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Fracking, THE NATURAL GAS ECONOMY, AND THE EMERGING US INDUSTRIAL RENAISSANCE

James Levy

Fracking, also known as hydraulic fracturing, is a natural gas and petroleum extraction technology that is already transforming the energy sector in the United States, and has the potential to fundamentally alter not only the US economy, but also the geo-political balance of the world in the coming decades. Fracking has become worthy of careful study for two reasons. Firstly, the utilization of this new technology is not only breathing new life into old oil and gas wells which had already capped as depleted wells, but also is opening huge new swaths of the continental United States for profitable oil and gas production from enormous reserves which can now be profitably exploited through the use of fracking technology. The economic benefits to the US of the creation of hundreds of thousands of new jobs and a sharp reduction of oil and gas imports are difficult to overstate. Secondly, as thousands of fracking wells have been drilled in these newly opened new oil and gas production fields, a controversy has grown concerning the safety of fracking and its potential to contaminate groundwater supplies, or even cause earthquakes. The documentary film Gasland (2010, directed by Josh Fox) has become the rallying cry for the anti-fracking movement that seeks to ban or severely restrict fracking wells in the future. In this essay the author will attempt to shed some light and common sense analysis on the fracking controversy, explore the potential impact of fracking on the United States in the coming decades, and the implications for the world economy and geopolitical balance as the United States moves from becoming the world's greatest importer of oil and gas to possibly becoming an exporter to rival many of the current members of OPEC.

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1 Historic evolution of oil exploitation and fracking

From prehistoric times oil deposits have been exploited where there were naturally forming pools of oil brought to the surface after seeping through the cracks in rock formations. Once the easily gathered oil was exhausted, it did not take long for human ingenuity to devise ways to increase the supply of this valuable substance through drilling holes into oil bearing rock to create a pathway for more of the oil and gas under pressure to come up to the surface to be collected. As far back as the year 357 there are records in China of oil wells drilled with bits attached to bamboo poles to a depth of up to 240 meters. There are records from the 7th century in Japan that refer to petroleum as ¨burning water¨ and the use of natural gas both for heating and lighting. In the 8th century the streets of Baghdad were paved with tar from oil exploitations. The human hunger of petroleum and its derivatives only increased through the centuries, especially after Arab and Persian chemists learned how to distil crude oil to produce more volatile products with military applications. Petroleum distillation techniques were widespread throughout Europe by the 12th century.

From the earliest time until the first fracking well was demonstrated in 1947, all oil wells had two characteristics. First, drilling was conducted vertically, that is, straight down, in hopes of penetrating a rich deposit of crude oil. Second, if the well did strike oil, it would be extracted mainly by controlling the natural gushing of the highly pressurized oil as it rushed to the surface. After a period of production had passed, this pressure might no longer be sufficient to bring oil to the surface, though a large pool of oil remained underground. In this case, the iconic oil horsehead pumpjack would be used to suction as much as possible of the remaining oil from the reservoir, thus considerably extending the productive life of the well.

