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ENERGY OPTIONS AND ISSUES FACING THE USA

A.J.S. (Sam) Spearing PhD PE PrEng CEng CSci
Dept of Mining and Mineral Resources Engineering
Southern Illinois University Carbondale

ABSTRACT

The USA is facing an energy crunch as oil reserves are finite and dwindling internationally, global warming is an issue and our appetite for energy continues to grow with little signs of any necessary and meaningful savings. The country desperately needs a long term federal energy policy but little seems to be forthcoming in this regard. This paper critically reviews the energy options available and suggests a way forward that may not be popular.

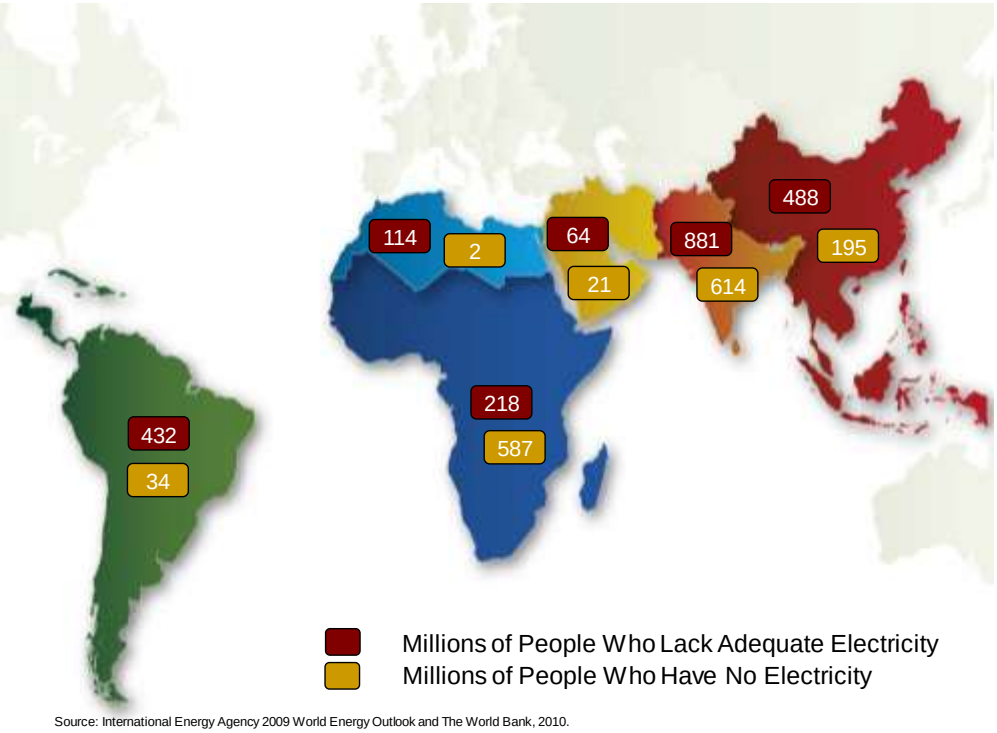
1. INTRODUCTION

While the developed world strives to spend money to reduce climate change and stifles growth with new punitive green house gas related legislation, third world countries still deal with illiteracy, a lack of basic services and starvation. According to the International Energy Agency (2009) and World Bank (2010) about 3.6 billion people have little or no access to energy. That is 3,600,000,000 people just to emphasize the magnitude of the problem, about ten times the population of the USA. The geographical location of these forgotten souls is given in Figure 1. In addition over 1.5 million (World Bank) people die globally as a result of energy poverty from being forced to use mainly wood and animal dung in dwellings.

Energy availability is vital for well being and longevity. The United Nations (UN) defines a Human Development Index (HDI). This is a way of measuring human development by combining indicators of life expectancy, educational attainment and income into a single composite index. The breakthrough for the HDI was the creation of a single statistic which was to serve as a frame of reference for both social and economic development. The HDI sets a minimum and a maximum for each dimension, called goalposts, and then shows where each country stands in relation to these goalposts, expressed as a value between 0 and 1. The higher the index the better the longevity and quality of life. Figure 2 shows the clear relationship between electricity availability and HDI.

