	2.40	2.34	2.19	2.14	2.12	2.04	1.95	1.96	1.92	1.91	1.90	1.87	1.94	1.89
198.0	200.1	197.8	199.7	188.6	195.1	194.5	189.3	194.8	187.6	173.4	183.7	185.6	174.8	169.6	167.3	173.7	171.6
245.8	242.1	240.6	237.8	230.6	232.5	229.4	218.3	215.8	210.6	200.0	204.3	206.5	203.7	200.6	198.5	199.3	197.4
353	347	348	326	318	310	311	319	326	319	310	309	302	302	308	304	302	300
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	3,545	3,538	3,498	3,561	3,579
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%	28.3%	25.8%	26.8%	27.6%	28.8%
222	226	228	212	207	212	223	235	223	250	248	256	273	270	261	263	265	266
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	17.9	17.9	18.7	19.1	19.4
196	193	191	186	183	181	178	182	178	174	170	169	167	166	167	164	162	161
3.3%	3.3%	3.3%	3.5%	3.9%	4.5%	5.6%	6.3%	6.7%	7.2%	7.5%	8.2%	7.7%	7.7%	8.0%	7.8%	7.4%	7.5%
5,805	5,855	5,971	5,992	5,912	6,005	5,815	5,396	5,591	5,454	5,243	5,372	5,419	5,274	5,188	5,140	5,257	5,230
20.2	20.2	20.4	20.3	19.8	19.9	19.1	17.6	18.1	17.5	16.7	17.0	17.0	16.4	16.1	15.8	16.0	15.8
0.40	0.39	0.38	0.37	0.36	0.36	0.35	0.33	0.33	0.32	0.30	0.30	0.30	0.28	0.27	0.27	0.26	0.26
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%	33.4%	35.2%	37.7%	36.6%	37.5%
$0.15	$0.16	$0.19	$0.21	$0.29	$0.36	$0.37	$0.35	$0.34	$0.33	$0.34	$0.35	$0.36	$0.38	$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	$0.74	$0.79	$0.80	$0.77	$0.77	$0.77
37.8	39.2	39.7	39.4	39.1	39.0	40.2	42.4	42.6	44.4	46.2	47.3	47.7	47.7	47.7	47.7	47.7	47.7

