2018 EDITION

INTERNATIONAL INDEX OF ENERGY SECURITY RISK®

ASSESSING RISK IN A GLOBAL ENERGY MARKET

Foreword by
U.S. Secretary of Energy Rick Perry

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CONTENTS

PREFACE

When the Global Energy Institute (GEI) set out to create its Index of U.S. Energy Security Risk and its International Index of Energy Security Risk (International Index) nearly 10 years ago, it did so to answer a simple question: How do we know if our energy security is getting better or worse, both over time and compared to other large energy users?

Little did we know at the time of the tremendous changes that would take place in the energy landscape, and how valuable our indexes would be in chronicling those changes—especially here in the United States. The resulting improvement to U.S. energy security has been beyond what we could have anticipated when we started this project. This year's International Index shows the U.S. was in 2016 the second-most energy secure country (after Norway) of the 25 large energy consuming countries we compare it against. This is an astonishing result considering the United States was ranked ninth in 2008.

It is a truly compelling story, and GEI is delighted that U.S. Department of Energy Secretary Rick Perry tells it to such great effect in the foreword that follows. Secretary Perry weaves together the many different threads of the U.S. energy revolution that has turned scarcity in abundance and made the United States and energy superpower. The Secretary also lays out how we can sustain the many energy advantages we have over the longer term. We hope that future editions of both the U.S. and International Indexes will feature contributions from other recognized energy experts.

Our International Index now is issued on a two-year schedule. This 2018 edition contains data through 2016. Information on the methodology used to create the International Index appears in Appendix 1 while source of data are listed in Appendix 2. All of the data presented in the reports also are available at GEI's website, as are data for the countries not specifically highlighted in the report.

Finally, the International Index could not have been completed without the extraordinary efforts of many people. In particular, our thanks go to Daniel E. Klein, President of Twenty-First Strategies of Santa Fe, New Mexico, and his assistant, Christopher D. Russell, for their updating of the international database—a monumental task that requires sifting through huge amounts of data. Special thanks also go to GEI's Kara Conrad for her reviews of the manuscript. The entire production team here at the U.S. Chamber of Commerce is owed a huge debt of gratitude for designing and producing the publication under a tight deadline. Finally, special thanks go to the entire GEI team for creating what is still the most widely used energy security index that has changes the way we look at energy security.

KAREN HARBERT
PRESIDENT & CEO
GLOBAL ENERGY INSTITUTE
U.S. CHAMBER OF COMMERCE

FOREWORD

As U.S. Secretary of Energy, I am pleased to contribute the foreword for this fifth edition of the Global Energy Institute's International Index of Energy Security Risk. As with prior editions, this report uses one of the best available sources for energy data, the Energy Information Administration (EIA) within the U.S. Department of Energy (DOE).

This index and the EIA have spotlighted striking energy trends across nations. None is more consequential than the energy transformation that has occurred in the United States. In less than a decade, the U.S. has moved from heavy dependence on energy imports to the cusp of energy independence.

This remarkable story began at the dawn of DOE's creation more than 40 years ago. For the United States, those were troubled times of price controls at home, oil boycotts imposed from abroad, and cars waiting on long lines for short supplies of gasoline.

U.S. energy policy was disproportionately influenced by people who believed domestic production was in permanent decline, resulting in permanent energy scarcity. Even if new reserves were discovered, it was thought they would be too costly to produce or impossible to use without harming the environment.

Eventually our leaders began saying they were for greater domestic energy development. They just didn't want to explore for it, drill for it, transport it, or sell it.

Essentially, they kept trying to solve a problem caused by regulation by imposing even more of it.

Those promoting this policy saw it as realism, but in fact it was pessimism rooted in a flawed view of reality. There never was a shortage of energy, only a shortage of imagination and a loss of confidence in a nation's ability to innovate.

Understanding this perfectly well, the actual realists ignored the conventional wisdom. While Washington chose regulation, they embraced innovation.

Much of this innovation took place in DOE's national laboratories but it didn't end there. In states like Texas, where I served as governor, taxes were reduced and regulations kept simple and transparent, providing people both the incentive and the freedom to innovate.

THERE NEVER WAS A SHORTAGE OF ENERGY, ONLY A SHORTAGE OF IMAGINATION AND A LOSS OF CONFIDENCE IN A NATION'S ABILITY TO INNOVATE.

And with innovation came a revolution in technology.

The breakthroughs in hydraulic fracturing and horizontal drilling—leading to America's natural gas boom—began in Texas. And our national labs helped make not only this technology possible, but other technologies as well, achieving substantial gains that unleashed every energy source the United States had.

With science and technology leading the way, the U.S. made outstanding energy progress. From fossil fuels to renewables, supply rose, costs fell, efficiencies increased, and energy diversity expanded.

U.S. energy progress has been on vivid display in the arena of oil output. U.S. crude oil production rose from 5.5 million barrels per day (MMbbl/d) in 2010 to 9.3 MMbbl/d in 2017.

Progress in natural gas production has been no less remarkable. Production has risen from 58.4 billion cubic feet/day (Bcf/d) in 2010 to 73.6 Bcf/d in 2017.

The United States is now the number-one combined oil-and-gas producer in the world.

Technological advances are also driving renewables growth. Solar and wind energy costs have fallen, triggering increased electricity output from renewable sources. U.S. companies are actively selling solar and wind solutions in the global marketplace.

From refrigerators to LED lighting, technology is also raising energy efficiency.

And the same technology revolution that was producing energy more abundantly and efficiently and from a wider range of sources than previously thought possible was also making U.S. fuels cleaner.

From 2005 to 2017, while our economy grew, the United States led the world in reducing carbon emissions, cutting them by 14%. And from 1970 through 2016, while U.S. GDP grew by 253% and vehicle miles traveled rose by 190%, total air pollution from six common pollutants fell by 73%, while the U.S. coal fleet reduced emissions of nitrogen oxide, sulfur dioxide, and airborne particulates by as much as 93%.

NO COUNTRY SHOULD HAVE TO CHOOSE BETWEEN DEVELOPING ITS ENERGY AND ECONOMY AND CARING FOR ITS ENVIRONMENT. WHEN NATIONS EMBRACE INNOVATION OVER REGULATION, THEY CAN DO BOTH.

And what works for the United States can work for other nations as well. No country should have to choose between developing its energy and economy and caring for its environment. When nations embrace innovation over regulation, they can do both.

That is the heart of what we at DOE are calling The New Energy Realism. Through innovation, the U.S. is breaking through the self-imposed limits of the old energy pessimism.

Over the past year, the Trump Administration has brought this approach to Washington.

Today, Washington is advancing policies like tax and regulatory reform.

The President has approved new pipelines, removed draconian oil-and-gas restrictions on responsible exploration, and supported clean coal technologies. He has sought to reinvigorate civilian nuclear energy while supporting research and development efforts that enable renewables, storage and energy efficiency to remain critical elements of U.S. energy strategy.

As a result, "all-of-the-above" has moved from being a slogan to becoming a serious energy strategy for the United States.

The U.S. is on the verge of energy independence and is on track to become a net exporter of multiple energy sources and the technologies and know-how that produce these fuels.

Already, the U.S. has become a net exporter of natural gas. After spending billions to construct LNG import facilities to address a predicted domestic gas shortage, U.S. natural gas producers are now converting to export operations. Today, the United States is exporting LNG to 30 countries on five continents.

The United States is also increasing its coal exports substantially. These exports rose by an estimated 61% in 2017 over the previous year, according to the EIA. The United States is now exporting coal to countries around the world, from India to Brazil to the Netherlands, from South Korea to the Ukraine.

By exporting its energy, the U.S. is exporting freedom of choice and all that comes with it. The United States is helping empower its friends and allies, liberating them from dependence on nations that wield their energy resources as a political weapon.

THE CHOICE FOR EVERY NATION IS WHETHER TO REDUCE EMISSIONS BY STARVING ITSELF OF THESE INDISPENSABLE FUELS, OR BY MAKING THEM CLEANER.

And by exporting its energy technology and know-how, the United States can help developing countries in Latin America, Africa, and Asia break the bonds of poverty by harnessing more energy to improve people's lives.

There are some who, in the name of environmental protection, would rather the U.S. refrain from exporting this technology. They oppose production of fossil fuels, which comprise 80% of world energy usage and continue to produce carbon emissions. They support zero-emissions renewables alone.

But studies show that even by the year 2040, fossil fuels will comprise 77% of world energy use. Even if, as I believe, technology will make renewables competitive with other energy sources a lot sooner than we think, it might still take decades for renewables to reach critical mass of world energy use.

Given that reality, the choice for every nation is whether to reduce emissions by starving itself of these indispensable fuels, or by making them cleaner. It is ultimately the choice between regulation and innovation.

If the United States continues to pursue policies that are friendly to innovation, it will likely have a bright energy future. And to the extent that it exports this idea, along with its energy bounty and technical know-how, we can expect other nations will share in a more promising tomorrow.

I am hopeful that the U.S. and other nations will secure a great energy future by favoring innovation.

THE HONORABLE RICK PERRY
SECRETARY
U.S. DEPARTMENT OF ENERGY

HIGHLIGHTS

This fourth edition of the Global Energy Institute's (GEI) *International Index of Energy Security Risk* (International Index) provides an updated look at energy security risks across different countries for the years 1980 through 2016. The International Index is now published every two years, so this edition not only includes revised data but also adds new data for two years, 2015 and 2016, instead of just one. The risk index scores are calculated for the United States and 24 other countries that make up the Index's large energy user group: Australia, Brazil, Canada, China, Denmark, France, Germany, India, Indonesia, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Poland, Russian Federation, South Africa, South Korea, Spain, Thailand, Turkey, Ukraine, and the United Kingdom. The scores for these countries are reported in relation to an average reference index measuring risks for the Organization for Economic Co-operation and Development (OECD) member countries. The OECD average risk index is calibrated to a 1980 base year figure of 1,000.

As you view the results, keep in mind that because of data revisions, changes in methodology compelled by the unavailability of some data, changing databases, and other factors, that each edition of the International Index should be seen as a standalone document. While general trends should not change all that much from edition to edition, some specifics almost certainly will, making it difficult to compare risk scores, rankings, and other data from one edition of the index to another.

2016 ENERGY SECURITY RANKINGS

Table H-1 ranks the energy security scores of 25 large energy-consuming countries in 2016. This is a risk index, so keep in mind that the highest (best) rank has the lowest numerical risk score and the lowest (worst) rank the highest numerical risk score.

Top Five

Norway remains the most energy secure country in the large energy user group in 2016, a position it has held since it took over first place from the United Kingdom in 2006. Since 1980 Norway has never slid below third place. Its 2016 total risk score of 678 is 20% below the OECD average score of 846, and it scores 87 points better than second-place United States. Looking at the metrics individually, of the 20 "country-specific" metrics[1] used in the Index, Norway scores in the top five in 12 of them, with only three in the bottom five. With a total risk score of 765, the United States is ranked second for the second consecutive year, a remarkable rise up the table for a country that was ranked 11th in 2000. The United Kingdom is in third position with a risk score (769) just four points higher than the U.S. score. The United Kingdom's ranking has slipped over the years (from first place in 2005), and while its risk scores are still lower relative to the OECD average, they have been rising relative to that benchmark since about 2005. Mexico is a perennial presence in the top five, and its risk score of 788 is enough for a 2016 rank of four. Like the UK, however, its position vis-à-vis the OECD average has been deteriorating steadily, in this case since 1980. Denmark rounds out the top five with a score of 788, just fractionally higher than Mexico's score.

Bottom Five

Ukraine continues its unbroken record (since 1992) of the least energy secure country in the large energy user group. Its score of 1,842 is almost 300 points higher than the second worst score registered by Thailand. Ukraine's poor showing, however, belies significant gains the country has made compared to the OECD average—but it still has a long way to go.

1 Although the International Index uses 29 metrics, nine of them—Crude Oil Price and World Refinery Utilization Rate, to name two—are not country-specific but are proxies for global energy market risk. These global risks are the same for every country, so there is no country-to-country variation for these nine metrics—all countries are assigned the same scores for them. The scores for the 20 country-specific metrics reflect country-level conditions and can vary widely from country to country.

TABLE H-1

Energy Security Risk Scores and Rankings for 25 Large Energy Using Countries: 2016

COUNTRY	RISK SCORE	LARGE ENERGY USER GROUP RANK
Norway	678	1
United States	765	2
United Kingdom	769	3
Mexico	788	4
Denmark	788	5
New Zealand	802	6
Canada	842	7
OECD	846	
Australia	875	8
Germany	905	9
Poland	974	10
France	1,023	11
Russia	1,027	12
Netherlands	1,054	13
South Africa	1,066	14
China	1,079	15
Spain	1,096	16
Brazil	1,099	17
Italy	1,102	18
Indonesia	1,141	19
India	1,153	20
Japan	1,154	21
Turkey	1,198	22
South Korea	1,389	23
Thailand	1,556	24
Ukraine	1,842	25

Political turmoil in the country, however, could frustrate policies aimed at improving its energy situation. Thailand sits in the number 24 spot, a position it has been in since 2001, with a score of 1,556. Since 1990, the gap between the scores for that country and for the OECD have widened, keeping Thailand entrenched in the wrong end of the table. South Korea, with an index score of 1,389, and Turkey, with an index score of 1,198, come in 23rd and 22nd place, respectively. South Korea has never ranked higher than 21st place since 1980. Turkey was ranked as high as sixth in the early to mid- 1980s, but since then its scores have gotten relatively worse compared to the OECD baseline, and it has accordingly slid down the rankings. Japan comes in at number 21. It is no secret Japan has had to confront many energy challenges, and the 2011 Fukushima Daiichi nuclear incident has reversed the consistent gains relative to its peers Japan made from the late 1980s to 2010.

United States[2]

The United States reached its highest ranking yet—second—in 2015 and maintained that rank in 2016. America's total risk score of 765 is its second lowest on record—a single point higher than the record low recorded in 2015. The revolution in U.S. crude oil and natural gas production from shale formations continues to drive total U.S. energy risks downward, especially for those risks linked to imports. Much lower imports of crude oil and natural gas have lowered the share of total risk attributed to Fuel Import Exposure risks from about 12% in 2005 to just 2% in 2016. These trends in oil and gas production come on top of continuing improvements in energy use, power sector, and environmental metrics. From 2005 to 2016, the United States has seen its energy security risk relative to the OECD benchmark decline from 5% to -10%. Over the same period, its rank rose from nine to two. Of the 20 country-specific metrics, the U.S. ranks in the top five in five of them (related to import risks and energy expenditures and prices) and the bottom five in three of them (related to per capita energy use).

Movers

This edition of the International Index extends two years beyond the last report, which covered 1980 through 2014. Ten countries have lower risk scores in 2016 than they did in 2014 and 15 have higher scores. Only two countries saw their scores change appreciably over that period. Brazil's risk score in 2016 was 4.6% higher than in 2014 while India's was 5% lower. As a result, Brazil fell four places in the ranking from 2014 to 2016, from 13th to 17th. One the other hand, India's lower score meant it inched up the table two places to 20th, just out of the bottom five. Even though China had a smaller improvement in risk score, it climbed three places since 2014 to 15th in the table.

KEY DEVELOPMENTS

All countries benefited tremendously from a huge decline in crude oil volatility risk that occurred between 2011 and 2014. This trend reversed in 2015, however, as the price for a barrel of crude oil plunged by more than half in 2015, ending a trend of stable, if high, oil prices and leading to much greater volatility risk. From 2011 to 2014, the risk attached to crude oil price volatility declined 1,452 points (80%). From 2014 to 2016, the volatility risk score for this fuel rose 1,019 points (273%). The spike in volatility risk is attributable directly to the effort by Saudi Arabia to capture greater market share by increasing production sharply and driving down the price of crude oil from more than $100 per barrel to less than $50 per barrel in less than a year. After falling further to the mid-$20 range in early 2016, prices for most of the year fluctuated between $40 to $55 per barrel and averaged $43 per barrel over the entire year. Even though prices stabilized somewhat in 2016 compared to 2015 (due in

2 It should be emphasized that the index data presented here and the index data presented in GEI's *Index of U.S. Energy Security Risk* measure different things and are not strictly comparable, though the general trend is substantially the same. Moreover, the concern in this section is primarily with U.S. energy security risks in reference to those of the OECD average and other large energy users over time.

part to cuts in production in Organization of Petroleum Exporting Countries (OPEC), our volatility metric is based on a three-year running average of annual differences in average prices.

It is likely that over the next few years crude oil prices will settle within a range well below $100 per barrel. Saudi Arabia's motive was to drive U.S. crude oil producers out of business and force off the market as much U.S. production as possible, since U.S. production was depressing the global crude oil price. While this Saudi move affected some U.S. production—it fell about 550,000 barrels per day in 2016—and caused some consolidation in the industry, the ability of U.S. oil producers to adjust rapidly to new market conditions and innovate limited the damage and made the U.S. industry much more agile and resilient. Looking forward, it is difficult to say where prices, and therefore price volatility, will be headed. It is clear, however, that while Saudi Arabia's excess production capacity once made it the global "price maker," the ability of U.S. producers to respond rapidly to price increases and ramp up production almost instantly from large and growing inventories of untapped wells effectively makes the America the world's "price braker," able to apply the brakes to large crude oil price spikes.

The flip side of higher crude oil price volatility risk has been lower crude oil price risk. From 2014 to 2016, the average price of crude oil declined nearly 60%, providing the global economy a huge economic boost. U.S. production should help keep the lid on large price spikes for the foreseeable future. The Energy Information Administration's (EIA) *Annual Energy Outlook 2018* estimates that annual U.S. crude oil production will soon climb to between 11 and 12 million barrels per day and stay within this range out to 2050—a rate that is about 2 million barrels per day above the previous U.S. record of 9.6 million barrels per day set in 1970, an astonishing development (Figure H-1). This would make the United States the world's largest crude oil producer and a major exporter (EIA expects about 1.1 to 1.3 million barrels per day of exported U.S. crude oil over the period). As a result of greater U.S. output, EIA expects crude oil prices to increase at a much slower rate than it did in recent forecasts. Indeed, crude oil prices rise gradually in EIA's current projection and do not top the $100 per barrel mark until 2036. An analysis by the International Energy Agency (IEA) suggests even greater U.S. output. IEA's *Oil 2018* report estimates that over the next three years, growing U.S. output will cover 80% of the world's demand growth, with output from Canada, Brazil, and Norway covering the remainder. This would leave very little room for greater supply from OPEC, limiting its ability to send prices higher (though it could send them lower, but that would lead to economic and budgetary consequence many OPEC members would rather avoid).

Global crude oil production surged nearly 2.5 million barrels per day (bbl/d) from 2014 to 2016. This increase is a continuation of a seven-year trend, beginning in 2009, of rising global crude oil production that reached 7.7 million bbl/d in 2016, a 10% jump. The country showing the largest volumetric increase in production in 2016 versus 2009 was the United States at 3.5 million bbl/d, or 66%,[3] with "unconventional" sources primarily responsible for the jump. (This U.S. increase would have been higher had not Saudi Arabia intentionally flooded the market with crude oil in a push—largely unsuccessful as it turned out—to drive U.S. frackers out of business.) Saudi Arabia, Iraq, Canada, and Russia also show large increases (Table H-2). The increases from these countries and other countries were more than enough to offset sharply declining oil output from politically unstable countries (primarily Libya, down nearly 1.3 million bbl/d) and longer-term declining trends in output from the North Sea producers (primarily Norway and the United

3 Of the significant oil producers, only Iraq had a larger percent increase (86%) in output than the United States over this period.

TABLE H-2

Global Crude Oil Production: 2009-2016
(Thousand Barrels per Day)

COUNTRY	2009	2016	CHANGE	PERCENT CHANGE
Russia	9,495	10,551	1,056	11
Saudi Arabia	8,250	10,461	2,211	27
United States	5,349	8,857	3,508	66
Iraq	2,391	4,452	2,061	86
Iran	4,037	4,068	31	1
China	3,796	3,981	185	5
Canada	2,579	3,679	1,100	43
United Arab Emirates	2,413	3,106	694	29
Kuwait	2,350	2,924	574	24
Brazil	1,950	2,515	565	29
Venezuela	2,520	2,277	-243	-10
Mexico	2,646	2,187	-459	-17
Nigeria	2,208	1,871	-337	-15
Angola	1,877	1,770	-107	-6
Norway	2,067	1,648	-419	-20
Kazakhstan	1,455	1,595	140	10
Qatar	1,279	1,523	244	19
Algeria	1,585	1,348	-237	-15
Oman	813	1,007	194	24
United Kingdom	1,328	933	-395	-30
Colombia	671	886	215	32
Azerbaijan	1,006	834	-172	-17
Indonesia	949	832	-117	-12
India	680	735	54	8
Libya	1,650	385	-1,265	-77
Other	7,587	6,109	-1,478	-19
World Total	72,930	80,531	7,601	10

Source: Energy Information Administration

Kingdom), and Mexico. It is also anticipated that unrest in Venezuela will push production from that country much lower for the next couple of years at least and maybe for an extended period.

On average the three largest sources of *weighted* risk in 2016 for the large energy user group are related to energy intensity, natural gas imports, and crude oil price volatility. Energy intensity was by far the largest source of weighted risk, on average, in 1980, and despite the largest point drop of any metric since then, it still remains the highest source of risk in 2016. Energy intensity measures the amount of energy needed to produce a unit of GDP. Countries that use energy more efficiently are better able to weather energy price shocks, for instance, than countries that use more energy per unit of economic output. It can be a moderating force when low or an enhancing one when high.

Energy intensity can be improved through: (1) greater energy efficiency; and (2) relative shifts in economic activity from more to less energy intensive activities (*e.g.,* from industrial to service activities). Historical data suggest, in general, that as incomes rise, so do the resources available for investment in new, more efficient technologies, and there also is a shift to less energy-intensive economic activity. The result is that energy intensity tends to rise as countries develop before peaking and then declining. Although the developed countries in the large energy user group continue to see declines, often very large declines, in energy intensity, the economies in transition and the emerging economies show greater variation. All but four countries—Brazil, Indonesia, Thailand, and Turkey—have seen their Energy Intensity scores decline since 1980 (or 1992). Of particular note is that the three former communist countries—Poland, Russia, and Ukraine—and China, a communist country that has instituted market reforms, have shown the greatest improvement since 1980. This rapid improvement can be attributed largely to the emergence of market pressures after the Soviet Union and the institution of market reforms, pressures that have led to greater efficiency and the closure of obsolete industrial facilities.

Natural gas import exposure risk scores have increased for most of the countries in the large energy user group. There are two reasons for this. The first concerns the global natural gas market. While it is true that increases in natural gas supplies and supply diversity—there are now 26 countries producing at least 1 quadrillion British thermal units (Btus) of gas in 2016 versus nine in 1990—have moderated market risks, these benefits have been more than offset by higher risks accompanying rising production from countries with high risk profiles, such as Russia, Iran, Qatar, and Algeria. The second concerns rising demand for natural gas that must be met by imports. These demand increases can stem from greater economic growth in developing countries, environmental policies that favor natural gas over coal, or, in the case of Japan, a nuclear accident that compels greater electricity generation from gas (and coal) plants. Combined with higher market risk, these demand-side factors have caused Natural Gas Import Exposure risks for most of the large energy user group countries to increase—with the United States being the most obvious exception. Once forecasted to be a large natural gas importer, the U.S. is now poised to become a net natural gas exporter, which should not only improve the reliability of global supplies but also the diversity of supplies. (Many countries also have seen their risks related to coal imports increase, and for many of the same reason as for Natural Gas Import Exposure. Developing countries, in particular, have increased their demand for coal imports significantly as they work to increase access to electricity of their populations.)

The wide divergence in retail electricity prices reported in the previous report is still evident in this 2018 edition. As in the last report, those countries with the highest electricity rates (based on prices in the industrial and residential sectors), tend to cluster in Western Europe. Seven of the bottom 10 countries for this metric in the large energy user group are located

FIGURE H-1

Electricity Prices for Households: 2016

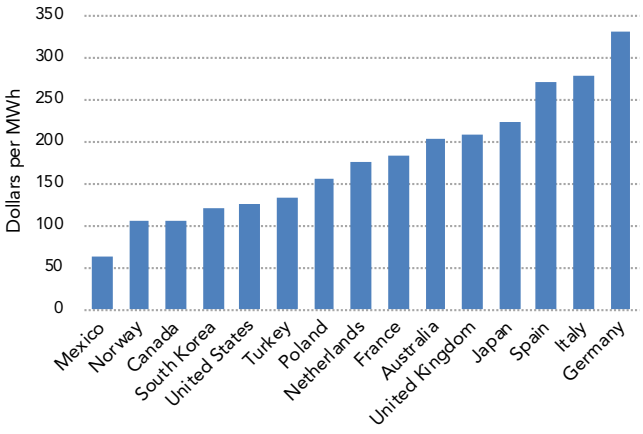
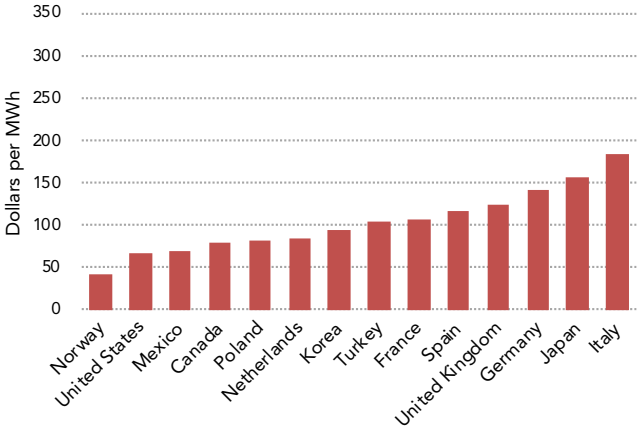


FIGURE H-2

Electricity Prices for Industry: 2016



Source: International Energy Agency, Key World Energy Statistics 2016.

in Western Europe. The only European country in the top 10 (at number 10) is Norway. The use of affordable coal for power production in North America, Australia, and Asia, plus cheap natural gas in the North America, has kept electricity prices comparatively low in these regions. Large-scale hydropower in Canada and Norway also has contributed to lower electricity prices in those countries.

Electricity prices are on the rise in most OECD countries. Electricity prices in South Korea, Germany, Italy, New Zealand, the United Kingdom, Canada, and France have all increased more than 10% since 2010. Only four OECD countries have seen their average electricity price decline since 2010: Norway, Poland, Turkey, and the United States. The divergence in electricity prices has increased in recent years and is creating competitive pressures on energy-intensive, trade-exposed industries in OECD countries. Figures H-1 and H-2 show the large divergence in energy prices for selected OECD countries that are in the large energy user group.

Environmental metrics tend to be something of a mixed bag. All but four countries have higher emissions than in 1980, but developed-country emissions in particular have decreased over the past 15 to 20 years. Developed countries carbon dioxide emissions per capita also have trended lower for decades. Carbon dioxide emissions intensity has improved for all countries except Thailand, which has much higher intensity scores than it did in 1980. It is too early to see the impacts, if any, of the Paris Agreement on climate change in the data for 2016. For most countries in the large energy user group declining emissions intensity has been driven mostly by greater economic efficiency, and we expect that to be the dominant pattern for the next decade or so. The adoption of low-emitting energy technologies in developed countries renewables, especially in the power sector, means decarbonization of the energy supply will be an increasing factor in lower emissions intensity in those countries. Data from Platt's World Electric Power Plants database, IEA, EIA, and others show that in developing countries, however, coal-fired electricity generation will continue to be built at a fast

pace, which will put upward pressure on emissions intensity. Although the build-out of coal-fired power generation capacity is slowing in China, it is increasing in places like India, Southeast Asia, South Africa, and Turkey. It is also possible growing energy use in developing countries could stall further drops in Emissions per Capita, at least for a while. How these trends actually develop will be contingent on how the Paris Agreement and the pledges made under it are implemented by the Parties.

HISTORICAL TRENDS IN INTERNATIONAL ENERGY SECURITY RISKS: 1980-2016

Figure H-3 shows the trends in total energy security risk scores for the large energy user group and the OECD average from 1980 to 2016. In general, risk scores for these countries were high at the beginning of the period, were comparatively low in the middle part of the period, rose from late 1990s to about 2011, and declined thereafter. Naturally, the trends for individual countries have varied widely. Of the 23 countries in the large energy user group in existence since 1980, seven have higher total energy security risks in 2016 than they did in 1980, which was a year of extraordinarily high risk connected to the Iran hostage crisis. Sixteen countries have 2016 risk scores lower than their 1980 baseline risk scores.[4] (Russia and Ukraine's total scores in 2016 also are lower than their beginning scores in 1992.) Turkey's 2016 score is 31% higher than its 1980 score, the worst performer of the group. China's 2016 score was 51% lower than its 1980 score, making it the best over performer by this standard. The 2016 score for the United States is 29% lower than in 1980.

The decade of the 1990s generally was the best for energy security risks. Of the 23 countries in the large energy user group in existence in 1980, 13 had their best risk score somewhere between 1990 and 1999 (there were eight lowest risk scores in 1998 alone). The United States had its lowest score in 2015. The highest scores tend to be clustered in two years: 1980, a year in which seven countries (including the United States) had their highest risk scores; and 2011, a year in which 14 countries had their highest scores.

The range of risk scores from highest to lowest among the 23 countries in the large energy user group (excluding Russia and Ukraine which only entered the database in 1992) narrowed from 1980 to the early 1990s and has increased since then. Table H-3 shows the remarkable decline in total risk scores for China from 1980 to 2000, which tends to exaggerate both the spread of scores in 1980 and the decline in that spread in the early 1990s. With China included, the recent range of risk scores among the 23 countries in the large energy user group is still smaller than in 1980 despite an increasing trend over the last 25 years. If China is removed from consideration, however, there has been greater variability in risk scores over the past decade than in 1980. The data suggest this growing spread has more to do with risk scores for more countries getting higher over time rather than getting lower.

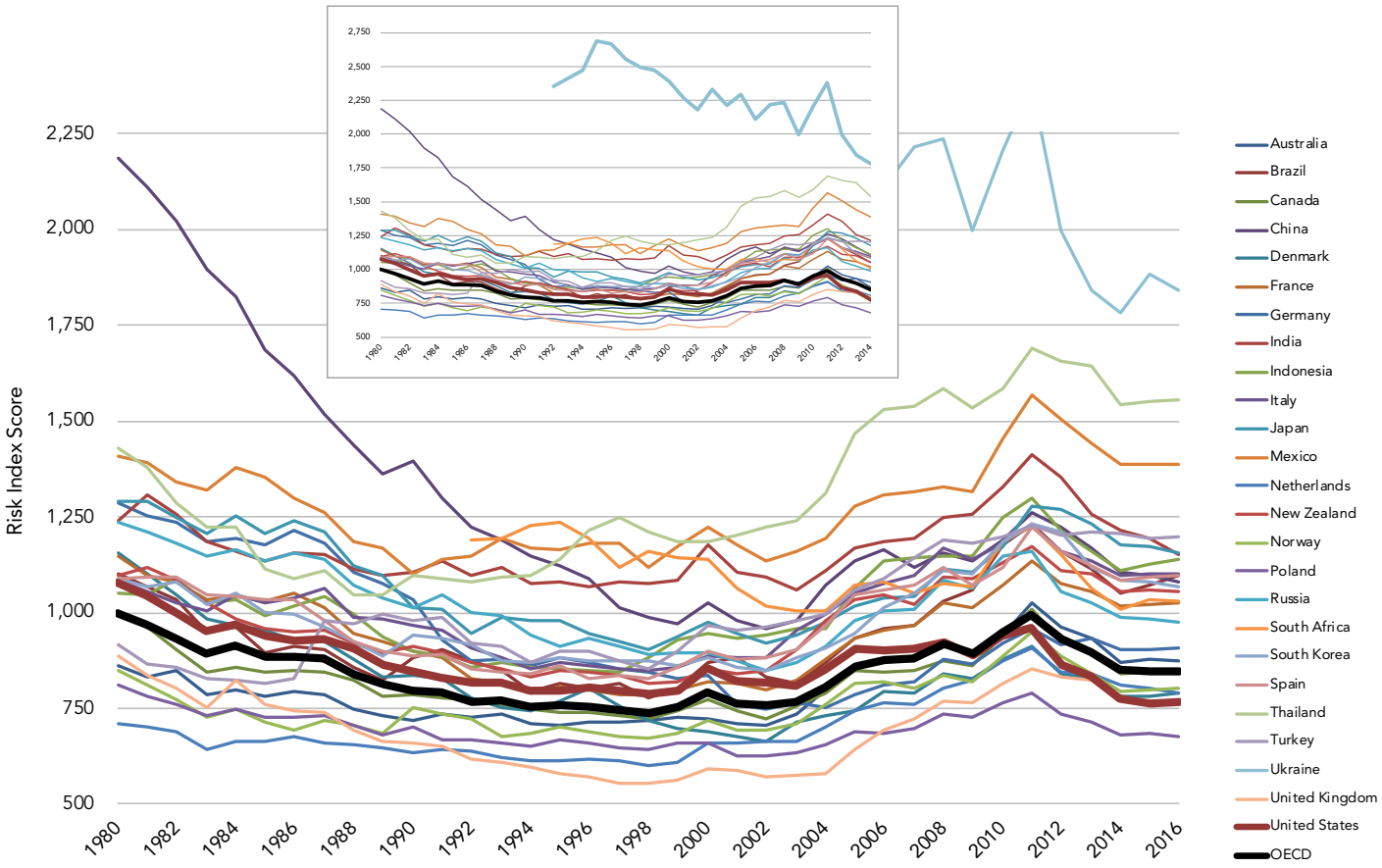
There is considerable movement of countries up and down the rankings based on many factors, some of which are out of the control of the countries being impacted. Table H-3 shows how countries have ranked since 1980. Each country moves up and down the ranking based on two factors: (1) how much its energy security risk scores move up and down over time; and (2) how these changes compare to changes being made in other countries. Even if a country improves its energy security, it can still move down the ranking if those countries close to it in the rankings improve their scores by an even greater amount.