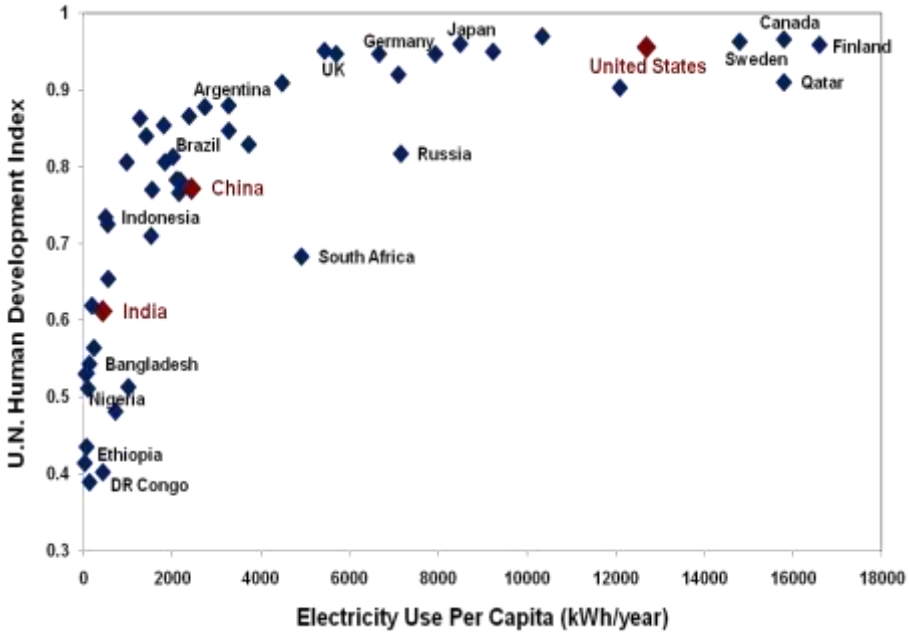
The International Energy Agency defines a minimum benchmark for electrical use of 63 kWhr/year. To put this into perspective, this is only enough power to a floor fan, two fluorescent lights and a radio for 5 hours a day for a family of 4. A tenfold increase in this usage would only be enough to permit the added usage of a small refrigerator and a low powered electrical device such as a computer. Even such a tenfold increase in electrical

usage is far from ideal. Figure 3 shows the annual power usage in several countries and illustrates the huge gap.



Source: International Energy Agency 2009 World Energy Outlook and The World Bank, 2010.

Figure 1: Geographic location of people with little or no energy access



Source: CIA World Fact Book 2009, United Nations Development Program's Human Development Report, 2009.

Figure 2: The relationship between electricity usage and quality of life

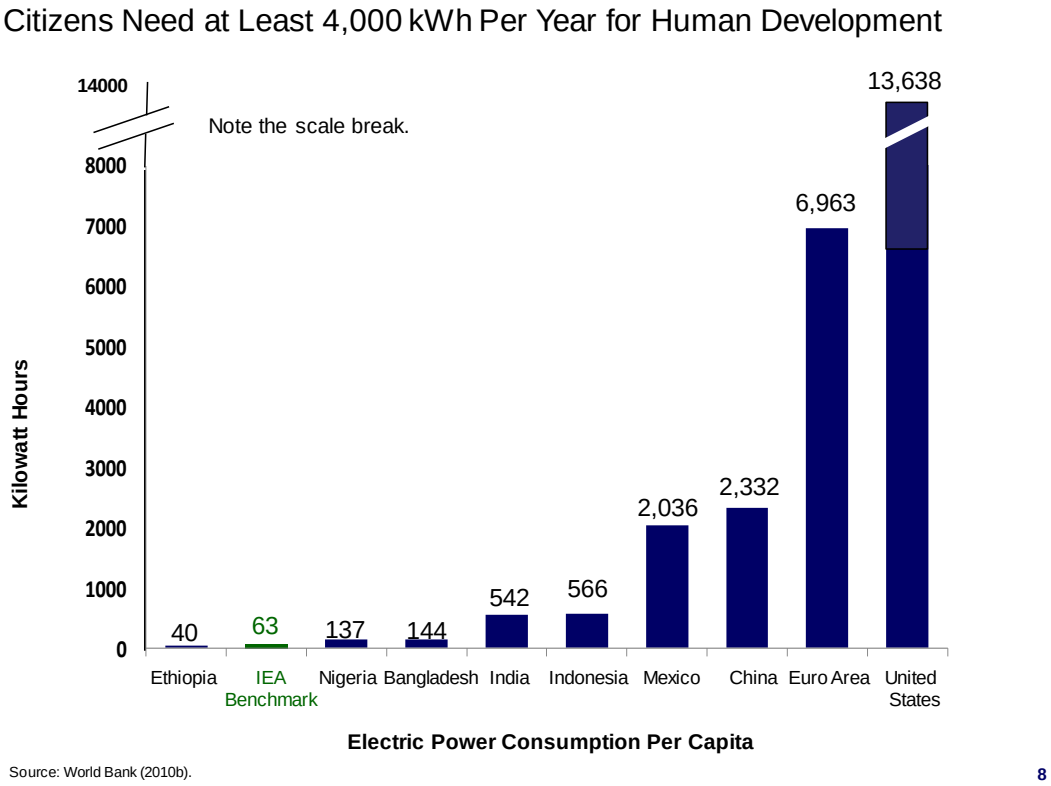


Figure 3: Power usage per capita in selected countries

It is obvious that globally more energy is needed, the only unknown is where it should come from. Figure 4 shows the historical cost of energy from the three main sources in the USA; coal, oil and natural gas. In 2010 it can be seen that the cost of coal was about half that of natural gas and far less than oil. Although these costs are in the USA, the qualitative values are relevant in any country. It is obvious therefore that coal is the most cost effective option and this is evidenced by the huge investment in modern coal thermal power plants in China and India. Replacing old thermal power plants with the modern supercritical coal plants internationally would create an equivalent pollution reduction of removing the entire vehicle fleet in the USA.

There is only a perceived impediment to this and that is the perception that coal is dirty and should be replaced because of carbon dioxide concerns caused global warming. It is therefore necessary to investigate pollution generally, green house gasses and climate change to assess the real issues.