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	105.9	105.9	105.9	105.9	105.9	105.9	105.9
2	Security of World Oil Production	production, freedom & diversity-weighted	92.8	91.5	92.8	93.0	93.1	93.1	93.1
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	107.6	107.6	107.6	107.6	107.6	107.6	107.6
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	101.3	101.3	102.2	101.6	101.7	101.1	100.8
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	67.5	67.5	67.5	67.5	67.5	67.5	67.5
6	Security of World Coal Production	production, freedom & diversity-weighted	201.8	201.8	201.8	201.8	201.8	201.8	201.8
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	8.9	6.7	5.6	5.0	3.7	2.7	1.6
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	-7.8	-8.4	-9.3	-10.2	-11.6	-12.5	-13.1
9	Oil & Natural Gas Import Expenditures	billions of 2015$	$46.0	$36.1	$26.6	$19.2	$5.7	($3.3)	($10.8)
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.2%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2015$)	$61.19	$61.73	$61.18	$60.57	$60.17	$59.10	$57.77
12	Energy Expenditures per Household	2015$/Household	$10,649	$10,877	$10,919	$10,925	$10,961	$10,876	$10,749
13	Retail Electricity Prices	cents/kWh (2015$)	10.9¢	10.9¢	10.9¢	11.0¢	11.0¢	11.1¢	11.2¢
14	Crude Oil Price	2015$/bbl	$69.96	$77.36	$80.55	$82.95	$84.51	$85.70	$87.47
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$15.28	$16.89	$17.59	$18.11	$18.45	$18.71	$19.10
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2015$)	$5.91	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62
17	World Oil Refinery Utilization	percent utilization	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%
18	Petroleum Stock Levels	average days supply	100	101	101	102	102	103	104
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	300.4	298.0	295.5	293.2	291.3	288.8	286.6
20	Energy Intensity	million Btu/$1,000 GDP (2015$)	4.8	4.7	4.6	4.5	4.5	4.4	4.3
21	Petroleum Intensity	million Btu/real $1,000 GDP (2015$)	1.83	1.78	1.73	1.68	1.64	1.60	1.55
22	Household Energy Efficiency	million Btu/household	168.5	165.5	163.0	160.5	158.8	157.0	155.7
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	194.1	191.0	188.4	186.0	184.4	182.8	181.2
24	Industrial Energy Efficiency	trillion Btu/IP Index	302	301	300	299	298	296	293
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,545	3,511	3,500	3,521	3,542	3,554	3,580
26	Electricity Capacity Margins	percent	28.9%	28.2%	27.5%	26.2%	25.6%	24.9%	24.9%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	267	267	267	267	267	267	267
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	19.8	20.2	20.6	21.1	21.6	22.1	22.7
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2015$)	158	155	152	150	147	144	142
30	Transportation Non-Petroleum Fuels	percent	7.6%	7.9%	8.1%	8.3%	8.5%	8.7%	8.8%
Environmental Metrics									
31	Energy-Related CO_2 Emissions	$MMTCO_2$	5,187	5,136	5,088	5,078	5,086	5,079	5,075
32	Energy-Related CO_2 Emissions per Capita	metric tons CO_2/Person	15.5	15.3	15.0	14.9	14.8	14.7	14.5
33	Energy-Related CO_2 Emissions Intensity	metric tons CO_2/$1,000 GDP (2015$)	0.25	0.24	0.23	0.23	0.23	0.22	0.22
