

# ***Measuring Energy Security Risk:*** **Assessing Risk in a Global Energy Market**

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# Energy security: A perennial political problem

❖ **Nixon:** “Project Independence 1980 is a series of plans and goals set to insure that by the end of this decade, Americans will not have to rely on any source of energy beyond our own.” (25-Nov-1973)

**Ford:** “I am recommending a plan to make us invulnerable to cutoffs of foreign oil. It will require sacrifices, but it--and this is most important--it will work.” (15-Jan-1975)

**Carter:** “Our decision about energy will test the character of the American people and the ability of the President and the Congress to govern. This difficult effort will be the “moral equivalent of war.” (18-Apr-1977)

**Clinton:** “... we must do more to free working families from the grip of rising energy costs, especially the price we pay at the pump. ... we still have more to do to strengthen our security over the long term. That's the most important thing.” (01-Jul-2000)

**Bush:** “Our imports of foreign oil have been climbing steadily since 1985 and now stand at 42 percent of our total consumption. Too many of those oil imports come from sources in troubled parts of the world.” (20-Feb-1991)

**Reagan:** “Overall, the outlook for this country's energy supplies is not nearly as grim as some have painted it, although our problems are not all behind us... Given our continued vulnerability to energy supply disruptions, certain emergency preparations ... remain principally a Government responsibility.” (17-Jul-1981)

**Bush:** “Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world.” (31-Jan-2006)

**Obama:** “So we have a choice to make. We can remain one of the world's leading importers of foreign oil, or we can make the investments that would allow us to become the world's leading exporter of renewable energy. We can let climate change continue to go unchecked, or we can help stop it. We can let the jobs of tomorrow be created abroad, or we can create those jobs right here in America and lay the foundation for lasting prosperity.” (19-Mar-2009)

# What do we mean by “energy security”?

Is it . . .

- ❖ How much oil we import?
- ❖ Who controls the energy supplies?
- ❖ How much we pay?
- ❖ Which countries get the money?
- ❖ How sustainable over the long-term?
- ❖ How vulnerable to war, weather, supply disruption, etc.?
- ❖ Do we have a trained and educated labor force to build and maintain energy systems?



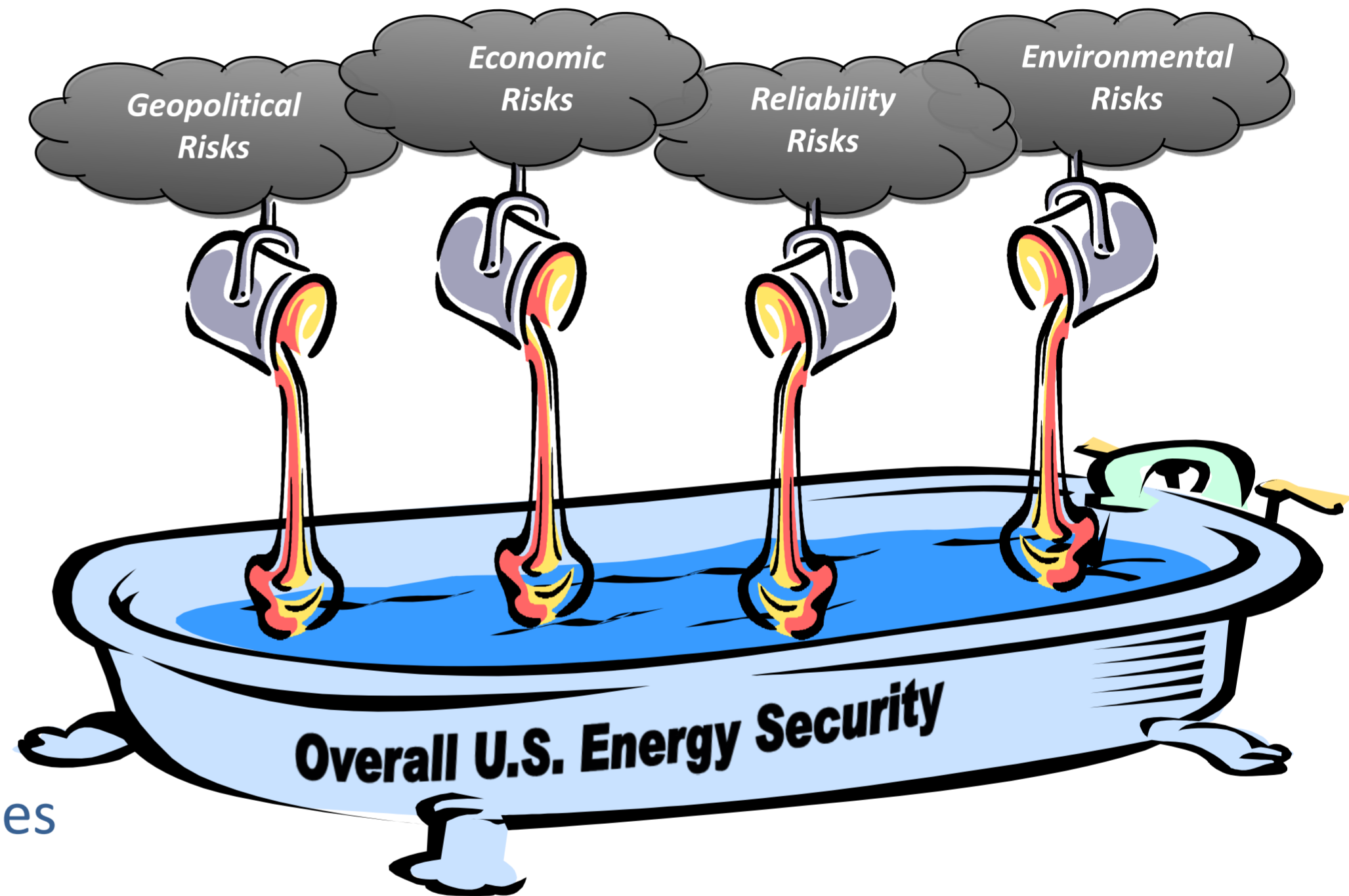
Yes, and more! But . . .

- ❖ “Energy independence” ≠ “energy security”

**And it’s about more than oil!**

# Many dimensions to energy security

- ❖ **Time frame:**
  - short-term vs. long-term
- ❖ **Geopolitical:**
  - Military vs. political
  - Regional vs. country-specific
- ❖ **Economic:**
  - National vs. international
  - Absolute prices vs. volatility
- ❖ **Reliability:**
  - Disruptions vs. chronic shortages
  - Human-caused vs. natural causes
- ❖ **Environmental:**
  - Physical vs. political/regulatory vulnerability





## Why an energy security index?

- ❖ How can we tell if U.S. energy security is getting better or worse?
- ❖ U.S. Index provides two frames of reference:
  - Historical measures of energy security from 1970 to present day (2017); and
  - Forecasts of U.S. energy security (out to 2040).
- ❖ International Index provides third frame of reference:
  - How does the U.S. compare to other countries?

# What makes for a good metric?

- ❖ **Sensible**—Data should relate to common- sense expectations
- ❖ **Credible**—Data sources should be well-recognized and authoritative
- ❖ **Accessible**—Data should be readily and publicly available.
- ❖ **Transparent**—Data derivations and manipulations must to be clear
- ❖ **Complete**—Data had to extend back in history for a reasonable amount of time, preferably back to 1970.
- ❖ **Updatable**—Historical data have to be revised each year, with a new historical year added and new forecast prepared
- ❖ **Prospective**—Historical data should dovetail cleanly with forecast data

## ... But reality sometimes falls short of the ideal

- Historical data missing, esp. in the 1970s
- Forecasts weak, and sometimes impossible
- Dovetailing of historical and forecast data series

**Compromises inevitable: Don't let the perfect be the enemy of the good!**

# What to measure? 37 metrics in 9 categories

**9**  
Categories

## GLOBAL FUELS METRICS

1. Security of World Oil Reserves
2. Security of World Oil Production
3. Security of World Natural Gas Resources
4. Security of World Natural Gas Production
5. Security of World Coal Reserves
6. Security of World Coal Production

## FUEL IMPORT METRICS

7. Security of U.S. Petroleum Imports
8. Security of U.S. Natural Gas Imports
9. Oil & Natural Gas Import Expenditures
10. Oil & Natural Gas Import Expenditures per GDP

## ENERGY EXPENDITURE METRICS

11. Energy Expenditures per GDP
12. Energy Expenditures per Household
13. Retail Electricity Prices
14. Crude Oil Prices

## PRICE AND MARKET VOLATILITY METRICS

15. Crude Oil Price Volatility
16. Energy Expenditure Volatility
17. World Refinery Utilization
18. Petroleum Stock Levels

## ENERGY USE INTENSITY METRICS

19. Energy Consumption per Capita
20. Energy Intensity
21. Petroleum Intensity
22. Household Energy Efficiency
23. Commercial Energy Efficiency
24. Industrial Energy Efficiency

## ELECTRIC POWER SECTOR METRICS

25. Electricity Capacity Diversity
26. Electricity Capacity Margins
27. Electricity Transmission Line Mileage

## TRANSPORTATION SECTOR METRICS

28. Motor Vehicle Average MPG
29. Transportation VMT per \$ GDP
30. Transportation Non-Petroleum Fuels

## ENVIRONMENTAL METRICS

31. Energy-Related Carbon Dioxide Emissions
32. Energy-Related Carbon Dioxide Emissions per Capita
33. Energy-Related Carbon Dioxide Emissions Intensity
34. Electricity non-CO<sub>2</sub> Generation Share

