World Natural-Gas Future

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Contents

Introduction

In this Anthropocene era (http://en.wikipedia.org/wiki/Anthropocene) the amount of natural gas extracted from the Earth and burned for fuel was crucial for the continuation of the industrial revolution c 1930 after coal got it started c1760 (http://en.wikipedia.org/wiki/Industrial_Revolution) and crude oil continued it ~1900. Now it is crucially deleterious for the survival of *Homo sapiens sapiens* on the Earth. See http://en.wikipedia.org/wiki/Natural_gas for much information about natural gas.

This document discusses many salient facts and displays many graphs about the extraction of natural gas from the Earth and burning it for fuel. Especially emphasized will be the environmental effects of burning natural gas, including the effects on the health of humans and the effects on global warming (aka climate change)(http://en.wikipedia.org/wiki/Global_warming).

Environmental Effects of Crude-Oil Extraction

Conventional natural-gas wells are not as extremely detrimental to the environment as are surface coal mines, unless they are drilled very close together as has been the case sometimes in Oklahoma and Texas.

However, unconventional natural-gas extraction can be very detrimental to the environment:

- Shale gas (http://en.wikipedia.org/wiki/Shale_gas) horizontal wells involve putting millions of gallons of water and a mix of chemicals, some of which are toxic, and sand into a well in order to use high pressure to fractionate the shale (http://en.wikipedia.org/wiki/Fracking). Both the source of the water used and the final deposition of the water mix can be detrimental to the environment. Also, such gas wells deplete much faster than conventional oil wells, so that many more of wells have to be drilled to extract the crude-oil than is the case for conventional crude oil. (http://en.wikipedia.org/wiki/Oil_depletion , http://www.postcarbon.org/drill-baby-drill/)

- Coalbed gas (http://en.wikipedia.org/wiki/Coalbed_methane) involves wells drilled into coal beds and is accompanied by much water with typically contains toxic chemicals.

Environmental Effects of Burning Natural Gas for Energy Production

The main toxic chemical released by burning natural gas is carbon monoxide (http://en.wikipedia.org/wiki/Carbon_monoxide). In addition to being toxic to humans and other animals it produces ground-level ozone (http://en.wikipedia.org/wiki/Ozone).

Global Warming Due to Burning Crude-oil Products for Energy Production

There has been a movement to use the term "climate change" instead of "global warming". The author prefers "global warming" because the average warming of the Earth due to more solar energy being absorbed by the Earth is what is causing climate change. The warming of the Earth is not uniform; in fact, it is possible that some areas will be colder than they were before global warming started. The artic is warming about twice as fast at the temperate and tropic areas.

Burning fossil fuels for energy releases greenhouse gases (GHG) into the atmosphere (http://en.wikipedia.org/wiki/Greenhouse_gases#Relative_CO2_emission_from_various_fuels):

Fuel	CO_2 emitted ($g/10^3J$)
Natural gas	~50
Gasoline	~67
Coal	~90

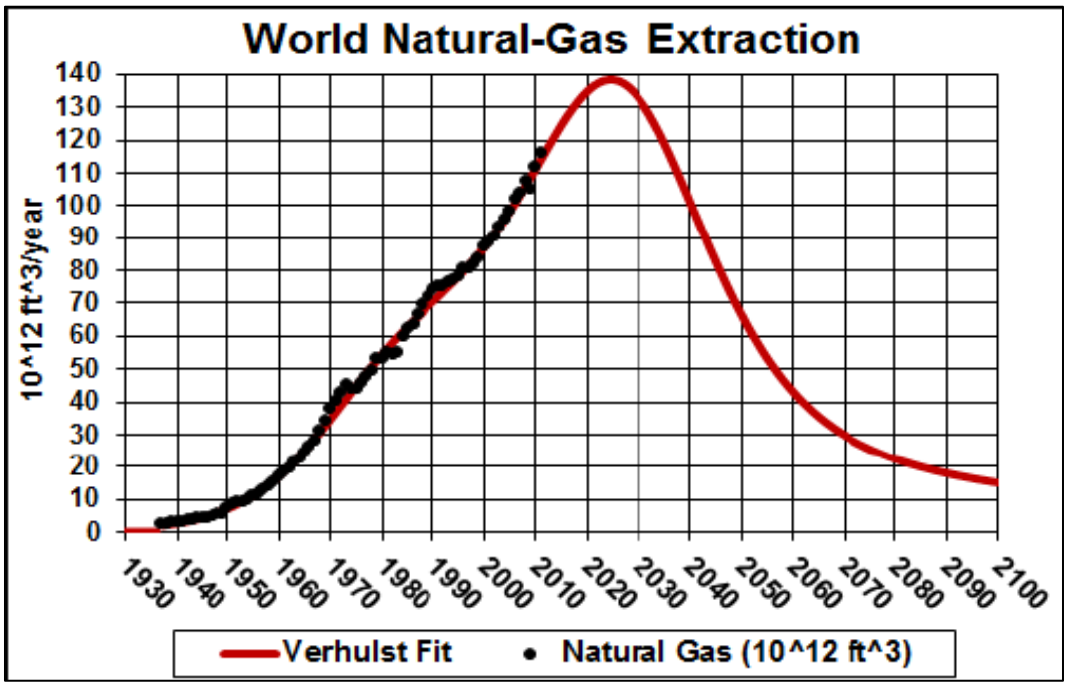
So, quitting burning coal for energy will have the largest effect in mitigating global warming than quitting burning natural gas or gasoline. Next in line for GHG emissions is gasoline or diesel, which emits slightly more than gasoline (http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11).

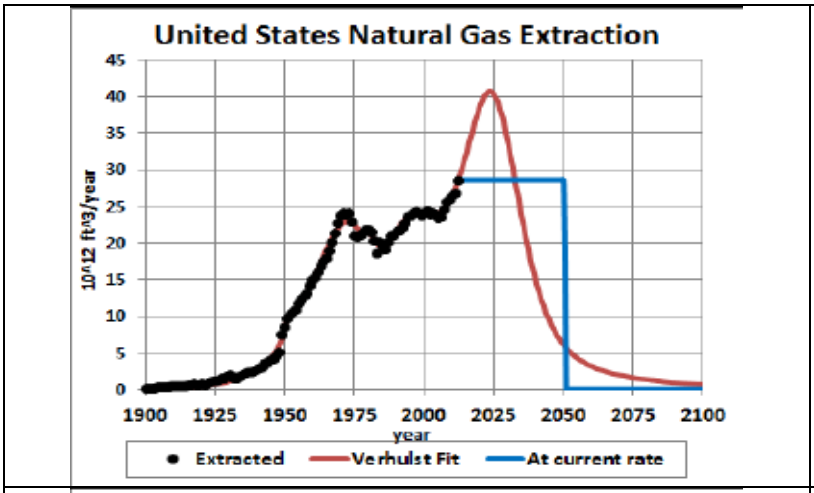
Amount of Natural Gas Available for Extraction from the Earth

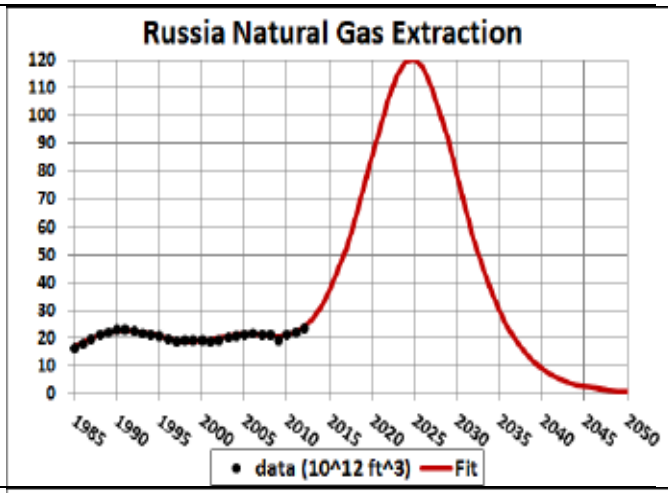
In the following fits to natural-gas-extraction data:

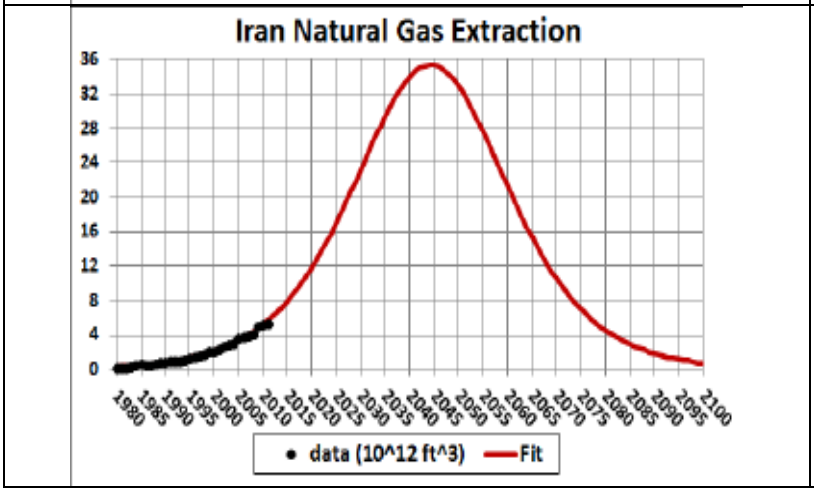
- If the data are decreasing during the last few years, a best fit is done.
- If the data are rising during the last few years, a fit is done using the current recoverable-reserves value with the assumption that the future peak will be symmetric.