34	Electricity Non-CO_2 Generation Share	percent of total generation	39.0%	40.0%	40.4%	40.0%	39.8%	39.4%	39.2%
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 $/$1,000 GDP (2015$)	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77
37	Science & Engineering Degrees	# degrees/$billion GDP (2015$)	47.7	47.7	47.7	47.7	47.7	47.7	47.7

Summary Table 1: Energy Security Metrics (Values)

2027-2040

2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9
93.1	93.2	93.3	93.3	93.3	93.3	93.4	93.4	93.5	93.6	93.7	93.8	93.8	93.7
107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6
100.4	100.3	101.4	101.7	101.0	101.4	100.7	100.4	101.9	101.3	101.2	101.2	101.4	101.2
67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8
0.6	-0.1	-0.5	-1.0	-1.7	-2.0	-2.2	-2.7	-2.9	(2.5)	(3.0)	(2.1)	(2.2)	(2.6)
-13.6	-13.8	-14.2	-14.3	-14.1	-14.2	-14.1	-14.1	-14.4	-14.4	-14.5	-14.5	-14.5	-14.5
($20.6)	($27.0)	($30.9)	($35.0)	($41.4)	($44.1)	($45.3)	($50.9)	($52.2)	($50.6)	($56.1)	($48.2)	($50.2)	($54.8)
-0.1%	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%	-0.2%
$56.77	$55.82	$55.09	$54.08	$53.39	$52.47	$51.69	$50.96	$50.15	$49.46	$49.10	$48.58	$48.02	$47.42
$10,698	$10,664	$10,667	$10,611	$10,615	$10,569	$10,538	$10,518	$10,476	$10,457	$10,503	$10,514	$10,520	$10,523
11.2¢	11.2¢	11.2¢	11.2¢	11.3¢	11.3¢	11.3¢	11.2¢	11.2¢	11.2¢	11.2¢	11.2¢	11.2¢	11.2¢
$88.66	$90.31	$91.80	$92.82	$94.87	$95.84	$97.17	$98.74	$99.87	$100.32	$102.77	$103.92	$104.87	$106.08
$19.36	$19.72	$20.05	$20.27	$20.71	$20.93	$21.22	$21.56	$21.81	$21.90	$22.44	$22.69	$22.90	$23.16
$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62	$5.62
83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%	83.5%
105	105	105	106	106	106	106	106	106	106	106	106	106	105
285.0	283.8	282.4	280.8	279.4	278.1	277.0	276.1	275.5	274.9	274.6	274.5	274.3	274.1
4.2	4.1	4.0	4.0	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4	3.4
1.51	1.48	1.44	1.40	1.37	1.34	1.31	1.28	1.26	1.23	1.21	1.19	1.17	1.15
154.4	153.3	152.2	150.8	149.4	148.2	147.1	146.1	145.3	144.4	143.6	142.7	142.0	141.0
179.6	178.1	176.8	175.1	173.4	172.0	170.9	169.7	168.8	167.8	166.9	166.1	165.4	164.5
291	289	286	283	280	277	275	272	270	267	265	263	260	258
3,586	3,594	3,598	3,606	3,610	3,597	3,585	3,585	3,571	3,579	3,577	3,578	3,576	3,579
24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%	24.7%
267	267	267	267	267	267	267	267	267	267	267	267	267	267
23.2	23.8	24.3	24.8	25.3	25.7	26.1	26.5	26.8	27.1	27.4	27.6	27.8	28.0
140	138	136	134	132	130	128	126	124	122	121	119	118	116
9.0%	9.2%	9.3%	9.4%	9.5%	9.6%	9.8%	10.0%	10.1%	10.3%	10.4%	10.6%	10.7%	10.9%
5,067	5,062	5,060	5,053	5,043	5,030	5,022	5,025	5,024	5,035	5,045	5,056	5,068	5,080
14.4	14.3	14.2	14.1	14.0	13.9	13.7	13.7	13.6	13.6	13.5	13.5	13.4	13.4
0.21	0.21	0.20	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.17	0.17	0.17	0.16
39.3%	39.2%	39.2%	39.3%	39.5%	39.9%	40.3%	40.4%	40.8%	40.9%	41.0%	41.3%	41.5%	41.6%
$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
$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77
47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7	47.7