Risk scores, in turn, are driven by four factors: (1) global factors that affect all countries and are largely immune to policy; (2) country-specific factors such as resource base, stage of economic development, population density, climate, and others; (3) technology innovation and adoption; and (4) energy policies.

4 Though Brazil's 2016 score is essentially equal to its 1980 score.

FIGURE H-3

Energy Security Risk Index Scores for Large Energy User Group: 1980-2016



Norway and the United Kingdom have consistently had at least a top five ranking for the entire period since 1980, and Mexico only fell out of the top five in 2014 and 2015 (it was sixth in both years). Denmark has improved its rankings greatly and has been fifth or higher since 1998. The United States is another country that has improved and since 2012 has consistently been in the top five. Once a perennial in the top five, Australia now occupies between sixth and 10th place. New Zealand has hovered just outside the top five since 2009, when it was ranked third. At the other end of the table, Ukraine, South Korea, and Thailand consistently have been ranked among the bottom five. China also was stuck in the bottom five for the decade after 1980, but it has since climbed to a mid-table ranking. Perhaps no country, however, has moved as rapidly up the table as the United States, which jumped five spots in five years and now stands at number two. The United States surge up the rankings is a good example of how technology innovation and adoption—in this case hydraulic fracturing, horizontal drilling, and advanced seismic imaging—have changed energy security for the better.

TABLE H-3

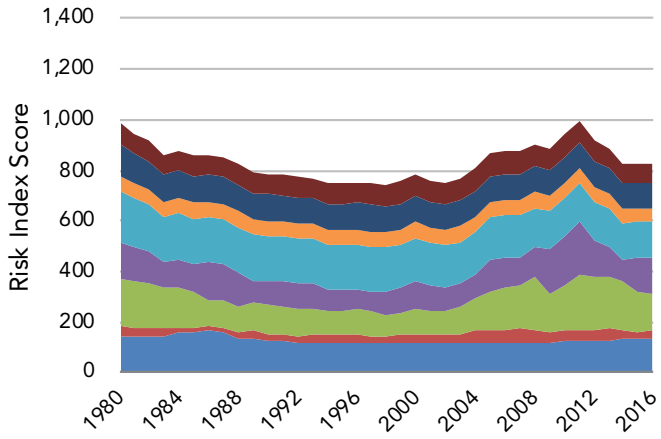
Energy Security Rankings for Large Energy User Group: 1980-2016

COUNTRY	1980	1985	1990	1995	2000	2005	2010	2014	2015	2016
Australia	4	5	4	5	6	8	9	8	8	8
Brazil	14	8	9	10	12	10	15	13	14	17
Canada	7	7	6	6	7	7	8	7	7	7
China	23	23	23	21	20	21	19	18	17	15
Denmark	16	10	7	7	4	4	4	4	4	5
France	15	15	11	9	8	11	10	12	11	11
Germany	19	20	19	16	9	5	6	9	9	9
India	18	18	22	20	22	22	22	22	22	20
Indonesia	8	12	12	12	17	19	21	19	19	19
Italy	10	14	15	14	14	17	16	17	18	18
Japan	20	21	18	19	19	14	14	20	20	21
Mexico	1	1	1	2	3	3	3	6	6	4
Netherlands	13	11	13	11	10	15	12	14	13	13
New Zealand	3	2	5	4	5	6	5	5	5	6
Norway	2	3	3	3	2	2	1	1	1	1
Poland	17	19	17	18	15	13	13	10	10	10
Russia	–	–	–	24	21	20	18	11	12	12
South Africa	11	13	14	15	13	12	17	15	15	14
South Korea	21	22	21	23	24	23	23	23	23	23
Spain	12	16	10	13	16	16	11	16	16	16
Thailand	22	17	20	22	23	24	24	24	24	24
Turkey	6	6	16	17	18	18	20	21	21	22
Ukraine	–	–	–	25	25	25	25	25	25	25
United Kingdom	5	4	2	1	1	1	2	2	3	3
United States	9	9	8	8	11	9	7	3	2	2

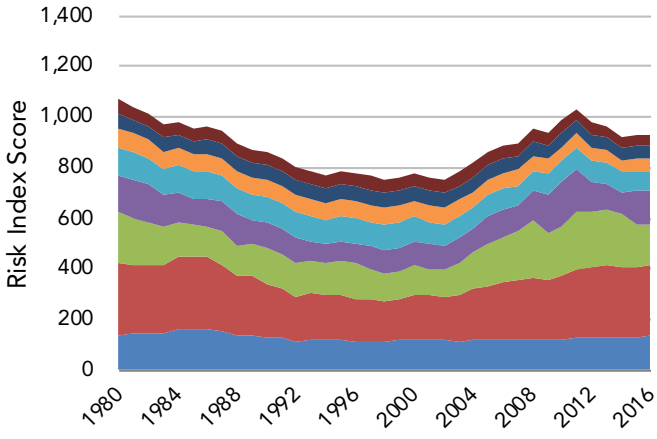
FIGURES H-4, H-5, H-6

Weighted Risk Scores by Metric Group

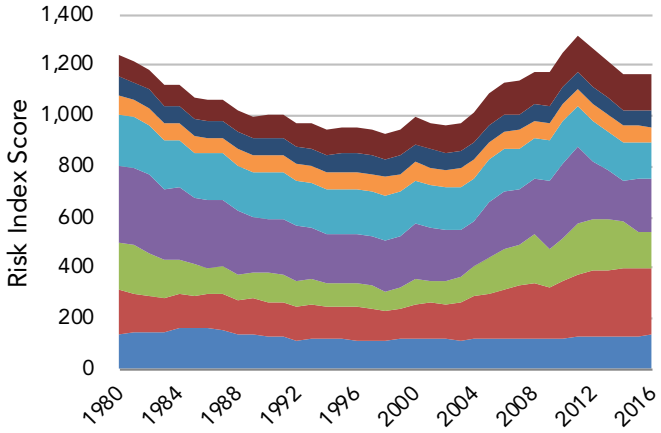
H-4: Australia, Canada & U.S. Average

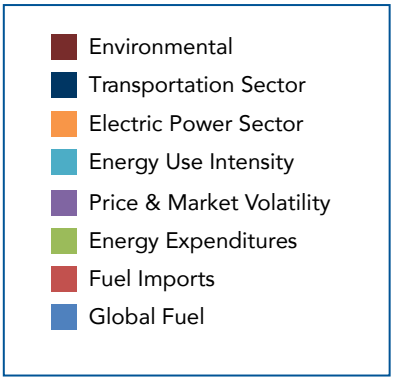


H-5: Western Europe Average



H-6: Developing Countries Average





The sources of risk can vary considerably over time because of changing economic and other circumstances. A new feature of the 2018 edition of the International Index are charts showing how much the eight metric groups contribute to each country's total score over time, both nominally and as a share of the total score. These have been added to each of the country pages that appear later in the report. Here, some similar countries are grouped together to make larger points about the energy security challenges countries face.

Figures H-4, H-5, and H-6 show the average nominal contribution from 1980 to 2016 for each metric group for three groups of countries with similar attributes from the large energy user group: (1) Australia, Canada, and the United States; (2) Western Europe; and (3) Developing Countries. These metric groups include Global Fuels, Fuel Imports, Energy Expenditures, Price & Market Volatility, Energy Use Intensity, Electric Power Sector, Transportation Sector, and Environmental. Note that each chart is scaled to 1,400 points to make them comparable.

The Australia-Canada-U.S. group consistently has the lowest average risk scores of the three groups. Because these are all large energy producing countries, it is not surprising that the scores for the combined Fuel Imports metric group are a much smaller aspect of overall risk than in the Western Europe or Developing Country groups. The Fuel Imports Exposure risk combined score for the Australia-Canada-U.S. group averaged just 35 points from 1980 to 2016 compared to 228 for the Western Europe group and 168 for the Developing Country group. This is obviously a big security advantage for these three countries. (It should be pointed out that not all countries in the Western Europe group have large import risks (*e.g.,* Norway and the United Kingdom).) Higher energy costs in Western Europe also mean these three countries on average have lower risks related to Energy Expenditures.

Western Europe, however, has much lower combined scores in Energy Use Intensity, Transportation, and Environmental metric categories compared to the other two groups. So what Western Europe lacks in energy resources, it generally makes up for in greater efficiency stimulated by higher taxes and other fees and regulations on energy use.

It should come as no surprise that developing countries have generally higher levels of energy security risk than developed countries—with some exceptions, to be sure—and risks associated with imports explain a large portion of the difference. As Figure H-6 illustrates, the average Developing Country tends to display the worst aspects of the two developed country groups. Combined Fuel Import risk scores, for example, have increased since roughly 2005 as these countries have developed economically and increased their demand for imported energy. The recent scores for Fuel Imports metric group for the Developing Country group are in the ballpark with those of Western Europe. The scores for the Energy Use Intensity metric category for the Developing Country group also are quite high and are comparable to those from the Australia-Canada-U.S. group. Environmental metric scores also are much higher than those in either of the developing countries groups. We also probably should expect risks associated with Transportation to increase as the growing middle classes in these countries begin to purchase more and more automobiles.

No country scores well or poorly in every category. Even countries that have very low overall risk scores can face sometimes significant energy security challenges. Of the 29 metrics used in the International Index, nine are "global" metrics that apply equally to every country (*e.g.,* the price of crude oil) and 20 are "country-specific." Scores for these 20 metrics for 2016 were ranked (Table H-4). The table shows than even a country the top-ranked country, Norway, with 12 of 20 metric scores ranked in the top five, also has three metric scores ranked in the bottom five (one of which has the lowest ranking—electricity capacity diversity). Third place United Kingdom has 10 metric scores in the top five and none in the bottom five. Even though it is ranked second, the United States has just five individual metric scores in the top five and three in the bottom five. It also, however, has six top-10 scores, and the metrics it does score well in tend to have higher weightings, that is, have greater importance, and therefore influence, on overall index scores. At the other end of the table, the last three ranked countries—South Korea, Thailand, and Ukraine—have nine, 11, and eight metric scores, respectively, in the bottom five, and only Ukraine has any in the top five (two).

On average, the five top ranking countries in 2016 for overall energy security have 7.8 individual metrics scores ranked in the top five and 1.6 metrics scores ranked in the bottom five. The five countries with the worst overall scores in 2016 had an average of only 1.4 metric scores ranked in the top five and 7.4 metric scores ranked in the bottom five. The other 15 countries in the middle averaged 4.1 metric risk scores in the top five and 3.7 in the bottom five. (The number of metrics in the top and bottom five for each country can be found in the Energy Security Profiles.)

TABLE H-4

Energy Security Metric Rankings for Large Energy User Group: 2016

Fuel Import Metrics				
Petroleum Import Exposure	**Natural Gas Import Exposure**	**Coal Import Exposure**	**Total Energy Import Exposure**	**Fossil Fuel Import Expenditures per GDP**
1. (tied) Canada	1. (tied) Australia	1. (tied) Australia	1. (tied) Canada	1. (tied) Canada
1. (tied) Mexico	1. (tied) Canada	1. (tied) Canada	1. (tied) Norway	1. (tied) Norway
1. (tied) Norway	1. (tied) Denmark	1. (tied) India	1. (tied) Russia	1. (tied) Russia
1. (tied) Russia	1. (tied) Indonesia	1. (tied) Indonesia	4. United States	4. Denmark
5. Brazil	1. (tied) Netherlands	1. (tied) New Zealand	5. Mexico	5. United Kingdom
6. Denmark	1. (tied) New Zealand	1. (tied) Norway	6. Brazil	6. United States
7. United States	1. (tied) Norway	1. (tied) Russia	7. Denmark	7. Mexico
8. United Kingdom	1. (tied) Russia	1. (tied) South Africa	8. China	8. Germany
9. Indonesia	1. (tied) United States	1. (tied) United States	9. United Kingdom	9. Brazil
10. China	10. Thailand	10. China	10. South Africa	10. New Zealand
11. Thailand	11. Mexico	11. Poland	11. Australia	11. Australia
12. Australia	12. China	12. Mexico	12. New Zealand	12. France
13. Germany	13. United Kingdom	13. Germany	13. Germany	13. Italy
14. New Zealand	14. India	14. Turkey	14. India	14. Netherlands
15. India	15. Brazil	15. Ukraine	15. Indonesia	15. Japan
16. Ukraine	16. Ukraine	16. Thailand	16. Poland	16. Spain
17. South Africa	17. Poland	17. United Kingdom	17. Ukraine	17. China
18. Italy	18. South Africa	18. Spain	18. France	18. Poland
19. Turkey	19. Italy	19. Brazil	19. Thailand	19. Turkey
20. Poland	20. Germany	20. South Korea	20. Netherlands	20. India
21. Netherlands	21. Japan	21. Italy	21. Spain	21. South Africa
22. South Korea	22. Turkey	22. Denmark	22. Italy	22. Indonesia
23. France	23. South Korea	22. France	23. Turkey	23. South Korea
24. Spain	24. Spain	22. Japan	24. South Korea	24. Thailand
25. Japan	25. France	22. Netherlands	25. Japan	25. Ukraine

TABLE H-4 (CONTINUED)

Energy Security Metric Rankings for Large Energy User Group: 2016

Energy Expenditure Metrics			Price & Market Volatility Metrics	
Energy Expenditure Intensity	**Energy Expenditures Per Capita**	**Retail Electricity Prices**	**Energy Expenditure Volatility**	**GDP Per Capita**
1. United Kingdom	1. India	1. South Africa	1. United Kingdom	1. Norway
2. Germany	2. Indonesia	2. India	2. Germany	2. Denmark
3. Norway	3. China	3. China	3. Norway	3. United States
4. France	4. South Africa	4. Russia	4. South Africa	4. Netherlands
5. United States	5. United Kingdom	5. Indonesia	5. Japan	5. United Kingdom
6. Denmark	6. Mexico	6. South Korea	6. France	6. Germany
7. Spain	7. Ukraine	7. United States	7. United States	7. Australia
8. Italy	8. Germany	8. Thailand	8. Russia	8. Canada
9. Mexico	9. Poland	9. Canada	9. Italy	9. Japan
10. Australia	10. Turkey	10. Norway	10. Denmark	10. France
11. Japan	11. Russia	11. Mexico	11. New Zealand	11. New Zealand
12. Poland	12. Brazil	12. Australia	12. Spain	12. Italy
13. New Zealand	13. Thailand	13. New Zealand	13. Mexico	13. Spain
14. South Africa	14. Spain	14. Ukraine	14. Canada	14. South Korea
15. Canada	15. France	15. Poland	15. Australia	15. Poland
16. China	16. Italy	16. Brazil	16. Brazil	16. Turkey
17. Netherlands	17. United States	17. France	17. Indonesia	17. Mexico
18. Turkey	18. New Zealand	18. Turkey	18. Poland	18. Russia
19. India	19. Denmark	19. Netherlands	19. Netherlands	19. South Africa
20. Indonesia	20. Norway	20. United Kingdom	20. Turkey	20. Brazil
21. South Korea	21. Australia	21. Japan	21. Thailand	21. China
22. Russia	22. Japan	22. Spain	22. China	22. Thailand
23. Brazil	23. Canada	23. Denmark	23. India	23. Indonesia
24. Thailand	24. South Korea	24. Germany	24. South Korea	24. Ukraine
25. Ukraine	25. Netherlands	25. Italy	25. Ukraine	25. India

TABLE H-4 (CONTINUED)

Energy Security Metric Rankings for Large Energy User Group: 2016

Energy Use Intensity Metrics			Electric Power Sector Metrics	
Energy Consumption Per Capita	**Energy Intensity**	**Petroleum Intensity**	**Electricity Capacity Diversity**	**Non Carbon Generation**
1. India	1. Denmark	1. Germany	1. Spain	1. Norway
2. Indonesia	2. United Kingdom	1. United Kingdom	2. New Zealand	2. France
3. Brazil	3. Italy	3. Denmark	3. Canada	3. Canada
4. Mexico	4. Japan	4. Norway	4. Germany	4. New Zealand
5. Turkey	5. Germany	5. Italy	5. Italy	5. Brazil
6. Thailand	6. France	6. France	6. United Kingdom	6. Spain
7. China	7. Spain	7. Japan	7. Brazil	7. Denmark
8. South Africa	8. Norway	8. Spain	8. Ukraine	8. Ukraine
9. Ukraine	9. Netherlands	9. Turkey	9. Turkey	9. Italy
10. Poland	10. New Zealand	10. New Zealand	10. France	10. Germany
11. Italy	11. Australia	11. Poland	11. United States	11. United Kingdom
12. Spain	12. United States	12. United States	12. China	12. Russia
13. United Kingdom	13. Mexico	13. Australia	13. Russia	13. United States
14. Denmark	14. Turkey	14. Netherlands	14. Denmark	14. South Korea
15. Japan	15. South Korea	15. Canada	15. South Korea	15. China
16. France	16. Poland	16. Mexico	16. Japan	16. Turkey
17. Germany	17. Canada	17. South Korea	17. India	17. Mexico
18. New Zealand	18. Brazil	18. China	18. Mexico	18. India
19. Russia	19. India	19. South Africa	19. Australia	19. Netherlands
20. South Korea	20. Indonesia	20. India	20. Netherlands	20. Australia
21. Netherlands	21. South Africa	21. Brazil	21. Poland	21. Japan
22. Australia	22. Thailand	22. Ukraine	22. Thailand	22. Poland
23. United States	23. China	23. Russia	23. Indonesia	23. Thailand
24. Norway	24. Russia	24. Indonesia	24. South Africa	24. South Africa
25. Canada	25. Ukraine	25. Thailand	25. Norway	25. Indonesia

TABLE H-4 (CONTINUED)

Energy Security Metric Rankings for Large Energy User Group: 2016

Transportation Sector Metrics		Environmental Metrics		
Transport Energy Per Capita	**Transport Energy Intensity**	**CO_2 Emissions**	**CO_2 Per Capita**	**CO_2 GDP Intensity**
1. India	1. Japan	1. Denmark	1. India	1. Denmark
2. Ukraine	2. Norway	2. France	2. Indonesia	2. Norway
3. Indonesia	3. Netherlands	3. United Kingdom	3. Brazil	3. France
4. China	4. United Kingdom	4. Poland	4. Ukraine	4. United Kingdom
5. Turkey	5. Denmark	5. Italy	5. Mexico	5. Italy
6. South Africa	6. Germany	6. United States	6. Turkey	6. Germany
7. Thailand	7. Italy	7. Netherlands	7. Thailand	7. Japan
8. Mexico	8. France	8. Japan	8. France	8. Spain
9. Poland	9. South Korea	9. Germany	9. Denmark	9. New Zealand
10. Brazil	10. Spain	9. Russia	10. Italy	10. Netherlands
11. Russia	11. Turkey	9. Ukraine	11. Spain	11. United States
12. Japan	12. Poland	12. Norway	12. China	12. Australia
13. Italy	13. Australia	13. Spain	13. United Kingdom	13. Mexico
14. South Korea	14. New Zealand	14. Canada	14. South Africa	14. Canada
15. Spain	15. United States	15. South Africa	15. Poland	15. Turkey
16. Netherlands	16. Mexico	16. Mexico	16. Norway	16. Brazil
17. United Kingdom	17. Canada	17. Australia	17. New Zealand	17. South Korea
18. France	18. China	18. New Zealand	18. Japan	18. Poland
19. Germany	19. India	19. Brazil	19. Germany	19. Indonesia
20. Denmark	20. South Africa	20. Turkey	20. Russia	20. India
21. Norway	21. Russia	21. South Korea	21. South Korea	21. South Africa
22. New Zealand	22. Brazil	22. China	22. Netherlands	22. Thailand
23. Australia	23. Ukraine	23. Indonesia	23. Australia	23. China
24. Canada	24. Thailand	24. India	24. United States	24. Ukraine
25. United States	25. Indonesia	25. Thailand	25. Canada	25. Russia

LARGE ENERGY USER GROUP ENERGY SECURITY PROFILES

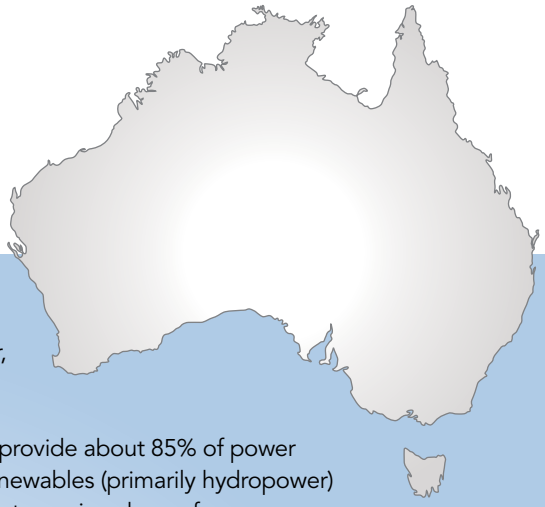
The summaries that follow provide brief snapshots of the energy security risks for each country in the large energy user group, including a description of how it compares to the OECD average and those factors that have had the greatest impact, both positively and negatively, on their energy security. The countries are listed in alphabetical order.

Included in each summary are:

- A table showing current year and previous year total risk scores and those years with historically high and low risk scores both absolutely and relative to the OECD baseline average. (More detailed data on the energy security risk scores for each country are presented in Appendix 3.)
- A line chart showing trends in the country's risk ranking since 1980.
- A line chart showing the country's energy security risk trend and the OECD average trend since 1980.
- A line chart showing the country's risk trend relative to the OECD average (measured as percent variance) since 1980. This provides an indication of progress or deterioration in energy security risks compared to an international baseline
- Two area charts showing the weighted contribution of the eight metric groups since 1980. One shows the absolute contribution of each metric group to the total risk score and the other shows the relative contribution, as a percent, of each metric group to the total risk score.
- A table showing by metric grouping how the countries risk scores fare against the comparable OECD averages in five-year increments plus the most recent year of data. Cells highlighted in green indicate country risk scores at least 10% lower (better) than the comparable OECD scores while cells highlighted in red indicate country risk scores at least 10% higher (worse) than the comparable OECD scores. Cells with no highlighting indicate risk scores within 10% either way of the comparable OECD average. These tables provide an "at-a-glance" indication of how the country's metric groups have performed over time vis-à-vis the OECD average, with those cells in green performing considerably better and those in red performing considerably worse.

As a word of caution, because the data for many countries are not as robust or as detailed as U.S. data, readers should place less emphasis on precise values or changes in metrics from one year to the next and more emphasis on broader trends within and across countries is more suited to the available data.

AUSTRALIA



Australia's overall energy security risk score for 2016 was 875, good enough for a ranking of eighth, the same position it has held since 2014. Australia has consistently ranked in the top 10, but since 1998 it has not been in the top five. Of the 20 country-specific metrics used in the International Index, Australia ranks in the top five for two of them and in the bottom five for four of them.

Australia is rich in coal and natural gas resources, and it exports large quantities of these fuels, primarily to Asia. It is the world's largest exporter of coal and second largest exporter of liquefied natural gas (LNG). The country also has a large amount of coal bed methane. It is, however, a net oil importer, and since around 2000, Fuel Import Exposure risks have emerged as a growing share of Australia's total risk score.

Compared to the OECD benchmark, Australia has been losing ground for a number of years. Its overall energy security risk score was once well below the OECD's (between 10% and 15% lower), but it has been losing ground steadily since 1980 and its 2016 score was 3% higher. Energy Use Intensity and Environmental metrics in Australia have not improved as much compared to the average OECD, and its Fuel Import metrics also have trended higher since 2000, reflecting rising oil imports.

Australia's economy is relatively energy intensive, with mining being a major contributor, and its energy use per capita scores are quite high (only the United States, Norway, and Canada have higher per capita scores). Its transportation energy use per capita and carbon dioxide emissions per capita also are very high (it ranks 23rd for both of those metrics).

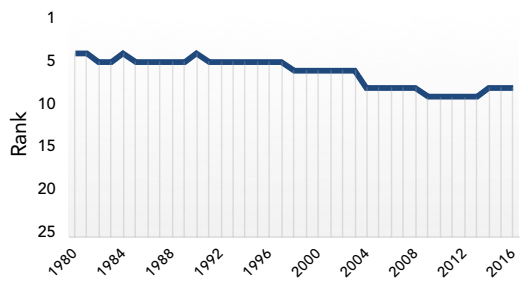
In the power sector, coal and natural gas are the main fuels and together provide about 85% of power generation, with renewables (primarily hydropower) providing a small but growing share of power generation. A prohibition on nuclear power means it plays no role at all, despite Australia possessing large uranium resources (which it exports). This large dependence on just two fuels for the lion's share of its power generation contributes to Australia's relatively poor showing in the metric measuring electric power sector diversity (it ranked 19th in 2016). Because low-cost coal is the dominant fuel used in power production, supplying about 60% to 65% of all power, Australia enjoys relatively low electricity prices (though these are increasing).

Wind and solar have grown rapidly and now account for about 8% of electricity generation, with hydropower at about 5%. In 2009, Australia set a goal to produce 20% of the country's electricity production with renewables by 2020. The growth of renewables has not been without some controversy. In 2016, there was a massive weather-related blackout in South Australia, a state with a renewable-heavy power mix. The Australian Energy Market Operator concluded that wind farms were a key factor, finding that control settings on wind farm turbines led to statewide blackout. A reduction in wind farm output caused a very large and rapid demand for imported power flowing through a single interconnector, which caused it to trip. As intermittent renewables become a bigger part of electricity output, similar sorts of risks may arise in others countries.

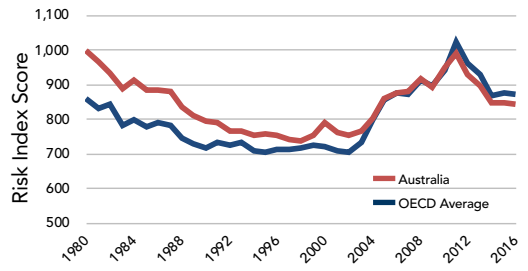
Energy Security Risk Summary: Australia

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	875	Average Annual Difference 1980-2016	-5%
2016 Large Energy User Group Rank	8	Best Relative Score	-14% (1981)
Score in Year	878	Worst Relative Score	4% (2013)
Rank in Previous Year	8	**Country-Specific Metric Ranking—2016:**	
Score in 1980	862		
Average Score: 1980-2016	804	Number in Top Five	2
Best Energy Security Risk Score	706 (1995)		
Worst Energy Security Risk Score	1,024 (2011)	Number in Bottom Five	4

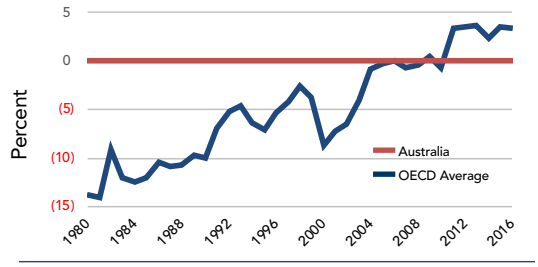
Australia: Risk Ranking



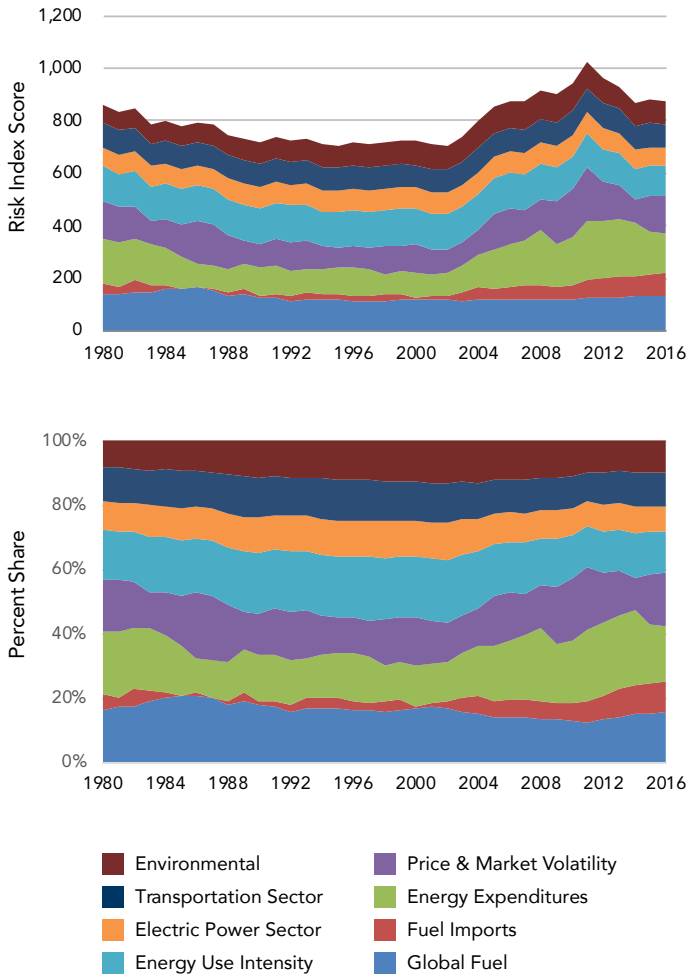
Australia vs. OECD: Risk Index Scores



Australia: Risk Variance from OECD



Australia: Risk Scores by Metric Group and Share of Total Risk by Metric Group



Australia vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-75	-100	-93	-85	-98	-75	-74	-52	-50
Energy Expenditure Metrics	-16	-15	-18	-10	-10	5	7	12	12
Price & Market Volatility Metrics	-6	11	-4	1	3	13	2	4	4
Energy Use Intensity Metrics	-4	10	14	12	18	33	25	22	21
Electric Power Sector Metrics	6	23	30	33	33	32	38	30	31
Transportation Sector Metrics	31	38	38	26	23	26	40	46	44
Environmental Metrics	17	34	45	33	42	58	68	53	54
Total Weighted Index	**-14**	**-12**	**-10**	**-7**	**-9**	**0**	**-1**	**4**	**3**

BRAZIL

Brazil's risk scores increased in 2015 and 2016, and with a score of 1,099 sits in 17th place. It was ranked 10th as recently as 2007, so its recent position represents a rapid increase in energy security risk, both absolutely and compared to the OECD baseline. Indeed, the data show that since about 2005 Brazil's risk scores went from about 9% higher than the OECD score to 30% higher in 2016.

Rapid economic growth has pushed Brazil's energy consumption higher, which has doubled over the past decade. It is also the eighth largest energy producer in the world, and it is a significant producer of petroleum and other liquids, primarily fuel ethanol. Since 2009, Brazil's crude oil production has jumped 29%—about 565,000 barrels per day to 2.5 million barrels per day—and the country is now the 10th largest producer in the world (Table H-3). The country's large sugar cane-based ethanol industry produced more than one-quarter of the world's ethanol (about 7.3 million gallons) in 2016, making it the second largest producer behind the United States, which produced about 58% of the world's supply that year. Biofuels have displaced some of the demand for petroleum-based liquid fuels. Despite corruption within the state-run oil industry and very high debt at Petrobras, the country is poised to be a net producer of petroleum. Reforms in the industry, especially local content requirements, could speed up development of Brazil's very large "pre-salt" offshore basins that could hold as much as 50 billion barrels of oil. While oil import risks have declined over the years, import risks from natural gas and coal pose increasing risks for Brazil.