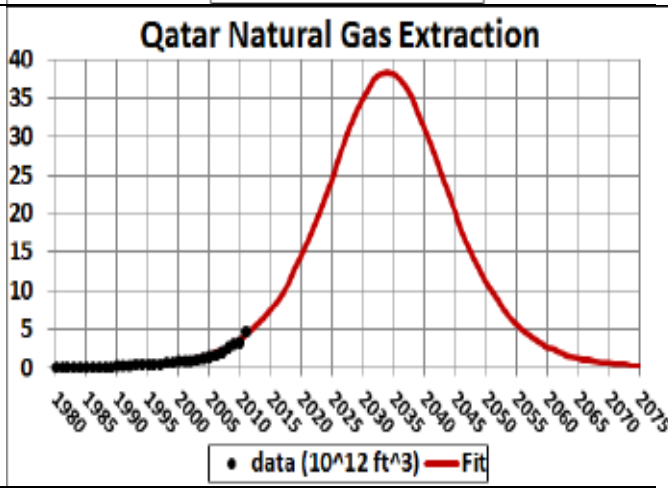
World Natural-Gas Extraction

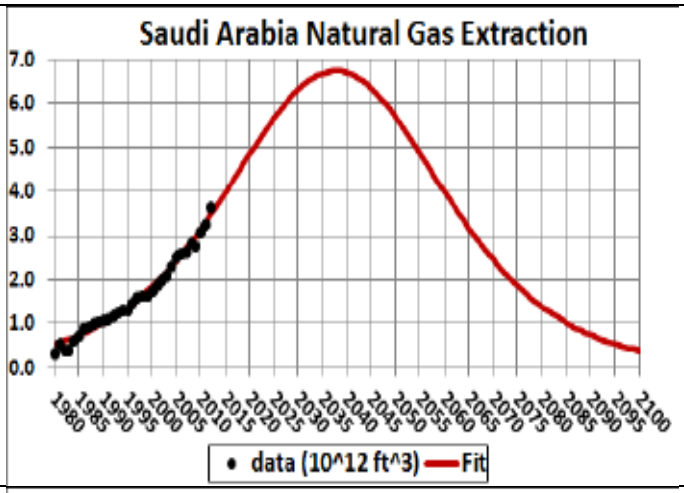


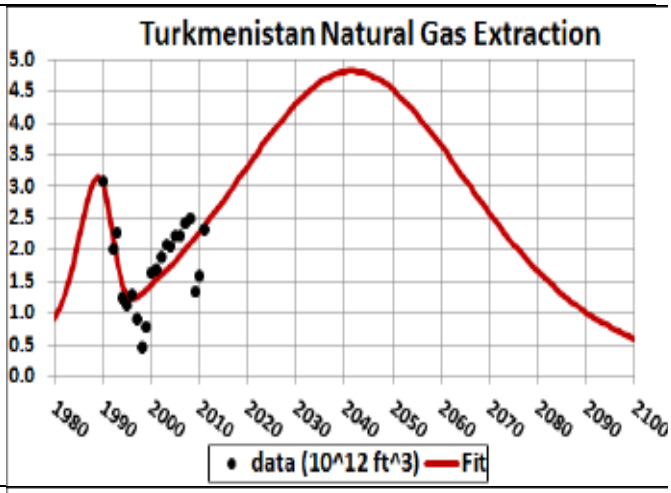


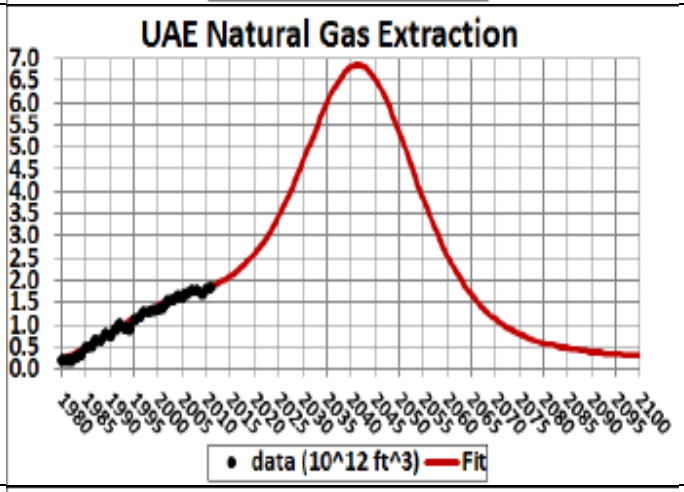


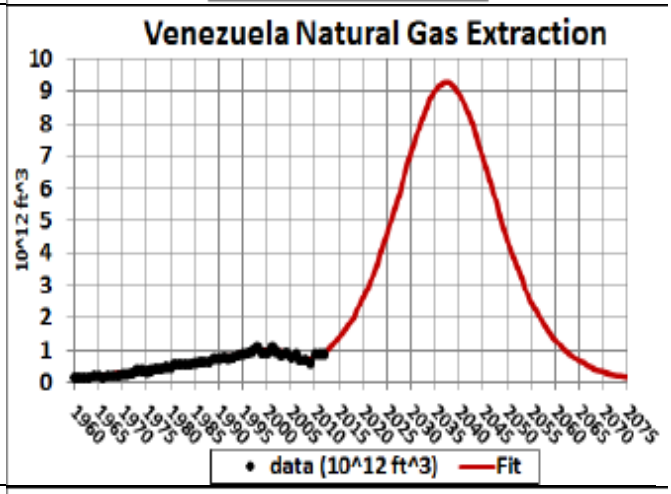


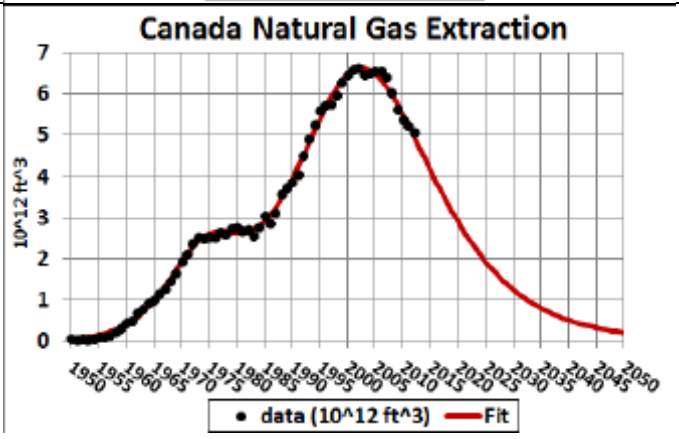


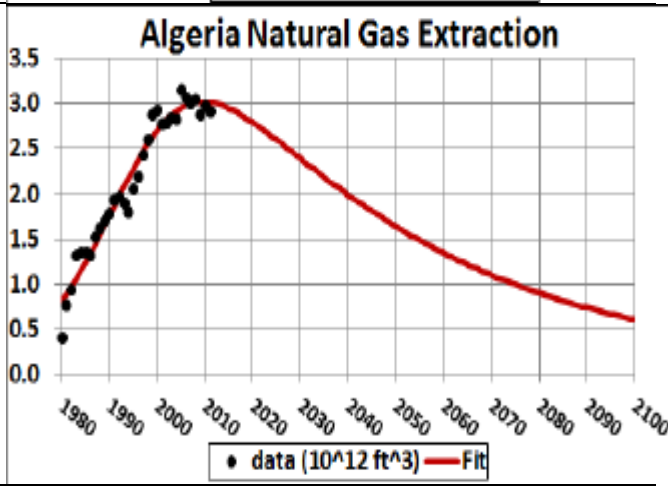

Saudi Arabia Natural Gas Extraction
data (10^12 ft^3)
Fit

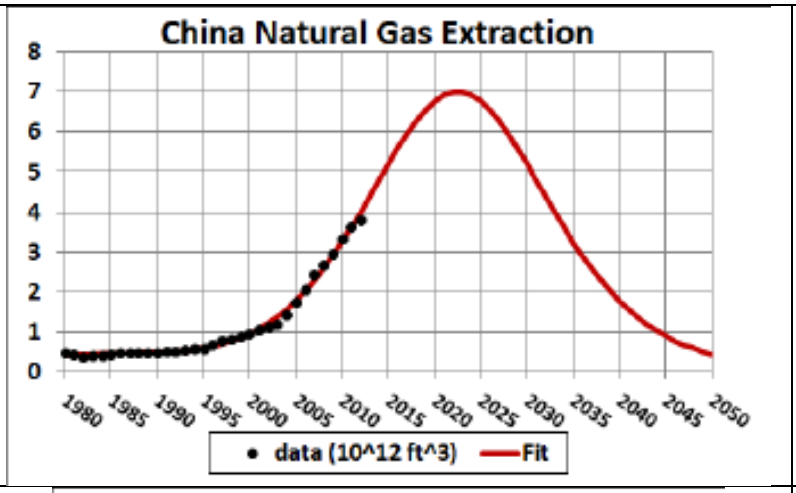

Turkmenistan Natural Gas Extraction
data (10^12 ft^3)
Fit


UAE Natural Gas Extraction
data (10^12 ft^3)
Fit