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	77.8	77.8	79.5	84.3	91.2	91.1	94.0	91.0	86.9	92.6	100.0	97.3
	Sub-Indexes												
	Geopolitical	71.6	72.1	74.4	80.3	87.1	90.3	94.4	93.1	86.8	92.8	100.0	96.5
	Economic	62.1	62.5	62.8	68.2	81.8	81.8	83.9	82.4	78.9	87.7	100.0	97.8
	Reliability	82.5	81.1	82.6	88.0	97.1	95.4	96.1	85.3	81.1	87.8	100.0	98.7
	Environmental	106.1	106.0	109.0	110.7	105.6	102.2	106.5	106.6	104.8	104.3	100.0	96.4
	Global Fuels Metrics												
1	Security of World Oil Reserves	122.6	114.7	113.0	105.9	104.3	110.6	114.3	107.2	97.5	102.1	100.0	96.5
2	Security of World Oil Production	88.0	89.4	91.1	92.4	97.8	106.2	111.1	104.4	94.2	91.6	100.0	100.4
3	Security of World Natural Gas Reserves	57.4	67.3	73.8	78.0	83.8	101.5	106.1	113.4	100.0	98.0	100.0	106.0
4	Security of World Natural Gas Production	69.8	69.1	67.7	67.5	71.2	84.9	89.9	91.8	87.4	88.5	100.0	103.4
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	94.4	96.0	103.1	103.3	94.9	93.4	90.7	100.0	100.4
	Fuel Import Metrics												
7	Security of U.S. Petroleum Imports	52.4	59.9	69.2	87.6	94.9	104.7	122.1	130.3	107.5	104.8	100.0	92.5
8	Security of U.S. Natural Gas Imports	74.5	75.9	73.9	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	159.3	147.0	141.9	154.6	129.7	110.3	112.0	106.4	108.4	111.4	100.0	91.4
18	Petroleum Stock Levels	117.9	118.9	139.7	140.1	126.6	117.6	128.5	114.7	120.4	112.7	100.0	88.3
	Energy Use Intensity Metrics												
19	Energy Consumption per Capita	96.3	97.1	100.8	104.0	100.7	97.0	101.4	103.0	104.5	104.6	100.0	96.5
20	Energy Intensity	118.7	117.4	117.0	115.3	113.3	110.4	110.6	108.5	105.4	103.3	100.0	95.0
21	Petroleum Intensity	117.9	118.2	121.0	121.1	116.9	114.6	116.9	117.9	114.2	108.3	100.0	91.0
22	Household Energy Efficiency	109.3	110.7	112.2	109.4	105.0	104.1	106.1	105.9	106.5	102.3	100.0	93.2
23	Commercial Energy Efficiency	111.9	113.1	113.1	111.2	110.0	111.3	112.1	108.7	106.0	104.1	100.0	97.2
24	Industrial Energy Efficiency	124.2	122.3	116.6	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	34.8	41.6	70.9	95.4	74.1	56.2	91.9	110.7	117.3	126.0	100.0	83.4
32	Energy-Related CO_2 Emissions per Capita	98.8	98.7	106.7	113.3	103.9	95.9	105.8	110.1	110.0	110.5	100.0	93.0
33	Energy-Related CO_2 Emissions Intensity	122.5	120.1	119.9	118.1	114.7	111.5	112.2	110.5	105.7	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	87.0	83.8	82.7	84.1	81.7	79.5	79.1	76.8	75.0	76.3	75.1	75.8	77.7	78.7	78.6	81.6	87.4
90.9	86.6	90.4	87.6	85.7	86.4	80.6	80.6	79.5	76.5	73.3	75.6	74.3	73.8	74.5	74.3	72.6	75.8	83.4
90.0	82.5	80.9	76.5	70.1	71.7	68.6	67.0	68.6	65.6	63.9	63.3	61.5	61.7	64.4	64.0	61.1	64.0	72.4
91.6	84.7	83.7	79.8	87.1	89.0	88.4	79.2	78.9	78.2	76.0	77.8	76.0	78.7	80.5	84.8	91.4	96.2	99.9
92.4	91.4	94.2	93.1	92.9	94.4	96.3	96.9	94.2	92.6	93.3	95.5	96.0	96.9	99.6	101.3	101.1	102.0	103.6
93.4	98.5	104.4	104.0	110.8	109.8	99.3	100.5	124.1	119.2	127.0	133.6	132.2	131.3	127.5	128.6	125.3	124.5	127.7