Carbon dioxide is a real issue but in itself it is not toxic whereas heavy metals, mercury, nitrate and phosphate run-off are all toxic but these are kept on the back-burner.

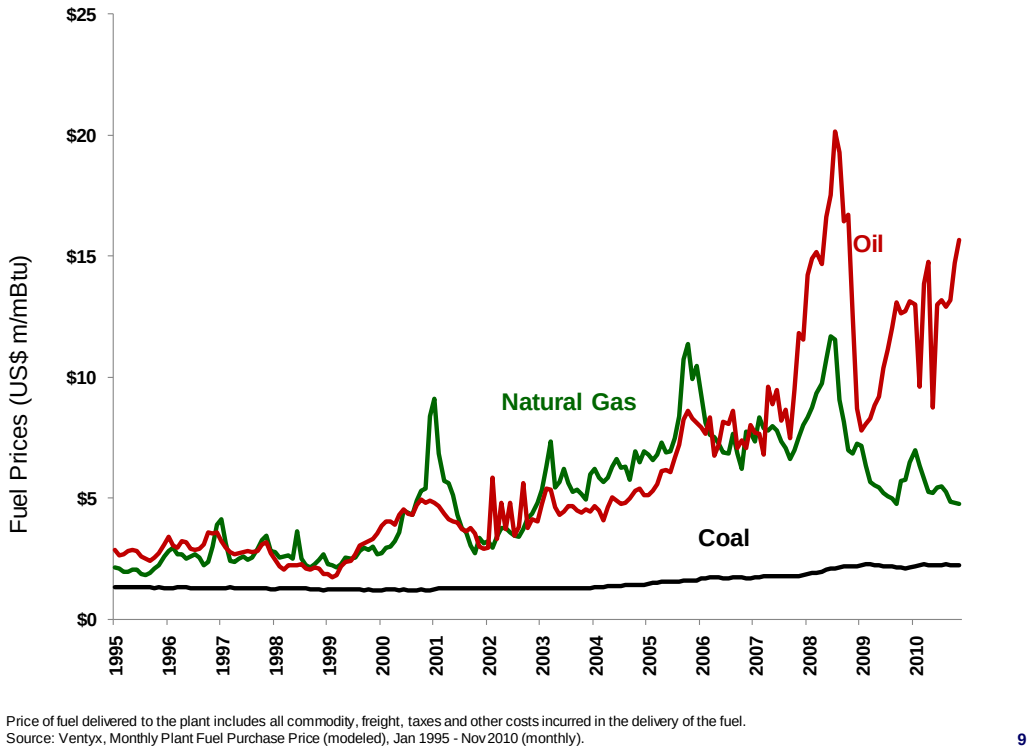


Figure 4: Historical energy costs in the US

The Europeans to date tend to more proactive concerning actions to combat greenhouse gases and pollution in general so they are generally referenced below.

The greenhouse gases are made up as follows, the general public is generally not even aware that water vapor is by far the largest component:

- Water vapor 60-70%
- Carbon dioxide 9-26%
- Methane 4-9%
- Ozone 3-7%
- Traces of other gases especially nitrous oxide

Clearly water vapor is the largest contributor, but the other gases have more adverse effects so are more important.

The percentages below are the average sources of the major "nasty" greenhouse gases considered to be carbon dioxide, methane and nitrous oxide:

- Thermal power stations 21.3% (i.e. from coal)
- Industrial processes 16.8% (nothing to do with coal)
- Transportation 14.0%
- Agricultural byproducts 12.5% (nothing to do with coal)
- Fossil fuel processing 11.3% (mainly natural gas)

- Residential use 10.3% (caused by many people critical of coal)
- Land use (biomass burning) 10.0%
- Other minor contributors

The Table below, also after the Netherlands Environmental Assessment Agency (NEAA), lists the individual contributors to each of the gases:

Table 1: Greenhouse gas contributors

Source	Carbon dioxide	Methane	Nitrous oxide
Power stations	29.5%	0%	1.1%
Industrial processes	20.6%	0%	5.9%
Transportation	19.2%	0%	1.5%
Agricultural byproducts	0%	40%	62%
Fossil fuel processing	8.4%	29.6%	0%
Residential use	12.9%	4.8%	0%
Land use	9.1%	6.6%	26%
Waste disposal	0%	18.1%	2.3%
Others	0.3%	0.9%	1.2%

The primary focus on carbon dioxide only from thermal power stations does not seem to be a sound cost effective approach and globally pollution as a whole should be the main concern.

2. ENERGY OPTIONS

Many potential energy sources exist but a base load must always be available to meet the needs of customers always. Not all energy sources are available 24 hours a day, 7 days a week. Figure 5 shows how the main energy user in the USA (electricity) is produced by source.