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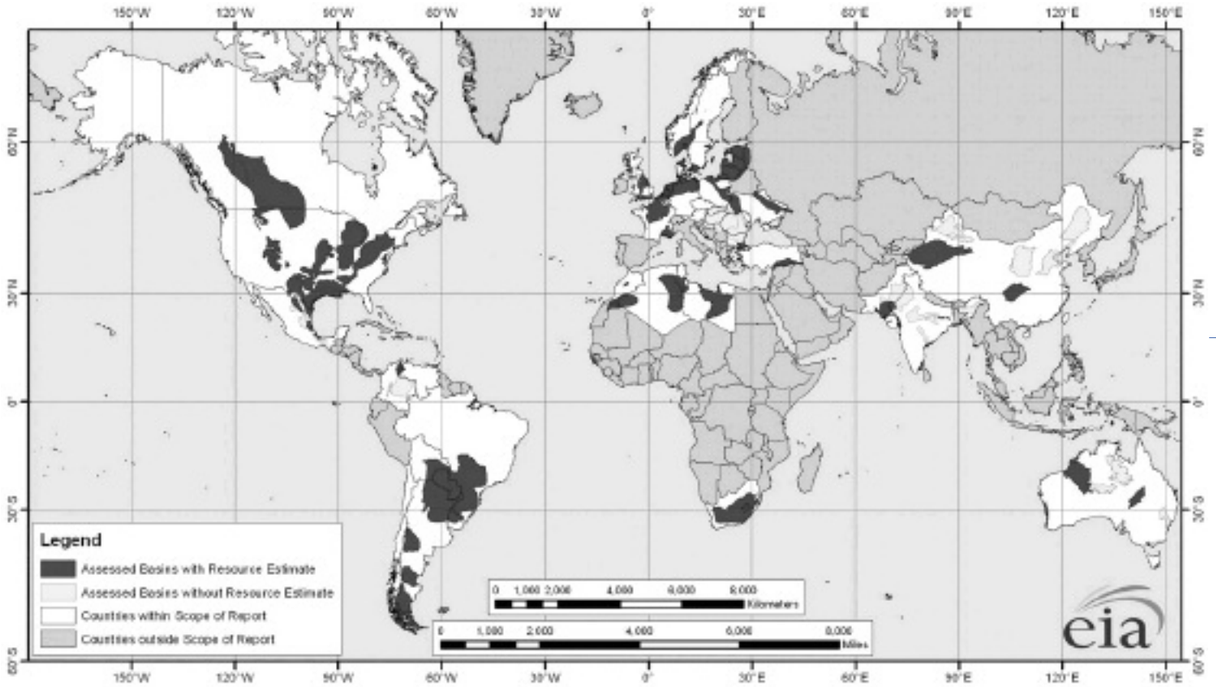
Fracking technology combined with greatly improved underground seismic survey techniques has changed both of these traditional characteristics of oil wells. In the first place, oil wells no longer have to be drilled only vertically. Today's technology allows for drilling which is more analogous to a directed snake, which can change direction and angles to reach not just one oil reservoir straight down from the drilling head, but several different oil formations identified by seismic surveys with three dimensional precision. The drill can be directed in various directions, and indeed drill horizontally for several kilometres. In parts of the United States today, where offshore oil drilling is not permitted, huge amounts of oil is being extracted from offshore reservoirs by oil rigs located on land, but drilling horizontally for several kilometres to reach these rich reserves.

Secondly, fracking technology has given a third stage to the exploitation of oil reserves. After the pressure of the oil no longer is sufficient to bring it to the surface, when the horsehead pumpjack is no longer able to economically suction the oil to the surface, it is possible to extend the productive life of oil gas wells through fracking, as well as open new oil fields which were not economically viable until this time using traditional oil extraction techniques.

Map of major shale gas basin in the United States from: EIA. *World Shale Gas Resources: An Initial Assessment of 14 Regions outside the United States*. Web. June 10, 2013.

2 What then is fracking?

It is simply a technique which involves pumping millions of litres of fluid under great pressure down the well hole to hydraulically fracture the oil and gas bearing rock formations, thus creating cracks through which more oil and gas can reach the well bore and be brought to the surface. The fracking fluid pumped under great pressure to fracture the gas and oil bearing rock is itself 99.5% water and sand, with the remaining portion being a mix of lubricants, acids, pH adjustors and other trace elements chosen to help facilitate the movement of the gas and oil through the cracks in the rocks produced by the high pressure. The composition of the fracking fluid used in each particularly well is variable depending on the particular geology of the gas and oil bearing shale at the well, but the fluid composition is regulated by both state and federal law in the US, and must be fully disclosed after fracking operations commence. Though first demonstrated in 1947, it is the application of horizontal drilling and great advancements in seismic mapping of oil and gas deposits during the last 15 years which has brought fracking to the forefront of the energy debate as huge gas and oil deposits in shale formations throughout the United States can be profitably exploited for the first time through applying this technology.