94.0	90.7	93.9	91.1	95.1	90.0	80.8	83.2	78.2	76.6	73.8	78.5	76.7	75.2	71.0	71.2	69.2	69.1	69.7
120.2	122.2	141.6	136.0	136.5	124.1	94.4	100.9	86.5	88.2	77.1	85.9	87.3	87.6	87.3	87.0	88.7	92.9	99.3
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	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	57.6	62.4	58.3	56.6	53.1	50.7	49.8	52.8	58.2
102.3	102.8	110.4	109.3	108.7	102.8	96.7	103.1	89.0	87.4	82.7	91.2	90.5	89.5	88.6	83.5	74.3	74.6	82.6
72.2	69.7	75.9	66.5	84.2	83.8	79.4	87.7	82.6	76.6	74.1	84.7	84.3	80.5	78.8	83.3	84.3	82.4	86.5
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
58.8	49.7	51.7	43.1	25.9	35.9	31.7	40.2	50.0	38.4	38.4	37.3	36.1	36.7	47.5	47.0	33.9	46.8	78.4
58.5	47.2	45.8	36.6	21.3	28.5	24.1	29.5	36.0	27.7	26.7	25.3	23.5	23.2	29.0	27.5	19.0	25.0	40.3
97.5	87.8	82.4	77.1	64.0	62.4	59.9	59.3	60.7	58.5	55.8	54.7	52.8	51.3	52.9	50.4	44.3	44.2	51.1
93.3	87.0	85.8	82.3	69.7	69.3	68.1	68.9	71.2	67.9	66.2	65.8	65.4	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	44.0	28.4	50.2	49.0	40.3	8.2	15.6	24.3	20.7	12.8	5.3	2.8	14.5	13.7	28.6	23.1	55.4
89.8	94.9	99.1	100.6	107.8	108.3	116.7	119.1	120.0	118.1	119.0	118.3	117.9	120.0	122.7	127.6	124.5	120.3	123.6
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	92.4	91.0	94.2	92.8	93.6	97.6	93.8	92.5	94.2	97.6
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	76.6	74.2	72.9	68.6	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
49.5	80.1	79.0	79.8	100.9	130.9	142.1	138.6	132.4	145.3	158.0	168.2	176.6	201.5	211.2	218.3	225.3	248.9	242.1
80.0	87.1	85.3	83.9	88.2	95.0	96.4	93.3	89.1	90.1	91.1	91.5	91.5	95.8	96.0	95.6	95.1	98.9	98.1
87.4	85.8	82.1	79.4	79.4	79.8	78.3	76.4	75.8	74.6	73.9	72.1	71.1	70.9	68.7	66.4	64.0	63.4	63.2
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	79.2
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	290.2
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	290.9
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	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	84.2	82.1	81.4	86.8	94.3	96.3	95.9	99.1	89.6	97.2	101.6	91.8
	Sub-Indexes												
	Geopolitical	81.7	78.7	77.9	84.7	92.3	95.1	96.4	101.1	87.8	94.7	101.4	93.4
	Economic	68.7	66.9	68.5	75.3	86.5	90.5	91.0	100.1	83.7	93.1	102.0	92.1
	Reliability	94.5	91.0	86.8	92.3	102.5	105.0	100.5	99.5	104.4	113.8	115.3	97.0
	Environmental	100.9	101.0	100.6	101.5	100.8	98.4	98.2	94.4	86.5	90.3	87.4	83.8
Global Fuels Metrics													
1	Security of World Oil Reserves	126.9	123.8	90.7	91.9	87.0	86.7	86.3	86.8	86.8	88.2	93.2	94.0
2	Security of World Oil Production	70.3	67.1	70.0	74.7	74.3	74.8	74.9	77.7	76.0	78.7	82.6	82.8
3	Security of World Natural Gas Reserves	98.7	94.7	92.5	97.1	97.9	96.7	97.0	96.0	96.0	92.8	93.0	95.3
4	Security of World Natural Gas Production	72.4	71.1	71.5	76.3	77.0	78.3	78.6	78.0	74.2	77.2	82.1	81.3
5	Security of World Coal Reserves	57.5	55.3	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	84.5	87.6	100.4	111.2	116.1	124.1	129.2	133.3	144.9	154.0	161.3	163.9