## RESEARCH AND DEVELOPMENT METRICS

35. Industrial Energy R&D Expenditures
36. Federal Energy & Science R&D Expenditures
37. Science & Engineering Degrees

**4**  
Sub-Indexes



**GEOPOLITICAL**  
*30% of index*



**ECONOMIC**  
*30% of index*



**RELIABILITY**  
*20% of index*

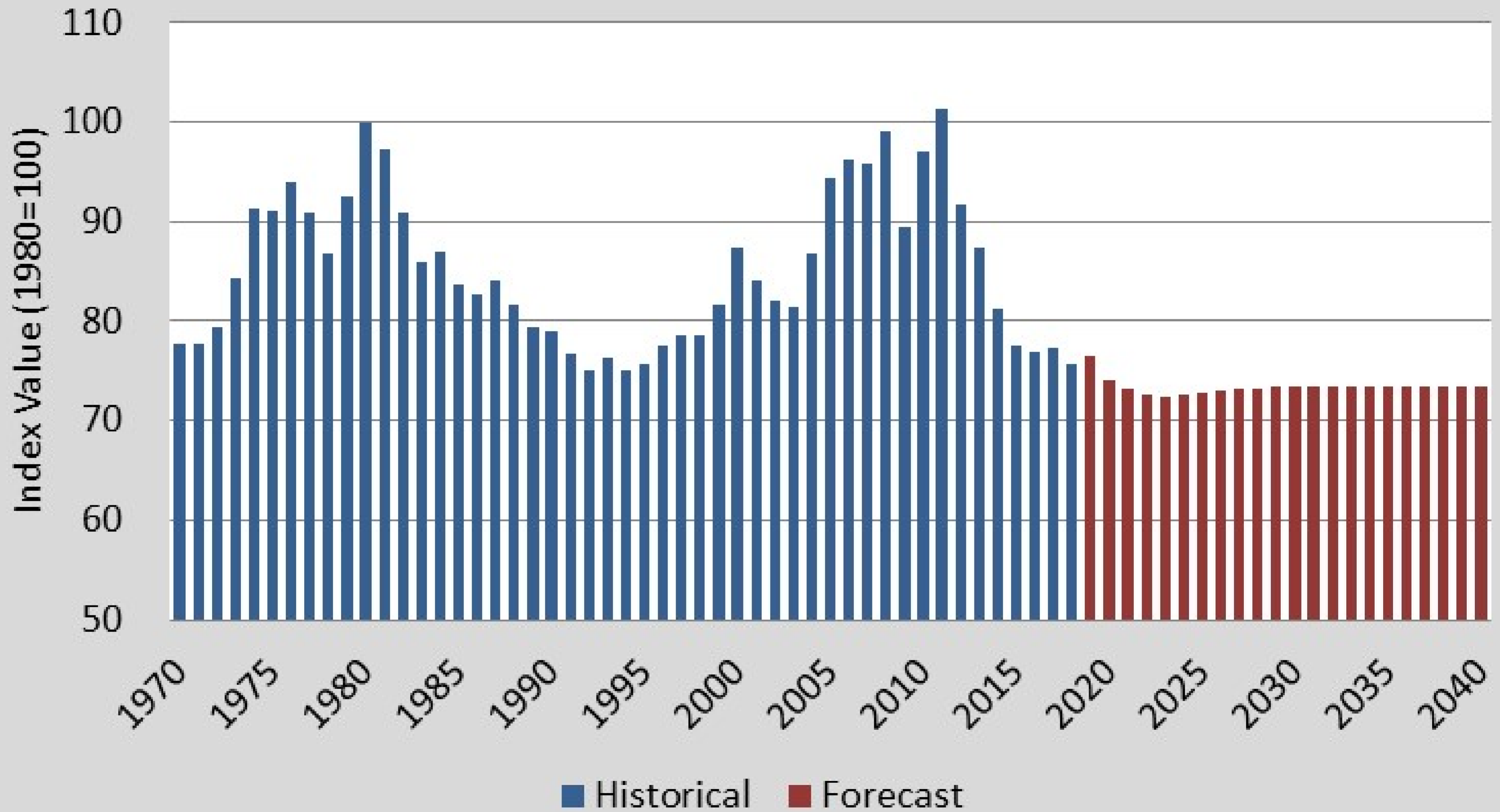


**ENVIRONMENTAL**  
*20% of index*

**INDEX**  
OF U.S.  
ENERGY  
SECURITY  
**RISK**

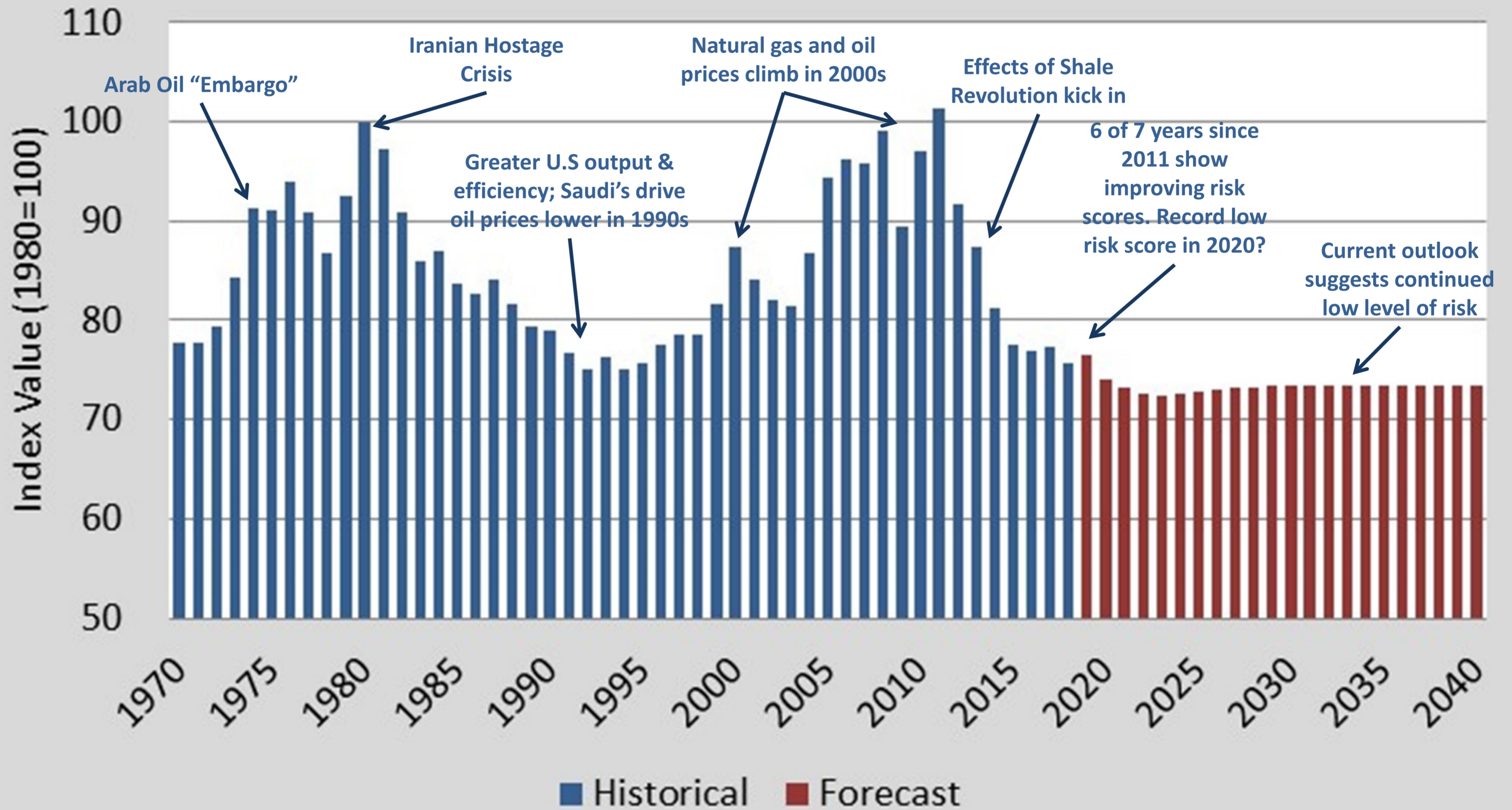
# U.S. energy security risks over the years

