INDEX OF U.S. ENERGY SECURITY RISK®

ASSESSING AMERICA'S VULNERABILITIES IN A GLOBAL ENERGY MARKET

2013 Edition




Institute for 21st Century Energy • U.S. Chamber of Commerce

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

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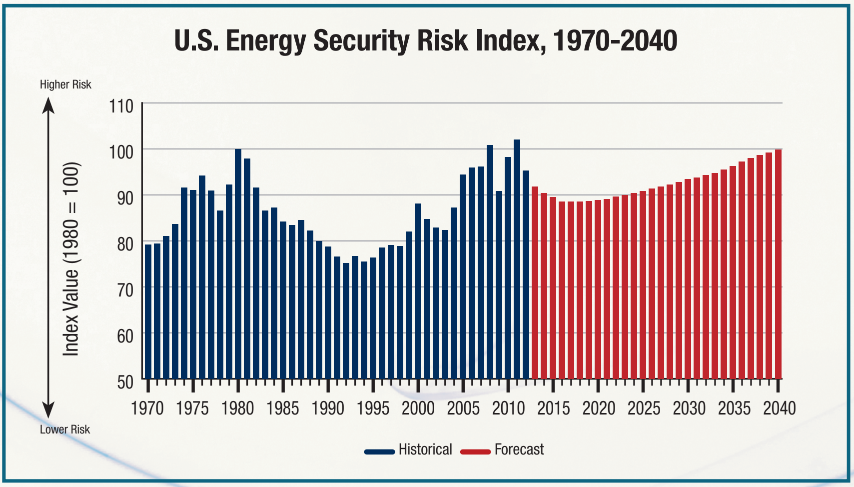

INSTITUTE FOR 21ST CENTURY ENERGY
U.S. CHAMBER OF COMMERCE

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Foreword

This 2013 Edition of the Institute for 21st Century Energy 's Index of U.S. Energy Security Risk (U.S. Index) illustrates, perhaps more than any of the previous editions, the scale and scope of the changes taking place in U.S. energy markets and how those are improving energy security at a pace unseen since the early 1980s. It also is a good time to take stock of how the U.S. Index, after four editions, has done at answering the simple question: Is our energy security is getting better or worse, and why?

As the report details, there are signs of improvement. Nevertheless, the overall level of energy security risk is uncomfortably high and is projected to remain so. However, the situation is not quite as gloomy as it was in recent years, and the current projection over the next several years looks to be less precarious than was thought a few years ago.

One positive trend in particular that has emerged is the rise in domestic unconventional oil and gas production. It is noteworthy both for how it has influenced U.S. energy security risks over the past few years and how it might lessen future risks.

This is especially important because the United States now accounts for a shrinking portion of global oil demand. As a global commodity, oil is priced in a global market, and swings in price have a lot to say in whether risks go up or down.

The ability of the United States to influence the price from the demand side, however, is waning. When the United States accounted for more than one-quarter of global demand, it had a big influence on the price of oil. By 2030, when it is expected to account for 18% of global demand, what the United States does or does not do on the demand side will have less of an impact. There will also be growing competition from other countries, Asian countries in particular, for spare OPEC output capacity, which will put upward pressure on crude oil prices.

Nevertheless, the United States is still a large energy producer, and its rapidly increasing production of unconventional oil will take on added significance at a time when supplies from other reliable and secure sources, such as Mexico, Norway, the United Kingdom, is declining.

Before the middle of the last decade, production of oil and natural gas from shale resources was considered to be speculative and probably not a significant contributor to future U.S. supplies. In very short order, those views were overturned by events. In the 2011 and 2012 editions of the U.S. Index, there were clear indications that the use of hydraulic fracturing, horizontal drilling, and multidimensional geologic imaging was inciting a revolution in unconventional natural gas production from shale formations that was beginning to have measurable and beneficial impacts on U.S. energy security. In this edition, covering data year 2012, the beneficial impacts of the "Shale Gale" blowing through the oil patch are becoming more apparent, too. The only thing comparable to this recent increase in domestic crude oil production—815,000 barrels per day alone in 2012—was the opening of the Trans-Alaska Pipeline System in 1977 and the surge in Alaskan North Slope production that followed, but even that was not enough to offset production shortfalls elsewhere.

The combination of higher domestic supplies and a leveling of oil demand will have a dramatic effect on the net oil and gas import picture. Whereas just a few years ago imports were projected by the Energy Information Administration (EIA) to grow sharply, nearly doubling within a couple of decades, current thinking is that oil and gas imports will decline throughout the forecast period. That is a remarkable turnaround.

It is also important to remember that this revolution has occurred on top of a long term trend of plentiful and inexpensive coal supplies. The United States has the world's largest reserves of coal—which has for decades been, and should continue to be, a secure energy mainstay—along with a large nuclear power industry, a variety of renewable sources of virtually all types, and an increasingly efficient economy.

This paradigm shift has become something of a challenge for policymakers used to nearly four decades of energy woes, some of which were beyond our control and some of which were self-inflicted. Oil embargos, gasoline lines and price spikes, power blackouts, natural gas shortages, and price volatility and other problems made up a parade of horribles that we remember all too clearly.

There is no getting around that fact that reliance on energy to power our modern economy inherently entails risk. That is, after all, what the U.S. Index is design to measure. But by continuing to look at energy policy exclusively through the lens of energy scarcity at a time when we could be embarking on an era of sustained energy abundance, we run the risk of losing out on the opportunities new U.S. technologies have created.

While there are strong grounds for optimism about the future, this optimism is tempered by the realization that the boom in U.S. energy production has come about largely in spite of national policy rather than because of it. Data compiled by the Congressional Research Service show that all of the increase in domestic crude oil and natural gas production since 2007 took place on non-federal lands and that output on federal lands was declining.

The lesson here is that our domestic energy renaissance is not inevitable. It will take a policy environment that encourages capitalizing on opportunities and, as important, addresses those challenges holding back energy production. At this point, it is not clear in which direction energy policy is headed. Overreaching by regulatory agencies targeting coal, limitations on access to resources on public lands, a broken siting and permitting process,

and a flawed nuclear waste disposal policy, to name a few, create roadblocks that could squander the tremendous prospect of a secure energy future.

The United States has a greater variety and quantity of energy resources than any other country in the world. When coupled with new exploration, production, and end-use technologies, there is no reason we cannot enjoy the security and economic benefits of the energy revolution underway. The Energy Institute's policy platform lays out a specific set of proposals that would help us accomplish this.

The ability of the U.S. Index to capture recent domestic energy trends is evident in the much lower risk scores reported for 2012. In previous editions of the U.S. Index it has been noted how the complexity of the U.S. energy economy requires many metrics to measure it and how it takes a lot of those metrics moving in the right direction to change the dial appreciably. Many of the metrics used in the U.S. Index display long term trends that do not change much from year to year. The impacts of gains in energy intensity, for example, build up over many years, as do the impacts of capital stock turnover. These things do not change overnight.

A few years ago, the same could have been said for energy production. Not today. The revolutionary application of new and not-so-new technologies to oil and gas production has had a bigger impact on the U.S. Index than anyone could have anticipated. Of particular note this year is the very large improvement in the volatility of energy markets and expenditures, a direct result of greater domestic energy production. Lower energy costs mean greater economic growth and a competitive edge in global markets.

It is not just domestically where these impacts are being felt, but internationally as well. The U.S. Index operates such that improvements in energy security anywhere lead to improvements everywhere. It is now expected that by 2020, the United States will be a net exporter of natural gas. Rising domestic production is already having an impact on overseas markets, where shipment once destined for the United States are being diverted to other markets, for example Europe. Japan, too, is looking at U.S. gas as a reliable source of energy as it considers closing some or all of its nuclear plants.

Increasing oil production in the United States and Canada is shifting the world's energy center of gravity from the Middle East to North America, and its benefits are rippling through world oil markets. It has made, for example, the removal of large quantities of Iranian oil by sanction from world markets less disruptive than it might have been. It has also played a role in prompting Mexico—which is seeing its oil output drop—to reconsider the prudence of its constitutional prohibition of foreign investment in the oil industry, and it is leading OPEC to worry that its sway over world oil market is weakening.

Add on top of these the growing markets for U.S. coal supplies in Europe, Asia, and South America. The International Energy Agency predicts that before 2020, coal could overtake oil as the world's largest energy source. U.S. coal could be a significant supplier in an expanding global market.

Greater U.S. energy output leads to greater diversity, which makes every country more energy secure. These and other benefits, however, are contingent on the ability to move these resources to global markets, which makes building liquefied natural gas export facilities and expanding port facilities for greater coal exports all the more critical.

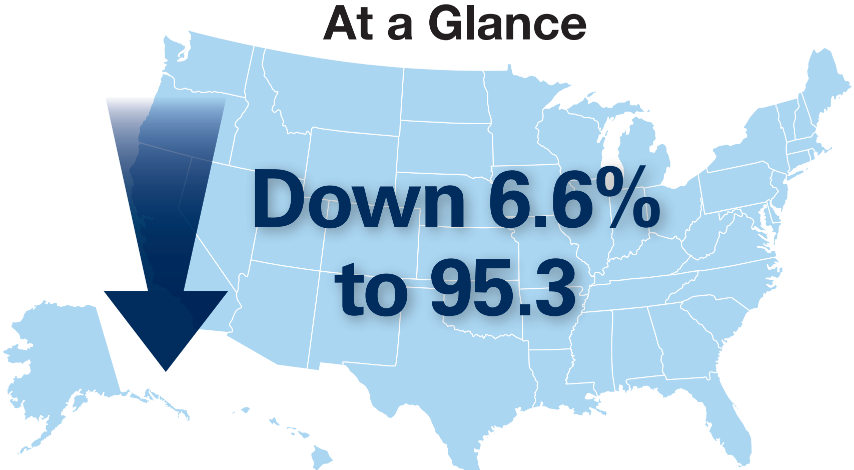
There are number of other things we should be doing to reform and modernize other aspects of our energy policy, recognizing that some trends are moving in the wrong direction. We need a sensible policy to manage the country's nuclear waste safely and efficiently, a streamlined siting and permitting system for approving energy plants and transmission lines, a coal policy that ensures it will remain an integral part of our energy mix, faster improvements in energy efficiency, strategic investments in pre-commercial energy research and development and in science, math, engineering and science education. These types of policies can complement the gains being made in unconventional oil and gas and will be critical aspects of a sustained improvement in energy security going forward.

As we look back over 40+ years of the U.S. Index scores, the story they tell in numbers is compelling. In the early 1980s, the United States adopted a market-based and aggressive energy policy that contributed to an almost continuous improvement in energy security risks through the mid-1990s. In 2012, the drop in energy security risks was the second largest in our database, but whether this is a harbinger of a longer term trend like that seen in the 1980s or a short-term blip remains to be seen. If policymakers apply the lessons the U.S. Index is teaching, there is every reason to believe we can deliver better energy security and a robust energy economy for years to come.

Karen A. Harbert
President and CEO
Institute for 21st Century Energy
U.S. Chamber of Commerce

2012 U.S. Energy Security Risk Score

At a Glance



Of the 37 Index metrics, 26 showed lower risk, 7 higher risk, and 4 no change in risk from 2011 to 2012.

An increase in unconventional oil and natural gas output in 2012 lowered energy supply, import, and import expenditure risks.

Volatility in energy expenditures moved much lower in 2012 because of relatively stable energy prices, slightly lower demand, and greater energy efficiency.

Energy-related carbon dioxide emissions fell for the second consecutive year, dipping to their lowest level since 1994.

CO_2

U.S. energy security risks are expected to average 92.7 from 2013 to 2040, lower than lasts year's forecast but still high by historical standards.

Highlights

The total U.S. energy security risk fell sharply in 2012, and while the trend in near term future looks better than projected last year, longer term risks out to 2040 still are expected to be quite high. The decline in risk in 2012 ends a run of two consecutive years of increasing risk. Unlike the large recession-related drop in risk in 2009, where the improvement was for all the wrong reasons, the drop in risk in 2012 was the result of real improvements in the energy picture, many of them related in one way or another to greater unconventional oil and natural gas output.

This 2013 edition of the Index of U.S. Energy Security Risk (U.S. Index) includes the most recent energy data available, including projections in the Energy Information Administration's (EIA) *Annual Energy Outlook* 2013 (*AEO 2013*). This edition provides an up-to-date assessment of those energy supply and use metrics having the greatest impact on energy security over the past year. The U.S. Index is based on a combination of 37 different energy security metrics beginning in 1970 and ending in 2040. Highlights include the following:

Total energy security risk in 2012 fell from its record high 2011 score. From a record high of 102 points in 2011, the total U.S. energy security risk score dropped 6.7 points (6.6%) in 2012 to 95.3. Despite the improvement, this is still 12.1 points above the 30-year (1970-1999) average, and it is the 8th highest score since 1970. Based on last year's forecast data, a small (2%) improvement was expected in 2012. The actual improvement was much better, however, because forecasts of the revolution in unconventional oil and natural production lagged reality. Greater domestic oil and natural gas production in 2012, all of which occurred on state and private lands, was the biggest single factor contributing to the improved U.S. energy security picture in 2012.

The Index of U.S. Energy Security Risk for the year 2012 is:

95.3

6.6% lower than the 2011 level.

Decreasing risks were seen across a broad range of energy security measures, but a handful standout as the main drivers of the lower U.S. risk score in 2012. Of the 37 Index metrics, 26 showed a decrease in risk, seven showed an increase in risk, and four showed no change in risk in 2012. Not only was the number of metrics displaying rising risk scores comparatively small, they generally had small increases. Of the 26 metrics with lower risk scores, however, six recorded improvements of at least 10 points largely as a result, both directly and indirectly, of greater domestic oil and natural gas output. These included risk measures associated with oil and natural gas import supplies and expenditures, energy price volatility, and carbon dioxide emissions, which were primarily responsible for the 6.7-point improvement in 2012.

The impacts of the unconventional oil and natural gas boom lowered U.S. energy security risks in 2012 by increasing supply security, reducing net imports, and putting downward pressure on energy costs and expenditures. The growing impacts of increasing shale gas production have been noted in previous years of the U.S. Index. In 2012, an 815,000 barrel per day increase in production, by far the largest single year jump in the period going back to 1970, began to have greater influence than in past years. Growing domestic production of these fuels led to greater domestic and global supplies than would have existed otherwise, reduced import exposure risks, and lowered import expenditures by 13% in 2012. Moreover, low-cost natural gas along with inexpensive coal contributed to lower energy costs for businesses and consumers.

Following three years of increases, some of them quite steep, energy expenditure volatility moved much lower in 2012. Energy costs are a significant portion of our overall economy, and extreme price volatility can slow economic growth. A 55% drop in energy expenditure volatility as a share of GDP marks a sharp departure from the previous four years, which saw expenditure volatility climb 139%. Stable (if high) oil prices, slightly lower energy demand, improving energy efficiency, and falling natural gas prices and retail electricity prices all contributed to sending energy expenditure volatility to its lowest level since 2008.

Risks related to energy-related carbon dioxide emissions declined for the second consecutive year, falling to their lowest level since 1994. Slow but steady trends towards greater energy efficiency in all sectors, fuel switching from coal to cheap natural gas in the power sector, and still sluggish economic growth all contributed to the decline in total emissions.

Based on EIA's latest *AEO 2013*, the U.S. Index is projected to average 92.7 points over the entire forecast period from 2013 to 2040, still high but an improvement over last year's forecast. Risks in the short term are expected to decline from the 2012 level and stay below it until 2034, after which the U.S. risk score is expected to rise steadily to a high of 99.9 in 2040. In comparison to last year's overall risk forecast, however, this year's forecast averages 4.0 points lower because of the impact of greater U.S. oil and gas output in the short- to mid-term. The rising risk trend late in the forecast period is being driven primarily by projections of increasing crude oil prices that in turn lead to generally higher energy prices and expenditures.

The growth in U.S. oil and gas production is proceeding much faster than expected just a few years ago. While EIA has been predicting greater oil production for many years, its forecasts have not kept pace with reality. Crude oil output in 2013, for example, is expected to be much higher than the peak level achieved in any of EIA's previous five forecasts, and it is still growing. Natural gas output also is exceeding previous forecasts. With development moving ahead so rapidly, it is probable that crude oil output in future EIA forecasts will exceed even EIA's *AEO 2013* forecast, both in quantity and duration, which would push future risks scores even lower.

Coal is expected to remain a mainstay of the U.S. energy mix. By 2040, coal-fired power stations are expected to provide 38% of the nation's electricity, down from the 40% share estimated for the same year in the *AEO 2012*, but still significant. New regulations, however, could threaten coal use and increase risks by reducing supply diversity. Exports of coal also are expected to increase even more than anticipated last year, and their growth will continue improve the security of worldwide coal supplies. It is important that regulators ensure that port facilities are able to accommodate higher coal exports.

Geopolitical energy security risks in 2012 declined from 2011's record high score of 102.0 to a score of 97.4. Despite the improvement, this is 14.2 points above the above the 30-year average score of 83.2. Lower crude oil and natural gas import and import expenditure risks stemming from growing unconventional domestic oil and natural gas production were the main factors contributing to lower geopolitical risks in 2012. Forecasts suggest rising geopolitical risks from 2020 to 2040 driven by increasing crude oil prices and volatility. Increasing unconventional crude oil gas production in North America, however, is expected to shift in the geopolitical center of gravity of oil production towards North America, moderating the risks associated with the large concentration of crude oil supplies in the Middle East.

Economic energy security risks fell 7.7 points in 2012 to 95.6, a level still well above the 30-year average of 73.8. The biggest improvements were noted in the metrics covering energy expenditure volatility and oil and gas import expenditures, which fell 72.6 points and 24.2 points, respectively. Looking ahead, further declines in economic risks are expected through about 2016, after which they will rise steadily, increasing to more than 100 in the late 2030s largely due to high crude oil prices and import expenditures. If the domestic boom in unconventional oil output can be maintained or even increased for a longer period than projected currently, expenditure risks could be moderated to a great extent over the forecast period.

Reliability energy security risks fell 12.3 points to 102.2 points, a nearly 11% drop, the largest of any of the four sub-indexes. Nevertheless, its 2012 score remains quite high and well above its 1970-1999 baseline average score of 86.1. The large drop was due almost entirely to a dramtic drop in energy expenditure volatility. Year-to-year crude oil price volatility also remained basically flat for the second year in a row. Forecast scores based on the *AEO 2013* suggest risk level above 94 will be the norm for this sub-index through 2028, and over 100 after that. A large contributor to the future trend in reliability risk is the metric measuring generating capacity diversity, which declines through the early– to mid-2020s, and increasing risks thereafter because of shrinking shares for baseload coal and nuclear generating capacity in the generating mix.

Environmental energy security risks fell for the second consecutive year to 84.7, 3.2 points below its 2011 score and 14.6 points below its 30-year average. This is the lowest score for this sub-index in the entire record going back to 1970. The single biggest factor accounting for the improvement in this sub-index was the 26.5 point drop in the metric measuring energy-related carbon dioxide emissions, which hit its lowest level since 1994. Scores for energy intensity and efficiency measures in 2012 also were close to, if not below, their best score in the record, and each is expected to improve even more out to 2040. Fuel switching in the power sector also contributed. The overall outlook for the Environment Sub-Index is for steadily declining scores through 2040, despite climbing carbon dioxide emissions. By 2023, the risk score for this sub-index could fall below 80 for the first time, three years earlier than reported in last year's edition.

Introduction

This 2013 edition of the Institute for 21st Century Energy's (Energy Institute) Index of U.S. Energy Security Risk (Index), the fourth in the annual series, provides an updated look at U.S. energy security since the 2012 edition was issued in October 2012 and incorporates the most recent historical data and reflecting the latest and updated forecasts. The Index incorporates 37 different measures of energy security risk that include: global fuels; fuel imports; energy expenditures; price and market volatility; energy use intensity; electric power sector; transportation sector; environmental; and basic science and energy research & development.[1] The Index looks back in time to 1970 and forward in time to 2040.

The Energy Institute's Index includes four Sub-Indexes that identify the major areas of risk to U.S. energy security: geopolitical, economic, reliability, and environmental. First, each of the 37 metrics is mapped to one or more of these four sub-indexes. These four Sub-Indexes were then merged 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 2013 edition reflects revisions to the historical data and the new forecast in the Energy Information Administration's (EIA) *Annual Energy Outlook (AEO) 2013* issued in April and May of 2013.

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 that approach or surpass 100, therefore, suggest a very high degree of risk.

The Energy Institute's Index includes four Sub-Indexes that identify the major areas of risk to U.S. energy security: geopolitical, economic, reliability, and environmental.

The average Index score for the 30-year period 1970 to 1999, a period that includes times with relatively very high (100) and very low (75.2) scores, is 84.2. The 1980 baseline score, the historical high and low scores, and the 30-average scores found in table 1 for the total composite Index and the four sub-indexes can be used as historical reference points against which to assess current and future risk scores. It is also important to note that for this report, unless noted otherwise, all dollar figures are in real 2010 dollars.

The Index discussed in this report is focused exclusively on the United States and how its energy security risks have trended over time and may trend into the future. The Energy Institute also has developed an International Index of Energy Security Risk that puts the U.S. energy risks in an international context and provides comparisons with other large energy consuming countries. Readers interested in how U.S. risks stack up against those faced by other countries should consult the International Index, which is available on the Energy Institute's website.

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

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

Table 1. U.S. Energy Security Risks from 1970 to 2012: Highest, Lowest and 30-Year (1970-1999) Average Index Scores

Indexes of U.S Energy Security Risk	2012 Score	1980 Baseline Score	Highest Risk		Lowest Risk		30-Year Average (1970-1999)
			Year	Index Score	Year	Index Score	
Total Composite Index	95.3	100	2011	102.0	1992	75.2	84.2
Sub-Indexes:							
Geopolitical	97.4	100	2008	103.1	1998	73.1	83.2
Economic	95.6	100	2011	103.3	1998	61.5	73.8
Reliability	102.2	100	2011	114.4	1992	75.2	86.1
Environmental	84.7	100	1973	110.7	2012	84.7	99.3

Index of U.S. Energy Security Risk: 2012

After rising for two years in a row to a record high of 102.0 in 2011, the overall U.S. Index fell 6.7 points 2012 to 95.3 (figure 1). While a big improvement—only the 9.9 drop in 2009, a year when the economic contracted sharply, was larger—2012's overall risk score remains high by historical standards at 12.1 points above the 1970-1999 baseline average and is the eighth highest risk score in the record.

Of the 37 metrics used in the Index, 26 showed an decrease in risk in 2012, seven showed a increase in risk, and four showed no change in risk. For the most part, the movement of the 37 metrics either up or down was fairly modest. Only one metric index rose more than five points (federal energy research and development expenditures at 8.1 points) while six metric indexes fell by 10 points of more. Leading the decliners were the indexes for energy expenditure volatility (-72.6 points), security of natural gas imports (-32.2 points), carbon dioxide emissions (-26.5 points), oil and natural gas import expenditures (-24.2 points), import expenditures as a share of GDP (-12.2 points), and security of petroleum imports (-10.6 points).

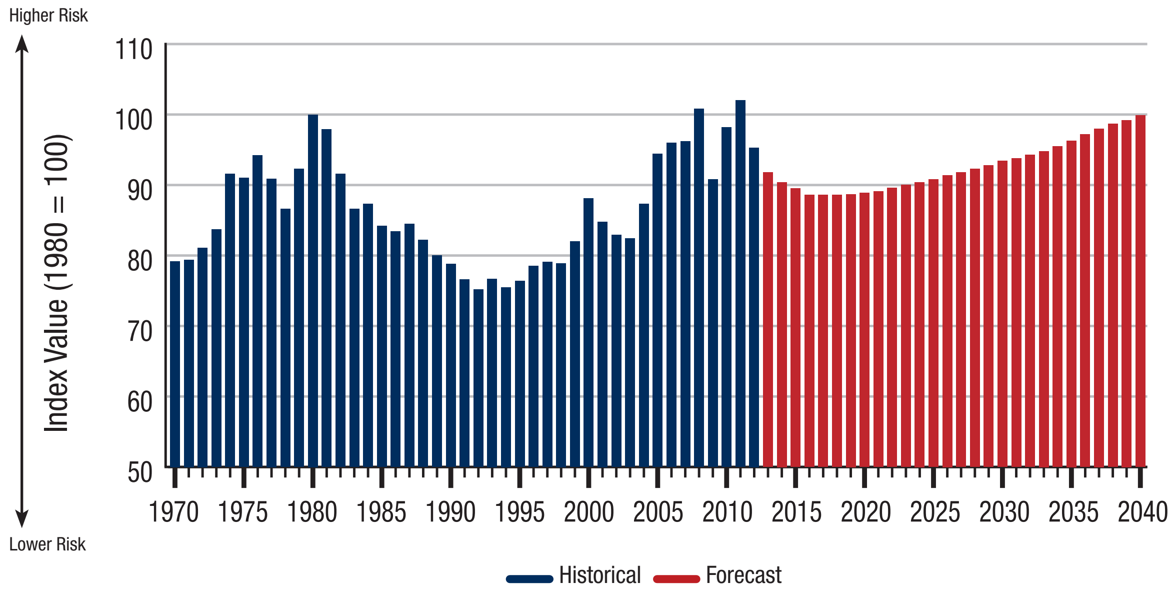
In addition to these large improvements, 20 other metric indexes showed at least some improvement. Most of the energy use and transportation metrics, which have been showing generally steady progress over the years, continued to show improvement in 2012.

The large (72.6 point) drop in the volatility of energy expenditures index to a score of 60.2 represents a decline of about 55%, a dramatic turnaround for a measure that jumped from 55.6 in 2008 to 132.9 in 2011 (139%). Stable (if high) oil prices, slightly lower energy demand, improved energy efficiency, and falling natural gas prices and retail electricity prices all contributed to lowering energy expenditure volatility in 2012.

Increasing unconventional oil and natural gas production also continued to lower energy security risks in 2012, and in a much bigger way than in the previous three years of the U.S. Index. From 18.1 trillion cubic feet in 2005, U.S. natural gas jumped 33% to 24.1 trillion cubic feet in 2012. Over the same period, shale gas went from accounting for less than 10% of output to accounting for about 40% of output.

Before the shale gas revolution, EIA was projecting steadily declining production and ever greater volumes of natural gas imports. EIA's most recent *AEO 2013* projection, however, shows the United

Figure 1 **U.S. Energy Security Risk Index, 1970-2040**



States becoming a net exporter of natural gas by 2020. As a result, there has been a steady and steep decline in natural gas import risks from 187.8 in 2007, it highest-ever score, to just 67.2 in 2012.

After declining for decades, crude oil production also has been on the rise since 2009, but really stepped up in 2012 when domestic production rose to almost 8.9 million barrels per day, an average of 1 million barrels per day above the previous year's figure. As a result, imports of crude oil and refined products declined about 900,000 barrels per day in 2012, which led to the 10.6 point decrease in the petroleum import risk metric.

Declining imports of both oil and natural gas have benefited the United States by lowering import expenditures. From $337 billion 2011, it is estimated that U.S. expenditures on imports of oil and natural gas slipped 13% to $294 billion, sending the risk index for this metric down 24.2 points. The index measuring these expenditures as a share of GDP, a gauge of the exposure of the United States to price shocks, also improved 12.2 points, proportionally about the same as for import expenditures.

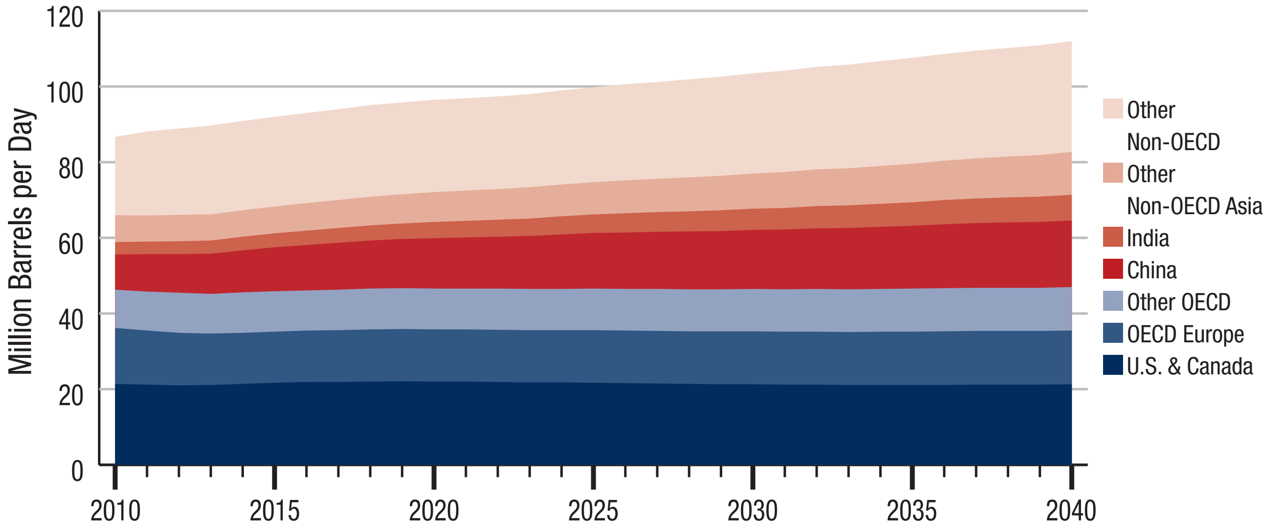
Another area of large improvement was in carbon dioxide emissions. Its index dropped for the second year running, falling to 26.5 points in 2012 because of a 200 million metric ton decline in energy-related emissions. Still-sluggish economic growth, fuel switching from coal to cheap natural gas in the power sector, and slow but steady trends towards greater energy efficiency in the buildings, industrial, and transportation sectors all contributed to this decrease.

Index of U.S. Energy Security Risk: Outlook to 2040

Based on EIA's latest *AEO 2013*, the U.S. Index is projected to average 92.7 points over the entire forecast period from 2012 to 2040, an improvement over last year's forecast (figure 1). Risks in the short term are expected to decline from the 2012 level of

Figure 2

EIA AEO 2013 Forecast of Global Liquids Consumption, 2010-2040



95.3 and stay below it until 2034. After slipping to a low of 88.6 in 2016 through 2018, U.S. risk scores are expected to rise steadily to a high of 99.9 in 2040. Of the 27 years in the forecast period, however, 20 years show risk indexes exceeding 90 points, a level that historically has been associated with geopolitical crises or energy shortages.

Looking at the individual metrics, 10 of the 37 metrics are essentially frozen going forward.[3] Of the remaining 26 metrics, 18 are expected to get better to one degree or another between 2013 and 2040, seven to get worse, and one to remain unchanged.

Although the forecast shows consistently high risks scores of 90+ points, this actually represents a change for the better when compared to the risk scores being forecast in the 2012 edition of the U.S. Index. From 2013 to 2035 (the last year in the *AEO 2012* forecast), the risk forecast based on *AEO 2013* data averages 4.0 points lower than that based on the AEO 2012. Most of the relative improvement comes early in the forecast period, but after 2015, the risks scores based on the AEO 2013 gradually lose ground to those based on the AEO 2012. An increasing crude oil price is responsible for much of the increased risk going forward, especially after 2020 or so. EIA is projecting that the price of a barrel of crude oil will rise from about $97 in 2012 to $159 to in 2040, 64% higher than in 2012.

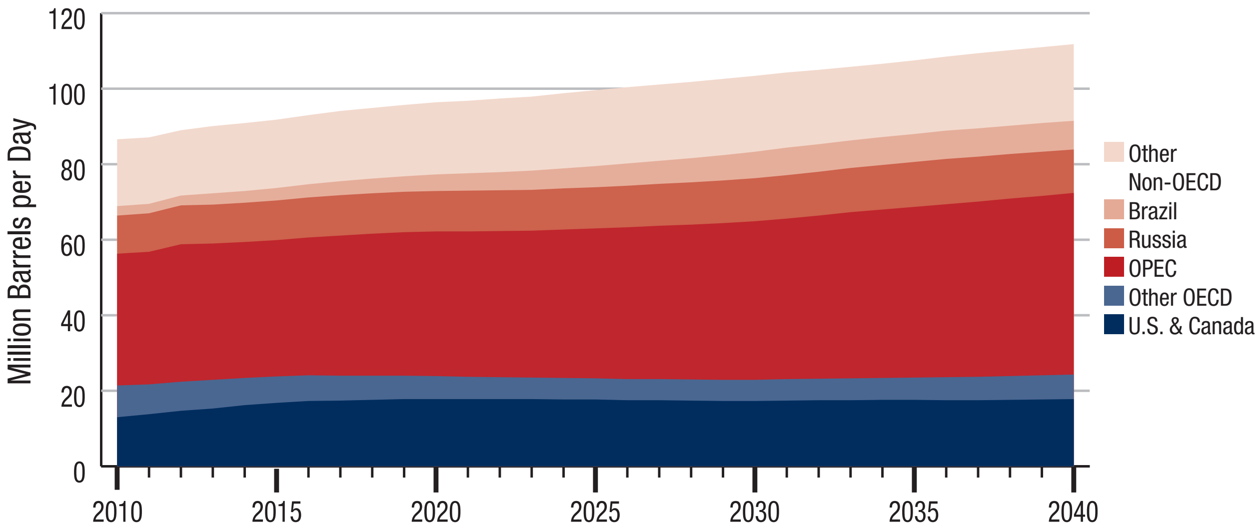
Crude oil prices affect and reflect the composite U.S. Index perhaps more than any single value. High crude oil prices adversely affect many of the other energy security risk metrics, particularly those measuring import expenditures. Our ability to manage the risk of high crude oil prices depends on many factors.

Crude oil is a global commodity whose price is set in the global marketplace. That marketplace is changing rapidly (figure 2). Whereas OECD countries once were the largest sources of demand, greater efficiency

3 This is by assumption because forecast data are not available for these 10 metrics, and there is no clear justification for assuming either improving or worsening trends.

Figure3

EIA AEO 2013 Forecast of Global Liquids Production, 2010-2040



measures and fuel substitution in the U.S. and other OECD countries in recent years means that demand in these countries is projected to be basically flat through 2040. Virtually all of the increase in demand is expected to come from emerging economies, most notably China.

A similar circumstance holds for crude oil production (figure 3). OECD production overall is projected to grow about 10 percent over the forecast period. The United States and Canada show large increases in unconventional output, but lower output from the North Sea and elsewhere means the other OECD countries will show collectively an overall production decline. Most of the increase in output is from non-OECD countries, particularly OPEC members and Brazil.

The increasing role by non-OECD producers and consumers in oil markets means options for managing crude oil price and volatility risks become more limited, which increases the importance of U.S. and Canadian production and fuel efficiency and fuel flexibility gains.