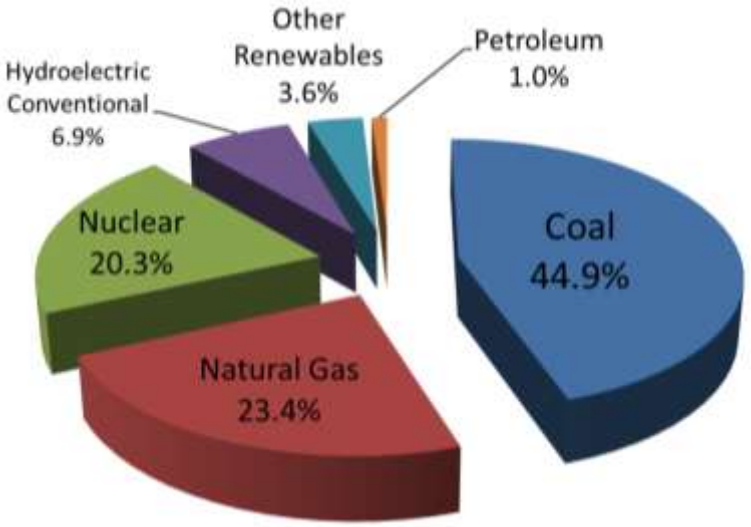


Figure 5: US electricity generation by source in the USA in 2009 (EPA)

2.1 Oil

Saudi Arabia has the largest oil reserves globally with about 25%, although according to some experts it would seem that their reserves may be unfortunately overstated. The next largest reserves are held by Iraq, Kuwait and Iran who each have between 9-11% of the global reserves.

The USA is the largest consumer of oil, using some 26% of the global consumption followed by the European Union at 19%.

With those producer and consumer statistics, it becomes clear why (rightly or wrongly) the USA is so involved in Iraq and Kuwait.

At current demands (which are in fact decreasing however which is positive), the world's supply of oil is around 40 years, although experts differ on the precise time, they do all agree that oil is running out soon.

Oil is used not only for gasoline and diesel but it is also a common source for plastics (along with coal). Running out of this vital energy source has serious consequences therefore and needs to be planned for to avoid late "knee jerk" reactions and huge waste. Conservation of this now relatively scarce commodity is therefore critical

It would not be unreasonable to expect that since the US government is aware of the supply and demand situation for oil, that they would initiate a long term staged goal to replace oil with other energy sources such as hybrid vehicles, coal, hydrogen etc. Coal may be a surprising choice but the US has huge reserves that will last for over a century and plastics will be needed even if less coal is used in conventional thermal power stations as gasification is more efficient and less polluting. This should be done by legislation, tax breaks and quotas and should not be difficult to initiate if based purely on good science and economics rather than on lobby groups.

A similar type of approach (but for purely economic reasons) has been done in Germany where coal mining is being phased out in a planned and organized way over several decades so that the fall-out from job losses etc can be managed and minimized. A similar phase out approach should be initiated for oil.

2.2 Natural Gas

Natural gas is a good relatively clean energy source. Its use has tended to be close to its source due to the relatively high cost of transporting it (even if liquefied) against other base energy sources such as nuclear, oil and coal.

Natural gas is a non-renewable energy source but there are still substantial reserves at present. As with oil however, reserves are not uniformly distributed and the former USSR

holds about a third of the world supply with the Middle East having about 25%. Both these regions cannot be considered as friends of the USA.

Russia has already shown the power that it can wield with these resources a few winters ago when it cut off Europe's supply through the Ukraine, allegedly over price issues, but the real issue was probably a signal that enlarging NATO to include more former Warsaw Pact countries would not be really tolerated.

The US wellhead cost of natural gas according to the Energy Information Administration (EIA) was relatively stable around $1-$3 per thousand cubic feet from 1975 to 2000. Since this period the prices have increased and fluctuated wildly and in 2008 the cost was around $7 per thousand cubic feet. It is fair to assume that as interest and usage in natural gas increases due to the environmental benefits the costs will rise substantially further.

In 2005, about 22% of the total energy used in the USA came from natural gas according to the EIA. It was used as follows (2007 base):

- 34% industrial use (often to produce other products such as plastics)
- 30% for electric power generation (it is a good source to meet peak demands but is relatively costly).
- 20% residential (mainly for heating where it is very cost effective).
- 13% commercial (mainly for heating)
- 3% other

The uses for natural gas can and should be expanded responsibly but using sources mainly in the Americas to avoid being strangled when unfriendly suppliers exert their energy muscles in the future. Major conflicts in the future will likely be over dwindling energy, mineral and water resources globally. Natural gas is very useful for producing electricity during higher demand periods as they can be started and stopped very easily and efficiently unlike most electricity producers, especially nuclear.

2.3 Coal

About 90% of the 1.1 billion tons of coal mined annually in the USA is used for power generation.

According to Alan Weakly (a retired civil and mining engineer), as of January1, 2008, 311 fossil fuel power plants have been cancelled or postponed, representing 138 gigawatts (one gigawatt equals 1,000 megawatts) of power that will not be available for future needs in the US. This future power capacity has not been replaced with alternatives. Whilst numerous environmental groups may congratulate themselves, who will be blamed when the country in the next one or two decades has inadequate power to sustain growth and rolling blackouts become common, leading to a possible recession that could make this one look trivial. This has happened in South Africa where power demand in the post-apartheid era had outstripped supply due to a poor energy policy.

The U.S. Energy Information Administration (EIA) projects a required increase of almost 200 gigawatts of electrical power by 2030.