Fuel Import Metrics													
7	Security of U.S. Petroleum Imports	91.5	83.9	92.2	101.7	104.0	103.7	101.0	102.5	91.1	90.5	86.9	78.8
8	Security of U.S. Natural Gas Imports	172.7	157.1	152.0	167.5	180.2	177.3	181.9	141.7	118.9	115.0	92.0	67.1
9	Oil & Natural Gas Import Expenditures	68.9	65.6	81.2	109.5	158.1	173.1	182.8	218.4	117.8	145.5	175.1	149.6
10	Oil & Natural Gas Import Expenditures per GDP	35.0	32.8	39.5	51.3	71.6	76.4	79.3	95.0	52.7	63.5	75.2	62.8
Energy Expenditure Metrics													
11	Energy Expenditures per GDP	50.1	46.2	50.2	54.3	61.1	64.0	65.2	73.2	56.5	62.0	68.6	64.1
12	Energy Expenditures per Household	73.3	70.2	77.9	86.6	99.2	105.3	108.5	120.3	90.4	101.2	112.0	106.2
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	128.8	126.0	66.0
17	World Oil Refinery Utilization	123.4	119.6	125.7	131.3	131.5	128.2	128.0	124.2	114.6	119.0	117.6	119.3
18	Petroleum Stock Levels	101.1	104.2	104.3	103.2	101.0	99.2	102.5	92.8	87.1	88.4	89.4	85.1
Energy Use Intensity Metrics													
19	Energy Consumption per Capita	98.2	98.8	98.2	99.5	98.7	97.0	97.6	94.7	89.3	91.8	90.6	87.6
20	Energy Intensity	62.7	62.5	61.0	60.0	58.2	56.2	56.1	55.1	53.9	54.5	53.3	50.9
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	101.1	100.0	100.9	95.4	98.6	98.3	95.7	98.5	94.8	87.7
23	Commercial Energy Efficiency	83.0	82.7	81.5	81.0	80.0	77.6	78.3	77.2	73.5	72.7	70.9	67.3
24	Industrial Energy Efficiency	57.3	57.0	56.1	56.2	52.7	51.4	50.1	50.3	51.6	52.6	51.6	50.2
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	118.5	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	235.0	240.8	247.4	262.8	265.6	255.0	267.4	242.1	186.1	212.2	193.8	165.7
32	Energy-Related CO_2 Emissions per Capita	93.6	93.2	93.2	95.2	94.1	89.9	91.0	83.7	70.8	74.8	70.1	63.8
33	Energy-Related CO_2 Emissions Intensity	61.7	61.1	59.9	58.9	57.2	54.9	54.8	53.3	50.8	51.4	49.3	46.4
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	166.4	168.4	165.7
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
87.8	81.4	77.9	77.8	77.5	74.4	73.9	75.3	75.4	75.2	75.2	74.9	74.6	74.4	74.2	74.2	74.2	74.1	74.2
89.2	83.5	76.6	76.5	76.1	72.5	71.9	73.9	74.2	74.1	74.0	73.5	73.1	73.0	72.7	72.7	72.9	72.9	73.1
86.9	79.2	68.9	67.1	68.5	66.0	65.9	68.6	69.3	69.4	69.3	68.9	68.6	68.6	68.5	68.6	68.7	68.6	68.8
89.0	77.5	88.2	91.8	90.3	82.8	82.1	83.4	83.8	84.3	85.0	85.3	85.4	85.6	85.6	85.8	86.1	86.3	86.7
85.7	85.7	82.9	81.7	80.1	81.5	80.6	79.3	77.9	76.7	76.0	75.5	74.9	74.3	73.7	73.1	72.6	72.0	71.4
94.8	99.0	97.3	103.6	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9
82.3	84.9	85.2	90.1	94.3	93.9	93.4	92.8	91.5	92.8	93.0	93.1	93.1	93.1	93.1	93.2	93.3	93.3	93.3
96.6	99.6	100.3	108.1	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6
82.7	87.7	88.0	93.5	97.5	97.2	99.0	101.3	101.3	102.2	101.6	101.7	101.1	100.8	100.4	100.3	101.4	101.7	101.0
67.4	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