Map of major shale gas basis all over the world from: EIA. *World Shale Gas Resources: An Initial Assessment of 14 Regions outside the United States*. Web. June 10, 2013.

3 Economic Benefits

In order to understand the importance of fracking, and how it is likely to change the world in the coming decades, it is first necessary to understand the sheer scale of the new oil and gas reserves that can be exploited using this technology. The US Department of Energy estimates that US natural gas production will increase from 23 trillion cubic feet (tcf) in 2011 to 33 tcf in 2040, with almost the entirety of this dramatic increasing coming from shale gas production in the newly viable shale gas fields. In his 2012 State of the Union speech, President Obama stated that the United States has enough natural gas to last 100 years, providing a path towards finally replacing imports from Middle East dictatorships and hostile regimes such as Venezuela with domestically produced gas. Furthermore, the scale of the reserves are such that it is not at all unreasonable to foresee a day when the United States could become a major natural gas exporter, supplying the hungry markets of Europe and Japan from gas export terminals in the the Atlantic and Pacific coasts respectively. Given that American produced natural gas costs approximately one fourth of the price of gas in Europe or one eighth of the price of gas in Japan, there is ample space here for developing a very lucrative export industry based on fracking natural gas from the domestic shale deposits, while generating huge economic benefits for the US (including hundreds of thousands or even millions of much needed jobs and enormous new tax revenue) in the process.

Fracking is now utilized in 90% of natural gas wells in the US, and as many as 35,000 wells are fracked each year

4 The fracking controversy

Given the clear economic and national security benefits to the United States of utilizing fracking technology to open and exploit vast new oil and gas reserves in the shale basins, it is important to understand why fracking is controversial with environmental groups. In fact, in many states these groups are actively lobbying legislators to ban fracking outright, while at the same time encouraging the US Environmental Protection Agency (EPA) to place strict new controls on fracking from the federal level, immediately applicable in all 50 states, to severely limit its future growth. To better understand the fracking controversy and the possible merits of the arguments of those who oppose fracking, one has to understand that hydraulic fracturing requires a huge amount of water mixed with sand and chemicals, as much as several million litres per well in most cases. The conservation of water resources is a very serious issue, and the potential for fracking to deplete water reserves or contaminate groundwater supplies is the first and most logical argument of those who oppose fracking wells.

To better evaluate the claims of the anti-fracking movement in an objective light, it is important to understand that the fracking debate is not taking place before fracking is approved, but rather after the technique has been used extensively for 15 years in an ever-increasing number of wells. Fracking is now utilized in 90% of natural gas wells in the US, and as many as 35,000 wells are fracked each year (the US has a total of over 500,000 natural gas wells currently, more than twice the number of wells in 1990) Fracking is now being applied on a massive scale across the US with an excellent safety and environment record. Mostly thanks to the 2010 anti-fracking documentary *Gasland*, anti-fracking groups claim that fracking leads to polluted water aquifers and flaming water taps as natural gas infiltrates water in domestic water wells. The movie famously includes a scene

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where a Colorado landowner who had granted a drilling lease to a fracking drilling company turns on the water tap in his home and lights the natural gas which emerges mixed with the water.

The evidence from thousands of fracking wells in operation dictates that the fracking fluid injected into rocks kilometers beneath the earth does not contaminate drinking water aquifers located near the surface

This made for effective cinema, but did not contribute to an honest debate about fracking, as it is a common occurrence for domestic water wells in some regions of the US to penetrate natural gas deposits. The flaming faucets in this documentary resulted from this kind of naturally occurring infiltration of gas into domestic water wells, and had nothing to do with the fracking operations taking place on his land, as concluded by the Colorado Oil and Gas Conservation Commission appointed to investigate the incident.