Illinois for example has about 80 billion tons of coal reserves and although coal has had historical serious environmental problems these are being systematically addressed, possibly not fast enough, but hopefully they can be resolved if the issues are adequately researched, gasification used and carbon dioxide sequestration used on a large scale.

If coal is abandoned the only winners will be the sellers of carbon credits; and the USA will be welcomed into the third world with open arms as the economy stalls for many years.

2.4 Nuclear

Japan's Fukushima Daiichi nuclear plant disaster caused by the recent earthquake and subsequent tsunami has again highlighted the safety of nuclear power and the huge impact of a disaster however infrequent.

According to the World Nuclear Association:

- The USA has over 100 nuclear reactors providing almost 20% of its electricity.
- There have been 17 license applications to build 26 new nuclear reactors since mid 2007, following several regulatory initiatives preparing the way for new orders.
- Extension of reactor lifetimes from 40 to 60 years is enhancing the economic competitiveness of plants, while both ownership and operation of these is becoming concentrated.
- Both government and industry envisage significant new nuclear capacity by 2020.

Nuclear power is certainly “green” as regards carbon dioxide emissions which are obviously zero but there are two major issues; if anything goes seriously wrong the consequences are huge and long-term (also Chernobyl in Russia and the Three Mile Island in PA considered a “near miss”) and secondly, storing the very hazardous nuclear waste is not well organized at present.

There is still a very big decision that has to be made and implemented without delay; a secure nuclear waste storage facility has to be built in the USA, without it nuclear power becomes a much higher risk. This is because currently nuclear plants are being forced to store their own radioactive waste and they are not adequately equipped to do this, and should not be expected to do so. In addition this current storage situation represents many unnecessary terrorist targets with terrible consequences. The Federal Government needs to move forward urgently with a site either with Yucca Mountain in Nevada where huge money has already been spent investigating and preparing the storage facility but it seems to be stalled by NIMBY (Not In My Back Yard) or another area.

Based on the accidents and near misses, the future of conventional nuclear power plants may be in small reactors used regionally.

It is hoped that huge research funds will be channeled into nuclear fusion research as although the challenges are truly huge, steady progress is being made and this would be a good use of research money for the longer term power needs of the USA. Fusion avoids the nuclear waste issue at least potentially.

2.5 Hydropower

Mankind has been using water power for over 2,000 years initially it seems by the Greeks to grind corn. Hydropower is not new and was first conceptualized as a turbine in 1775 by a French military engineer, Bernard Forest de Bélidor. The use in North America grew very quickly from 1880 after Michigan's Grand Rapids Electric Light Company generated electricity from a water turbine through a dynamo to power lamps. In 1882 the first modern hydropower plant was commissioned on the Fox River in Wisconsin. According to the US Dept. of Energy by 1920, hydropower provided 25% of the power used in the USA.

Hydropower is used mainly for two basic applications:

- To generate base power, 24 hours a day (unlike other renewable such as solar and wind)
- To generate power to meet peak demand, by pumping water to an elevated storage facility during off-peak periods and then releasing the water during peak periods to generate additional power.

The US Department of Energy has completed a hydropower resource assessment. This assessment has identified 5,677 sites in the United States with an undeveloped capacity of about 30,000 MW. By comparison, today there is about 80,000 MW of hydroelectric generating plants in the United States, which only represents about 7% of the total generation.

Hydropower is clearly clean and renewable but the creation of large water diverts and dams has a serious negative impact on the local eco-system. However considering that every human activity has a negative impact on the eco-system to a greater or lesser extent, hydropower is a good power source and should be generally encouraged. It can never become a major contributor however because of a lack of potential sites.

Adequate research is lacking into new generation turbines that could further improve the efficiency of hydropower.

2.6 Geothermal

Heat from the earth's magma can be used as an energy source from large power stations to small and relatively simple heat pumping systems for domestic use. This geothermal energy can be found almost anywhere. Many regions of the world are already utilizing geothermal energy as an affordable and sustainable solution to reducing dependence fossil fuels. Geothermal plants produce 25% or more of electricity in the Philippines,

Iceland, and El Salvador. The United States has more geothermal capacity than any other country, with more than 3,000 megawatts in eight states already operational. 80% of this capacity is in California, where more than 40 geothermal plants provide nearly 5% of the state's electricity, according to the Union of Concerned Scientists. In thousands of homes and buildings across the United States, geothermal heat pumps also use the steady temperatures just underground to heat and cool buildings, cleanly and inexpensively.

The main potential downside is with large geothermal power generators were inducing earthquakes can be a serious downside.

2.7 Solar and Wind power

Solar and wind power research has produced significant improvements in efficiency of both systems but they will always be intermittent power sources. Both systems are portrayed as "clean energy" sources which once constructed they clearly are. What seems to be missing is a clear and scientific energy balance for both sources that shows how much "dirty" energy is used to create them and what the pay-back period is before they actually start producing this "net clean green" energy. For a simple example, if they need $1 of "dirty" power to produce but over their useful life they can only produce $1 (or even worse, less than a $1) of "clean" power, we have made the polluting gas situation worse not better. Both solar and wind power generators use very energy intensive materials in their construction. The future benefits are obvious and enormous both environmentally and strategically if they can be made more efficient but both require storage and a highly complex and costly power grid.