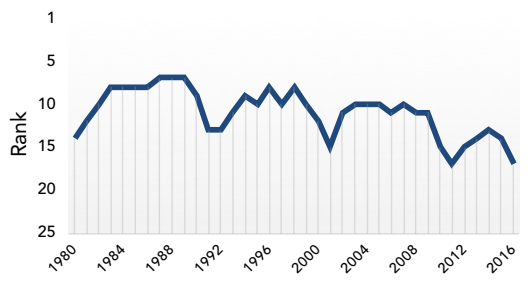
In the power sector, nearly two-thirds of Brazil's electricity generating capacity is hydropower and about 15% is natural gas/oil. Coal, nuclear (two plants), and solar—which is growing rapidly—round out the generation mix. Reduced output from hydropower facilities caused by recent drought conditions that were exacerbated by the 2015/2016 El Niño was offset mostly by increased generation at natural gas plants, which bumped up imports for this fuel.

Since about 2005, Fuel Import Exposure risks have taken on larger significance in Brazil's overall risk profile, as have the Transportation Sector, Environmental, and Energy Expenditure risk categories. This is a common pattern seen in developing countries. Brazil uses more energy and emits more carbon dioxide to produce a unit of GDP than the OECD average, not unusual for a country at this stage of economic development. Moreover, its scores for petroleum intensity and transportation energy intensity are in the bottom five, indicating that Brazil tends to use energy in general, and petroleum in particular, far less efficiently than other countries do.

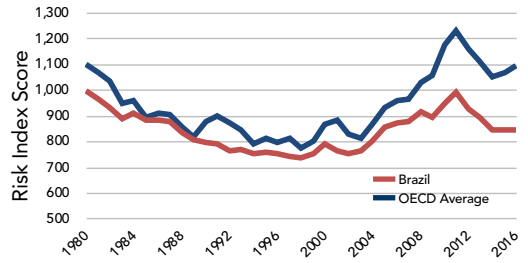
Energy Security Risk Summary: Brazil

Risk Scores:		Risk Scores Relative to OECD Average:	
2016 Energy Security Risk Score	1,099	Average Annual Difference 1980-2016	12%
2016 Large Energy User Group Rank	17	Best Relative Score	1% (1985)
Score in Year	1,070	Worst Relative Score	30% (2016)
Rank in Previous Year	14	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,099		
Average Score: 1980-2016	944	Number in Top Five	4
Best Energy Security Risk Score	777 (1998)		
Worst Energy Security Risk Score	1,232 (2011)	Number in Bottom Five	3

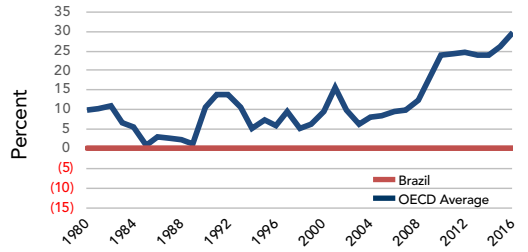
Brazil: Risk Ranking



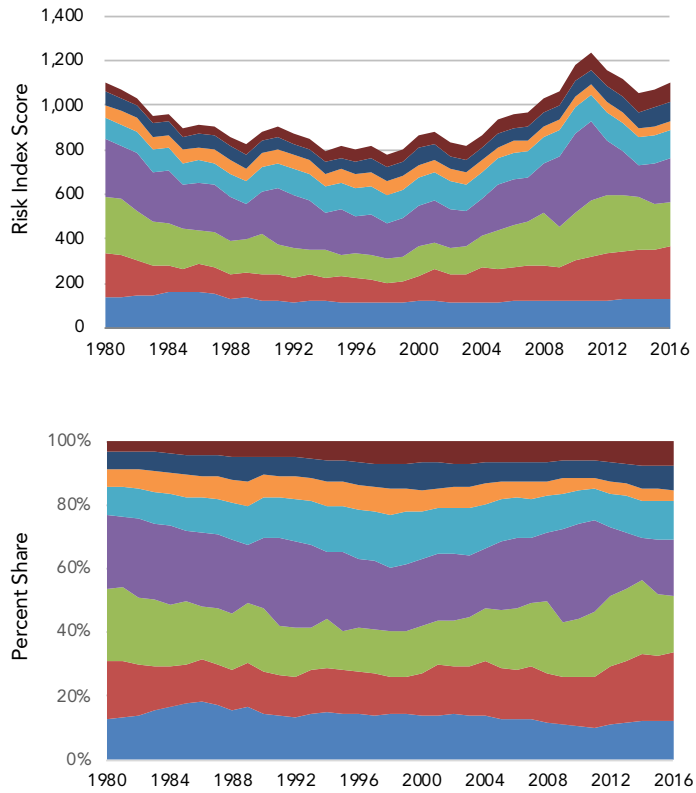
Brazil vs. OECD: Risk Index Scores



Brazil: Risk Variance from OECD



Brazil: Risk Scores by Metric Group and Share of Total Risk by Metric Group



Brazil vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	17	-35	-19	-20	-23	-17	-2	28	34
Energy Expenditure Metrics	26	24	37	-8	24	20	24	42	48
Price & Market Volatility Metrics	69	79	103	158	71	76	97	39	40
Energy Use Intensity Metrics	-31	-21	-5	-1	12	13	18	36	42
Electric Power Sector Metrics	-13	-4	1	3	-5	-16	-20	-27	-29
Transportation Sector Metrics	-15	-9	-22	-23	8	-13	1	28	38
Environmental Metrics	-38	-33	-22	-20	-9	-10	13	44	47
Total Weighted Index	**10**	**1**	**11**	**7**	**10**	**9**	**24**	**26**	**30**

CANADA

Canada's energy security risk scores have tracked fairly closely, usually 0% to 5%, below the OECD baseline average, and in 2016 its overall risk score fell into this range (1% below). The sources of Canada's risk, however, are quite a bit different compared to the OECD average. Unlike the OECD countries as a whole, Canada has no Fuel Import Exposure risk, but the country's Energy Use Intensity and Transportation Sector risks loom much larger. Since 1980, Canada's overall ranking has moved very narrowly between eighth and sixth place, and it was seventh in 2016. Of the 20 country-specific metrics in the database, Canada has seven scores in the top five and four in the bottom five.

Canada is one of the largest energy producers in the world. It is the world's seventh largest producer of crude oil, fifth largest producer of crude oil, and 12th largest producer of coal. As a net exporter of these fuels, Canada's Fuel Import Exposure risks are "0", and with large reserves of these fuels, import risks are likely to stay there. Canada has about 170 billion barrels of proved reserves of oil sands—only Venezuela and Saudi Arabia have higher reserve volumes. Canadian crude oil production has contributed to the steady climb in global oil production from 2009 to 2016, rising 1.1 million barrels per day over the period to 3.7 million barrels per day in 2016 (Table H-3). Canada potentially has very large reserves of natural gas as well, with an estimated 67 trillion cubic feet of proved conventional reserves and 573 trillion cubic feet of recoverable shale reserves.

Nearly all of Canada's oil exports are to the United States, primarily by pipeline. President Donald Trump approved the Keystone XL pipeline that, when built, would link Canadian oil sands to the U.S. pipeline network feeding refineries on the U.S. Gulf Coast. Canada has recognized the need to diversify its oil and natural gas export outlets and is working on alternate routes to move some of its output to Asian and other markets.

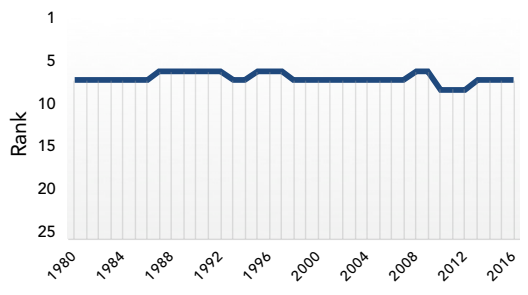
Canada's power sector is fairly diverse compared to other countries in the large energy user group. It is among the world's largest producers of hydroelectric power, which accounts for about 60% of its electricity generation. It also has nuclear power plants (17%) and growing wind capacity (6%). As a result, it ranks third for the non-carbon generation metric behind Norway and France. The country's electricity prices are comparatively low, and it ranks ninth for this metric in the large energy user group.

As previous mentioned, Canada's relatively poor scores for metrics in the Energy Use Intensity and Transportation Sector categories keep it from a higher ranking. Canada is a large country with a cold climate, a relatively low population density, and a lot of mining and other energy intensive economic activity. Canada's energy use per capita, transport energy use per capita, and carbon dioxide emissions per capita scores are, therefore, very high (ranked 25th, 24th, and 25th, respectively, in 2016), while its other environmental metrics are in the middle of the pack.

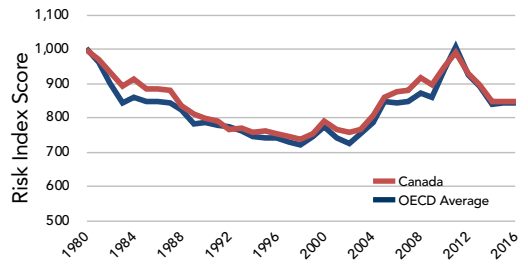
Energy Security Risk Summary: Canada

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	842	Average Annual Difference 1980-2016	-2%
2016 Large Energy User Group Rank	7	Best Relative Score	-6% (1984)
Score in Year	845	Worst Relative Score	1% (2011)
Rank in Previous Year	7	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,004		
Average Score: 1980-2016	827	Number in Top Five	7
Best Energy Security Risk Score	722 (1998)		
Worst Energy Security Risk Score	1,007 (2011)	Number in Bottom Five	4

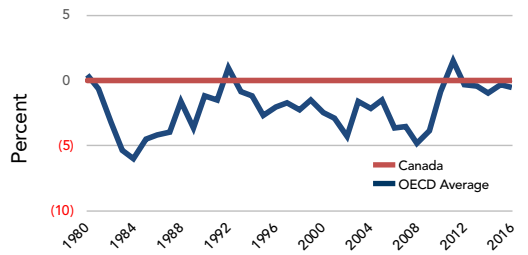
Canada: Risk Ranking



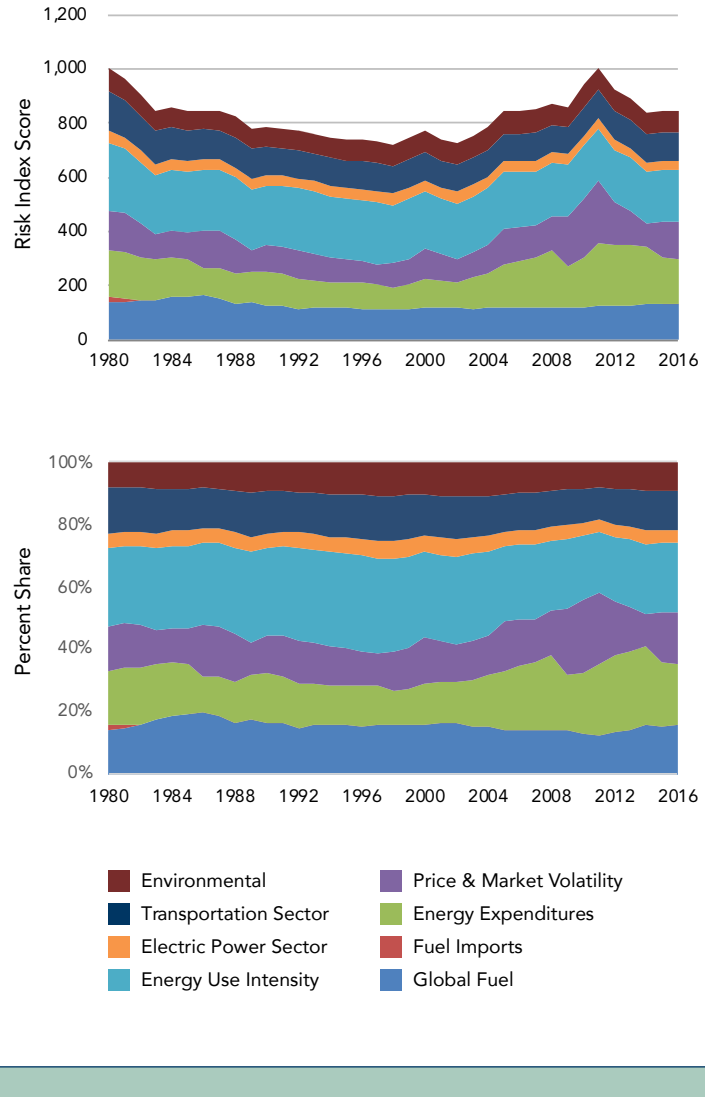
Canada vs. OECD: Risk Index Scores



Canada: Risk Variance from OECD



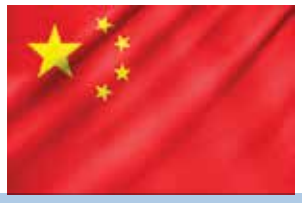
Canada: Risk Scores by Metric Group and Share of Total Risk by Metric Group



Canada vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-89	-100	-100	-100	-100	-100	-100	-100	-100
Energy Expenditure Metrics	-14	-3	-1	-17	-3	11	9	20	19
Price & Market Volatility Metrics	-4	-13	0	11	8	18	21	2	4
Energy Use Intensity Metrics	83	82	86	88	84	95	89	102	102
Electric Power Sector Metrics	-39	-36	-37	-37	-33	-36	-36	-37	-37
Transportation Sector Metrics	113	74	64	44	47	46	60	66	65
Environmental Metrics	39	34	31	21	22	31	30	39	40
Total Weighted Index	**0**	**-4**	**-1**	**-3**	**-2**	**-1**	**-1**	**0**	**-1**



CHINA

No country in the large energy user group has improved its energy security as much as China. Its ranking has improved from 23rd in 1980[5] to 15th in 2016. Its 2016 score of 1,079 is half of what it was in 1980. Much of that improvement came between 1980 and 2000. Over that period, its scores compared to the OECD average went from about 120% above to about 30% above. Since 2000, however, China's scores have moved in tandem with, and about 30% higher than, the OECD average. In 2016, three of its country-specific metric scores were in the top five and five were in the bottom five of the large energy user group.

China has very large hydrocarbon energy resources, more than 90% of which is coal. China is the world's largest producer of coal and the sixth larger producer of crude oil. China's energy demand also has grown at a brisk pace, and in 2010 it became the world's largest energy consumer. Because demand increased much faster than production growth, China has been importing a growing portion of the fuels it uses for oil and coal since the mid-1990s and since the mid-2000s for natural gas. Fuel Import Exposure risks, therefore, have grown from practically nothing to about 14% of its total risk today. One thing that could alleviate some of this risk is development of China's extraordinarily large resources of shale oil and gas on the order of, respectively, 32 billion barrels and 1.1 quadrillion cubic feet.

China's electricity generating sector is dominated by fossil fuels—especially coal, responsible for almost three-quarters of generation—and hydropower (15% to 20%), though in recent years it has added significant nuclear and renewable capacity. While coal dominates China's power sector, plans also call for more natural gas-fired and nuclear generating plants, which should improve the diversity of its electricity supply and reduce air pollution along that country's heavily-populated coastal areas.

Although imports and the power sector remain as challenges, China has seen very large improvement in its Energy Use Intensity metrics, once one of China's worst performing areas. Although its scores in this area are high–for example, its energy intensity score for 2016 ranks 23rd—and are quite a bit above the OECD average, the trends are moving in a positive direction and the difference with the OECD average has narrowed considerably. In 2016, Energy Use Intensity metrics accounted for just 17% of China's overall risks score compared to 33% in 1980. There is still a lot of room for improvement, and continued reductions in this metric category should have a beneficial effect on future index scores.

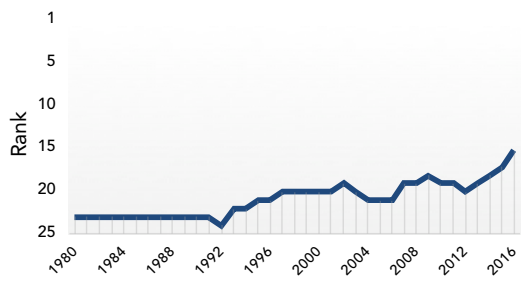
Metrics in the Environmental Category are a growing challenge for China and now account for about 17% of total risk versus 13% as recently as 2001. Its energy-related carbon dioxide emissions are the highest in the world and its per capita emissions are increasing (both of these metrics had scores in the bottom five in 2016). Since about 2000, China's economy generally has been carbonizing rather than decarbonizing, though the addition of some new hydro, nuclear, and wind capacities have lowered the carbon intensity of energy supplies in recent years.

5 Because data for Russia and Ukraine are not available from 1980 to 1991, 23rd place in 1980 was last place.

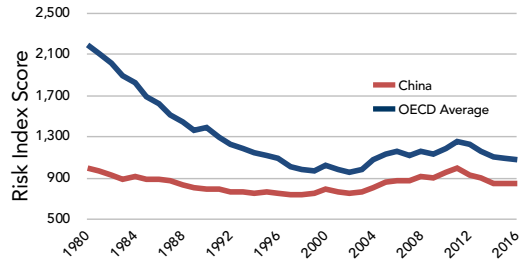
Energy Security Risk Summary: China

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,079	Average Annual Difference 1980-2016	52.4%
2016 Large Energy User Group Rank	15	Best Relative Score	25% (2010)
Score in Year	1,096	Worst Relative Score	119% (1980)
Rank in Previous Year	17	**Country-Specific Metric Ranking—2016:**	
Score in 1980	2,187		
Average Score: 1980-2016	1,296	Number in Top Five	3
Best Energy Security Risk Score	958 (2002)		
Worst Energy Security Risk Score	2,187 (1980)	Number in Bottom Five	5

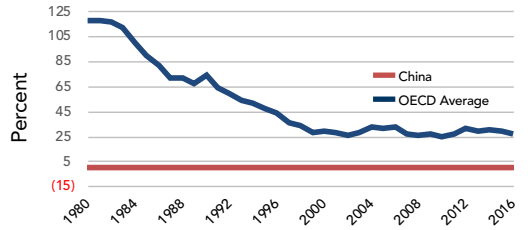
China: Risk Ranking



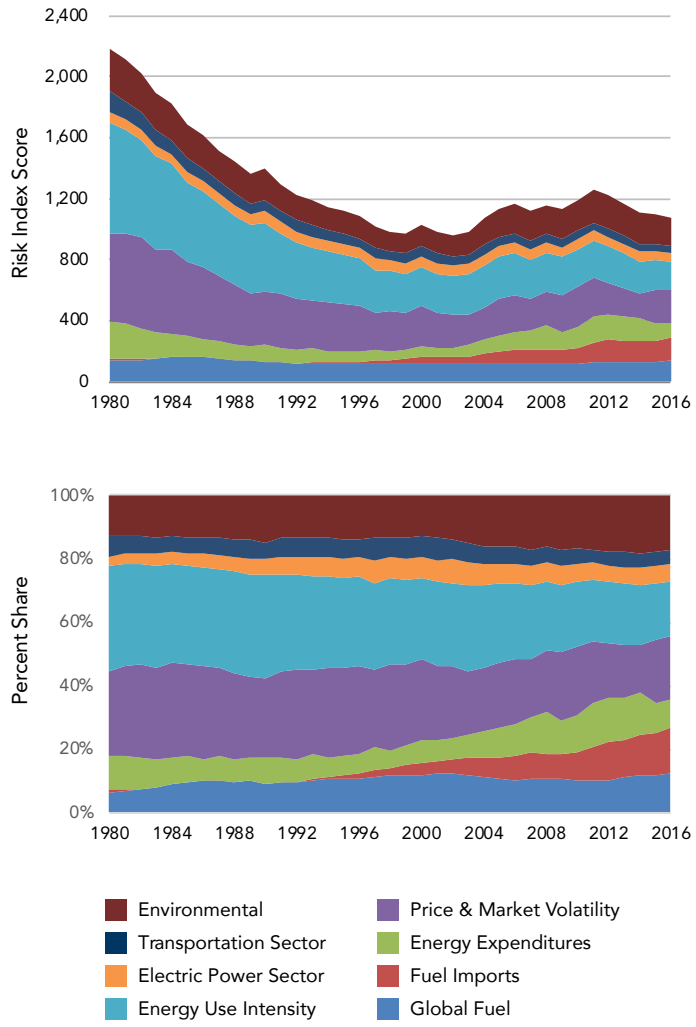
China vs. OECD: Risk Index Scores



China: Risk Variance from OECD



China: Risk Scores by Metric Group and Share of Total Risk by Metric Group



China vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-90	-100	-100	-89	-72	-56	-46	-18	-12
Energy Expenditure Metrics	19	-2	-13	-37	-33	-26	-18	-25	-28
Price & Market Volatility Metrics	287	340	270	298	147	105	44	65	59
Energy Use Intensity Metrics	417	324	284	169	127	165	136	108	97
Electric Power Sector Metrics	-2	5	13	14	14	16	15	7	6
Transportation Sector Metrics	94	35	11	-6	-3	-12	-18	-18	-21
Environmental Metrics	373	300	265	146	104	176	226	240	232
Total Weighted Index	**119**	**90**	**75**	**48**	**30**	**32**	**25**	**29**	**27**

DENMARK

In 1980, Denmark was ranked 15th in the large energy user group. Since 1998, it has been in ranked in the top five, and its score of 788 in 2016 was good enough for fifth place, a drop of one place since 2014. From a total risk score of about 15% above the OECD average in 1980, it moved to 13% below that average by 2000. Since then the gap between Denmark's score and the OECD baseline has narrowed largely because of increased Fuel Import Exposure and Energy Expenditures risks. Of the 20 country-specific metrics, it has eight scores in the top five and two in the bottom five.

Denmark produces more than enough natural gas for its needs from fields located in the North Sea. It also produces a great deal of crude oil, but recent data suggest that the country has moved from being a net exporter to a net importer of oil. It is also a net importer of coal. Even though the share of total risks attached to Fuel Import Exposure has increased in recent years, it still accounts for a lower share of overall risk than in the mid-1980s.

Denmark's power sector diversity is not all that different from the OECD average. Renewables provide a large portion of Denmark's electricity generation (about 60%), with coal providing about 25% and natural gas about 15%. Since about 1997, Denmark has installed renewable capacity, mostly wind and biomass/waste, at a very rapid pace, and the share of output from renewables has increased since then from about 6% of total generation to 60%. Recent years also have seen more natural gas also is being used in place of coal.

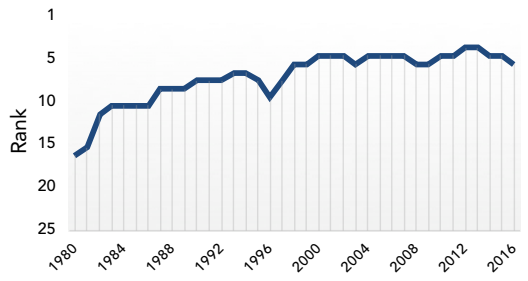
This shift towards intermittent and more expensive sources of energy, however, is related to the one area where Denmark has seen the largest increase in relative risk: Energy Expenditures. Denmark has the third highest electricity prices among the large energy user group, and its 2016 risk score for this metric is about 32% higher than the comparable OECD baseline score. Its energy expenditures per capita also are fairly high, about 12% above the OECD baseline.

Moderating the risks from increasing energy prices is the country's efficient use of energy. Denmark has one of the most energy efficient economies in the world, and its energy intensity and petroleum intensity in 2016 were ranked first and third among the large energy user group. Denmark's carbon dioxide emission trends generally slightly better than the OECD average.

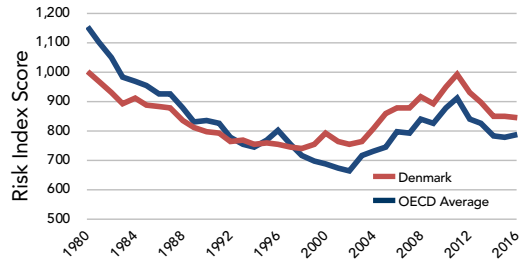
Energy Security Risk Summary: Denmark

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	788	Average Annual Difference 1980-2016	-1.9%
2016 Large Energy User Group Rank	5	Best Relative Score	-13% (2005)
Score in Year	779	Worst Relative Score	16% (1980)
Rank in Previous Year	4	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,156		
Average Score: 1980-2016	830	Number in Top Five	8
Best Energy Security Risk Score	665 (2002)		
Worst Energy Security Risk Score	1,156 (1980)	Number in Bottom Five	2

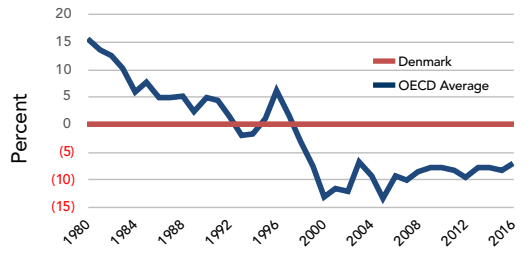
Denmark: Risk Ranking



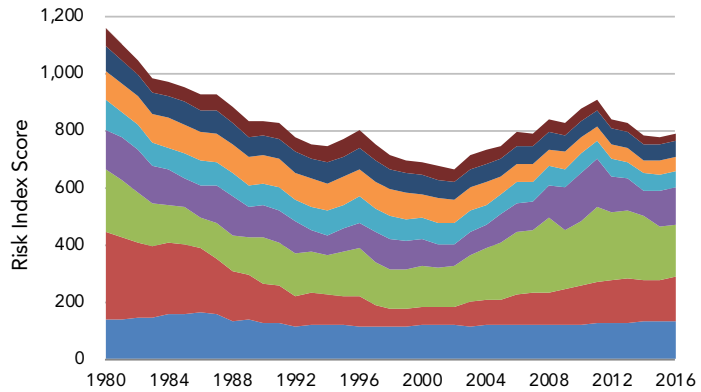
Denmark vs. OECD: Risk Index Scores

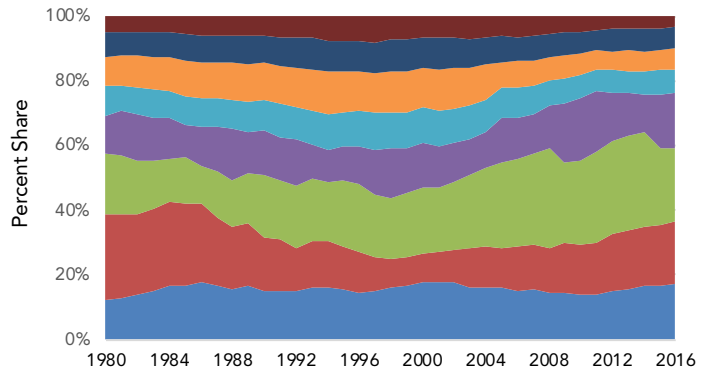


Denmark: Risk Variance from OECD



Denmark: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Denmark vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	81	45	-5	-25	-59	-49	-28	-17	-11
Energy Expenditure Metrics	9	-5	26	39	35	38	33	31	33
Price & Market Volatility Metrics	-10	-11	20	6	-10	-10	-6	-2	-1
Energy Use Intensity Metrics	-24	-30	-35	-31	-36	-36	-36	-39	-40
Electric Power Sector Metrics	45	60	60	59	40	1	-1	-11	-8
Transportation Sector Metrics	26	21	9	2	-8	-13	-12	-15	-16
Environmental Metrics	-1	-2	-13	-7	-32	-34	-32	-51	-53
Total Weighted Index	**16**	**8**	**5**	**1**	**-13**	**-13**	**-8**	**-8**	**-7**

FRANCE

France's total risk score of 1,023 earned it a ranking of 11, respectable for a country with few energy resources. Since 2003, France has been ranked either 10th or 11th except for one year (2014) when it was 12th. This stability in the rankings, however, masks a worsening in France's position compared to the OECD baseline. From about 1985 to 2000 the gap between France's and the OECD baseline's risk scores narrowed from nearly 20% higher to about 5% higher. Since then the gap has widened steadily to 21% in 2016. Further deterioration may see France move lower in the table in future International Indexes. France has four metrics that rank in the top five of the large energy user group, mostly related to energy use and emissions, and three in the bottom five related to imports.

France has Europe's second largest economy (after Germany) and is a large consumer of energy. It has the second largest demand for oil, fourth largest for natural gas, and 12th largest for coal in Europe. It produces very little crude oil and natural gas domestically and no coal. It must, therefore, rely on imports for much of its energy supply, and Fuel Import Exposure risks are therefore a big and growing factor influencing France's energy security risk scores. In the last few years, total import risks have been higher than any other time since 1980 (only scores from the mid-1980s are comparable). Natural gas imports, in particular, are a growing source of risk for France, and in 2016, it had the worst score for this metric among the 25 large energy users. Despite a potentially large natural gas reserve in French shale basins, the French government has placed this shale resource off limits to exploration and production.

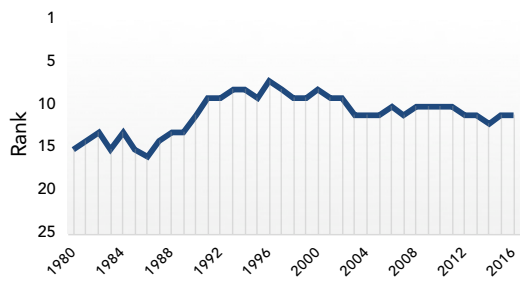
France has, after the United States, the largest nuclear generating capacity in the world. The Arab oil embargo of 1973 prompted the country to make nuclear power a substantial part of its electricity generation mix. The country's 58 reactors total about 63 gigawatts and account for nearly half of France's installed capacity and about three quarters of France's total electricity production. These nuclear plants also produce electricity for export. Combined with a fair bit of hydropower and growing wind and solar capacity, France is ranked second in the non-carbon generation metrics behind Norway. Recently, however, the French government has set a goal of reducing the share of total electricity from nuclear reactors to 50% by 2025. Though France's electricity price score ranked 17th in 2016, Poland and Norway were the only two European countries with better rankings.

France shows a relatively high degree of energy efficiency, which also helps moderate a variety of risks. Its transport energy intensity score is particularly good compared to its peers. Its three carbon dioxide emission metrics also are quite good, with its carbon dioxide intensity metric ranked second in the large energy user group.

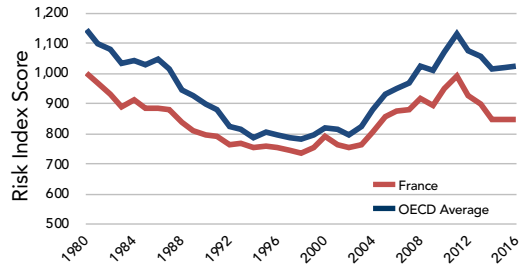
Energy Security Risk Summary: France

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,023	Average Annual Difference 1980-2016	11.6%
2016 Large Energy User Group Rank	11	Best Relative Score	4% (2000)
Score in Year	1,020	Worst Relative Score	21% (2016)
Rank in Previous Year	11	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,146		
Average Score: 1980-2016	945	Number in Top Five	4
Best Energy Security Risk Score	785 (1998)		
Worst Energy Security Risk Score	1,146 (1980)	Number in Bottom Five	3

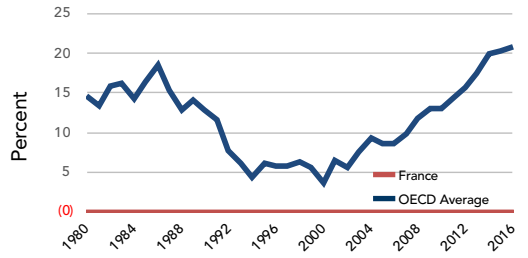
France: Risk Ranking



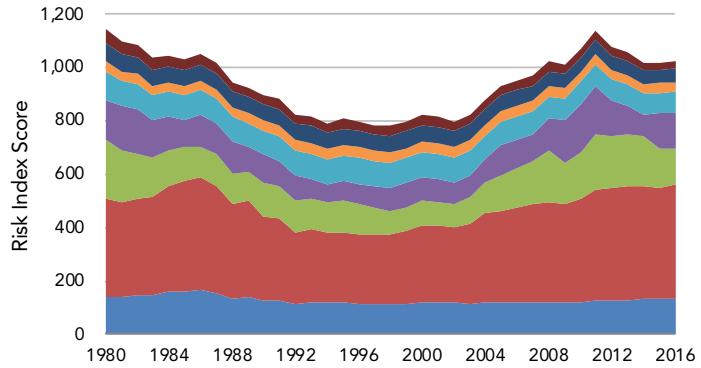
France vs. OECD: Risk Index Scores

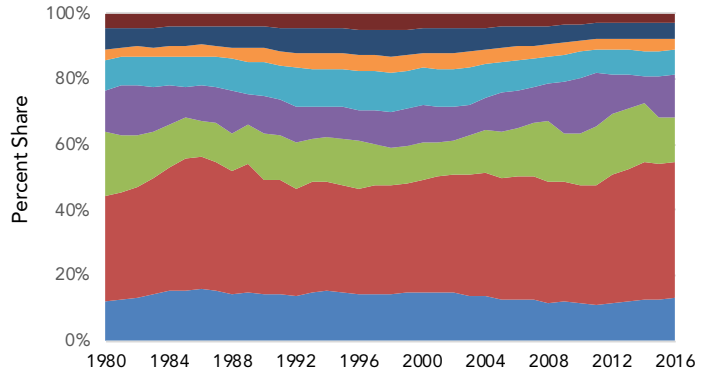


France: Risk Variance from OECD



France: Risk Scores by Metric Group and Share of Total Risk by Metric Group





France vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	117	149	115	90	92	92	106	143	144
Energy Expenditure Metrics	11	-10	2	6	-11	-6	0	1	1
Price & Market Volatility Metrics	-3	-10	10	0	-12	-5	1	-1	0
Energy Use Intensity Metrics	-24	-24	-24	-21	-20	-15	-18	-17	-17
Electric Power Sector Metrics	-44	-46	-37	-36	-36	-34	-38	-36	-34
Transportation Sector Metrics	1	-5	-8	-15	-15	-18	-17	-21	-23
Environmental Metrics	-13	-26	-36	-43	-42	-43	-45	-49	-47
Total Weighted Index	**15**	**16**	**13**	**6**	**4**	**9**	**13**	**20**	**21**

GERMANY

Note: For consistency, East German data and West German data have been combined to yield "German" data from 1980 to 1990. These data should not be considered as reliable as the data after 1990.