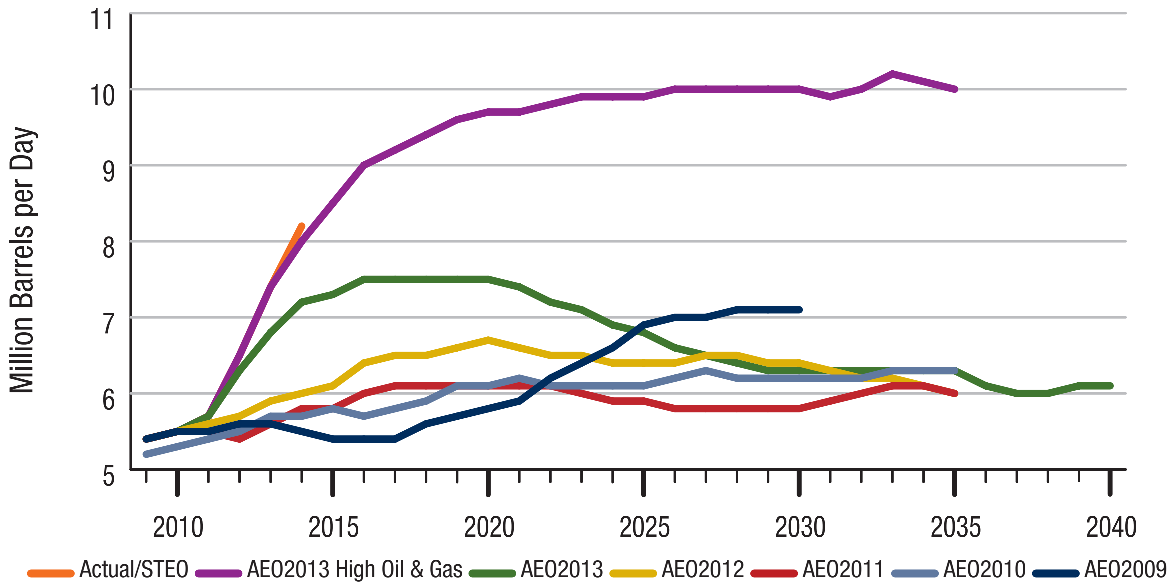
Over the mid-term, the importance of growing U.S. output is evident. Compared to its AEO -2012 forecast, the price increase in EIA's *AEO 2013* forecast is a bit slower. EIA now forecasts that from 2013 to 2030 a barrel of crude oil will cost on average $9, or 8%, less than it was forecasting in 2012.

Import expenditure risk is a function of the volume of imports and their unit price. The total cost that the United States is anticipated to pay for imports is expected to be much higher in 2040 than in 2012, but as with the price of crude oil, the trend in this metric actually represents a comparatively lower risk over most of the forecast period when set against earlier forecasts.

There are a number of reasons for this. In 2011, the United States became a net exporter of refined petroleum products, and that is not expected to change. Moreover, EIA forecasts that the United States will be a net exporter of natural gas in 2020, two years sooner than it was forecasting just last

Figure 4

EIA Forecasts of U.S. Crude Oil Production, 2010-2013



year.[4] (The security of natural gas imports metric is examined in greater detail in the section covering the Sub-Index of U.S. Geopolitical Energy Security Risk later in this report.)

Added to this are the recent improvements in producing oil from tight oil from low-permeability shale and chalk formations, such as the Bakken, Eagle Ford, and Three Forks formation. The result has been a reversal in the decades-long trend in declining U.S. production 2008 to 2012. EIA expects momentum in tight oil production to continue, contributing to a rise in overall domestic crude oil production to about 7.5 million barrels per day in the 2020s.

The magnitude and pace, of the changes taking place in U.S. crude oil production can be seen in figure 4, which plots different EIA production forecasts. EIA's 2009 forecast shows a large increase in crude oil output occurring, but not until about 2020. In reality, the jump in oil output has happened much sooner. And each subsequent forecast, while more optimistic than its predecessor, nevertheless has been found in retrospect to be too timid in its outlook. In fact, actual crude oil output seems to be hewing most closely to EIA's *AEO 2013* "High Oil and Gas Resource" scenario. With development moving ahead so rapidly, it is probable that crude oil output in future EIA forecasts will exceed even EIA's *AEO 2013* forecast both in quantity and duration.

When the growing output being projected is combined with flat petroleum demand, it is expected that oil and gas import expenditures risk will decline in the short- to mid-term and not exceed the 2012 value until 2027.

Some forecasts of U.S. crude oil production are much higher than EIA's, and if correct would lower the trajectory of oil and gas import expenditures even more. The research firm IHS, in what it calls the

4 Once the United States becomes a net exporter of natural gas, the risk for this metric will be measured as "0." There are no "negative" risks.

"Great Revival," sees the production of "tight" oil rising from a not-insignificant 2.0 million barrels per day in 2012 to about 4.5 million barrels per day out of a total crude oil 8.5 million barrels per day of oil production in 2020.[5] The International Energy Agency is even more optimistic, projecting that the United States would become the world's largest oil producer by 2017. In a recent report, it said U.S. oil production could rise to 10 million barrels per day by 2015 and 11.1 million barrels per day in 2020 before slipping to 9.2 million barrels per day by 2035. Either scenario would decrease the risks associated with oil and gas import below those used in this year's U.S. Index.

> *Who could have predicted such a turnaround five years ago? What seems obvious in hindsight was not at all obvious back then.*

In addition to these relatively recent developments, the long-term trend towards greater energy efficiency across most sectors continues to moderate future U.S. energy risks.

Metrics measuring energy intensity and sectoral energy efficiency, energy expenditures as a share of GDP, transportation energy use and fuels, and energy-related carbon dioxide emissions all show considerable improvement compared to 2012. The expected gains in efficiency also will lessen energy expenditures both in total (discussed above) and as a share of GDP, increasing the resiliency of the economy to energy price shocks.

Unlike the crude oil price and supply trends discussed above, however, future trends in energy use metrics out to 2040 do not look all that much different than they did over the past three editions of the U.S. Index; that is, EIA's latest *AEO* projections generally have rates of change comparable to its projections of recent years.

Greater production and use of natural gas is a main factor contributing to lower estimates of future carbon dioxide emissions from energy, particularly its use in the power sector, where it is expected to back out some coal. In addition to competition from natural gas, coal faces significant and growing regulatory challenges. Final and proposed regulations would have the effect of limiting coal's production and use, and even go so far as to effectively ban the construction of new coal-fired plants using current commercially available technology.

Nevertheless, EIA expects coal to remain a mainstay of the U.S. energy mix. By 2035, coal power stations are expected to provide 38% of the nation's electricity, down slightly from the 40% share estimated for the same year in the *AEO 2012*. However, new regulations could threaten the use of coal and increase risk by reducing supply diversity.

Exports of coal also are expected to increase even more than anticipated last year. The *AEO 2013* forecast also suggests that in 2035 net coal exports, at 136 million short tons, could be 45% greater than projected in the *AEO 2012*. Growing U.S. coal exports will continue improve the security of worldwide coal supplies. It is important, however, that regulators ensure that port facilities are able to accommodate higher coal exports.

When considering the projected trends discussed here, it is important to recognize that there are many factors that go into these forecasts, any number of which could unexpectedly change. One need look no further than the revolution in unconventional oil and gas production now sweeping the United States, and maybe in the not too distant future the countries. Who could have predicted such a turnaround five years ago? What seems obvious in hindsight was not at all obvious back then.

Improvements in demand side metrics have worked almost steadily to moderate U.S. energy

5 IHS Global Insight. 2012. *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy. Volume 1: National Economic Contributions.* Available at: http://www.energyxxi.org/sites/default/files/pdf/americas_new_energy_future-unconventional_oil_and_gas.pdf.

security risks over the entire period since 1970, even as total risks were rising. On the supply side, the gains have been more sporadic. Certainly the addition of Alaskan North Slope crude oil to domestic U.S. production was a significant event, but the revolution in unconventional oil and gas has the potential to have an even greater impact provided companies are allowed to explore and develop these resources and build the infrastructure necessary to move new supplies to businesses, consumers, and overseas markets.

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

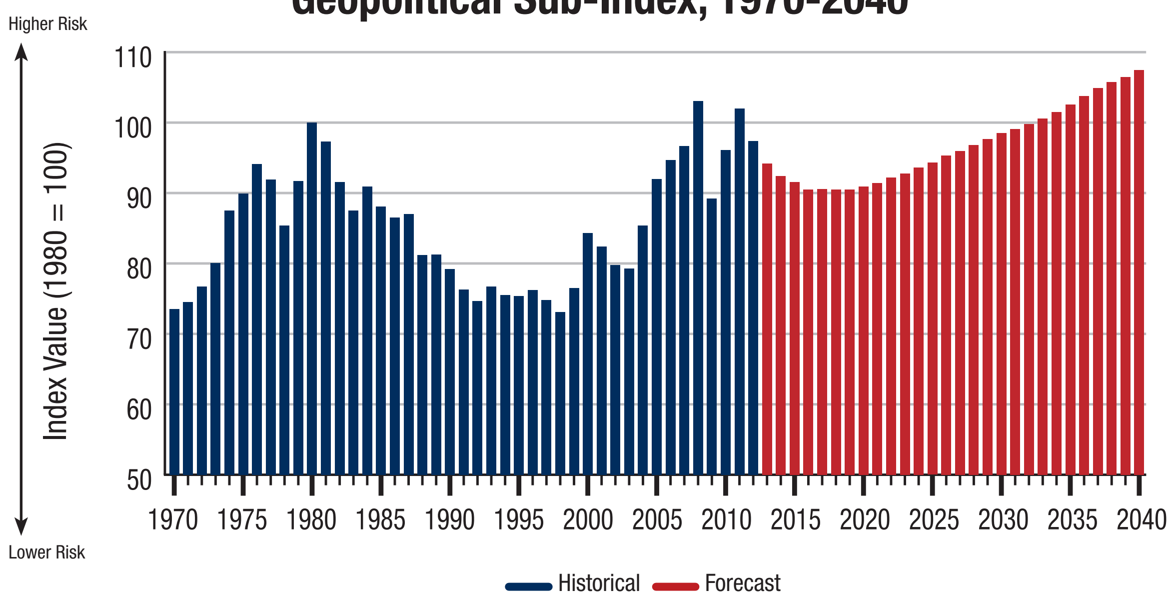
The Geopolitical Sub-Index measures the security of global oil, gas, and coal supplies and other factors that affect the ability of the U.S. economy to withstand supply disruptions from whatever causes. Geopolitical energy security risks in 2012 declined from 2011's record high score of 102.0 points to a score of 97.4 (figure 5). This is 14.2 points above the above the 30-year average score of 83.2. Improvement was observed in 16 of the 23 metrics that make up this sub-index, but a few showed particularly large drops.

Forecasts suggest rising geopolitical risks out to 2040, with a 2013 to 2040 yearly average risk score of 96.9, 13.7 points above the 1970 to 1999 baseline average. Persistently high scores are largely driven by crude oil prices and volatility. However, sweeping political changes—both good and bad—in oil producing countries are impossible to predict and can have as big an impact on risk as the size and diversity of energy supplies. This forecast assumes that the political situation in energy producing countries in 2012, measured along a scale of political and civil liberties, persists into the future, an unlikely prospect.

Most of the increase in risks seen in the Geopolitical Sub-Index over the past decade or more was due to

Figure 5

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



higher crude oil prices and price volatility, which led to greater import expenditures. Increasing demand in the large emerging economies like China, India, Brazil and others kept upward pressure on global prices. Moreover, tension in the Middle East related to terrorism, the "Arab Spring," the Libyan and Syrian civil war, and Iran's pursuit of nuclear weapons all contributed to nervousness in the market. These dynamics remained little changed in 2012. As a result, the security of international supplies of oil, natural gas, and coal supplies did not change appreciably.

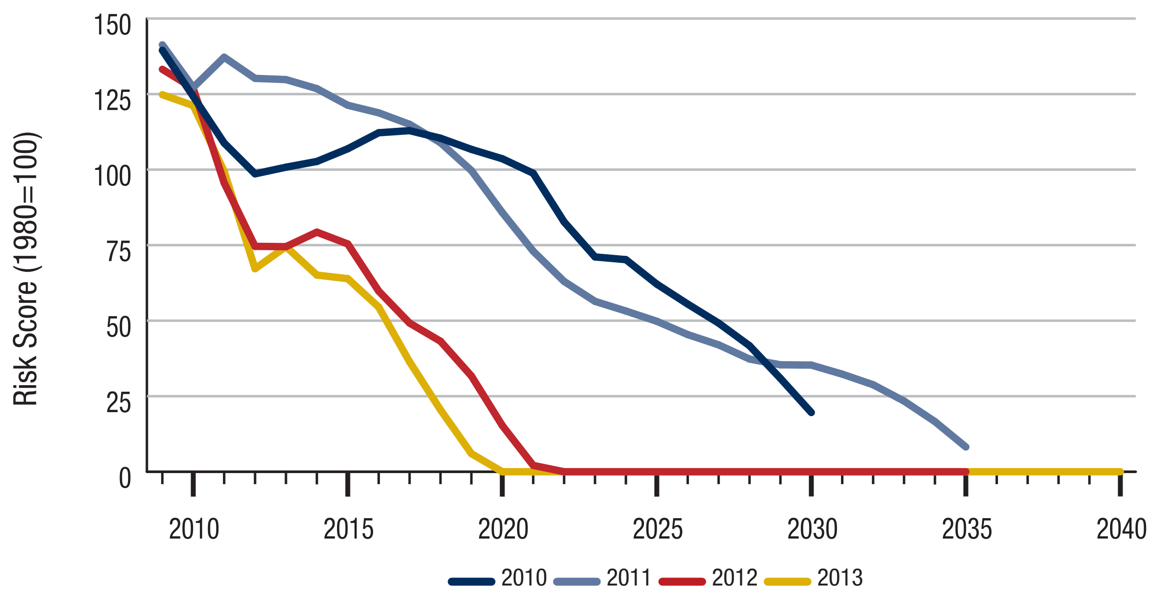
What has changed is appreciably, however, is U.S. oil and gas production. Past editions of the U.S. Index have noted the increasingly beneficial impact that rising natural gas production in the United States is having on the security of natural gas supplies. Nowhere is this more evident than in the changes observed in the security of U.S. natural gas imports metric, which measures the degree to which changes in import levels exposes the United States to potentially unreliable or concentrated gas suppliers. From 2007, when it peaked at nearly 188, the risk index for this metric tumbled 88.4 points, a 47% drop.

Expectations about future risk also have changed as the shale gas revolution has picked up steam. In the middle of the last decade, before shale gas technologies were in widespread use, expectations were that natural gas imports would rise steadily over time. When the first U.S. Index report was issued in 2010, projections of future natural gas import growth had already begun to be scaled back, and further revisions have been seen in subsequent years.

Figure 6 plots the changing risk outlooks reported for this metric in this and previous editions of the U.S. Index.[6] It shows risk with each iteration of the U.S. Index. While all four forecasts the risk of natural gas imports drops in the future, the earlier projections (based on the *AEO 2008* and *2010*) show risks lingering to 2030 at least. The drop in import risks

6 These forecasts are based on EIA's *AEO* for 2008, 2010, 2012, and 2013 which go out to 2030, 2035, 2035, and 2040, respectively.

■ Figure 6 **Forecasts of U.S. Natural Gas Import Risk, 2010-2040**



based on the last two EIA projections, especially the *AEO 2013*, is much steeper, suggesting that the import risk will be eliminated entirely by 2020.

The U.S. also is now a net exporter of refined petroleum products, but even with the increase in crude oil production, it is doubtful that the United States will be become a net exporter of petroleum—though that could conceivably be the case for domestically-produced light, sweet crude oil. Therefore, it remains unlikely that the U.S. oil import risk will fall to zero, like we expect with natural gas, but it certainly will be much lower than anticipated a few years ago.

Because we live in a global energy marketplace, the Geopolitical Sub-Index also incorporates measures of the reliability and concentration of oil, natural gas, and coal supplies worldwide. Greater production of oil and natural gas from countries like the United States, therefore, also contributes to increased energy security worldwide. The security of world oil production and security of world natural gas production risk indexes measure the risk level attached to the average barrel or cubic foot of oil or gas produced globally. Because of the large volume of production worldwide, and in the absence of a dramatic political shift in a large producing country, it requires a large shift in production to move the either risk index up or down.

Greater U.S. natural gas output is having a measureable and positive impact globally. The projected 2012 risk score for global natural gas production in the 2009 edition of the index was of 84.8. In this edition, the 2012 score is 81.6, a decline of over 3.2 points. Greater production from the United States and Australia, in particular, offset production increased from riskier sources, such as the Russian Federation, Saudi Arabia, Qatar, China, and others.

Something similar is happening with crude oil, though not to the same extent because of the turmoil created by political upheavals in many oil producing countries along with declining production from the North Sea, has contributed to less global supply diversity.

Although the security of world oil production rise index worsened slightly (0.9 points) in 2012, it would have been 2.5 points higher were it not for additional U.S. and Canadian output of 815,000 barrels and 235,000 barrels per day, respectively. As it happened, greater production from the United States and Canada offset increases in production from sources like Libya, Saudi Arabia, and the Russian Federation, and kept the increase in risk for this measure lower than it would have been otherwise. It is also worthy to note that the increase in oil output from the United States alone in 2012 was more than enough to offset the decline in oil output from Iran (687,000 barrels per day), whose oil production is under international export sanctions.

> *Greater production of oil and natural gas from countries like the United States, therefore, also contributes to increased energy security worldwide.*

Lower global risks stemming from increased U.S. and Canadian oil output can have a tremendously important impact on geopolitical risks of oil supplies. Figure 7 shows the share of the world's crude oil supply is being produced in countries Freedom House has categorized as Free, Partly Free, and Not Free and how production in each of these categories has changed from 1970 to 2012.[7] Over the entire 42-year period, production in Fee countries has averaged about 29% of world output, Partly Free 19%, and Not Free 52%.

A number of political changes are apparent in the chart. For example, the collapse of the former Soviet Union, a large oil producer, in 1989, which led to expanded political and civil freedoms in the Russian

7 Our world oil, natural gas, and coal reserves and production risk indexes incorporates two parameters: (1) reliability, as measured using a scale of political and civil liberties developed by Freedom House (reasoning that political volatility can lead to supply volatility and that countries with broad and entrenched civil and political liberties are more likely to be politically stable and less likely to engage in market manipulation); and (2) supply diversity as measured by the Herfindahl-Hirschman Index (HHI), a calculation based on each country's share of supply.

Federation shortly thereafter, and the subsequent deterioration of those same freedoms in the late 1990s and early 2000s.

The chart also shows that production in Free countries was just 23% of global output in 2010, 2011, and 2012, the lowest level since the mid-1970s. Declining production in the North Sea—United Kingdom and Norwegian production fell a combined 907,000 barrels per day from 2009 to 2012—was a major reason for the slumping share of Free country supply. That makes U.S. and Canadian supplies all the more critical. Over the same period, U.S. and Canadian crude oil production jumped almost 1.7 million barrels per day and in 2012 accounted for a combined 12.7% of global supplies, the highest level since 1998.

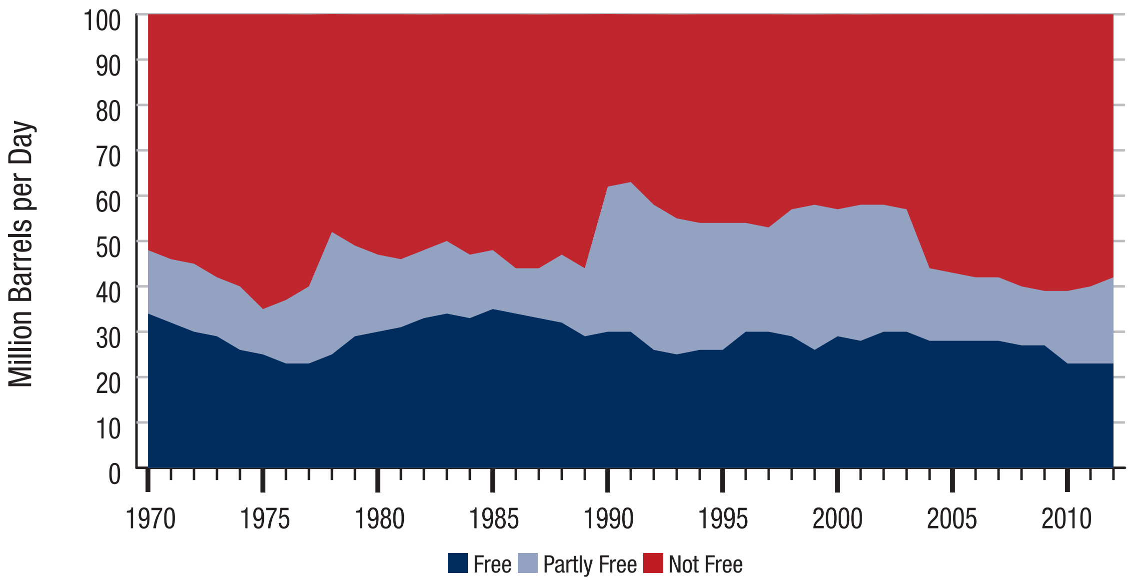
The Not Free category was responsible for 57% of global supplies in 2012. Given the high concentration of crude oil production (and reserves) in this region, there is a large potential risk.

Projections continue to suggest that unconventional oil production in non-OPEC countries, and in North America in particular, will increase substantially in the coming decades. U.S. unconventional resources are potentially enormous, perhaps as high a 2 trillion barrels, and Canada also has a tremendous resource of 175 billion barrels in its oil sands. The shift in the geopolitical center of gravity of oil production away from the Middle East and towards North America has the potential to moderate the risks associated with the large concentration of crude oil supplies in politically unstable regions.

Access to resources, however, remains an issue in the United States. Data compiled by the Congressional Research Service (CRS), however, show that all of the increase in domestic crude oil production (and natural gas, also) occurring from fiscal years 2007 to 2012 took place on non-federal lands. While output on federal lands declined 4% over these fiscal years, output on non-federal lands jumped 35%, or nearly 1.2 MMbbl/d. As a

Figure 7

Share of World Oil Production in Free, Partly Free, and Not Free Countries, 1970-2012



result, the federal share of U.S. oil production fell 7%.[8] The numbers for natural gas are similar. CRS finds that while overall U.S. natural gas production from fiscal years 2007 to 2012 climbed 4 trillion cubic feet to 24 trillion cubic feet, an increase of 20%, production on federal onshore and offshore lands combined fell 33% while production on non-federal lands soared 40% to 20.2 trillion cubic feet. The degree to which access to oil and gas resources is allowed could have a large impact on the country's future energy security.

U.S. coal remains a very secure source of supply, and increasing exports are contributing to global energy security. The latest estimates place recoverable U.S. coal reserves at 261 billion short tons, the largest reserves of any country in the world and more than one-quarter of the global total.

However, federal regulations targeting coal and greater use of natural gas are expected to reduce domestic demand for coal. Many U.S. companies, therefore, are increasing their exports. The *AEO 2013* forecast forecasts that annual coal exports could rise to more than 160 short tons.

Growing U.S. coal exports can have a beneficial effect on the security of global supplies. Over the past few years, a tremendous increase in output in China and to a lesser extent Russia and India have lessened supply diversity and reliability (supply freedom), increasing global risks. Greater U.S. exports to energy-hungry Asia would provide an energy security benefits as well as an economic one.[9]

8 CRS. 2013. *U.S. Crude Oil and Natural Gas Production in Federal and Non-Federal Areas*. Available at: http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/20130228CRSreport.pdf.

9 A report by the Energy Policy Research Foundation found that the economic value of only 50 to 100 million short tons per year of U.S. coal would be worth $2 to $6 billion dollars per year to the U.S. economy. See: EPRFINC. 2012. *The Economic Value of American Coal Exports*. Available at: http://eprinc.org/?p=929.

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

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 and the competitiveness of U.S. industries. Since so much of U.S. petroleum consumption is supplied through imports—even with the recent increase in domestic output—the U.S. balance of trade is affected by potentially hundreds of billions of dollars each year.

> *Energy costs are a significant portion of our overall economy. In 2012, roughly $1.3 trillion was spent for end-use energy in the residential, commercial, industrial, and transportation sectors, amounting to about 9% of GDP.*

As shown in figure 8, the sub-index for economic energy security risk fell 7.7 points in 2012 to 95.6. Still, the 2012 score is 21.8 points higher than the 30-year average of 73.8. Of the 23 metrics used to produce this sub-index, all but seven showed improvement in 2012. The biggest improvements were noted in the metrics covering energy expenditure volatility and oil and gas import expenditures, which fell 72.6 points and 24.2 points, respectively.

The energy expenditure volatility metric measures energy expenditures per $1,000 of GDP and provides an indication of the how susceptible the U.S. economy is to wide swings in energy prices. Energy costs are a significant portion of our overall economy. In 2012, roughly $1.3 trillion was spent for end-use energy in the residential, commercial, industrial, and transportation sectors, amounting to about 9% of GDP.

When energy markets are volatile, the large swings in the total energy costs can hurt economic growth.

When households suddenly have to devote more of their budgets to energy, there is less money available in household budgets for other competing demands. EIA examined the impact of price volatility in a 2001 analysis of the economic effects of the two years of rapidly falling energy prices in 1997 and 1998 and the two years of rapidly rising prices in 1999 and 2000. The study estimated what the impact would be on economic growth if energy prices had remained steady throughout this four-year period. It found that a steady energy price path could have boosted GDP growth by 0.2 percentage points compared to the volatile price path. EIA concluded that all other things equal, the economy would most likely perform better with stable or predictable energy prices than when the price of energy fluctuates greatly.[10]

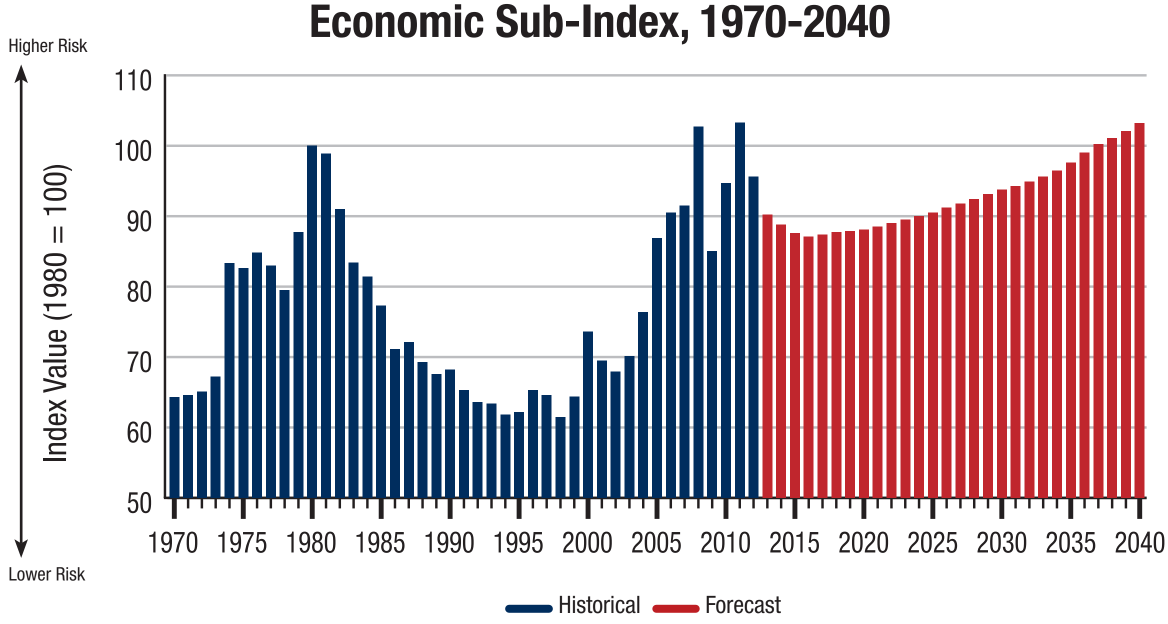
In 2012, the risk index for energy expenditures as a share of GDP moved the most of any metric in the U.S. Index, dropping nearly 55% to a score of 68.0, its historical average. Price spikes and market chaos peaked in 2008, and is now somewhat tamer. In absolute terms, energy expenditure volatility was about $15.17 per $1,000 of GDP in 2011, That slipped to $6.88 in 2012. Comparatively flat oil, natural gas, and retail electricity prices were largely responsible for the drop in volatility.

With a large part of our energy use consisting of fuel imports, volatility in the markets can lead to sudden and large shifts in international trade. Greater expenditures on imported fuels represent lost economic investment opportunities closer to home, and this risk is captured in metrics measuring how much the U.S. spends on imported oil and natural gas, both in total and as a share of GDP. Both of these measures got significantly better in 2012, the former by 24.2 points to 167.8 and the latter by 12.2 points to 72.0. Historically, however, the scores for these two metrics remain well above their 30-year averages of 47.8 for total import expenditures and 42.3 for import expenditures as a share of GDP.

10 EIA. 2001. *Energy Price Impacts on the U.S. Economy*. Available at: http://www.eia.doe.gov/oiaf/economy/energy_price.pdf.

Figure 8

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



Longer term trends increasing energy efficiency continued in 2012 pretty much across the board. Since 1970, steady improvement in the energy intensity—our ability to produce economic output with less energy—has lessened the economic impact of energy price increases and volatility, with many metrics at or near record lows.

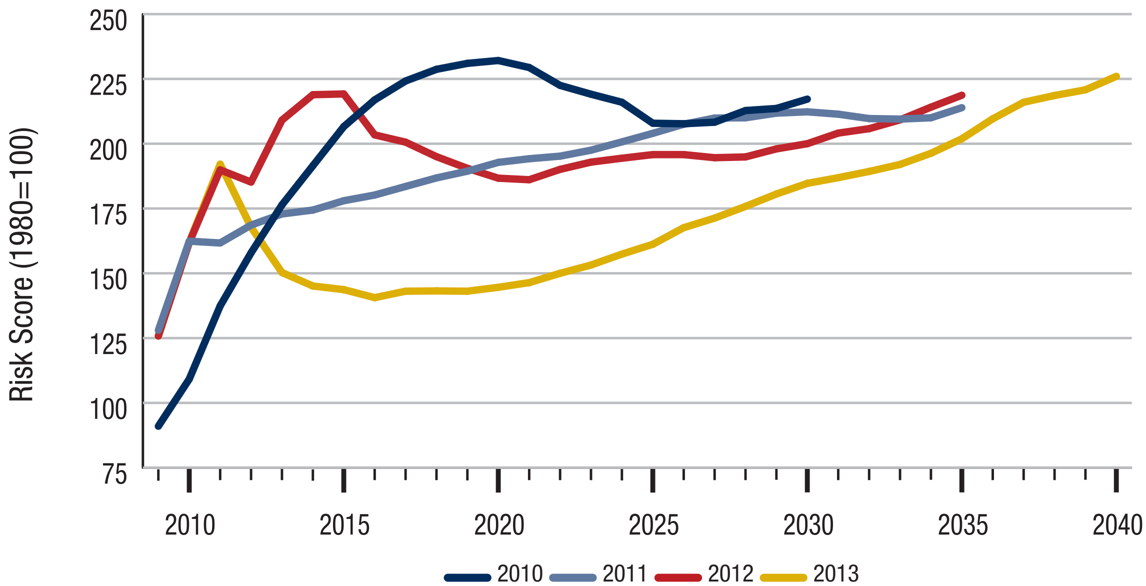
Lower retail electricity prices in 2012 also moderated economic risks. Plentiful and inexpensive supplies of both coal and natural gas have helped send electricity prices lower for the fourth consecutive year.

Looking ahead, further declines in economic risks are expected through about 2016, after which they will steadily increase, reaching more than 100 in the late 2030s. Over the 2013 to 2040 period, an average risk score of 92.8 is projected for this sub-index, 19 points higher than the historical average.

High crude oil prices and import expenditures—all from crude oil, not natural gas—are the main factors that could send economic risks to record high levels in the future, but not until late in the forecast period. In the medium-term, import expenditures are expected to stay below—sometimes well below—the 2012 score through about the mid-2020s, which corresponds to the period of greatest domestic crude oil production forecast by EIA.

Figure 9 shows this edition's risk index scores for the oil and natural gas import expenditure from 2009 to 2040 and compares them to the same risk scores in previous editions of the Index. The lower risks have resulted more from reduced quantities of net imports than from changes in unit prices. Clearly, the perception of future oil and gas import expenditures has changed greatly since the first (2010) edition of the U.S. Index was released, with each subsequent forecast generally showing a lower import expenditures risk trend than the previous forecast. Recent data continue to suggest trends lower than previously projected, such that next year's forecast could be lower still.

Figure 9 **Forecasts of Oil & Natural Gas Import Expenditures Risk, 2010-2013**



Import expenditures are a function of two factors: the amount of imports needed and their price. Naturally, if the domestic boom in unconventional oil output—discussed in more detail in the section covering the Outlook to 2040 above—is maintained for a longer period, it could keep import expenditure risks from rising after the mid-2020s. Given the right policy environment and access, there is reason to believe this could happen.

Although crude oil price volatility is not embedded to EIA's forecasts, history suggests that it could be quite high, but is at any rate completely unpredictable.

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

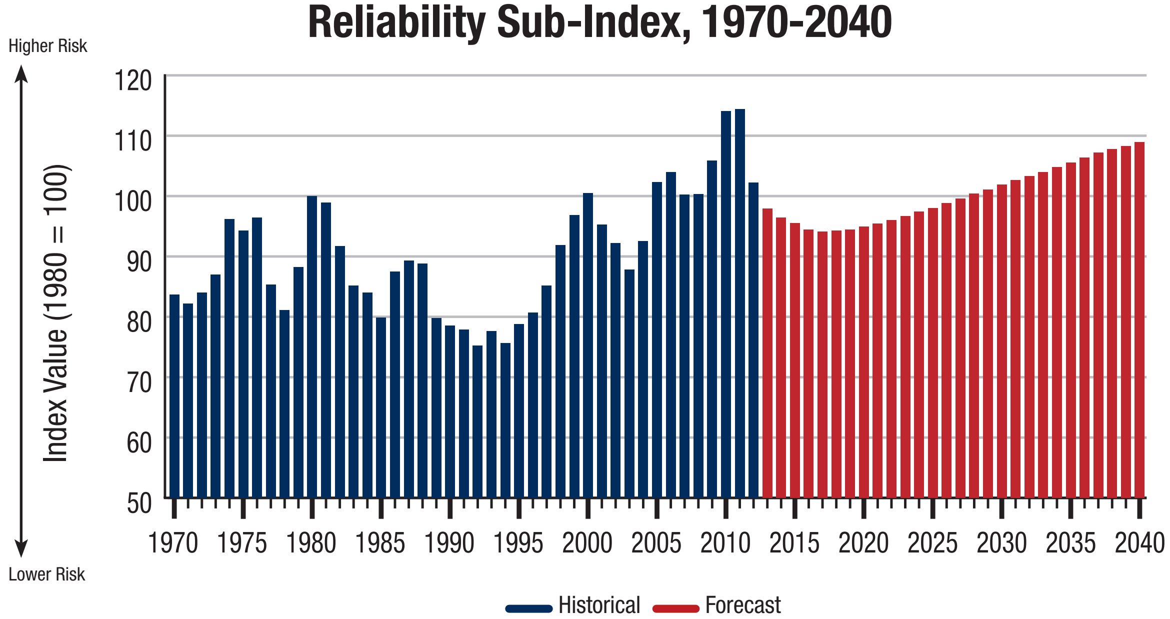
The metrics that make up the Reliability Sub-Index measure such things as global fossil fuel production and imports, crude oil price and volatility, oil refining and stock levels, the power sector, and research and development. In 2012, reliability risks fell 12.3 points, the largest point drop of any of the four sub-indexes, measured both in points and percent (-10.7%) (figure 10). Still, at 102.2, it is quite high by the standards of recent history. It was noted in last year's edition that only one year since 2005 has had a Reliability Sub-Index score below 100, and that did not change in 2012.

There are 15 metrics that make up into this sub-index, nine of which showed improvement in 2012. The large drop observed in 2012 was due almost entirely to a nearly 73 point drop in energy expenditure volatility, which is covered in the section on the Economic Sub-Index.

Also contributing to the decline was what did not happen—crude oil price volatility remained basically flat, slipping just 0.7 points from its 2011 level. This is the second year in a row of relatively stable crude oil volatility, which is good news. But it is also true that the score for this metric is much higher than in previous years, and at $24.61, it was the third highest level ever.