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

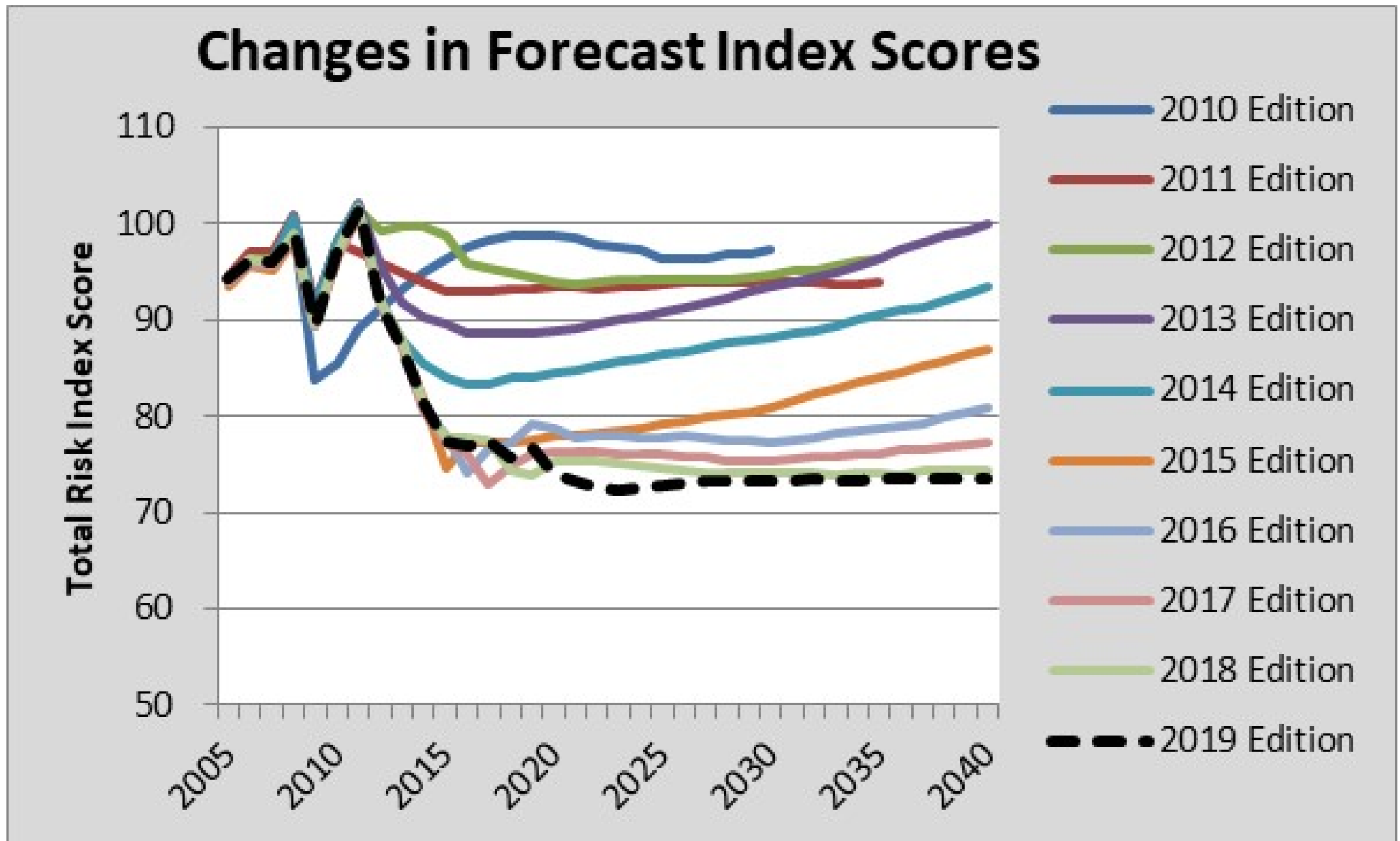


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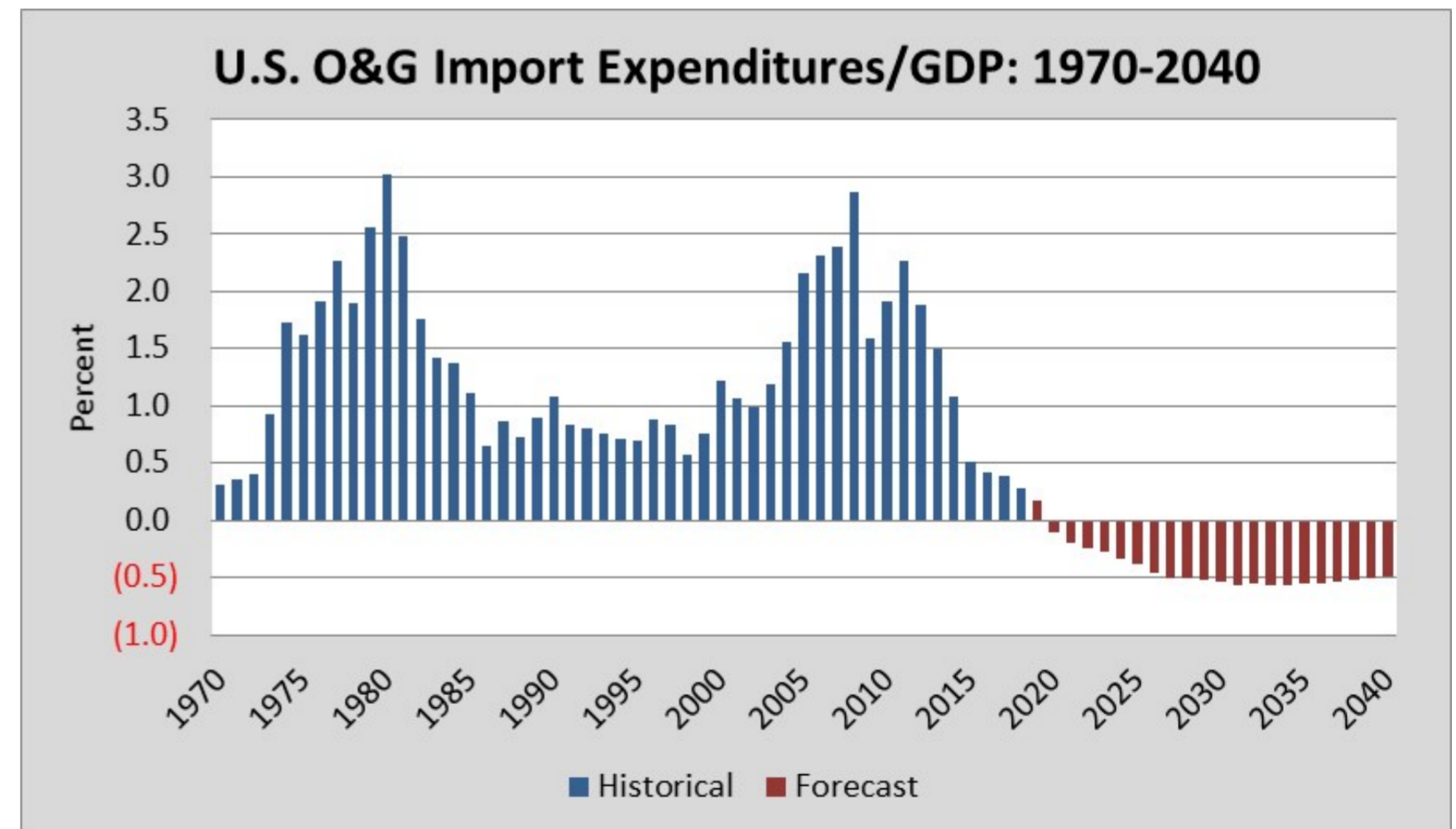
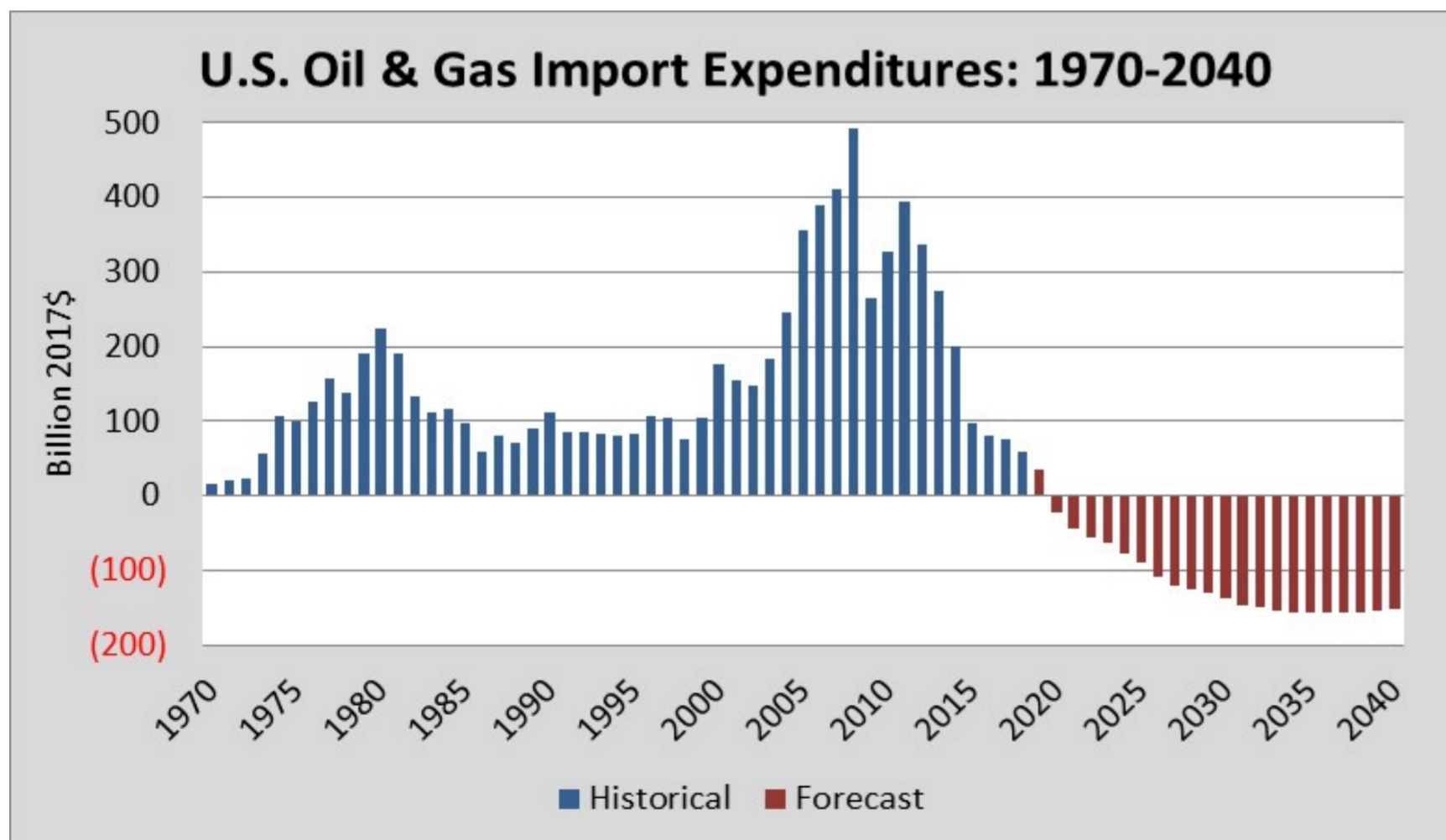
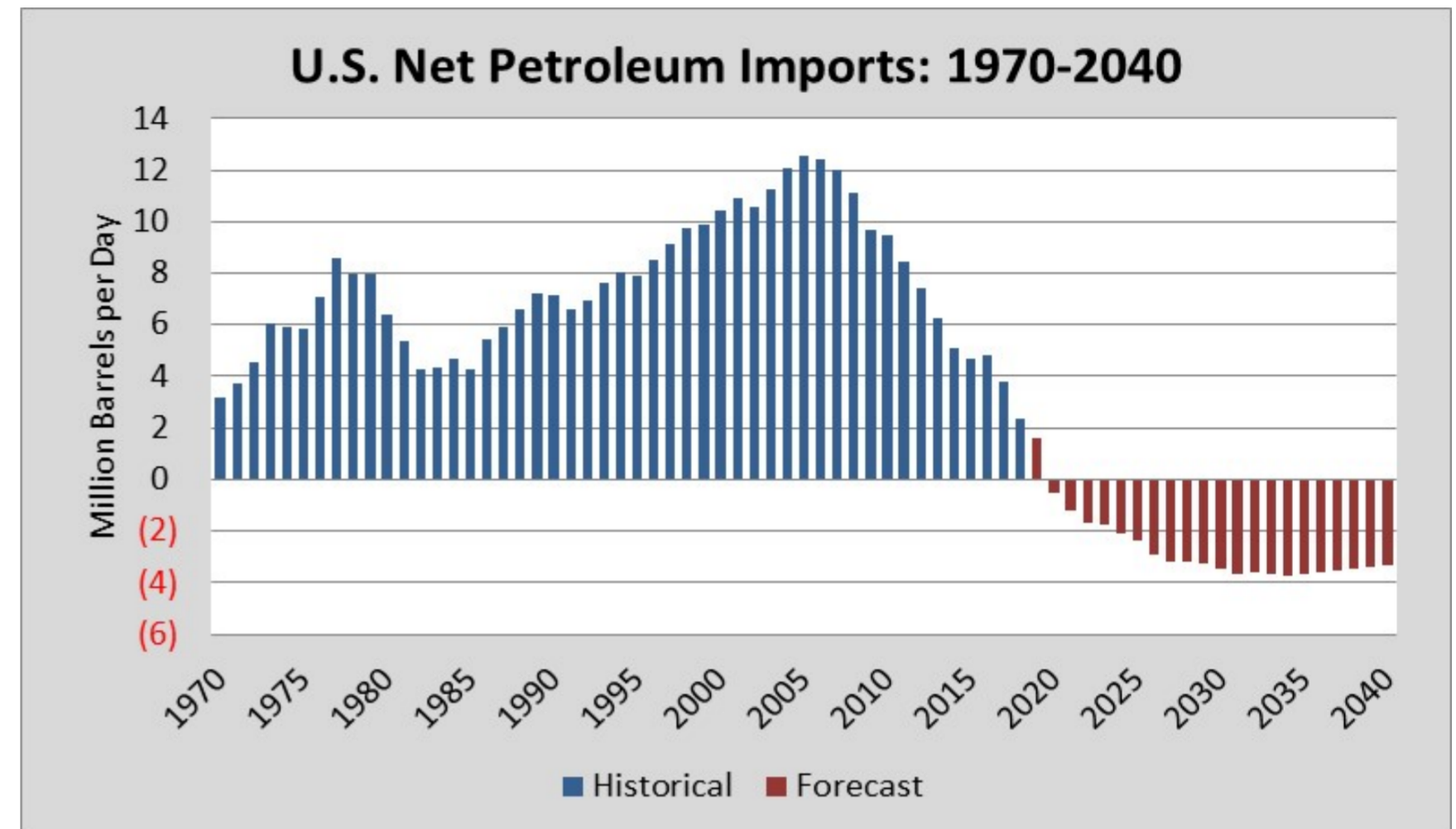
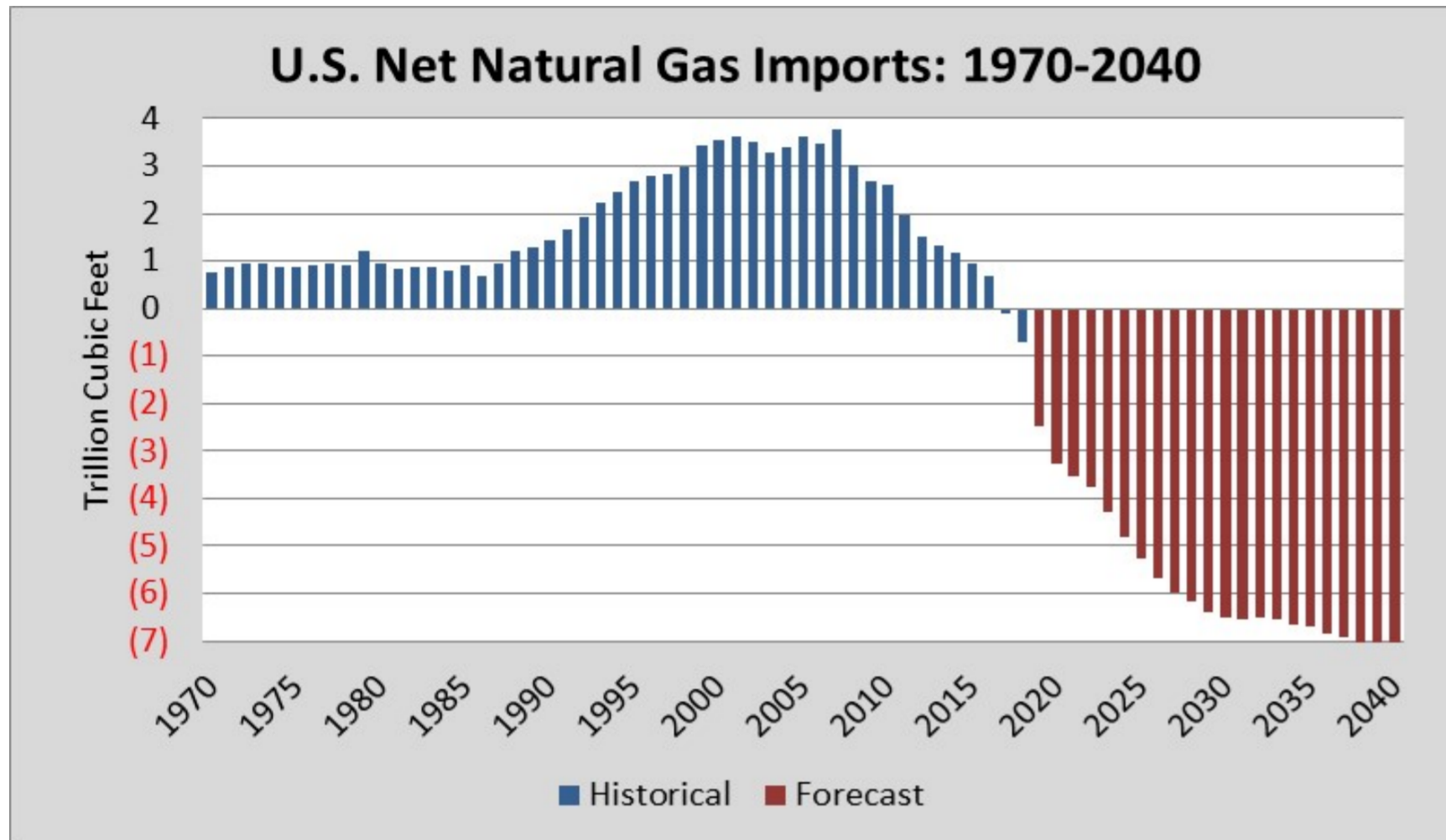