Venezuela Natural Gas Extraction
10^12 ft^3
data (10^12 ft^3)
Fit


Canada Natural Gas Extraction
10^12 ft^3
data (10^12 ft^3)
Fit


Algeria Natural Gas Extraction
data (10^12 ft^3)
Fit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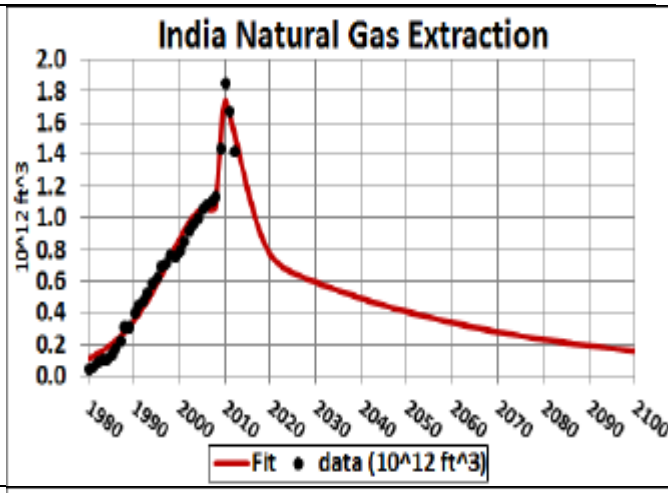
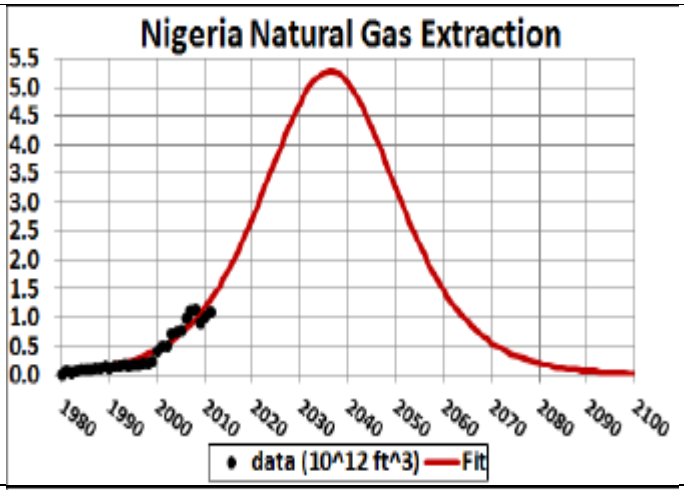
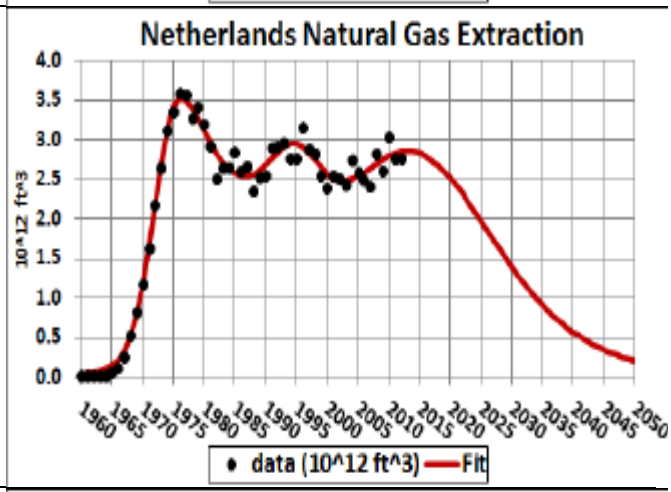
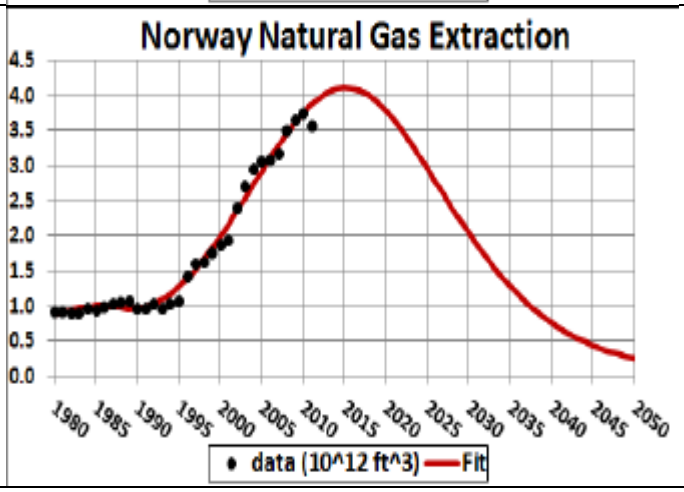
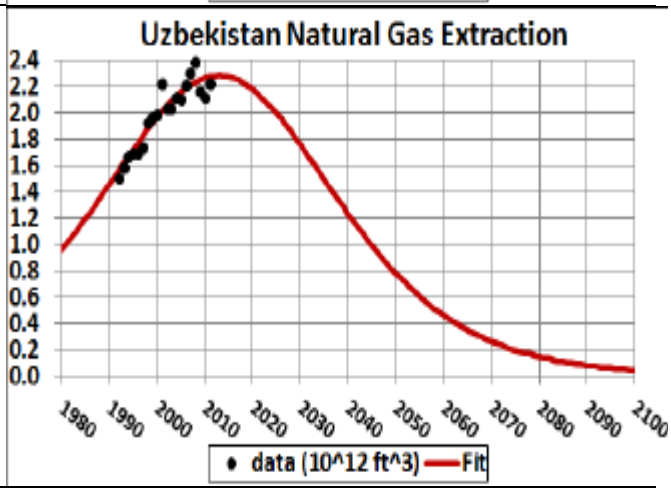
data (10^12 ft^3)
Fit

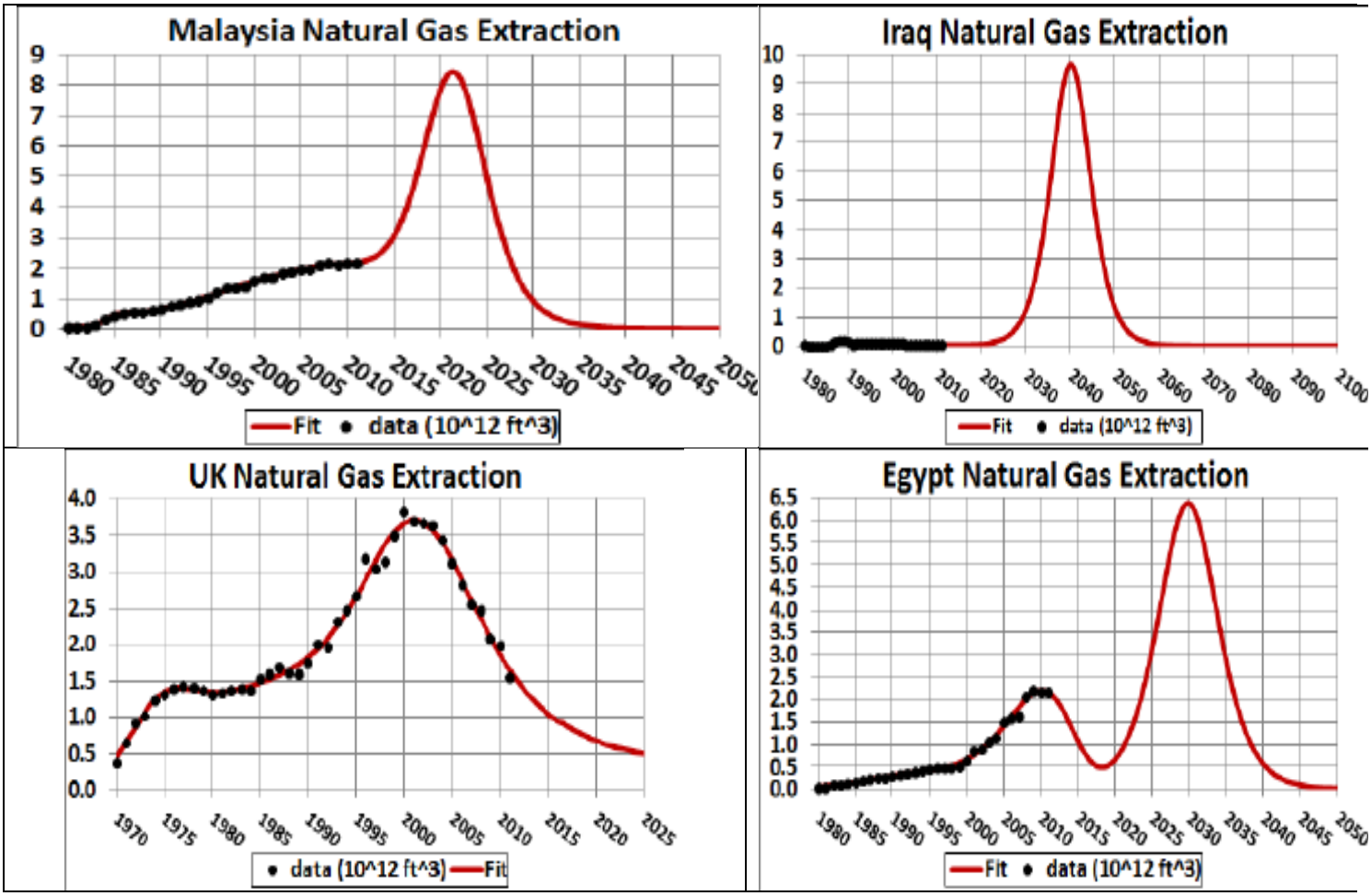

India Natural Gas Extraction
10^12 ft^3
Fit
data (10^12 ft^3)