Apart from confusing naturally occurring gas leakage into domestic water wells with contamination from fracking, the anti-fracking movement also ignores the fact that oil and gas wells are fracked at huge depths below the earth, as much as two kilometers down. The cracks in the rocks created by the high-pressure fracking fluid typically extend for less then 100 meters from the well bore at these great depths. Both common sense and the evidence from thousands of fracking wells in operation dictates that the fracking fluid injected into rocks kilometers beneath the earth does not contaminate drinking water aquifers located near the surface, typically at depths that rarely exceed a couple of hundred meters. The rocks which are cracked in the fracking process to release gas and oil are subjected to fracking precisely because they are impermeable, and do not permit a free flow of trapped gas and oil to the oil well borehole. The cracks created by fracking to permit gas and oil movement into the borehole to be pumped out does not change the fact that there are hundred if not thousands of meters of impermeable layers of rock remaining between the greatest extent of the cracked rocks from the fracking process and the beginning of the water table much closer to the surface.

While concerns that fracking gas and oil shale deep below the surface of the earth will contaminate groundwater supplies can be discarded given the weight of the evidence from tens of thousands of functioning wells, there are two ways in which fracking can contaminate groundwater if correct procedures are not applied. First, the well hole itself must be cased with impermeable cement when drilling through the water table on the way down to the depths where gas and oil bearing shale are found. If this casing is not applied correctly, it would be possible for highly pressurized fracking fluids to seep through the walls of the borehole at the shallow depths of the water table to contaminate drinking water supplies. Second, the millions of liters of flacking fluid must be correctly contained and treated to remove any possible harmful additives when they are withdrawn from the well after the fracking is completed. Current state regulations in force as well as federal regulations place these requirements on the fracking industry.

Of tens of thousands of fracking wells in existence, documented cases of contamination of water supplies due to fracking are extremely scarce, numbering either zero (according to fracking advocates) or possibly as many as three or four (according to fracking opponents). In short, there is no fracking Three Mile Island, Chernobyl, or Fukushima to provide an unquestionable rallying point for opponents to show the dangers and halt the growth of fracturing technology as has occurred with the nuclear energy industry.

5 Peak oil and alternative energy arguments

This being the case, why is fracking such a potent rallying point for environmental activists? Why has anti-fracking become the fashionable cause celebre of the Hollywood progressives? The author would suggest that fracking is perceived as a serious threat to many who have financial or simply emotional commitment to the developing alternative energy sources, with alternative generally understood with respect to the current fossil fuel based world economy and involving solar, wind, and biofuel energy sources. Simply put, the potential for fracking technology to open huge new reserves of gas and oil not only in the US, but in many other parts of world (including many European nations) is a severe threat to the very existence of these alternative energy industries, particularly in the current age of austerity when government budget deficits are forcing cuts in wasteful subsidies. Until very recently, the voters where bombarded with dire predications that the world supply of oil and gas would soon be depleted, based on the "peak oil" theory that world oil production had already reached its peak, and $200 dollar a barrel oil and world economic stagnation, or even collapse, was likely to ensue unless alternative energies such as solar, wind and biofuel were developed. The peak oil argument was in turn used as a justification of billions of dollars of tax revenue to be spent on developing and subsidizing wind and solar energy production facilities, even though energy from these sources is much more expensive than energy from efficient gas and oil plants. High electric bills, more deficit spending and ultimately higher taxes where sacrifices that had to be made, since oil and gas would not be available in the future to power our economy as reserves were depleted. Fracking has blown this argument to pieces, and put at risk billions of dollars of expensive and economically uncompetitive alternative energy projects worldwide. Rather than becoming