The current subsidies for renewable technologies with tax payer dollars are acceptable if there is evidence that in time the subsidy is justified. The upfront capital costs with these technologies are very high, although the operating costs are not which provides some encouragement.

2.8 Ethanol from corn

The question of ethanol from corn is just a part of a larger problem associated with farming in general in this country. Small scale farmers are being forced off their land or into other jobs because the prices paid for their produce is not adequate to sustain them. A system is needed, possibly a sliding or tiered price scale where the first yield (for example based off say 500 acres) pays a premium and the rest a lower price. This would support small scale farmers and help them stay full time on their land and not adversely affect the huge operators.

The focus of farming must be on food supply especially since hunger remains a serious issue even in this country. Excess food production (such as corn) should then only be used for fuel production or similar but at a lower price.

According to an article by David Biello in Scientific America (March, 2008), the waters in the USA (worse in many other countries) carry a heavy load of nitrates from fertilizers.

This creates fertilizing blooms of algae that deplete oxygen and leave vast "dead zones" in their wake. Under these conditions fish and other aquatic life cannot survive, and scientists warn that a federal mandate to produce more bio fuel may make the situation even worse. This is far more serious in many ways than carbon dioxide emissions that we are focused on which in themselves are at least not toxins.

In 2006, David Pimentel, a leading Cornell University agricultural expert, has calculated that the energy costs of corn production and its conversion into ethanol, 131,000 BTUs are needed to make one gallon of ethanol. One gallon of ethanol has an energy value of only 77,000 BTUs. Therefore, 70% more energy is required to produce ethanol than the energy that actually is in it. Mr. Pimentel concluded that "abusing our precious croplands to grow corn for an energy-inefficient process that yields low-grade automobile fuels amounts to unsustainable subsidized food burning".

Even if ethanol from corn was more energy efficient, I still cannot support its use at the expense of food supply. A federal farming policy is needed to protect the small scale farmer and promote food supply locally and internationally. Fuel from other biomass sources would appear positive and desirable; and bio-diesel in many applications really helps to efficiently reduce pollutants.

2.9 Bio fuels

There is no doubt that bio fuels are renewable and can potentially reduce our nation's lust for imported dwindling fossil fuels. They also generally require less capital investment and can be easily implemented on any scale.

According to Matthew Brown, the former Energy Director at the National Conference of State Legislatures, replacing only 5% of the nation's diesel consumption with biodiesel would require diverting approximately 60% of today's soy crops to biodiesel production.

The use of bio fuels are also accelerating deforestation (consider Brazil) and this further increases carbon dioxide levels.

There does seem to be more potential in using waste biomass and even algae. Before however starting freely cultivating organic materials anywhere apart from in very controlled and enclosed facilities an understanding of the long term ramifications is essential. Consider the kudzu vine introduced from Japan to the USA initially in 1876 as a forage crop. The US Department of Agriculture declared it a pest weed in 1953 as it continues as a destructive invasive plant. The use of foreign plants and algae for bio fuels cannot be permitted to do the same.

3. DISCUSSION

It is likely that wars in the future will be less about ideology (although this will remain the guise) and more about the availability of resources especially raw materials, fresh

clean water and energy. This is already happening just considering the following 3 examples:

- The dispute over the control of the Golan Heights between Israel and Syria is as much over water resource control in an arid area, than the obvious military importance.
- Russia has already flexed its muscles over gas supplies to Europe allegedly over the Ukraine stealing some, but more to show displeasure with NATO expansion to include more former Warsaw Pact countries.
- China currently mines almost 90% of all rare earths that are vital in communications and computers. It has starting rationing these exports for various reasons, the one being the need to protect its long term requirements. The USA has rare earth resources but the US anti-mining attitude will only cause huge problems in the medium term.

In an article in the New York Times (October 12, 2009) it was reported that China has now active trade agreements with 40 African countries. This is mainly as a result of China's desire to meet its ever increasing thirst for raw materials including energy and food. This comes at the same time as the West seems to be disengaging due to issues of human rights and transparent governance. China is mainly concerned about its long term economic and strategic future.

Contrast this with the US approach of "strings attached" trade deals or alternatively free trade agreements and the manufacturing sector in the US continues to shrink. This becomes more serious in the energy field in the USA as the politicians are becoming more hostile to coal mining, cannot finalize a site for a nuclear waste depository and don't have an energy policy that would ensure the US can meet its energy requirements in the future. The projected needs are well known.

Energy independence is therefore essential for the USA.

3.1 Reducing Energy Usage

Canada and the USA are the largest major users of energy per capita. As the world's superpower this does not set a good example for the rest of the world, especially the major developing economies such as China, India and Brazil who also want the benefits of cheap energy to develop their economies into the first world.

Energy conservation is therefore vital and many simple ways exist to achieve meaningful savings but the US is not a nation of conservers. Just look at the poor mass transit systems (road and rail), how many people drive to work alone and the poor fuel economies of most of our vehicles.

It is not just about reducing our direct energy usage, recycling is also an important component of energy conservation. For example in Switzerland, citizens are "financially encouraged" to recycle because garbage disposal carries a unit volume cost, the more you "trash" the more you pay as you purchase "stamps" and standard sized bags each

requiring the costly stamp before it is collected; a very simple but very effective approach.