Germany's energy security risk score of 905 for 2016 put it at number nine in the large energy user group ranking, a position it has held since 2014. Germany's total energy security risk scores have declined steadily, both absolutely and relative to the OECD baseline, from 1980 to about 2005, when it was ranked fifth. Since then, however, its scores have lost ground against the OCED, and thus its drop of four places. In 2016, Germany had five metrics scores in the top five of the large energy user group and one score in the bottom five.

Germany produces very little crude oil but enough natural gas to make it the fourth largest producer in Europe (but 44th in the world). It is also the world's eighth biggest, and Europe's biggest, coal producer. As the largest economy in Europe, Germany consumes large amounts of all of these fuels and has had to rely on imports to meet its needs. In 2016 its Fuel Import Exposure risk accounts for almost one-third of its overall risk, not too different from the share in 1980.

Germany's power sector has undergone big changes over the years. The country's "Energiewende," or energy transition, was passed in 2010 and sets ambitious renewable targets. After the Fukushima Daiichi incident in Japan in 2011, Germany also included a phase-out of Germany's nuclear reactors by 2022. Today more than one-quarter of Germany's electric power is generated from renewables (mostly wind). Germany hopes to increase its offshore wind capacity target to 6.5 gigawatts by 2020 and 15 gigawatts by 2030. Policymakers have recognized, however, that a large industrial economy like Germany's depends on reliable, baseload electricity generation. Coal, however, remains the lowest-cost generating option in Germany and accounts for roughly 45% of power generation. Over the past few years new coal stations have been brought online to offset the expected loss nuclear generating capacity.

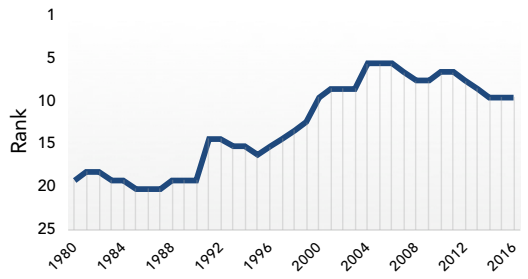
The large costs of renewable subsidies has become a political issue in Germany. The country's average electricity rate is the second highest in the large energy user group after Italy's (its rate for households is the highest (Figure H-1)). Since 2000, electricity rates have grown at a much faster rate than the OECD average. It also has very high gasoline tax. Softening the blow of high fuel and electricity costs is Germany's excellent risk scores for Energy Use Intensity. The amount Germany pays for energy per unit of GDP is ranked second, its energy intensity is ranked fifth, and its petroleum intensity is ranked first in the large energy user group.

Germany's Environmental metrics are mixed. Its carbon dioxide intensity score is good (ranked 6th), but its carbon dioxide per capita scores are fairly high, not unusual for such a wealthy and highly-industrialized economy. Improvement in the Environmental metrics is occurring roughly at the same pace as the OECD average.

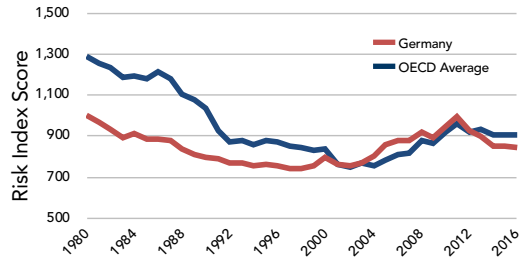
Energy Security Risk Summary: Germany

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	905	Average Annual Difference 1980-2016	12.6%
2016 Large Energy User Group Rank	9	Best Relative Score	-9% (2005)
Score in Year	904	Worst Relative Score	37% (1986)
Rank in Previous Year	9	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,288		
Average Score: 1980-2016	952	Number in Top Five	5
Best Energy Security Risk Score	748 (2002)		
Worst Energy Security Risk Score	1,288 (1980)	Number in Bottom Five	1

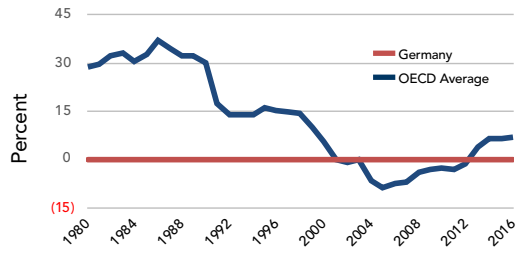
Germany: Risk Ranking



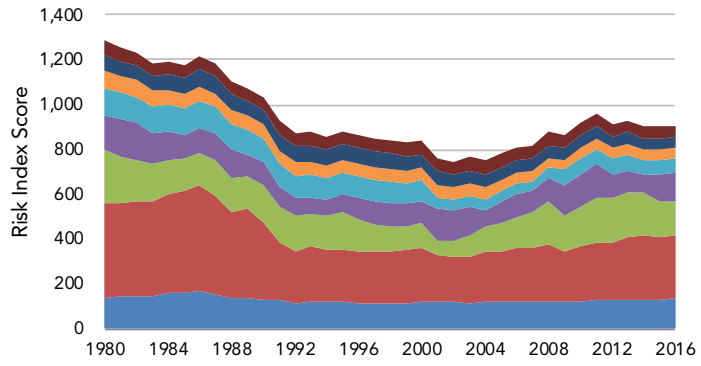
Germany vs. OECD: Risk Index Scores

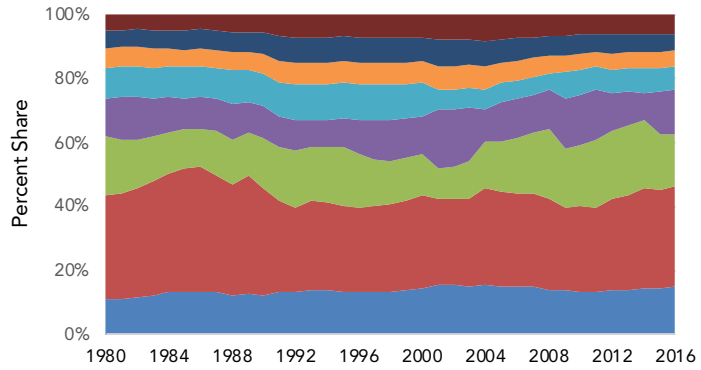


Germany: Risk Variance from OECD



Germany: Risk Scores by Metric Group and Share of Total Risk by Metric Group



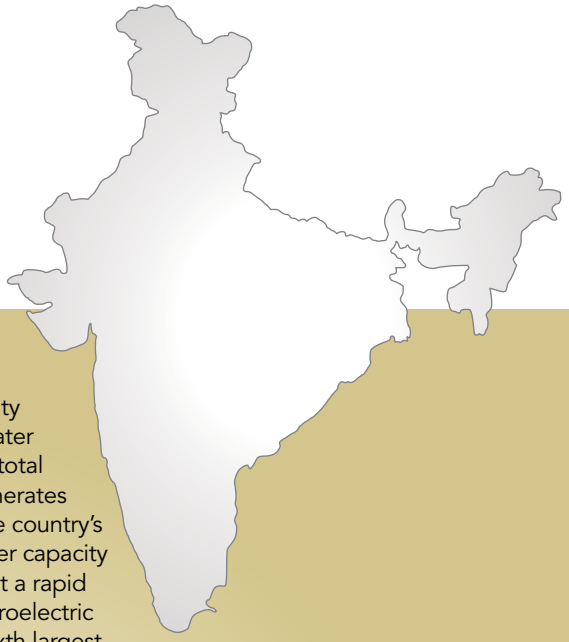


Germany vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	148	173	137	70	65	28	32	61	63
Energy Expenditure Metrics	18	2	29	47	2	-11	1	9	11
Price & Market Volatility Metrics	1	0	9	2	-6	-16	-18	-7	-8
Energy Use Intensity Metrics	-10	-5	-13	-20	-23	-57	-30	-29	-29
Electric Power Sector Metrics	10	1	5	-2	-8	-19	-22	-19	-18
Transportation Sector Metrics	7	9	5	-4	-11	-17	-17	-20	-23
Environmental Metrics	2	2	2	-5	-10	-9	-8	-6	-6
Total Weighted Index	**29**	**33**	**30**	**16**	**6**	**-9**	**-3**	**7**	**7**

INDIA



India's total energy security risk score of 1,153 for 2016 placed it in 20th position. This score is a considerable improvement from its record high total risk index score of 1,411 reached in 2011. Since 1980, India's rank within the large energy user group has fluctuated between 17th and 22nd. Over this time, India's energy security score has generally tracked between about 30% and 45% above the OECD average. Of the 20 country-specific metrics, India has six scores in the top five and the three in the bottom five of the large energy user group.

Although India ranks last in GDP per capita among the among the large energy group, it still has a very large economy—fourth largest in the world—by virtue of its population in excess of one billion people. Its economy is growing and modernizing rapidly and demand for energy is increasing briskly. India is an oil and natural gas producer, but its output is much less than its demand for these fuels (India consumes more oil than just three other countries—the United States, China, and Japan). India is well supplied with coal, however. It boasts the fifth largest coal reserves in the world and is the world's third largest producer of coal (and is predicted to overtake the United States in the number two spot). It is hardly surprising, then, that coal is the dominant fuel in India's economy, supplying more than 45% of primary energy demand. Still, while domestic coal production has been increasing—and India has a goal to double domestic output by 2020 (that it will have difficulty meeting)—consumption is projected to rise further, making India the world's second-largest consumer (after China) and the largest importer of coal. As a result of these trends, India's Fuel Import Exposure risks have accounted for a growing share of India's risk profile over the past decade or so.

Despite a great deal of progress in electrification, and estimated 300 million Indians do not have access to electricity. Coal-fired capacity accounts for greater than 60% of the total capacity and generates about 75% of the country's power, and further capacity is being added at a rapid pace. India's hydroelectric capacity is the sixth largest capacity in the world and provides about 10% of total generation. Other renewable capacity is rising rapidly also, and India is planning 1 gigawatt of solar capacity and about 55,000 megawatts of wind capacity. Government policy keeps electricity rates fairly low, but the inadequacy of fuel supplies means power deficits remain an issue, with some industrial customers relying on dedicated off grid power sources to avoid blackouts.

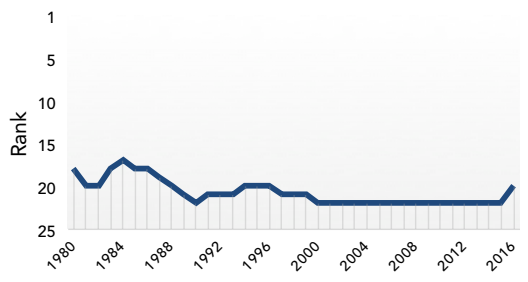
One category of shrinking risk, at least as a share of total risk, is Energy Use Intensity. With hundreds of millions of people lacking access to electricity, India's per capita scores for total energy demand, transport energy demand, energy expenditures, and carbon dioxide emissions are the lowest in the group. India's score for the comparable energy and emissions intensity metrics—use or emissions per unit of economic output—are not particularly good. As it develops economically, we can expect risk scores for per capita metrics to increase while the scores for the intensity metrics decrease.

India is a major emitter of carbon dioxide, but again due mostly to its large population. India's economy over the entire period since 1980 has been carbonizing consistently rather than decarbonizing as it pushes to increase energy access to its populace, a trend that is likely to continue for some time as India develops.

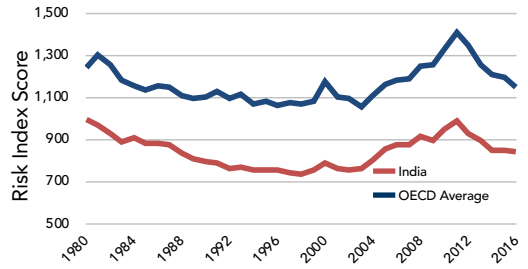
Energy Security Risk Summary: India

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,153	Average Annual Difference 1980-2016	38.5%
2016 Large Energy User Group Rank	20	Best Relative Score	24% (1980)
Score in Year	1,195	Worst Relative Score	48% (2000)
Rank in Previous Year	22	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,242		
Average Score: 1980-2016	1,168	Number in Top Five	6
Best Energy Security Risk Score	1,060 (2003)		
Worst Energy Security Risk Score	1,411 (2011)	Number in Bottom Five	3

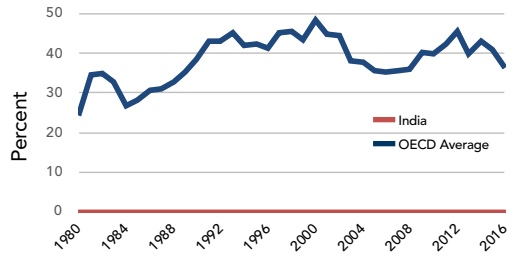
India: Risk Ranking



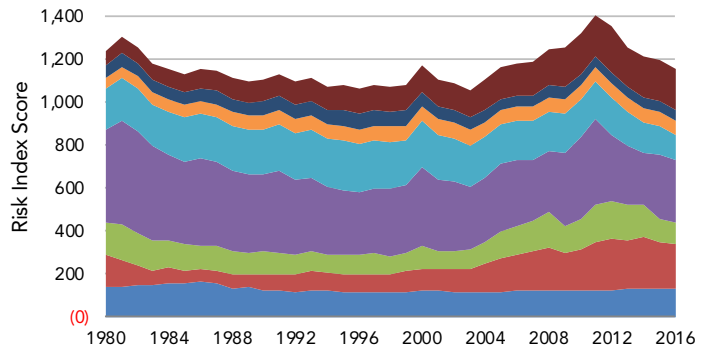
India vs. OECD: Risk Index Scores

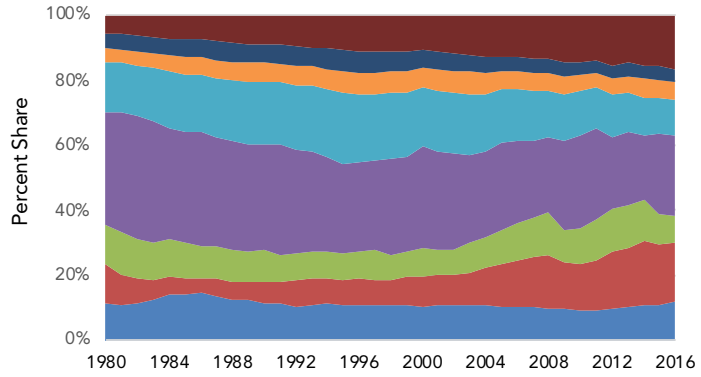


India: Risk Variance from OECD



India: Risk Scores by Metric Group and Share of Total Risk by Metric Group





India vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-13	-66	-51	-41	-28	-15	0	27	20
Energy Expenditure Metrics	-24	-11	-15	-23	2	-13	-15	-23	-26
Price & Market Volatility Metrics	189	248	278	291	248	173	112	127	110
Energy Use Intensity Metrics	34	64	77	97	83	79	74	39	31
Electric Power Sector Metrics	-25	-7	3	16	17	11	15	21	20
Transportation Sector Metrics	-18	-5	-1	2	-7	-27	-21	-24	-25
Environmental Metrics	16	53	75	82	90	122	213	234	240
Total Weighted Index	**24**	**28**	**38**	**42**	**48**	**36**	**40**	**41**	**36**

INDONESIA

Although its risk scores are much higher than Mexico's, Indonesia shares a lot of characteristics with the country. Both are extraordinarily rich in energy resources, but both countries appear to be sacrificing their evident energy advantages rather than maintaining them. Indonesia's risk score of 1,141 places it in 19th place in the large energy user group. It was ranked eighth in 1980, its highest ranking. Since then, its total risk score has deteriorated from about 5% above the OECD average to 35% above in 2016. Indonesia has seven individual metric scores in the top five and another seven in the bottom five.

Indonesia is rich in energy resources, producing large amounts of oil, natural gas, and, especially, coal. The focus of energy policy, however, has shifted away from exporting and towards meeting rapidly growing national demand. Once a large exporter of petroleum, it became a net importer in 2004. While it remains a net exporter of natural gas, increased domestic demand for these fuels is shrinking the share available for export. EIA estimates that Indonesia could have large quantities of shale oil and natural gas, which if tapped would contribute to lower import supply risks and expenditure risks. Indonesia also is rich in coal, about 80% of which is exported. Surging demand for coal in Asia, especially in China, pushed Indonesian production much higher over the last decade, helping to make Indonesia the world's largest coal exporter.

Along with rapid demand growth, aging infrastructure, regulatory uncertainty, and inadequate investment have caused Indonesia's energy security position to slip compared to others in the large energy user group. Most of the coal used domestically is for power production, and its use in power generation is encouraged because it is abundant and costs comparatively less than fuel oil.

Electrification of the country is a top priority of the government, and about 85% of the population now has access to electricity. Demand for electricity, however, has outpaced generating capacity, creating constraints affecting the reliability of the national power system. In 1980, more than 80% of its power production came from oil-fired power plants and none from coal- or natural gas-fired plants. Today, oil is used to generate only about 10% of the country's electricity while coal generates about half and natural gas 25%. The country also has large geothermal and hydropower resources. Its electricity rates are ranked fifth in the large energy user group, with prices set by the government below market rates.

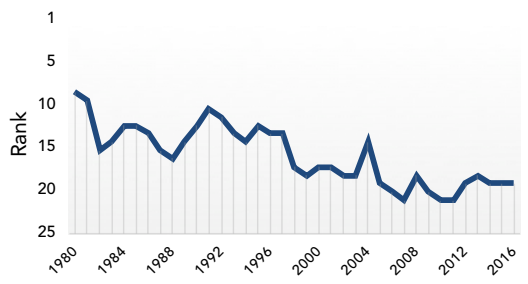
Indonesia's energy use per capita score was second best in 2016, but its energy intensity and petroleum intensity risk scores are quite high. As the country develops further, it is expected that energy intensity metrics will show considerable improvement even as its energy per capita scores climb.

A similar pattern is evident in the Environmental metrics, which with Fuel Import Exposure risks, explains much of the deterioration in Indonesia's position in the large energy user group. While its emissions per capita score for 2016 is quite low—like energy use per capita, second only to India—its emissions intensity scores and over emission scores are fairly high.

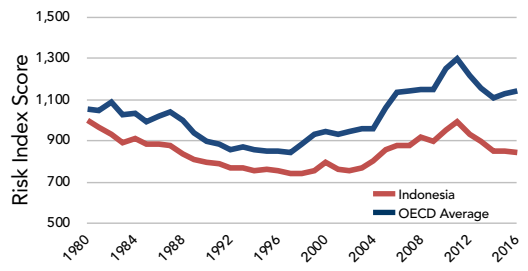
Energy Security Risk Summary: Indonesia

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,141	Average Annual Difference 1980-2016	20%
2016 Large Energy User Group Rank	19	Best Relative Score	5% (1980)
Score in Year	1,125	Worst Relative Score	35% (2016)
Rank in Previous Year	19	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,053		
Average Score: 1980-2016	1,017	Number in Top Five	7
Best Energy Security Risk Score	844 (1997)		
Worst Energy Security Risk Score	1,299 (2011)	Number in Bottom Five	7

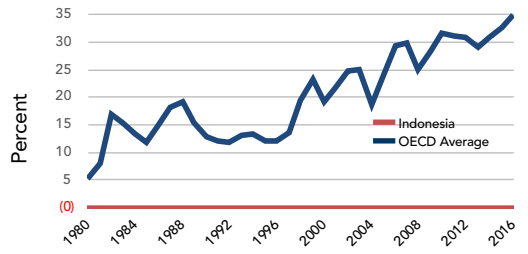
Indonesia: Risk Ranking



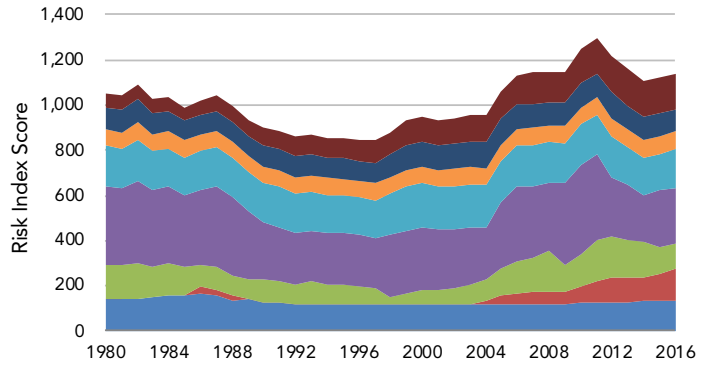
Indonesia vs. OECD: Risk Index Scores

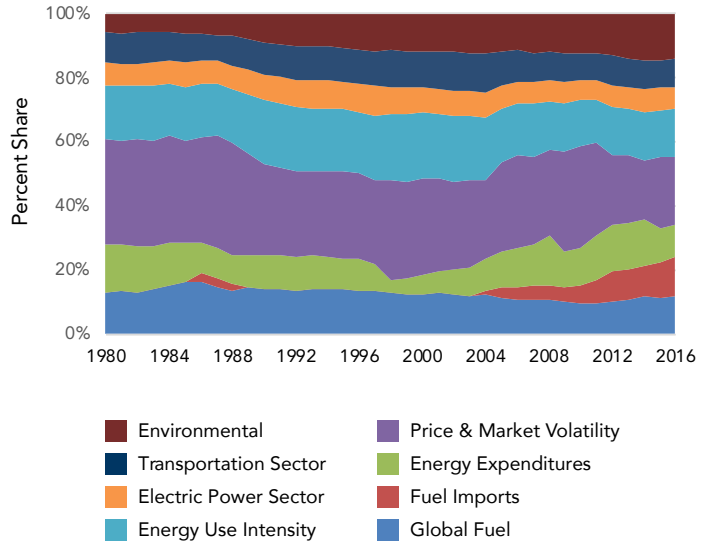


Indonesia: Risk Variance from OECD



Indonesia: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Indonesia vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-100	-100	-100	-100	-100	-80	-62	-30	-20
Energy Expenditure Metrics	-23	-11	-24	-23	-46	-16	-14	-18	-15
Price & Market Volatility Metrics	132	181	168	198	167	154	119	92	79
Energy Use Intensity Metrics	26	37	50	37	67	72	76	73	81
Electric Power Sector Metrics	3	21	17	22	22	23	25	45	47
Transportation Sector Metrics	42	34	44	29	53	63	63	58	54
Environmental Metrics	2	12	40	41	68	87	150	184	190
Total Weighted Index	**5**	**12**	**13**	**12**	**19**	**24**	**32**	**33**	**35**

ITALY

From about 2000 to 2016, the gap between the overall energy security risk scores for Italy and the OECD average widened from about 15% to 30%. As a result, over the same period its ranking vis-à-vis its large energy user group peers dropped four places to number 18, the lowest ranking for any Western European country in 2016. Moreover, its 2016 score of 1,102 is higher than its 1980 score, making one of a handful of countries with current scores higher than they were at the beginning of the record. Five of its metric scores, mostly related to energy usage, are in the top five, and three are in the bottom five.

Like many countries in Western European, Italy produces very little energy domestically and must rely largely on imports to fuel its economy. As a consequence, Fuel Import Exposure risks have accounted for at least one-third of Italy's overall risk score (38% in 2016). Its metrics measuring import supply and expenditure risks, especially those related to coal and natural gas, are much greater than the OECD average. The recent decline in the price of crude oil has been of tremendous benefit to Italy, which would have had much larger import expenditure risks otherwise.

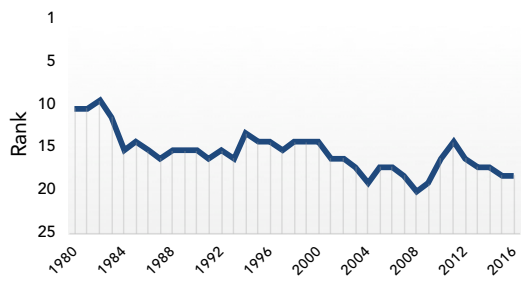
Italy has a diverse power sector. Whereas about two decades ago oil provided a significant share of Italy's power generation, since the mid-1990s the country has shifted towards natural gas, which is now the most widely used fuel for producing electricity. Natural gas prices in Italy, however, are extraordinarily high. Coal use also has been growing. Renewable energy sources, excluding hydroelectricity, have increased their share in Italy's electricity generation from less than 1% in 2000 to about 223% in 2016. (Italy's nuclear capacity was shut down after passage of an anti-nuclear power referendum in 1987 following the Chernobyl nuclear accident in 1986.) Because of its reliance on expensive natural gas (which in 2016 accounted for 38% of power production) and its increased use of renewables, Italy's electricity prices are the highest in the large energy user group (Figures H-1 and H-2).

Italy—again, like many other countries in Western Europe—does comparatively well in the metrics from the Energy Use Intensity category, especially those measuring energy intensity. Both its energy intensity and petroleum intensity measures are ranked in the top five, and its carbon dioxide emissions intensity scores also rates a top five ranking.

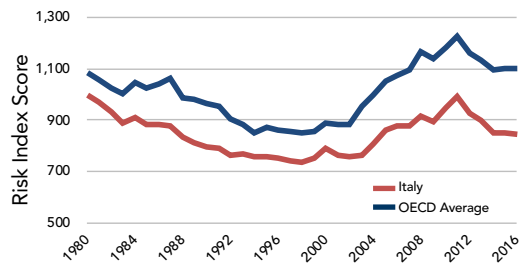
Italy scores relative well in the Transportation Sector, Electric Power Sector, and Environmental metric categories. Together, the metrics in these groups account for less than 20% of Italy's total risk score compared to a country like Indonesia where these metrics make up about 45% of the total score. It is expected that Fuel Import Exposure and related risks will continue to dominate Italy's overall risk scores.

Energy Security Risk Summary: Italy			
Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,102	Average Annual Difference 1980-2016	19.3%
2016 Large Energy User Group Rank	18	Best Relative Score	9% (1980)
Score in Year	1,101	Worst Relative Score	30% (2016)
Rank in Previous Year	18	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,085		
Average Score: 1980-2016	1,008	Number in Top Five	5
Best Energy Security Risk Score	850 (1998)		
Worst Energy Security Risk Score	1,227 (2011)	Number in Bottom Five	3

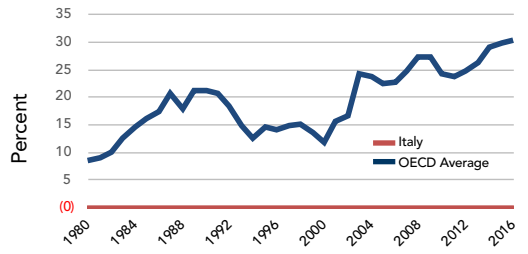
Italy: Risk Ranking



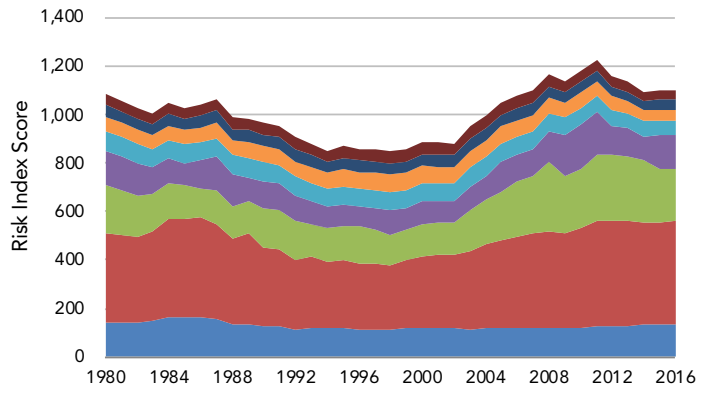
Italy vs. OECD: Risk Index Scores

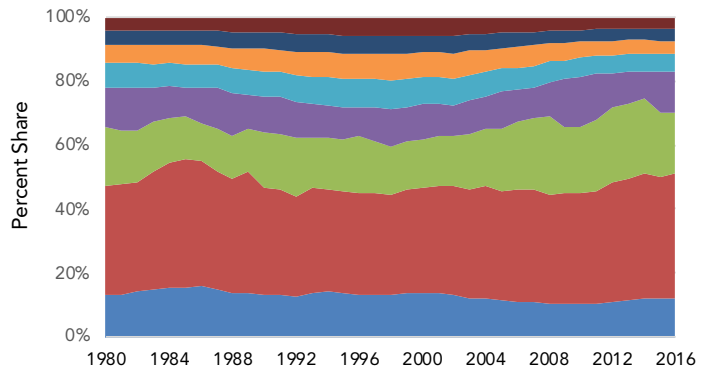


Italy: Risk Variance from OECD



Italy: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Italy vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	120	147	122	101	99	102	118	144	145
Energy Expenditure Metrics	-1	-1	29	28	27	42	42	53	57
Price & Market Volatility Metrics	-9	-19	16	14	-10	7	2	7	3
Energy Use Intensity Metrics	-40	-38	-36	-36	-35	-28	-30	-33	-33
Electric Power Sector Metrics	-14	-7	12	14	12	13	2	-19	-18
Transportation Sector Metrics	-33	-26	-26	-30	-31	-31	-33	-35	-34
Environmental Metrics	-24	-22	-16	-23	-24	-22	-25	-32	-30
Total Weighted Index	**9**	**16**	**21**	**15**	**12**	**22**	**24**	**30**	**30**

JAPAN

The aftereffects of the Fukushima Daiichi nuclear power plant incident in 2011 have had a big impact on Japan's energy security risk since 2010. In 2016, the country's nominal energy security risk score declined 17 points to 1,154. This was the fifth year of declining risk scores, a positive development that can be attributed to the impact of declining energy costs related to the drop in the price of crude oil. Japan has, however, lost ground compared to the OECD average, which means its risk scores have been improving generally at a slower rate than scores for its peers. From the mid-1980s to about 2010, Japan improved its energy security posture in relation to the OECD baseline, reducing the disparity by half (from about 40% to about 20% to 25%). Since 2010, however, the gap has grown to between 30% and 35%, about where it was in the late 1980s. As a result, Japan's ranking has fallen from 14th in 2010 to 21st in 2016. For 2016, Japan has three country-level metrics ranked in top five and seven in the bottom five.

Japan has a very large industrialized modern economy, but it produces little crude oil and natural gas and no coal. As a consequence, Japan is the world's largest importer of LNG and the third largest net importer of oil and coal. Japan did, however, have a very large nuclear power industry, but the Fukushima Daiichi accident in 2011 caused Japan to close its reactors, worsening its already high Fuel Import Exposure risks. Japan's scores for four of the five fuel import metrics are ranked in the bottom five. As a result, Fuel Import Exposure metrics account for 41% of Japan's total risk score, higher than it has been since the mid-1980s.