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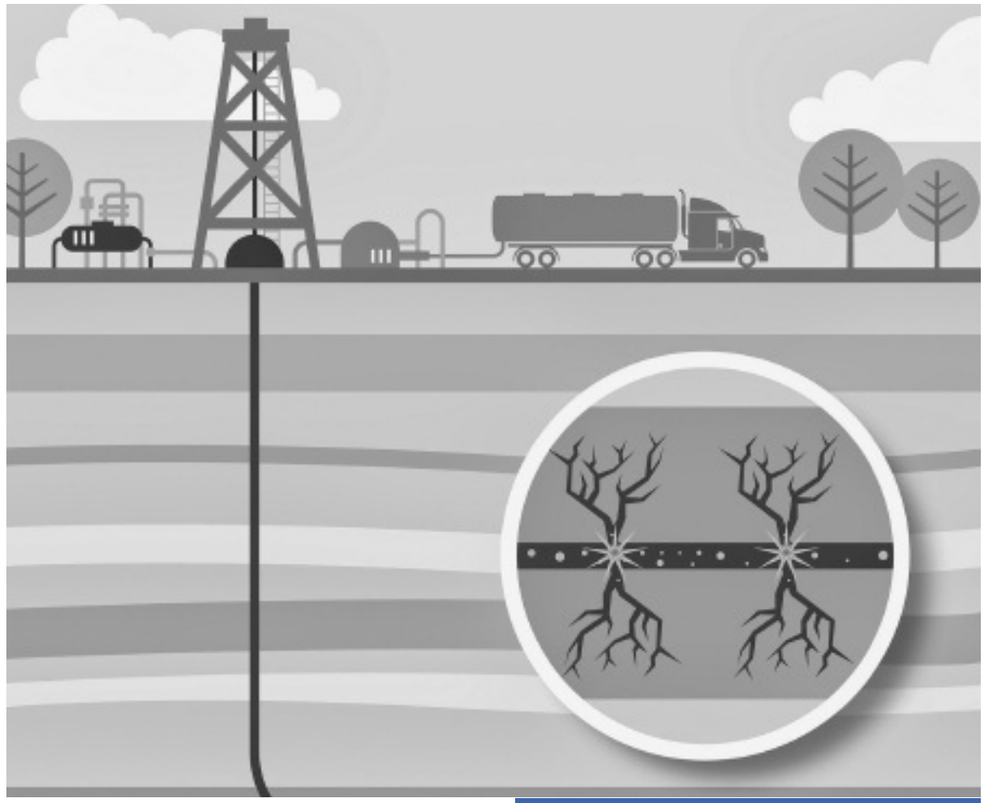
increasingly scarce and expensive, it is now clear that oil and gas will become increasingly abundant and no doubt less expensive in the future as fracking technology is applied not only in the US but in other countries which are not traditional oil and gas producers. The Stone Age did not end because the supply of stones was exhausted. It is now clear that the current fossil fuel age will not end because the supply of oil and gas becomes exhausted, as fracking permits an economically viable exploitation of oil and gas reserves worldwide, sufficient for more than the next one hundred years, with a high probability of further increasing these reserves as this technology advances and new shale gas reserves are discovered in the future. For example, it is known that Spain has ample reserves of shale gas in regions such as Cantabria, the Basque Country and Castilla-León. Poland is thought to have huge gas reserves that could be exploited through fracking as well as the UK. In the case of Poland, fracking is heavily favored in public opinion polls with support of over 70% of the population, as fracking is seen as the key to reduce Poland´s dependence on imported gas from Russia. Poland may have shale gas reserves



A simple diagram of how fracking works.

sufficient for 300 years of national consumption according to a US Department of Energy announcement in April of 2011. The Polish government has already granted 111 exploration concessions on an area equivalent to one third of the size of the country.