Nigeria Natural Gas Extraction
data (10^12 ft^3)
Fit


Netherlands Natural Gas Extraction
10^12 ft^3
data (10^12 ft^3)
Fit


Norway Natural Gas Extraction
data (10^12 ft^3)
Fit

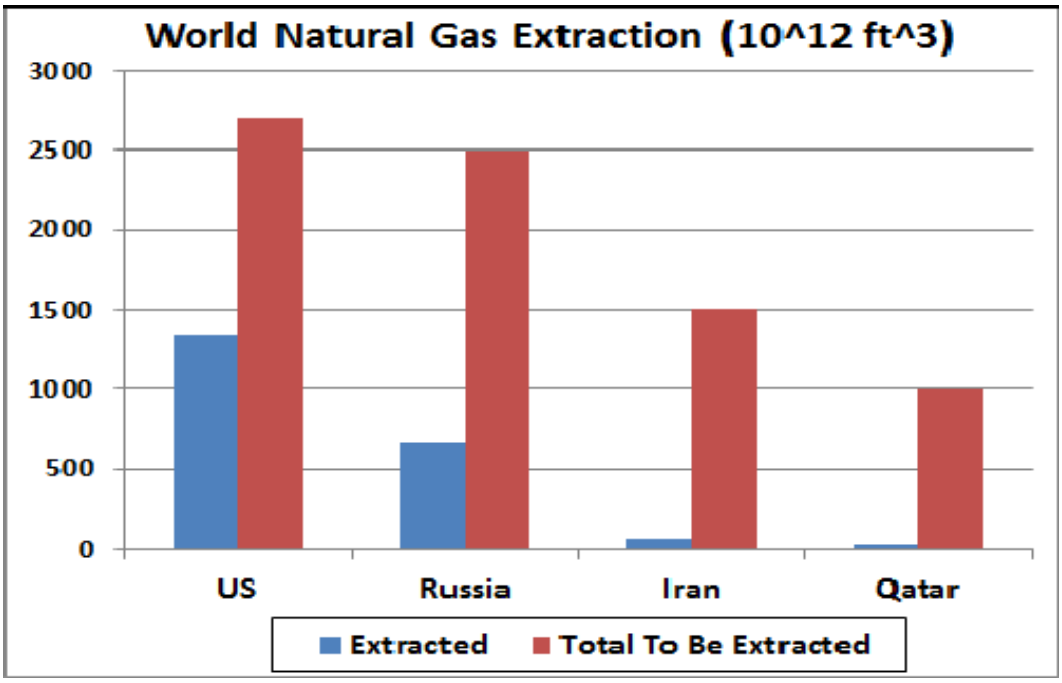

Uzbekistan Natural Gas Extraction
data (10^12 ft^3)
Fit



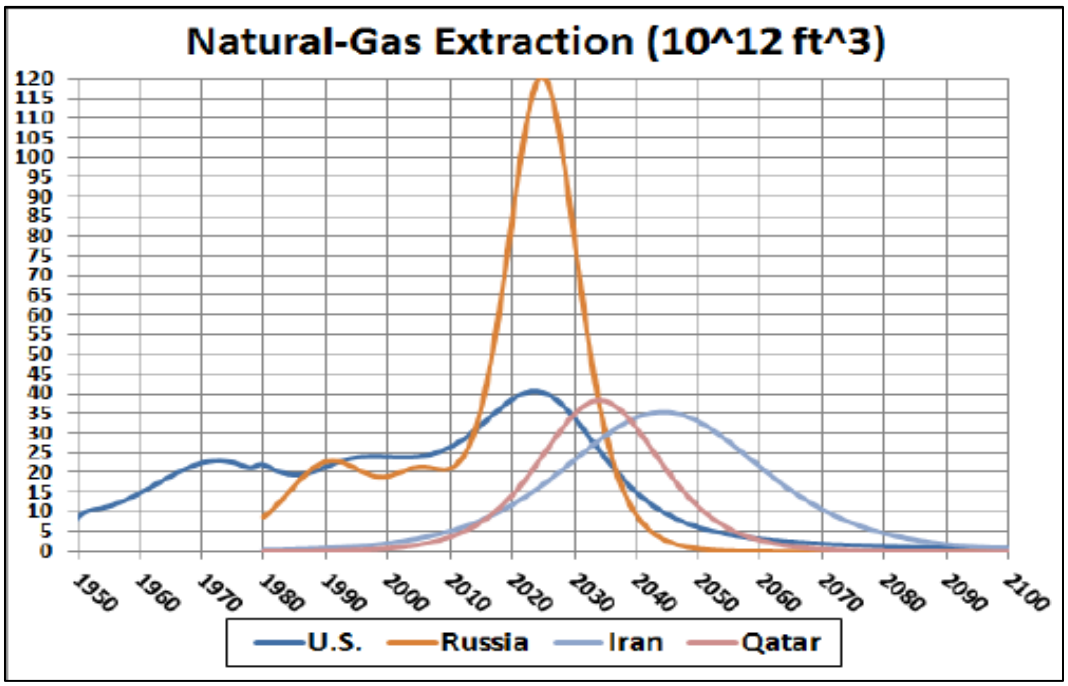
The extraction curves shown above are for the twenty nations that will extract the most natural gas from the Earth. Of course, there are many other nations that have extracted natural gas from the Earth.

In the graph for the U.S. above, a blue curve shows the case for which the estimated reserves would be extracted at the current rate of extraction, a very unrealistic, but often stated, case.

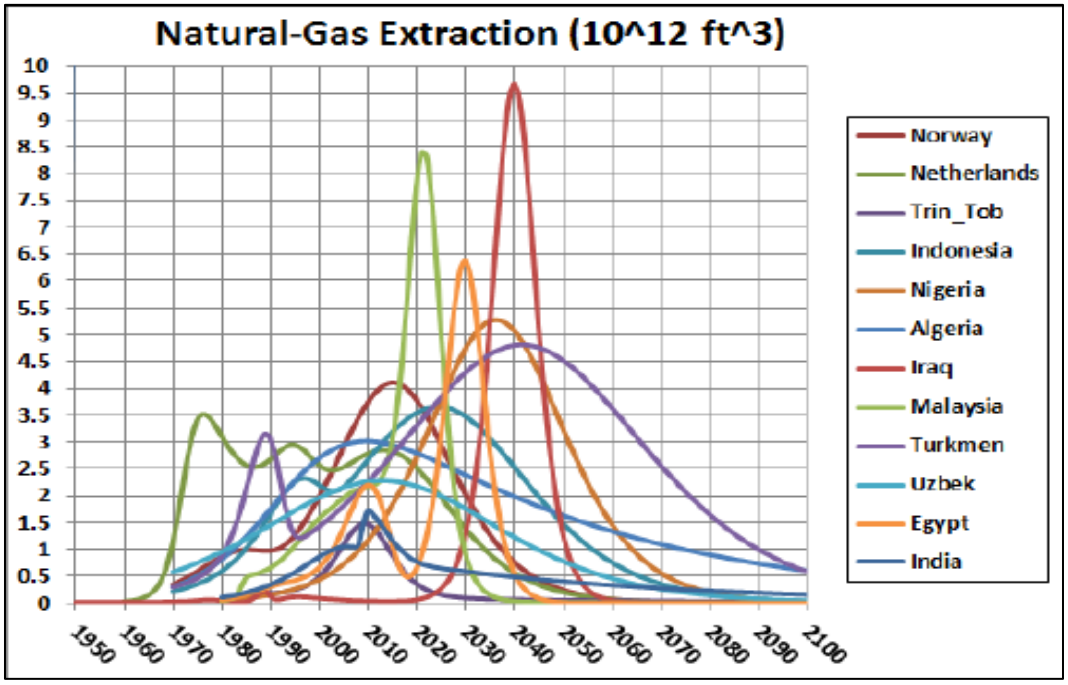
The following graph shows the amount already extracted and the total amount to be extracted for the four nations with the largest extraction amounts.



The following graph shows year extraction rates for the four nations with the largest extraction amounts.



The following graph shows the extraction rates versus year for some nations with the large extraction.