# Energy security outlooks have been improving



*“It's tough to make predictions, especially about the future.” — Yogi Berra*

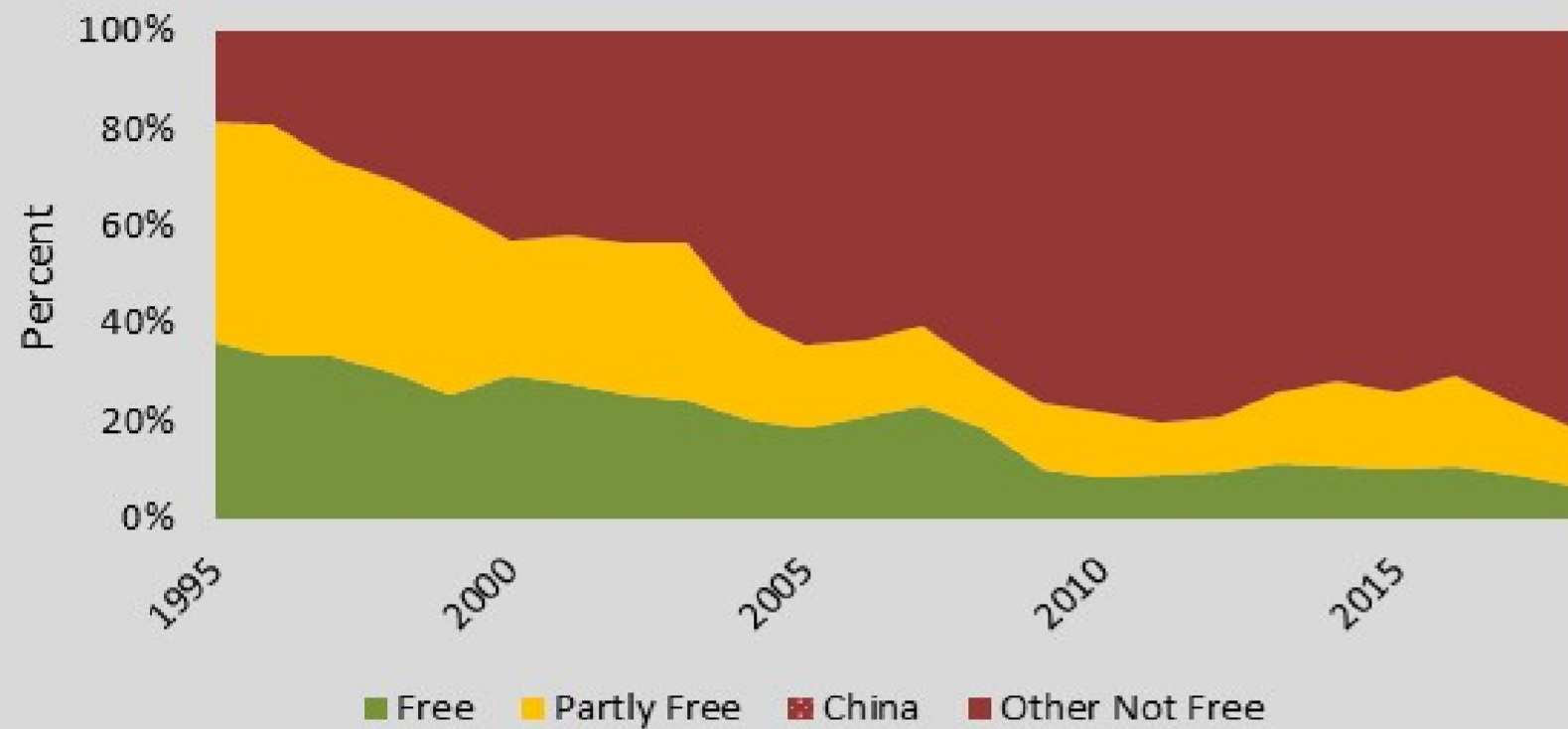
# Some oil & gas import-related risks drop to "0"



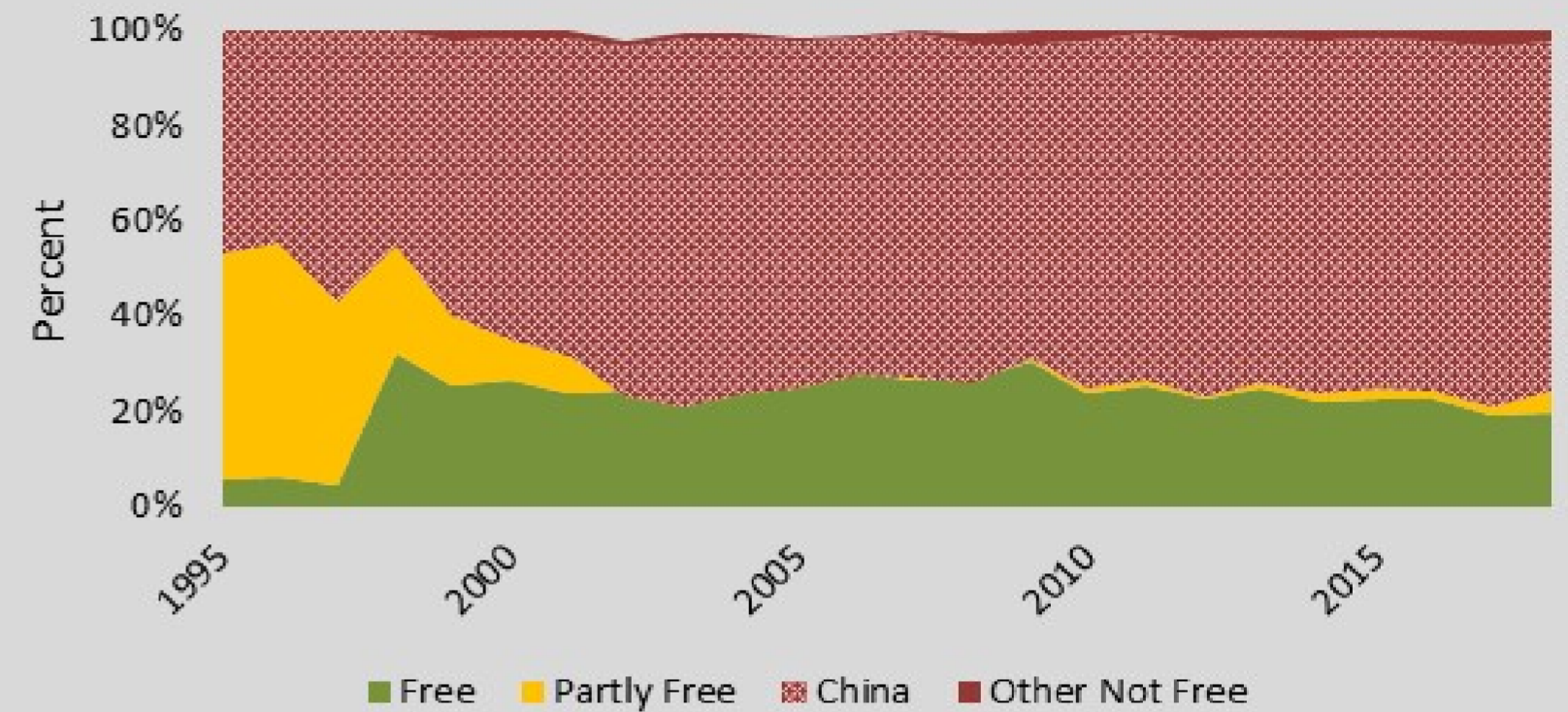
Source: Energy Information Administration