185.3	182.4	189.2	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8
65.4	55.2	50.6	54.1	41.5	38.4	30.4	23.8	18.0	15.0	13.4	9.9	7.3	4.4	1.6	0.0	0.0	0.0	0.0
57.6	54.0	41.8	31.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
121.5	89.1	43.3	36.1	33.4	30.3	24.2	20.9	16.4	12.1	8.7	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50.2	35.9	17.0	13.9	12.6	11.2	8.7	7.3	5.7	4.1	2.9	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63.0	61.2	47.6	42.6	43.3	43.1	43.1	46.0	46.4	46.0	45.5	45.2	44.4	43.4	42.6	41.9	41.4	40.6	40.1
106.0	104.8	82.5	74.4	79.5	80.5	82.0	88.6	90.5	90.9	90.9	91.2	90.5	89.5	89.0	88.8	88.8	88.3	88.4
88.9	90.6	89.3	87.0	87.7	88.1	88.9	90.9	90.8	91.1	91.3	91.6	92.6	92.9	93.0	93.1	93.2	93.5	93.7
123.9	111.0	58.0	47.8	58.2	56.9	60.5	75.3	83.2	86.7	89.2	90.9	92.2	94.1	95.4	97.1	98.8	99.9	102.1
78.4	37.3	130.5	139.0	134.4	68.1	72.4	90.1	99.6	103.7	106.8	108.8	110.3	112.6	114.1	116.2	118.2	119.5	122.1
39.7	12.1	47.6	63.4	60.8	58.2	55.6	53.0	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4
117.9	117.5	121.8	121.9	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4
89.6	85.4	80.4	79.4	85.6	81.7	82.0	81.4	81.1	80.6	80.2	79.8	79.1	78.4	78.1	77.8	77.6	77.4	77.2
89.6	90.0	88.5	87.9	87.3	87.7	87.8	87.4	86.7	86.0	85.3	84.8	84.1	83.4	83.0	82.6	82.2	81.7	81.3
51.5	50.8	48.9	48.2	47.2	46.7	46.0	45.2	44.2	43.3	42.4	41.7	40.9	40.1	39.4	38.6	37.9	37.1	36.4
41.8	41.1	40.8	40.6	40.0	41.4	40.4	39.1	38.1	37.0	36.0	35.2	34.2	33.2	32.4	31.6	30.8	30.0	29.4
92.9	93.8	88.4	85.7	84.6	87.8	86.8	85.2	83.7	82.4	81.2	80.3	79.4	78.7	78.0	77.5	77.0	76.3	75.5
68.8	69.5	68.6	67.5	66.8	67.1	66.5	65.3	64.3	63.4	62.6	62.1	61.5	61.0	60.5	60.0	59.5	58.9	58.4
50.0	48.9	48.9	49.8	49.1	48.8	48.6	48.9	48.6	48.5	48.3	48.2	47.8	47.3	47.0	46.7	46.2	45.8	45.3
88.5	88.5	89.0	88.6	86.3	89.9	91.0	89.0	87.0	86.4	87.6	88.8	89.5	91.0	91.3	91.8	92.1	92.5	92.7
99.8	86.5	92.7	101.4	97.8	94.9	90.9	90.5	92.9	95.4	100.0	102.4	105.0	105.3	106.0	106.0	106.0	106.0	106.0
108.6	101.7	103.0	106.4	105.9	105.0	104.7	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2
75.6	76.0	74.3	74.3	71.1	69.7	68.5	67.2	65.8	64.4	63.0	61.6	60.1	58.6	57.3	56.0	54.8	53.6	52.7
80.8	80.2	79.4	80.1	78.6	77.7	76.9	75.7	74.4	73.0	71.7	70.3	69.0	68.0	67.0	66.0	64.9	64.0	63.0
90.5	91.4	91.5	91.0	91.2	92.0	91.8	91.6	91.1	90.7	90.3	90.0	89.5	89.2	88.9	88.6	88.3	88.1	88.0
182.9	189.3	169.9	158.4	152.1	167.6	164.0	158.3	151.5	145.1	143.7	144.8	143.9	143.3	142.3	141.6	141.3	140.4	139.1
66.0	66.2	61.8	59.0	57.0	58.6	57.1	55.3	53.4	51.6	50.6	50.0	49.1	48.4	47.6	46.8	46.2	45.4	44.7
46.7	46.0	43.5	42.1	40.8	40.8	39.6	38.4	37.3	36.1	35.4	34.8	34.1	33.4	32.7	32.0	31.3	30.6	29.9
71.4	70.7	70.0	66.5	62.1	63.8	62.5	59.9	58.5	57.9	58.6	58.8	59.4	59.6	59.6	59.7	59.7	59.5	59.2
164.9	160.9	158.0	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4
236.8	227.7	214.7	212.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3
113.6	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7