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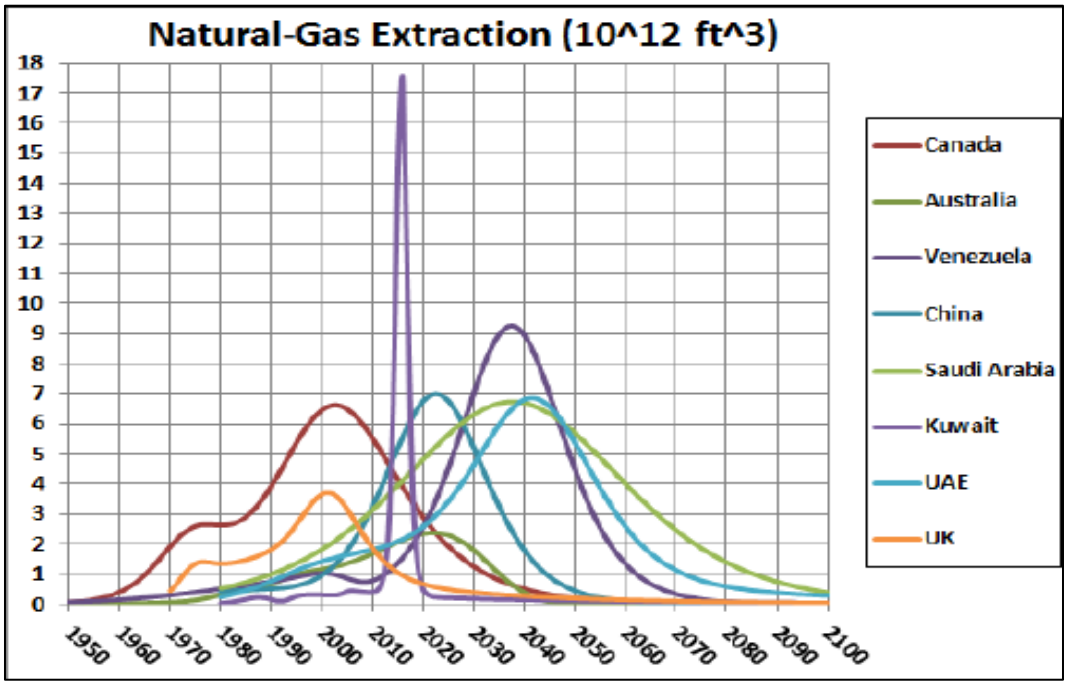
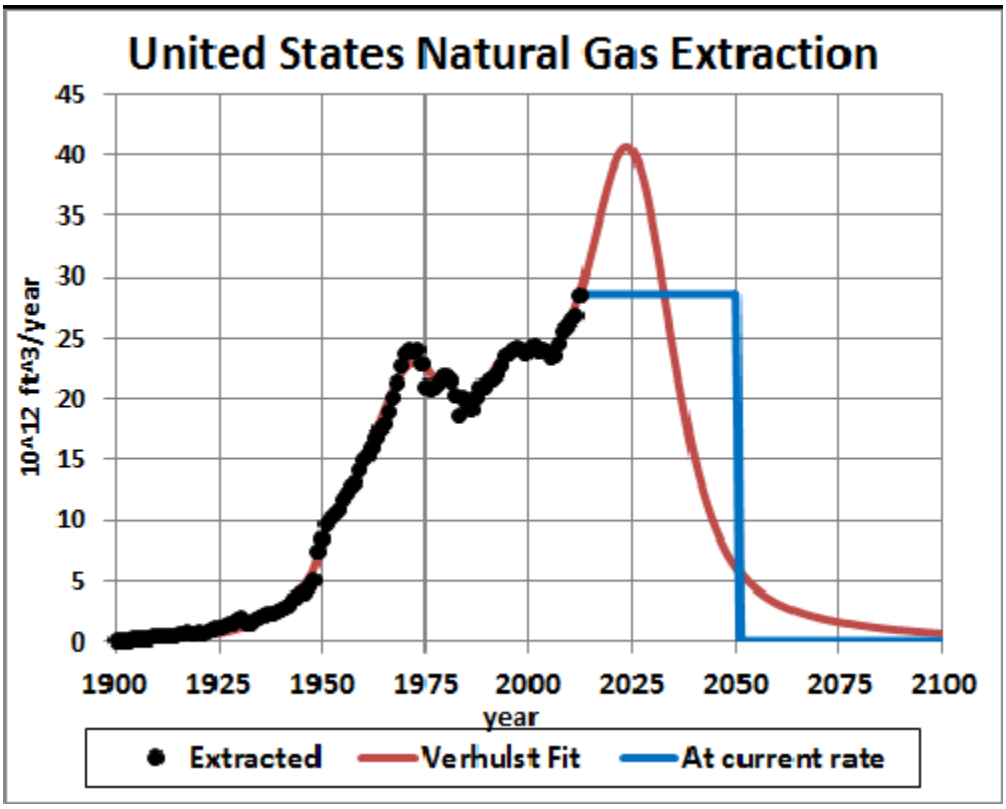
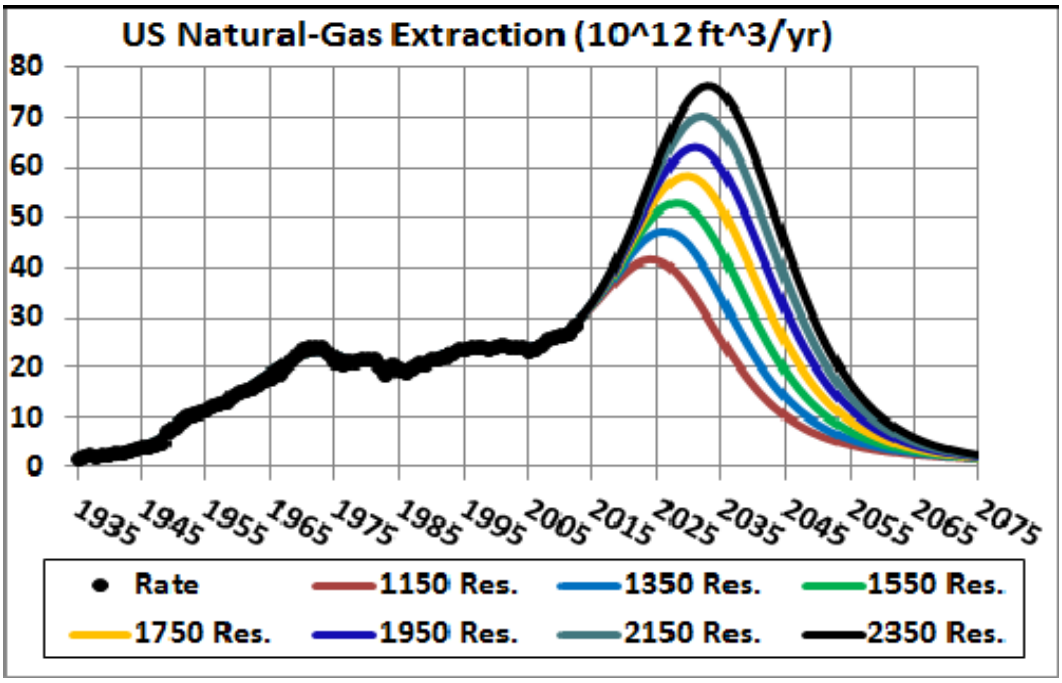


United States Natural-Gas Extraction

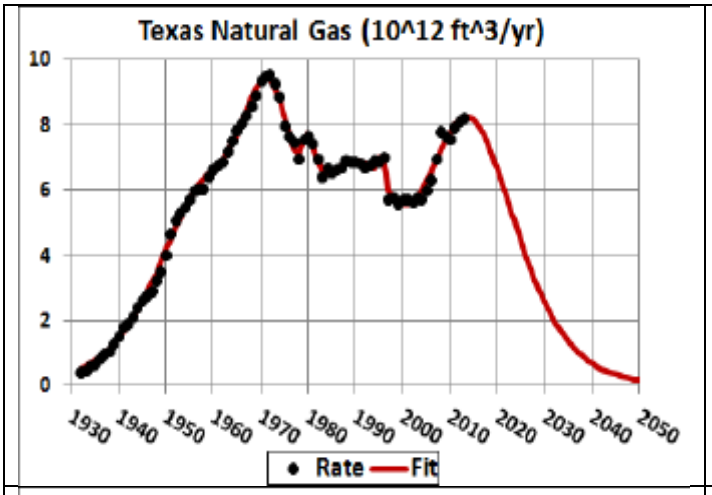


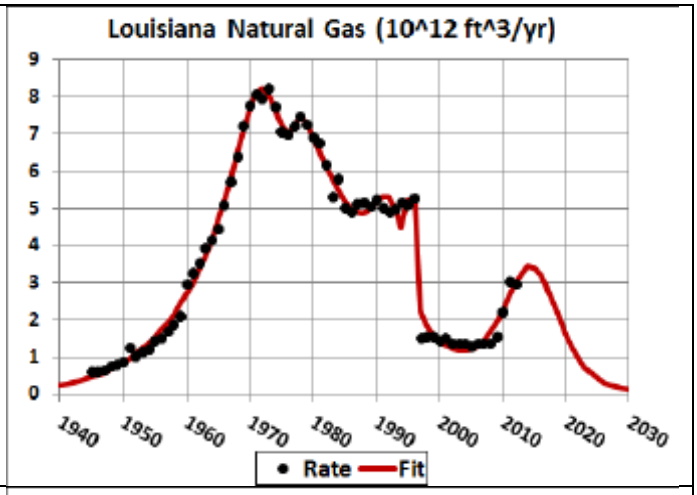
The blue curve shows the case for which the estimated reserves would be extracted at the current rate of extraction, a very unrealistic, but often stated, case.