Figure 10

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



Unrest in the Middle East in Libya, Egypt, Syria, and other countries, and continued concern about Iran's efforts to develop a nuclear weapon, and the of terrorist attacks on energy installations, like the one that occurred at a Libyan refinery in 2011, have kept oil markets unsettled and price volatility high. While these events have not seriously disrupted oil supplies lately, risks remain for future incidents, and it is conceivable that future incidents could disrupt supplies.[11]

The reliability score would have been worse had it not been for the tremendous improvement in the security of natural gas imports metric in 2012, also noted earlier in this report. Although the index for this metric is not weighed very heavily in this sub-index, its 32.2-point drop was large enough to have a moderating influence. Added to this, the security of crude oil imports risk index also fell 10.2 points. Large supplies of unconventional oil and gas in the United States can enhance the reliability of supplies both in the United States and globally.

Reliability risks related the power sector remained largely unchanged from 2011, with each of the three metric indexes moving either up or down by less than one point. In 2012, the risk index for capacity margins was quite a bit lower than its 1970-1999 baseline average, while those for capacity diversity and transmission, a critical aspect of grid reliability, were not appreciably different from their historical average. World oil refining capacity utilization and domestic petroleum stock also were little changed from 2011.

Future risks levels for this sub-index also are expected to be above the historical average. The index assumes crude oil price volatility will not stay as high as it was in 2011, but will over five years return to historical averages. Even with this assumption, and after dipping below 100 for a number of years (but never below 94), risks for this sub-index should rise to over 100 by 2028 and stay there for the remainder of the forecast period.

11 These metrics of energy security risk are intended to measure the *potential* for supply disruptions and other adverse effects. Like most measures of risk, the presence or absence of a particular outcome in a given yea r may say little about the underlying risk going forward.

A large contributor to the future trend in reliability risk is the metric measuring generating capacity diversity. This metric captures the flexibility of the power sector's ability to dispatch electricity from a diverse range of sources. Since there are inherent differences in availability among different generating technologies, the generating capacities are weighted by an availability factor.

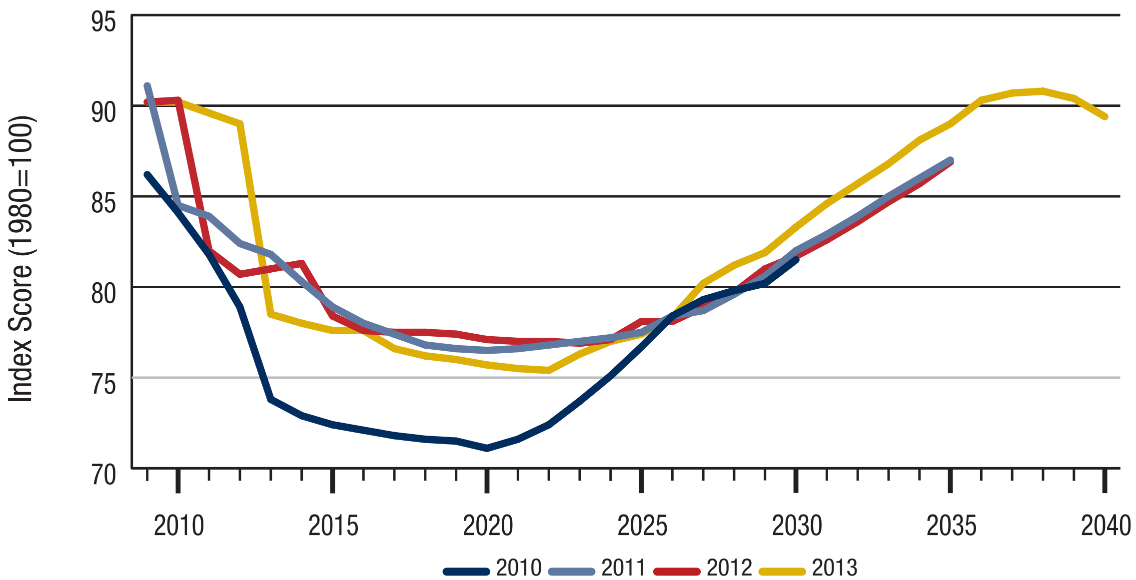
As illustrated in figure 11 nearby, the trends in future index scores for this metric have been fairly consistent since the 2010 edition of the U.S. Index. They showing declining risks (i.e., greater diversity) through the early- to mid-2020s, and increasing risks thereafter, primarily because not enough baseload coal and nuclear generating capacity, each of which operates at a high capacity factor, is being added to the generating mix.

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. At 84.7, this measure of overall environmental risk came in 3.2 points below its 2011 score and 14.6 points below its 30-year average (figure 12). This is the lowest score for this sub-index in the entire record going back to 1970. Twenty metrics contribute to this sub-index, with 14 showing lower scores in 2012.

The single biggest factor in the improvement in this sub-index was the 26.5 point drop in the risk index for energy-related carbon dioxide emissions from 2011 to 2012 that was the result of a more than 200 million metric tons drop in carbon dioxide emissions. (Since 2007, carbon dioxide emissions from energy have fallen by more than 730 million metric tons.) With a score of 167.6, it is still

Figure 11 Forecasts of Electricity Generating Capacity Diversity Risk, 2010-2013



well above its historical average of 114.2 but also at its lowest level since 1994.

Total carbon dioxide emissions from energy use are the product of four variables: (1) GDP per capita; (2) population; (3) energy intensity (energy use per unit of GDP); and (4) the carbon intensity of energy supply.[12] Figure 13 shows how these four elements have contributed to annual *changes* in U.S. emissions, either plus or minus, each year from 2000 to 2012.

Typically, in the United States GDP and population growth tend to pull emissions higher while almost continual improvements in energy intensity tend to work push emissions lower. Changes in the carbon intensity of the energy supply a much more variable pulling emissions higher in one year and pushing them lower in another. How these factors balance each other determines whether and how much total emissions rise or fall in any given year.

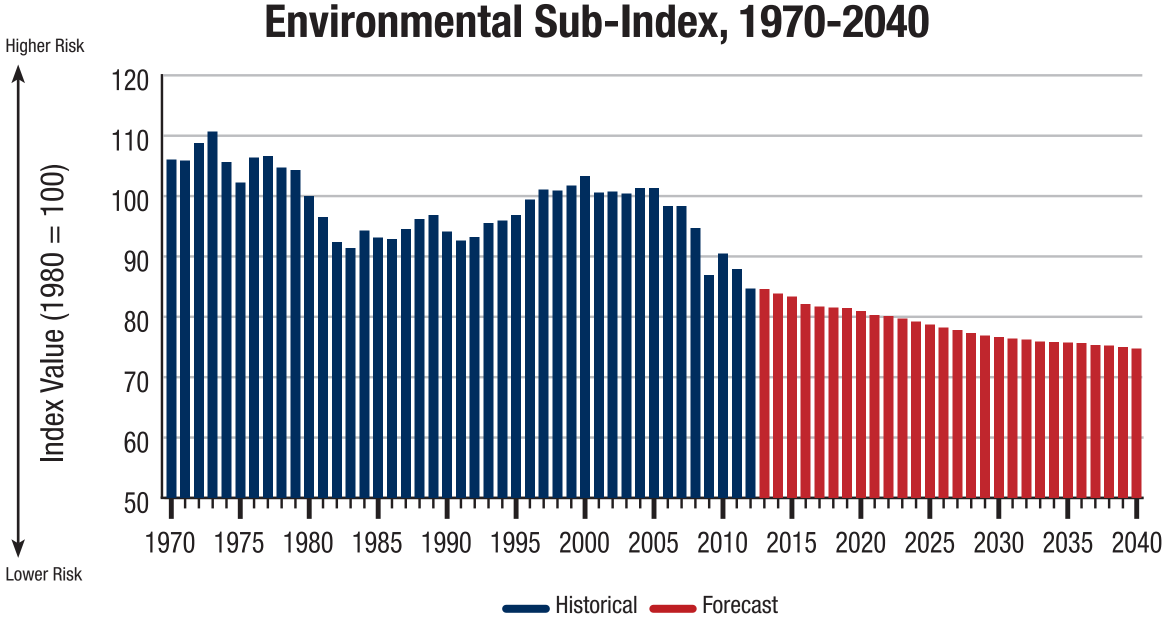
The interplay of these factors since 2000 is seen in Figure 13. It is apparent that most of the annual declines before 2008 we driven by gains in energy intensity that were more than enough to offset gains due to GDP and population growth. During the recession years of 2008 and 2009, population growth was the only factor on the positive side of the ledger, with GDP, energy intensity, and the carbonization of energy supplies all forcing emissions lower. The decarbonization in energy supplies that occurred during these two years, however, was not caused by fuel switching but by a much lower electricity generation, which altered the overall energy mix of the economy.

In 2011 and 2012, as in past years, better energy intensity was the primary cause of lower emissions, but decarbonization of the energy supply from greater

12 The calculation would be expressed as: Population × GDP per Capita × Energy Intensity × Carbon Intensity = carbon dioxide Emissions. This calculation, known as the Kaya Identity, was developed by the Japanese energy economist Yoichi Kaya.

Figure 12

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

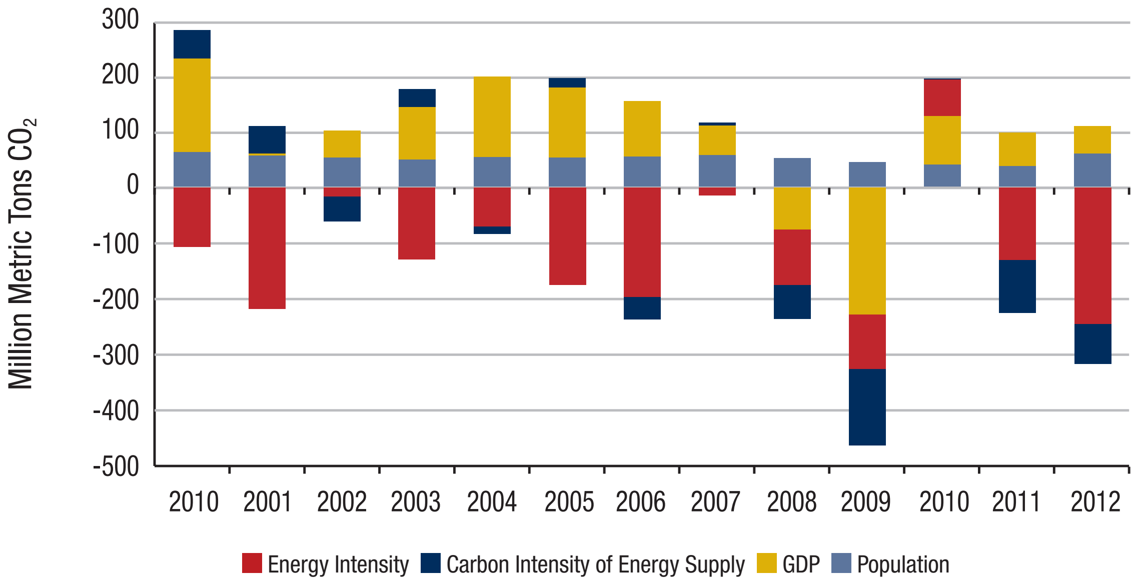


natural gas use in the power sector also played a significant role. Other factors include lower scores for energy intensity and efficiency measures, which were close to, if not below, their best score in the record. These metrics are expected to improve even more out to 2040.

EIA's outlook for energy-related carbon dioxide emissions is lower than last year's. Its *AEO 2013* has emissions rising, but at a more modest rate than in previous AEOs used to prepare the U.S. Index.

The overall outlook for the Environment Sub-Index is for steadily declining scores through 2040, despite some increase in carbon dioxide emissions. This is only one of the four sun-indexes showing consistently lower risks throughout the forecast period. By 2023, the risk score for this sub-index could fall below 80 for the first time, three years earlier than reported in last year's edition. There are a number of reasons for EIA's lower estimate, such as greater use of natural gas and renewables in power production, regulations targeting coal-fired power plants, improved energy intensity, and greater automobile efficiency

Figure 13 **Annual Changes in Energy-Related CO_2 Emissions by Component, 2000-2012**



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

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

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

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

Selecting and Developing the Metrics

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

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

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

The metrics selected were organized around nine broad types of metrics that represent and balance some key and often competing aspects of energy security. These are found in table A1-1.

Using these categories as guides, 37 individual metrics were selected and developed covering a wide range of energy supplies, energy end-uses, operations, and environmental emissions. Anywhere from three to six metrics were selected for each metric category.

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

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

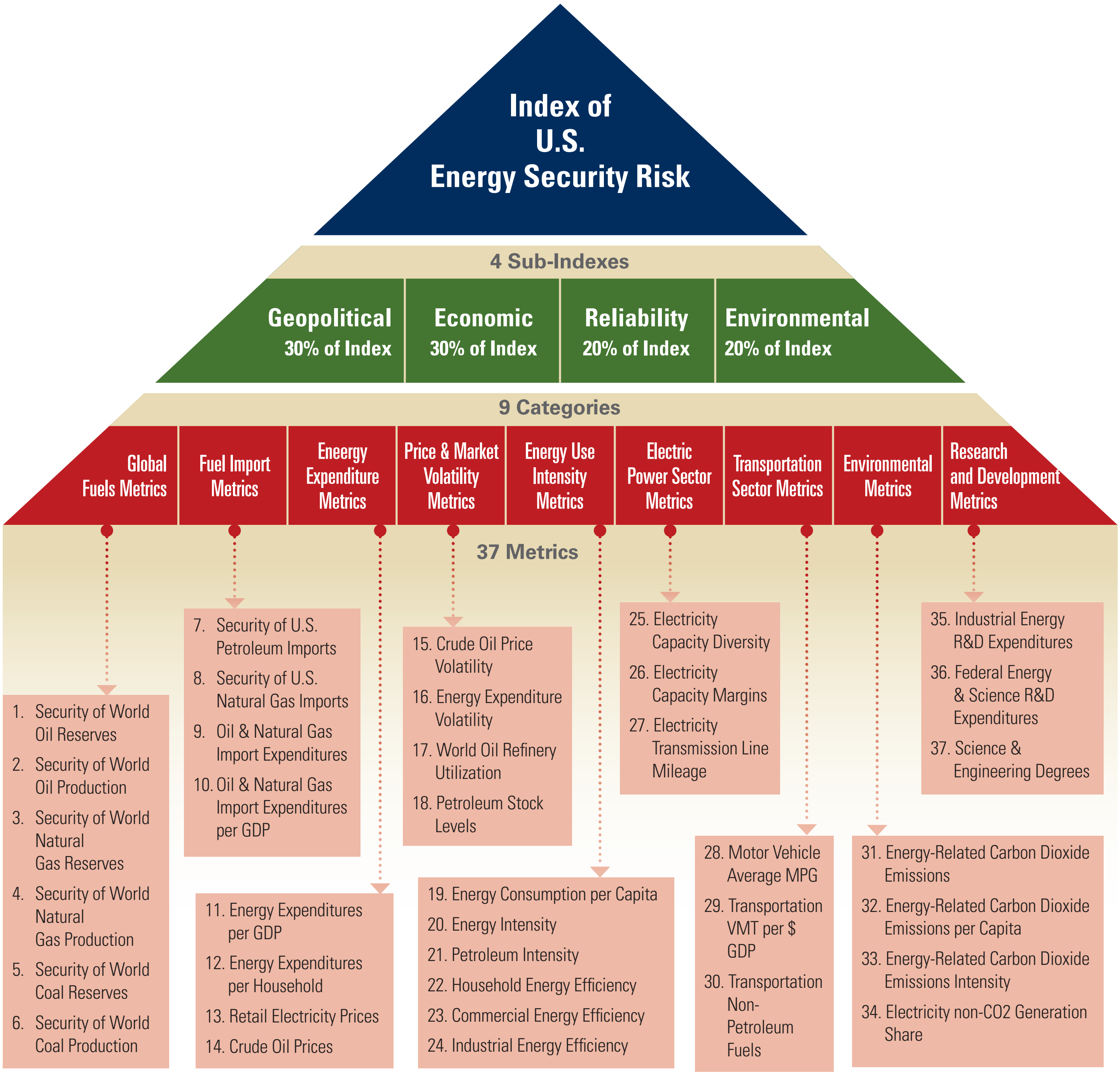


Table A1-1. Categories of Energy Security Metrics

	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.

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

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

Several of the metrics use similar data in different ways 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 2011 (AEO 2013)* was the primary source for metric forecasts out to 2040. *AEO 2013* projections, however, are not available for all of our metrics. In these cases, a neutral assumption was adopted and the last year of available data was extended over the forecast period.[4]

All of these data transformations are discussed in detail in the documentation material available on the Energy Institute's web site.

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

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

- **Geopolitical:** Petroleum is a globally-traded commodity with a supply that is concentrated in a relative handful of countries. Natural gas also is increasingly becoming a globally-traded commodity, and it too is fairly well concentrated, with about 70% of proven reserves located in the Middle East, Russia, and other former Soviet Union states. Trade in coal is more regional, but as China, India, and other large economies expand, it also may become a more international commodity. For both oil and gas, several of the top reserve-owning countries have uncertain political stability and are at best reluctant business partners with the United States.

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.

Dependence upon these fuel sources—for both the United States and the rest of the world—poses political and military risks. Because international disputes can quickly turn into energy problems, and vice versa, energy necessarily occupies a consequential role in U.S. foreign policy.

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

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

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

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

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

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

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

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

The final step was to merge the four Sub-Indexes into an overall annual Index of U.S. Energy Security Risk for each year from 1970 to 2035. 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 2035. The nine types of metrics categories are as follows:

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

The following information is provided for each metric:

• **Definition:** Describes what is being measured and the units of measurement.

• **Importance:** Describes the potential impact and risks associated with each metric.

• **Category of Metric:** Identifies the metric as one of nine broad types of metrics.

• **Historical and Forecast Values:** Provides two charts: one that shows the metric in its units of measurement and another that shows the metric as a normalized index in which 1980 equals 100. Historical values are in blue and forecast values are in red. Lighter shades of blue or red indicate assumed data or combined forecast/assumed data.

• **Observations:** Provides a brief overview of major trends, policies, and events that contributed to the observe trends in the metric.

• **Weighting and Average Historical Contribution of Metric to Energy Security Indexes:** Provides a table with: (1) the weight each metric was assigned in creating each of the four Sub-Indexes and its average weight for the total U.S. Index and (2) the average historical contribution of each metric to the resulting Sub-Index value. These weights are given as percentages. The weight assigned to each metric is an input measure, and it remains the same for each year over the entire period (both historical and forecast). The average historical contribution (1970-2012) of each metric to the Sub-Index and Index values is an output measure. It can and does change from year-to-year as the metric moves up or down in relation to other metrics.

• **Primary Data Sources:** Lists government and other sources used to compile the metric.

• **Data Issues:** Describes briefly how the metric data were manipulated, where necessary, to arrive at the annual metric values and metric indexes and how gaps and discontinuities in the data were resolved.

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

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

Acronyms

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

Metric #1

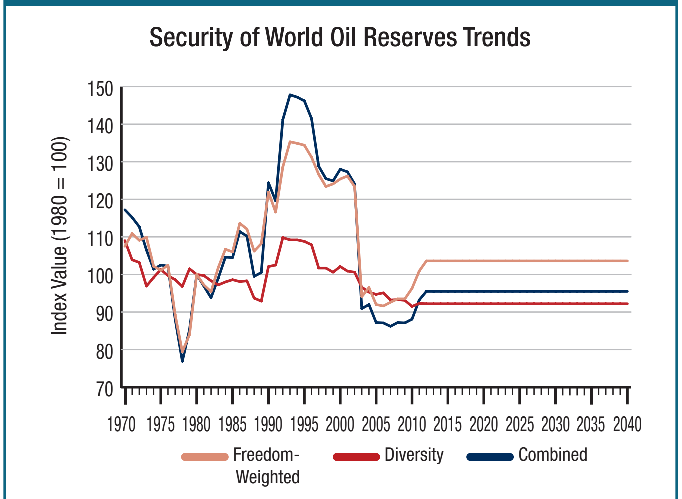
Security of World Oil Reserves

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

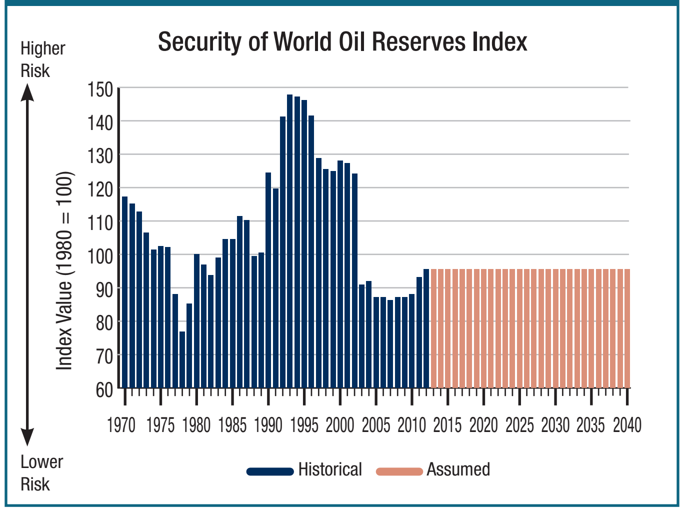
Importance: Indicates risk attached to the average barrel of global crude oil reserves. As a measure of reserves and not production, it largely reflects longer-term concerns.

Category of Metric: Global Fuels

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Changes over time reflect both the effects of changes in oil reserve estimates among countries having different Freedom rankings, as well as changes in the Freedom rankings over time for different countries.
- From 1970 to 2008, global oil reserves more than doubled. Also during this time, the world saw many changes in global freedom, for better and for worse.
- Most growth in oil reserves until early 2000s was concentrated in a handful of countries, particularly Iran, Iraq, Saudi Arabia, UAE, and Venezuela. Over much of this period, the freedom rankings in those countries tended to worsen. The combination of the two led to a worsening of the global average.
- In the earlier years, much of the change in diversity is tied to changes in Saudi Arabia reserves, both in absolute terms as well as relative to global supplies. In 2003, Canada's massive deposits of oil sands were included in the global reserves, producing a dramatic improvement in the global average for freedom of reserves.
- Looking ahead, we have no methodology for projecting future reserves or freedom rankings. Growth in reserves in the freer countries, and/or improvements in freedom rankings anywhere, would lessen the future risks.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	9	N/A	N/A	N/A	2.7
Average Contribution	11.4	N/A	N/A	N/A	3.4

Primary Data Sources:

Historical: EIA International Statistics from 1980; *O&G Journal* for pre-1980; Freedom House.

Forecast: Not available.

Data Issues:

General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; the Herfindahl-Hirschman Index (HHI) was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Mix of two historical datasets that match up closely.

Forecast: Metric was assumed to remain constant at its most recent measured value.

Metric #2

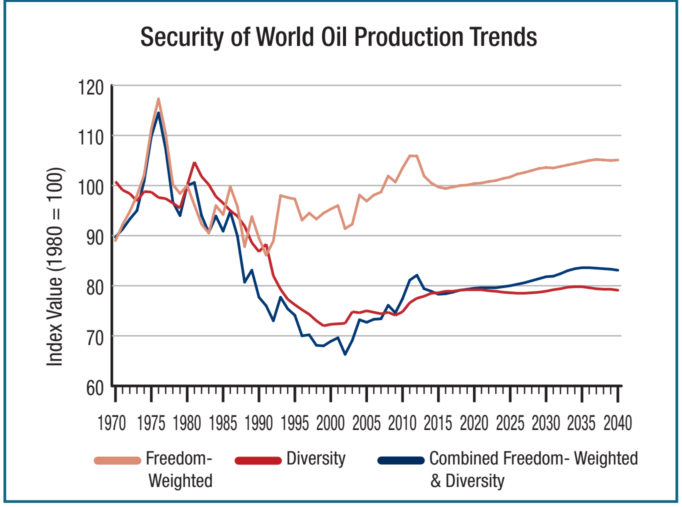
Security of World Oil Production

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

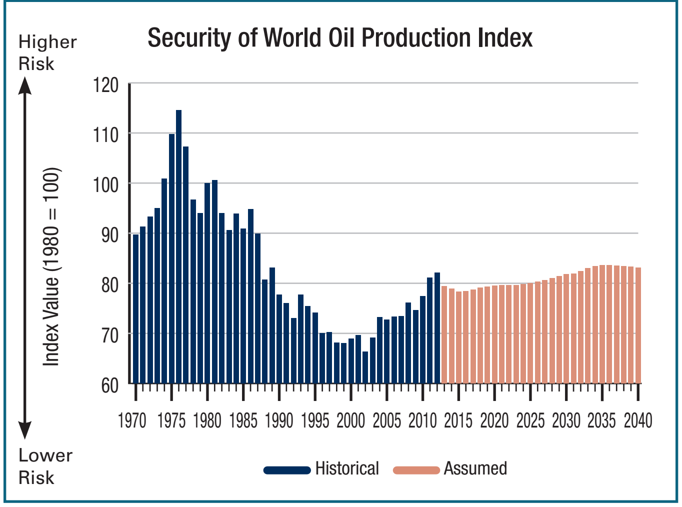
Importance: Indicates the level of risk attached to the average barrel of crude oil produced globally.

Category of Metric: Global Fuels

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Changes over time reflect changes in oil production among countries, different Freedom House rankings, as well as changes in the Freedom rankings over time for different countries.
- The biggest change has been in the diversity trend, which has improved markedly since the 1970s. Part of this improvement is tied to the decline in the U.S. share of world production over the years, from over 20% in 1970 to less than 8% today. However, this increase in diversity was accompanied by a worsening in the freedom-weighted global oil production.
- The ups and downs in the freedom-weighted production trend reflect a variety of events around the world, including declining production in Iran after the fall of the Shah in 1978, increasing production in the U.S. from the Alaskan North Slope and the UK and Norway in the 1970s and 1980s, and declining production in the Former USSR after its breakup in 1989.
- Since the early 2000s, risks have begun a modest increase. Oil production in the UK, Norway, and Mexico has been declining in recent years, with increases in Iran, Iraq, Russia, and Saudi Arabia.
- Looking ahead, the projection methodology suggests a continuing but modest worsening of risks associated with the security of world oil. Growth in production in the freer countries and improvements in freedom rankings anywhere would lessen the future risks.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	7.0	5.0	6.0	N/A	4.8
Average Contribution	6.9	5.4	5.5	N/A	4.8

Primary Data Sources: **Historical:** EIA International Statistics, Freedom House.
Forecast: EIA *IEO 2011* for world oil production.

Data Issues: **General:** Freedom House's Freedom Index was used as a proxy for reliability of a supplier; the HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.
Historical: Mix of two historical datasets that match up fairly closely.
Forecast: Freedom metric assumed to remain constant at most recent measured value; diversity calculated from *IEO 2010*. Metric combined to come up with forecast.

Metric #3

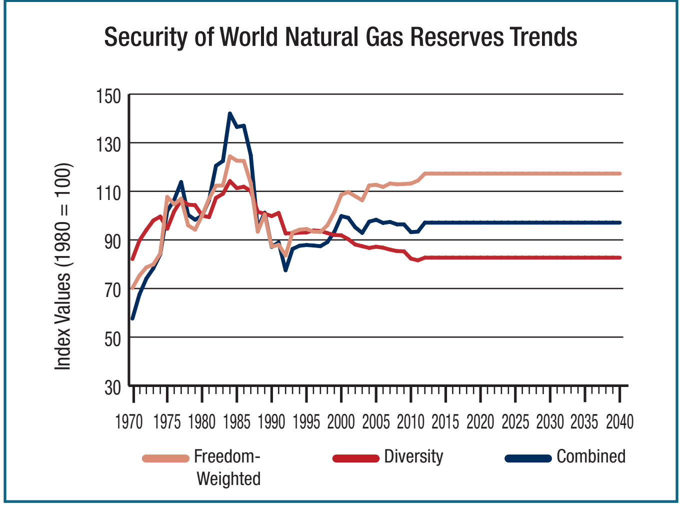
Security of World Natural Gas Reserves

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

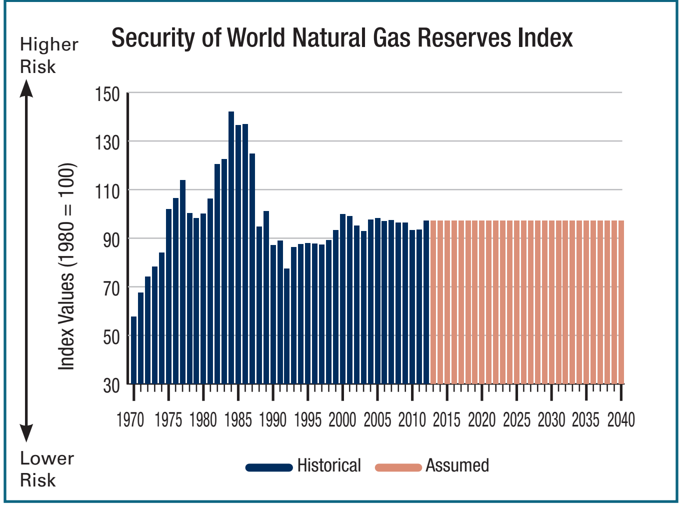
Importance: Indicates the risk attached to the average cubic foot of natural gas reserves globally. As a measure of reserves and not production, it largely reflects longer-term concerns.

Category of Metric: Global Fuels

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Changes in the values over time reflect both the effects of changes in natural gas reserves among countries having different Freedom rankings, as well as changes in the Freedom rankings over time for different countries.
- Much of the changes observed in the above graphs result from the rapid growth in global gas reserves, which increased five-fold between 1970 and 2008. Much of this growth has been in countries such as Russia, Iran, Saudi Arabia, and Qatar, where the Freedom House rankings have fluctuated, but are generally worse than average. Part of this growth is related to actual discoveries, and part is related to improvements in global data reporting.
- The trend in diversity shows a couple of major shifts. Up until the mid 1980s, much of the change in diversity is tied to changes in Russian reserves estimates (and for earlier years, the Former Soviet Union), both in absolute terms as well as relative to global supplies.
- Looking ahead, there is no methodology for projecting future reserves or how Freedom House's rankings will change. Growth in reserves in the freer countries, and/or improvements in Freedom House rankings anywhere, would lessen future risks. In particular, in recent years the developments in shale gas and the subsequent increased estimates of the shale reserves are expected to have a significant impact on this metric in future years.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	6.0	N/A	N/A	2.0	2.2
Average Contribution	6.8	N/A	N/A	2.0	2.4

Primary Data Sources: Historical: EIA International Statistics from 1980; *O&G Journal* for pre-1980; Freedom House.
Forecast: Not available.

Data Issues: General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.
Historical: Mix of two historical datasets that match up fairly closely.
Forecast: Metric was assumed to remain constant at its most recent measured value. Methodology for future production could be developed.

Metric #4

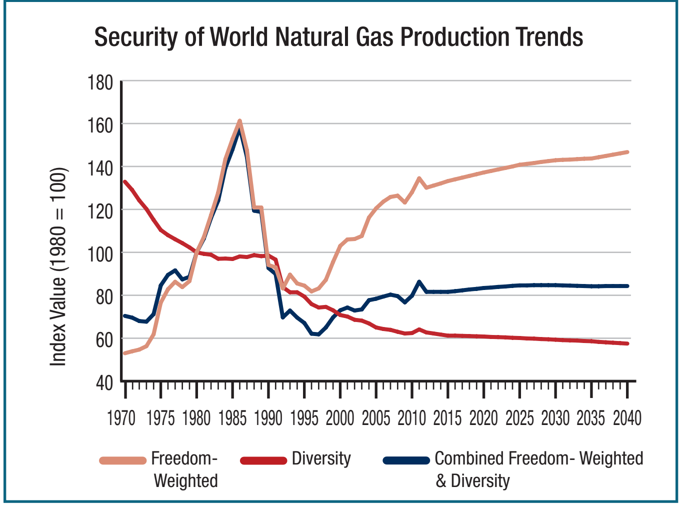
Security of World Natural Gas Production

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

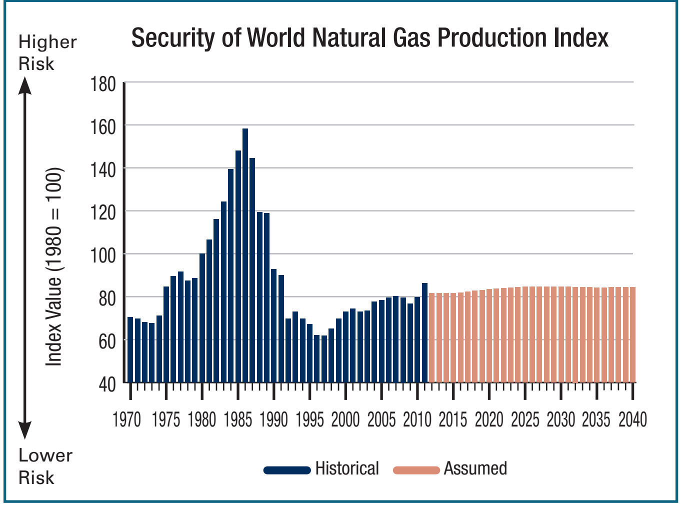
Importance: Indicates the level of risk attached to the average cubic foot of natural gas produced globally.

Category of Metric: Global Fuels

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Natural gas production more than tripled since 1970. As world markets grew, U.S production fell as a percentage of global production, which improved diversity but worsened the average-weighted measure of supplies.
- From 1970 to the mid-1980s, there is a sharp trend toward less freedom in production, as the largest growth in production was seen in the USSR, which at the time was ranked as "not free."
- In the late 1980s and the 1990s, conditions improved, with greater gas production in the U.S. and the North Sea and improving freedoms in Russia and other FSU countries.
- In the last few years, the index has been worsening, largely due to adverse trends in freedom in Russia and other major gas-producing countries.
- The net effect of these trends was to increase global supply security risks through the mid-1980s. Beginning in the late 1980s, the energy security index shows a substantial overall improvement due to improving freedom among producing countries, expansion of production in many regions, and the subsequent breakup of the Former Soviet Union.
- The Index's projections suggest a continuing worsening in the security trends, but a slight improvement in diversity as the United State and other countries ramp up gas production. These two trends roughly offset each other. Growth in production in the freer countries (especially from shale), and/or improvements in Freedom House rankings anywhere would lessen future risks.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	5.0	2.0	3.0	2.0	3.1
Average Contribution	5.2	2.3	2.9	1.8	3.2

Primary Data Sources: Historical: EIA International Statistics from 1980; BP data for pre-1980; Freedom House.
Forecast: EIA *IEO 2011* for world natural gas production.

Data Issues: General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.
Historical: Mix of two historical datasets that match up fairly closely.
Forecast: Metric was assumed to remain constant at its most recent measured value.