Mankind is a disappointing dominant species and needs to be coerced into doing the right things, and financial "carrots and sticks" work the best. Services should be provided using tiered fee structures for electricity, water and trash removal where a basic minimum usage is very inexpensive (or free) per unit and increases rapidly the more that is used. This would assist financially strapped low and middle class households and encourage heavy users to conserve or pay very heavily.

3.2 Base Power Generation

Base power generation is the key requirement for electrical generation and the government is pushing solar and wind as the main renewable but neither can ever be considered economic for base generation and with current technology the efficiency is also a potential issue. This leaves mainly coal and nuclear because a long term dependence on natural gas is unlikely to be cost effective. Hydropower is desirable but limited and geothermal may have serious seismic issues in large applications.

3.3 The Need for Coal

The fact is that like it or not, coal generates about half the US electrical power and will do for many years to come as any type of power generation complex takes many years to permit and even more to build. Coal will never be pollution free but will be acceptable overall.

The US has been heading in the right pollution direction for many years now as regards pollution control, as Figure 6 clearly illustrates. Many would argue that this has not been nearly fast enough but the bottom line is that significant progress has been made and more progress is needed.

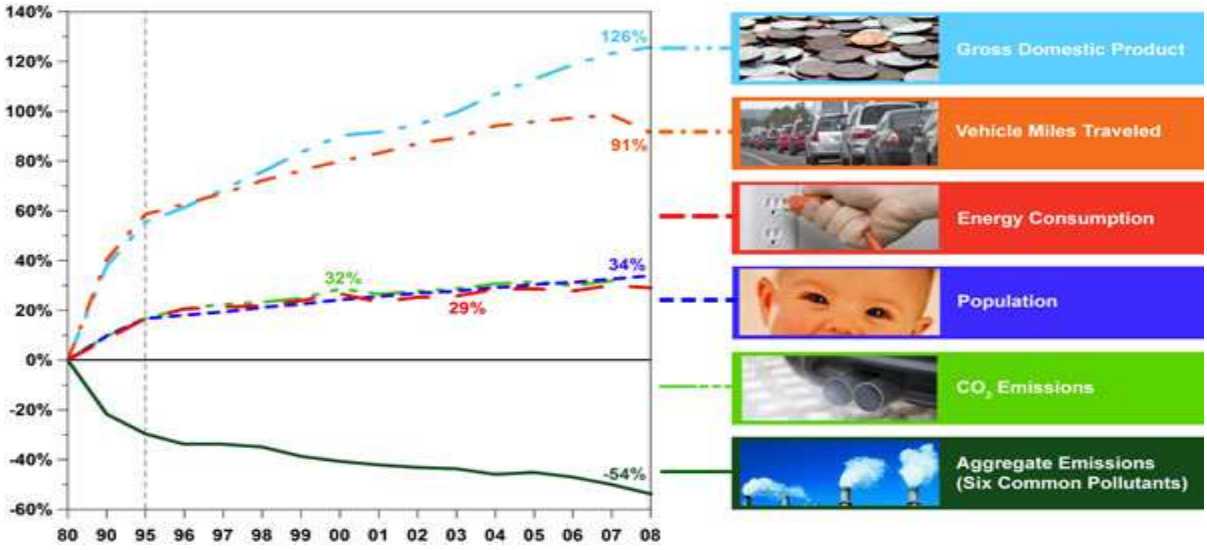


Figure 6: Growth and pollution changes over time in the USA (EPA air trends)

Modern thermal power plants are now much more effective in removing sulfur, nitrogen oxide and other toxins as shown in Figure 7 and the so called Integrated Gasification Combined Cycle (IGCC) power plants of which FutureGen was to be one will be close to zero toxic emissions and with carbon dioxide capture and storage it should have been close to zero for that too. To show a specific example, Figure 8 gives the projected nitrogen oxide and related gases for FutureGen against some historical data, the improvement is huge. These gases are toxic unlike carbon dioxide so these should be the reduction priority without forgetting about the carbon dioxide issue obviously; where other industries and our own homes are significant producers too.

So the question has to be why are we not moving ahead quickly with all "cleaner" coal technologies because most of our touted "green fuels" cannot readily produce the base power load needed? The environmental lobby responsible for halting or delaying construction of modern "cleaner" thermal power stations means that older, less efficient and more polluting ones need to be kept operating at the expense of reducing at least the toxic pollutants.

Whether coal is supported for the main electrical energy supplier or not, everyone should be supporting the building of FutureGen because it will provide real pollution data that can be verified and prove the long term viability one way or the other.