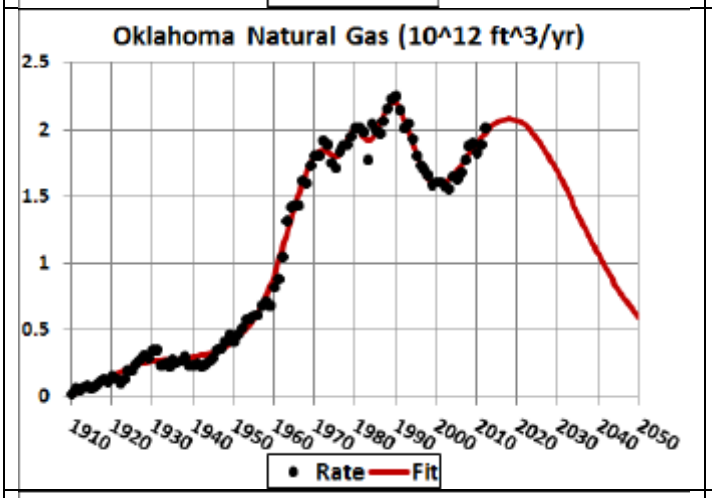
Increasing the reserves by large amounts will not change the peak data by very much:

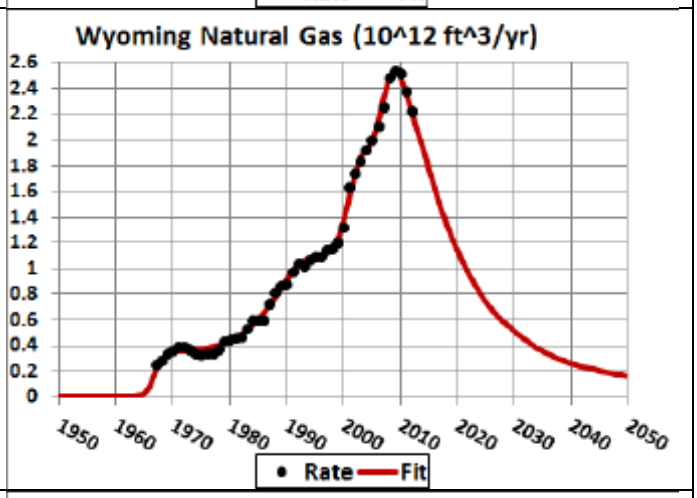


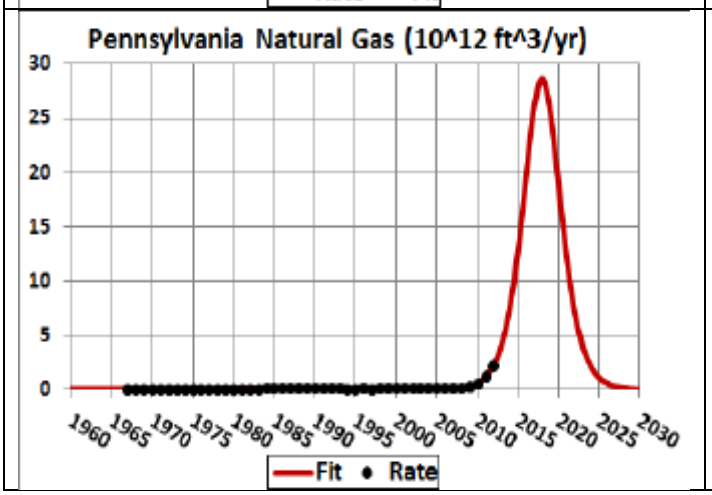
The following graphs show natural-gas extraction data for the seven US states with the largest extraction. The red curves are the best fits to the data using the Verhulst function (http://www.roperld.com/science/minerals/VerhulstFunction.htm) to fit the data.