Metric #5

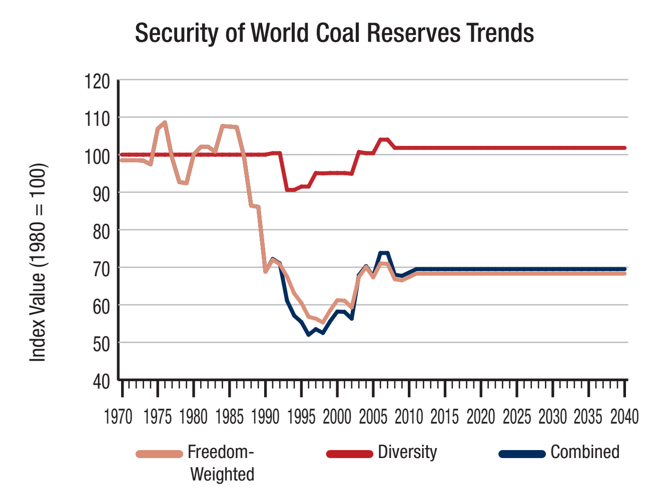
Security of World Coal Reserves

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

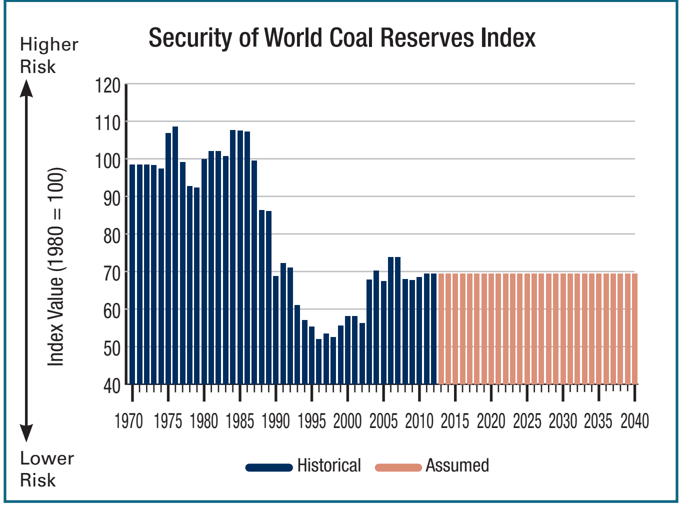
Importance: Indicates the risk attached to the average ton of coal reserves globally. As a measure of reserves, it largely reflects longer-term concerns.

Category of Metric: Global Fuels

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Estimates of coal reserves generally do not exhibit the kinds of rapid shifts seen in oil and natural gas reserve estimates. The location of coal deposits is generally well-known and reserves tend to be large relative to production. Consequently, there is relatively little change in overall reserves and few shifts in diversity among countries.
- The changes in the values seen here tend to reflect more the changes in the Freedom House rankings of the major coal reserve-holding countries. Political developments in South Africa and Eastern Europe in the late 1980s, and in the Former Soviet Union in the 1990s, account for most of the changes observed here.
- Additionally, for the Former Soviet Union, what had been measured as one country was now split among several, resulting in a greater degree of global diversity.
- Looking ahead, there is methodology for projecting future reserves or freedom rankings. Growth in reserves in the freer countries and improvements in freedom rankings anywhere would lessen future risks.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	4.0	N/A	N/A	N/A	1.2
Average Contribution	3.8	N/A	N/A	N/A	1.1

Primary Data Sources:

Historical: Historical: EIA International Statistics; Freedom House.

Forecast: Not available.

Data Issues:

General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Incomplete time series for historical coal reserves. Assumed that from 1970 to 1989, reserves remained constant at 1990 measured value.

Forecast: No data on future reserves or future Freedom rankings. Metric was assumed to remain constant at its most recent measured value. Methodology for future production could be developed.

Metric #6

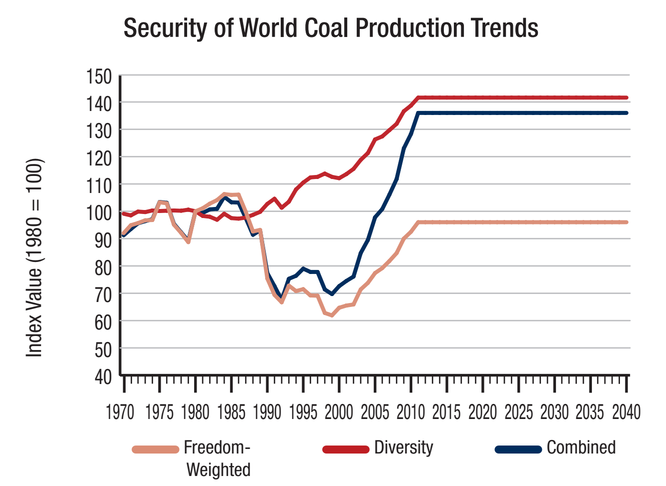
Security of World Coal Production

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

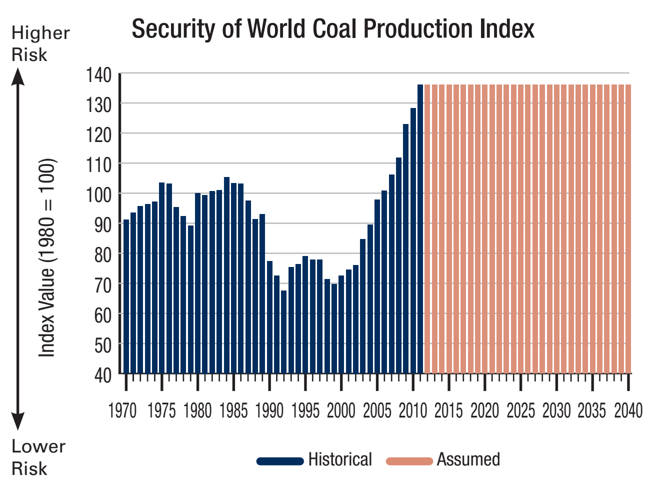
Importance: Indicates the level of risk attached to the average ton of coal production globally.

Category of Metric: Global Fuels

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Globally, most of the growth in coal production has taken place in the U.S., China, India, Australia, and Indonesia. Changes in the values over time reflect both the effects of changes in coal production among countries having different Freedom rankings, as well as changes in the Freedom rankings over time for different countries.
- Most of the changes in the metric stem from changes in the freedom component. Most significantly, the events leading up to and following the breakup of the Former Soviet Union, as well as the political developments in South Africa and Eastern Europe beginning in the late 1980s, brought a significantly greater degree of freedom to a large part of the global reserves.
- More recently, changes in the metric are dominated by the rapid growth in Chinese coal production, where China's production now accounts for over 40% of global coal production.
- Looking ahead, there is no methodology for projecting future reserves or freedom rankings. Growth in production in the freer countries and improvements in freedom rankings anywhere would lessen future risks.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	2.0	1.0	1.0	N/A	1.1
Average Contribution	2.2	1.2	1.0	N/A	1.2

Primary Data Sources:

Historical: EIA International Statistics from 1980; IEA for pre-1980; Freedom House.

Forecast: Not available.

Data Issues:

General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Mix of two historical datasets that match up fairly closely.

Forecast: No data on future Freedom rankings. Metric was assumed to remain constant at its most recent measured value.

Metric #7

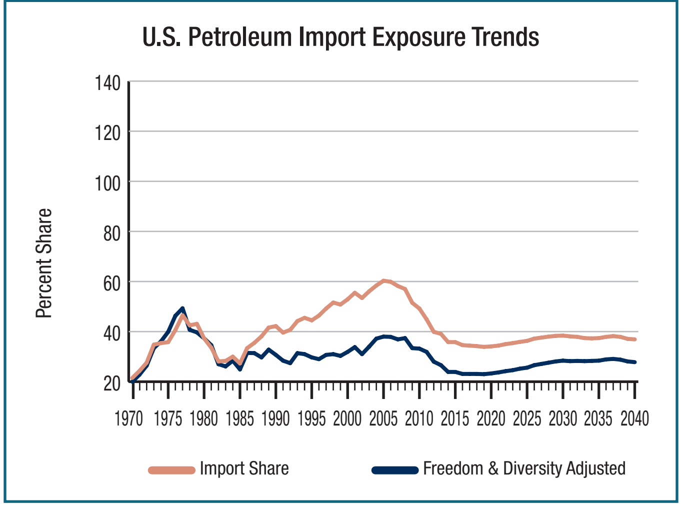
Security of U.S. Petroleum Imports

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

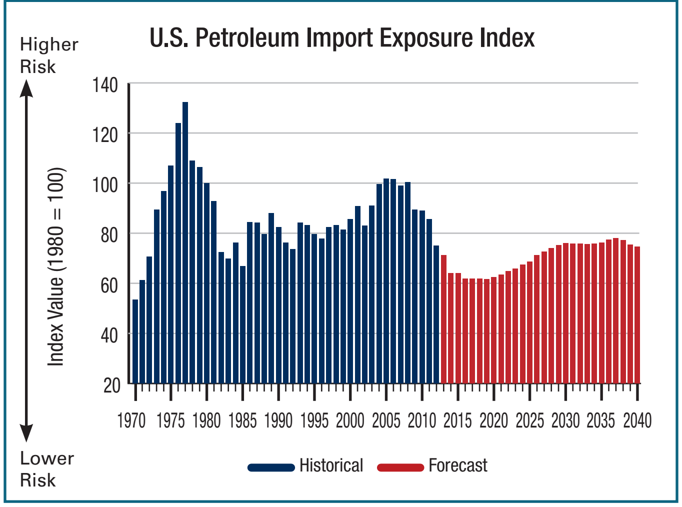
Importance: Indicates the degree to which changes in import levels expose the U.S. to potentially unreliable and/or concentrated supplies of crude and refined petroleum.

Category of Metric: Fuel Imports

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- At the beginning of the 1970s, imports were barely 20% of U.S. supply. This rapidly grew to more than 40%, before oil price shocks, supply disruptions, economic recessions, and fuel economy standards caused oil imports to decline as a share of demand.
- From the mid-1980s until recently, however, imported oil's share started growing, hitting 60% of total supply in 2005.
- Looking forward, EIA's projections in *AEO 2012* indicate a gradual reduction in the share of imports in U.S. petroleum supplies.
- A somewhat different picture emerges when the freedom and diversity weightings are applied. Even though imports accounted for a smaller portion of oil usage in the late 1970s than they do today (or are forecast to do in the future), the import risk at that time was much larger because the freedom and diversity of those supplies was much more adverse at that time. Conversely, the risk of high levels of U.S. oil imports today is tempered by increased domestic output and the relative increases in diversity and freedom seen in world markets.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	8.0	N/A	9.0	N/A	4.2
Average Contribution	8.2	N/A	8.7	N/A	4.2

Primary Data Sources:

Historical: EIA *AER,* Table 5.1; EIA International Statistics; Freedom House.

Forecast: EIA *AEO 2013,* Tables 11; EIA *IEO 2011* for world oil production.

Data Issues:

General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: None.

Forecast: No data on future Freedom rankings. Freedom ranking assumed to remain constant at most recent measured value and applied to projected imports.

Metric #8

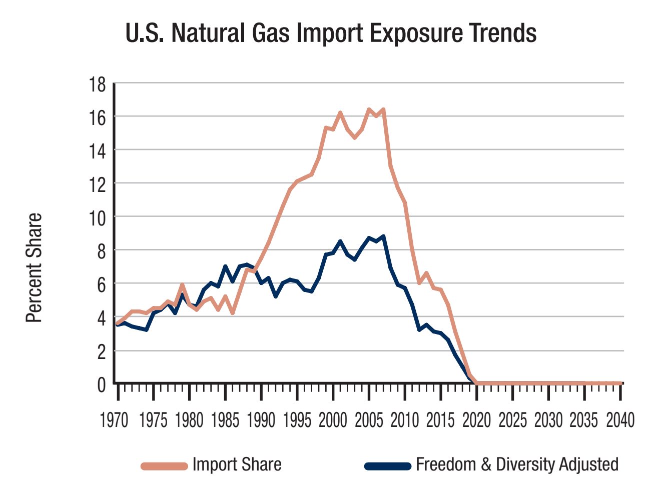
Security of U.S. Natural Gas Imports

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

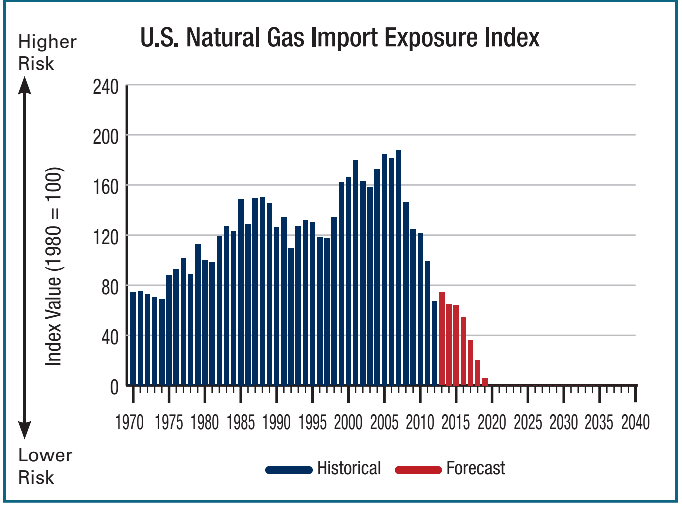
Importance: Indicates the degree to which changes in import levels expose the U.S. to potentially unreliable and/or concentrated supplies of natural gas.

Category of Metric: Fuel Imports

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show a strong increasing trend in natural gas import shares. In 1970, the U.S. met more than 95% of its natural gas demand with domestic resources. Since then, and continuing into this decade, natural gas imports climbed sharply, recently reaching about 16% of total U.S. supply.
- This growth in imports was accompanied by deterioration in the freedom index for global gas production, driven largely by growth from Russia and other FSU countries.
- Prior to the 1990s, the non-U.S. portion of global gas was dominated by FSU production. With the breakup of the FSU, coupled with growing production in other regions, there was a marked improvement in both supply freedom and supply diversity.
- Looking forward, EIA's projections in *AEO 2012* indicate a substantial reduction in U.S. gas imports. This is a significant change from the projections of just a few years ago. Decreasing projections of economic growth, increasing domestic supplies, and other factors are combining to reduce our expectations of future natural gas import volumes.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	3.0	N/A	2.0	N/A	1.3
Average Contribution	4.4	N/A	2.8	N/A	1.9

Primary Data Sources:

Historical: EIA *AER,* Table 6.1; Freedom House.

Forecast: EIA *AEO 2013,* Table 13; EIA *IEO 2011* for world natural gas production.

Data Issues:

General: Freedom House's Freedom Index was used as a proxy for reliability of a supplier; HHI was used as a measure of diversity. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: None.

Forecast: No data on future Freedom rankings. Freedom ranking assumed to remain constant at most recent measured value and applied to projected imports.

Metric #9

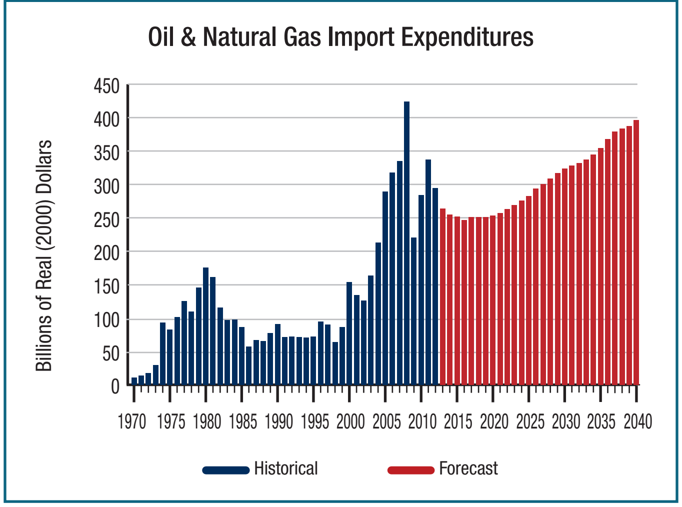
Oil & Natural Gas Import Expenditures

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

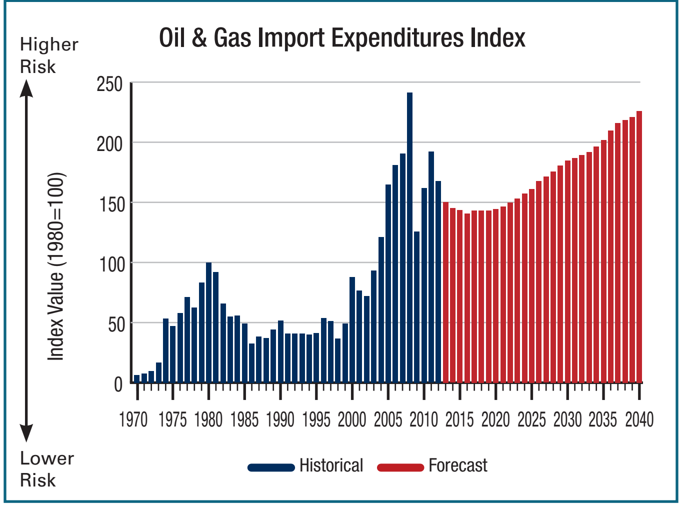
Importance: Indicates lost domestic economic investment and opportunity and the relative magnitude of revenues received by foreign suppliers.

Category of Metric: Fuel Imports

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data dramatically show the effects of the oil shocks of the 1970s, as well as the recent run-up in oil prices. In the early 1970s, import costs were less than $10 billion per year measured in real (2000) dollars. By the end of that decade, we were spending over $100 billion per year on oil and natural gas imports.
- Lower fuel prices and reduced imports held U.S. import costs in check throughout much of the 1980s and 1990s. Since 2000, however, sharply increasing imports coupled with sharply higher prices, led to import costs exploding to over $200 billion per year.
- Looking forward, EIA's projections in *AEO 2013* indicate a brief easing in import costs through 2020. However, EIA's projections indicate that by 2040 import costs will reach more than $400 billion per year (in 2010 dollars) because of increasing crude oil prices.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	6.0	6.0	N/A	N/A	3.6
Average Contribution	5.4	6.0	N/A	N/A	3.4

Primary Data Sources:

Historical: EIA *AER,* Table 3.9.

Forecast: EIA *AEO 2013,* Table 11 & Supplemental Table 116.

Data Issues:

General: Cost data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #10

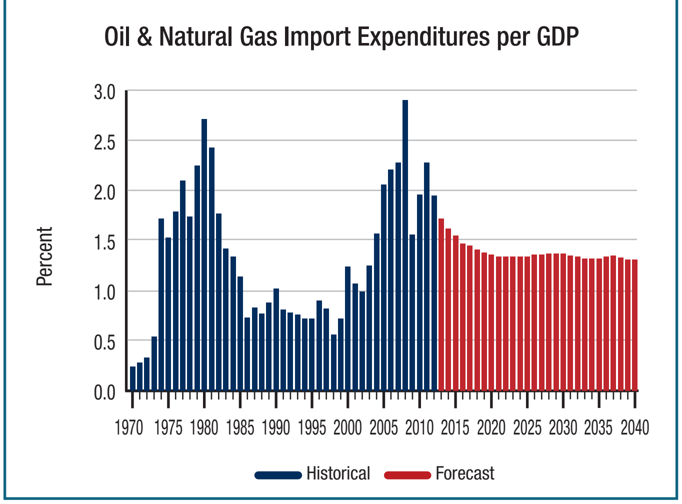
Oil & Natural Gas Import Expenditures per GDP

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

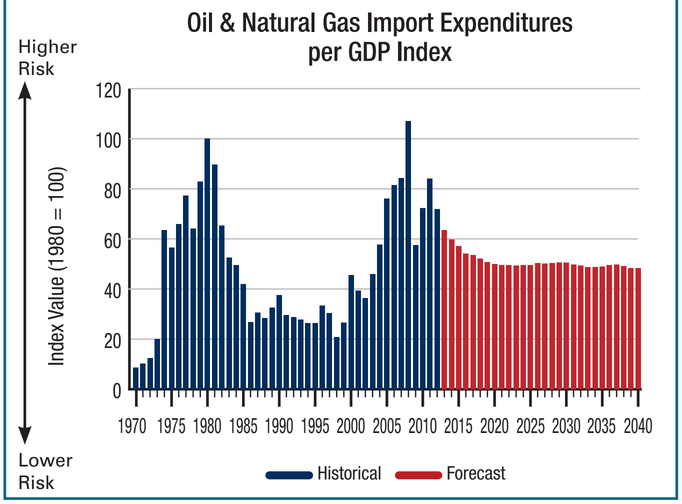
Importance: Indicates the susceptibility of the U.S. economy to imported oil and gas price shocks.

Category of Metric: Fuel Imports

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Expressed as a percentage of GDP, historical data show the dramatic effects of the oil shocks of the 1970s as well as the recent run-up in oil prices. Because the economy was much smaller in the 1970s than it is today, the dollar cost of those oil shocks was a relatively bigger share of total GDP, even though the U.S. imported much less oil then than we do today.
- The second large rise in risk occurred in the late 2000s. This peak reflects record real oil prices coupled with significantly larger import volumes, which pushed the oil and natural gas import expenditure risk index to its highest point in about 30 years.
- Looking forward, EIA's projections in *AEO 2013* indicate that costs for oil and natural gas imports again will rise within a few years. However, since the U.S. economy is also projected to grow, the percentage of GDP directed toward these fuel imports gradually declines.
- Still, over the entire period from 2013 to 2040, the level of import expenditures as a share of GDP generally is forecast to remain below 1.5%. Previous forecasts indicated levels of 1.5% or more.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	9.0	N/A	N/A	2.7
Average Contribution	N/A	5.8	N/A	N/A	1.7

Primary Data Sources:

Historical: EIA *AER,* Table 3.9; DOC BEA for GDP.

Forecast: EIA *AEO 2013,* Tables 11 & 20.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #11

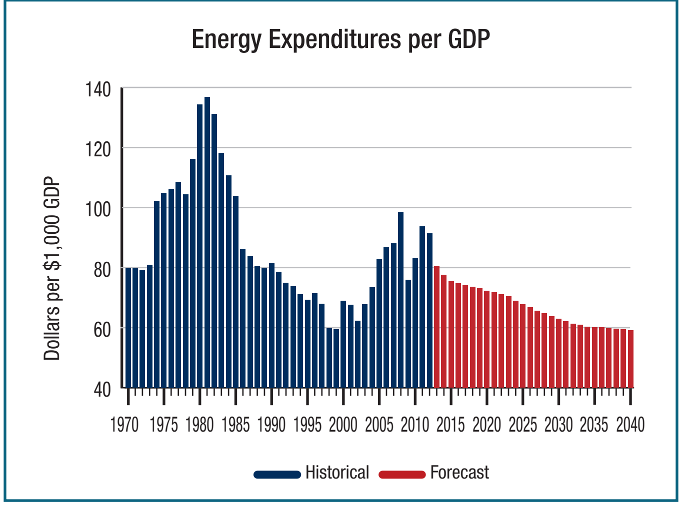
Energy Expenditures per GDP

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

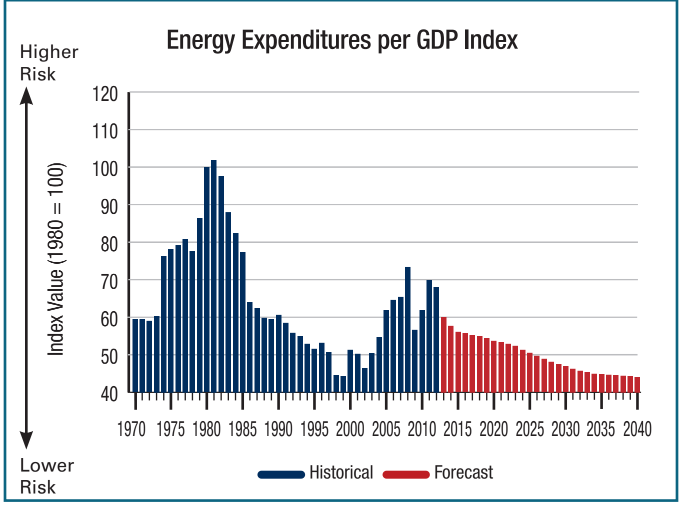
Importance: Indicates the magnitude of energy costs in the U.S. economy and its susceptibility to energy price shocks and exposure to price changes.

Category of Metric: Energy Expenditures

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- While the trends in energy consumption per capita or energy intensity generally show only modest year-to-year changes, expenditure data show a much more volatile picture.
- The price increases in the 1970s and early 1980s led to a sharp rise in energy costs per dollar of GDP. This eased in the mid-1980s and remained at moderate levels until after 2000.
- In recent years, energy costs have risen sharply, peaking in 2008. However, despite the high absolute prices for energy, a greater level of energy efficiency and a larger GDP combined to make the 2008 peak significantly below the 1980s peak.
- Looking forward, EIA's projections in *AEO 2013* indicate energy prices and expenditures gradually declining. By 2040, expenditures are expected to be lower than at any time since 1970.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	5.0	7.0	N/A	N/A	3.6
Average Contribution	3.8	5.9	N/A	N/A	2.9

Primary Data Sources:

Historical: EIA *AER,* Table 3.5; DOC BEA for GDP.
Forecast: EIA *AEO 2013,* Tables 2, 3 & 20.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100.
Historical: Incomplete data pre-1973; proxies developed.
Projection: None.

Metric #12

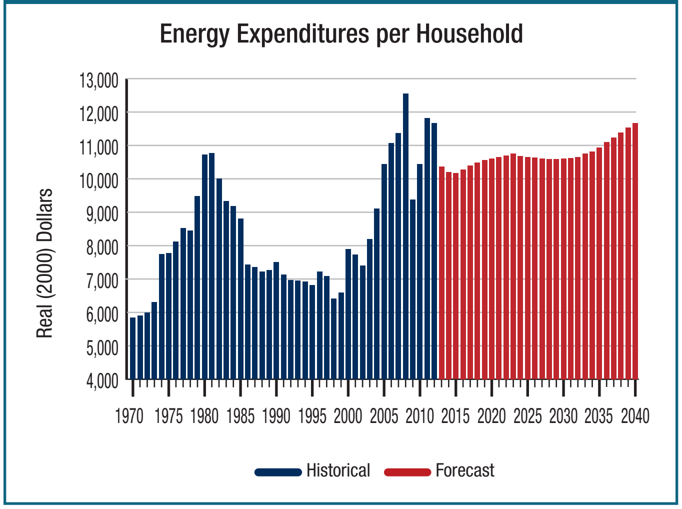
Energy Expenditures per Household

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

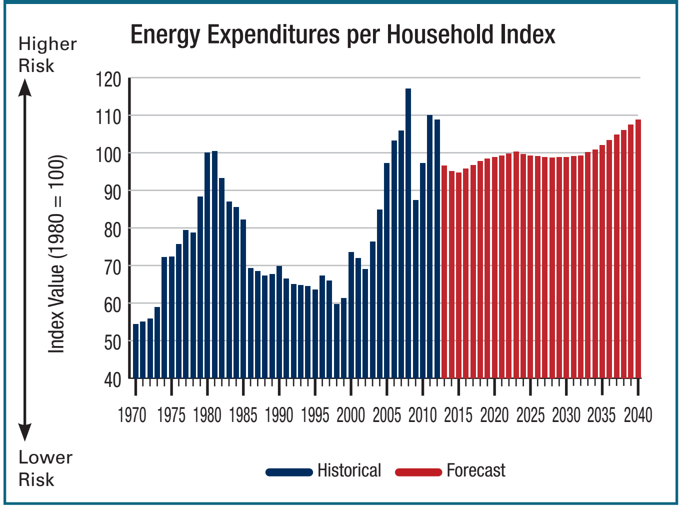
Importance: Indicates the importance of energy in household budgets and the susceptibility of U.S. households to energy price shocks.

Category of Metric: Energy Expenditures

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- While the trends in energy consumption per capita and energy intensity generally show only modest year-to-year changes, expenditure data show a much more volatile picture.
- Price increases in the 1970s led to a doubling of per-household energy costs. Similarly, the recent price spikes led to nearly a doubling in per-household energy expenditures, even after starting from a higher base.
- Looking forward, EIA's projections in *AEO 2013* indicate steady and continuing increases in per-household energy expenditures. This projection is driven partly by continuing and increasing high prices, particularly for petroleum products.
- Over the *AEO* projection period of 2012-2040, the total energy expenditures are projected to rise at over 0.4% per year in real terms, much slower rate than in previous forecasts.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	9.0	N/A	N/A	2.7
Average Contribution	N/A	9.1	N/A	N/A	2.7

Primary Data Sources:

Historical: EIA *AER,* Table 3.5; DOC BEA for GDP; Census Bureau *Housing Vacancy Survey.*

Forecast: EIA *AEO 2013,* Tables 3 & 4.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Number of housing units, the category the Census Bureau uses, used as a proxy for number of households, the category EIA uses.

Forecast: None.

Metric #13

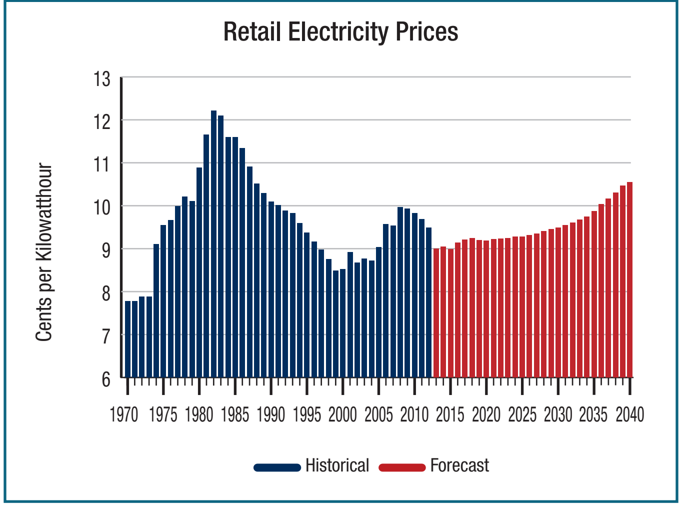
Retail Electricity Prices

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

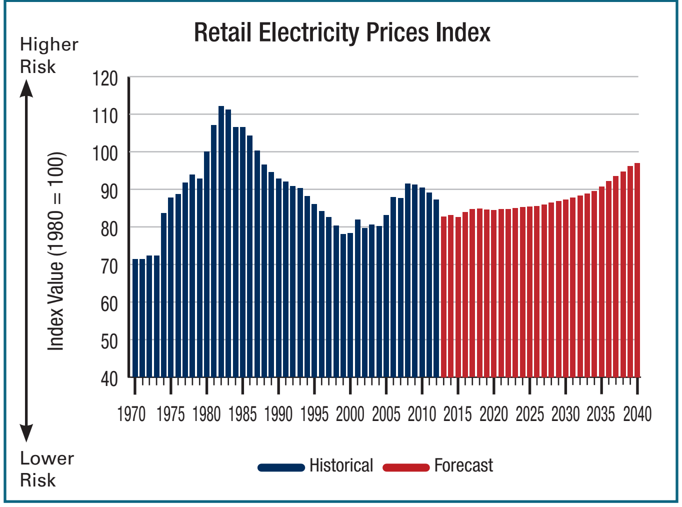
Importance: Indicates the availability of low-cost, reliable forms of power generation.

Category of Metric: Energy Expenditures

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- During the 1970s, rapidly increasing fuel prices, construction costs for new capacity, and financing costs led to a sharp increase in electricity rates.
- From the mid-1980s until 2000, prices fell at a steady rate as a result of lower fossil fuel prices, improvements in natural gas supplies, combined cycle generating technologies, and reduced levels of capital-intensive capacity construction.
- In this decade, the increases in natural gas and coal prices, plus sharply higher costs for new construction, have contributed to an increasing price trend for power generation.
- The economic recession beginning in 2008 led to sharply lower fuel prices, reversing the recent upward trend.
- Looking forward, EIA's projections in *AEO 2013* indicate that retail electricity prices will decline in the short term and because of low natural gas prices increase after 2020 because of new regulations targeting coal and greatly expanded use of renewables.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	10.0	N/A	N/A	3.0
Average Contribution	N/A	11.6	N/A	N/A	3.5

Primary Data Sources:

Historical: EIA *AER,* Table 8.10.

Forecast: EIA *AEO 2013,* Table 8.

Data Issues:

General: Price data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed. Retail prices include taxes, which are transfer prices rather than economic costs.

Metric #14

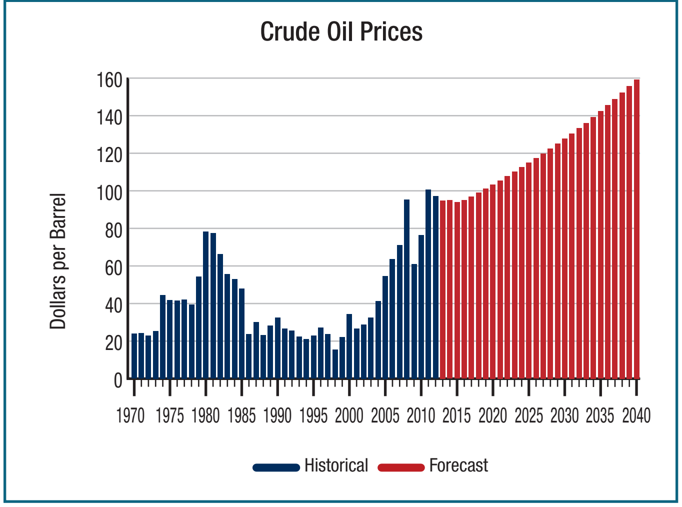
Crude Oil Prices

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

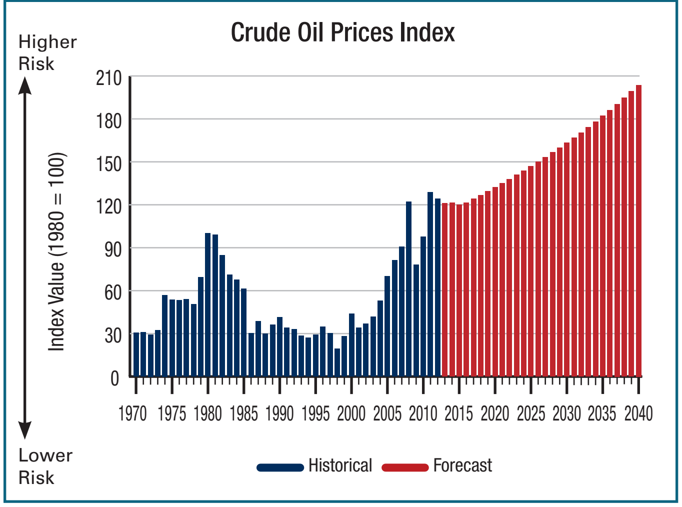
Importance: Indicates the susceptibility of the U.S. economy to high prices for petroleum, which supplies a significant portion of U.S. energy demand.

Category of Metric: Energy Expenditures

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The oil price shocks of the 1970s and early 1980s are clearly seen in the historical data for this metric. Because high inflation rates were also experienced over much of this period, real prices jumped at a slightly less dramatic pace.
- From the early 1980s until just a few years ago, oil prices remained at relatively low levels.
- Beginning earlier this decade, imported oil prices began a steady and rapid climb, peaking in 2008. Greater demand from China, India, and other large emerging economies and turmoil in the Middle East contributed to the rise. Currently, the global recession and the response to earlier high prices have dampened global oil demand and prices.
- Looking forward, EIA's projections in *AEO 2013* indicate that crude oil prices will climb, reaching nearly $160.00 per barrel by 2040 (in constant 2010 dollars).

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	13.0	13.0	6.0	N/A	9.0
Average Contribution	8.4	9.3	3.7	N/A	6.1

Primary Data Sources:

Historical: EIA *AER,* Table 5.19 & 5.21.

Forecast: EIA *AEO 2013,* Table 1.

Data Issues:

General: Cost data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: EIA data on imported crude costs do not go back further than 1973. Estimates for 1970 to1972 were based upon crude oil refiner acquisition costs.

Forecast: None.