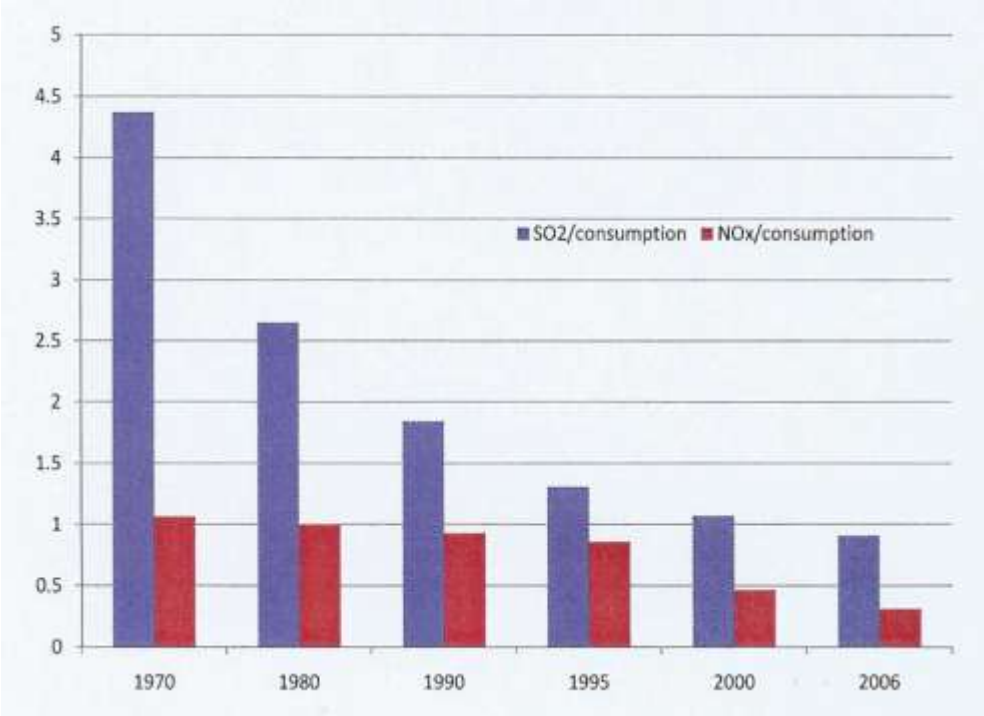


Figure 7: Historical gas emissions from thermal power plants (lbs/million BTU)
Energy Information Administration, Annual Energy Review 2007

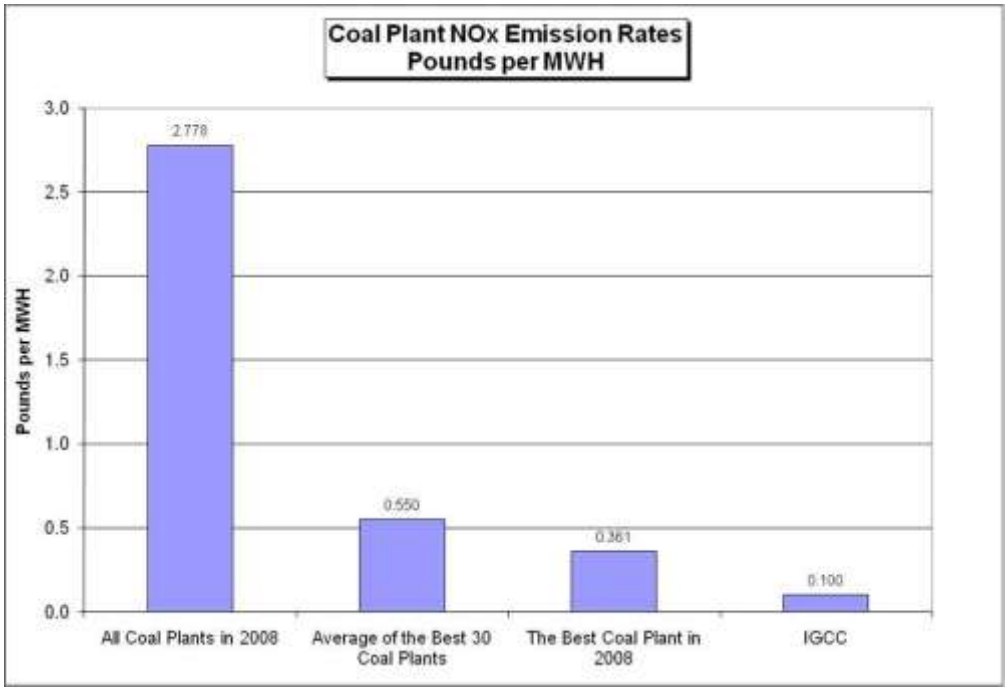


Figure 8: Gas emissions comparison (Clean Air Task Force)

Carbon dioxide sequestration is not a new technology and has been used to expand gas and oil field years for many years. More research is needed including operational protocols, testing and safety methods and the expertise exists but more funding is needed.

It is clear that the future of power generation in the US will need coal and the industry has been making positive strides in increasing efficiency and decreasing pollution and will continue of this positive path if legislation is judiciously and scientifically applied.

4. CONCLUSIONS

It is clear that the US must become energy independent. For this to occur the federal government must create a long term energy policy based on science not hype, considering all the options and the real costs. All energy options need to be funded so that research can be on-going to improve efficiencies, reduce pollution and reduce costs.

Coal and nuclear will remain global base electrical generation and their usage is likely to increase in the future. It is vital therefore that the new generation coal thermal plants and coal gasification facilities be built and researched as the US appears to be lagging in this regard, especially behind China.

The public need to be informed of the options without bias and make decisions that are made based on science not perception or hype.

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