The diversity of generating capacity and the share of non-carbon emitting generation in Japan's power sector has been one of Japan's strengths, but not as much as it was a few years ago. Before the Fukushima Daiichi accident in 2011, Japan had a very balanced power sector. Nuclear power then accounted for about 25% to 30% of Japan's power generation. Today, only two of Japan's 43 operable nuclear plants are operating.

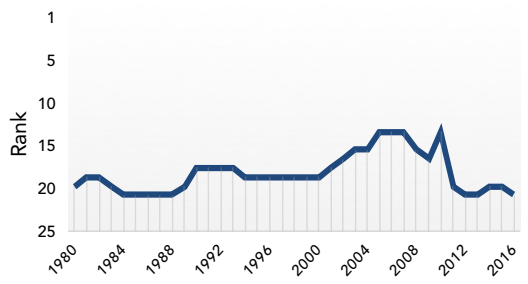
To make up for this lost capacity, Japan has relied more extensively on natural gas and coal, both of which have to be imported. Nearly 75% of Japan's electricity is now generated from these fuels versus about 55% before the accident. The Japanese government intends to restore much of the previous balance in the fuel mix, which means some nuclear plants will have to be restarted. Restart applications have been filed for 21 reactors, but it is unclear how many of the remaining plants will be brought back on line. Japan's average electricity price has always been comparatively high and in 2016 was ranked 21st.

The efficient use of energy is, of course, one of Japan's strengths and a characteristic that helps moderate and offset some of the unavoidable risks of importing such a large share of its energy. The country's risk score for energy intensity and transport energy intensity are ranked fourth and first, respectively. Moreover, its per capita energy use scores are better than the corresponding scores for its OECD peers, and its emission scores are about average.

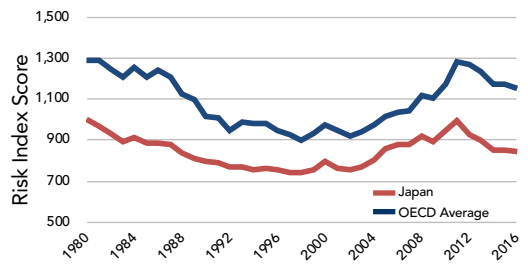
Energy Security Risk Summary: Japan

Risk Scores:		Risk Scores Relative to OECD Average:	
2016 Energy Security Risk Score	1,154	Average Annual Difference 1980-2016	28.8%
2016 Large Energy User Group Rank	21	Best Relative Score	18% (2007)
Score in Year	1,171	Worst Relative Score	40% (1986)
Rank in Previous Year	20	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,290		
Average Score: 1980-2016	1,089	Number in Top Five	3
Best Energy Security Risk Score	902 (1998)		
Worst Energy Security Risk Score	1,290 (1981)	Number in Bottom Five	7

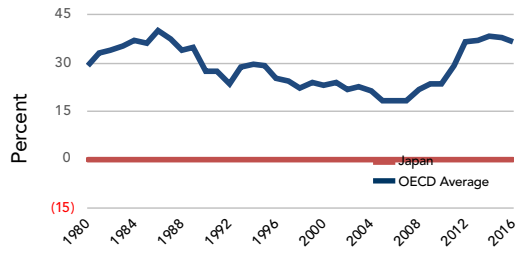
Japan: Risk Ranking



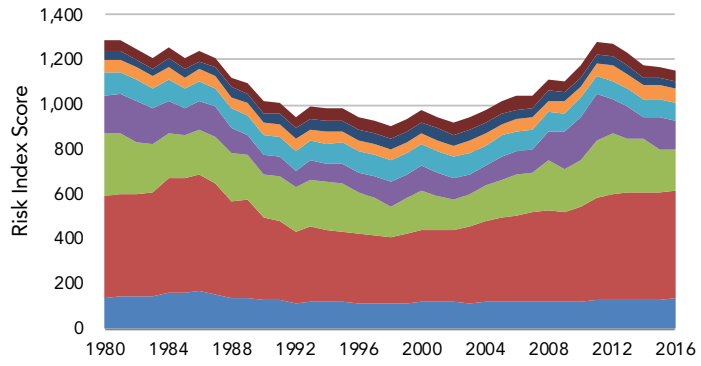
Japan vs. OECD: Risk Index Scores

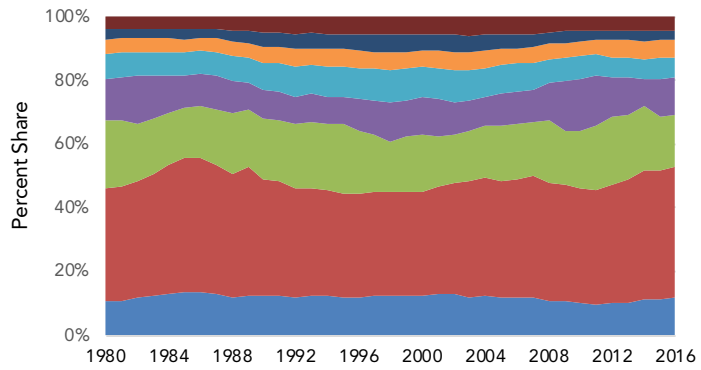


Japan: Risk Variance from OECD



Japan: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Japan vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	168	209	153	128	116	108	123	174	174
Energy Expenditure Metrics	38	34	49	92	63	23	24	36	38
Price & Market Volatility Metrics	9	8	-3	12	8	-11	6	8	-2
Energy Use Intensity Metrics	-25	-29	-26	-22	-18	-14	-18	-19	-19
Electric Power Sector Metrics	-17	-19	-14	-16	-18	-15	-11	17	16
Transportation Sector Metrics	-44	-42	-32	-32	-30	-33	-43	-44	-45
Environmental Metrics	-15	-15	-12	-17	-17	-14	-15	-10	-12
Total Weighted Index	**29**	**36**	**27**	**29**	**23**	**18**	**23**	**38**	**36**

MEXICO

Mexico was ranked number one for the first 12 years of the International Index, and it never ranked below number three until 2014, when it slipped to sixth. In 2016, its risk score was 778, good enough for fourth place. Mexican scores always have been lower than the OECD average scores, but the gap between them has narrowed steadily, from 29% in 1980 to 7% in 2016. This means that during this period Mexico, a nation with many energy advantages, was losing ground in relation to the OECD average at the same time many of its peers were gaining ground in relation to the OECD average. The result has been a very gradual slippage in rank over the years. The country has five country-specific metric scores in the top five and none in the bottom five.

Mexico is a very large energy producer of crude oil (12th in the world), and it also produces significant quantities of natural gas and coal. However, oil production levels are declining, especially from Cantarell, Mexico's largest oil field located off Mexico's southeastern coast. As table H-2 shows, since 2009, Mexican production has dropped about 460,000 barrels per day, or 17%. While it is still a net oil exporter, the disparity between production and consumption is closing. To combat declining production and attract international investment, the Mexican government instituted constitutional reforms to put an end to the monopoly enjoyed by state-owned oil company Petroleos Mexicanos since 1938 and to open up its hydrocarbon sector to competition.

Unlike the situation with oil, Mexican demand for natural gas and coal has outstripped domestic production. As a result, Fuel Import Exposure risks and Energy Expenditure risks, especially for imports, have taken on a much larger significance in Mexico's risk profile since 2000 (though scores for these are still below the OECD average). New pipelines capacity between the United States and Mexico will help expand the market for U.S. shale gas in the country. Mexico's oil and gas industry has focused largely offshore. EIA estimates that Mexico has very large—545 trillion cubic feet—onshore shale gas resources (linked geologically to plays in the United States). The constitutional reforms described earlier were passed in part by a desire to bring into the country the expertise needed to tap these resources.

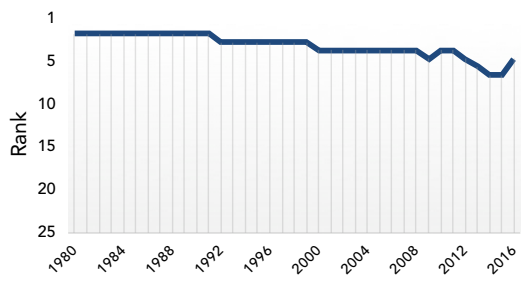
Mexico's power sector has become increasingly diverse. The oil-fired plants that once dominated Mexico's power sector are giving way to natural gas-fired plants, which now account for more than half of generation. Oil-, gas-, and coal-fired stations produce more than 80% of Mexico's power, hydroelectric around 10%, and the rest from nuclear and other renewables.

When it comes to Energy Use Intensity metrics, results are mixed. Per capita metrics measuring overall energy use (ranked fourth), energy use in the transport sector, and carbon dioxide emissions (ranked fifth) are lower than the OECD average. Mexico does not do as well, however, in scores energy intensity and emissions intensity. As Mexico continues to grow and develop and its middle class expands, these intensity metrics should begin to converge closer to the OECD average. Because some oil capacity is being replaced by natural gas capacity in the power sector, Mexico's petroleum intensity metric should continue to improve at a faster rate than the OECD average.

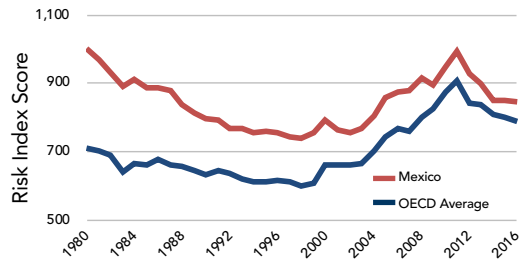
Energy Security Risk Summary: Mexico

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	788	Average Annual Difference 1980-2016	-16.8%
2016 Large Energy User Group Rank	4	Best Relative Score	-29% (1980)
Score in Year	802	Worst Relative Score	-5% (2014)
Rank in Previous Year	6	**Country-Specific Metric Ranking—2016:**	
Score in 1980	709		
Average Score: 1980-2016	703	Number in Top Five	4
Best Energy Security Risk Score	599 (1998)		
Worst Energy Security Risk Score	907 (2011)	Number in Bottom Five	0

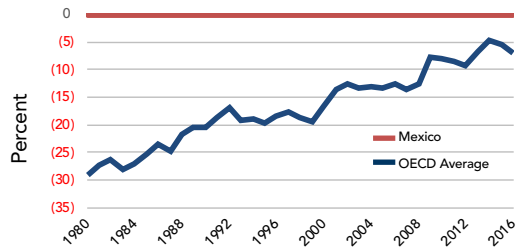
Mexico: Risk Ranking



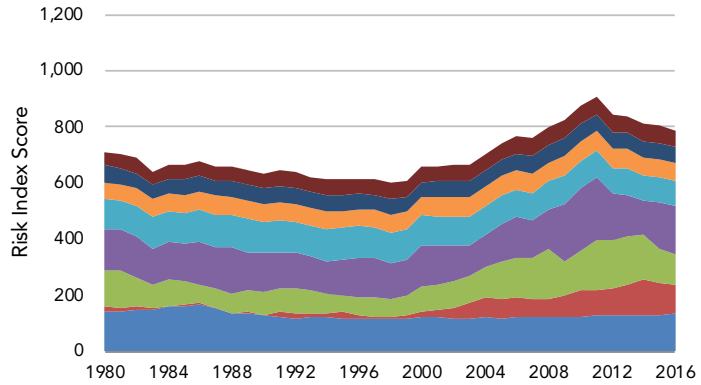
Mexico vs. OECD: Risk Index Scores

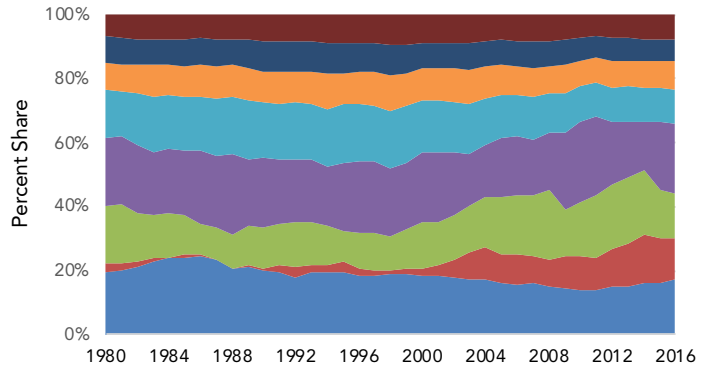


Mexico: Risk Variance from OECD



Mexico: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Mexico vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-89	-97	-98	-85	-88	-61	-50	-36	-42
Energy Expenditure Metrics	-36	-41	-35	-47	-12	-8	-14	-16	-17
Price & Market Volatility Metrics	0	21	44	68	40	19	23	28	26
Energy Use Intensity Metrics	-24	-10	-8	-6	-8	-4	-5	-7	-7
Electric Power Sector Metrics	-11	-1	2	0	5	12	19	20	22
Transportation Sector Metrics	-16	-16	-9	-20	-23	-16	-7	-13	-15
Environmental Metrics	-23	-8	-7	-16	-11	-11	2	8	11
Total Weighted Index	**-29**	**-25**	**-21**	**-20**	**-17**	**-13**	**-8**	**-5**	**-7**

NETHERLANDS

The Netherlands has not been ranked higher than 10th or lower than 15th, and in 2016, it was ranked 13th with a total energy security score of 1,054. From 1980 to 2000, scores for the Netherlands fluctuated between about 5% and 15% of the OECD average, with no apparent trend. Since 2000, however, it scores relative to the OECD baseline have gotten progressively worse and in 2016 were 25% higher. The Netherlands has three country-specific metric scores in the top five and five in the bottom five.

The Netherlands plays a key role as a processing, storage, and distribution center for the rest of Europe. Although it produces very little crude oil of its own, it has a large oil refining and storage industry centered on Rotterdam. It therefore imports large volumes of crude oil, both for re-export to other countries in Europe and for refining into finished products. It is, however, among the world's largest net exporters of refined petroleum, which has helped keep its overall oil import risks lower than they would be without these exports.

The Netherlands is, however, a fairly large producer (16th in the world) of natural gas, most of which is produced onshore. As a net exporter of gas, its import risk for this fuel, at "0", is much better than the OECD average. Although it produces coal, the country depends on imports of this fuel to satisfy domestic demand.

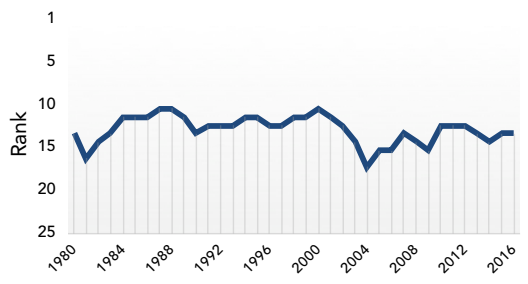
About 80% of the Netherlands electricity generation is from thermal plants fueled by fossil energy. Close to 45% is from natural gas and 35% from coal. Renewables also are playing a larger role in electricity generation, with biomass, waste, and wind combining for about 12% of the total. The Dutch government recently instituted a plan to phase out its production from its 11 coal-fired power plants, with five slated for closure by 2020 and two others sometime after that. Four of these plants, however, may be converted to biomass. The Netherlands, like almost all Western European countries, has comparatively high retail electricity prices, not surprising given the reliance on relatively expensive natural gas to produce electricity.

Turning to Energy Use Intensity and Environmental metrics, the Netherlands per capita energy expenditures, energy use, and carbon dioxide emissions are all ranked in the bottom five. A similar pattern is seen in other countries with comparatively large refining and industrial sectors, such as Norway and Trinidad and Tobago. Its energy intensity scores, however, are generally in the middle of the pack of the large energy user group except for transportation energy intensity, which is ranked third.

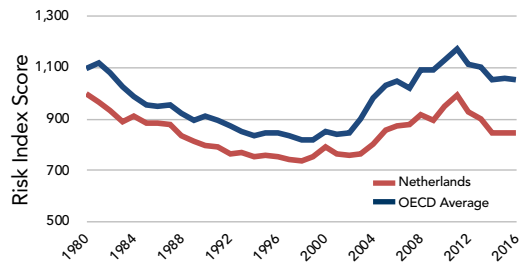
Energy Security Risk Summary: Netherlands

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,054	Average Annual Difference 1980-2016	14.7%
2016 Large Energy User Group Rank	13	Best Relative Score	7% (1986)
Score in Year	1,058	Worst Relative Score	25% (2015)
Rank in Previous Year	13	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,096		
Average Score: 1980-2016	970	Number in Top Five	3
Best Energy Security Risk Score	817 (1998)		
Worst Energy Security Risk Score	1,172 (2011)	Number in Bottom Five	5

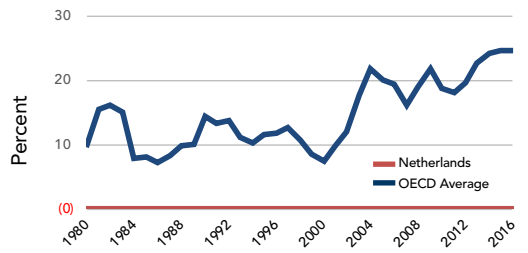
Netherlands: Risk Ranking



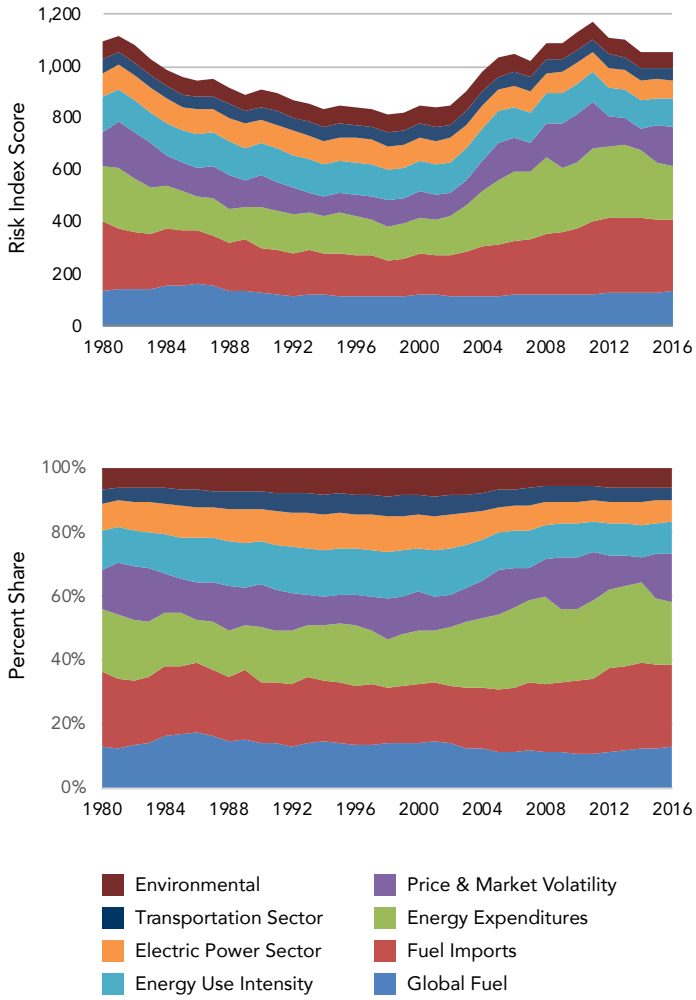
Netherlands vs. OECD: Risk Index Scores



Netherlands: Risk Variance from OECD



Netherlands: Risk Scores by Metric Group and Share of Total Risk by Metric Group



Netherlands vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	54	24	21	16	6	10	35	61	57
Energy Expenditure Metrics	7	11	20	41	35	73	48	53	54
Price & Market Volatility Metrics	-12	-5	32	1	-2	24	4	9	13
Energy Use Intensity Metrics	-3	0	4	2	0	16	17	11	16
Electric Power Sector Metrics	31	47	51	53	48	31	33	32	31
Transportation Sector Metrics	-27	-25	-26	-28	-26	-24	-22	-29	-32
Environmental Metrics	16	15	18	7	8	7	4	11	13
Total Weighted Index	**10**	**8**	**15**	**12**	**7**	**20**	**19**	**25**	**25**

NEW ZEALAND

New Zealand is one of the top performers in the large energy user group, but its scores in recent years have taken it out of the top five in rank. In 2016, it score of 802 earned it a ranking of sixth. New Zealand's total overall risk scores have consistently been well below the OECD baseline average. Since the mid-1990s, however, total risk scores have been trending closer to the OECD average and were about 5% below in 2016. It has four country-specific metrics in the top five of the large energy user group and one in the bottom five.

New Zealand is not a large producer of oil, natural gas, or coal, but it does not have to be because its demand for these products is relatively low compared to other countries in the large energy user group. Domestic oil production must be supplemented with imports, all of which must come in by tanker, but it produces enough natural gas and coal (most of which is exported) to meet domestic needs. New Zealand's import-related risk metrics, therefore, are much better than the OECD average. Its expenditures on energy imports as a share of GDP also are in line with the OECD average.

About 80% of New Zealand's electricity generation came from renewables, with hydroelectric power providing around 55%, other renewables (geothermal and wind) 25%, natural gas 15%, and coal about 5%. The comparatively high level of zero emission electricity output places New Zealand's risk score for non-carbon generation among the top five.

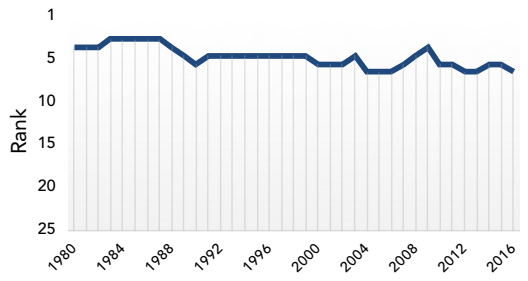
Over most of the period since 1980, New Zealand has benefited from relatively low electricity rates. But since 2000, when its score for this metric was ranked number six in the large energy user group, rising prices caused the country's scores for this metric to slip down the table to number 13 by 2016.

New Zealand also uses slightly more energy, both overall and in the transport sector, to generate a dollar's worth of GDP than the baseline of OECD countries. Its carbon dioxide emissions trend is also somewhat worse than the OECD average, but its emissions intensity and emissions per capita generally track OECD scores.

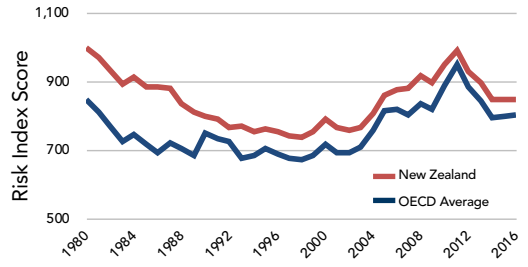
Energy Security Risk Summary: New Zealand

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	802	Average Annual Difference 1980-2016	-10.2%
2016 Large Energy User Group Rank	6	Best Relative Score	-22% (1986)
Score in Year	797	Worst Relative Score	-4% (2011)
Rank in Previous Year	5	**Country-Specific Metric Ranking—2016:**	
Score in 1980	847		
Average Score: 1980-2016	758	Number in Top Five	4
Best Energy Security Risk Score	673 (1998)		
Worst Energy Security Risk Score	950 (2011)	Number in Bottom Five	1

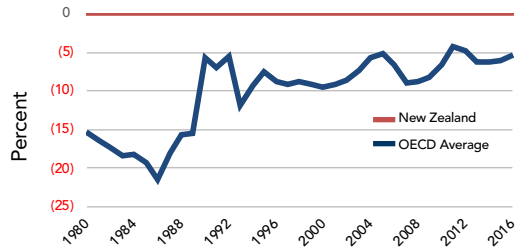
New Zealand: Risk Ranking



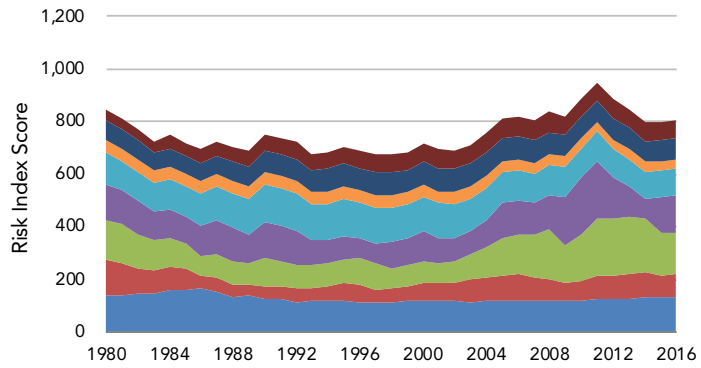
New Zealand vs. OECD: Risk Index Scores

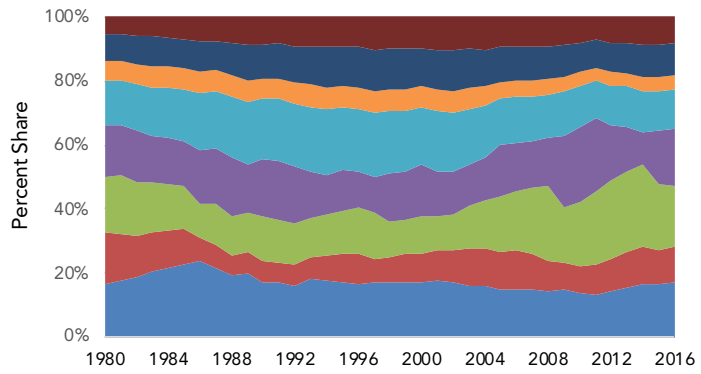


New Zealand: Risk Variance from OECD



New Zealand: Risk Scores by Metric Group and Share of Total Risk by Metric Group



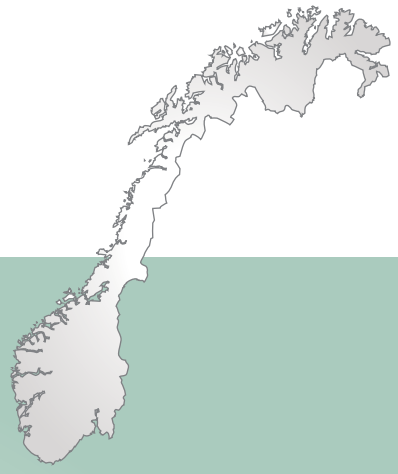


New Zealand vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-21	-52	-66	-53	-55	-47	-60	-51	-49
Energy Expenditure Metrics	-25	-32	-17	-16	-22	1	3	14	14
Price & Market Volatility Metrics	-8	-9	42	15	9	14	17	1	5
Energy Use Intensity Metrics	-16	-6	20	16	13	11	11	8	7
Electric Power Sector Metrics	-29	-26	-24	-20	-26	-30	-36	-37	-37
Transportation Sector Metrics	5	0	27	23	23	24	23	26	26
Environmental Metrics	-26	-10	12	1	6	17	14	21	21
Total Weighted Index	**-15**	**-19**	**-6**	**-7**	**-10**	**-5**	**-7**	**-6**	**-5**

NORWAY



Norway was ranked the most energy secure country in the large energy user group, a position it has held since 2006. It has never ranked lower than third. Norway's 2016 score of 678 was 20% below the OECD average, and its scores have never been less than 12% below the OECD baseline. Norway is not likely to lose its number on ranking anytime soon. The 87-point gap between its first place score and the United States' second place score is large, greater than the gap between the United States and seventh place Canada. Norway scores well in many different metrics and poorly in just a few. The country has 12 scores in the top five and three in the bottom five.

Norway is rich in energy resources. It is the largest producer of crude oil and natural gas in Europe and is a large exporter of both, especially to Europe. It also produces more than enough coal to meet its needs. Oil production has been declining for a couple of decades. Indeed, while world production was increasing 10% from 2009 to 2016, Norway's production was decreasing by about 20% to about 1.6 million barrels per day, well off its peak of 3.2 million barrels per day in 2000. Norway's natural gas output, however, has increased continuously for the past 25 years. Almost all of its production is exported, mostly by pipeline to Europe, where it is the second largest supplier behind Russia. Norway became a net exporter of coal in 2001. Domestically, coal is used primarily for industrial purposes.

Therefore, Norway scores very well in the fuel import measures compared to the OECD baseline. Stable and democratic, Norway also is a reliable supplier of fossil fuels to regional and global markets. Moreover, thanks in large part to its robust energy sector, Norway has the best per capita GDP score of the 25 countries in the major energy user group.

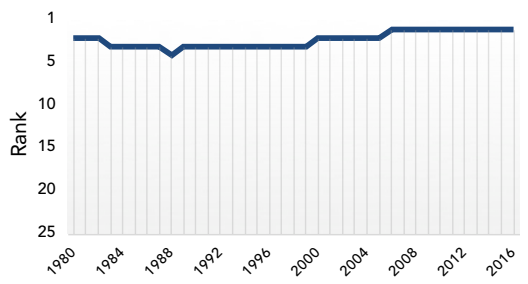
Norway's electricity sector is the least diverse in the group—it ranks last in this metric—with more than 95% of its generation coming from hydroelectric facilities, which makes its electricity supply susceptible to drought-related interruptions. This is balanced, however, by the best score for non-carbon generation. In addition to being a large fuel exporter, Norway also exports between roughly 10% and 15% of the power it generates to neighboring Denmark, Finland, the Netherlands, and Sweden. Its large hydroelectric output means electricity rates are relatively low, and in 2016, it ranked number 10 for this metric with the best score for any Western European country.

Where Norway scores poorest compared to its peers in the large energy user group (other than in electricity capacity diversity) is in per capita energy use (ranked 24th) and per capita transportation energy use (ranked 21st). For a country of just around 5 million people, Norway has large-scale industrial oil and gas facilities that use a lot of energy, including two refineries that produce enough refined products to make Norway a net exporter of refined products. Also, Norway has one of the coldest climates of any country in the large energy user group, so it is not surprising that its per capita energy use—like Canada and Russia's—is high, with large amounts of energy needed for residential and commercial space heating. These risks are moderated somewhat by Norway's relatively good energy intensity score.

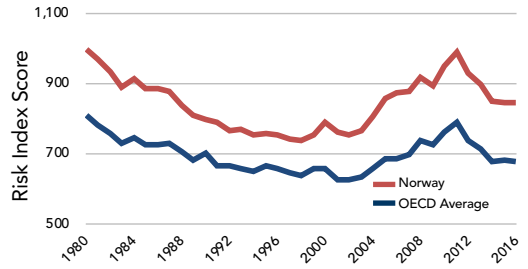
Energy Security Risk Summary: Norway

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	678	Average Annual Difference 1980-2016	-17.2%
2016 Large Energy User Group Rank	1	Best Relative Score	-22% (2006)
Score in Year	683	Worst Relative Score	-12% (1990)
Rank in Previous Year	1	**Country-Specific Metric Ranking—2016:**	
Score in 1980	810	Number in Top Five	12
Average Score: 1980-2016	698	Number in Bottom Five	3
Best Energy Security Risk Score	626 (2002)		
Worst Energy Security Risk Score	810 (1980)		

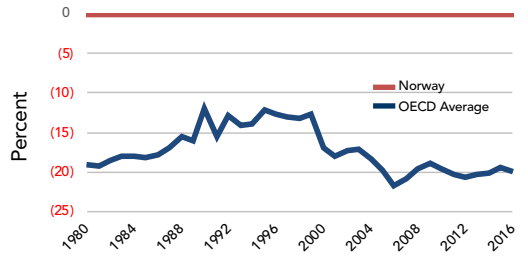
Norway: Risk Ranking



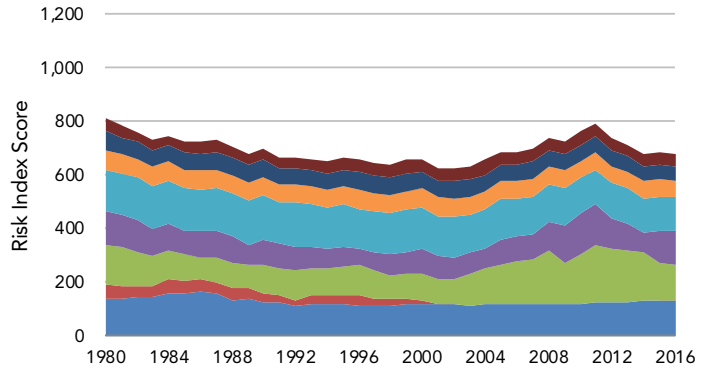
Norway vs. OECD: Risk Index Scores

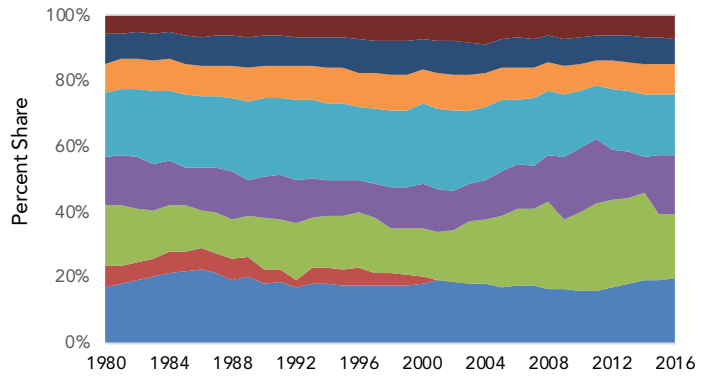


Norway: Risk Variance from OECD



Norway: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Norway vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-70	-74	-79	-76	-90	-100	-100	-100	-100
Energy Expenditure Metrics	-24	-29	-14	-1	-10	4	7	-2	-3
Price & Market Volatility Metrics	-20	-24	-6	-7	-13	-17	-16	-7	-9
Energy Use Intensity Metrics	13	29	41	32	38	42	31	35	35
Electric Power Sector Metrics	1	11	13	17	12	10	8	13	14
Transportation Sector Metrics	7	-2	-1	-13	-13	-14	-5	-15	-17
Environmental Metrics	-26	-23	-22	-28	-27	-27	-21	-18	-15
Total Weighted Index	**-19**	**-18**	**-12**	**-12**	**-17**	**-20**	**-20**	**-19**	**-20**

POLAND

Poland has made steady progress since the collapse of the Soviet Empire in 1992 both in relation to the OECD baseline and in its ranking. It also has the lowest risk scores of the three economies in transition in the large energy user group. Poland's total risk score of 974 puts it in the number 10 position in the ranking for 2016, a position it has held since 2012. From the early 1990s to the mid-2000s, the gap between Poland's and the OECD's risk scores narrowed from more than 30% to less than 15%, and since then, scores have fluctuated generally between 10% and 20%. When considering the group of 20 country specific metrics, most of Poland's scores are in the middle of the pack, with just one score in the top and two scores in bottom five of the large energy user group.