# New risks?

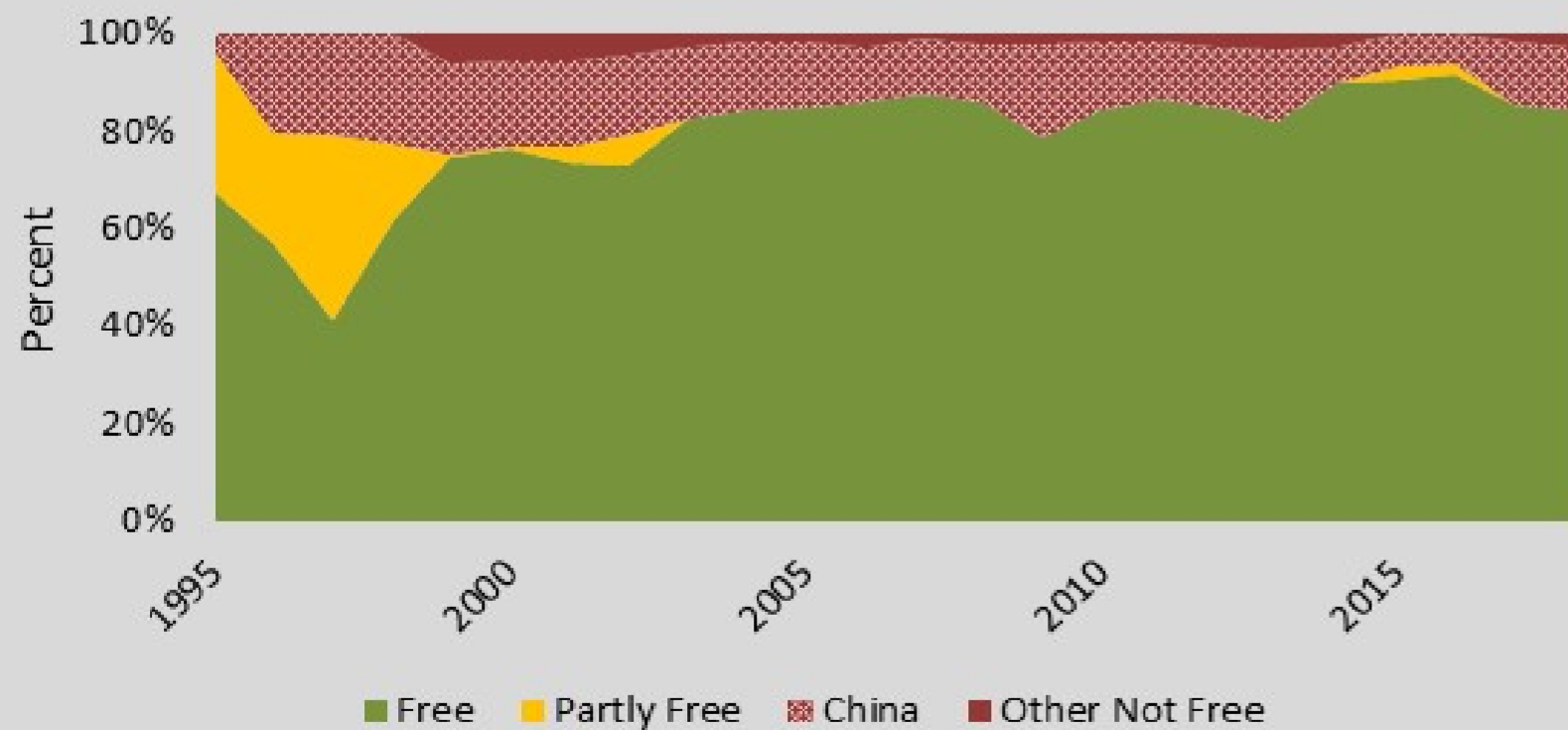
Share of World Cobalt Production in Free, Partly Free & Not Free Countries: 1995-2018



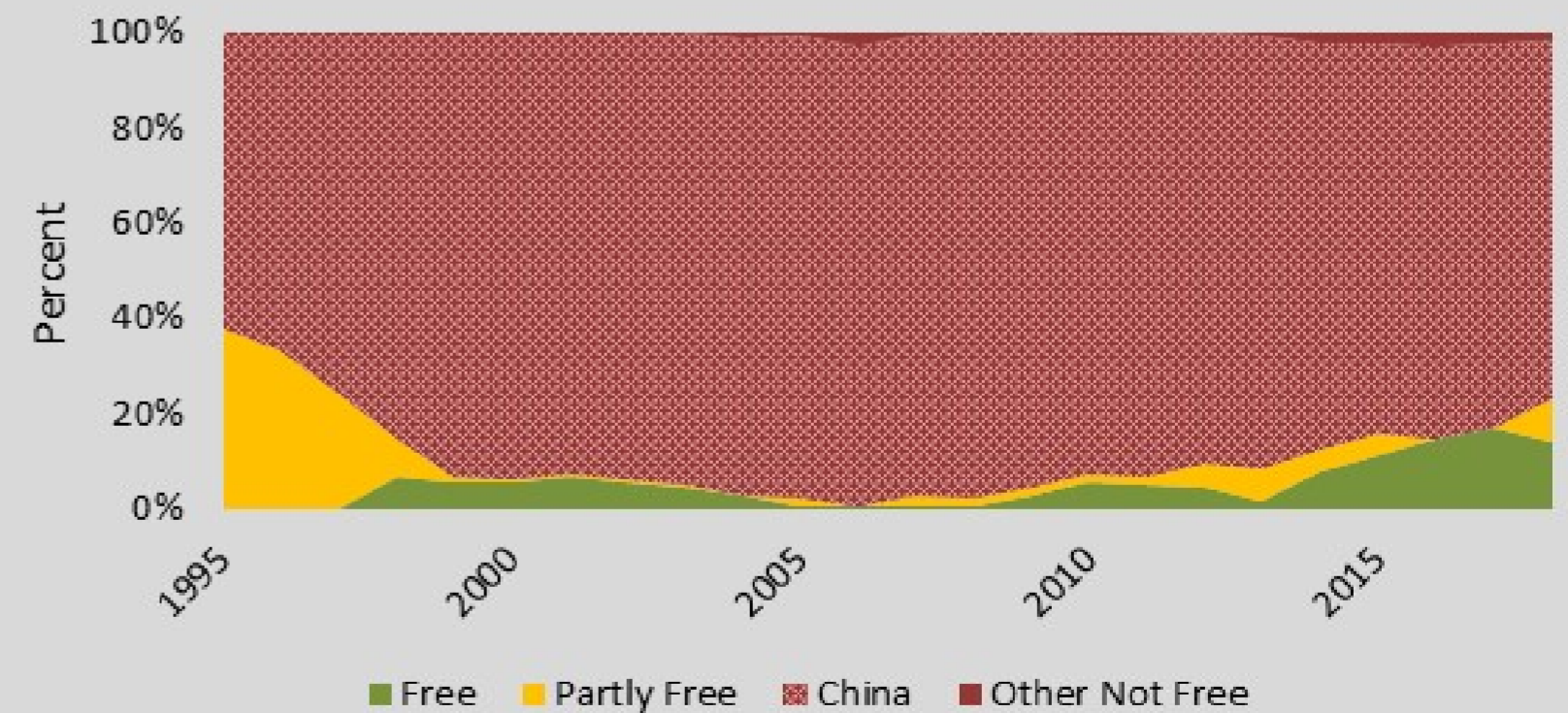
Share of World Graphite Production in Free, Partly Free & Not Free Countries: 1995-2018



Share of World Lithium Production in Free, Partly Free & Not Free Countries: 1995-2018



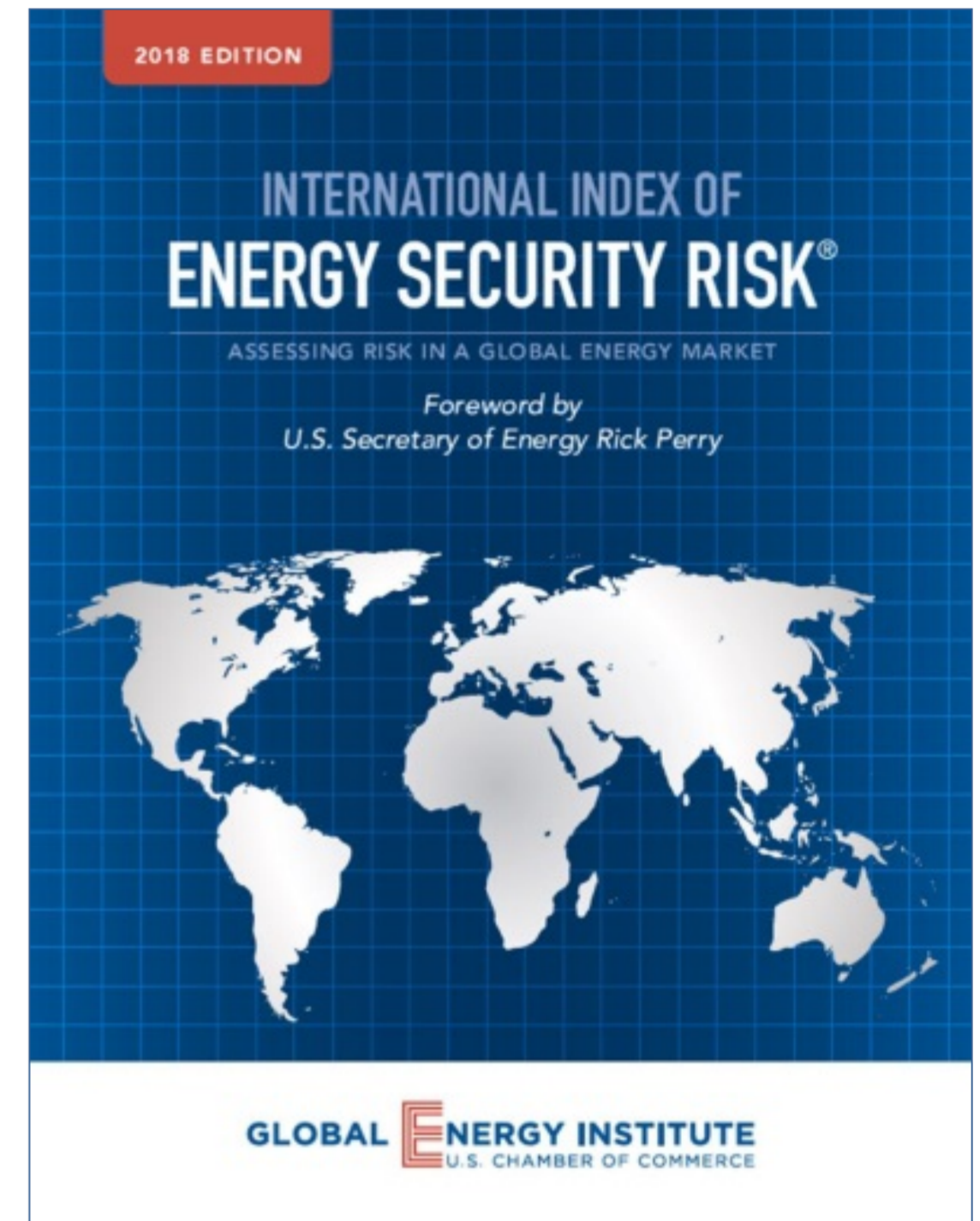
Share of World Rare Earths Production in Free, Partly Free & Not Free Countries: 1995-2018