Metric #15

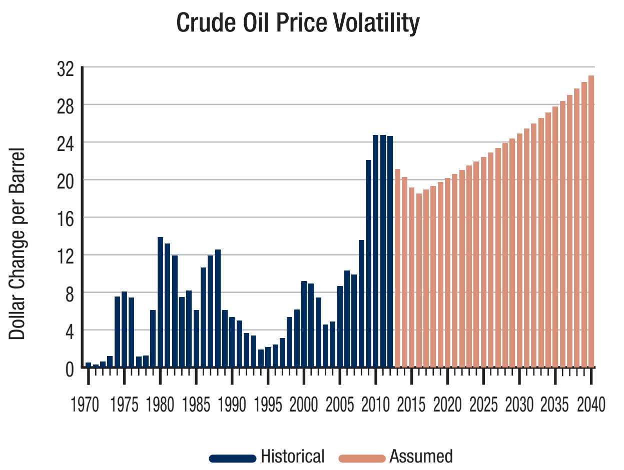
Crude Oil Price Volatility

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

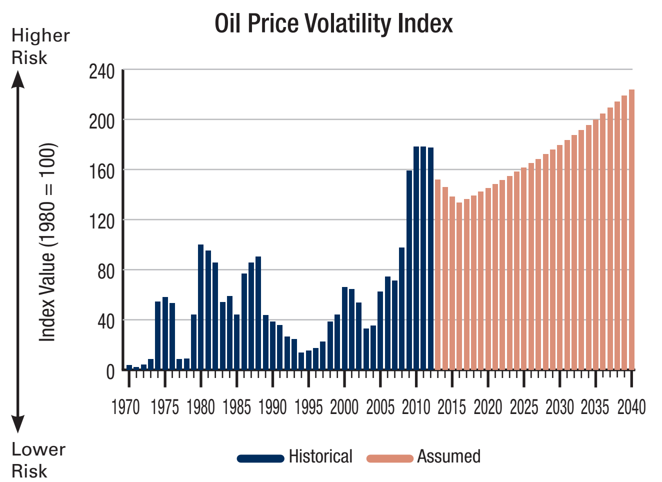
Importance: Indicates the susceptibility of the U.S. economy to large swings in the price of petroleum, which supplies a significant portion U.S. energy demand.

Category of Metric: Price Volatility

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical trend vividly shows the high volatility seen in the oil market in recent decades. The two oil price shocks in the 1970s and early-1980s show up as periods of high volatility, as does the oil price plummet of the mid-1980s.
- More recently, the oil market turmoil—both up and down—has raised volatility to record levels. Upside price volatility created economic pain, raised shipping costs, disrupted transportation economics, and created massive windfalls for oil-exporting countries.
- But downside price volatility has not been without problems and dislocations either, as oil exploration and drilling plans are deferred and renewable energy projects become less attractive.
- Looking over the forecast period from 2013 to 2040, there are no comparable data indicating price volatility. Forecasting models generally assume a market in balance, and typically do not show volatility. But as these data show, long periods of price stability are not the norm.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	5.0	3.0	10.0	N/A	4.4
Average Contribution	3.4	2.3	6.4	N/A	3.0

Primary Data Sources:

Historical: EIA *AER*, Table 5.21 & 5.18.

Forecast: Not available.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Proxy data used to develop pre-1970 data inputs for a 1970 estimate.

Forecast: Metric was assumed to remain constant at its 1970-2009 average after a five-year transition period. The 1970-2009 dollar average was arrived at using average volatility measured as a percent.

Metric #16

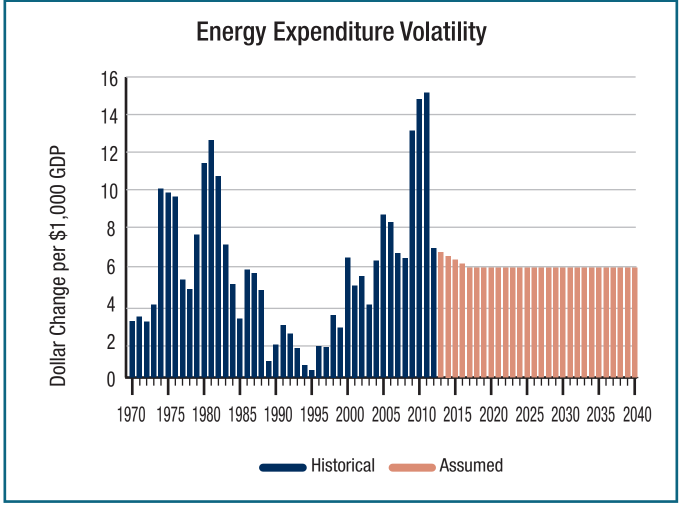
Energy Expenditure Volatility

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

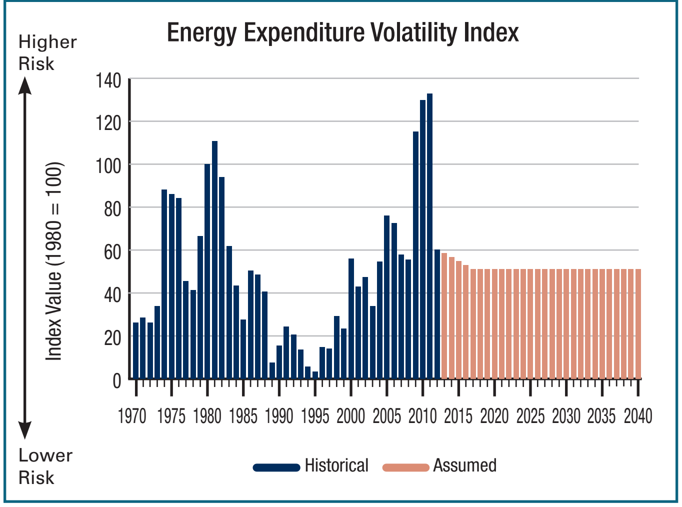
Importance: Indicates the susceptibility of the U.S. economy to large swings in expenditures for all forms of energy.

Category of Metric: Price Volatility

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical trend shows the dramatic changes in energy costs and high volatility in energy expenditures in recent decades. The two oil price shocks in the 1970s and early 1980s can be seen in the Index as periods of high volatility. Similar volatility is seen in oil markets in the 2000s.
- During these volatile periods, the annual changes in energy costs approached one % of total GDP, equal to many tens of billions of dollars.
- The changes seen in the 1970s and early-1980s are actually slightly larger than the volatility observed in the 2000s, mainly because GDP was much larger, and partly because U.S. petroleum and other energy use today is proportionately smaller than it used to be.
- Looking forward from 2013-2040, there are no comparable data indicating volatility of energy expenditures. Forecasting models such as that used in EIA's *AEO 2013* project energy expenditures, but generally assume a market in balance, and typically do not show year-to-year volatility. But as with crude oil prices, these data show that long periods of stability are not the norm.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	5.0	14.0	N/A	4.3
Average Contribution	N/A	3.3	7.9	N/A	2.6

Primary Data Sources:

Historical: EIA *AER,* Table 3.6 & 3.1; EIA MER Table 1.3 & 1.6; DOC BEA for GDP.

Forecast: Not available.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Additional data sources were needed to estimate values for 1970 because these data were not available.

Forecast: Metric was assumed to remain constant at its 1970-2009 average after a five-year transition period.

Metric #17

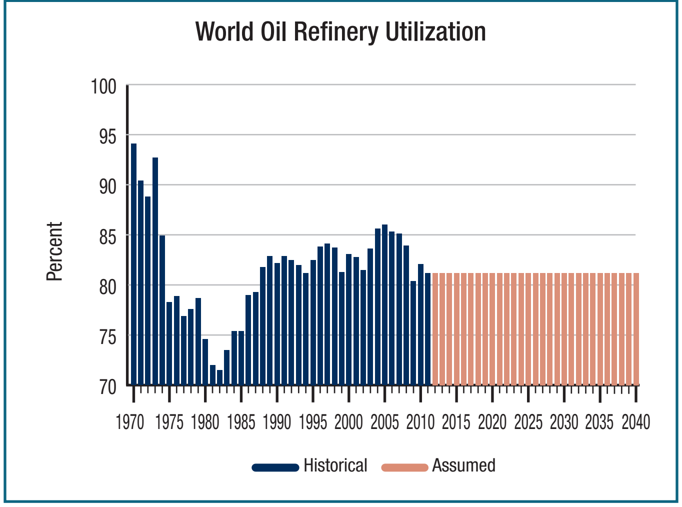
World Oil Refinery Utilization

Definition: Average percentage utilization of global petroleum refinery capacity.

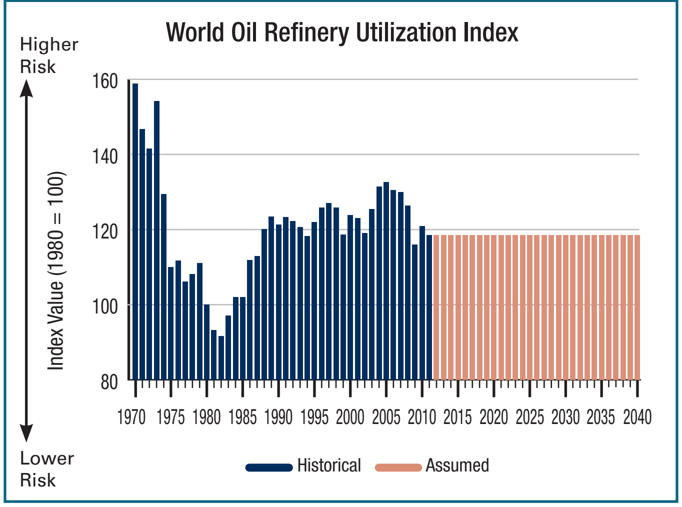
Importance: Indicates the likelihood of higher prices at high capacity utilization, and higher risk of supply limitations during refinery outages or disruptions.

Category of Metric: Price Volatility

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The 1970s began as a time of very high capacity utilization, and this lack of excess capacity greatly increased our vulnerability during the Arab Oil Embargo.
- Following the oil price shocks of the 1970s, rapid growth in refinery capacity and a moderating of oil consumption led to a sharp drop in capacity utilization rates through much of the 1980s.
- Utilization rates have gradually increased over the years, and in recent years the refinery utilization rates have reached levels not seen since the 1970s.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	3.0	N/A	6.0	N/A	2.1
Average Contribution	4.2	N/A	8.0	N/A	2.9

Primary Data Sources:

Historical: *BP Statistical Review* from 1980; API data pre-1980.

Forecast: Not available.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Minor differences observed in comparing historical data trends seen in the BP and API datasets. Possible improvements could be realized in quantifying risks as utilization approaches full capacity.

Forecast: Metric was assumed to remain constant at its most recent measured value.

Metric #18

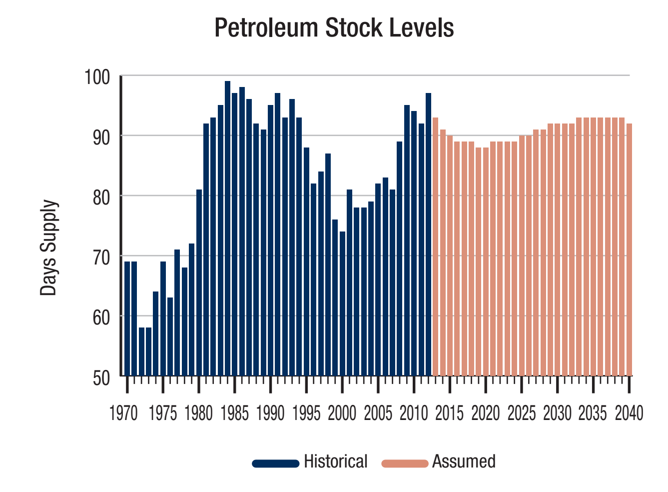
Petroleum Stock Levels

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

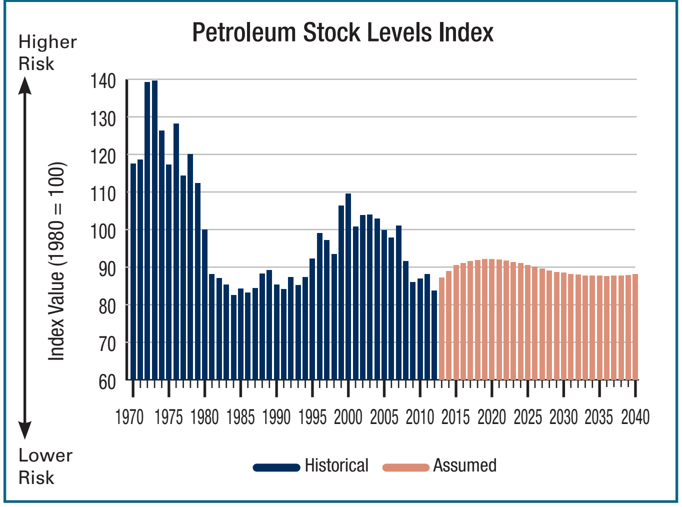
Importance: Indicates vulnerability of the U.S. to a supply disruption based on the quantity of oil stocks that are available domestically to be drawn down.

Category of Metric: Price Volatility

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical trend shows the relatively low level of petroleum stocks that persisted through much of the 1970s.
- During the 1980s and into the 1990s, stocks levels were collectively at a higher level, largely as a result of the SPR build-up and partly due to an increase in non-SPR crude stocks.
- During the 1990s, SPR levels held roughly steady while non-SPR stocks declined, resulting in a downward trend in days supply, and thus greater energy security risk.
- Since 2000, stock levels have again improved, primarily as a result of further increases in the SPR.
- Looking forward over the forecast period, we do not have a good methodology for projecting stock levels long-term. By holding the physical stock levels constant, the days supply estimate gradually declines as the petroleum consumption gradually increases.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	2.0	N/A	6.0	N/A	1.8
Average Contribution	2.3	N/A	6.6	N/A	2.0

Primary Data Sources:

Historical: EIA *AER,* Tables 5.13a-d & 5.16.

Forecast: EIA *AEO 2013,* Table 11.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Historical: None.

Forecast: Uses *AEO 2013* projections of consumption and assumes petroleum stocks remain constant at most recent measured value.

Metric #19

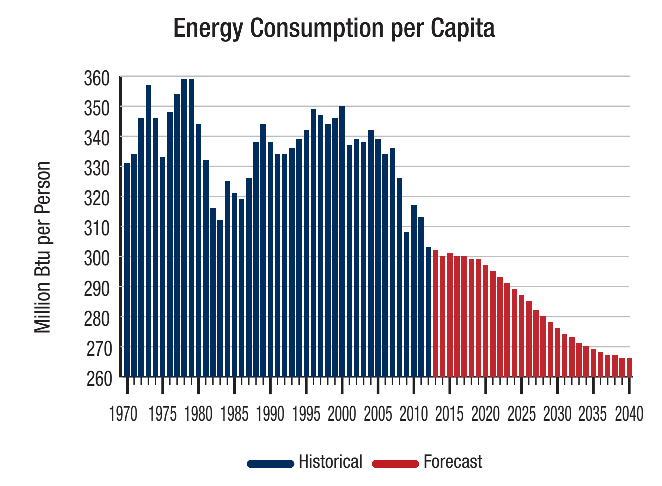
Energy Consumption per Capita

Definition: Million Btu consumed per person per year.

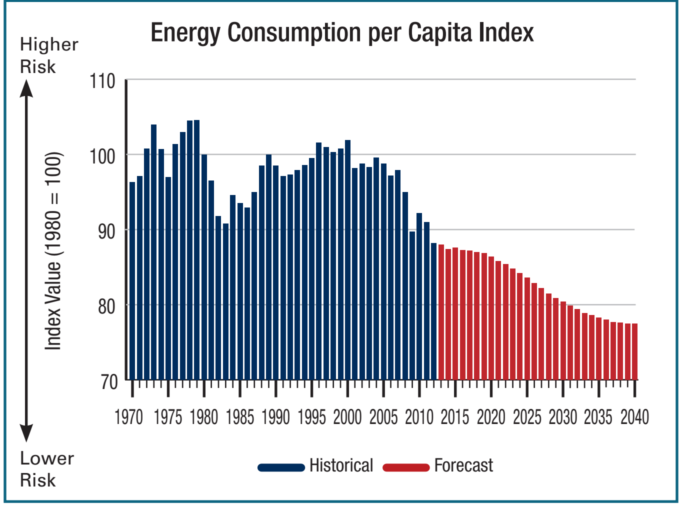
Importance: Indicates changes in both energy intensity and in per-capita GDP.

Category of Metric: Energy Use Intensity

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show rising per-capita energy consumption during the 1960s and early 1970s. This period was marked by rapid growth in electricity use, automobile ownership, and the economy that outpaced energy intensity gains, leading to a rise in per capita energy use.
- Oil shocks and rising prices in the 1970s led to a decline in per-capita consumption.
- During much of the 1980s and 1990s, relatively low energy prices began to undo some of the earlier improvements, but the per-capita levels never again reached the peaks seen in the late 1970s.
- More recently, the high fuel prices, especially for petroleum and natural gas, have dampened overall energy consumption.
- EIA's projections indicate a continuing gradual reduction. This projection is driven partly by continuing high prices, and partly by policy changes relating to CAFE standards and other energy efficiency requirements. But the overall decline is modest: By 2040, per capita energy use is projected to be 80% of the 1970 level.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	3.0	N/A	8.0	2.5
Average Contribution	N/A	3.8	N/A	7.9	2.7

Primary Data Sources:

Historical: EIA *AER,* Table 2.1; U.S. Statistical Abstract 2009, Table 2.

Forecast: EIA *AEO 2013,* Tables 2 & 20.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #20

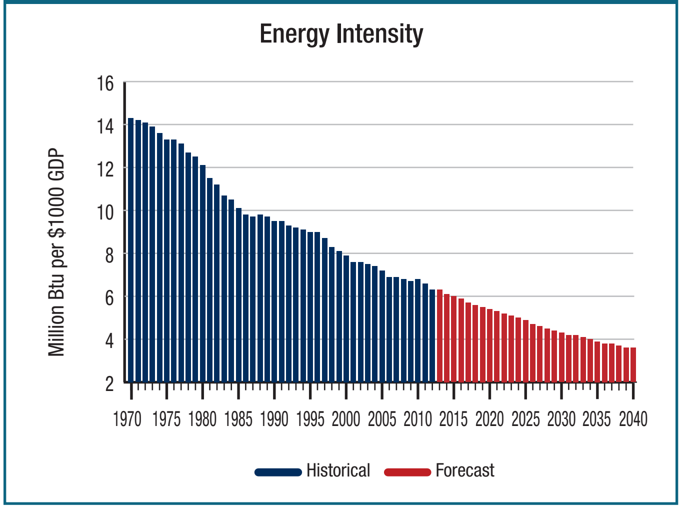
Energy Intensity

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

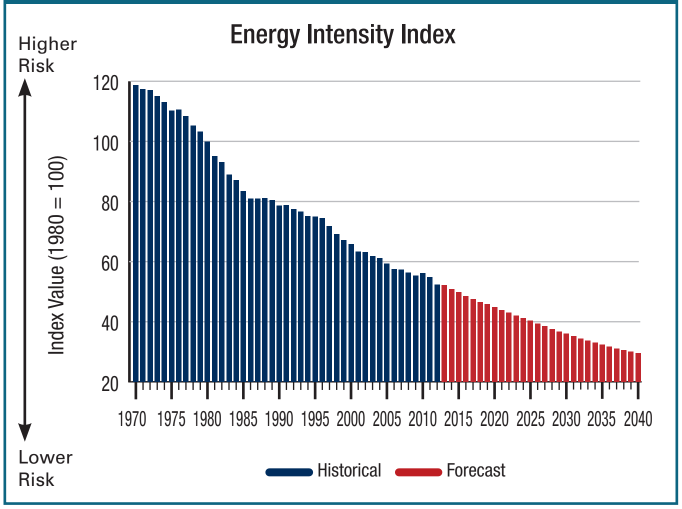
Importance: Indicates the importance of energy as a component of economic growth.

Category of Metric: Energy Use Intensity

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Long-term trends show considerable improvement in U.S. energy intensity. Whereas in 1970 it took about 18,000 Btu to produce one dollar of real (2000) GDP, it now takes less than half of that.
- The historical data show a relatively rapid pace of energy intensity improvement during the 1970s and early 1980s, responding to oil price shocks, automobile mileage standards, and other policies and measures.
- Beginning in the mid-1980s, the pace of improvement slowed, possibly due in part to the lower fuel prices that prevailed.
- In recent years, higher energy costs have quickened the pace of improvement to levels near those attained in the 1970s. The long-term trend towards a more service-orientated economy also has contributed to the improvement in intensity.
- Looking forward, EIA's projections in *AEO 2013* indicate a gradual continuation in the reduction of energy intensity. Over 2013-2040, EIA projects an annual rate of improvement of 2.1%. In EIA's projections, the energy intensity in the year 2040 is well less than one-quarter the intensity seen in 1970. In other words, each million Btu consumed in 2040 will power more than four times as much GDP as in 1970.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	4.0	N/A	10.0	3.2
Average Contribution	N/A	4.2	N/A	8.3	2.9

Primary Data Sources:

Historical: EIA *AER,* Table 2.1; DOC BEA for GDP.

Forecast: EIA *AEO 2013,* Tables 2 & 20.

Data Issues:

General: GDP data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #21

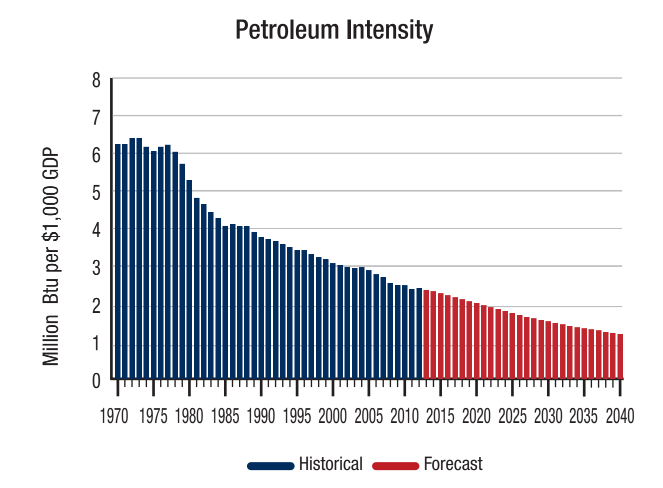
Petroleum Intensity

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

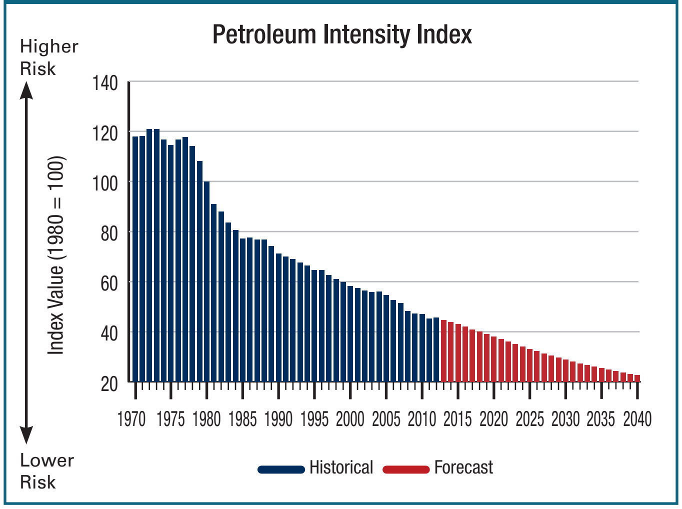
Importance: Indicates the importance of petroleum as a component of economic growth.

Category of Metric: Energy Use Intensity

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show a much higher level of petroleum consumption per dollar of GDP during the 1970s. The oil shocks and rising prices during that period were followed by sharp reductions in petroleum consumption in subsequent years. From 1973 to 1983, U.S. petroleum use intensity fell by over 30%, for an average annual improvement exceeding 3.5%.
- Since the mid-1980s, U.S. petroleum use intensity has continued to improve, but at a much slower pace, averaging less than 2% annually.
- Looking forward, EIA's forecasts in *AEO 2013* indicate a continuing and gradual reduction in petroleum use intensity. From 2013-2040, EIA projects an improvement of 2.5% annually, such that by 2040 U.S. petroleum use intensity will be less than one-fourth of the level that prevailed in the early 1970s.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	8.0	3.0	N/A	6.0	4.5
Average Contribution	7.2	3.0	N/A	4.7	4.0

Primary Data Sources:

Historical: EIA *AER,* Table 2.1(b-f); DOC BEA for GDP.

Forecast: EIA *AEO 2013,* Tables 2 & 20.

Data Issues:

General: GDP data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #22

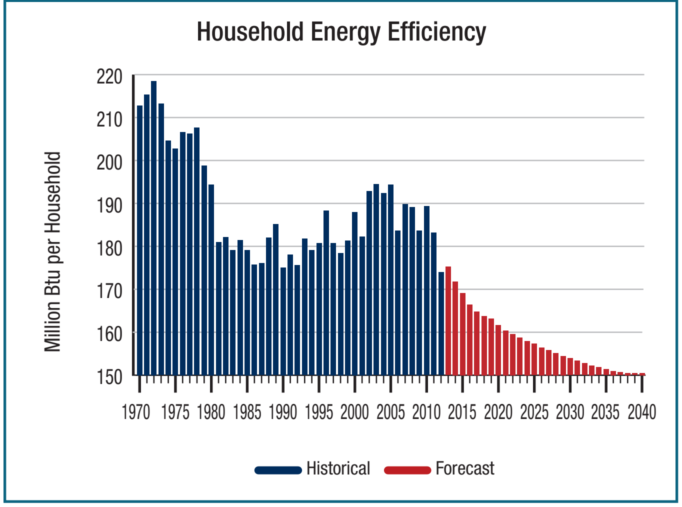
Household Energy Efficiency

Definition: Million Btu of total energy consumed per household.

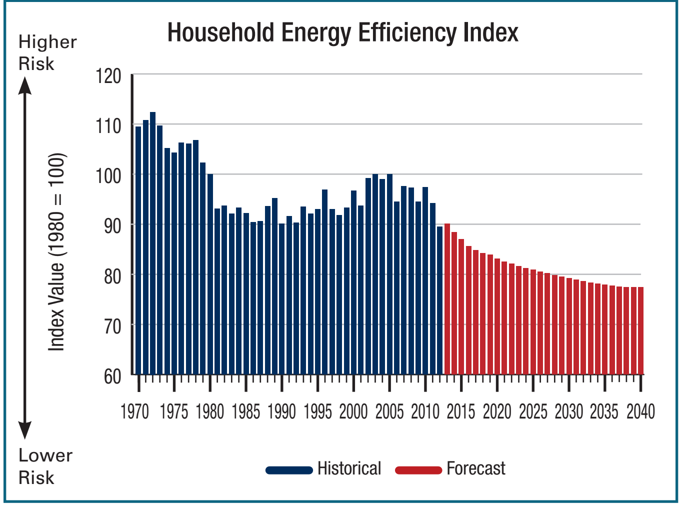
Importance: Indicates the degree to which the typical household uses energy efficiently.

Category of Metric: Energy Use Intensity

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The long-term trend shows the effects of several interacting trends. The historical data show a relatively rapid pace of improvement in energy use per household during the 1970s and early 1980s, responding to energy price shocks and other policies and measures.
- For most of the 1980s and 1990s, per-household consumption was steady, even rising slightly over time. Efficiencies were still improving, but larger houses, more appliances, and home computers required additional energy.
- Looking forward, EIA's projections in *AEO 2013* indicate a gradual return to lower levels of per-household energy use. Under EIA's projections, per-household energy use in 2040 is lower than at any other time in the record.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	3.0	N/A	4.0	1.7
Average Contribution	N/A	3.8	N/A	4.0	1.9

Primary Data Sources:

Historical: EIA *AER,* Table 2.1b; Census Bureau *Housing Vacancy Survey.*

Forecast: EIA *AEO 2013,* Tables 2 & 4.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: Adequate square footage data were unavailable for the entire historical period; number of housing units was used as a proxy. Categories of housing units were used to come up with an approximation of households, which is what EIA uses in its forecasts.

Forecast: *AEO 2013* projections are based on number of households, not the number of housing units used for historical data.

Metric #23

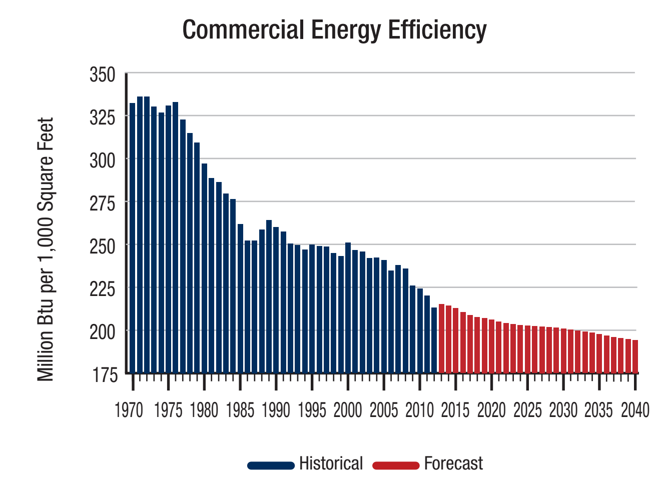
Commercial Energy Efficiency

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

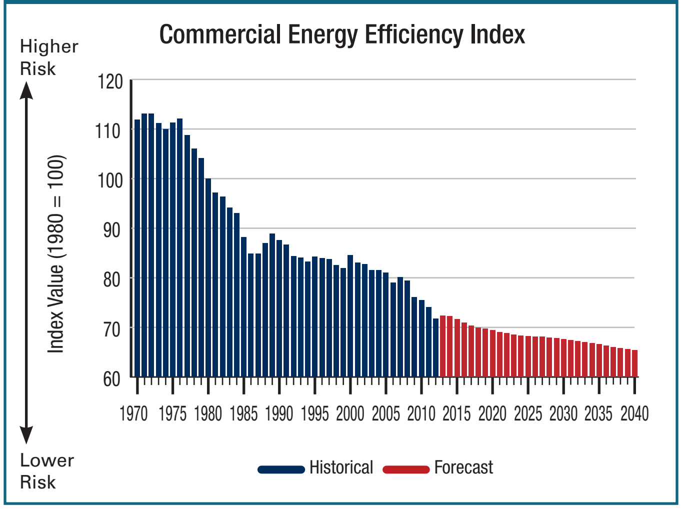
Importance: Indicates the degree to which commercial enterprises use energy efficiently.

Category of Metric: Energy Use Intensity

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The long-term trend shows an improvement in energy intensity. From the mid- 1970s through the mid-1980s, the improvements were most pronounced, driven largely by higher energy costs.
- Beginning in the mid-1980s, the pace of improvement slowed as energy prices dropped. Consumption per square foot of natural gas and fuel oil declined over time while consumption of electricity rose modestly.
- In addition to the overall improvements reflected in individual technologies, the data also indicate shifts from natural gas to electricity and greater use of electricity consuming technologies such as computers.
- Looking forward, EIA's projections in *AEO 2013* indicate only a very small continuation in the reduction of energy intensity. Commercial floorspace is projected to increase at about 1.0% annually. While direct use of fossil fuels grows at a slower rate than floorspace, the consumption of electricity shows a faster rate of growth. The combined effect is that energy efficiency in the commercial sector is projected to improve by about 0.4% annually from 2013-2040.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	3.0	N/A	4.0	1.7
Average Contribution	N/A	3.5	N/A	3.7	1.8

Primary Data Sources:

Historical: EIA *AER,* Table 2.1c & 2.10.

Forecast: EIA *AEO 2013,* Tables 2 & 5.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Historical: The commercial floor space survey changed scope in 1995, requiring adjustments to be made to earlier years. No data source for floor space is available pre-1979. Data for 1970 to 1978 was estimated based on the relationship of floor space to GDP.

Forecast: None.

Metric #24

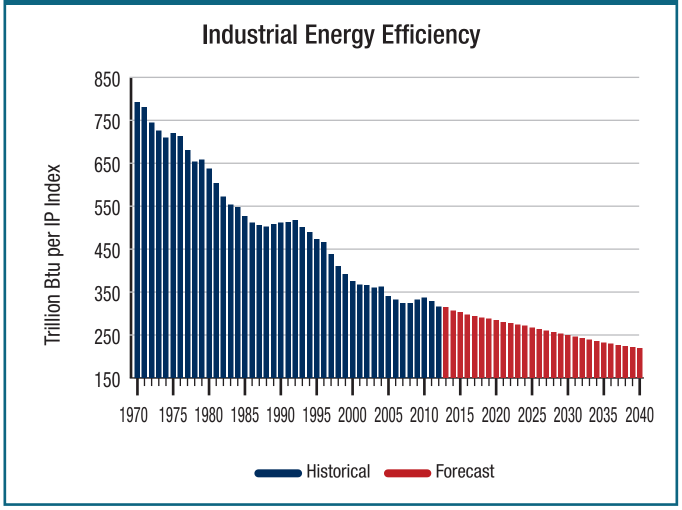
Industrial Energy Efficiency

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

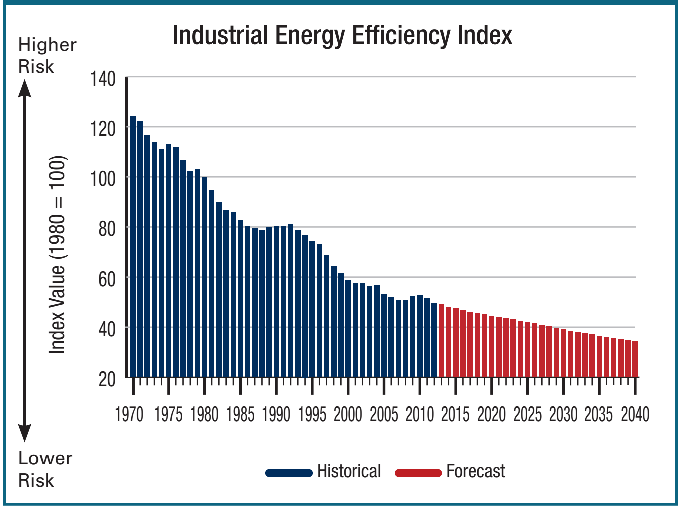
Importance: Indicates the degree to which the typical commercial enterprise uses energy efficiently.

Category of Metric: Energy Use Intensity

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The long-term trend shows a dramatic improvement in overall industrial energy efficiency. Between 1970 and 2007, the efficiency of the U.S. industrial sector improved by more than half.
- This historical improvement reflects both improvement in the efficiencies of most industries and processes, but also the broader shifts in our economy towards services and less energy-intensive goods.
- Looking forward, EIA's projections in *AEO 2013* indicate a continuing if gradual improvement in industrial energy efficiency averaging about 1.3% per year.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	3.0	N/A	4.0	1.7
Average Contribution	N/A	3.1	N/A	3.2	1.6

Primary Data Sources:

Historical: EIA *AER,* Table 2.1d; Federal Reserve Board for Industrial Production Index.

Forecast: EIA *AEO 2013,* Tables 2 & 6.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Minor definitional differences for "industrial sector" as used by FRB in its IP Index and by in EIA in its historical and forecast data.