Poland has an abundant coal resource. It is the ninth largest coal producer and consumer in the world and second largest producer and consumer in Europe (after Germany). Coal represents a secure domestic supply of very affordable energy, and it is a source of many jobs in the mining sector. Small amounts of oil and natural gas also are produced, but not nearly enough to meet domestic needs. (Poland has, at least on paper, a fairly large shale gas resource, but exploration results have been disappointing and no shale gas is being produced in commercial quantities.) Fuel Import Exposure risks in 2016 accounted for about 27% of Poland's total risk score, the highest share for this metric category in the record. As Poland has developed, especially since 1992, its demand for oil and natural gas has grown, and these fuels now account for a combined 45% or so of the country's total energy consumption and the increase in Fuel Import Exposure risk scores.

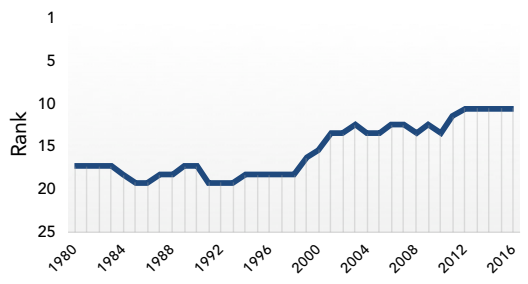
Coal provides a bit more than half of the energy used in Poland, and most of that is consumed in the power sector, where about four-fifths of the electricity is generated at coal-fired power stations. As a result, its 2016 scores for electricity capacity diversity and non-carbon generation are ranked in the bottom five (21st and 22nd, respectively). Although the government has set a goal for renewable generation (about 19% of power generation by 2020), recent reports suggest this goal is not likely to be met. The almost complete reliance on affordable coal for generating electricity has kept Polish electricity prices well below rates for countries in Western Europe. Among European countries in the large energy user group only hydropower-rich Norway had a lower average rate in 2016.

Polish energy demand is expected to increase as its economy grows and develops. Its energy use measures are typical for a country undergoing a transition to a market-based economy. While its energy use per capita scores tend to be better than the OECD average scores for these, its energy intensity scores are worse, though they are improving. Poland's carbon dioxide emissions are still comparatively better than the OECD baseline, reflecting Poland's economic transition, though its carbon dioxide emissions intensity is high by OECD standards. Poland is unlikely to get off coal anytime soon, so the Polish government has taken a keen interest in carbon capture and storage technologies as a way to help reduce emissions.

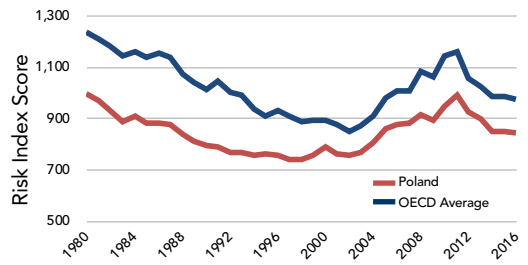
Energy Security Risk Summary: Poland

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	974	Average Annual Difference 1980-2016	21.2%
2016 Large Energy User Group Rank	10	Best Relative Score	12% (2002)
Score in Year	984	Worst Relative Score	32% (1991)
Rank in Previous Year	10	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,236		
Average Score: 1980-2016	1,024	Number in Top Five	1
Best Energy Security Risk Score	849 (2002)		
Worst Energy Security Risk Score	1,236 (1980)	Number in Bottom Five	2

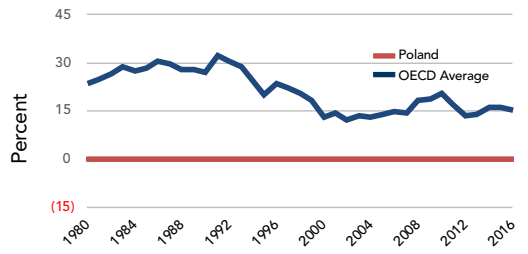
Poland: Risk Ranking



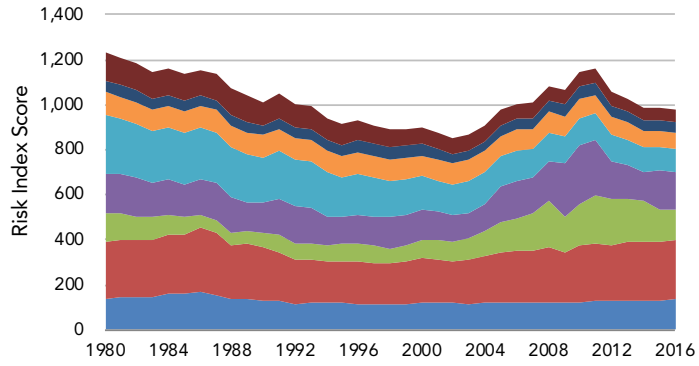
Poland vs. OECD: Risk Index Scores

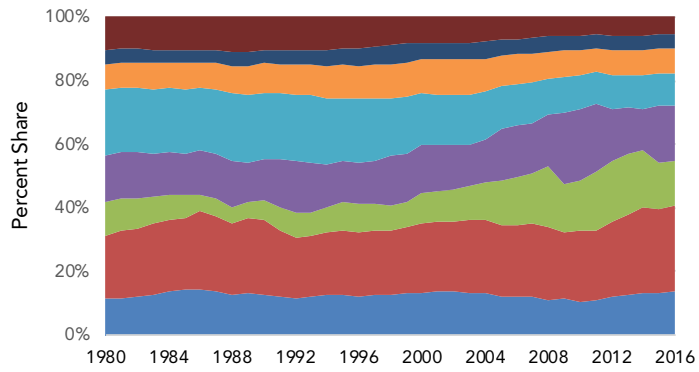


Poland: Risk Variance from OECD



Poland: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Poland vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	46	57	63	31	32	23	34	50	52
Energy Expenditure Metrics	-37	-41	-50	-29	-22	-5	7	-1	-2
Price & Market Volatility Metrics	21	30	39	55	31	38	45	33	26
Energy Use Intensity Metrics	87	85	73	49	24	26	20	8	7
Electric Power Sector Metrics	37	50	57	59	55	54	49	37	36
Transportation Sector Metrics	-26	-29	-34	-35	-32	-32	-19	-30	-31
Environmental Metrics	117	114	86	45	11	5	7	-3	-3
Total Weighted Index	**24**	**28**	**27**	**20**	**13**	**14**	**21**	**16**	**15**

RUSSIAN FEDERATION

Given the energy resources at Russia's disposal—second only to the United States—one would expect Russia to be ranked much higher in the large energy user group than it actually is. That is largely because although Russia has vast amounts of energy, it uses it inefficiently, a hangover from its 60 plus years as a centrally-planned economy. Soon after the collapse of the Soviet Union, Russia's ranking in the large energy user groups was second from bottom. In 2016, it was ranked 12th with a score of 1,027, a rise of 12 places. The country has six country-specific metric scores in the top five (all related to imports) and five in the bottom five (all related to energy usage).

In 2016, Russia was the world's top oil producer, the second largest producer of natural gas, and the sixth largest producer of coal. It produces much more of these fuels than it needs to meet national demand. In addition to having the second largest total conventional energy resource, Russia also has a very large unconventional energy resource. It is no wonder, then, that its total Fuel Import Exposure risk is "0" and has been since 1992. It is the only country in the large energy user group with no fuel import risks since 1980 (only Canada comes close). Because energy exports account for such a big portion, about one-third of its government budget, Russia is susceptible to energy price volatility especially when it results in low energy prices. It is also worth pointing out that despite the large volumes of fuels Russia sells on world markets, its low scores for political and civil liberties make it a potentially unreliable global actor.

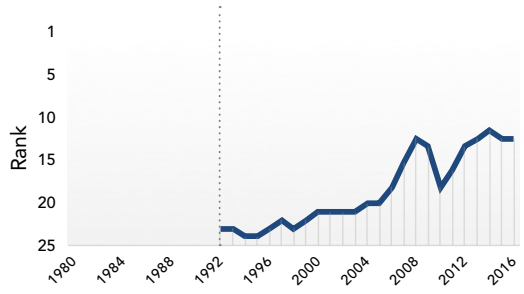
Russia's power sector is largely reliant on fossil fuels, mostly natural gas, which supply about two-thirds of the country's electricity. The remaining third is about evenly divided between hydropower and nuclear. Instead of intermittent renewables, Russia is looking to nuclear as the biggest source of non-emitting power in the future. Thirty-three units are either under construction or planned for completion by 2035. Given the abundance of inexpensive fossil fuels, Russia's electricity prices are on the low side.

Similar to Poland and Ukraine, Russia's energy and emissions per capita scores are pretty good, but its energy and emissions intensity scores are very poor. Russia has an economy with a lot of heavy industry, but after decades of communist rule and the lack of competitive pressures, Russia's industries and economy remain very inefficient. The amount of energy expenditures, overall energy use, petroleum use, transportation energy use, and carbon dioxide emissions per unit of GDP have consistently ranked in the bottom five, and scores for these metrics in 2016 are no exception. These metrics have improved, however, and will continue to do so, which makes it likely Russia will continue to climb the rankings.

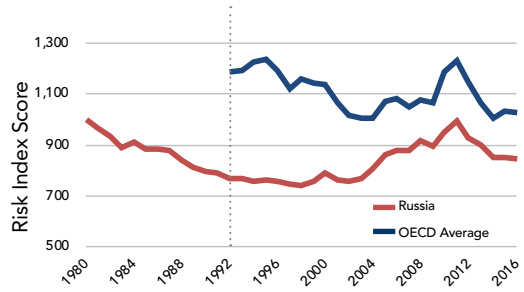
Energy Security Risk Summary: Russia

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,027	Average Annual Difference 1980-2016	35.3%
2016 Large Energy User Group Rank	12	Best Relative Score	-100% (23826)
Score in Year	1,034	Worst Relative Score	63% (1995)
Rank in Previous Year	12	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,187	Number in Top Five	6
Average Score: 1980-2016	1,109		
Best Energy Security Risk Score	0 (23826)	Number in Bottom Five	5
Worst Energy Security Risk Score	1,238 (1995)		

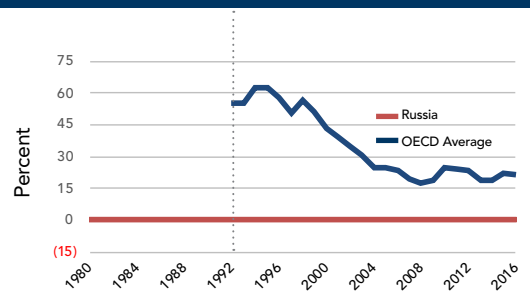
Russia: Risk Ranking



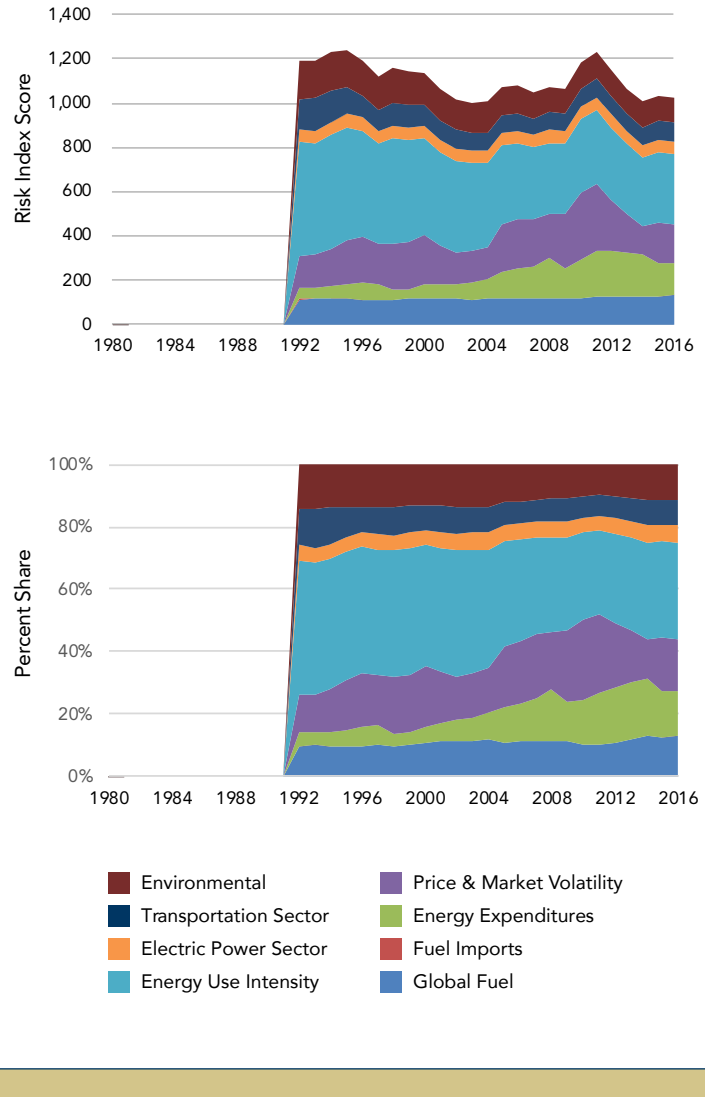
Russia vs. OECD: Risk Index Scores



Russia: Risk Variance from OECD



Russia: Risk Scores by Metric Group and Share of Total Risk by Metric Group

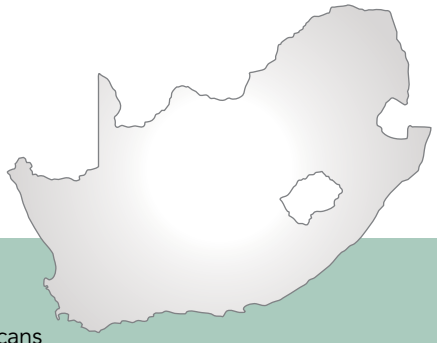


Russia vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	N/A	N/A	N/A	0	0	0	0	0	0
Fuel Import Metrics	N/A	N/A	N/A	-100	-100	-100	-100	-100	-100
Energy Expenditure Metrics	N/A	N/A	N/A	-42	-44	-16	0	5	7
Price & Market Volatility Metrics	N/A	N/A	N/A	160	114	83	70	35	28
Energy Use Intensity Metrics	N/A	N/A	N/A	325	279	239	224	238	240
Electric Power Sector Metrics	N/A	N/A	N/A	-5	-9	-9	-3	1	2
Transportation Sector Metrics	N/A	N/A	N/A	71	31	12	22	34	38
Environmental Metrics	N/A	N/A	N/A	163	127	97	95	104	105
Total Weighted Index	**N/A**	**N/A**	**N/A**	**63**	**44**	**25**	**25**	**22**	**21**

SOUTH AFRICA



South Africa's energy security risk score for 2016 was 1,066 for a ranking of 14. For most of the period from 1980 to 2005, South Africa's risk scores generally tracked about 10% to 20% higher than the OECD average with no discernable trend. From 2005 on, however, its scores have increased compared to the baseline and since about 2010 have fluctuated within a range of 25% to 30% higher. The country has a large energy resource base but exhibits many of the drawbacks typical in a large developing economy. It has four of the 20 country-specific metrics ranked in each of the top five and the bottom five.

South Africa, the largest economy in Africa, is rich in coal—it is the world's sixth largest producer—but produces relatively little oil and natural gas. Coal provides about 70% of South Africa's energy supply, and about one-quarter of its coal output is exported primarily to Europe, China, and India. The country also built the world's first commercial coal-to-liquids facility (China has since built some as well) with a production capacity of 160,000 barrels per day of liquids. More coal-to-liquids capacity is being put on hold pending the development of cost-effective carbon capture and storage technologies. The country has relatively small proved reserves of (offshore) oil and natural gas, so it relies on imports to meet demand for these products. In 2006, South Africa's natural gas import risk rose sharply as the country began importing that fuel by pipeline from neighboring Mozambique. Largely as a result of this, Fuel Import Exposure risks have increased their combined share of total risk to 25% from less than 10%. South Africa may have a fairly large shale gas resource that could, if developed successfully, lower its import-related risks significantly.

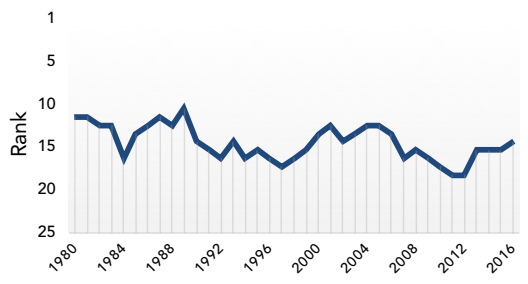
About 90% of South Africans have access to power, one of the highest rates in Africa. Coal dominates the power sector, accounting for well more than about 90% of generation. South Africa has in recent years added large amounts of capacity. Despite these additions, the margin between peak demand and capacity is quite small, and its grid operates under severe constraints. Most of the remaining electricity demand is supplied by nuclear power and hydropower. The predominance of coal in the power sector puts both South Africa's 2016 electricity capacity diversity and non-carbon generation risk scores second from the bottom (only Norway's and Indonesia's rankings, respectively, are lower for these metrics). Its average retail electricity price, however, was estimated to be the best in the group.

South Africa has a growing middle class, a large mining sector, and other energy-intensive industries, all of which increase the country's energy use. Scores for the individual metrics in the Energy Use Intensity and Environmental categories for South Africa tend to follow a familiar pattern. Per capita metric scores are in general lower than the OECD average while intensity metrics tend to have higher relative scores. In South Africa's case, risk scores from Energy Use Intensity grew from roughly 15% of total risk in the 1980s to the 25% range in the late 1990s and early 2000s. As the country has developed further, however, these scores came back down to 2016's range of roughly 15%. Most of the emerging economies in our large energy user group also are increasing their carbon dioxide emissions, and South Africa is no exception.

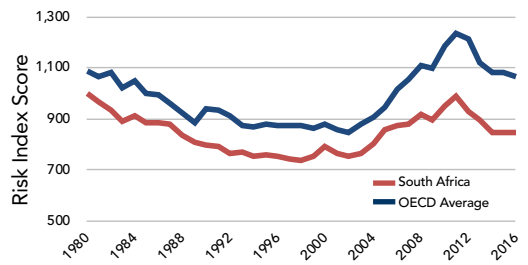
Energy Security Risk Summary: South Africa

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,066	Average Annual Difference 1980-2016	16.8%
2016 Large Energy User Group Rank	14	Best Relative Score	9% (1980)
Score in Year	1,080	Worst Relative Score	30% (2012)
Rank in Previous Year	15	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,087		
Average Score: 1980-2016	988	Number in Top Five	4
Best Energy Security Risk Score	849 (2002)		
Worst Energy Security Risk Score	1,233 (2011)	Number in Bottom Five	5

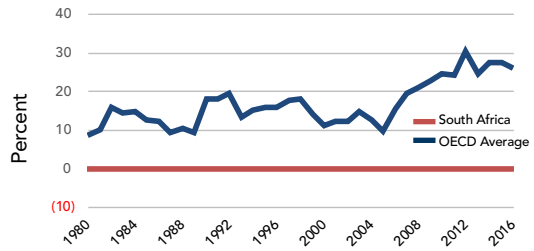
South Africa: Risk Ranking



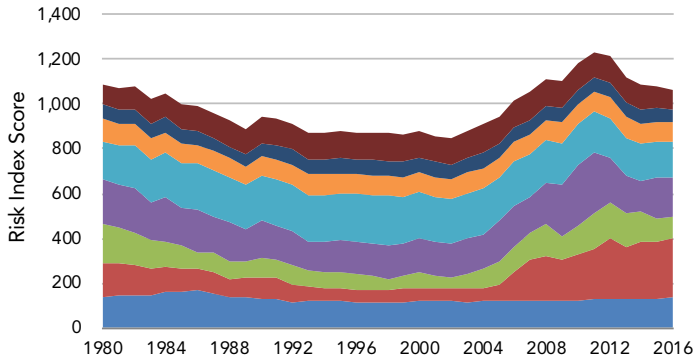
South Africa vs. OECD: Risk Index Scores

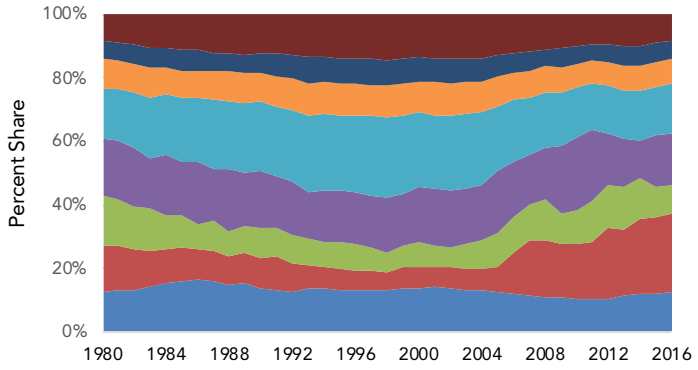


South Africa: Risk Variance from OECD



South Africa: Risk Scores by Metric Group and Share of Total Risk by Metric Group



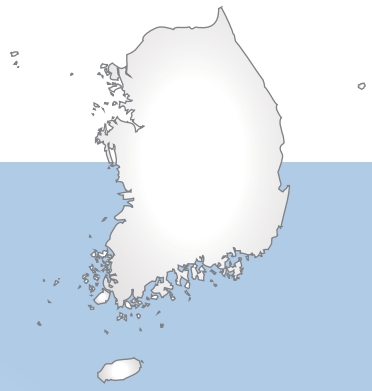


South Africa vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-10	-36	-35	-59	-60	-59	10	49	52
Energy Expenditure Metrics	-14	-30	-30	-35	-35	-28	-26	-28	-30
Price & Market Volatility Metrics	32	52	78	85	45	58	51	34	28
Energy Use Intensity Metrics	23	62	70	76	79	83	80	76	77
Electric Power Sector Metrics	41	39	44	47	45	47	53	53	54
Transportation Sector Metrics	-11	-1	-14	-2	-8	-9	-2	1	-1
Environmental Metrics	53	103	105	91	86	80	92	72	55
Total Weighted Index	**9**	**13**	**18**	**16**	**11**	**10**	**25**	**27**	**26**

SOUTH KOREA



South Korea has many energy security challenges, not least of which is its almost total lack of domestic energy resources. In 2016, its total energy security risk score, 1,389 points, was third from bottom at number 23. It has been ranked 23rd since 2001, and has never ranked higher than 21st. Its 2016 score is nearly 65% higher than the OECD average—the highest it has ever been. In 2016, it had one country-specific metric scores in the top five for the large energy user group and nine in the bottom five, mostly related to import risks.

South Korea is one of the world's largest energy consumers (ninth), but it must rely on imports for practically all of its energy needs, making it one of the world's largest energy importers. It produces very small amounts of crude oil, natural gas, and coal. It is the world's second largest importer of LNG behind Japan and third largest coal importer behind Japan and China. Since 1980, metrics in the Fuel Import Exposure category typically accounted for 35% to 40% of the country's total risk score (it was 37% in 2016). Its 2016 import exposure scores for oil, natural gas, total energy and its energy expenditure and energy expenditures per capita scores are all ranked in the bottom five for the large energy user group. To compensate for its lack of resources, many South Korean energy companies conduct exploration and production operations overseas.

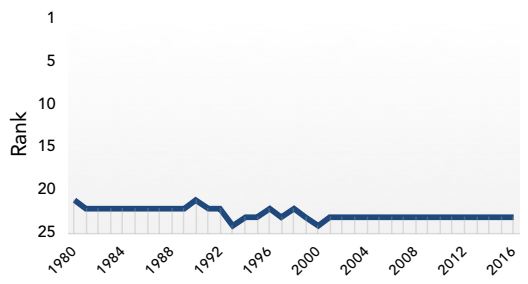
South Korea's power sector is fairly diverse, with risk measures of power sector diversity and non-carbon emitting generation being comparable to the OECD average. Fossil fuels—mostly coal—are used to generate about 70% of power the country's power, nuclear about 30%. Renewables account for a small fraction of generation. Construction in the 1980s of nuclear capacity has lowered the need for as much natural gas, which has lowered natural gas import risk scores below where they would have been without these plants. Even though South Korea imports almost all of its energy, the country's large use of coal for power generation means its score for average retail electricity rate in 2016 was better than the scores for all but five countries in the large energy user group.

South Korea is a highly industrialized economy with lots of oil refining and energy-intensive industry. Its Energy Use Intensity group and Environmental group metric scores trend higher than their OECD averages. The country's Transportation Sector metrics, however, are a bright spot, as these combined scores for this category tends to run below the OECD average, though the difference has narrowed as South Korea has developed.

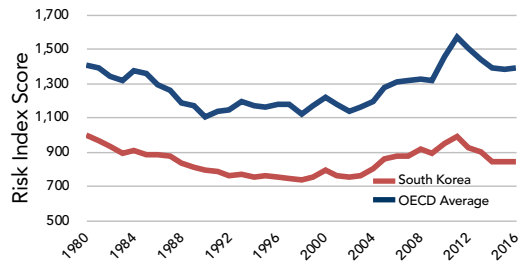
Energy Security Risk Summary: South Korea

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,389	Average Annual Difference 1980-2016	51.2%
2016 Large Energy User Group Rank	23	Best Relative Score	38% (1990)
Score in Year	1,386	Worst Relative Score	64% (2016)
Rank in Previous Year	23	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,409		
Average Score: 1980-2016	1,277	Number in Top Five	0
Best Energy Security Risk Score	1,103 (1990)		
Worst Energy Security Risk Score	1,566 (2011)	Number in Bottom Five	9

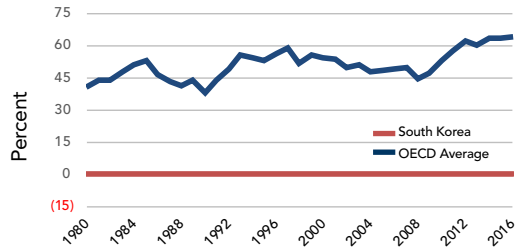
South Korea: Risk Ranking



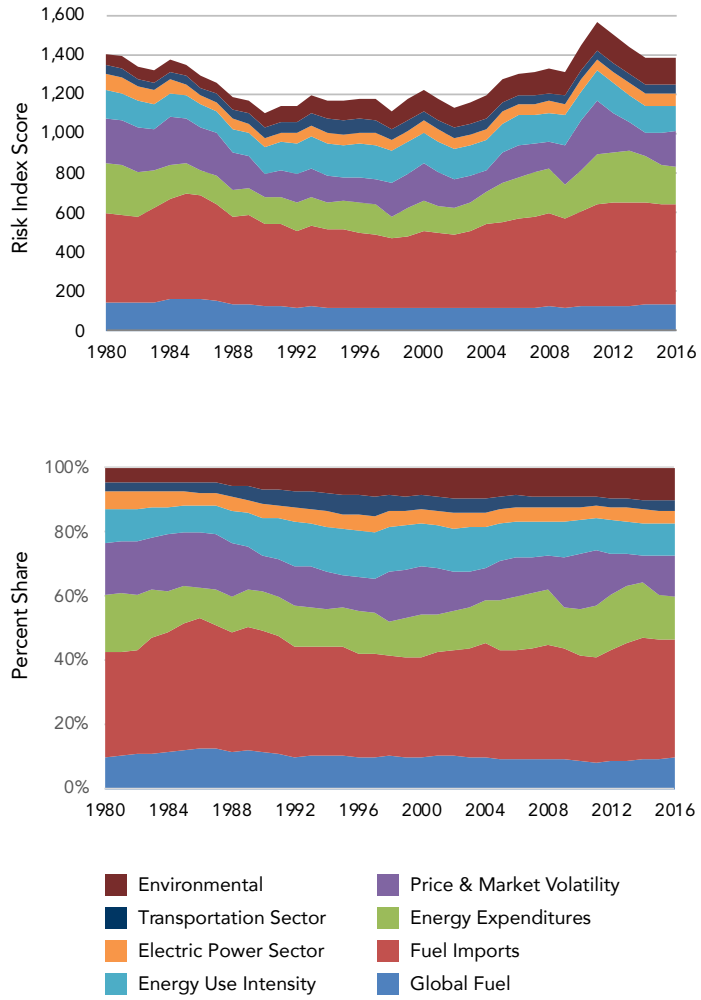
South Korea vs. OECD: Risk Index Scores



South Korea: Risk Variance from OECD



South Korea: Risk Scores by Metric Group and Share of Total Risk by Metric Group



South Korea vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	171	224	184	184	157	141	155	196	194
Energy Expenditure Metrics	24	10	7	30	51	38	24	37	37
Price & Market Volatility Metrics	54	106	28	52	77	34	40	27	32
Energy Use Intensity Metrics	5	-6	11	38	38	44	47	45	44
Electric Power Sector Metrics	13	-10	-24	-8	-9	-8	3	6	7
Transportation Sector Metrics	-43	-40	-18	1	-26	-31	-33	-28	-28
Environmental Metrics	4	12	28	52	62	76	114	145	152
Total Weighted Index	**41**	**53**	**38**	**53**	**54**	**49**	**53**	**63**	**64**

SPAIN

Of the Western European countries in the large energy user group, only Italy has a lower ranking than Spain in 2016. Spain's overall energy security risk score of 1,096 puts it in16th place. From about 1980 to 2000, Spanish scores tended to move in tandem with the OECD average within a band roughly 10% to 15% higher. Since 2000, its scores have worsened vis-à-vis the OECD's and its 2016 total score is 30% higher. Spain has just one metric in the top five of the large energy user group in 2016 and four in the bottom five.

Fuel Import Exposure risks have constituted the largest source of risk for Spain—it has never dropped below 31%—and in 2016 accounted for 41% of its total risk score. Spain produces almost no oil or natural gas and little coal (which it is phasing out). It must, therefore, import the lion's share of its domestic demand. Spanish law caps the share of oil or natural gas imported from any single source country as a way to maintain supply diversity. Algeria is the country's largest supplier of natural gas. In addition, Spain has seven LNG facilities with a total of 2.4 trillion cubic feet of regasification capacity, the largest in Europe.

As a result of its large imports, its fossil fuel import risks are comparatively large, as is the amount it pays for these imports as a share of GDP. Spain's country-specific metrics measuring oil, gas, and total import exposure were in the bottom five of the large energy user group in 2016.