So far in Europe the only major country in Europe to ban fracking outright has been France, which has a huge nuclear power industry that already supplies a large part of their energy needs. Even after a study commissioned by the European Union concluded that current legislation regarding fracking is adequate to protect the environment, the anti-fracking movement in Europe continues to be much more effective than in the US in their fight to prevent this huge source of clean and inexpensive domestic energy from being exploited. If Europe does not develop its gas and oil reserves that can be obtained through fracking not only will consumers continue to be suffer extremely high gas costs from such unstable suppliers as Russia and Algeria, but also energy dependent European industries while be at a severe competitive disadvantage in relation to American firms, which have access to very low cost domestic natural gas. It is interesting to note that one reason for the widespread growth of fracking in the United States is that under American law, landowner has mineral rights as well to whatever is below the surface of the property. For this reason, fracking companies can approach landowners directly, offering them payment for the temporary use of a part of their land to mount a fracking well and ancillary equipment. Most landowners in the US have been very glad to accept this windfall income, which is giving an additional important boost to many rural economies throughout the United States. In contrast, in Europe for example, the

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state owns the mineral rights by default, and hence landowners have no vested interest in allowing fracking operations on their property. This legal difference provides another reason why the political debate concerning fracking is much more evenly divided in the US than in Europe, as there is no pro-fracking landowner lobby in Europe as there is in the US.

The beneficial impact of abundant natural gas supplies from large-scale fracking in the US is becoming ever more apparent, as are the geopolitical implications of a United States which is no longer a major oil and gas importer. The United States is expected to produce 7.3 million barrels per day of domestic oil this year, up from 6.4 million barrels per day last year. Oil production is at its highest level in the past twenty years, while at the same time U.S. oil demand is at a 17 year low due to increasing energy efficiency and reduced consumption linked to high unemployment and weak economic conditions in general. At the same time, oil imports are running currently at 7.7 million barrels per day, down 1.2 million barrels per day from last year´s levels. The International Energy Agency expects the United States to surpass Russia and Saudi Arabia as the biggest producer of oil and gas in the world by the end of the current decade.

6 Geopolitical implications

The geopolitical implications of a fracking-driven transformation of the United States into an energy exporting superpower are difficult to overstate. In economic terms, the United States can look forward to firstly and quickly decreasing bill for importing foreign oil, followed in later years by steadily increasing revenue from providing oil and gas to hungry markets of Asia and Europe. The oil and gas industry will be an important source of new high paying jobs, not only for petroleum engineers and seismic analysts, but importantly for hundreds of thousands of drilling workers, truck drivers, refinery workers and other blue collar jobs which provide a decent living for people without a four year university degree. The tax revenues from this new economic activity will make a strong contribution to reducing the chronic Federal budget deficit, and help the oil and gas producing states to maintain balanced budgets without raising taxes. All of this will contribute to maintain the United States as the world´s foremost economic power for decades to come, and help American industry to compete effectively against European and Asian producers burdened with much higher costs for their energy inputs to production. Already global manufacturing companies are beginning to transfer energy intensive production processes to American factories to take advantage of the much lower energy costs in the U.S.

In military terms, a United States which no longer imports oil and gas from the Middle East, and is not dependent on safe navigation by oil tankers through the Straits of Hormuz may view its military commitment overseas in a different light than is does currently. In times when there is a growing demand by many American voters to reduce foreign military commitments and concentrate on renewing the aging infrastructure of the US, how long will the American people be willing to shoulder the enormous costs of maintaining the complex web of military bases, fleets of fighter and bomber aircraft and dozens of warships which are always on call now in the Middle East? There is a growing movement in the United States known as "ethical oil" to purchase oil only from governments that grant basic civil rights to their citizens, depriving totalitarian regimes such as Iran and Saudi Arabia of the oil revenue that they use to continue the brutal repression of their population to sustain the elite currently in power. Already the United States is nearly at the point where oil imports from Canada and Mexico are sufficient to cover all needs for imported oil until fracking has grown sufficiently to make all imports unnecessary.