Metric #25

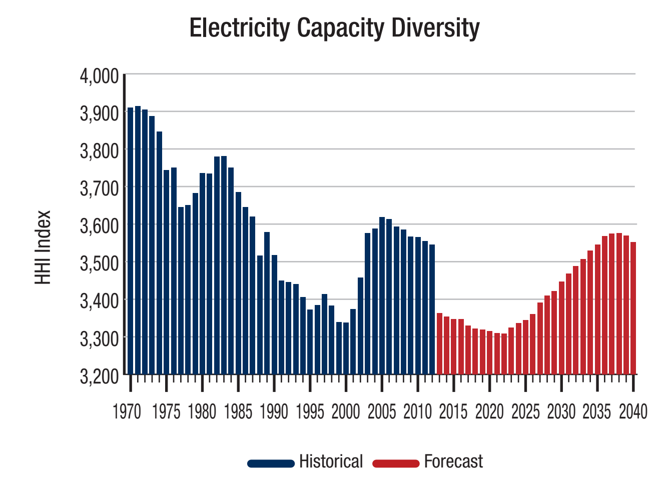
Electricity Capacity Diversity

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

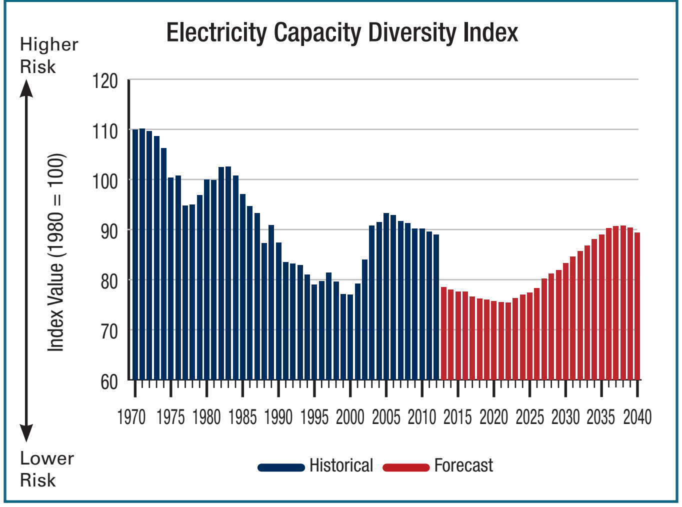
Importance: Indicates the flexibility of the power sector and its ability to dispatch electricity from a diverse range of sources.

Category of Metric: Electric Power Sector

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Except for a short period in the 1980s, from 1970 to 1990, there was a generally improving trend in capacity diversity. Most of this is attributable to an increasing share of nuclear capacity and to improving availability factors. The decreasing capacity diversity that occurred in the early 1980s reflects the closing of oil-fired generating capacity in response to the oil crises of the 1970s.
- During the 1990s, capacity became more diverse, primarily as a result of increasing nuclear capacity availability and the construction of natural gas combined-cycle units.
- However, since the late 1990s, the diversity in potential generation has declined (i.e., it has a higher HHI), as nuclear capacity gains became fewer and a large over-building of natural gas combined cycle units occurred. Today, although generation from coal-fired plants is much greater than that from natural gas-fired plants, natural gas capacity, and hence potential generation, is greater than coal capacity. Therefore, the recent addition of natural gas capacity decreased the diversity of potential generation.
- Looking forward, EIA's projections in *AEO 2013* suggest an improvement in electricity capacity diversity through the mid-2020s, and a worsening out to 2040.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	N/A	7.0	3.0	2.0
Average Contribution	N/A	N/A	7.1	2.8	2.0

Primary Data Sources:

Historical: EIA *AER,* Table 8.11a & 8.2a from 1989; EIA-860 data for pre-1989.
Forecast: EIA *AEO 2013,* Table 9 & Supplemental Table 101.

Data Issues:

General: Used the HHI Index value in excess of 2,000 (the theoretical minimum for five categories) and normalized the time series to an indexed value where the year 1980 is set at 100. No further data transformations were needed. Uncertainties on availability factors for intermittent and dispatchable capacity types.

Metric #26

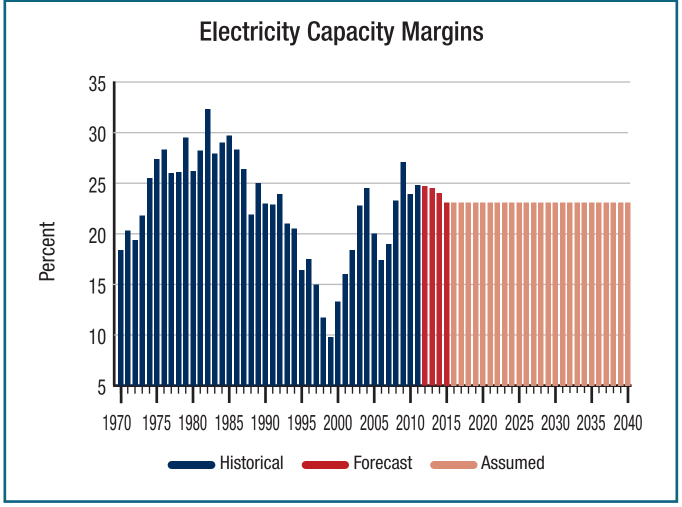
Electricity Capacity Margins

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

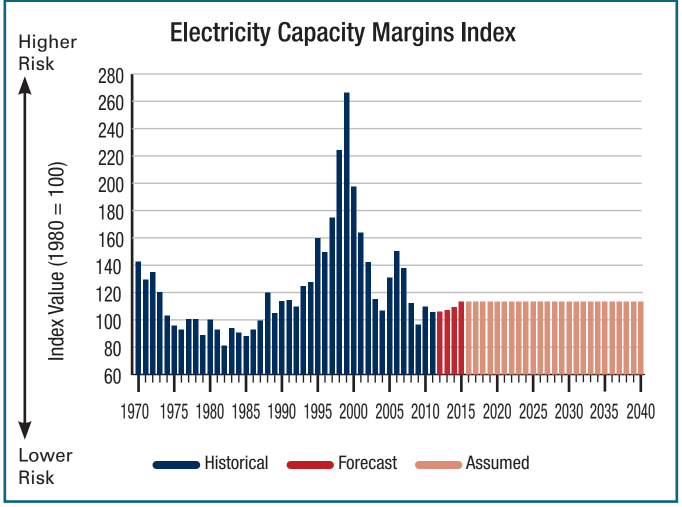
Importance: Indicates the ability of the power sector to respond to the disruption or temporary loss of some production capacity without an uneconomic overhang of excess capacity.

Category of Metric: Electric Power Sector

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show the ups and downs the electric power sector has experienced over time. Construction of electricity generating capacity is generally a long-term process, typically requiring several years and often longer for assets such as coal and nuclear. With long lead times, demand changes from business cycles, changes in fuel markets, and regulatory uncertainty, the industry has moved from periods of relative excess capacity to periods of near under capacity and back again.
- Looking forward, the data show a slight near-term improvement, reflecting increases in demand response and supply-side resources, as well as a reduction in peak demands resulting from the economic recession.
- This adequacy is not assured over time, however, and NERC's assessment is that more resources will be needed in the coming years to maintain reliability.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	1.0	7.0	N/A	1.7
Average Contribution	N/A	1.6	9.5	N/A	2.4

Primary Data Sources:

Historical: EIA *AER,* Table 8.12 from 1990; EIA archive data pre-1990.

Forecast: EIA Form EIA-411 data.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series was normalized to an indexed value where the year 1980 is set at 100.

Historical: Pre-1990 data developed from different data sets.

Projections: Future trends based on planning projections and do not include as-yet firm plans. Metric was assumed to remain constant at its most recent measured value.

Metric #27

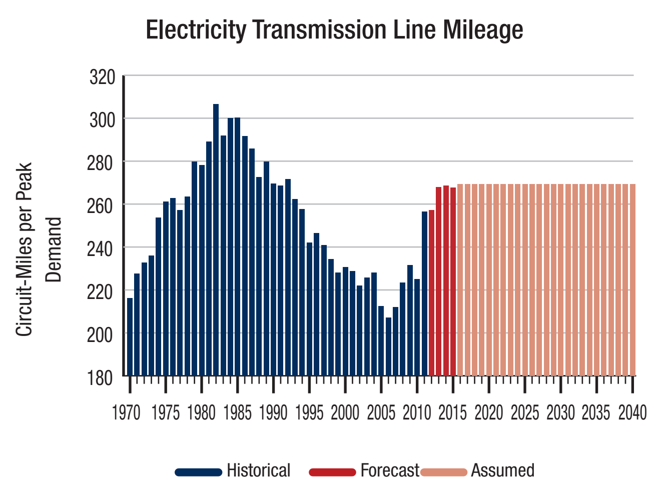
Electric Power Transmission Line Mileage

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

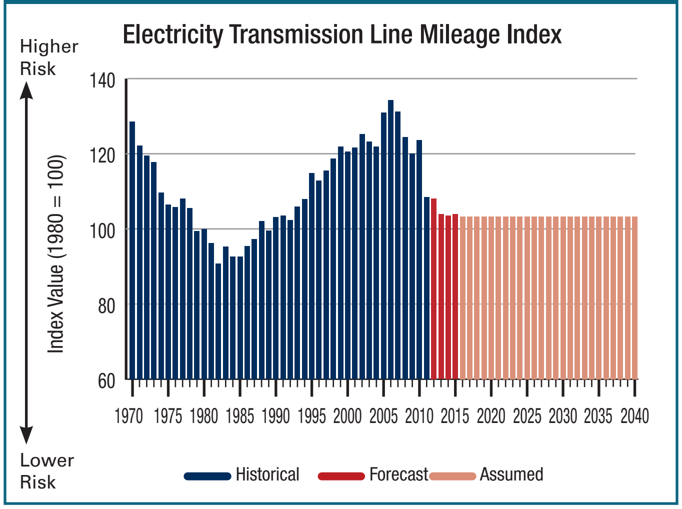
Importance: Indicates the integration of the transmission system and its ability to meet increasing demand reliably.

Category of Metric: Electric Power Sector

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show declines in transmission infrastructure and growing risks associated with underinvestment in infrastructure. In 1989, there were about 280 circuit-miles for each GW of peak capacity. As of 2006, this had declined to only 207 circuit-miles for each GW of peak capacity, a decline of about 25%.
- Further troubling is that this decline has occurred at the same time when growth in wholesale power markets and demand for renewable energy resources would benefit from growing transmission capacity.
- Looking forward, the data show a slight near-term improvement, reflecting in part the drop in demand in the current recession. But continued underinvestment in transmission, as seen in the NERC projections, is seen as a further inability of transmission to keep up with peak power demand.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	1.0	8.0	3.0	2.5
Average Contribution	N/A	1.4	9.8	3.4	3.1

Primary Data Sources:

Historical: EIA *AER,* Table 8.12; North American Electric Reliability Council for circuit-miles.

Forecast: NERC data.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Historical: Data before 1989 were not available. Assumed that from 1970 to 1988, the metric remained constant at 1989 measured value.

Forecast: Future trends are based on planning projections and do not include as-yet firm plans. Metric was assumed to remain constant at its most recent measured value.

Metric #28

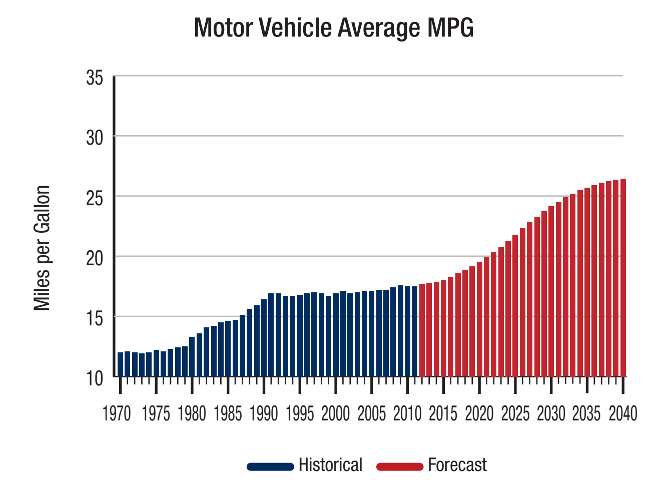
Motor Vehicle Average MPG

Definition: Average miles per gallon of passenger car fleet.

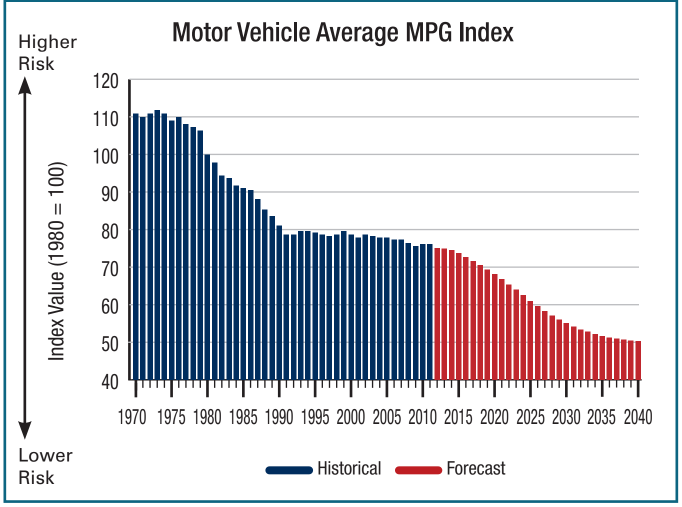
Importance: Indicates the degree to which the typical light vehicle uses energy efficiently (gasoline consumption accounts for about 16% of total U.S. energy demand).

Category of Metric: Transportation Sector

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show the steady increase in average mpg following the oil price shocks of the 1970s and the subsequent implementation of corporate average fuel economy (CAFE) standards for cars and light trucks. From a fleet average of about 12 in the early 1970s, motor vehicle average MPG rose to more than 16 by 1990.
- For the period from about 1990 to 2010, average MPG showed only modest improvement (0.390 per year).
- Average vehicle MPG is projected to increase about 1.6% per year as a consequence of higher fuel prices and new CAFE standards promulgated under EISA 2007.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	3.0	4.0	N/A	12.0	4.5
Average Contribution	3.1	4.6	N/A	10.8	4.5

Primary Data Sources:

Historical: EIA *AER,* Table 2.8.

Forecast: EIA *AEO 2013,* Supplemental Table 161.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Metric #29

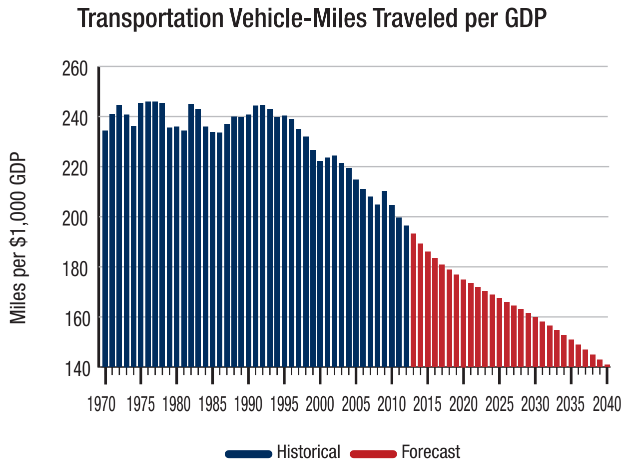
Vehicle-Miles Traveled per GDP

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

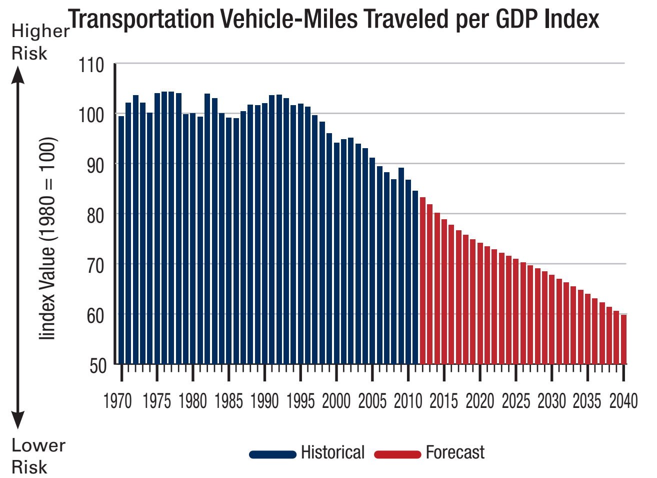
Importance: Indicates the importance of travel as a component of the economy.

Category of Metric: Transportation Sector

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show that for many years, VMT generally increased in lockstep with the overall economy. From 1970 through the late 1990s, VMT intensity was rather flat, indicating that growth in VMT moved in sync with expansions and contractions of the economy.
- A closer look at the most recent years indicates a break from this overall trend, and VMT as a share of the economy began to slow. From the mid-1990s through 2012, the VMT intensity improved (declined) by about 1.1% per year. While higher fuel prices have undoubtedly played a role in this decline, other causal factors are also likely involved, including telecommuting.
- EIA now forecasts a continuing improvement in VMT intensity, declining about 1.2% per year over the forecast period.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	2.0	2.0	N/A	8.0	2.8
Average Contribution	2.3	2.5	N/A	8.0	3.0

Primary Data Sources:

Historical: DOT/FHA for VMT; DOC BEA for GDP.

Forecast: EIA *AEO 2013,* Tables 2 & 7.

Data Issues:

General: GDP data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #30

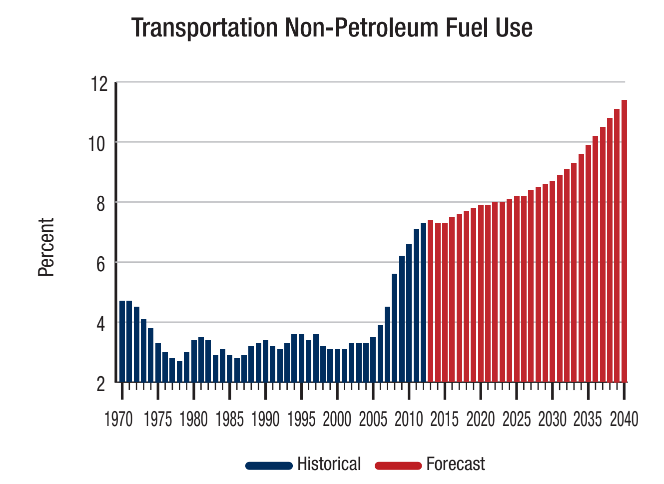
Transportation Non-Petroleum Fuel Use

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

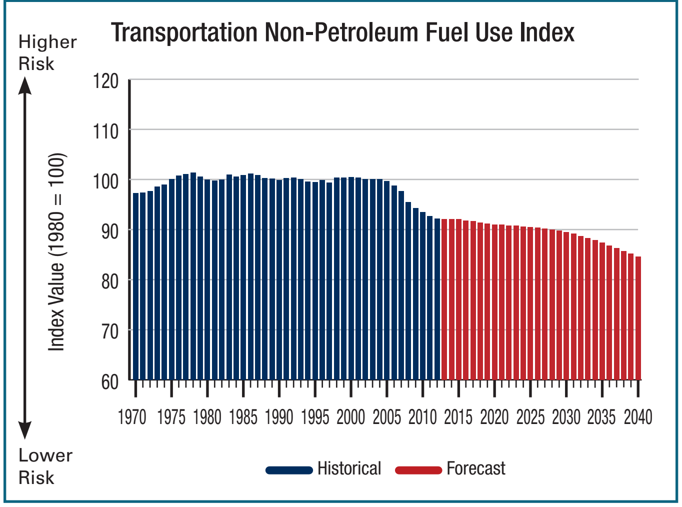
Importance: Indicates the diversity and flexibility of the fuel mix for transportation.

Category of Metric: Transportation Sector

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Over most of the historical data shown, non-petroleum fuels accounted for only about 2% to 4% of the energy used in the U.S. transportation sector. Most of this small amount was natural gas used in pipeline operations.
- But in recent years, this low market share has begun to rise, and is expected to continue rising. Most of the recent and expected future increase is from biomass production of ethanol resulting from renewable fuel mandates legislated in EPAct 2005 and EISA 2007.
- Over the longer term, greater use of electricity, natural gas, and biofuels is expected to increase the portion of non-petroleum energy sources in the transportation sector by about 2.1% per year.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	3.0	N/A	4.0	4.0	2.5
Average Contribution	3.5	N/A	4.4	4.0	2.7

Primary Data Sources:

Historical: EIA *AER,* Table 2.1e.

Forecast: EIA *AEO 2013,* Table 2.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Metric #31

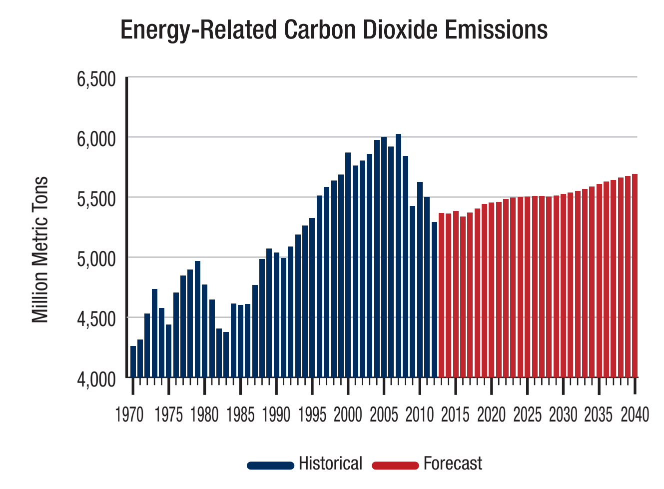
Energy-Related Carbon Dioxide Emissions

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

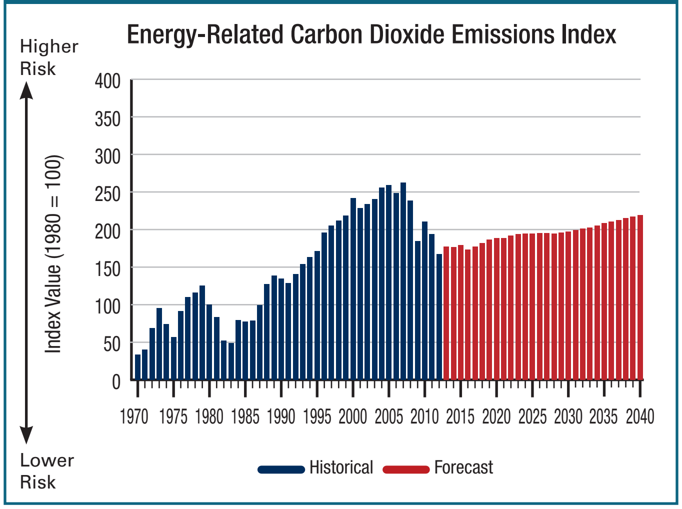
Importance: Indicates the exposure of the U.S. economy to domestic and international emissions reduction mandates.

Category of Metric: Environmental

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data generally show a rising level of CO_2 emissions, consistent with economic growth, population growth, and rising energy consumption.
- There are a couple of periods, notably the mid-1970s and early 1980s, when CO_2 emissions dipped, largely in response to oil price shocks and economic slowdowns.
- Over the past few years, CO_2 emissions have been essentially flat, with high fuel prices, economic slowdowns, and energy and environmental policies all playing a role.
- Looking forward, EIA's projections now indicate a very slow rate of increase in energy-related CO_2 emissions. In the *AEO 2012*, energy-related CO_2 emissions grow by 0.1% per year from 2013 to 2040, as compared with 0.9% per year from 1980 to 2005. By 2040, EIA projects energy-related CO_2 emissions to be only about 5% higher than in 2005.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	2.0	N/A	N/A	7.0	2.0
Average Contribution	3.5	N/A	N/A	10.6	3.2

Primary Data Sources:

Historical: EIA *Emissions Inventory Report*; EIA spreadsheet for pre-1990 emissions.

Forecast: EIA *AEO 2013,* Table 18.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #32

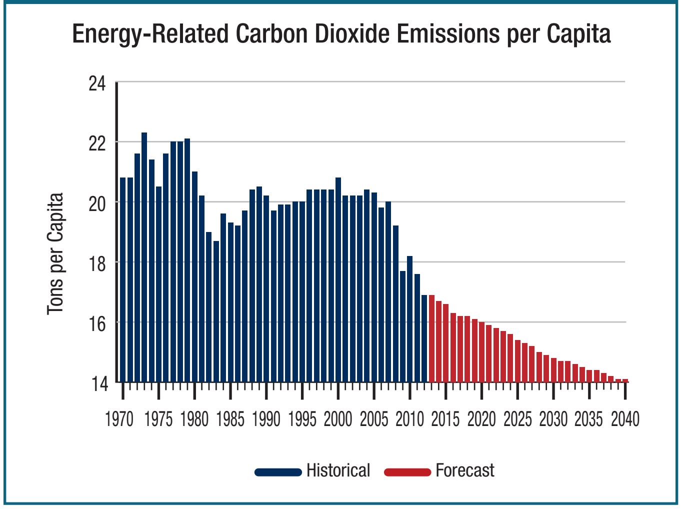
Energy-Related Carbon Dioxide Emissions per Capita

Definition: Million metric tons of CO_2 emissions from energy per capita.

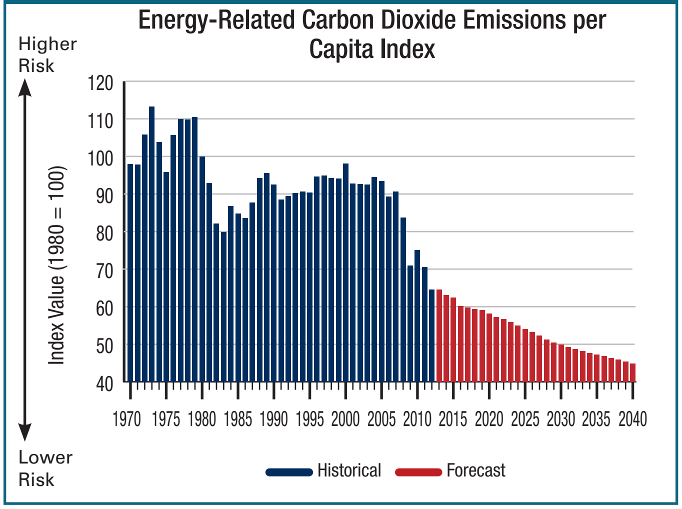
Importance: Indicates the joint effect of the amount of energy used per capita in the U.S. and the carbon intensity of that energy use.

Category of Metric: Environmental

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- During the 1950s and 1960s, per capita energy-related CO_2 emissions increased from about 15 to about 20 metrics tons per year.
- Per capita emissions peaked in 1973 at 22.1 metric tons per capita. That year ended with the first oil shock of the 1970s. Per-capita emissions fell for a couple of years, and then began rising again until the second oil shock took place around 1979-1980.
- Following a few years of falling per-capita emissions in the early 1980s, the trend again turned upward and has remained at about 20 tons per capita through the mid-2000s.
- Recently, higher fuel prices (especially for petroleum) and a weaker economic outlook point toward a gradual reduction in per capita emissions, leveling off at about 17 metric tons in the 2020 decade.
- Looking forward, EIA's projections show the U.S. economy becoming less carbon-intensive. By 2040, emissions per capita are forecast to decline 31% from the 2005 level, as increased demand for energy services is offset in part by shifts toward less energy-intensive industries, efficiency improvements, and increased use of renewables and other lower-carbon fuels.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	2.0	N/A	N/A	5.0	1.6
Average Contribution	2.2	N/A	N/A	4.7	1.6

Primary Data Sources:

Historical: EIA *Emissions Inventory Report*; EIA spreadsheet for pre-1990 emissions; *Statistical Abstract* for population

Forecast: EIA *AEO 2013*, Tables 18 & 20.

Data Issues:

General: To emphasize the relatively small changes in this metric, the values were squared and the time series normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #33

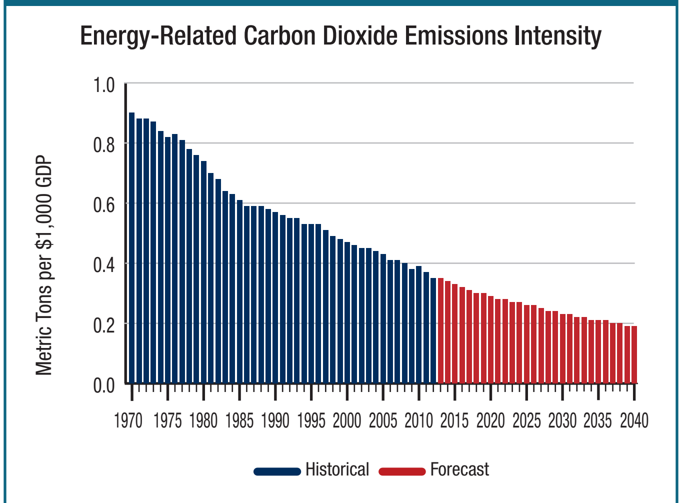
Energy-Related Carbon Dioxide Emissions Intensity

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

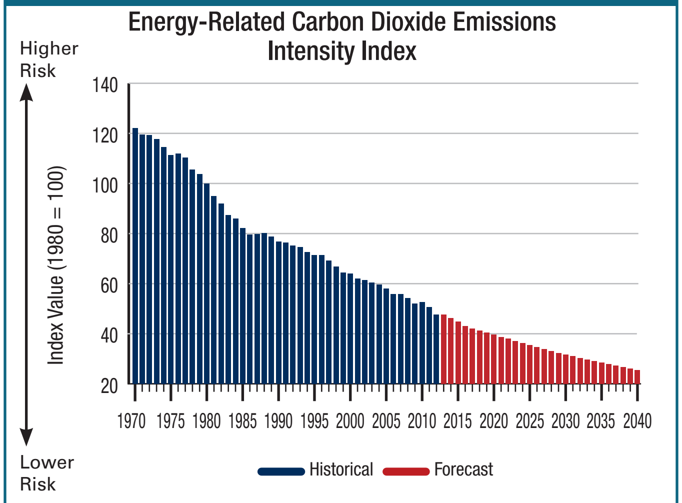
Importance: Indicates the importance of carbon-based fuels as a component of the economy.

Category of Metric: Environmental

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Historically, there has been a steady and substantial downward trend in the CO_2 intensity of the U.S. economy. In the 1970s through the mid-1980s, CO_2 intensity fell rapidly as a result of our response to the oil price shocks, vehicle efficiency standards, and industrial energy efficiency.
- Since the mid-1980s, the improvements in CO_2 intensity continued to improve, but as a slower rate. Transportation improvements were fewer, but gains were still realized through efficiency in others sectors and an on-going shift in the economy from manufacturing to services. By the year 2005, the economy's CO_2 intensity was only about one-half of what it was in 1970.
- Looking ahead, EIA projects a continuing improvement in the CO_2 intensity of the U.S economy, roughly 2.3% per year on average. As a result, the economy-wide CO_2 intensity in the year 2040 is projected to be 56% below the 2005 level.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	2.0	N/A	N/A	5.0	1.6
Average Contribution	1.9	N/A	N/A	4.1	1.4

Primary Data Sources:

Historical: EIA *Emissions Inventory Report*; EIA spreadsheet for pre-1990 emissions; DOC BEA for GDP.
Forecast: EIA *AEO 2013*, Tables 2 & 18.

Data Issues:

General: GDP data converted to 2010 dollars. The time series was normalized to an indexed value where the year 1980 is set at 100. No further data transformations were needed.

Metric #34

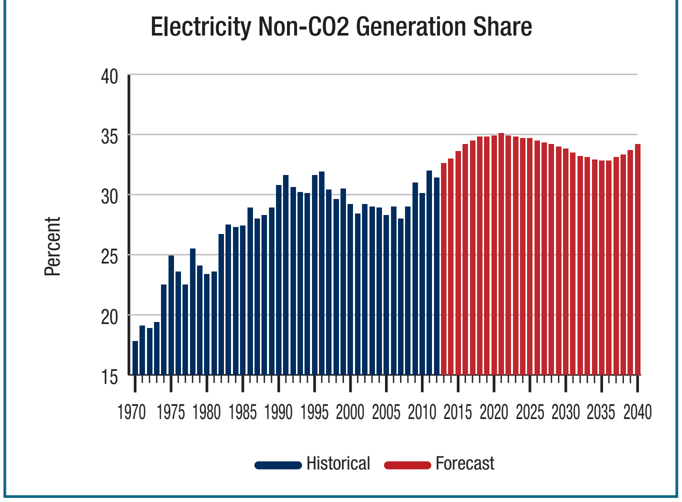
Electricity Non-CO_2 Generation Share

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

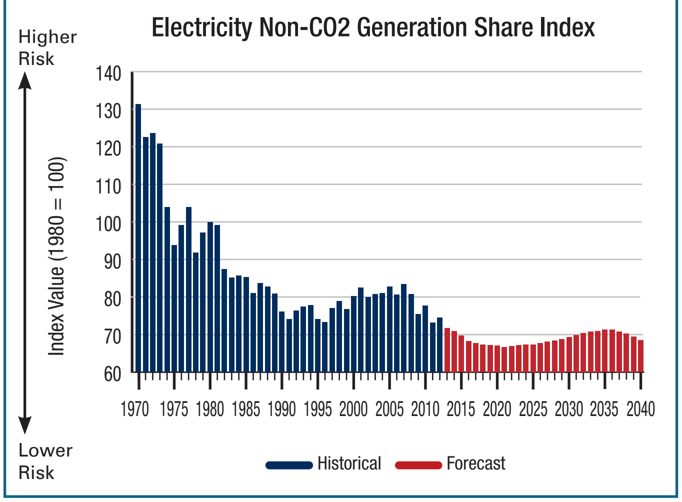
Importance: Indicates the degree to which the power sector is diversifying and employing non-CO_2 emitting generation.

Category of Metric: Environmental

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- During the 1970s and 1980s, the share of non-CO_2 generation nearly doubled, from about 17% in 1970 to about 32% in 1990. This increase was due primarily to the expansion of nuclear power capacity.
- After 1990, however, there were few additions to nuclear and renewable capacity, and growth in generation from these sources stemmed mainly from improving operating capacity factors at existing nuclear plants. However, with overall growth in demand being met disproportionately by coal and natural gas-fired plants, the non-CO_2 generation share began slipping.
- Looking forward, EIA's projections in *AEO 2013* indicate a continuation of recent trends, with the share of non-CO_2 emitting capacity climbing to about 35% of total generation. Most of this increase is due primarily to growth in renewables and secondarily to further increases in nuclear capacity.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	N/A	5.0	7.0	2.4
Average Contribution	N/A	N/A	4.8	6.2	2.2

Primary Data Sources:

Historical: EIA *AER,* Table 8.2a.

Forecast: EIA *AEO 2013,* Tables 8 & Supplemental Table on CCS.

Data Issues:

General: The time series was normalized to an indexed value where the year 1980 is set at 100. No additional data transformations were needed.

Historical: None.

Forecast: Published *AEO* tables currently do not include projections for the capacity of or generation from CCS-enabled power plants. However, they are part of the NEMS model that EIA uses, and EIA can provide those outputs upon request.

