



Emerging Trends Report

Bridging the Business Intelligence Gap

Nuclear Tide

by

Richard Karn 27-07-2006

EXECUTIVE SUMMARY

American culture is utterly dependent on cheap, abundant energy.

The price of oil, however, has risen relentlessly for the last seven years to the point we now send one-half billion dollars abroad each day to pay for our needs.¹ We spend at least another ten billion dollars each month to ensure access to it.

Natural gas burns more cleanly and is more thermally efficient than oil or coal. But like oil, our reserves are finite, and natural gas is found in countries whose interests are not necessarily aligned with our own.

Coal is plentiful and has been our primary workhorse for base load electrical generation for more than a century and will continue to play a significant role for decades to come. But coal is also filthy; it can be cleaned, indeed will be cleaned, but it is a difficult and expensive process.

Emissions from these fossil fuels are threatening climate changes we try not to imagine.

Renewable energy sources' promise will remain as secondary, additive sources of power.

Nuclear energy is perceived to be expensive, inefficient, hazardous, and fraught with danger.

...and within two generations will become America's primary source of energy.

The march of thermal efficiency, defined here as the ratio of usable energy output to energy input, has improved consistently from coal to oil to natural gas, with each producing fewer emissions of carbon dioxide and the like than its predecessor.² The next evolutionary step that will be taken in the decades ahead will be the development of dual-use nuclear power: base load electrical generation coupled with the electrolysis of water to produce either hydrogen, a carbon-neutral fuel posited as the clean replacement for fossil fuels, or potable water. There will be a dire need for both in the years ahead.

A changing, threatening world seems to be conspiring against us. Even the weather seems increasingly antagonistic.

Aging power stations near the end of their operational lives: hard choices must be made.

A groundswell is gathering momentum and awaits but the right catalyst to unite Americans behind the idea of being fed up with the stranglehold imported fossil fuels has on our lives. We will demand that something be done.

Energy Security.

Global Warming.

Nuclear energy: because it is time to end our reliance on imported fossil fuels.

¹ Pizer, Willaim A.: "Setting Energy Policy in the Modern Era: Tough Challenges Lie Ahead": Resources For the Future: p. 8, Winter 2005.

http://www.rff.org/rff/Documents/RFF_Resources_156.pdf

² Hoffert, M., et al: "Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet"; Science: Vol. 298. no. 5595, p. 983; 1-11-2002.

With a third of the world's power stations being more than 30 years old,³ a number of countries, principally those in eastern Asia, have arrived at this very conclusion. They are choosing to shoulder the higher capital costs of building nuclear power plants today, in effect fixing the price of electricity for decades to come, in order to lessen the impact of higher energy costs tomorrow. Over the next 25 years, it is estimated the number of nuclear power plants worldwide will increase by about forty percent.⁴

A year ago when we began compiling research for this report, there were no reactors planned in the United States. We did not think this situation could last and said so in our October report, "Coalescence."⁵ As we go to press, 18 utilities have notified the Nuclear Regulatory Commissions of their interest in building new nuclear reactors.⁶

The Emerging Trends Report (ETR) believes this is but a hint of what is to come, and the ensuing nuclear build-out will exceed the Manhattan Project in urgency, the Apollo Program in scope-- and both in cost. It will involve a generational reshaping of major aspects of the American economy, and it will prove prodigiously profitable for those who recognize the turn of the Nuclear Tide.

EDITOR'S NOTE: *Certain technical aspects of this paper would not have been possible without the patience and guidance of the following people: George S. Stanford, PhD., reactor physicist (ret.) at the US Argonne National Laboratory; L. John Perkins, PhD. at the Lawrence Livermore National Laboratory; and Glenn Catchpole, M.S., P. Eng. Thank you.*

DETAIL 1: "...and you may ask yourself-- 'well... how did I get here?'"⁷

A couple years ago, we were struck by a friend's comment to the effect that within five years only high school kids would be driving SUVs. As we go to press in July of 2006, oil is over \$70 per barrel, and gasoline is fluctuating around \$3.00 per gallon in California. People watch the pump with sick fascination, budgetary ruination unfolding before their very eyes. \$50 doesn't fill many cars' tanks these days, and people are beginning to wonder if it ever will again.

There is a mounting, pervasive edginess in our national psyche today: history is rhyming. Another hubristic administration is running low on credibility after generally running amok. Worldwide, political instability is spreading like wildfire, and regardless of intention our government seems as much part of the problem as the solution. Our foreign entanglements and the expense of maintaining them are becoming less palatable by the day. The inflation that Wall Street salesmen and government statisticians claim doesn't exist certainly does for the vast majority of Americans who have experienced the double whammy of real wage contraction over the last five years⁸ coupled with decreased buying power. We are left to ponder how things could have changed so little since the 1970's when energy vulnerability was first revealed to be our Achilles Heel.

³ Bream, Rebecca: "Power: Talkin' 'bout my generation"; the Financial Times: 29-05-2006.
http://news.ft.com/cms/s/fb8c7d70-ef04-11da-b435-0000779e2340,dwp_uuid=843ad722-ecd8-11da-a307-0000779e2340.html

⁴ World Nuclear Association (WNA): "The New Economics of Nuclear Power: WNA: p.6, 2005.
<http://www.world-nuclear.org/economics.pdf>

⁵ "Coalescence" is available free of charge on our website, www.emergingtrendsreport.com.