7 Natural gas versus alternative energies

To better understand why natural gas and oil from fracking will be the primary energy sources of the future rather than solar or wind, it is useful consider energy density. Fuels such as oil and natural gas store huge amounts of energy, far exceeding the energy that can possibly be extracted from an array of solar panels or collection of spinning windmills. For example, kilo for kilo, gasoline contains more energy than dynamite. A single litre of gasoline contains the energy equivalent of over 8 million calories, which is why the contents of a small gasoline tank are sufficient push a car up and down hills for hundreds of kilometres. Even extremely costly and accident prone lithium batteries such as those used in electric vehicles today cannot come anywhere close to this capacity. This leaving apart the consideration that oil and gas powered engines and electrical power facilities can work 24 hours a day at an optimal level of efficiency, while solar plants and windmills generate energy only when the sun shines or the wind blows, and thus require very costly backup systems to be on constant standby to take up the slack when the these alternative energy sources suddenly and unexpectedly lose power due to clouds over solar arrays or excessive or absent winds which make wind power useless.

Other alternatives to oil and gas drilling, such as biofuels, have been demonstrated to be costly errors that have an enormous human cost in terms of higher food prices for poor people worldwide. How can anyone defend the fact that while millions of children are malnourished, over 40% of the gigantic corn crop of the United States each year is converted in ethanol blended into gasoline at a huge cost to the American taxpayer in subsidies? The price of corn has more than doubled in the past ten years just as ethanol production has increased in yet another failed attempt to find an alternative to fossil fuels. Unfortunately, in this particular case, the cost can be counted in the lives of malnourished children as well as in billions of wasted dollars, particularly in Mexico where the poor are highly dependent on corn meal as a basic food.

Over time, the abundance of inexpensive, very clean burning natural gas in the US will encourage the use of natural gas as the primary energy source for electrical power generation, a position currently held by coal. Natural gas is a much cleaner fuel source than coal, particularly since it does not produce particulate emissions when burned. Modern gas burning power plants are not only extremely efficient, but also very environmentally friendly when compared to coal fired plants. Given that almost no new nuclear power plants are being or likely to be built in the US, and the fact that renewable

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energy sources such as biomass, solar and wind only produce just over 5% of the US electricity production even after hundreds of billions of dollars of subsidies under the Obama administration, it is clear the natural gas should be the energy source of choice for those who truly care both about national security, a growing economy, and the environment. Natural gas is so clean burning that one way to significantly improve air quality in urban areas would be to the conversion of gasoline-powered vehicles to natural gas. Once again, the question of energy density comes to the forefront to explain why electric cars are a failure, and will continue to be a failure except as very expensive status symbols for wealth people eager to demonstrate ecofriendly credentials. It is simply impossible to achieve sufficient energy density with today's battery technology to make electric vehicles viable for the mass market. This is why despite billions of dollars in tax revenues spent on subsidies for electric cars, they have been an enormous failure.

Furthermore, short of a change in the laws of physics and chemistry, it is unlikely that battery technology will ever improve sufficiently to make the electric vehicle a viable option at an affordable price. Even if someday we do achieve a battery breakthrough which would make electric cars a viable option, there would have to be reliable power plants to generate the electricity to recharge the batteries of those cars. Windmills, solar panels or biofuels cannot power those electrical power plants. Those who want to see smog free cities should strongly support fracking, as it will be abundant and cheap natural gas that will lead to the widespread use of natural gas in vehicles as well as low emission electric power generation.

8 Future energy sources

Fill the natural gas economy made possible by fracking technology be the final word in energy supplies to fuel the modern economy? Almost certainly not. Innovation will continue, and someday perhaps it will be possible to generate huge amounts of energy cleanly and inexpensively from an inexhaustible and clean source. Such an inexhaustible and inexpensive energy source would open the door to developing the cleanest of all possible power sources, that is, hydrogen, with water vapor as the only by-product of combustion. However, until that day, the best available option to power the economy of today and tomorrow is an abundant and inexpensive supply of low emissions natural gas made possible by fracking technology.

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