Metric #35

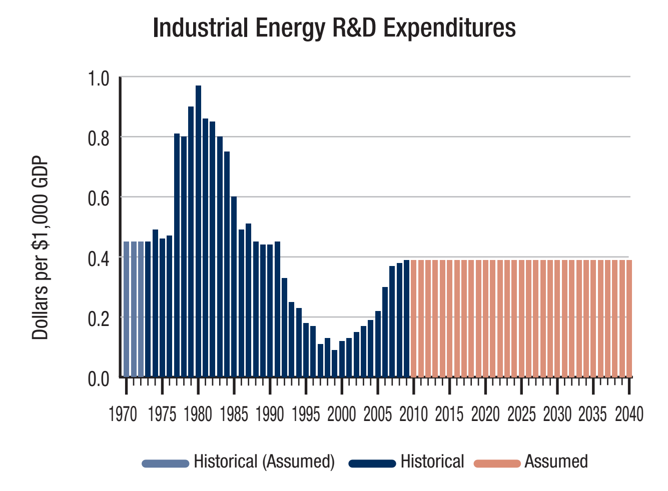
Industrial Energy R&D Expenditures

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

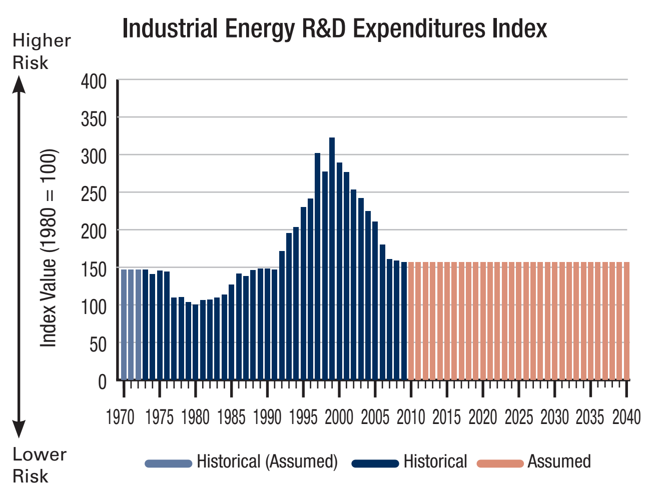
Importance: Indicates private industry engagement in improving performance and enabling new technological breakthroughs.

Category of Metric: Research & Development

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical trend shows a dramatic swing. Beginning in the late 1970s, industry R&D on energy increased substantially, more than doubling earlier levels.
- But by the mid-1980s and continuing since then, the pattern has generally been one of decreasing investment. In recent years, the relative investment has only been 10% to 20% of the amounts seen in 1980.
- More recently, industrial R&D expenditures have begun to turn higher, though it still remains far below earlier levels.
- Over the forecast period through 2040, a constant level of industrial spending on energy R&D is assumed. With recent interest in energy policy, and market experience of the past few years, this assumption may turn out to be conservative.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	1.0	2.0	2.0	1.1
Average Contribution	N/A	2.2	3.8	3.5	2.1

Primary Data Sources:

Historical: NSF, Industrial Research & Development Information System; DOC BEA for GDP.

Forecast: Not available.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Historical: Incomplete data pre-1973. Assumed that for 1970-1972, the metric remained constant at value measured for 1973.

Forecast: Metric was assumed to remain constant at its most recent measured value.

Metric #36

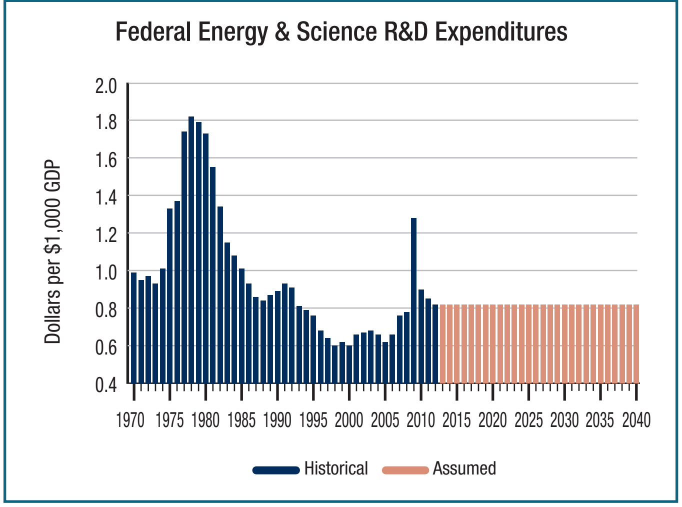
Federal Energy & Science R&D Expenditures

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

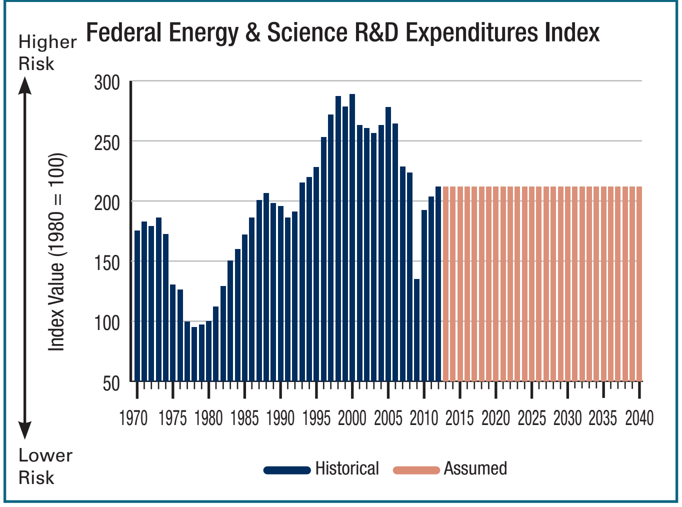
Importance: Indicates prospects for new scientific and technological breakthroughs through federally-supported public-private research.

Category of Metric: Research & Development

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- Following the oil price shocks beginning in the mid-1970s, federal support for energy and science R&D increased substantially, nearly doubling from earlier levels.
- Since peaking in the early 1980s, however, the pattern has generally been one of decreasing investment, such that by the year 2000, the relative investment was only about one-third of the amounts seen in 1980.
- Since around 2000, energy and science R&D funding has begun to increase again, though it is still far below its level in earlier years.
- Over the forecast period through 2040, a constant level of spending on federal energy and science R&D is assumed. With recent interest in energy policy, this assumption may turn out to be conservative.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	1.0	2.0	2.0	1.1
Average Contribution	N/A	2.5	4.3	4.0	2.4

Primary Data Sources:

Historical: NSF data on federal R&D; DOC BEA data for GDP.

Forecast: Not available.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Historical: None.

Forecast: Metric was assumed to remain constant at its most recent measured value. Budget documents might provide basis for near-term projections.

Metric #37

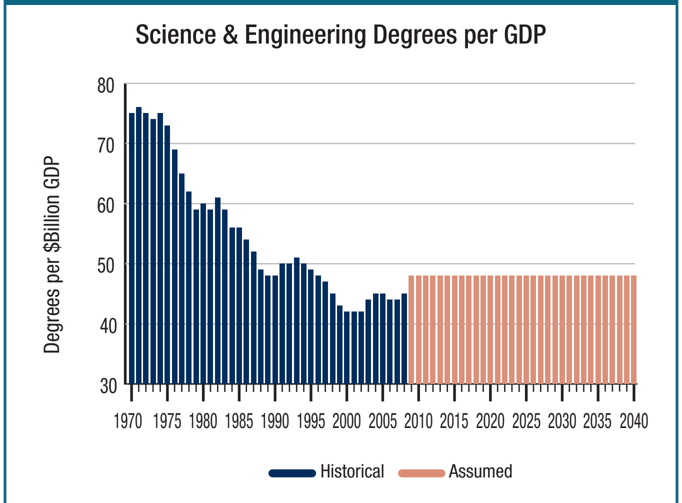
Science & Engineering Degrees

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

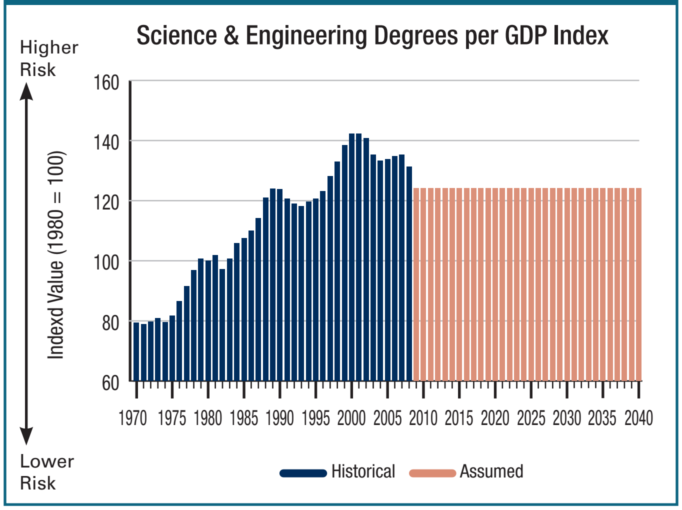
Importance: Indicates the degree to which human capital in high-tech science, technology, engineering, and mathematics fields will be available to the economy.

Category of Metric: Research & Development

Historical and Forecast Values (1970-2040):



Index (1970-2040):



Observations:

- The historical data show a steadily worsening trend relative to the economy. Over the 1970 to 2006 period, while the total number of college degrees more than doubled and rose relative to overall population, the share of science and engineering degrees fell as a share of all degrees. From over 34% in 1970, science and engineering degrees account for less than 30% of all college degrees today.
- Relative to the more rapid growth in GDP over the period, the degrees awarded have not kept pace.
- The U.S. share of Ph.D.s has been in steady decline since peaking in the early 1970s, when more than half of the world's graduate degrees in science and engineering were issued by U.S. universities.
- Over the forecast period through 2040, a constant level of science and engineering degrees, per billion dollars of GDP is assumed. Potentially, college admissions datasets could be developed to project degrees awarded over the next few years.

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

	Geopolitical	Economic	Reliability	Environmental	Total Index
Weight	N/A	1.0	2.0	2.0	1.1
Average Contribution	N/A	1.5	2.5	2.3	1.4

Primary Data Sources:

Historical: NSF data from Integrated Postsecondary Education Data System Completions Survey (IPEDS); DOC BEA data for GDP.

Forecast: Not available.

Data Issues:

General: For this metric, a higher value indicates lower risk. Therefore, the values were inverted and the time series normalized to an indexed value where the year 1980 is set at 100.

Historical: None.

Forecast: Metric was assumed to remain constant at its most recent measured value. College admissions datasets might provide basis for near-term projections.

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	117.2	115.2	112.7	106.5	101.4	102.5	102.2
2	Security of World Oil Production	production, freedom & diversity-weighted	89.7	91.3	93.3	95.0	100.9	109.8	114.5
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	57.6	67.5	74.1	78.3	84.1	101.9	106.5
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	70.4	69.6	68.0	67.7	71.2	84.6	89.5
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	91.2	93.5	95.6	96.4	97.1	103.4	103.1
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	20.0	22.8	26.4	33.4	36.1	39.9	46.3
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	3.5	3.6	3.4	3.3	3.2	4.2	4.4
9	Oil & Natural Gas Import Expenditures	billions of 2010$	$11.2	$13.5	$17.3	$29.5	$93.5	$83.0	$101.8
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.2%	0.3%	0.3%	0.5%	1.7%	1.5%	1.8%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$79.80	$79.89	$79.21	$80.94	$102.27	$104.93	$106.27
12	Energy Expenditures per Household	2010$/Household	$5,842	$5,911	$6,003	$6,316	$7,743	$7,773	$8,123
13	Retail Electricity Prices	cents/kWh (2010$)	7.8¢	7.8¢	7.9¢	7.9¢	9.1¢	9.5¢	9.7¢
14	Crude Oil Price	2010$/bbl	$23.95	$24.16	$23.02	$25.29	$44.56	$41.96	$41.62
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$0.53	$0.31	$0.59	$1.20	$7.55	$8.04	$7.40
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2010$)	$2.99	$3.25	$2.98	$3.88	$10.06	$9.83	$9.62
17	World Oil Refinery Utilization	percent utilization	94.1%	90.4%	88.8%	92.7%	84.9%	78.3%	78.9%
18	Petroleum Stock Levels	average days supply	69	69	58	58	64	69	63
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	330.8	333.6	346.3	357.2	345.9	333.2	348.5
20	Energy Intensity	million Btu/$1,000 GDP (2010$)	14.3	14.2	14.1	13.9	13.6	13.3	13.3
21	Petroleum Intensity	million Btu/real $1000 GDP (2010$)	6.23	6.24	6.39	6.39	6.17	6.05	6.17
22	Household Energy Efficiency	million Btu/household	212.8	215.4	218.5	213.2	204.6	202.8	206.6
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	332.4	336.0	336.0	330.2	326.6	330.7	332.9
24	Industrial Energy Efficiency	trillion Btu/IP Index	792	780	744	725	709	720	713
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,910	3,913	3,905	3,887	3,846	3,743	3,750
26	Electricity Capacity Margins	percent	18.4%	20.3%	19.4%	21.8%	25.5%	27.4%	28.3%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	216	228	233	236	254	261	263
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	12.0	12.1	12.0	11.9	12.0	12.2	12.1
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2010$)	234	241	244	241	236	245	246
30	Transportation Non-Petroleum Fuels	percent	4.7%	4.7%	4.5%	4.1%	3.8%	3.3%	3.0%
Environmental Metrics									
31	Energy-Related CO2 Emissions	MMTCO2	4,261	4,312	4,532	4,735	4,575	4,439	4,707
32	Energy-Related CO2 Emissions per Capita	metric tons CO2/Person	20.8	20.8	21.6	22.3	21.4	20.5	21.6
33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.90	0.88	0.88	0.87	0.84	0.82	0.83
34	Electricity Non-CO2 Generation Share	percent of total generation	17.8%	19.1%	18.9%	19.4%	22.5%	24.9%	23.6%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.45	$0.45	$0.45	$0.45	$0.49	$0.46	$0.47
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.99	$0.95	$0.97	$0.93	$1.01	$1.33	$1.37
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	75.2	75.6	74.9	73.8	75.1	73.1	68.9

Summary Table 1: Energy Security Metrics (Values)

1977-1993

1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
88.1	76.9	85.3	100.0	96.9	93.8	99.0	104.6	104.5	111.4	110.2	99.5	100.5	124.4	119.6	141.2	147.8
107.3	96.7	94.0	100.0	100.6	94.0	90.6	93.9	90.9	94.8	89.9	80.7	83.1	77.7	76.0	73.0	77.7
113.8	100.3	98.3	100.0	106.3	120.5	122.5	142.0	136.5	137.0	124.8	94.7	101.2	87.1	89.0	77.5	86.3
91.6	87.4	88.6	100.0	106.4	116.0	124.1	139.3	148.0	158.2	144.4	119.4	118.8	92.7	89.9	69.7	72.9
99.1	92.7	92.4	100.0	102.1	102.1	100.8	107.6	107.5	107.3	99.6	86.4	86.1	68.8	72.2	71.0	61.1
95.4	92.3	89.2	100.0	99.4	100.7	100.9	105.3	103.3	103.2	97.5	91.4	93.0	77.4	72.6	67.6	75.3
49.3	40.7	39.7	37.3	34.6	27.0	26.1	28.4	24.9	31.5	31.4	29.7	32.8	30.7	28.4	27.4	31.4
4.8	4.2	5.3	4.7	4.6	5.6	6.0	5.8	7.0	6.1	7.0	7.1	6.9	6.0	6.3	5.2	6.0
$125.0	$109.6	$145.8	$175.5	$161.4	$115.4	$96.9	$97.7	$86.5	$57.4	$67.4	$65.2	$77.2	$90.7	$71.6	$72.0	$71.5
2.1%	1.7%	2.2%	2.7%	2.4%	1.8%	1.4%	1.3%	1.1%	0.7%	0.8%	0.8%	0.9%	1.0%	0.8%	0.8%	0.8%
$108.60	$104.31	$116.13	$134.26	$136.85	$131.10	$118.11	$110.71	$103.94	$85.99	$83.73	$80.49	$79.84	$81.48	$78.55	$75.00	$73.68
$8,530	$8,452	$9,481	$10,731	$10,776	$10,009	$9,331	$9,181	$8,819	$7,436	$7,352	$7,221	$7,268	$7,502	$7,137	$6,973	$6,949
10.0¢	10.2¢	10.1¢	10.9¢	11.7¢	12.2¢	12.1¢	11.6¢	11.6¢	11.3¢	10.9¢	10.5¢	10.3¢	10.1¢	10.0¢	9.9¢	9.8¢
$42.18	$39.39	$54.36	$78.20	$77.44	$66.40	$55.70	$52.96	$48.03	$23.77	$30.22	$23.31	$28.20	$32.46	$26.73	$25.72	$22.29
$1.16	$1.23	$6.11	$13.87	$13.19	$11.88	$7.50	$8.16	$6.12	$10.64	$11.88	$12.54	$6.09	$5.35	$4.96	$3.66	$3.39
$5.20	$4.71	$7.61	$11.41	$12.64	$10.73	$7.06	$4.97	$3.14	$5.75	$5.55	$4.64	$0.86	$1.75	$2.78	$2.34	$1.55
76.9%	77.6%	78.7%	74.6%	72.0%	71.5%	73.5%	75.4%	75.4%	79.0%	79.3%	81.8%	82.9%	82.2%	82.9%	82.5%	82.0%
71	68	72	81	92	93	95	99	97	98	96	92	91	95	97	93	96
354.0	359.2	359.3	343.6	331.7	315.5	312.1	325.0	321.1	319.2	326.3	338.3	343.5	338.5	333.8	334.4	336.3
13.1	12.7	12.5	12.1	11.5	11.2	10.7	10.5	10.1	9.8	9.7	9.8	9.7	9.5	9.5	9.3	9.2
6.22	6.03	5.72	5.28	4.81	4.64	4.42	4.26	4.07	4.10	4.05	4.05	3.91	3.77	3.70	3.65	3.57
206.3	207.6	198.8	194.4	181.0	182.1	179.1	181.4	179.2	175.8	176.1	182.0	185.1	175.1	178.1	175.6	181.8
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
680	653	658	638	603	572	553	547	527	512	506	502	508	511	512	517	502
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
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%
257	263	280	278	289	307	292	300	300	292	286	273	280	270	269	272	262
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
246	245	235	236	234	245	243	236	234	233	237	240	240	241	244	245	243
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%
4,847	4,897	4,966	4,771	4,646	4,405	4,377	4,614	4,600	4,608	4,766	4,984	5,070	5,039	4,993	5,087	5,189
22.0	22.0	22.1	21.0	20.2	19.0	18.7	19.6	19.3	19.2	19.7	20.4	20.5	20.2	19.7	19.9	19.9
0.81	0.78	0.76	0.74	0.70	0.68	0.64	0.63	0.61	0.59	0.59	0.59	0.58	0.57	0.56	0.55	0.55
22.5%	25.5%	24.1%	23.4%	23.6%	26.7%	27.5%	27.3%	27.4%	28.9%	28.0%	28.3%	28.9%	30.8%	31.6%	30.6%	30.2%
$0.81	$0.80	$0.90	$0.97	$0.86	$0.85	$0.80	$0.75	$0.60	$0.49	$0.51	$0.45	$0.44	$0.44	$0.45	$0.33	$0.25
$1.74	$1.82	$1.79	$1.73	$1.55	$1.34	$1.15	$1.08	$1.01	$0.93	$0.86	$0.84	$0.87	$0.89	$0.93	$0.91	$0.81
65.3	61.7	59.3	59.7	58.6	61.4	59.4	56.4	55.5	54.3	52.3	49.4	48.1	48.2	49.5	50.2	50.6

Summary Table 1: Energy Security Metrics (Values)

1994-2000

#	Metric	Units of Measurement	1994	1995	1996	1997	1998	1999	2000
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	147.2	146.2	141.5	128.8	125.5	124.9	128.0
2	Security of World Oil Production	production, freedom & diversity-weighted	75.4	74.1	70.0	70.2	68.1	68.0	68.9
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	87.6	87.9	87.7	87.4	89.1	93.3	99.8
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	69.6	67.1	62.1	61.8	65.0	69.7	73.0
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	57.1	55.4	52.0	53.5	52.5	55.6	58.2
6	Security of World Coal Production	production, freedom & diversity-weighted	76.4	79.0	77.8	77.8	71.4	69.7	72.6
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	31.0	29.7	29.0	30.7	31.0	30.3	31.9
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	6.2	6.1	5.6	5.5	6.3	7.7	7.8
9	Oil & Natural Gas Import Expenditures	billions of 2010$	$70.4	$72.2	$94.4	$89.9	$64.2	$86.5	$153.9
10	Oil & Natural Gas Import Expenditures per GDP	percent	0.7%	0.7%	0.9%	0.8%	0.6%	0.7%	1.2%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$71.14	$69.31	$71.43	$68.01	$59.76	$59.48	$68.92
12	Energy Expenditures per Household	2010$/Household	$6,921	$6,823	$7,217	$7,085	$6,415	$6,594	$7,898
13	Retail Electricity Prices	cents/kWh (2010$)	9.6¢	9.4¢	9.2¢	9.0¢	8.7¢	8.5¢	8.5¢
14	Crude Oil Price	2010$/bbl	$21.08	$22.82	$27.11	$23.75	$15.36	$22.02	$34.44
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$1.88	$2.13	$2.41	$3.13	$5.35	$6.14	$9.16
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2010$)	$0.66	$0.38	$1.68	$1.62	$3.33	$2.66	$6.38
17	World Oil Refinery Utilization	percent utilization	81.2%	82.5%	83.8%	84.1%	83.7%	81.3%	83.1%
18	Petroleum Stock Levels	average days supply	93	88	82	84	87	76	74
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	338.6	341.9	349.0	347.0	344.4	346.4	350.2
20	Energy Intensity	million Btu/$1,000 GDP (2010$)	9.1	9.0	9.0	8.7	8.3	8.1	7.9
21	Petroleum Intensity	million Btu/real $1000 GDP (2010$)	3.51	3.41	3.41	3.31	3.23	3.17	3.07
22	Household Energy Efficiency	million Btu/household	179.1	180.8	188.4	180.8	178.4	181.3	188.0
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	247.0	249.9	249.1	248.7	244.9	243.2	251.0
24	Industrial Energy Efficiency	trillion Btu/IP Index	489	473	466	438	410	392	376
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,406	3,372	3,384	3,414	3,383	3,339	3,337
26	Electricity Capacity Margins	percent	20.5%	16.4%	17.5%	15.0%	11.7%	9.8%	13.3%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	258	242	247	241	234	228	231
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	16.7	16.8	16.9	17.0	16.9	16.7	16.9
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2010$)	240	240	239	235	232	226	222
30	Transportation Non-Petroleum Fuels	percent	3.6%	3.6%	3.4%	3.6%	3.2%	3.1%	3.1%
Environmental Metrics									
31	Energy-Related CO2 Emissions	MMTCO2	5,262	5,323	5,510	5,584	5,635	5,688	5,868
32	Energy-Related CO2 Emissions per Capita	metric tons CO2/Person	20.0	20.0	20.4	20.4	20.4	20.4	20.8
33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.53	0.53	0.53	0.51	0.49	0.48	0.47
34	Electricity Non-CO2 Generation Share	percent of total generation	30.1%	31.6%	31.9%	30.4%	29.6%	30.5%	29.2%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.23	$0.18	$0.17	$0.11	$0.13	$0.09	$0.12
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.79	$0.76	$0.68	$0.64	$0.60	$0.62	$0.60
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	49.9	49.5	48.5	46.6	44.9	43.1	42.0

Summary Table 1: Energy Security Metrics (Values)

2001-2017

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
127.3	124.1	90.9	92.0	87.2	87.1	86.2	87.2	87.1	88.1	93.2	95.5	95.5	95.5	95.5	95.5	95.5
69.6	66.3	69.1	73.2	72.7	73.3	73.4	76.1	74.6	77.4	81.1	82.1	79.4	78.9	78.3	78.4	78.7
99.1	95.2	92.9	97.5	98.3	97.0	97.4	96.4	96.4	93.2	93.4	97.1	97.1	97.1	97.1	97.1	97.1
74.3	72.9	73.4	77.7	78.4	79.4	80.3	79.6	76.7	79.8	86.3	81.6	81.6	81.6	81.6	81.9	82.3
58.1	56.3	67.9	70.3	67.5	73.8	73.8	68.0	67.7	68.6	69.5	69.5	69.5	69.5	69.5	69.5	69.5
74.5	76.1	84.7	89.5	97.8	100.8	106.1	111.8	123.0	128.3	136.0	136.0	136.0	136.0	136.0	136.0	136.0
33.8	31.0	34.0	37.2	38.0	37.9	36.9	37.4	33.4	33.2	31.9	28.0	26.6	23.9	23.9	23.1	23.1
8.5	7.7	7.4	8.1	8.7	8.5	8.8	6.9	5.9	5.7	4.7	3.2	3.5	3.1	3.0	2.6	1.7
$134.5	$126.3	$163.7	$212.9	$289.3	$317.6	$334.7	$423.8	$220.8	$284.3	$337.0	$294.5	$263.7	$254.7	$252.2	$246.7	$251.0
1.1%	1.0%	1.2%	1.6%	2.1%	2.2%	2.3%	2.9%	1.6%	2.0%	2.3%	2.0%	1.7%	1.6%	1.5%	1.5%	1.5%
$67.52	$62.24	$67.73	$73.49	$82.94	$86.69	$87.98	$98.58	$75.94	$83.10	$93.65	$91.32	$80.49	$77.53	$75.37	$74.74	$74.11
$7,726	$7,399	$8,198	$9,113	$10,445	$11,071	$11,369	$12,561	$9,384	$10,445	$11,816	$11,671	$10,368	$10,207	$10,168	$10,282	$10,391
8.9¢	8.7¢	8.8¢	8.7¢	9.0¢	9.6¢	9.5¢	10.0¢	9.9¢	9.8¢	9.7¢	9.5¢	9.0¢	9.0¢	9.0¢	9.1¢	9.2¢
$26.69	$28.78	$32.65	$41.36	$54.71	$63.55	$71.02	$95.40	$61.04	$76.50	$100.77	$97.10	$94.78	$94.98	$93.91	$94.98	$97.01
$8.94	$7.42	$4.57	$4.89	$8.64	$10.30	$9.88	$13.56	$22.07	$24.74	$24.70	$24.61	$21.09	$20.25	$19.16	$18.51	$18.90
$4.90	$5.40	$3.88	$6.22	$8.67	$8.27	$6.61	$6.35	$13.13	$14.82	$15.17	$6.88	$6.68	$6.47	$6.26	$6.05	$5.84
82.8%	81.5%	83.6%	85.6%	86.0%	85.3%	85.1%	83.9%	80.4%	82.1%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%
81	78	78	79	82	83	81	89	95	94	92	97	93	91	90	89	89
337.5	339.5	337.7	342.1	339.3	333.9	336.3	326.5	308.2	316.8	312.8	303.1	302.3	300.4	301.1	300.1	299.6
7.6	7.6	7.5	7.4	7.2	6.9	6.9	6.8	6.7	6.8	6.6	6.3	6.3	6.1	6.0	5.9	5.7
3.03	2.98	2.95	2.96	2.88	2.78	2.71	2.55	2.50	2.48	2.39	2.41	2.36	2.32	2.27	2.22	2.16
182.3	192.9	194.5	192.4	194.4	183.7	189.8	189.1	183.7	189.3	183.2	174.0	175.3	171.8	169.1	166.5	164.8
246.6	245.8	242.0	242.2	240.7	234.8	238.0	235.8	226.0	224.2	220.1	213.1	215.2	214.5	212.8	210.5	208.8
367	366	360	362	340	332	324	325	333	337	329	316	314	307	303	298	294
3,374	3,458	3,576	3,588	3,619	3,613	3,593	3,585	3,566	3,566	3,555	3,545	3,363	3,354	3,347	3,347	3,330
16.0%	18.4%	22.8%	24.5%	20.0%	17.4%	19.0%	23.3%	27.1%	23.9%	24.8%	24.7%	24.5%	24.0%	23.1%	23.1%	23.1%
229	222	226	228	212	207	212	223	232	225	256	257	268	269	268	269	269
17.1	16.9	17.0	17.1	17.1	17.2	17.2	17.4	17.6	17.5	17.5	17.7	17.8	17.8	18.0	18.3	18.6
224	224	221	219	215	211	208	205	210	205	200	196	193	189	186	183	181
3.1%	3.3%	3.3%	3.3%	3.5%	3.9%	4.5%	5.6%	6.2%	6.6%	7.1%	7.3%	7.4%	7.3%	7.3%	7.5%	7.6%
5,761	5,804	5,855	5,975	5,999	5,920	6,023	5,841	5,424	5,623	5,498	5,293	5,368	5,361	5,381	5,336	5,370
20.2	20.2	20.2	20.4	20.3	19.8	20.0	19.2	17.7	18.2	17.6	16.9	16.9	16.7	16.6	16.3	16.2
0.46	0.45	0.45	0.44	0.43	0.41	0.41	0.40	0.38	0.39	0.37	0.35	0.35	0.34	0.33	0.32	0.31
28.4%	29.2%	29.0%	28.9%	28.3%	29.0%	28.0%	29.0%	31.0%	30.1%	32.0%	31.4%	32.6%	33.0%	33.6%	34.2%	34.5%
$0.13	$0.15	$0.17	$0.19	$0.22	$0.30	$0.37	$0.38	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
$0.66	$0.67	$0.68	$0.66	$0.62	$0.66	$0.76	$0.78	$1.28	$0.90	$0.85	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82
42.0	42.4	44.1	44.8	44.6	44.3	44.1	45.5	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1

Summary Table 1: Energy Security Metrics (Values)

2018-2024

#	Metric	Units of Measurement	2018	2019	2020	2021	2022	2023	2024
Global Fuels Metrics									
1	Security of World Oil Reserves	reserves, freedom & diversity-weighted	95.5	95.5	95.5	95.5	95.5	95.5	95.5
2	Security of World Oil Production	production, freedom & diversity-weighted	79.1	79.3	79.5	79.6	79.6	79.6	79.8
3	Security of World Natural Gas Reserves	reserves, freedom & diversity-weighted	97.1	97.1	97.1	97.1	97.1	97.1	97.1
4	Security of World Natural Gas Production	production, freedom & diversity-weighted	82.7	83.0	83.4	83.6	83.9	84.1	84.4
5	Security of World Coal Reserves	reserves, freedom & diversity-weighted	69.5	69.5	69.5	69.5	69.5	69.5	69.5
6	Security of World Coal Production	production, freedom & diversity-weighted	136.0	136.0	136.0	136.0	136.0	136.0	136.0
Fuel Import Metrics									
7	Security of U.S. Petroleum Imports	oil imports, freedom & diversity-weighted	23.1	23.0	23.3	23.7	24.2	24.6	25.2
8	Security of U.S. Natural Gas Imports	gas imports, freedom & diversity-weighted	1.0	0.3	0.0	0.0	0.0	0.0	0.0
9	Oil & Natural Gas Import Expenditures	billions of 2010$	$251.3	$251.1	$253.7	$256.9	$263.3	$268.8	$276.2
10	Oil & Natural Gas Import Expenditures per GDP	percent	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%
Energy Expenditure Metrics									
11	Energy Expenditures per GDP	$ per $1,000 GDP (2010$)	$73.67	$73.04	$72.28	$71.68	$71.03	$70.36	$68.95
12	Energy Expenditures per Household	2010$/Household	$10,492	$10,566	$10,606	$10,654	$10,705	$10,758	$10,689
13	Retail Electricity Prices	cents/kWh (2010$)	9.2¢	9.2¢	9.2¢	9.2¢	9.2¢	9.2¢	9.3¢
14	Crude Oil Price	2010$/bbl	$99.08	$101.21	$103.37	$105.58	$107.84	$110.15	$112.51
Price & Market Volatility Metrics									
15	Crude Oil Price Volatility	$ change in year-to-year price	$19.31	$19.72	$20.14	$20.57	$21.01	$21.46	$21.92
16	Energy Expenditure Volatility	average yearly price change/$1,000 GDP (2010$)	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84
17	World Oil Refinery Utilization	percent utilization	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%
18	Petroleum Stock Levels	average days supply	89	88	88	89	89	89	89
Energy Use Intensity Metrics									
19	Energy Consumption per Capita	million Btu/Person	299.1	298.5	296.8	294.7	293.2	291.3	289.2
20	Energy Intensity	million Btu/$1,000 GDP (2010$)	5.6	5.5	5.4	5.3	5.2	5.1	5.0
21	Petroleum Intensity	million Btu/real $1000 GDP (2010$)	2.11	2.06	2.01	1.95	1.90	1.85	1.80
22	Household Energy Efficiency	million Btu/household	163.8	163.2	161.7	160.4	159.5	158.7	158.0
23	Commercial Energy Efficiency	million Btu/1,000 sq.ft.	207.7	207.1	206.2	205.1	204.2	203.5	202.9
24	Industrial Energy Efficiency	trillion Btu/IP Index	291	287	284	280	277	274	271
Electric Power Sector Metrics									
25	Electricity Capacity Diversity	HHI Index	3,322	3,319	3,315	3,310	3,309	3,325	3,337
26	Electricity Capacity Margins	percent	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%
27	Electricity Transmission Line Mileage	circuit-miles/peak GW	269	269	269	269	269	269	269
Transportation Sector Metrics									
28	Motor Vehicle Average MPG	miles per gallon	18.9	19.2	19.5	19.9	20.3	20.8	21.3
29	Transportation VMT per $ GDP	vehicle miles traveled/$1,000 GDP (2010$)	179	177	175	173	172	170	169
30	Transportation Non-Petroleum Fuels	percent	7.7%	7.8%	7.9%	7.9%	8.0%	8.0%	8.1%
Environmental Metrics									
31	Energy-Related CO2 Emissions	MMTCO2	5,404	5,441	5,455	5,456	5,482	5,497	5,501
32	Energy-Related CO2 Emissions per Capita	metric tons CO2/Person	16.2	16.1	16.0	15.9	15.8	15.7	15.6
33	Energy-Related CO2 Emissions Intensity	metric tons CO2/$1,000 GDP (2010$)	0.30	0.30	0.29	0.28	0.28	0.27	0.27
34	Electricity Non-CO2 Generation Share	percent of total generation	34.8%	34.8%	34.9%	35.1%	34.9%	34.8%	34.7%
Research and Development Metrics									
35	Industrial Energy R&D Expenditures	energy R&D $/$1,000 GDP (2010$)	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
36	Federal Energy & Science R&D Expenditures	R&D $/$1,000 GDP (2010$)	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82
37	Science & Engineering Degrees	# degrees/$billion GDP (2010$)	48.1	48.1	48.1	48.1	48.1	48.1	48.1

Summary Table 1: Energy Security Metrics (Values)