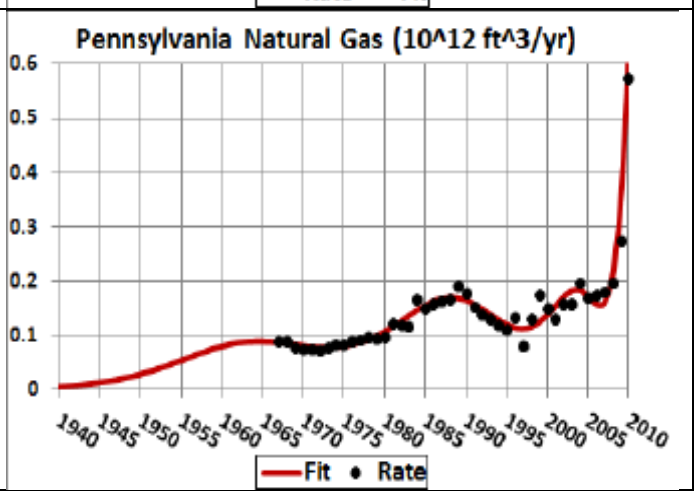


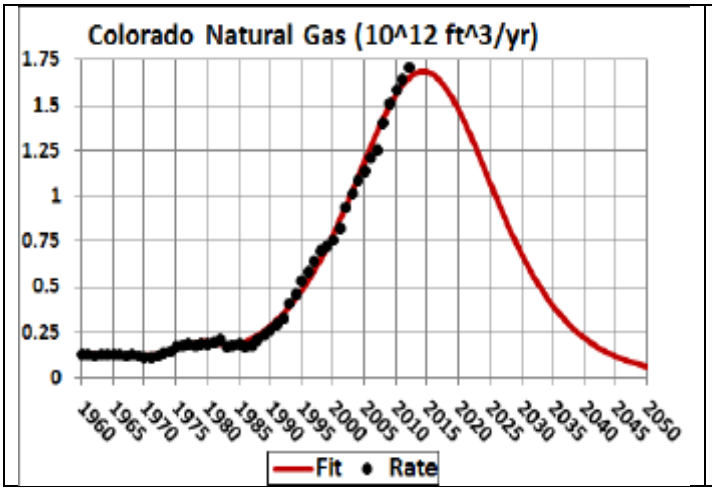


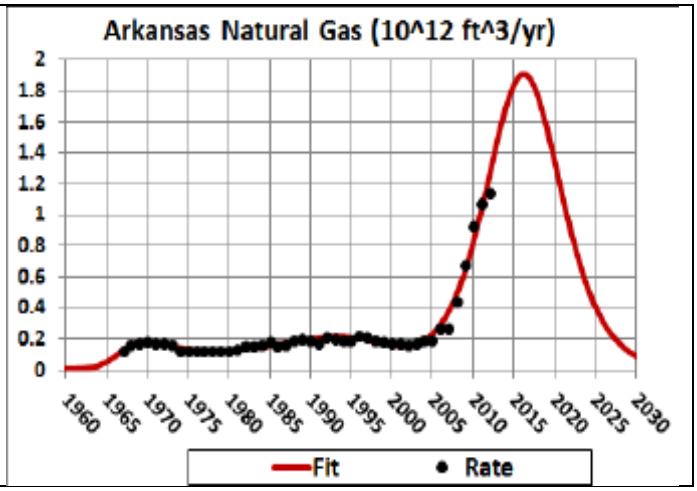




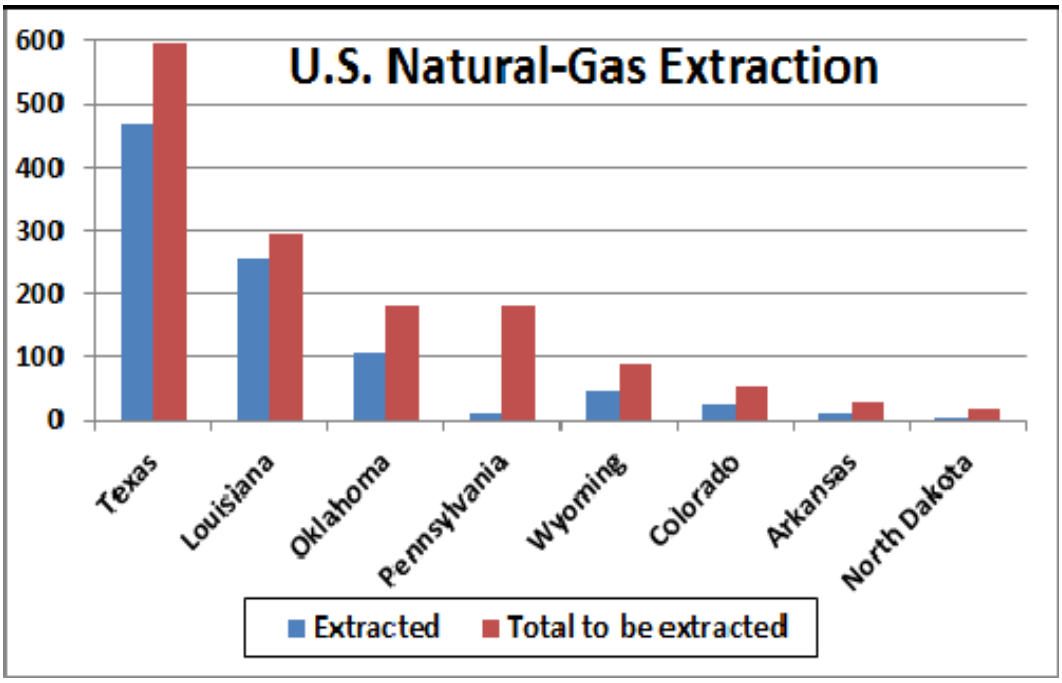




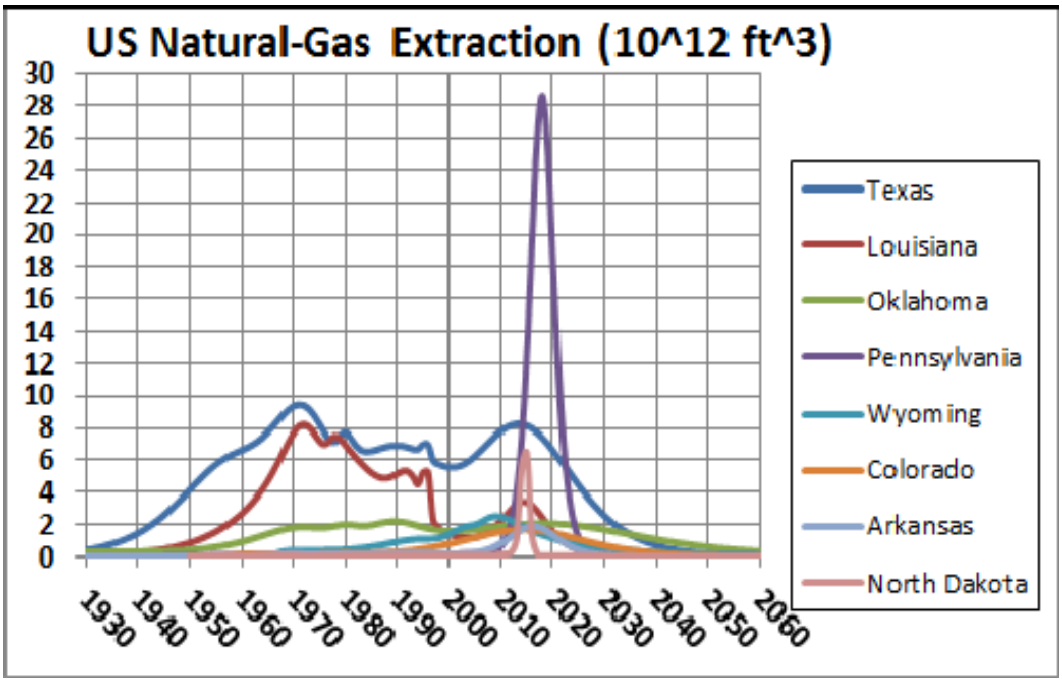

Colorado Natural Gas (10^12 ft^3/yr)
1.75
1.5
1.25
1
0.75
0.5
0.25
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
Fit
Rate

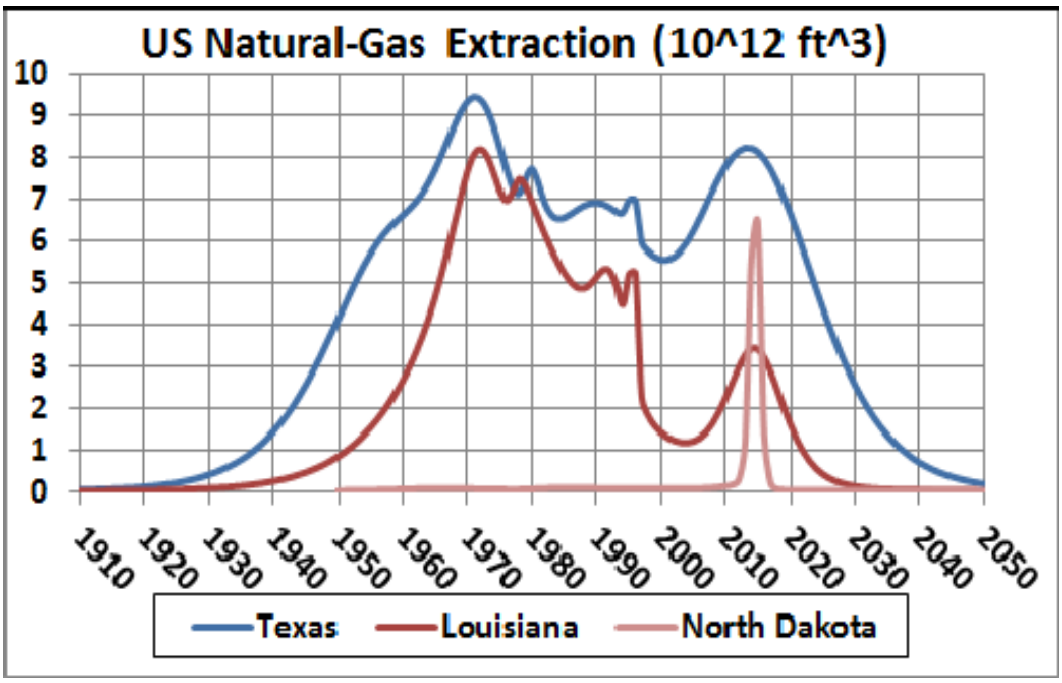

Arkansas Natural Gas (10^12 ft^3/yr)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
Fit
Rate

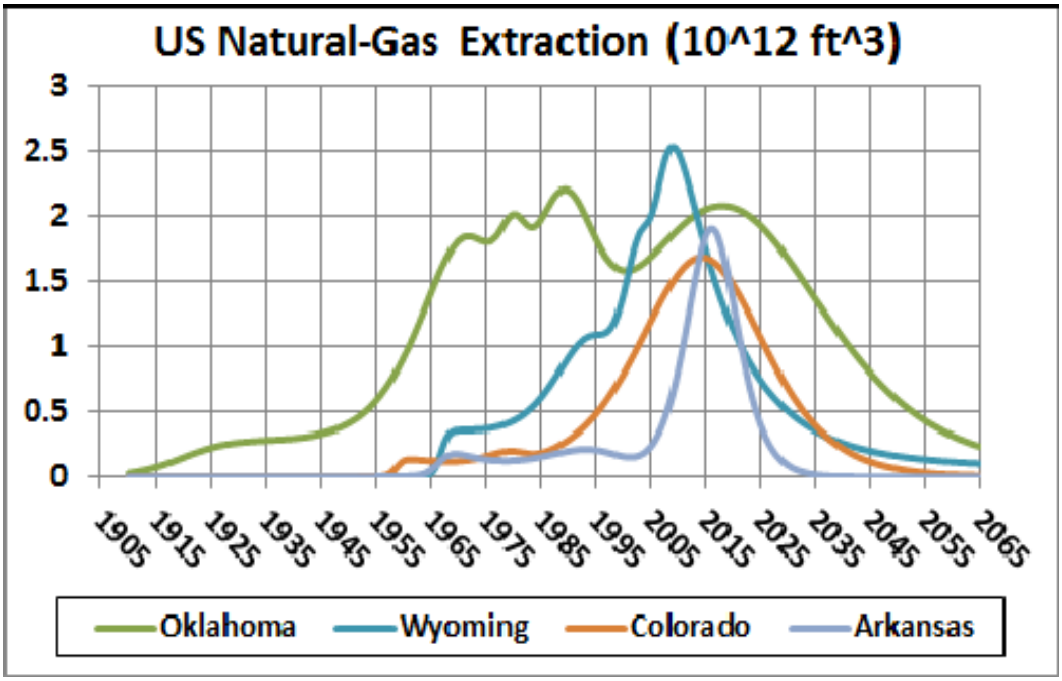
The following graph shows the amount already extracted and the total amount to be extracted for the eight states with the largest extraction amounts.



The following graph shows the extraction rates versus year for the eight states with the largest extraction.



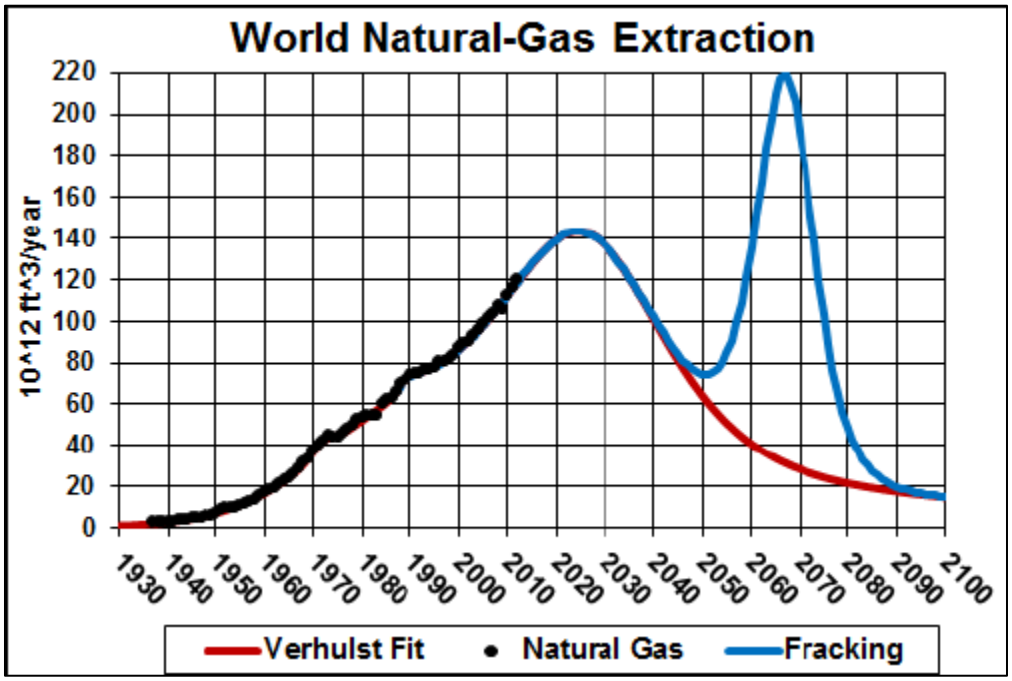




The large recent peaks are due to fracking (http://en.wikipedia.org/wiki/Fracking); the natural gas is being extracted so fast that extraction will peak very soon.