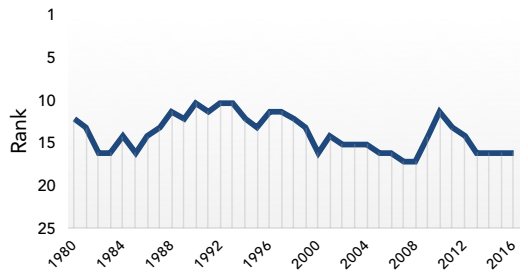
Spain has the most diverse power generation sector of any country in the in the large energy user group. A mix of fossil fuels (mostly natural gas and coal) are used to generate about 45% Spain's electricity while renewables supply about 25%, nuclear 20%, and hydropower 10%. This large supply of zero-emissions power puts Spain in sixth position for the non-carbon generation metric. While the diversity of Spain's power sector is an asset, its electricity prices are quite high, with the risk score for this metric coming in at number 22 in 2016, just ahead of Italy, Germany, and Denmark.

Spain scores relatively well in the energy use risk categories. It generally has had a smaller energy intensity score than the OECD average, and this has helped moderate the impact of rising energy costs. Meanwhile, its carbon dioxide emissions have moved largely in step with the OECD average.

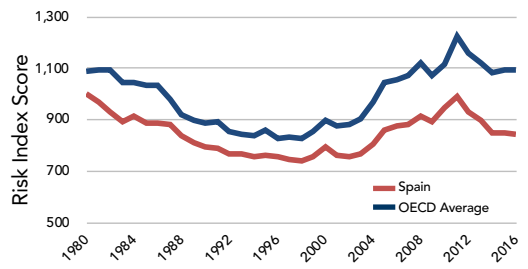
Energy Security Risk Summary: Spain

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,096	Average Annual Difference 1980-2016	16.7%
2016 Large Energy User Group Rank	16	Best Relative Score	9% (1980)
Score in Year	1,094	Worst Relative Score	30% (2016)
Rank in Previous Year	16	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,088		
Average Score: 1980-2016	988	Number in Top Five	1
Best Energy Security Risk Score	826 (1996)		
Worst Energy Security Risk Score	1,223 (2011)	Number in Bottom Five	4

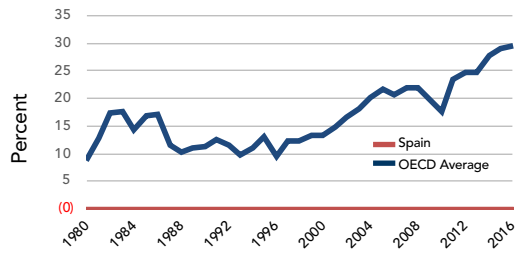
Spain: Risk Ranking



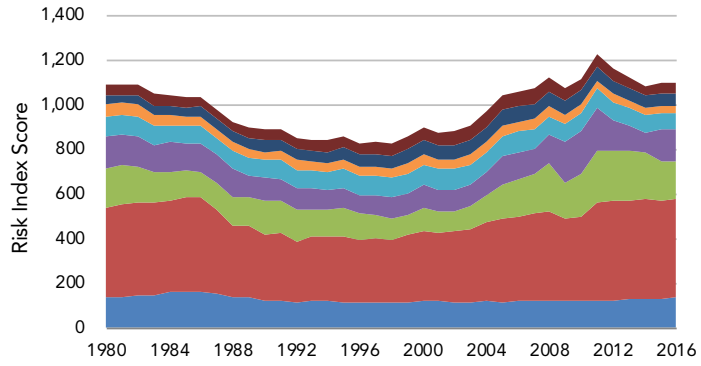
Spain vs. OECD: Risk Index Scores

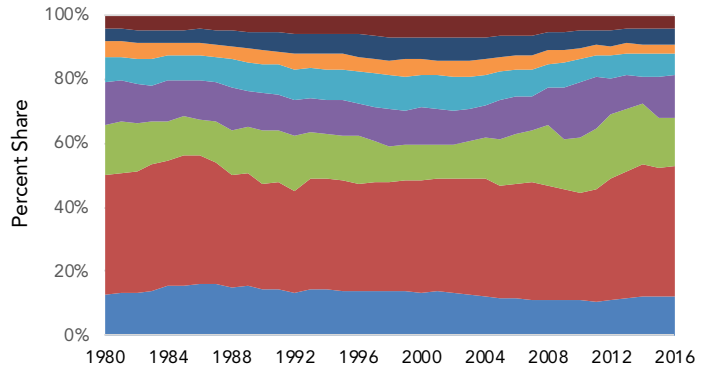


Spain: Risk Variance from OECD



Spain: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Spain vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	137	155	100	112	112	106	99	156	156
Energy Expenditure Metrics	-13	-12	17	11	-6	7	13	19	20
Price & Market Volatility Metrics	-5	6	8	21	0	9	7	9	8
Energy Use Intensity Metrics	-40	-36	-33	-30	-20	-11	-18	-20	-21
Electric Power Sector Metrics	-19	-34	-37	-31	-29	-22	-38	-40	-38
Transportation Sector Metrics	-40	-35	-24	-24	-12	-4	-8	-17	-18
Environmental Metrics	-25	-16	-16	-20	-7	3	-12	-17	-13
Total Weighted Index	**9**	**17**	**11**	**13**	**13**	**22**	**18**	**29**	**30**

THAILAND

Thailand's 2016 score of 1,556 places it in 24th place, a position it has held since 2001. From about 1990 on, Thailand's energy security risks have worsened steadily relative to the OECD baseline, from about 25% higher to nearly 85% higher. Only the spread between Ukraine and the OECD is larger, but Ukraine has been narrowing its gap whereas Thailand has been increasing its gap. Thailand has no country-specific metric scores in the top five and 11 in the bottom five, the worst showing of any country in the large energy user group.

Thailand produces small amounts of crude oil, natural gas, and coal, but it must import all of these fuels to satisfy domestic demand. The country has a relatively large amount of oil refining (with a total throughput capacity of 1.2 million barrels per day), and it is a net exporter of refined products to other countries in the region, which reduces its overall oil import risk. It also produces liquid biofuels. Although natural gas production has grown, domestic supplies have not been enough to meet demand since 1999. Thailand also produces substantial amounts of coal—it is ranked second in Southeast Asia after Indonesia—but since 2004 it has relied on imports to supplement domestic production, mainly for industrial purposes. Except for coal, Thailand's fuel import risks are not too far apart from the OECD average. The country, however, spends much larger amounts on imported fuels as a share of GDP than other countries in the large energy user group—it is ranked 24th for this metric. This is not only because of the relatively large volume of imports Thailand needs but also because its uses energy comparatively inefficiently.

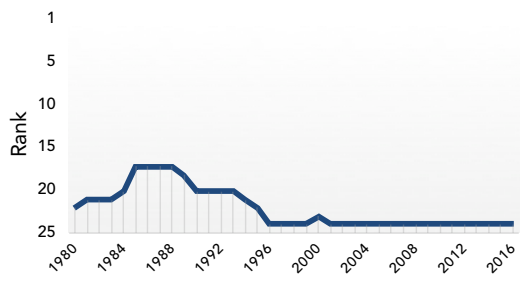
In 2016, about 70% of Thailand's electricity generating capacity was fired using natural gas and 20% using coal (it also imports coal-generated electricity from neighboring Laos's new Hongsa power station). More coal capacity is in the works to reduce the reliance of imported gas for power generation. Oil-fired plants, which decades ago accounted for about 30% of total generation, have been all but phased out. The cost of electricity is one of the few areas where Thailand appears to compare favorably with its large energy user group peers, but the data are not as robust as one would like.

Thailand's 2016 scores for the three energy intensity risk metrics—total energy, oil, and transportation energy—and its and carbon dioxide emissions intensity metric are all ranked in the bottom five of the large energy user group. Although the metrics measuring energy use and emissions per capita compare favorably to other countries in the group. Like other developing countries, it is likely that the intensity metrics will begin to improve as the economy modernizes even as per capita risk scores rise as greater prosperity takes hold.

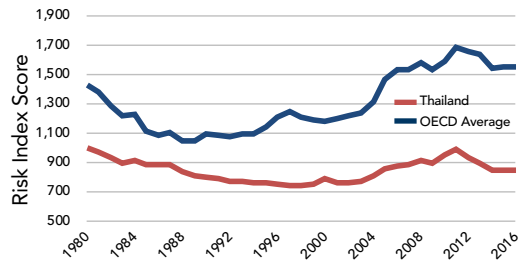
Energy Security Risk Summary: Thailand

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,556	Average Annual Difference 1980-2016	54.9%
2016 Large Energy User Group Rank	24	Best Relative Score	23% (1986)
Score in Year	1,551	Worst Relative Score	84% (2016)
Rank in Previous Year	24	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,431		
Average Score: 1980-2016	1,309	Number in Top Five	0
Best Energy Security Risk Score	1,046 (1988)		
Worst Energy Security Risk Score	1,692 (2011)	Number in Bottom Five	11

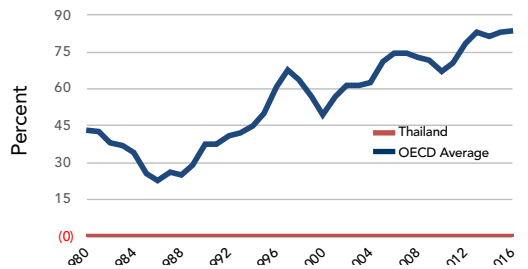
Thailand: Risk Ranking



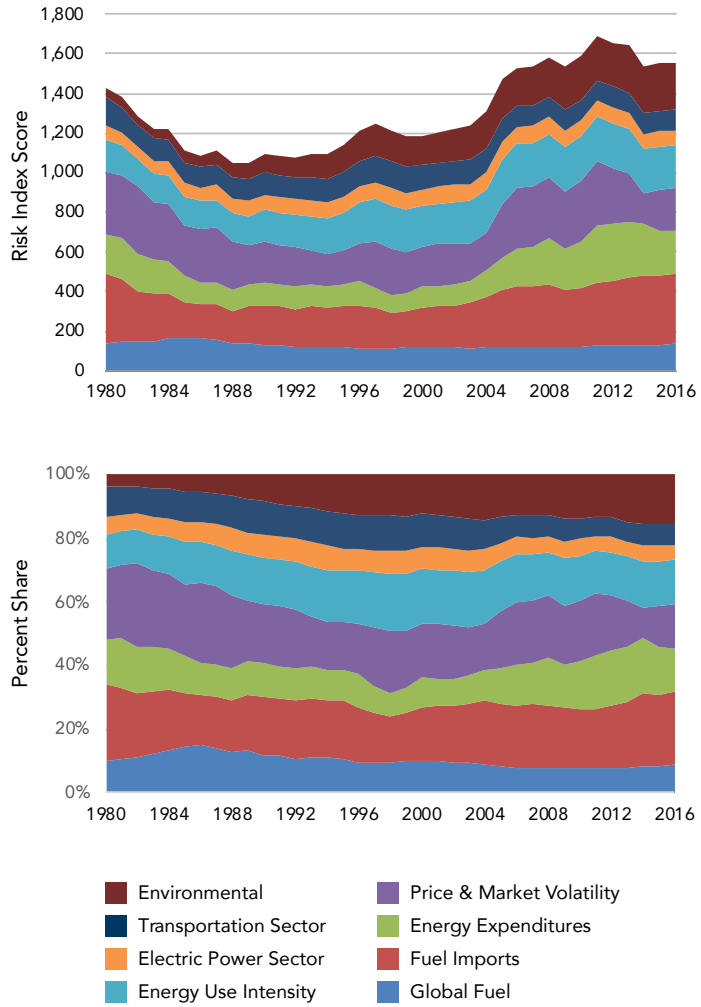
Thailand vs. OECD: Risk Index Scores



Thailand: Risk Variance from OECD



Thailand: Risk Scores by Metric Group and Share of Total Risk by Metric Group



Thailand vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	103	11	38	50	30	61	57	102	104
Energy Expenditure Metrics	2	-3	-10	0	6	15	39	58	59
Price & Market Volatility Metrics	112	125	116	122	90	132	70	55	62
Energy Use Intensity Metrics	12	17	36	55	78	118	116	133	128
Electric Power Sector Metrics	11	13	25	37	38	38	44	40	39
Transportation Sector Metrics	96	63	79	77	74	68	50	65	64
Environmental Metrics	-15	9	64	116	122	197	260	322	326
Total Weighted Index	**43**	**26**	**38**	**50**	**49**	**71**	**67**	**83**	**84**

TURKEY

Turkey's total risk score of 1,198 for 2016 puts it in 22nd place, seven places off its ranking in 2011. From 1980 to the mid-1980s, the country was ranked number six and it risk scores were well below (about 10%) the OECD average. In 1987, however, Turkey's score jumped 152 points owing to a sharp increase in risk related to natural gas imports needed to supply new gas-fired power stations. In that one year Turkey's score went from 7% below the OECD average to 11% above it, a very large swing, and the gap has grown since then. Turkey's 2016 score also was much higher than its 1980 score, meaning its energy security has gotten worse both absolutely and relative to the OECD. Of the 20 country-specific metrics, Turkey has two scores in both the top and bottom five.

Turkey is positioned as a strategic crossroads for energy. It not only is a major transit point for the ocean-going oil trade, but the pipelines that crisscross the country are increasingly important in the movement of oil and natural gas from the Caspian region to Europe.

Turkey produces very small quantities of crude oil and natural gas, but it is a reasonably large coal producer (15th). Production of none of these fuels is sufficient to satisfy domestic demand. Turkey has been a net importer of oil and coal since before 1980, and it became a net importer of natural gas in 1987 after it added natural gas-fired generation capacity in its power sector. Fuel Import Exposure risk scores for Turkey have accounted for a growing share of the country's overall risk. EIA reports that Turkey could have as much as 24 trillion cubic feet of technically recoverable shale gas and also is looking at potentially large reserves of natural gas offshore.

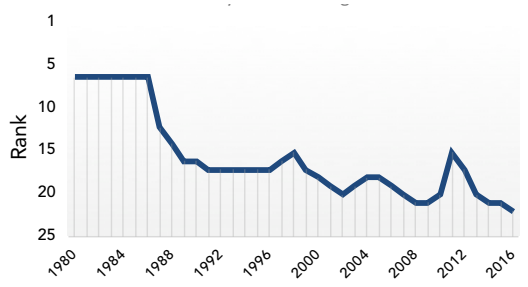
Turkey's demand for electricity has been growing rapidly. Fossil fuels are used to generate about four-fifths of Turkey's electricity, with natural gas accounting for about 45% of the total and coal 30% or so. Hydropower adds about 25% and other renewables make up the rest. Turkey has no nuclear reactors, but two plants are in the works. Turkey also is planning to add between 25 and 30 gigawatts of coal-fired generating capacity. Retail electricity prices in Turkey were once comparatively low but began trending higher in the late 1990s and now rank about 18th.

In addition to Fuel Import Exposure risks becoming a much bigger aspect of Turkey's overall risk scores, Environmental metrics also have increased, both absolutely and as a share of overall risk. Whereas these metrics once collectively accounted for less than 5% of total risk, they now account for 10%. Also, while energy use intensity metrics do not compare well to the OECD average, scores for this category have begun to head in a more positive direction, if slowly.

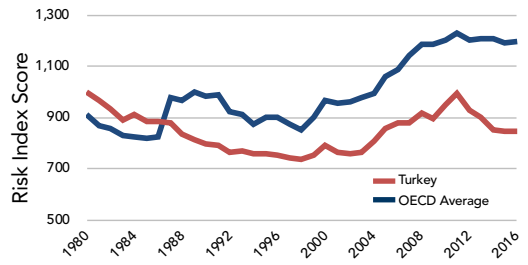
Energy Security Risk Summary: Turkey

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,198	Average Annual Difference 1980-2016	18.5%
2016 Large Energy User Group Rank	22	Best Relative Score	-10% (1981)
Score in Year	1,193	Worst Relative Score	42% (2014)
Rank in Previous Year	21	**Country-Specific Metric Ranking—2016:**	
Score in 1980	914		
Average Score: 1980-2016	998	Number in Top Five	2
Best Energy Security Risk Score	816 (1985)		
Worst Energy Security Risk Score	1,229 (2011)	Number in Bottom Five	2

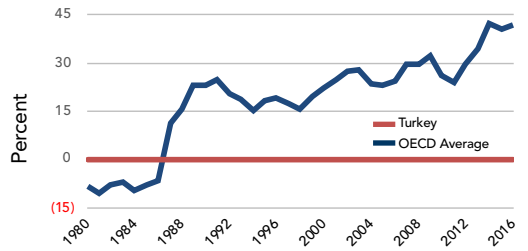
Turkey: Risk Ranking



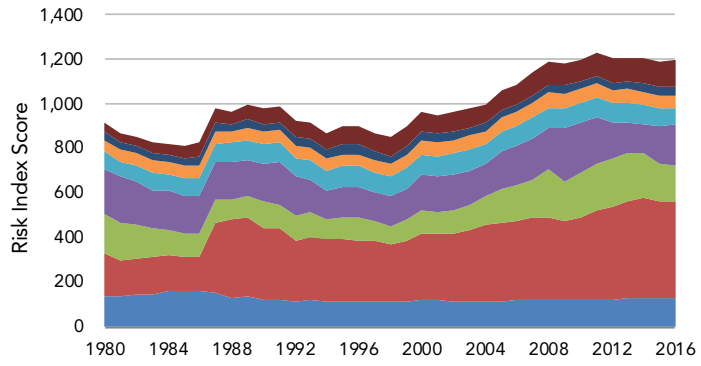
Turkey vs. OECD: Risk Index Scores

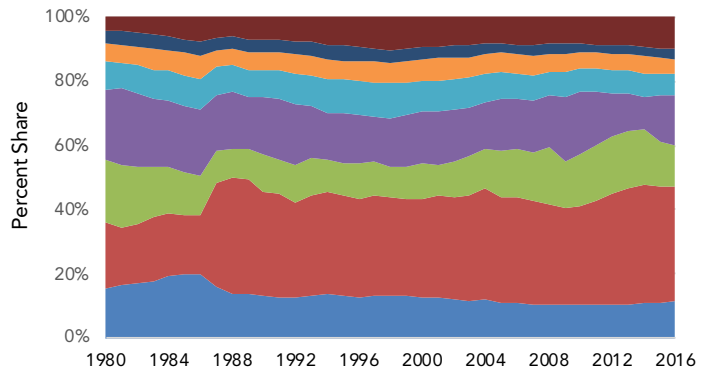


Turkey: Risk Variance from OECD



Turkey: Risk Scores by Metric Group and Share of Total Risk by Metric Group





Turkey vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	11	-8	118	101	102	93	98	151	148
Energy Expenditure Metrics	-10	-22	-9	-17	-2	7	14	15	14
Price & Market Volatility Metrics	32	51	82	82	51	48	28	29	35
Energy Use Intensity Metrics	-42	-37	-28	-22	-19	-18	-15	-13	-14
Electric Power Sector Metrics	-26	-9	-11	-11	2	5	5	7	4
Transportation Sector Metrics	-53	-47	-39	-39	-50	-54	-49	-39	-37
Environmental Metrics	-32	0	19	23	42	31	57	101	110
Total Weighted Index	**-7**	**-7**	**24**	**19**	**23**	**24**	**27**	**42**	**43**

UKRAINE

Since 1992, the first year for which data are available for Ukraine, the country has been ranked last with by far the worst energy security index scores of any country in the large energy user group. Its scores over the period from 1980 to 2016 averaged 177% higher than those for the OECD. However, Ukraine's overall risk scores, both nominally and in relation to the OECD baseline, have been trending downward. From its 1995 peak of 2,689 points—254% above the OECD average—the country's total risk score fell to 1,842 in 2016. While greatly improved, it is still almost 120% above the OECD average. Despite its last-place ranking, Ukraine still has two metric scores in the top five but eight in the bottom five.

Ukraine is positioned between Russia and Europe, making it an important transit country for natural gas and crude oil flowing west from Russia. Ukraine produces small amounts of crude oil and natural gas, and it is the 13th largest coal producer. Nevertheless, there is nowhere near enough of any of these fuels to satisfy domestic needs, a situation that hasn't changed much since 1992. Risk scores in the Fuel Import Exposure category accounted for about 25% of its total risk score. These import risk scores are liable to rise in the future, especially for coal. Ukraine's coal production is located in the eastern part of the country that is being contested by pro-Russian separatists. This has caused a sharp decline in coal output, leading to power outages owing to lack of fuel supplies and higher import levels (ironically from Russia, the source of the unrest). Recently, Ukraine's state-run utility agreed to import coal from the United States, which should reduce the need for Russian coal, an important political consideration.

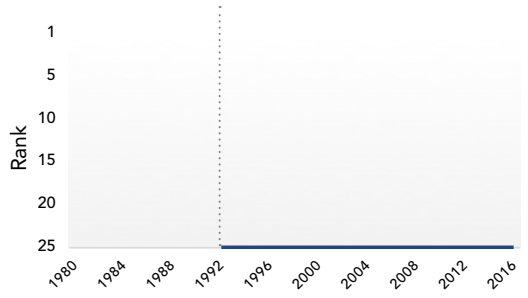
Ukraine's power sector relies on two main sources of generation. It gets about 50% of its electricity from 15 nuclear reactors and another 40% or so from coal-fired power stations. The remainder is roughly divided between natural gas and renewables (hydropower). Natural gas used to play a much bigger role in power but has given way to help ease a natural gas supply shortage. Retail electricity prices rank in the middle of the large energy user group.

Ukraine's energy, transportation energy, oil, and carbon intensity scores are among the worst in the large energy user group. Scores for these intensity measures are, however, getting better. The group score for the Energy Use Intensity category, for example, declined from 925 points in 1995—30% of Ukraine's total score—to a significantly better 459 points in 2016—25% of the total score. Indeed, scores for the seven country-specific risk categories all have lower scores in 2016 than in 1992, which suggest Ukraine is addressing its large energy security challenges but still has a long way to go.

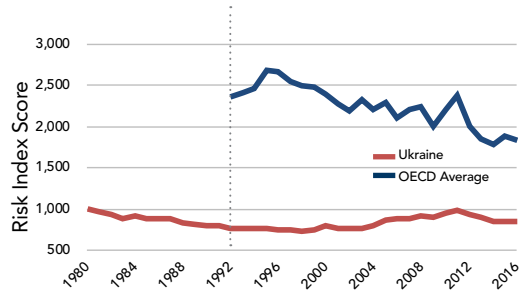
Energy Security Risk Summary: Ukraine

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	1,842	Average Annual Difference 1980-2016	175.9%
2016 Large Energy User Group Rank	25	Best Relative Score	-100% (23826)
Score in Year	1,885	Worst Relative Score	254% (1995)
Rank in Previous Year	25	**Country-Specific Metric Ranking—2016:**	
Score in 1980	2,352		
Average Score: 1980-2016	2,251	Number in Top Five	2
Best Energy Security Risk Score	0 (23826)		
Worst Energy Security Risk Score	2,689 (1995)	Number in Bottom Five	8

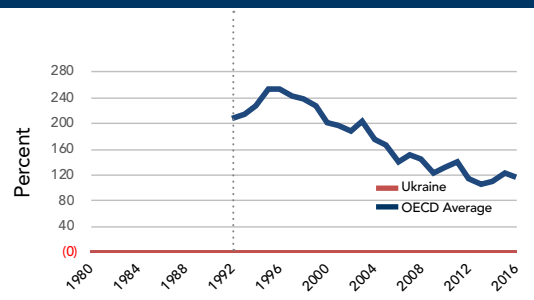
Ukraine: Risk Ranking



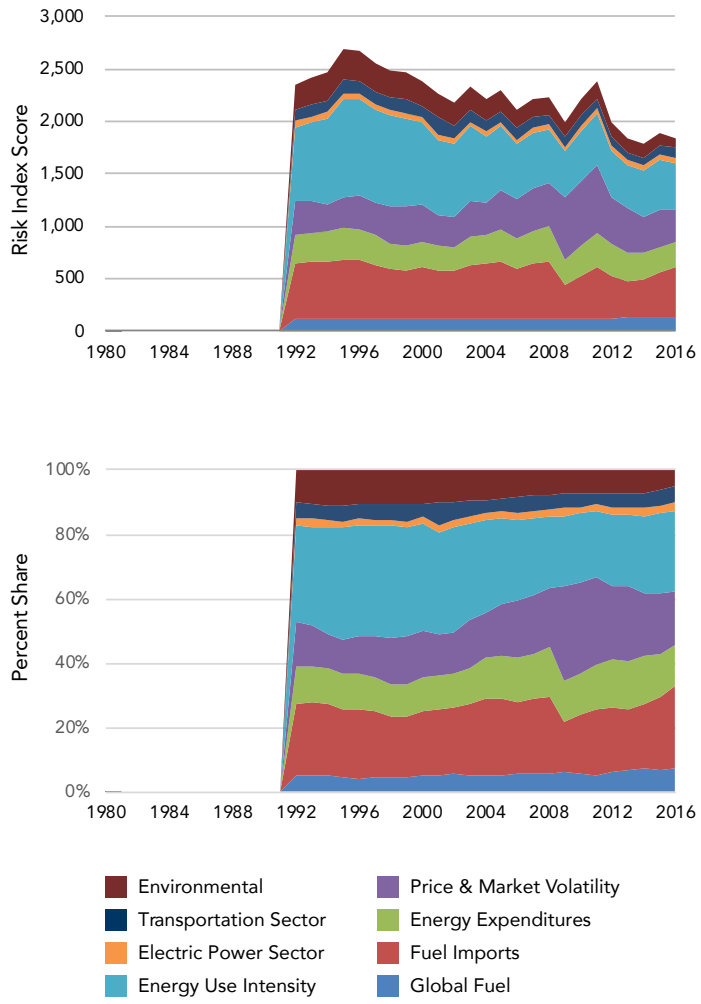
Ukraine vs. OECD: Risk Index Scores



Ukraine: Risk Variance from OECD



Ukraine: Risk Scores by Metric Group and Share of Total Risk by Metric Group



Ukraine vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	N/A	N/A	N/A	0	0	0	0	0	0
Fuel Import Metrics	N/A	N/A	N/A	308	226	204	119	148	171
Energy Expenditure Metrics	N/A	N/A	N/A	165	139	118	66	71	75
Price & Market Volatility Metrics	N/A	N/A	N/A	286	227	218	244	168	124
Energy Use Intensity Metrics	N/A	N/A	N/A	672	583	471	361	402	392
Electric Power Sector Metrics	N/A	N/A	N/A	-12	-19	-22	-21	-16	-15
Transportation Sector Metrics	N/A	N/A	N/A	89	37	41	47	45	44
Environmental Metrics	N/A	N/A	N/A	368	287	202	154	103	74
Total Weighted Index	**N/A**	**N/A**	**N/A**	**368**	**287**	**202**	**154**	**103**	**74**

UNITED KINGDOM

The United Kingdom's total risk scores consistently ranks very high in the large energy user group. It has never been out of the top five, and from 1992 to 2001, it was ranked number one. Its 2016 score of 769—just four points higher than the U.S. score—puts it in third place. When compared to the OECD benchmark average, from 1980 to about 2005 the United Kingdom's relative total risk scores fell from about 10% to 15% below the OECD to nearly 30% below. Over this period, its rank rose from fifth to first. Since 2005, however, the United Kingdom has been losing ground against its peers. In 2016, its total risk score was less than 10% below the OECD baseline, and its ranking fell to number three. Increasing risks related to imports and electricity prices were mainly responsible for the narrowing gap between United Kingdom and OECD scores. The country still scores very well in many areas and has 10 top-five metric scores and no bottom five scores.

The United Kingdom has significant reserves of oil, gas, and coal. Although it is the world's 19th largest producer of both crude oil and natural gas, it is Europe's second and third largest producer of these fuels. While coal production has declined close to 95% since 1980, it is still the eighth largest in Europe. Despite these resources, the United Kingdom is a net (and growing) importer of all of these fuels. The United Kingdom is taking steps to take advantage of a sizeable shale gas resource that EIA estimates may contain as much as 26 trillion cubic feet of natural gas, nearly three times the estimated proved figure of 9 trillion cubic feet. (The British Geological Survey central estimate of 1,300 trillion cubic feet of shale gas is 50 times larger than EIA's.)

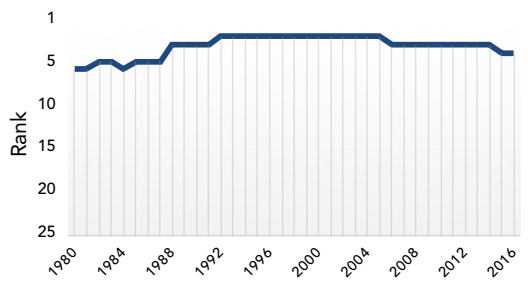
The United Kingdom has a diverse electric power sector ranked sixth. In 2016, fossil fuels (natural gas and coal) accounted for about 50% to 55% of generation, nuclear 20%, and hydropower and other renewables—primarily wind but also biomass—25%. Biomass is burned instead of coal to fire three of six boilers that generate about 70% of the electricity at the nearly 4 gigawatt Drax power station, the United Kingdom's largest. Most of the wood pellets used as fuel are imported from the United States. These developments have contributed to the country's very high electricity rates, which are ranked 20th. This may become an even larger concern in the future as more and more affordable base load capacity is retired and more expensive power generation sources, such as offshore wind, are added to the system.

The United Kingdom uses energy more efficiently than many other countries. Its intensity risk scores for total energy use, petroleum use, transportation sector energy use, as well as carbon dioxide emissions are all ranked in the top five, a big advantage. These trends also keep the country's energy expenditure risks low. Improvement in all of these has helped moderate the United Kingdom's overall risk, but increased imports and retail electricity prices may lead to the United Kingdom continuing to lose ground against it peers.

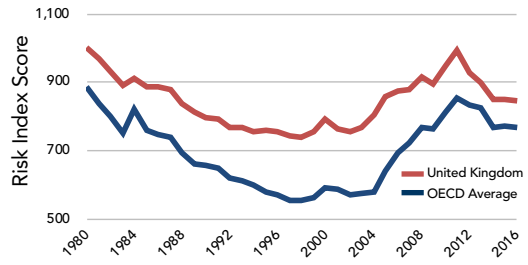
Energy Security Risk Summary: United Kingdom

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	769	Average Annual Difference 1980-2016	-17.8%
2016 Large Energy User Group Rank	3	Best Relative Score	-28% (2004)
Score in Year	771	Worst Relative Score	-8% (2013)
Rank in Previous Year	3	**Country-Specific Metric Ranking—2016:**	
Score in 1980	887	Number in Top Five	10
Average Score: 1980-2016	697		
Best Energy Security Risk Score	556 (1997)	Number in Bottom Five	0
Worst Energy Security Risk Score	887 (1980)		

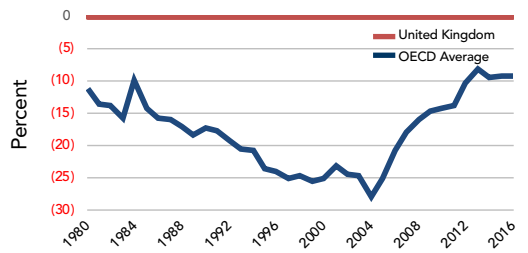
United Kingdom: Risk Ranking



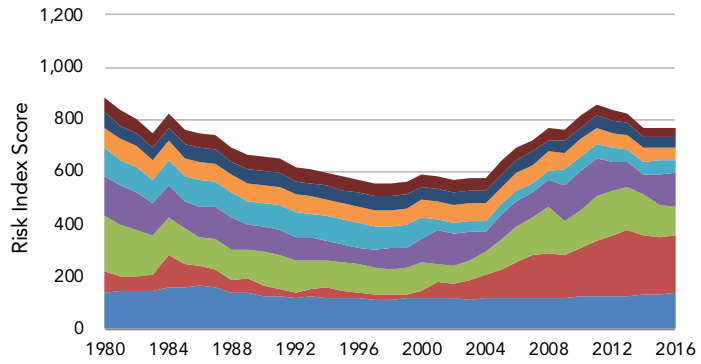
United Kingdom vs. OECD: Risk Index Scores

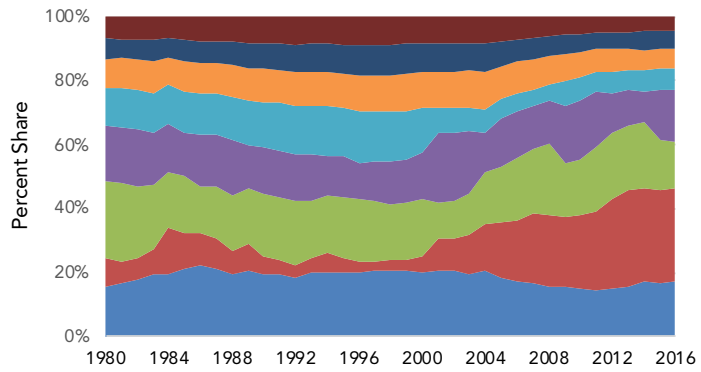


United Kingdom: Risk Variance from OECD



United Kingdom: Risk Scores by Metric Group and Share of Total Risk by Metric Group





United Kingdom vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-54	-48	-73	-82	-81	-39	1	28	27
Energy Expenditure Metrics	5	-5	0	-2	-1	-19	-17	-16	-15
Price & Market Volatility Metrics	3	-6	1	-4	-15	-19	-18	-9	-9
Energy Use Intensity Metrics	-24	-21	-22	-25	-29	-61	-43	-45	-45
Electric Power Sector Metrics	16	12	13	5	9	7	13	-12	-13
Transportation Sector Metrics	-20	-22	-17	-28	-25	-28	-31	-31	-31
Environmental Metrics	1	-1	-6	-21	-26	-27	-30	-40	-41
Total Weighted Index	**-11**	**-14**	**-17**	**-24**	**-25**	**-25**	**-14**	**-9**	**-9**

UNITED STATES

Note: It should be emphasized that the index data presented here and the index data presented in the Energy Institute's U.S. Index of necessity measure different things and are not strictly comparable, though the general trend is substantially the same. Moreover, the concern in this section is primarily with U.S. energy security risks in reference to those of the OECD average and other large energy users over time.