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	74.1	74.0	74.0	74.1	74.0	74.3	74.4	74.4	74.5
	Sub-Indexes									
	Geopolitical	73.1	73.2	73.3	73.5	73.5	73.9	74.1	74.2	74.4
	Economic	68.7	68.7	68.8	68.8	68.7	69.1	69.2	69.2	69.3
	Reliability	86.8	86.9	87.2	87.4	87.5	87.9	88.1	88.3	88.5
	Environmental	70.8	70.2	69.8	69.4	69.2	69.0	68.8	68.6	68.4
Global Fuels Metrics										
1	Security of World Oil Reserves	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9	105.9
2	Security of World Oil Production	93.3	93.4	93.4	93.5	93.6	93.7	93.8	93.8	93.7
3	Security of World Natural Gas Reserves	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6	107.6
4	Security of World Natural Gas Production	101.4	100.7	100.4	101.9	101.3	101.2	101.2	101.4	101.2
5	Security of World Coal Reserves	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5
6	Security of World Coal Production	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8	201.8
Fuel Import Metrics										
7	Security of U.S. Petroleum Imports	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	Oil & Natural Gas Import Expenditures per GDP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Energy Expenditure Metrics										
11	Energy Expenditures per GDP	39.4	38.8	38.3	37.7	37.2	36.9	36.5	36.1	35.6
12	Energy Expenditures per Household	88.0	87.7	87.5	87.2	87.0	87.4	87.5	87.6	87.6
13	Retail Electricity Prices	93.7	93.7	93.6	93.4	93.3	93.2	93.2	93.2	93.1
14	Crude Oil Price	103.1	104.5	106.2	107.4	107.9	110.6	111.8	112.8	114.1
Price & Market Volatility Metrics										
15	Crude Oil Price Volatility	123.3	125.1	127.1	128.5	129.1	132.3	133.8	135.0	136.5
16	Energy Expenditure Volatility	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4	50.4
17	World Oil Refinery Utilization	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4	125.4
18	Petroleum Stock Levels	77.0	76.9	76.8	76.7	76.7	76.8	77.1	77.2	77.4
Energy Use Intensity Metrics										
19	Energy Consumption per Capita	80.9	80.6	80.4	80.2	80.0	79.9	79.9	79.8	79.8
20	Energy Intensity	35.7	35.1	34.5	33.9	33.4	32.9	32.4	31.9	31.4
21	Petroleum Intensity	28.7	28.1	27.5	26.9	26.4	25.9	25.5	25.1	24.6
22	Household Energy Efficiency	74.9	74.4	73.9	73.5	73.0	72.6	72.2	71.8	71.3
23	Commercial Energy Efficiency	57.9	57.5	57.1	56.8	56.5	56.2	55.9	55.7	55.4
24	Industrial Energy Efficiency	44.9	44.5	44.0	43.6	43.1	42.8	42.5	42.1	41.6
Electric Power Sector Metrics										
25	Electricity Capacity Diversity	92.0	91.3	91.3	90.5	91.0	90.8	90.9	90.8	90.9
26	Electricity Capacity Margins	106.0	106.0	106.0	106.0	106.0	106.0	106.0	106.0	106.0
27	Electricity Transmission Line Mileage	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2	104.2
Transportation Sector Metrics										
28	Motor Vehicle Average MPG	51.7	50.9	50.2	49.6	49.0	48.6	48.2	47.8	47.5
29	Transportation VMT per $ GDP	62.1	61.2	60.3	59.5	58.7	57.9	57.1	56.3	55.5
30	Transportation Non-Petroleum Fuels	87.7	87.5	87.1	86.8	86.5	86.2	86.0	85.7	85.5
Environmental Metrics										
31	Energy-Related CO_2 Emissions	137.4	136.3	136.7	136.6	138.1	139.4	140.8	142.4	144.1
32	Energy-Related CO_2 Emissions per Capita	43.9	43.2	42.8	42.3	42.0	41.7	41.5	41.2	41.0
33	Energy-Related CO_2 Emissions Intensity	29.2	28.6	28.1	27.5	27.0	26.6	26.1	25.7	25.2
34	Electricity non-CO_2 Generation Share	58.6	58.1	57.9	57.3	57.3	57.1	56.7	56.4	56.2
Research and Development Metrics										
35	Industrial Energy R&D Expenditures	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4	155.4
36	Federal Energy & Science R&D Expenditures	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3	220.3
37	Science & Engineering Degrees	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7	112.7

Primary Data Sources

GEI 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 2018 (AEO2018)* 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 GEI's Index of U.S. Energy Security website at https://www.globalenergyinstitute.org/energy-security-risk-index.

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

BP:
BP Statistical Review of World Energy. Available at: https://www.bp.com/en/global/corporate/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: https://www.census.gov/programs-surveys/popest.html. 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 https://www.census.gov/library/publications/time-series/statistical_abstracts.html. For pre-1989 summer peak load aggregates.

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

Energy Information Administration:

- *Annual Energy Outlook 2018*. 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: https://freedomhouse.org/report-types/freedom-world. For historical international political rights and civil liberties data. Freedom House's annual index of political rights and civil liberties was used as a proxy for reliability of international trading partners.

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

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

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

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

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