Fracking for Shale Natural Gas

The Energy Information Administration estimates that the world technically recoverable resources for shale natural gas are about 7,500 trillion (10^{12}) ft^3. Using 3 x 10^{15} barrels as the amount of world shale natural-gas reserves and reasonable values for the peak position and rising time constant for world tight oil, the following is a reasonable depletion curve for world natural gas:



So, fracking for shale natural gas might delay the extraction peak for world crude oil by ~40 years, which will be followed by a fast decline.

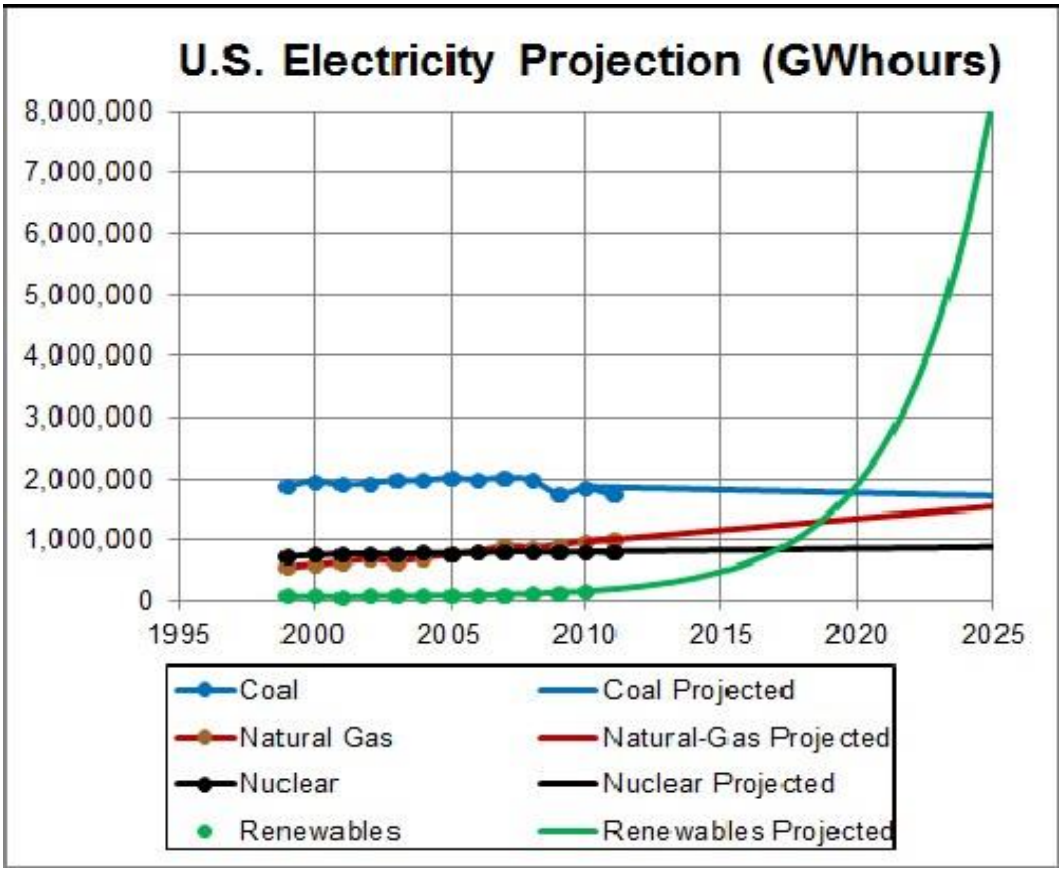
Replacing Natural Gas as a Source of Energy

The curves above make it very clear that other sources of energy beside natural gas must be developed very soon. Fortunately, wind and solar energy are well underway, but their development needs to be greatly accelerated. Fortunately, wind is most available at night and solar energy is most available during the day, so they complement each other.

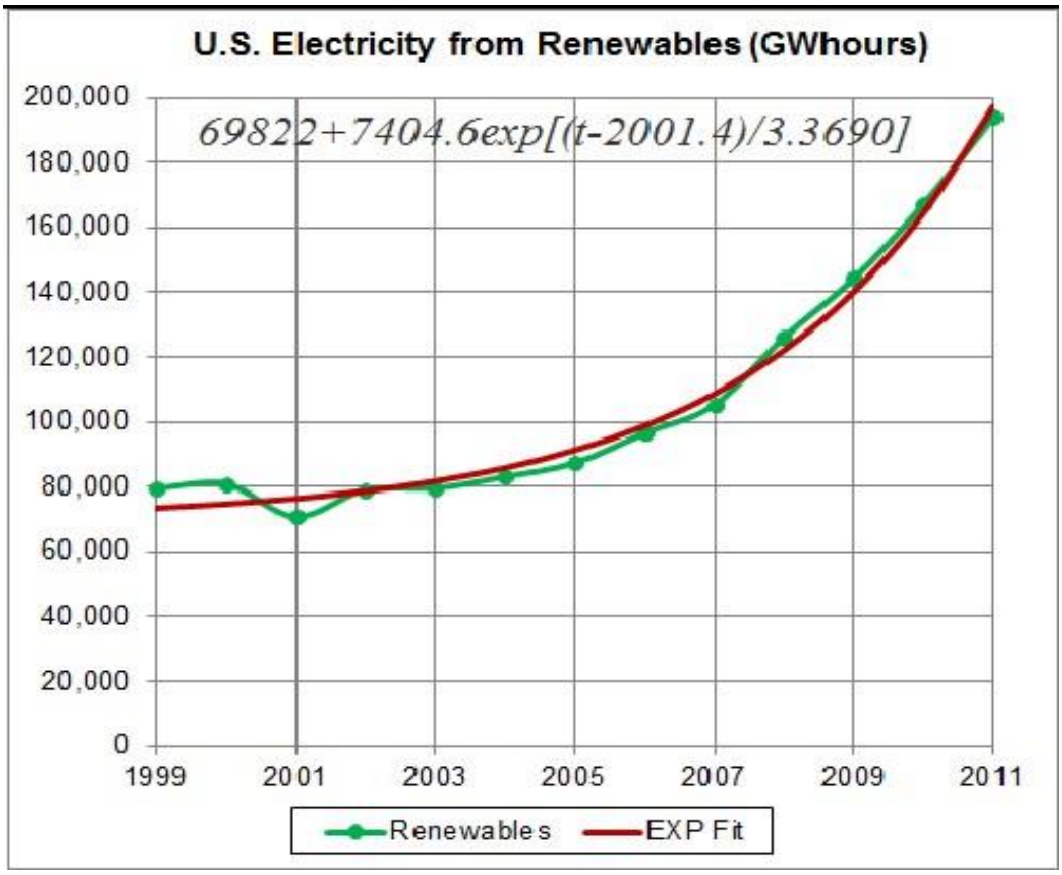
The major use of crude oil for energy is in for heating and generating electricity. The world needs to move very rapidly to replace heating by solar and generating electricity by renewable energy.

A large fleet of electric vehicles would enable those vehicles to be used as energy storage, when not being driven, for renewable wind and solar energy. Also, when slightly less capacity batteries are replaced in electric vehicles, the replaced batteries can be used for storage for renewable wind and solar energy.

Construction of renewable energy infrastructure is increasing so fast in the United States that by 2020 it will generate much more electricity than coal, natural gas and nuclear reactors:


U.S. Electricity Projection (GWhours)
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
1995
2000
2005
2010
2015
2020
2025
Coal
Coal Projected
Natural Gas
Natural-Gas Projected
Nuclear
Nuclear Projected
Renewables
Renewables Projected

Generating electricity by renewable energy is growing exponentially in the United States:



So, there is hope that the current exponential rate of creating the infrastructure for electricity generated from renewable sources in the United States will continue for several more decades. In some countries, such as Germany and Spain, it is increasing faster than in the United States

References

- http://www.roperld.com/science/minerals/minerals.htm
- http://www.roperld.com/science/minerals/FossilFuels.htm
- http://www.roperld.com/science/minerals/NaturalGasUs.htm
- http://www.roperld.com/science/minerals/USGasBoom_Bust.htm