2025-2040

2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5
80.0	80.3	80.6	81.0	81.4	81.8	81.9	82.4	83.0	83.4	83.6	83.6	83.5	83.4	83.3	83.1
97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1
84.6	84.6	84.7	84.7	84.7	84.7	84.6	84.5	84.4	84.3	84.2	84.2	84.3	84.3	84.3	84.3
69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5
136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0
25.6	26.6	27.1	27.6	28.1	28.4	28.2	28.3	28.2	28.3	28.4	28.9	29.1	28.8	28.1	27.8
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	0.0
$282.9	$294.0	$300.5	$308.5	$316.8	$324.1	$327.9	$332.2	$336.9	$344.5	$354.3	$367.8	$379.0	$383.6	$387.5	$396.6
1.3%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
$67.75	$66.70	$65.63	$64.70	$63.84	$62.94	$62.11	$61.34	$60.97	$60.35	$60.13	$60.04	$59.85	$59.61	$59.42	$59.14
$10,652	$10,630	$10,600	$10,592	$10,598	$10,609	$10,629	$10,658	$10,755	$10,812	$10,942	$11,095	$11,244	$11,387	$11,538	$11,678
9.3¢	9.3¢	9.4¢	9.4¢	9.5¢	9.5¢	9.5¢	9.6¢	9.7¢	9.7¢	9.9¢	10.0¢	10.2¢	10.3¢	10.5¢	10.5¢
$114.92	$117.37	$119.89	$122.45	$125.07	$127.75	$130.48	$133.27	$136.13	$139.22	$142.38	$145.61	$148.91	$152.29	$155.75	$159.29
$22.39	$22.87	$23.36	$23.86	$24.37	$24.89	$25.42	$25.97	$26.52	$27.12	$27.74	$28.37	$29.01	$29.67	$30.35	$31.04
$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84	$5.84
81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%	81.2%
90	90	91	91	92	92	92	92	93	93	93	93	93	93	93	92
287.1	284.8	282.4	280.1	277.9	276.1	274.4	272.7	271.1	269.9	268.9	267.9	267.1	266.7	266.4	266.2
4.9	4.7	4.6	4.5	4.4	4.3	4.2	4.2	4.1	4.0	3.9	3.8	3.8	3.7	3.6	3.6
1.75	1.70	1.65	1.61	1.56	1.52	1.48	1.44	1.41	1.37	1.34	1.31	1.28	1.25	1.22	1.19
157.3	156.5	155.9	155.2	154.5	153.9	153.4	152.8	152.3	151.8	151.4	151.0	150.7	150.5	150.4	150.5
202.7	202.3	202.2	201.8	201.5	200.9	200.3	199.7	199.1	198.5	197.8	197.0	196.1	195.4	194.7	194.2
268	264	260	256	253	249	246	242	239	236	232	230	227	224	222	220
3,344	3,360	3,392	3,410	3,422	3,447	3,468	3,488	3,507	3,529	3,545	3,568	3,574	3,576	3,569	3,552
23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%	23.1%
269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269
21.8	22.3	22.8	23.3	23.7	24.2	24.5	24.9	25.2	25.5	25.7	25.9	26.1	26.2	26.3	26.4
167	166	165	163	162	160	158	156	155	153	151	149	147	145	143	141
8.2%	8.2%	8.4%	8.5%	8.6%	8.7%	8.9%	9.1%	9.3%	9.6%	9.9%	10.2%	10.5%	10.8%	11.1%	11.4%
5,501	5,507	5,506	5,503	5,510	5,523	5,538	5,551	5,565	5,585	5,607	5,627	5,640	5,661	5,676	5,691
15.4	15.3	15.2	15.0	14.9	14.8	14.7	14.7	14.6	14.5	14.4	14.4	14.3	14.2	14.1	14.1
0.26	0.26	0.25	0.24	0.24	0.23	0.23	0.22	0.22	0.21	0.21	0.21	0.20	0.20	0.19	0.19
34.7%	34.5%	34.3%	34.2%	34.0%	33.8%	33.5%	33.2%	33.1%	32.9%	32.8%	32.8%	33.1%	33.3%	33.7%	34.2%
$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39	$0.39
$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82	$0.82
48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1	48.1

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	79.2	79.4	81.1	83.7	91.6	91.0	94.2	90.9	86.6	92.3	100.0	97.9
Sub-Indexes												
Geopolitical	73.5	74.5	76.7	80.1	87.5	89.8	94.0	91.9	85.4	91.7	100.0	97.3
Economic	64.3	64.7	65.1	67.2	83.3	82.6	84.8	83.0	79.5	87.7	100.0	98.9
Reliability	83.7	82.3	84.0	87.0	96.2	94.3	96.4	85.3	81.1	88.2	100.0	98.9
Environmental	106.0	105.9	108.8	110.7	105.5	102.2	106.4	106.6	104.7	104.3	100.0	96.5
Global Fuels Metrics												
1 Security of World Oil Reserves	117.2	115.2	112.7	106.5	101.4	102.5	102.2	88.1	76.9	85.3	100.0	97.0
2 Security of World Oil Production	89.7	91.3	93.3	95.0	100.9	109.8	114.5	107.3	96.7	94.0	100.0	100.6
3 Security of World Natural Gas Reserves	57.5	67.4	74.0	78.2	83.9	101.7	106.3	113.6	100.2	98.2	100.0	105.9
4 Security of World Natural Gas Production	70.4	69.6	68.0	67.7	71.2	84.6	89.5	91.6	87.4	88.6	100.0	106.4
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	91.2	93.5	95.6	96.4	97.1	103.4	103.1	95.4	92.3	89.2	100.0	99.4
Fuel Import Metrics												
7 Security of U.S. Petroleum Imports	53.5	61.2	70.6	89.4	96.7	106.9	124.0	132.2	109.0	106.3	100.0	92.7
8 Security of U.S. Natural Gas Imports	74.5	75.6	73.2	70.2	68.5	88.4	92.6	101.3	89.2	112.5	100.0	98.0
9 Oil & Natural Gas Import Expenditures	6.4	7.7	9.8	16.8	53.3	47.3	58.0	71.2	62.5	83.1	100.0	92.0
10 Oil & Natural Gas Import Expenditures per GDP	8.7	10.2	12.4	20.0	63.6	56.6	65.9	77.4	64.2	82.9	100.0	89.7
Energy Expenditure Metrics												
11 Energy Expenditures per GDP	59.5	59.5	59.0	60.3	76.2	78.1	79.1	80.9	77.7	86.5	100.0	101.9
12 Energy Expenditures per Household	54.5	55.1	56.0	58.9	72.2	72.4	75.7	79.5	78.8	88.4	100.0	100.4
13 Retail Electricity Prices	71.4	72.4	72.4	72.4	83.7	87.8	88.8	91.8	93.9	92.9	100.0	107.1
14 Crude Oil Price	30.6	30.9	29.4	32.3	57.0	53.7	53.2	53.9	50.4	69.5	100.0	99.0
Price & Market Volatility Metrics												
15 Crude Oil Price Volatility	3.7	2.6	4.3	8.6	54.5	58.0	53.4	8.4	8.9	44.0	100.0	95.1
16 Energy Expenditure Volatility	26.2	28.5	26.1	33.9	88.0	85.9	84.2	45.5	41.2	66.6	100.0	110.8
17 World Oil Refinery Utilization	158.9	146.7	141.5	154.2	129.4	110.0	111.7	106.1	108.1	111.1	100.0	93.2
18 Petroleum Stock Levels	117.5	118.6	139.3	139.7	126.3	117.3	128.2	114.4	120.1	112.4	100.0	88.1
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	118.8	117.4	117.0	115.1	113.1	110.3	110.5	108.4	105.3	103.3	100.0	95.1
21 Petroleum Intensity	118.0	118.2	121.0	120.9	116.8	114.5	116.8	117.8	114.1	108.2	100.0	91.0
22 Household Energy Efficiency	109.5	110.8	112.4	109.7	105.2	104.3	106.3	106.1	106.8	102.3	100.0	93.1
23 Commercial Energy Efficiency	111.9	113.1	113.1	111.2	110.0	111.3	112.1	108.7	106.0	104.1	100.0	97.2
24 Industrial Energy Efficiency	124.2	122.3	116.7	113.7	111.2	112.9	111.7	106.7	102.4	103.2	100.0	94.6
Electric Power Sector Metrics												
25 Electricity Capacity Diversity	110.0	110.2	109.7	108.7	106.3	100.4	100.8	94.8	95.0	96.9	100.0	99.9
26 Electricity Capacity Margins	142.7	129.2	135.0	120.1	102.9	95.7	92.6	100.6	100.4	88.6	100.0	92.7
27 Electricity Transmission Line Mileage	128.6	122.2	119.5	117.8	109.7	106.5	105.8	108.1	105.6	99.4	100.0	96.2
Transportation Sector Metrics												
28 Motor Vehicle Average MPG	110.8	109.9	110.8	111.8	110.8	109.0	109.9	108.1	107.3	106.4	100.0	97.8
29 Transportation VMT per $ GDP	99.4	102.1	103.6	102.1	100.1	104.0	104.3	104.3	104.0	99.8	100.0	99.3
30 Transportation Non-Petroleum Fuels	97.3	97.4	97.7	98.6	99.0	100.1	100.8	101.1	101.4	100.6	100.0	99.8
Environmental Metrics												
31 Energy-Related CO2 Emissions	33.9	40.5	69.1	95.2	74.5	56.8	91.6	109.9	116.4	125.2	100.0	83.4
32 Energy-Related CO2 Emissions per Capita	98.0	97.8	105.8	113.2	103.8	95.8	105.7	109.9	109.8	110.4	100.0	92.9
33 Energy-Related CO2 Emissions Intensity	122.2	119.6	119.4	117.8	114.5	111.3	112.0	110.3	105.6	103.8	100.0	94.9
34 Electricity non-CO2 Generation Share	131.3	122.6	123.6	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	147.0	147.0	147.0	147.0	140.9	145.1	143.9	109.2	110.0	103.8	100.0	106.2
36 Federal Energy & Science R&D Expenditures	175.5	182.8	179.1	186.1	172.5	130.5	126.2	99.6	95.1	97.0	100.0	112.0
37 Science & Engineering Degrees	79.4	78.9	79.7	80.9	79.5	81.7	86.6	91.5	96.8	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
91.6	86.6	87.3	84.2	83.4	84.5	82.2	80.0	78.8	76.6	75.2	76.7	75.5	76.4	78.5	79.1	78.9	82.0	88.1
91.6	87.5	90.9	88.1	86.5	87.0	81.2	81.3	79.2	76.3	74.7	76.7	75.5	75.4	76.2	74.8	73.1	76.5	84.3
91.0	83.4	81.4	77.3	71.1	72.1	69.3	67.6	68.2	65.3	63.6	63.4	61.8	62.2	65.3	64.6	61.5	64.4	73.6
91.7	85.2	84.0	79.9	87.5	89.3	88.8	79.8	78.5	77.9	75.2	77.6	75.6	78.8	80.7	85.2	91.9	96.8	100.5
92.4	91.4	94.3	93.1	92.9	94.5	96.2	96.8	94.1	92.6	93.2	95.5	95.9	96.8	99.4	101.1	100.9	101.7	103.3
93.8	99.0	104.6	104.5	111.4	110.2	99.5	100.5	124.4	119.6	141.2	147.8	147.2	146.2	141.5	128.8	125.5	124.9	128.0
94.0	90.6	93.9	90.9	94.8	89.9	80.7	83.1	77.7	76.0	73.0	77.7	75.4	74.1	70.0	70.2	68.1	68.0	68.9
120.5	122.5	142.0	136.5	137.0	124.8	94.7	101.2	87.1	89.0	77.5	86.3	87.6	87.9	87.7	87.4	89.1	93.3	99.8
116.0	124.1	139.3	148.0	158.2	144.4	119.4	118.8	92.7	89.9	69.7	72.9	69.6	67.1	62.1	61.8	65.0	69.7	73.0
102.1	100.8	107.6	107.5	107.3	99.6	86.4	86.1	68.8	72.2	71.0	61.1	57.1	55.4	52.0	53.5	52.5	55.6	58.2
100.7	100.9	105.3	103.3	103.2	97.5	91.4	93.0	77.4	72.6	67.6	75.3	76.4	79.0	77.8	77.8	71.4	69.7	72.6
72.4	69.9	76.2	66.8	84.4	84.1	79.6	87.9	82.3	76.1	73.5	84.1	83.1	79.5	77.8	82.3	83.2	81.3	85.6
118.9	127.2	123.3	148.6	129.0	149.2	150.2	145.6	126.6	134.3	109.6	126.9	132.0	130.3	118.4	117.8	134.5	162.5	166.0
65.8	55.2	55.7	49.3	32.7	38.4	37.1	44.0	51.7	40.8	41.0	40.8	40.1	41.1	53.8	51.3	36.6	49.3	87.7
65.4	52.6	49.5	42.0	26.9	30.7	28.5	32.6	37.6	29.7	28.9	27.9	26.4	26.4	33.3	30.4	20.8	26.7	45.6
97.6	88.0	82.5	77.4	64.0	62.4	59.9	59.5	60.7	58.5	55.9	54.9	53.0	51.6	53.2	50.7	44.5	44.3	51.3
93.3	87.0	85.6	82.2	69.3	68.5	67.3	67.7	69.9	66.5	65.0	64.8	64.5	63.6	67.3	66.0	59.8	61.4	73.6
112.2	111.2	106.6	106.6	104.3	100.3	96.6	94.6	92.8	92.0	90.8	90.3	88.2	86.1	84.2	82.6	80.4	78.1	78.4
84.9	71.2	67.7	61.4	30.4	38.6	29.8	36.1	41.5	34.2	32.9	28.5	27.0	29.2	34.7	30.4	19.6	28.2	44.0
85.6	54.1	58.9	44.2	76.7	85.7	90.5	43.9	38.6	35.7	26.4	24.4	13.6	15.4	17.4	22.6	38.6	44.3	66.1
94.0	61.8	43.5	27.5	50.4	48.6	40.6	7.5	15.4	24.4	20.5	13.6	5.8	3.3	14.7	14.2	29.2	23.3	55.9
91.7	97.1	102.0	102.0	111.9	112.9	120.1	123.4	121.3	123.3	122.2	120.7	118.2	122.0	125.9	127.0	125.8	118.6	123.9
87.1	85.3	82.5	84.3	83.2	84.4	88.3	89.2	85.3	84.1	87.3	85.2	87.3	92.3	99.1	97.2	93.5	106.4	109.6
91.8	90.8	94.6	93.5	92.9	95.0	98.5	100.0	98.5	97.1	97.3	97.9	98.6	99.5	101.6	101.0	100.3	100.8	101.9
93.1	88.9	87.1	83.4	80.9	80.9	81.2	80.4	78.7	78.8	77.4	76.7	75.1	74.9	74.5	71.8	69.1	67.1	65.8
87.9	83.6	80.6	77.1	77.6	76.7	76.7	74.1	71.3	70.0	69.1	67.6	66.5	64.6	64.6	62.6	61.1	59.9	58.2
93.7	92.1	93.3	92.2	90.4	90.6	93.6	95.2	90.1	91.6	90.3	93.5	92.1	93.0	96.9	93.0	91.8	93.3	96.7
96.3	94.1	93.0	88.2	84.9	84.9	87.0	88.9	87.6	86.7	84.3	84.0	83.2	84.2	83.9	83.7	82.5	81.9	84.5
89.7	86.7	85.8	82.6	80.2	79.3	78.7	79.7	80.1	80.3	81.0	78.6	76.7	74.2	73.0	68.7	64.2	61.5	58.9
102.5	102.6	100.8	97.1	94.7	93.3	87.3	90.9	87.4	83.5	83.2	82.9	81.0	79.0	79.7	81.4	79.6	77.1	77.0
81.1	93.7	90.4	88.1	92.7	99.2	119.7	104.8	113.7	114.3	109.5	124.5	127.6	159.8	149.6	174.7	224.3	266.4	197.5
90.8	95.3	92.7	92.6	95.4	97.3	102.1	99.5	103.2	103.6	102.4	106.0	108.0	114.9	112.8	115.5	118.7	121.9	120.6
94.3	93.7	91.7	91.1	90.5	88.1	85.3	83.6	81.1	78.7	78.7	79.6	79.6	79.2	78.7	78.2	78.7	79.6	78.7
103.9	103.0	100.0	99.1	99.0	100.4	101.7	101.6	102.0	103.6	103.7	103.0	101.6	101.9	101.3	99.6	98.3	96.0	94.1
100.0	101.0	100.6	100.9	101.2	100.9	100.3	100.2	99.9	100.3	100.4	100.1	99.6	99.5	99.9	99.4	100.4	100.4	100.5
52.5	48.9	79.6	77.8	78.8	99.3	127.6	138.7	134.6	128.7	140.9	154.1	163.5	171.4	195.7	205.3	212.0	218.8	242.1
82.1	79.8	86.8	84.8	83.6	87.7	94.2	95.6	92.5	88.5	89.5	90.3	90.6	90.4	94.6	94.9	94.2	94.1	98.1
91.9	87.4	85.9	82.2	79.6	79.7	80.1	78.7	76.8	76.3	75.2	74.5	72.6	71.5	71.4	69.2	66.9	64.5	64.0
87.5	85.2	85.7	85.3	81.0	83.7	82.8	80.9	76.1	74.1	76.4	77.4	77.8	74.1	73.4	77.0	78.9	76.8	80.2
106.7	109.7	113.3	126.8	141.1	137.9	145.9	148.1	148.1	146.8	171.6	195.1	203.2	229.6	240.9	302.0	277.2	322.3	289.2
129.1	150.3	160.2	172.1	186.0	200.6	206.4	198.4	195.9	186.0	191.1	215.4	220.0	228.1	253.3	271.9	287.3	278.7	289.0
97.2	100.6	105.8	107.5	110.0	114.2	120.9	124.0	123.8	120.6	119.0	118.1	119.6	120.7	123.1	128.1	133.0	138.5	142.2

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	84.8	82.9	82.4	87.3	94.4	96.0	96.2	100.8	90.8	98.2	102.0	95.3
Sub-Indexes												
Geopolitical	82.4	79.8	79.3	85.4	92.0	94.7	96.7	103.1	89.2	96.1	102.0	97.4
Economic	69.5	67.9	70.1	76.4	86.9	90.5	91.5	102.7	85.0	94.7	103.3	95.6
Reliability	95.3	92.2	87.8	92.5	102.3	104.0	100.2	100.3	105.9	114.1	114.4	102.2
Environmental	100.6	100.7	100.4	101.3	101.3	98.3	98.3	94.7	86.9	90.5	87.9	84.7
Global Fuels Metrics												
1 Security of World Oil Reserves	127.3	124.1	90.9	92.0	87.2	87.1	86.2	87.2	87.1	88.1	93.2	95.5
2 Security of World Oil Production	69.6	66.3	69.1	73.2	72.7	73.3	73.4	76.1	74.6	77.4	81.1	82.1
3 Security of World Natural Gas Reserves	99.1	95.2	92.9	97.5	98.3	97.0	97.4	96.4	96.4	93.2	93.4	97.1
4 Security of World Natural Gas Production	74.3	72.9	73.4	77.7	78.4	79.4	80.3	79.6	76.7	79.8	86.3	81.6
5 Security of World Coal Reserves	58.1	56.3	67.9	70.3	67.5	73.8	73.8	68.0	67.7	68.6	69.5	69.5
6 Security of World Coal Production	74.5	76.1	84.7	89.5	97.8	100.8	106.1	111.8	123.0	128.3	136.0	136.0
Fuel Import Metrics												
7 Security of U.S. Petroleum Imports	90.7	83.0	91.0	99.6	101.8	101.6	98.9	100.3	89.4	88.9	85.5	74.9
8 Security of U.S. Natural Gas Imports	179.5	163.3	158.0	172.5	185.0	181.3	187.8	146.1	124.8	121.2	99.4	67.2
9 Oil & Natural Gas Import Expenditures	76.6	72.0	93.3	121.3	164.9	181.0	190.7	241.5	125.8	162.0	192.1	167.8
10 Oil & Natural Gas Import Expenditures per GDP	39.4	36.4	46.0	57.8	76.2	81.5	84.3	107.0	57.5	72.4	84.2	72.0
Energy Expenditure Metrics												
11 Energy Expenditures per GDP	50.3	46.4	50.4	54.7	61.8	64.6	65.5	73.4	56.6	61.9	69.8	68.0
12 Energy Expenditures per Household	72.0	69.0	76.4	84.9	97.3	103.2	105.9	117.1	87.4	97.3	110.1	108.8
13 Retail Electricity Prices	82.0	79.7	80.6	80.2	83.1	88.0	87.7	91.5	91.3	90.4	89.1	87.3
14 Crude Oil Price	34.1	36.8	41.8	52.9	70.0	81.3	90.8	122.0	78.1	97.8	128.9	124.2
Price & Market Volatility Metrics												
15 Crude Oil Price Volatility	64.5	53.5	32.9	35.3	62.3	74.3	71.3	97.8	159.2	178.4	178.1	177.5
16 Energy Expenditure Volatility	42.9	47.3	34.0	54.5	76.0	72.5	57.9	55.6	115.1	129.8	132.9	60.3
17 World Oil Refinery Utilization	123.1	119.1	125.4	131.4	132.6	130.5	130.0	126.4	116.0	120.9	118.5	118.5
18 Petroleum Stock Levels	100.8	103.9	104.0	102.9	99.8	97.9	101.1	91.6	86.0	87.0	88.1	83.8
Energy Use Intensity Metrics												
19 Energy Consumption per Capita	98.2	98.8	98.3	99.6	98.8	97.2	97.9	95.0	89.7	92.2	91.0	88.2
20 Energy Intensity	63.4	63.2	61.9	61.1	59.4	57.5	57.3	56.4	55.4	56.1	54.8	52.3
21 Petroleum Intensity	57.4	56.5	55.9	56.1	54.6	52.6	51.4	48.3	47.3	47.0	45.3	45.7
22 Household Energy Efficiency	93.7	99.2	100.0	99.0	100.0	94.5	97.6	97.3	94.5	97.4	94.2	89.5
23 Commercial Energy Efficiency	83.0	82.7	81.5	81.5	81.0	79.0	80.1	79.4	76.1	75.5	74.1	71.7
24 Industrial Energy Efficiency	57.6	57.4	56.4	56.8	53.3	52.1	50.8	50.9	52.2	52.8	51.6	49.5
Electric Power Sector Metrics												
25 Electricity Capacity Diversity	79.2	84.0	90.8	91.5	93.3	92.9	91.7	91.3	90.2	90.2	89.6	89.0
26 Electricity Capacity Margins	163.7	142.3	115.0	106.8	131.0	150.2	137.8	112.3	96.5	109.6	105.6	106.1
27 Electricity Transmission Line Mileage	121.6	125.3	123.2	121.9	130.9	134.3	131.2	124.5	120.1	123.6	108.5	108.1
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	76.1	76.1	75.1
29 Transportation VMT per $ GDP	94.8	95.1	93.9	93.0	91.1	89.4	88.2	86.9	89.1	86.8	84.6	83.3
30 Transportation Non-Petroleum Fuels	100.4	100.1	100.1	100.1	99.7	98.8	97.7	95.5	94.3	93.5	92.7	92.2
Environmental Metrics												
31 Energy-Related CO2 Emissions	228.3	233.9	240.5	256.0	259.1	248.8	262.3	238.7	184.6	210.4	194.2	167.6
32 Energy-Related CO2 Emissions per Capita	92.7	92.6	92.5	94.5	93.4	89.3	90.7	83.7	71.0	75.0	70.6	64.5
33 Energy-Related CO2 Emissions Intensity	62.1	61.5	60.5	59.7	58.1	55.9	55.8	54.2	52.0	52.6	50.6	47.6
34 Electricity non-CO2 Generation Share	82.5	80.0	80.8	81.1	82.8	80.7	83.5	80.8	75.5	77.7	73.2	74.6
Research and Development Metrics												
35 Industrial Energy R&D Expenditures	276.4	253.4	241.6	224.3	210.3	179.8	160.6	158.6	156.8	156.8	156.8	156.8
36 Federal Energy & Science R&D Expenditures	263.1	260.7	256.6	263.3	278.3	264.2	228.8	223.7	135.2	192.3	203.6	211.9
37 Science & Engineering Degrees	142.3	140.8	135.3	133.3	133.7	134.7	135.2	131.3	124.1	124.1	124.1	124.1

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

2013-2031

2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
91.8	90.4	89.5	88.6	88.6	88.6	88.7	88.9	89.1	89.6	90.0	90.4	90.8	91.4	91.8	92.3	92.8	93.4	93.8
94.2	92.4	91.6	90.5	90.6	90.5	90.5	90.9	91.4	92.2	92.8	93.6	94.3	95.3	96.0	96.8	97.7	98.5	99.1
90.2	88.8	87.6	87.1	87.4	87.7	87.9	88.1	88.5	89.0	89.5	90.0	90.5	91.2	91.8	92.4	93.1	93.8	94.3
97.9	96.4	95.5	94.4	94.1	94.3	94.4	94.9	95.4	96.0	96.7	97.4	98.0	98.8	99.6	100.4	101.1	101.9	102.6
84.6	83.8	83.3	82.1	81.7	81.5	81.4	80.9	80.3	80.1	79.7	79.2	78.7	78.2	77.8	77.3	76.9	76.6	76.4
95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5
79.4	78.9	78.3	78.4	78.7	79.1	79.3	79.5	79.6	79.6	79.6	79.8	80.0	80.3	80.6	81.0	81.4	81.8	81.9
97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1
81.6	81.6	81.6	81.9	82.3	82.7	83.0	83.4	83.6	83.9	84.1	84.4	84.6	84.6	84.7	84.7	84.7	84.7	84.6
69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5
136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0
71.3	64.1	64.1	61.9	61.8	61.9	61.7	62.4	63.4	64.9	65.9	67.5	68.6	71.2	72.5	74.0	75.2	76.0	75.7
74.5	65.1	63.9	54.5	36.4	20.5	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
150.3	145.1	143.7	140.6	143.1	143.2	143.1	144.6	146.4	150.0	153.2	157.4	161.2	167.6	171.3	175.8	180.6	184.7	186.9
63.6	59.7	57.1	54.2	53.5	52.2	50.8	50.0	49.5	49.5	49.4	49.6	49.5	50.3	50.2	50.4	50.6	50.5	49.8
60.0	57.7	56.1	55.7	55.2	54.9	54.4	53.8	53.4	52.9	52.4	51.4	50.5	49.7	48.9	48.2	47.5	46.9	46.3
96.6	95.1	94.8	95.8	96.8	97.8	98.5	98.8	99.3	99.8	100.3	99.6	99.3	99.1	98.8	98.7	98.8	98.9	99.1
82.8	83.2	82.6	84.0	84.7	84.9	84.6	84.5	84.7	84.8	85.0	85.3	85.4	85.6	86.0	86.5	86.9	87.3	87.8
121.2	121.5	120.1	121.5	124.1	126.7	129.4	132.2	135.0	137.9	140.9	143.9	147.0	150.1	153.3	156.6	159.9	163.4	166.9
152.1	146.1	138.2	133.4	136.3	139.2	142.2	145.2	148.3	151.5	154.8	158.1	161.5	164.9	168.4	172.1	175.7	179.5	183.3
58.5	56.7	54.8	53.0	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2
118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5
87.2	89.0	90.5	91.1	91.6	91.9	92.2	92.2	92.0	91.8	91.4	91.1	90.6	90.1	89.6	89.1	88.7	88.5	88.2
88.0	87.4	87.6	87.3	87.2	87.0	86.9	86.4	85.8	85.4	84.8	84.2	83.6	82.9	82.2	81.5	80.9	80.4	79.9
52.2	50.8	49.8	48.6	47.5	46.6	45.8	44.8	43.9	43.0	42.1	41.2	40.3	39.4	38.5	37.6	36.8	36.0	35.2
44.7	43.8	43.0	42.0	40.9	40.0	39.0	38.0	37.0	36.1	35.1	34.1	33.1	32.2	31.3	30.4	29.6	28.8	28.1
90.1	88.4	87.0	85.6	84.8	84.2	83.9	83.1	82.5	82.1	81.6	81.2	80.9	80.5	80.2	79.8	79.5	79.2	78.9
72.4	72.2	71.6	70.9	70.3	69.9	69.7	69.4	69.0	68.8	68.5	68.3	68.2	68.1	68.1	67.9	67.8	67.6	67.4
49.3	48.1	47.4	46.7	46.1	45.6	45.1	44.5	43.9	43.5	43.0	42.5	41.9	41.4	40.7	40.2	39.6	39.1	38.5
78.5	78.0	77.6	77.6	76.6	76.2	76.0	75.7	75.5	75.4	76.3	77.0	77.4	78.3	80.2	81.2	81.9	83.3	84.6
107.0	109.3	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2
103.9	103.6	103.9	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3
74.9	74.5	73.7	72.7	71.6	70.5	69.4	68.2	66.8	65.4	64.0	62.5	61.0	59.6	58.3	57.1	56.0	55.1	54.2
81.9	80.2	78.9	77.8	76.7	75.8	74.9	74.2	73.5	72.9	72.2	71.6	71.0	70.3	69.7	69.1	68.5	67.8	67.0
92.1	92.1	92.1	91.8	91.7	91.4	91.2	91.0	91.0	90.8	90.8	90.6	90.5	90.4	90.2	90.0	89.8	89.5	89.2
177.3	176.5	179.0	173.2	177.6	182.0	186.8	188.5	188.7	192.1	194.0	194.5	194.6	195.3	195.2	194.9	195.7	197.4	199.4
64.5	63.1	62.4	60.2	59.8	59.4	59.1	58.2	57.2	56.7	55.9	55.0	54.1	53.2	52.3	51.3	50.5	49.9	49.3
47.6	46.2	44.8	43.1	42.1	41.3	40.5	39.6	38.7	38.0	37.1	36.3	35.4	34.7	33.9	33.1	32.3	31.6	31.0
71.7	71.0	69.7	68.3	67.8	67.3	67.2	67.1	66.7	67.0	67.2	67.4	67.4	67.8	68.2	68.4	68.8	69.3	69.9
156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8
211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9
124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1

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

2032-2040

Metric	2032	2033	2034	2035	2036	2037	2038	2039	2040
Index of U.S. Energy Security Risk	94.3	94.8	95.5	96.3	97.2	98.0	98.7	99.2	99.9
Sub-Indexes									
Geopolitical	99.8	100.6	101.5	102.6	103.8	104.9	105.8	106.5	107.5
Economic	94.9	95.6	96.5	97.6	99.0	100.2	101.1	102.1	103.2
Reliability	103.3	104.0	104.8	105.5	106.4	107.2	107.8	108.3	108.9
Environmental	76.2	75.9	75.8	75.7	75.6	75.3	75.2	75.0	74.7
Global Fuels Metrics									
1 Security of World Oil Reserves	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5	95.5
2 Security of World Oil Production	82.4	83.0	83.4	83.6	83.6	83.5	83.4	83.3	83.1
3 Security of World Natural Gas Reserves	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1	97.1
4 Security of World Natural Gas Production	84.5	84.4	84.3	84.2	84.2	84.3	84.3	84.3	84.3
5 Security of World Coal Reserves	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5	69.5
6 Security of World Coal Production	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0
Fuel Import Metrics									
7 Security of U.S. Petroleum Imports	75.8	75.5	75.7	76.1	77.3	77.9	77.1	75.3	74.6
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	189.3	192.0	196.3	201.9	209.6	216.0	218.6	220.8	226.0
10 Oil & Natural Gas Import Expenditures per GDP	49.3	48.8	48.7	48.9	49.5	49.8	49.1	48.4	48.3
Energy Expenditure Metrics									
11 Energy Expenditures per GDP	45.7	45.4	44.9	44.8	44.7	44.6	44.4	44.3	44.0
12 Energy Expenditures per Household	99.3	100.2	100.8	102.0	103.4	104.8	106.1	107.5	108.8
13 Retail Prices	88.3	88.9	89.5	90.7	92.2	93.5	94.7	96.2	97.0
14 Crude Oil Price	170.4	174.1	178.0	182.1	186.2	190.4	194.8	199.2	203.7
Price & Market Volatility Metrics									
15 Crude Oil Price Volatility	187.3	191.3	195.6	200.0	204.6	209.2	214.0	218.8	223.8
16 Energy Expenditure Volatility	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2	51.2
17 World Oil Refinery Utilization	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5	118.5
18 Petroleum Stock Levels	88.0	87.8	87.7	87.7	87.6	87.7	87.8	87.9	88.1
Energy Use Intensity Metrics									
19 Energy Consumption per Capita	79.4	78.9	78.6	78.3	78.0	77.7	77.6	77.5	77.5
20 Energy Intensity	34.4	33.7	33.0	32.4	31.8	31.1	30.6	30.0	29.5
21 Petroleum Intensity	27.3	26.6	26.0	25.4	24.8	24.2	23.6	23.1	22.6
22 Household Energy Efficiency	78.6	78.3	78.1	77.9	77.7	77.5	77.4	77.4	77.4
23 Commercial Energy Efficiency	67.2	67.0	66.8	66.6	66.3	66.0	65.8	65.6	65.4
24 Industrial Energy Efficiency	38.0	37.5	37.0	36.4	36.0	35.5	35.1	34.8	34.4
Electric Power Sector Metrics									
25 Electricity Capacity Diversity	85.7	86.8	88.1	89.0	90.3	90.7	90.8	90.4	89.4
26 Electricity Capacity Margins	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2	113.2
27 Electricity Transmission Line Mileage	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3	103.3
Transportation Sector Metrics									
28 Motor Vehicle Average MPG	53.4	52.8	52.2	51.7	51.3	51.0	50.7	50.5	50.3
29 Transportation VMT per $ GDP	66.3	65.5	64.8	64.0	63.1	62.3	61.4	60.6	59.8
30 Transportation Non-Petroleum Fuels	88.7	88.3	87.9	87.4	86.8	86.3	85.7	85.2	84.6
Environmental Metrics									
31 Energy-Related CO2 Emissions	201.0	202.8	205.5	208.3	210.9	212.6	215.3	217.2	219.2
32 Energy-Related CO2 Emissions per Capita	48.7	48.2	47.7	47.3	46.9	46.3	45.9	45.4	44.9
33 Energy-Related CO2 Emissions Intensity	30.3	29.7	29.1	28.5	27.9	27.3	26.7	26.1	25.5
34 Electricity non-CO2 Generation Share	70.4	70.8	71.0	71.3	71.3	70.8	70.3	69.5	68.5
Research and Development Metrics									
35 Industrial Energy R&D Expenditures	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8	156.8
36 Federal Energy & Science R&D Expenditures	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9	211.9
37 Science & Engineering Degrees	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1	124.1

Primary Data Sources

The Energy Institute relied primarily on government data from the Energy Information Administration (EIA), Department of Commerce, and Department of Transportation to develop its Index of U.S. Energy Security. Where historical data from government sources were not available (largely data before 1990 or so), other widely-used and respected sources were employed. EIA's *Annual Energy Outlook 2013 (AEO 2013)* was the primary source for metric forecasts out to 2040.

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

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

British Petroleum. *BP Statistical Review of World Energy*. Available at: http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481. For pre-1980 international natural gas production and post-1980 refinery utilization data.

Department of Commerce:

- Bureau of the Census, *Statistical Abstract*. Available at: http://www.census.gov/compendia/statab/. For historical population data.
- Bureau of the Census, Housing Housing Vacancies and Homeownership (CPS/HVS) - Historical Tables, Table 7. Annual Estimates of the Housing Inventory: 1965 to Present. Available at: https://www.census.gov/housing/hvs/data/histtabs.html. For historical household data.
- Bureau of Economic Analysis, National Economic Accounts: Current-Dollar and "Real" Gross Domestic Product. Available at: http://www.bea.gov/national/xls/gdplev.xls. For historical nominal and real GDP data.
- Bureau of the Census, *Statistical Abstract*, Energy & Utilities, Electric Power Industry - Capability, Peak Load, and Capacity Margin http://www.census.gov/compendia/statab/cats/energy_utilities.html. For pre-1989 summer peak load aggregates.

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

Energy Information Administration:

- *Annual Energy Outlook 2013.* Available at: http://www.eia.gov/forecasts/aeo/. For forecast import, expenditure, cost, electricity price, generating capacity, production, consumption, stock, miles per gallon, and energy-related carbon dioxide emissions data.
- *Annual Energy Review.* Available at: http://www.eia.gov/totalenergy/data/annual/. For historical import, expenditure, cost, electricity price, generating capacity, production, consumption, stock, miles per gallon, and energy-related carbon dioxide emissions data
- *International Energy Outlook.* Available at: http://www.eia.gov/forecasts/ieo/index/cfm. For forecast world oil and natural gas production data.
- International Energy Statistics. Available at: http://www.eia.gov/countries/data.cfm. For historical international reserves and production data.
- *Monthly Energy Review.* Available at: http://www.eia.gov/totalenergy/data/monthly/. For historical energy expenditure data and preliminary energy and emissions data.

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

Freedom House: *Freedom in the World: Comparative and Historical Data.* Available at: http://www.freedomhouse.org/report-types/freedom-world. 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 & 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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