The United States' total risk score of 765 in 2016 was one point higher than the record low international risk score set in 2015. It was ranked second in both years. The shale revolution in the United States has sent the country's total risk scores tumbling sharply, both absolutely and in comparison to the OECD baseline average. From 1980 to the early 2000s, U.S. risk scores moved within a narrow band 5% to 10% above the OECD average. Over the last fifteen years, its risk scores plunged to about 10% below the OECD average, and its ranking rose six places to second in the large energy user group, a truly remarkable turnaround for such a large developed economy. Of the 20 country-specific metrics, the U.S. ranks in the top five for five of them (related to import risks and energy expenditures and prices) and the bottom five for three of them (related to per capita energy use).

The United States is the world's largest economy and its second largest energy consumer. The country also has the largest hydrocarbon energy reserves of any other country and is the world's largest energy producer. Except for crude oil, the country produces more fuels and other forms of energy than it consumes. In 2016, it was the world's third largest producer of crude oil (after Russia and Saudi Arabia), the largest producer of natural gas, and the second largest producer of coal (after China). Although the United States has been a large importer of crude oil and natural gas for many years, large domestic production of these fuels meant that its Fuel Import Exposure risk scores were favorable when compared to the OECD average. The widespread adoption of hydraulic fracturing, horizontal drilling, and advanced seismic imaging technologies to shale formations unlocked large and growing volumes of crude oil and natural gas and reduced import risks for these fuels even further. Indeed, the country will soon become a net exporter of natural gas. These developments along with long-standing U.S. self-sufficiency in coal have improved U.S. energy security import risks relative to its peers in the large energy user group.

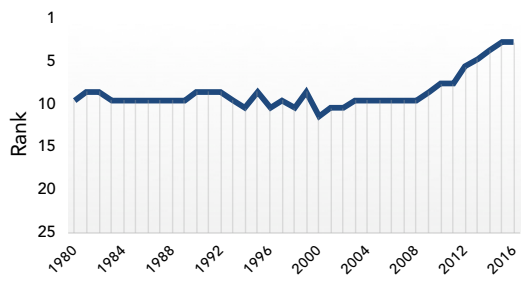
The U.S. power sector is fairly diverse by OECD standards. Coal and natural gas each supply about one-third of generation, with nuclear accounting for nearly 20%, and hydroelectric and other renewables for about 15%. Coal capacity, which once produced more than half of the power generated in the United States two decades ago, has been reduced because of competition from inexpensive gas, renewable subsidies, and regulation. Nuclear power also is experiencing difficulties for some of the same reasons. Both of these trends could have implications for future risk scores. The United States enjoys the lowest average electricity of any developed country in the large energy user group and is ranked seventh overall for this metric.

The United States uses more energy per person than all but two countries in the large energy user group (Canada and Norway), and its per capita emissions of carbon dioxide also are considerably higher than other countries in the group except Canada. Although these three metrics represent the largest source of risk for the United States vis-à-vis the OECD average, all three have shown rapid improvement relative to the OECD baseline over the last decade. The United States also uses generally more energy in the economy at large and in the transportation sector to produce a dollar of GDP, than the OCD average, but the differences are not all that large. The same goes for carbon dioxide intensity. Since 2000, each of these metrics has been improving at about the same rate as the OECD average.

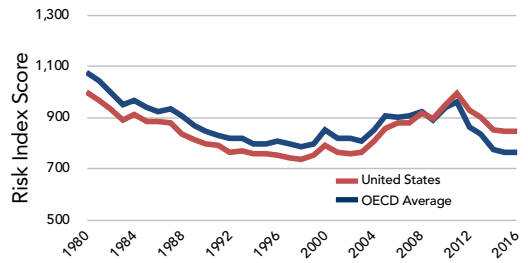
Energy Security Risk Summary: United States

Risk Scores:		**Risk Scores Relative to OECD Average:**	
2016 Energy Security Risk Score	765	Average Annual Difference 1980-2016	3%
2016 Large Energy User Group Rank	2	Best Relative Score	-10% (2015)
Score in Year	764	Worst Relative Score	8% (2002)
Rank in Previous Year	2	**Country-Specific Metric Ranking—2016:**	
Score in 1980	1,078		
Average Score: 1980-2016	872	Number in Top Five	5
Best Energy Security Risk Score	764 (2015)		
Worst Energy Security Risk Score	1,078 (1980)	Number in Bottom Five	3

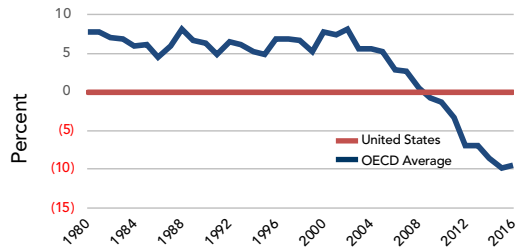
United States: Risk Ranking



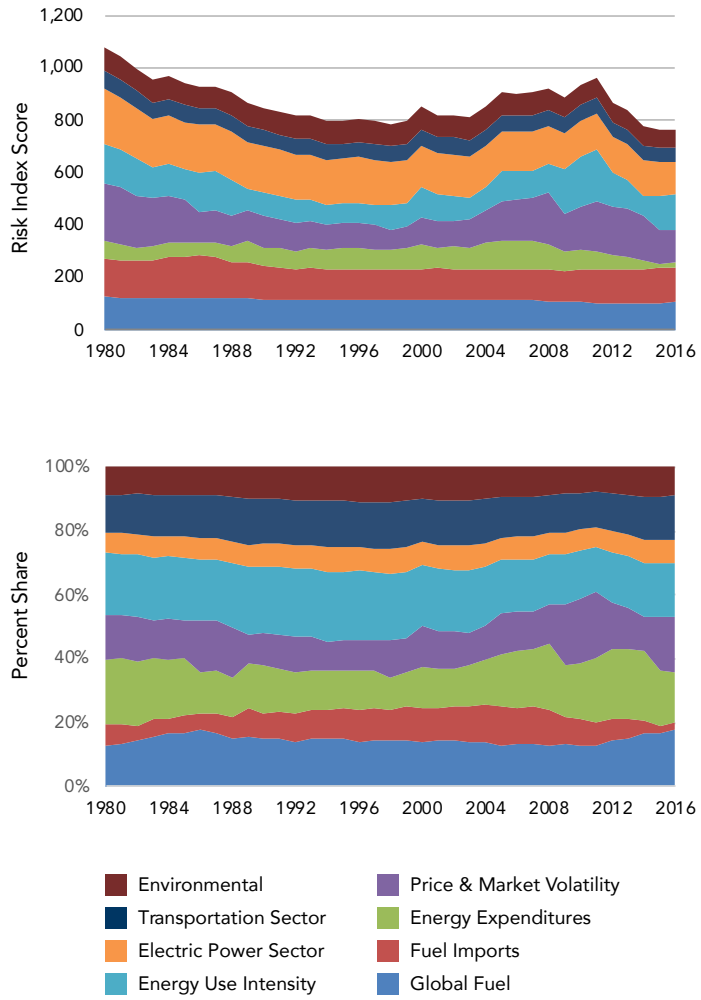
United States vs. OECD: Risk Index Scores



United States: Risk Variance from OECD



United States: Risk Scores by Metric Group and Share of Total Risk by Metric Group



United States vs. OECD: Percent Difference (Weighted Within Group)

(Red Cells ≥10% Above OECD; Green Cells ≤10% Below OECD; White Cells <10% to <-10% of OCED)

Metric Group	1980	1985	1990	1995	2000	2005	2010	2015	2016
Global Fuels Metrics	0	0	0	0	0	0	0	0	0
Fuel Import Metrics	-58	-69	-52	-43	-39	-40	-59	-91	-90
Energy Expenditure Metrics	8	17	-3	-16	1	3	-6	-8	-9
Price & Market Volatility Metrics	1	4	-10	-4	4	1	7	-5	-3
Energy Use Intensity Metrics	51	46	49	43	41	44	37	38	38
Electric Power Sector Metrics	-4	-1	-2	-1	1	4	4	1	1
Transportation Sector Metrics	85	88	84	62	62	64	62	66	69
Environmental Metrics	54	50	51	33	33	28	24	22	20
Total Weighted Index	**8**	**6**	**6**	**5**	**8**	**5**	**-1**	**-10**	**-10**

APPENDIX 1:

METHODOLOGY USED TO DEVELOP THE INDEX OF U.S. ENERGY SECURITY RISK

INTRODUCTION

In an increasingly interconnected world, where the risks faced by other nations affect our risks as well, a well-designed index covering many countries can improve our understanding of global energy security risks. Many aspects of U.S. energy security are by their very nature global. Recent years have seen global energy markets facing unprecedented challenges as well as opportunities. In previous decades, when the U.S. comprised a bigger share of global energy production and consumption, our policies and actions had a bigger impact on global markets. Increasingly, however, geopolitical risks are imposed upon us rather than set by us.

Energy is a fundamental prerequisite of growth and development around the world, and despite the global financial crisis, energy demand has been steadily growing, especially in the large emerging economies of China, India, and Brazil. In large part, energy security is complicated because key energy resources are geopolitically concentrated. Most of the world's oil and gas reserves are found in a handful of countries, several of which are in political turmoil and/or not especially friendly to U.S. interests. Further, there is relatively little overlap between those countries that are the leading energy resource countries and those that are the major energy consuming countries. Reliance on international trade is large, growing, and vulnerable to disruptions. For these global commodities, events anywhere can affect supply and prices everywhere, even for self-sufficient countries. Energy security risks, therefore, pose challenges to all countries—some are common challenges while others are more country-specific.

An enhanced understanding of energy security in other countries can deepen our insight into that of the U.S. Through the development of these metrics, we can observe not only absolute trends of interest, but to also see relative movement among and across countries. In a global marketplace, both matter. Communicating these energy security risks to an international audience helps the U.S. as well. Many of the benefits of improved technologies, greater energy efficiency, or democratic reforms anywhere can create energy security benefits everywhere.

BASIC APPROACH TO THE INTERNATIONAL INDEX

The International Index of Energy Security Risk is designed to allow comparisons of energy security risks across countries and country groups, and how these risks change over time. The International Index measures energy security risks in two ways: (1) in absolute terms; and (2) relative to a baseline average of the OECD countries.

The methods used to develop it build off much of the work and concepts used in developing the Energy Institute's Index of U.S. Energy Security Risk® (U.S. Index). The task of boiling down U.S. energy security risks to a single number posed many analytical challenges. The U.S. Index was constructed from a foundation of 37 metrics measuring broad aspects of energy security. The U.S. Index uses historical and forecast data from EIA.

The idea of extending the methodology used in the U.S. Index to other countries proved to be a difficult task, especially when it came to data availability. Accordingly, in developing the International Index, the measures and methodology developed for the U.S. Index had to be adapted.

The United States has a comparative wealth of richly detailed and comprehensive data covering long time

spans. The available international databases, however, are something of a mixed bag, and even at their best, they are not as complete and consistent as those we have for the United States. The data typically do not have the historical coverage we have in the United States, and often there are gaps. Data on energy prices and expenditures show gaps in coverage, particularly for non-OECD countries.

Further, whereas the United States has a detailed forecasting system extending decades into the future and dovetails well with historical data, the international forecasts necessarily entail aggregations that prevent the goal of country-by-country analysis.

DATA CRITERIA AND SOURCES

Data limitations make it necessary to strike a balance between the theoretically ideal and the realistically possible. Not every risk metric can be measured with solid data, but that does not mean that less-than-perfect data cannot be used provided its usefulness and limitations are well understood. Even data we commonly view as reliable—U.S. employment, inflation rates, GDP, etc.—are themselves developed from samples and extrapolations, and are best thought of as estimates rather than complete compilations. These issues are magnified when dealing with international data. The approach adopted to develop the International Index was, therefore, not to let the perfect be the enemy of the good.

One of the first tasks in developing the International Index was ensuring that the data being used were useful analytically and would be considered reliable by users of the Index. Before selecting the data, we established criteria to ensure the data used possessed several important characteristics. The criteria settled on are listed in table A1-1.

The primary data source for the International Index is the EIA's International Energy Statistics database, which is in turn compiled from hundreds of documents and

TABLE A1-1

Data Criteria used for International Index

Sensible	The data must relate to commonsense expectations.
Credible	The data must be well-recognized and authoritative.
Accessible	The data must be readily available to the public.
Transparent	Data derivations and manipulations must be clear.
Complete	The data must have a record extending back in history for a reasonable amount of time (in this case back to 1980)
Updatable	The historical data must be revised each year so that changes over time can be measured.

data sources. Other key data come from organizations such as the World Bank, IEA, OECD, and others. EIA's database reflects its efforts to compile and curate many disparate sources of information.

Where feasible, data from EIA were preferred over other those from other sources. This allowed for greater consistency in data collection, definitions, country names and changes, etc. Where circumstances warranted, EIA's source documents or other sources of information were employed. In particular, energy price data from IEA, transportation and power generation data from the World Bank, and refinery utilization data from British Petroleum were used.

Another important data series not presented in the EIA database but nonetheless conceptually vital to the International Index is a country-by-country measure of freedom over time. Several metrics related to global reserves and production and imports take into consideration the "freedom" and the diversity of global fuel supplies. Freedom House, an independent

nongovernmental organization, has developed composite indices for political rights and civil liberties that when averaged comprise a measure freedom for over 190 countries. The presumption is that countries exhibiting the greatest degree of political rights and civil liberties are more likely to be politically stable and reliable trading partners and are less likely to join cartels or use oil supplies to achieve geopolitical aims. Hence, by weighting each country's reserves or production of oil, natural gas, and coal by its respective Freedom House weighting, we can develop an aggregate global Freedom-weighted metric that provides a proxy for reliability and that can be tracked over time.

TIME DIMENSIONS AND GEOGRAPHIC COVERAGE OF METRICS

The data limitations discussed above compelled a starting date of 1980, more than sufficient for the purposes of the International Index. Further, because forecast data are not available at the desired level of detail, the series ends in the most recent year for which data are available.

EIA, IEA, the World Bank, and other sources provide comprehensive, country-by-country information on many measures of energy production, energy consumption, population, GDP, carbon dioxide emissions, and other energy-related measures. Accordingly, for a wide range of energy security risk metrics, time series were developed for all individual countries as well as groups of countries such as the OECD nations. The International Index incorporates the risk index scores for all of the countries globally.

However, differences in geographic coverage also shape the limits of what is possible. Particularly for some of the smaller and/or developing nations, the data are less complete, and it became necessary to develop neutral proxy assumptions and methods for filling in gaps in the historical record. Because of these data limitations, as well as recognition that fewer than 25 of the major economies account for well over half of total world energy consumption, the focus of this published report is aimed at the countries listed below:

- Australia
- Brazil
- Canada
- China
- Denmark
- France
- Germany
- India
- Indonesia
- Italy
- Japan
- Mexico
- Netherlands
- New Zealand
- Norway
- Poland
- Russia
- South Africa
- South Korea
- Spain
- Thailand
- Turkey
- Ukraine
- United Kingdom
- United States

METRICS OF ENERGY SECURITY RISK

The individual energy security measures selected were organized around eight broad categories that represent and balance some key and often competing aspects of energy security. These are found in table A1-2. Using these categories as guides, 29 individual metrics were developed covering a wide range of energy supplies, energy end uses, generating capacity, operations, and emissions.

In assessing security and risk, the ultimate goal is an improved understanding of the likelihood of an energy shock of some kind and how that might impact a countries economy. However, the data currently available typically describes only what actually happened, not what nearly happened or could have happened. So in this sense, some of the metrics are proxies for things that cannot be measured directly.

As an example, this Index uses measures of political and civil liberties to gauge a country's political stability, and indirectly its reliability as an energy supplier and trading partner. This does not mean that countries that perform poorly in these metrics have been unreliable suppliers

in the past or necessarily will be unreliable suppliers in the future. But it does mean the risks of a disruption are higher in countries that do not score well in this metric when compared to countries that do score well.

Recognizing that fuel imports and exports account for a higher share of supply in many countries than they do in the United States, new metrics were created. Coal is an example. The United States has long-term (over 250 years) and secure supplies of coal and risks to supply are largely regulatory in nature, so coal does not feature in the import metrics of the U.S. Index while oil and natural gas do. This is not the case in many other countries that rely on imported coal to meet domestic needs. Therefore, a metric measuring the net import exposure of coal was created in addition to the metrics for oil and natural gas.

These fuel-specific measures, however, do not do a good job of indicating how important that fuel is in the overall energy mix of the country. Consider two countries that meet most of their demand for a particular fuel, say natural gas, through imports. If in one of these countries gas is a relatively small part of the energy mix and in the other gas is a very large part of the energy mix, their level of risk is quite different. To help account for these broader dependencies as well as the fuel-specific concerns, a metric measuring total energy import exposure is used to reflect the diversity of the different fuel mix in the country. This metric helps even out the effects of outlying values for individual fuels and picks up nuclear and renewable energies.

Energy price and expenditure data are very important measures of certain aspects of energy security, but the availability and quality of these data varies greatly and overall there is much less coverage of prices by sector and fuel than there is in the United States. As a result, the focus of the International Index is on overall energy prices rather than sector-level or end-use prices.

The primary source of energy price and expenditure data for the International Index is the IEA. Given

TABLE A1-2

Classification of Energy Security Metrics Used in the International Index

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 national economies to unreliable and concentrated supplies of oil and natural gas, and coal. Higher supply reliability and diversity and lower import levels mean a lower risk to energy security.
3. Energy Expenditures	Measure the magnitude of energy costs to national economies 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 national economies 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 population and economic output. Lower use of energy by industry to produce goods and services means a lower risk to energy security.
6. Electric Power Sector	Measure indirectly the reliability of electricity generating capacity. Higher diversity means a lower risk to energy security.
7. Transportation Sector	Measure efficiency of energy use in the transport sector per unit of GDP and population. Greater efficiency means a lower risk to energy security.
8. Environmental	Measure the exposure of national economies to national and international greenhouse gas emission reduction mandates. Lower emissions of carbon dioxide from energy mean a lower risk to energy security.

IEA's mission and origins, it is not surprising that the amount and extent of price data for OECD countries is much greater than it is for non-OECD countries, but even the coverage in many OECD countries is less than ideal. To include energy price and expenditure metrics in the International Index, proxies had to be developed for energy prices for countries where IEA data were incomplete or unavailable. Using IEA price and consumption data for different fuels, we developed rough approximations of energy prices and expenditures that, while imperfect, meet the needs of the International Index.

Given all of these considerations, 29 metrics were developed for use in the International Index. These are listed and described in figure A1-3.

TABLE A1-3

Metrics Used to Create International Index of Energy Security Risk

METRIC BY CLASSIFICATION		DEFINITION	IMPORTANCE	WEIGHT (PERCENT)
Global Fuel Metrics				**14**
1.	**Security of World Oil Reserves**	Global proved oil reserves weighted by each country's relative Freedom Index and by an index of global diversity of oil reserves.	Indicates risk attached to the average barrel of global crude oil reserves. As a measure of reserves, it largely reflects longer-term concerns.	**2**
2.	**Security of World Oil Production**	Global oil production weighted by each country's relative Freedom Index and by an index of global diversity of oil production.	Indicates the level of risk attached to the average barrel of crude oil production globally.	**3**
3.	**Security of World Natural Gas Reserves**	Global proved natural gas reserves weighted by each country's relative Freedom Index and by an index of global diversity of gas reserves.	Indicates the risk attached to the average cubic foot of natural gas reserves globally. As a measure of reserves, it largely reflects longer-term concerns.	**2**
4.	**Security of World Natural Gas Production**	Global natural gas production weighted by each country's Freedom Index and by global diversity of gas production.	Indicates the level of risk attached to the average cubic foot of natural gas production globally.	**3**
5.	**Security of World Coal Reserves**	Global proved coal reserves weighted by each country's relative Freedom Index and by an index of global diversity of coal reserves.	Indicates the risk attached to the average ton of coal reserves globally. As a measure of reserves, it largely reflects longer-term concerns.	**2**
6.	**Security of World Coal Production**	Global coal production weighted by each country's relative Freedom Index and by an index of global diversity of coal production.	Indicates the level of risk attached to the average ton of coal production globally.	**2**

TABLE A1-3 (CONTINUED)

Metrics Used to Create International Index of Energy Security Risk

METRIC BY CLASSIFICATION		DEFINITION	IMPORTANCE	WEIGHT (PERCENT)
Fuel Import Metrics				**17**
7.	**Petroleum Import Exposure**	Net petroleum imports as a percentage of total national petroleum supply, adjusted to reflect the reliability of international petroleum production (measured using the Freedom Index) and the diversity across producing countries.	Indicates the degree to which changes in import levels expose the country to potentially unreliable and/or concentrated supplies of crude and refined petroleum.	**3**
8.	**Natural Gas Import Exposure**	Net natural gas imports as a percentage of total national gas supply, adjusted to reflect the reliability of international gas production (measured using the Freedom Index) and the diversity across producing countries.	Indicates the degree to which changes in import levels expose the country to potentially unreliable and/or concentrated supplies of natural gas.	**3**
9.	**Coal Import Exposure**	Net coal imports as a percentage of total national coal supply, adjusted to reflect the reliability of international coal production (measured using the Freedom Index) and the diversity across producing countries.	Indicates the degree to which changes in import levels expose the country to potentially unreliable and/or concentrated supplies of coal.	**2**
10.	**Total Energy Import Exposure**	Net energy imports as a share of total primary energy consumption.	Indicates the degree to the country is reliant on foreign sources for it energy needs.	**4**
11.	**Fossil Fuel Import Expenditures per GDP**	Net fossil fuel import costs as a share of GDP.	Indicates the susceptibility of a country to imported fossil fuel price shocks.	**5**
Energy Expenditure Metrics				**20**
12.	**Energy Expenditure Intensity**	Total real cost of energy consumed per real $1,000 USD of GDP per year.	Indicates the magnitude of energy costs in the economy to energy price shocks, and exposure to price changes.	**4**
13.	**Energy Expenditures per Capita**	Total real dollar cost of the energy consumed per person per year.	Indicates the importance of energy in personal budgets and the susceptibility of households to energy price shocks.	**3**
14.	**Retail Electricity Prices**	Average electricity costs in real cents per kWh.	Indicates the availability of low-cost, reliable forms of power generation.	**6**
15.	**Crude Oil Prices**	Real cost per barrel of crude oil.	Indicates the susceptibility of the economy to high prices for petroleum, which supplies a significant portion of national energy demand.	**7**

TABLE A1-3 (CONTINUED)

Metrics Used to Create International Index of Energy Security Risk

METRIC BY CLASSIFICATION		DEFINITION	IMPORTANCE	WEIGHT (PERCENT)
Price & Market Volatility Metrics				**15**
16.	**Crude Oil Price Volatility**	Annual change in crude oil prices, averaged over a three-year period.	Indicates the susceptibility of the economy to large swings in the price of petroleum.	**5**
17.	**Energy Expenditure Volatility**	Average annual change in energy expenditures per $1,000 USD of GDP.	Indicates the susceptibility of the economy to large swings in expenditures for all forms of energy.	**4**
18.	**World Oil Refinery Utilization**	Average percent utilization of global petroleum refinery capacity.	Indicates the likelihood of higher prices at high capacity utilization, and higher risk of supply limitations during refinery outages or disruptions.	**2**
19.	**GDP per Capita**	Total real dollar GDP per person per year.	Indicates the importance of wealth and productivity to the ability to innovate and respond to energy shocks.	**4**
Energy Use Intensity Metrics				**14**
20.	**Energy Consumption per Capita**	Million British thermal units (Btu) consumed per person per year.	Indicates changes in both energy intensity and in per-capita GDP and importance of energy to individuals.	**4**
21.	**Energy Intensity**	Million Btu of primary energy used in the domestic economy per $1,000 USD of real GDP.	Indicates the importance of energy as a component of economic growth.	**7**
22.	**Petroleum Intensity**	Million Btu of petroleum consumed per $1,000 USD of real GDP.	Indicates the importance of petroleum as a component of economic growth.	**3**
Electric Power Sector Metrics				**7**
23.	**Electricity Diversity**	Average of market share concentration indexes (HHI) of: (1) the primary categories of electric power generating capacity, adjusted for availability; and (2) primary categories of electric power generation.	Indicates the flexibility of the power sector and its ability to dispatch electricity from a diverse range of sources.	**5**
24.	**Non-CO_2 Emitting Share of Electricity Generation**	Percentage of total electric power generation contributed by renewables, hydroelectric, nuclear and fossil-fired plants operating with carbon capture and storage technology.	Indicates the degree to which the power sector is employing non-CO_2 emitting generation.	**2**

TABLE A1-3 (CONTINUED)

Metrics Used to Create International Index of Energy Security Risk

METRIC BY CLASSIFICATION		DEFINITION	IMPORTANCE	WEIGHT (PERCENT)
Transportation Sector Metrics				**7**
25.	**Transportation Energy per Capita**	Million Btu consumed in the transportation sector per person per year.	Indicates changes in both transportation energy intensity and in per-capita GDP and importance of transportation energy to individuals.	**3**
26.	**Transportation Energy Intensity**	Million Btu of primary energy used in the transportation sector per $1,000 USD of real GDP.	Indicates the importance of energy used in transportation as a component of economic growth.	**4**
Environmental Metrics				**6**
27.	**CO_2 Emissions Trend**	Annual change in total national energy-related CO_2 emissions.	Indicates the exposure of the economy to domestic and international emissions reduction mandates.	**2**
28.	**Energy-Related Carbon Dioxide Emissions per Capita**	Metric tons of CO_2 emissions (energy-related), per capita.	Indicates the joint effect of the amount of energy used per capita, and the carbon intensity of that energy use.	**2**
29.	**Energy-Related Carbon Dioxide Emissions Intensity**	Metric tons of CO_2 per $1,000 USD of real GDP.	Indicates the importance of carbon-based fuels as a component of the economy.	**2**

NORMALIZING THE METRICS INTO INDEXES

The International Index provides an understanding of the absolute trends in energy security risks in selected countries and the relative trends vis-à-vis to other countries. Tracking a country's relative progress in this way can provide insights into market conditions, policies, and other events affecting energy security at a national level.

The various metrics used in the index are measured in many different units making it necessary to transform them into comparable "building blocks" that could then be assembled into an index.

For the International Index to convey information about both changes in energy security risk within a country over time and changes in risk compared to other countries over time, an international benchmark against which the individual countries could be compared had to be created. For this, we selected the average of the present roster of OECD nations.

As a group, the OECD countries provide a good reference measure, with broad coverage across a range of developed nations. Importantly, data for the OECD nations generally are timely, complete, and wide-ranging, which enable an OECD-wide value for all of our metrics.

To set the OECD baseline, each of the 29 metric was normalized so that the value for 1980 equaled 1,000. For subsequent years, the indexed value for each metric was adjusted proportionally higher or lower relative to this 1980 value.

The country-level metrics were normalized by calibrating their 1980 values in reference to the common OECD 1980 baseline. If, for example, a country's 1980 value in energy intensity was 17% higher than the OECD average value for that metric, the 1980 value for that metric would be set at 1,170. Normalized metric scores for subsequent years would rise or fall relative to that starting point. In this way, both a country's relative performance against the OECD average and its absolute performance can be measured for each metric.

TABLE A1-4

Input Weights by Metric Category

Category	U.S. Index Weightings	International Index Weightings
Global Fuels	15.1	14
Fuel Imports	11.8	17
Energy Expenditures	18.3	20
Price & Market Volatility	12.6	15
Energy Use Intensity	15.3	14
Electric Power Sector	6.2	7
Transportations Sector	9.8	7
Environmental	7.6	6
R&D	3.3	NA

WEIGHING THE METRIC INDEXES

The 29 normalized metrics produced for each country from the procedure described above were combined to produce an overall risk score for each country that represents their weighted average.

The weighing of the 29 International metrics began with placing them into eight logical groupings. Each of the categories includes at least two and no more than six metrics (Table A1-3).

For weighting the metrics, the approximate weights of each metric category in the U.S. Index were assigned these categories in the International Index (Table A1-4). Fuel Imports were given a greater weighting in the International Index, and a lack of reliable and current data meant that no R&D metrics were used. Next, weights were allocated to the individual metrics based on weight of the category to which it belongs and, where possible, its relative importance within that category.

Using these steps, we were able to construct an energy security risk index for each country, as well as for the OECD. For each country, there are 29 metrics, each with a time series value that has been normalized into a risk measure where the OECD 1980 value is set to 1,000. For each country and each year, the 29 metrics are weighted according to the values shown in Table A1-3. The risk index for a country in any given year is then the sum of the metric values, each multiplied by its assigned weighted share.21 Using this logic, the OECD reference group, where each metric was normalized so that 1980 equals 1,000, therefore will have a 1980 total value of 1,000.

SIGNIFICANT CHANGES TO THE 2018 EDITION

A major change in the way transportation-related metrics are calculated was unavoidable for the 2018 Edition of the International Index because the dataset relied on in past editions is no longer available.

Two metrics relate to transportation energy consumption: Transportation Energy per Capita and Transportation Energy Intensity. For both metrics, transport energy consumption is the numerator of the metric. These consumption data came from the World Bank Development Indicators ("Road sector energy consumption (% of total energy consumption)"). These data were derived from the International Road Federation, World Road Statistics. "Road sector energy consumption" was defined to be the total energy used in the road sector including petroleum products, natural gas, electricity, and combustible renewables and waste.

These data were available through 2008. While it has been possible to estimate transportation energy consumption based on these and other data, it became clear that these data would not be updated. A suitable replacement dataset was sought to maintain the two transportation metrics.

EIA collects and publishes petroleum consumption data that include: distillate fuel oil, motor gasoline, aviation gasoline, and jet fuel. It also publishes data for fuel ethanol and biodiesel. It was determined that the collective consumption of these six fuel types could serve as a proxy for total transportation sector energy consumption. For the four petroleum fuels, the transportation sector accounted for 84% of their consumption in 1980 rising to 91% in 2016. For the two renewable fuels, the transportation sector accounted for over 95% of their consumption in 2016. Beginning with this 2018 edition, these EIA data replace the World Bank data used in earlier editions.

APPENDIX 2

DATA SOURCES

The Energy Institute relied primarily on government data from the Energy Information Administration and the International Energy Agency to develop its International Index of Energy Security Risk. Where historical data from government sources were not available, other widely-used and respected sources were employed. The following provides a list of the main sources of the data used to compile the metrics.

BP:
BP Statistical Review of World Energy.
Available at: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html. For refinery capacity and utilization data.

Energy Information Administration:
International Energy Statistics. Available at: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm. For historical international energy production, consumption, reserve, import, export, electricity capacity, transportation energy, and other energy data.

Annual Energy Review. Available at: http://www.eia.doe.gov/emeu/aer/contents.html. For crude oil price 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:
IEA Statistics, Energy Prices and Taxes. Available at: http://www.iea.org/stats/index.asp. Subscription required. For energy price and expenditure data.

World Bank:
Development Indicators. Available at: https://data.worldbank.org/indicator?tab=all. For population, gross domestic product, net energy imports, and electricity generation by energy source.

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