Sources: BP Statistical Review of World Energy 2019; Freedom House.

# International Index of Energy Security Risk

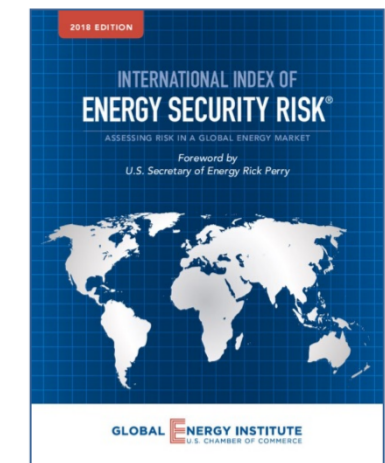
- ❖ Extends U.S. Index methods to other countries
  - Works within limitations of data availability
- ❖ 29 metrics instead of 37; same metric groupings except R&D
- ❖ Uses historical data beginning in 1980
- ❖ Focuses on 25 large energy consuming economies accounting for 80% of global energy demand
- ❖ No forecast component
- ❖ Establishes OECD baseline for comparison (1980=1,000)



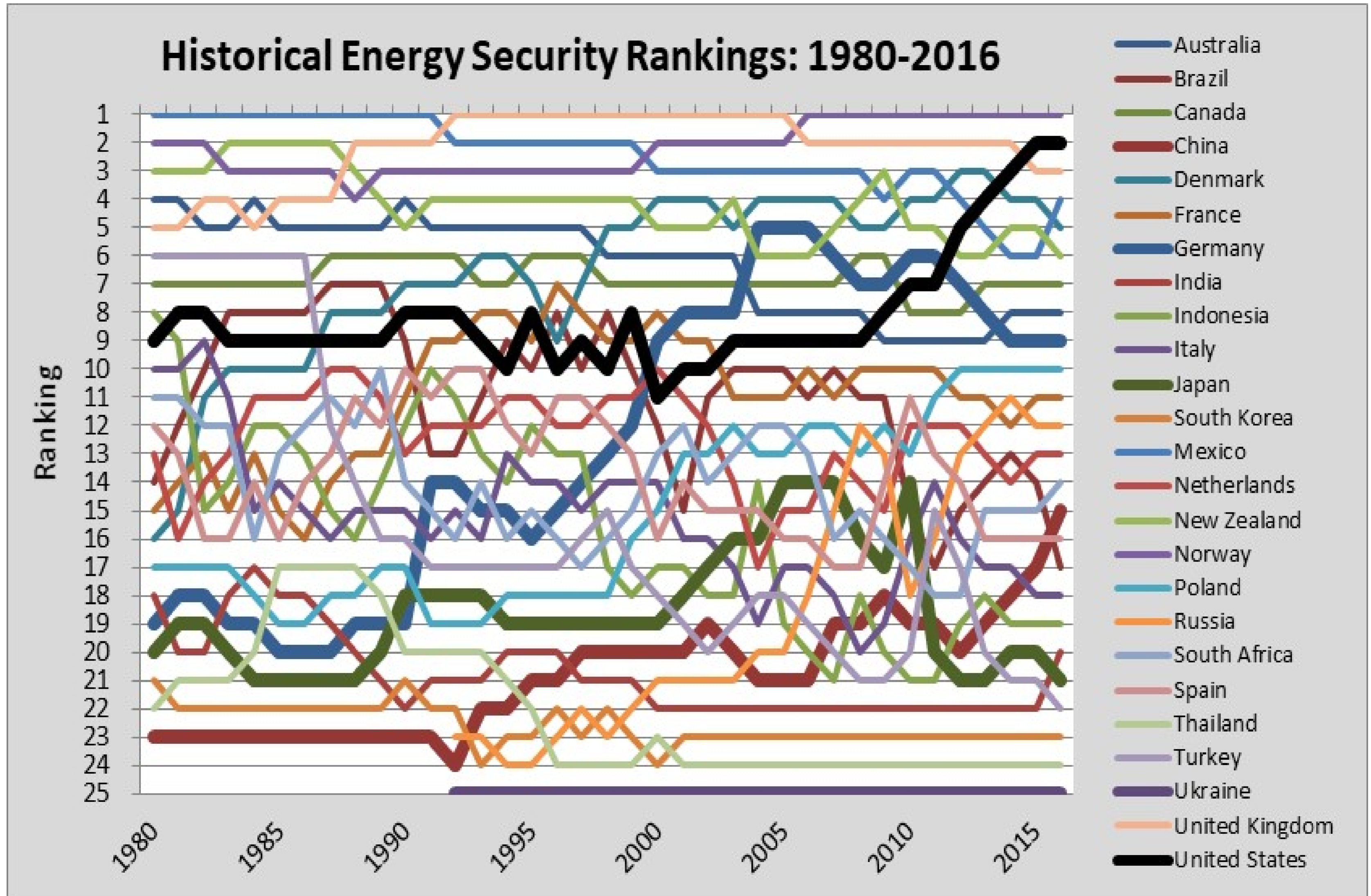
# Total risk scores & rankings for 2016

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

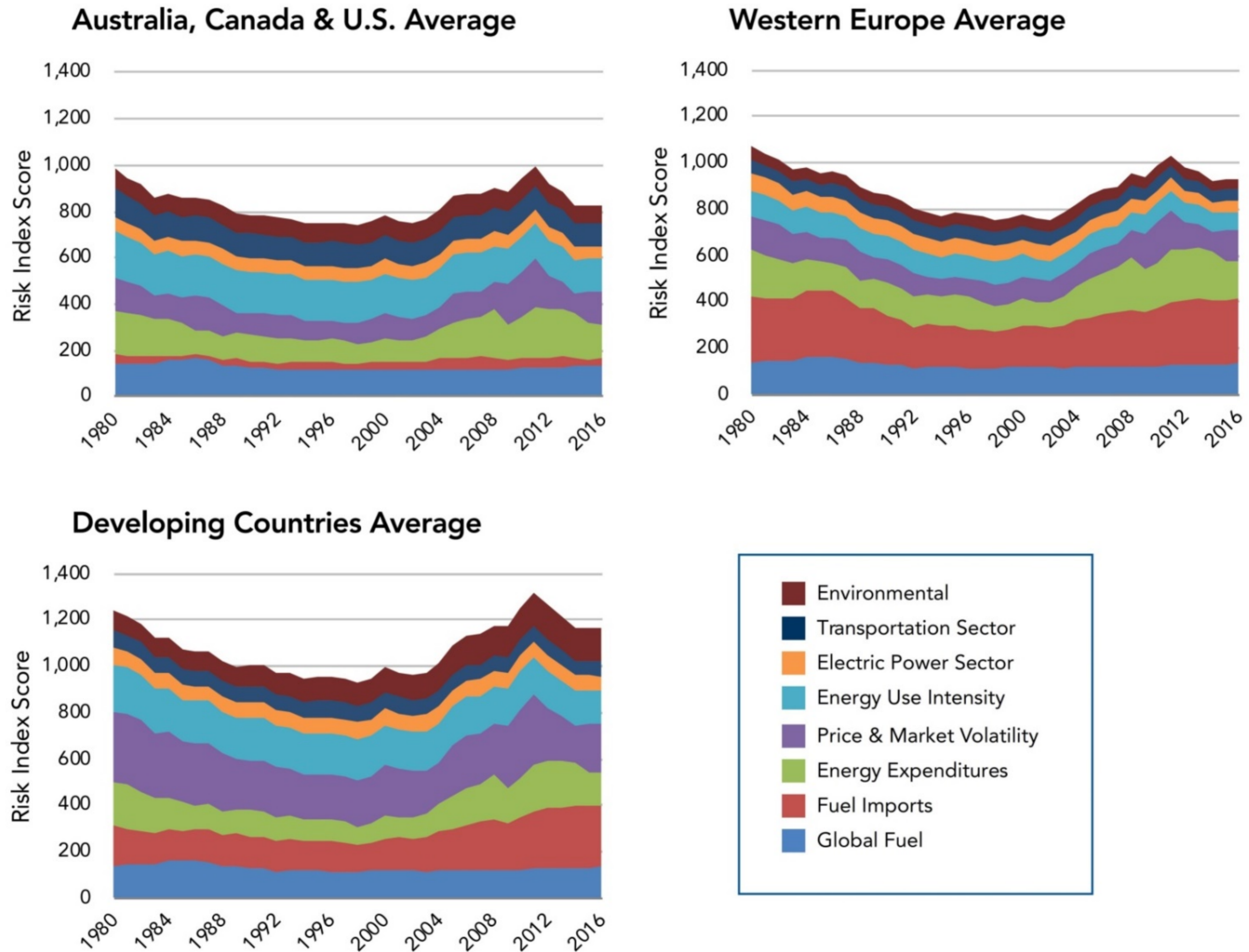


# Historical rankings

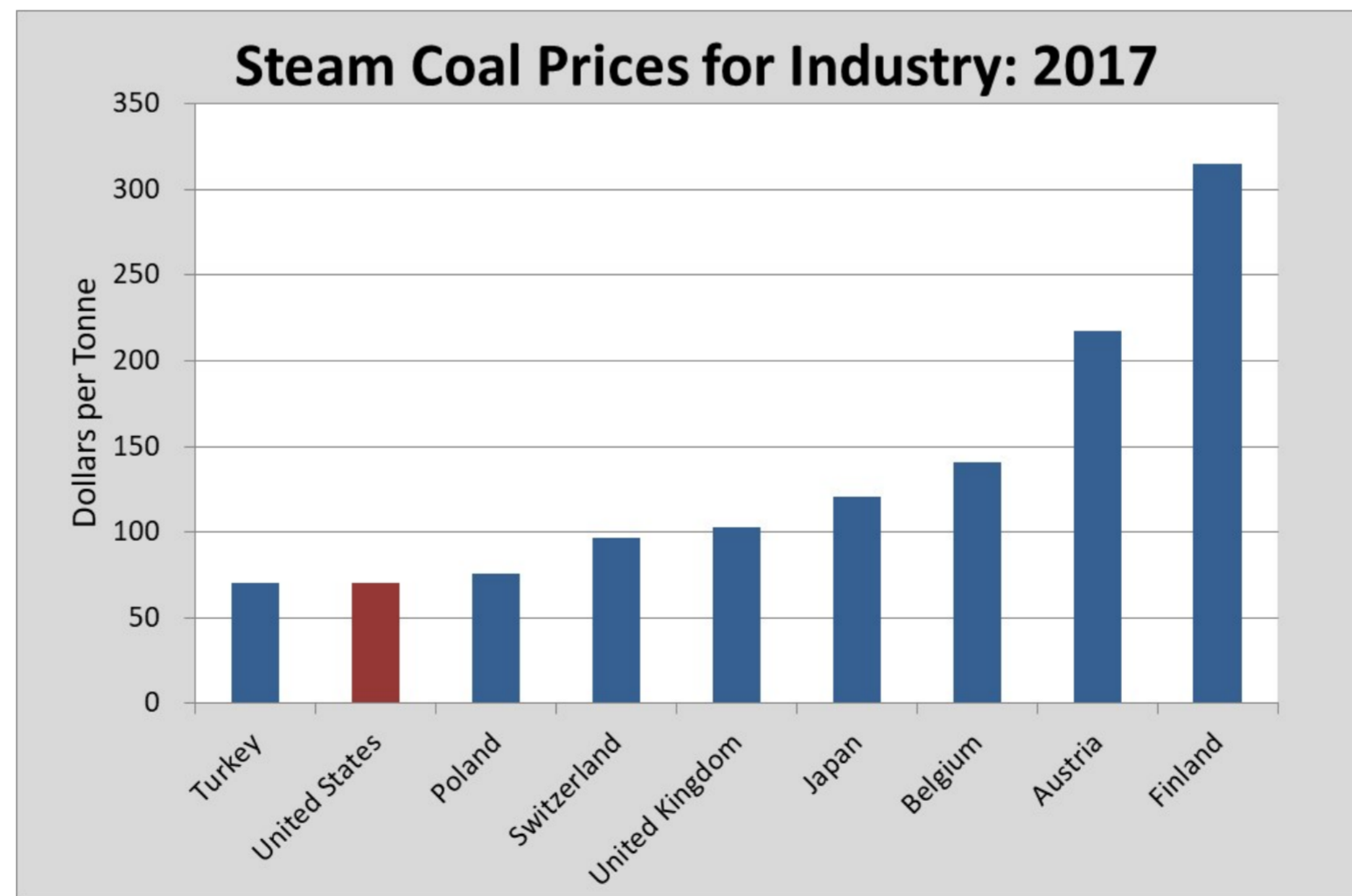
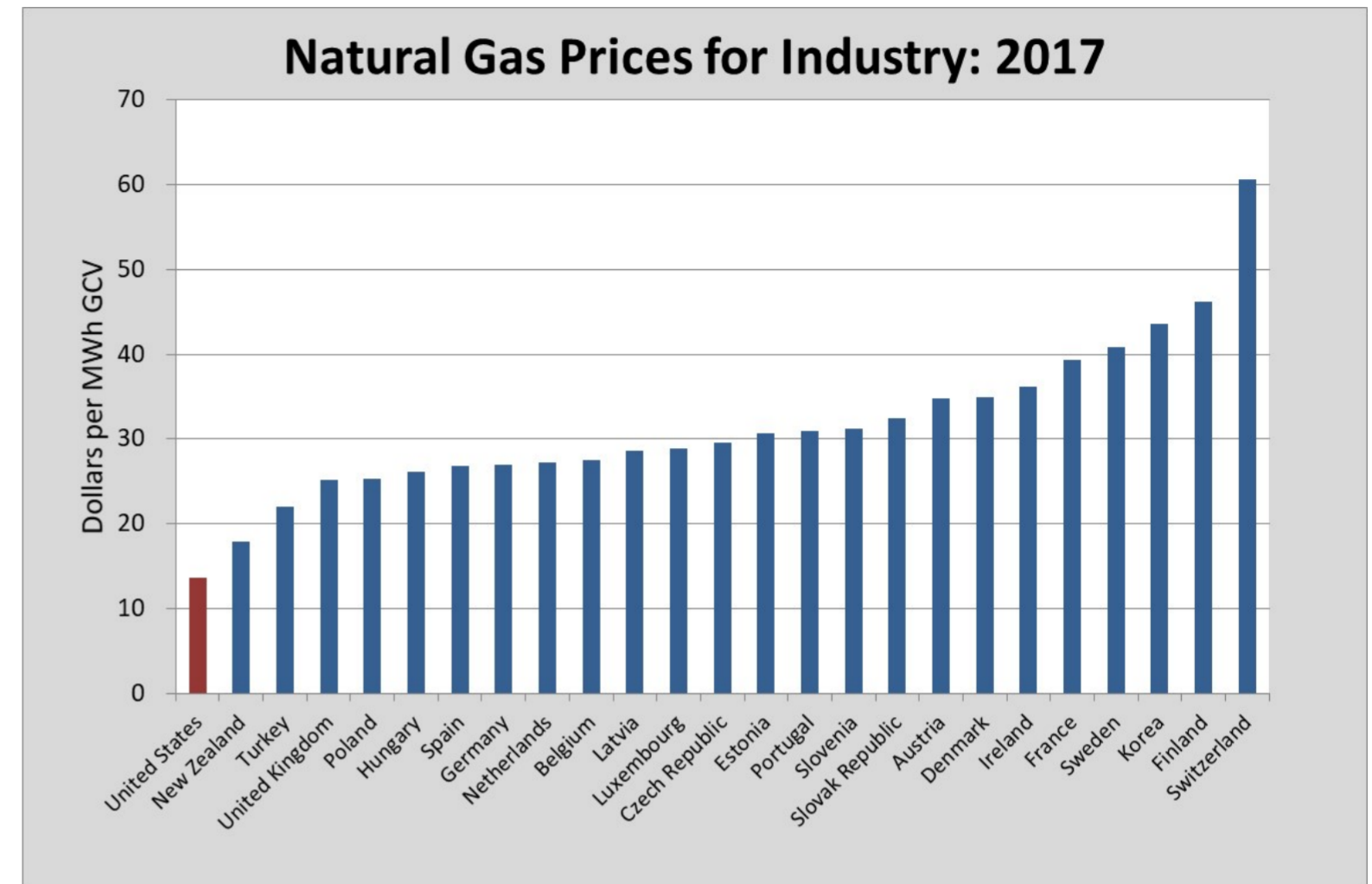
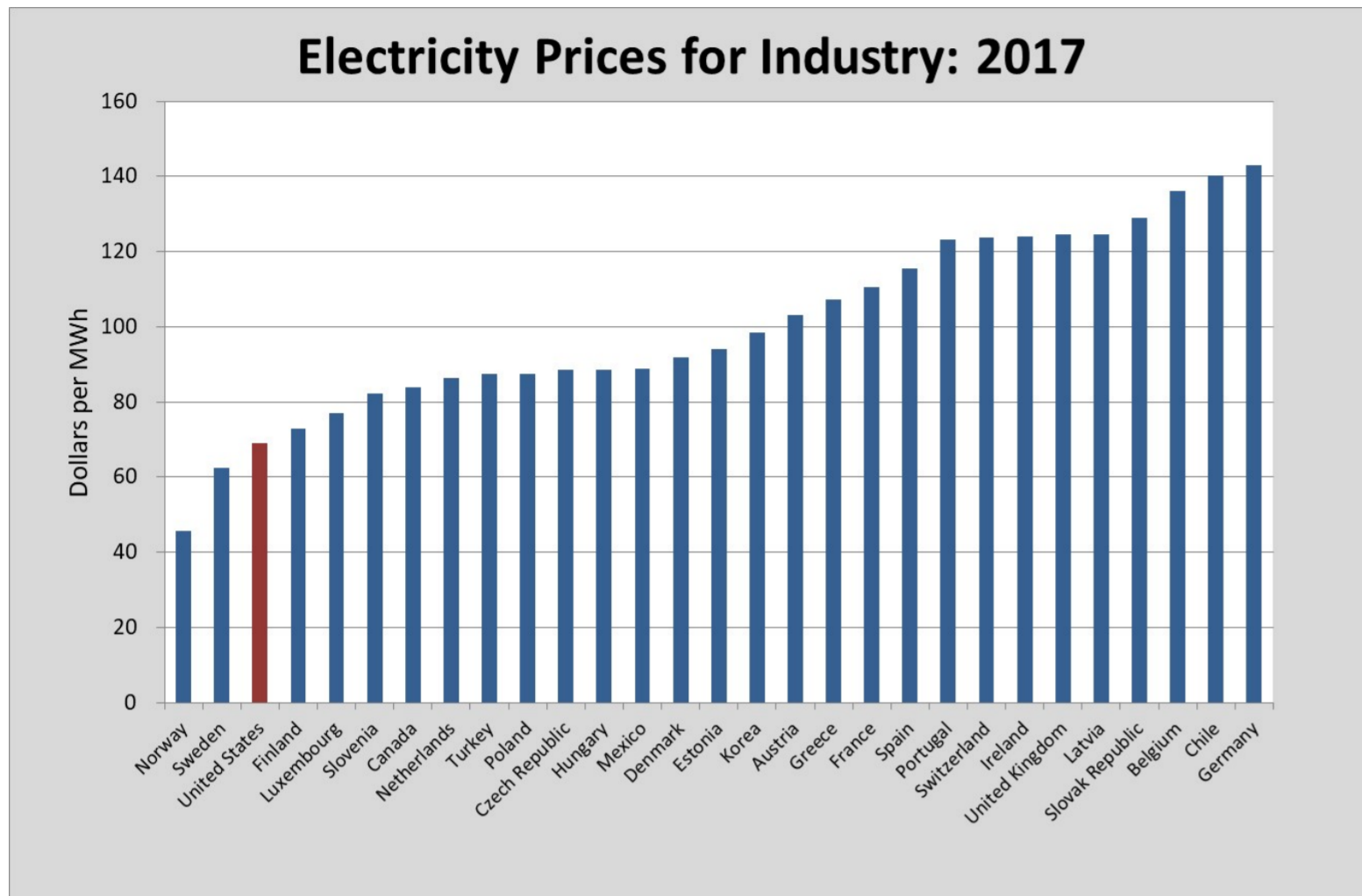


# Different types of energy security challenges

Weighted Risk Scores by Metric Group



# Affordable energy is a competitive advantage



Source: International Energy Agency

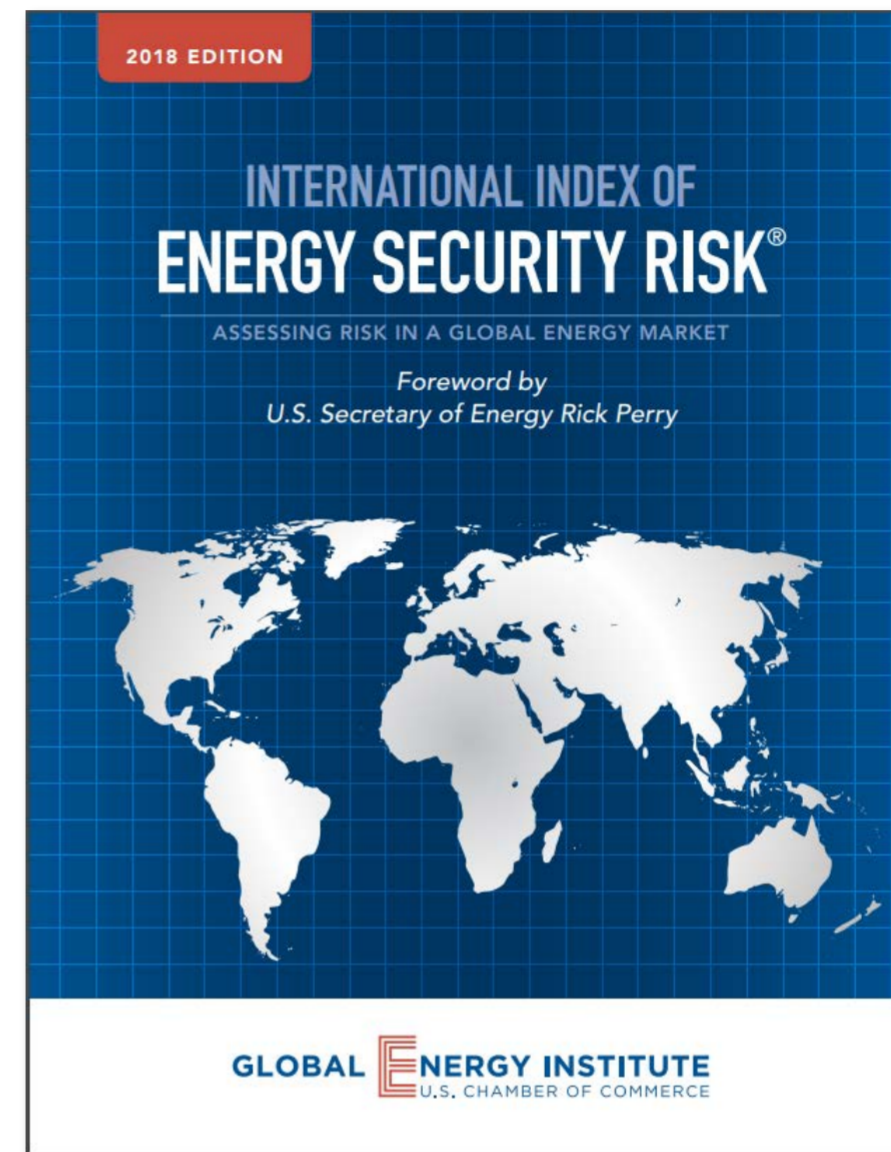
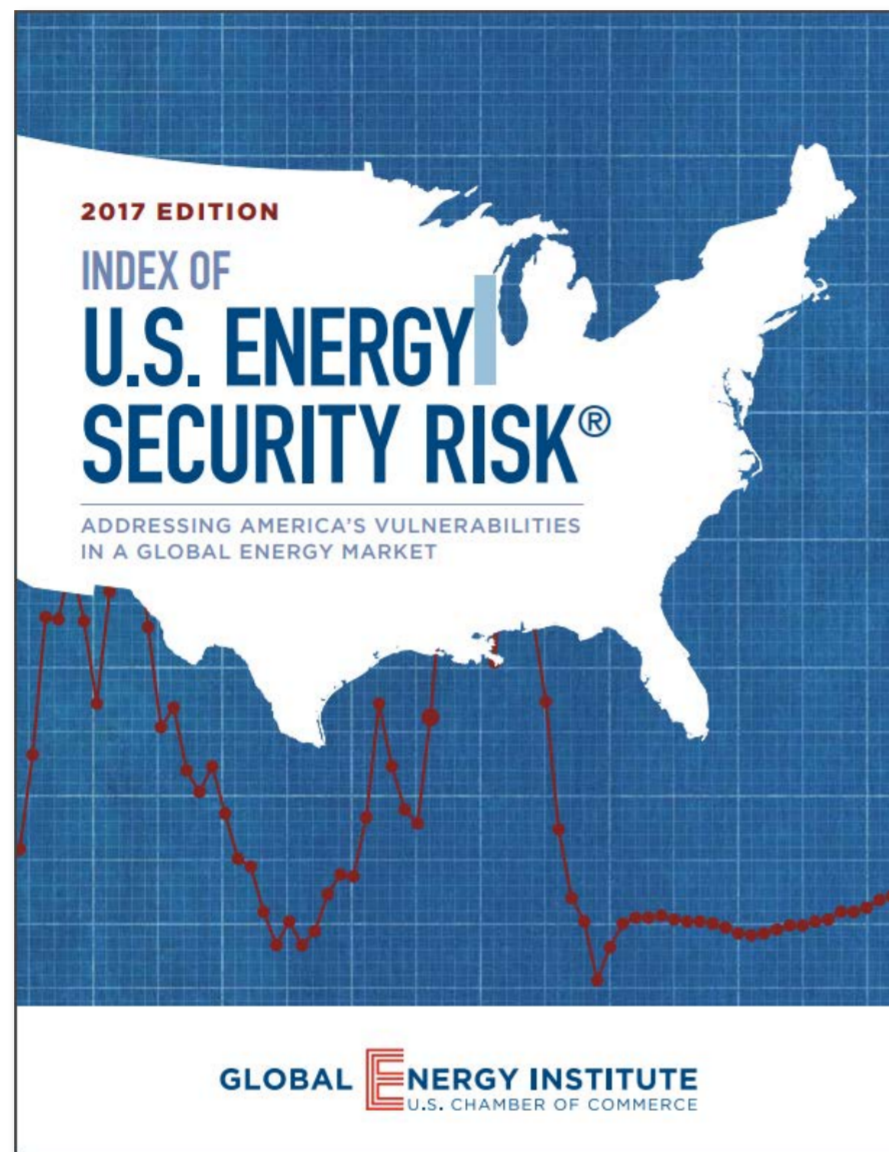


## Energy risks in perspective

### Top 10 Countries with lowest Risk Index Score

1. Norway
2. Colombia
3. Gabon
4. United States
5. United Kingdom
6. Chad
7. North Korea
8. Mexico
9. Denmark
10. Burma (Myanmar)

**Thank you!**



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# Metric Weightings

METRIC WEIGHTINGS						
Metric	Input Weightings				Overall Input	
	Geopolitical	Economic	Reliability	Environmental	Weighted Group %	Weighted Metric %
<b>Global Fuels Metrics</b>					15.1	
Oil Reserves	9.0					2.7
Oil Production	7.0	5.0	6.0			4.8
Natural Gas Reserves	6.0			2.0		2.2
Natural Gas Production	5.0	2.0	3.0	2.0		3.1
Coal Reserves	4.0					1.2
Coal Production	2.0	1.0	1.0			1.1
<b>Fuel Import Metrics</b>					11.8	
Petroleum Imports	8.0		9.0			4.2
Natural Gas Imports	3.0		2.0			1.3
O&G Import Expenditures	6.0	6.0				3.6
O&G Import Expenditures/GDP		9.0				2.7
<b>Energy Expenditure Metrics</b>					18.3	
Expenditures/GDP	5.0	7.0				3.6
Expenditures/Household		9.0				2.7
Retail Electricity Price		10.0				3.0
Crude Oil Price	13.0	13.0	6.0			9.0
<b>Price &amp; Market Volatility Metrics</b>					12.6	
Crude Oil Price Volatility	5.0	3.0	10.0			4.4
Energy Expenditure Volatility		5.0	14.0			4.3
World Oil Refinery Utilization	3.0		6.0			2.1
Petroleum Stock Levels	2.0		6.0			1.8

# Metric Weightings

METRIC WEIGHTINGS (con't)						
Metric	Input Weightings				Overall Input	
	Geopolitical	Economic	Reliability	Environmental	Weighted Group %	Weighted Metric %
<b>Energy Use</b>						
Energy Intensity		4.0		10.0		3.2
Petroleum Intensity	8.0	3.0		6.0		4.5
Household EE		3.0		4.0		1.7
Commercial EE		3.0		4.0		1.7
Industrial EE		3.0		4.0		1.7
<b>Electric Power Sector Metrics</b>					6.2	
Capacity Diversity			7.0	3.0		2.0
Capacity Margins		1.0	7.0			1.7
Transmission Line Mileage		1.0	8.0	3.0		2.5
<b>Transportation Sector Metrics</b>					9.8	
Average MPG	3.0	4.0		12.0		4.5
VMT/GDP	2.0	2.0		8.0		2.8
Non-Petroleum Fuels	3.0		4.0	4.0		2.5
<b>Environmental Metrics</b>					7.6	
Energy-Related CO2 Emissions	2.0			7.0		2.0
Energy-Related CO2 Emissions/Capita	2.0			5.0		1.6
Energy-Related CO2 Emissions Intensity	2.0			5.0		1.6
Electricity non-CO2 Generation Share			5.0	7.0		2.4
<b>Research and Development Metrics</b>					3.3	
Industrial Energy R&D Expenditures		1.0	2.0	2.0		1.1
Federal Energy & Science R&D Expenditures		1.0	2.0	2.0		1.1
Science & Engineering Degrees/GDP		1.0	2.0	2.0		1.1
<b>Total Weightings</b>	100.0	100.0	100.0	100.0	100.0	100.0