⁶ Gertner, Jon: "Atomic Balm?"; New York Times Magazine: 16-07-2006.
http://www.nytimes.com/2006/07/16/magazine/16nuclear.html?_r=1&oref=slogin

⁷ Byrne, David: "Once in a Lifetime"; EMI Records : Talking Heads: Once in a Lifetime, 1984.

⁸ Bloomberg: "Weekly wages adjusted for inflation fell 0.7% last month and are down 0.2% over the past year... Pay has been flat or declined in more than half of the 65 months since January 2001." Bulletin: 20-06- 2006.

Although Energy Security makes regular appearances on the Sunday morning talk show circuit, thirty years on politicians have yet to formulate a cohesive energy policy geared toward reducing, and then ending, our reliance on foreign oil. In fact, during the 1990's when oil was cheap, the government actually closed promising programs.⁹ The result of all this dithering has been that nothing has changed. If anything, ignoring the problem has made it worse: during the 1975-2005 time span, as American oil production *declined* from approximately 3 billion barrels per year (Bbl/y) to 1.9 billion Bbl/y,¹⁰ imports of foreign oil *increased* from approximately 1.5 billion Bbl/y to 3.6 billion Bbl/y.¹¹ When oil was cheap and plentiful, no one cared; now that the price has increased nearly 700% off the 1998 low and there is increased competition for supply, concerns about energy vulnerability have resurfaced and people are casting a jaundiced eye on the behavior of politicians. Employing tactics reminiscent of the tobacco industry regarding the relationship between cigarette smoking and lung cancer, the last two administrations have consistently denied, dismissed or denigrated the science behind Global Warming, thereby avoiding the economic consequences of having to respond to it. This in effect has maintained the status quo, which has benefited the Oil & Gas Industry and the Electrical Industry, the two largest businesses on the planet, both of which are opposed to carbon accountability.

But there's no conspiracy here, folks: it's all right out in the open. The control or accumulation of energy resources dominates the political landscape today. Pick an oil or natural gas exporting nation and the odds are good it is either causing or suffering civil strife of one sort or another.¹² Judging by the way permanent members of the UN Security Council trade protectionist vetoes for energy supply, things are clearly going to deteriorate further in countries like Sudan, Nigeria, Myanmar, Chad, Equatorial Guinea, and Iran, to name but a few.

This is demonstrative of the new urgency in the Grand Game. Alliances are shifting, rebalancing the global energy structure. The US is starting to be excluded from markets we have long taken for granted, such as those in South America where leftist rhetoric has led to a wave of quasi- and de facto nationalizations.

In the last few years China has made use of its surfeit of American dollars to purchase energy all over the globe, striking deals for long term supply in Angola, Ecuador, Egypt, Indonesia, Iran, Kazakhstan, Kuwait, Libya, Myanmar, Nigeria, Oman, Peru, Russia, Saudi Arabia, Sudan, Thailand, Venezuela, and Yemen. Unless something changes soon, growth projections place the combined US-Chinese oil demand accounting for 60 to 70% of world output, a clearly untenable situation.¹³ Hamstrung by environmental regulations and popular opposition, neither the US nor Europe is building the refining and infrastructure capacity needed to meet the ever-rising demand of the years ahead, which can only result in increased reliance on Middle Eastern supplies and OPEC.¹⁴

⁹ Stanford, George, S.: "Integral Fast Reactors: Source of Safe, Abundant, Non-Polluting Power"; National Policy Analysis: no.378, December 2001. <http://nationalcenter.org/NPA378.html>

¹⁰ Energy Information Agency: "U.S. Crude Oil Field Production"; Department of Energy, 12-06-2005. <http://tonto.eia.doe.gov/dnav/pet/hist/mcrfpus1a.htm>

¹¹ Energy Information Agency: "U.S. Crude Oil Imports from All Countries"; Department of Energy, 12-06-2006. <http://tonto.eia.doe.gov/dnav/pet/hist/mcrimus1a.htm>

¹² Organization for Economic Co-operation and Development (OECD): "Multinational Enterprises in Situations of Violent Conflict and Widespread Human Rights Abuse"; OECD: May, 2002. <http://www.oecd.org/dataoecd/46/31/2757771.pdf>

¹³ Ridley, Bill: "China and the Final War for Resources"; [jameswinston.com](http://www.jameswinston.com): 09-02-2005. <http://www.321energy.com/editorials/winston/winston020905html>

¹⁴ Hoyos, Carola: "Will the lights go off?"; the Financial Times: 29-05-2006. http://news.ft.com/cms/s/df156012-ef04-11da-b435-0000779e2340,dwp_uuid=843ad722-ecd8-11da-a307-0000779e2340.html

A nightmare in the making, as far as US interests are concerned, is the Shanghai Cooperation Organization (SCO), whose charter members include China, Russia, Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan. The SCO is apparently inducting Iran this year and plans to invite India, Pakistan and Mongolia to join in the future, promoting a "gas-and-oil arc" across Asia.¹⁵ This puts the US and especially its allies Japan, South Korea and Taiwan, and to a lesser extent Australia, between a rock and the proverbial hard place in the quest for Energy Security.

The rapid emergence and voracious appetites of developing countries in Asia has taken the developed world by surprise. The United States and Europe have been outmaneuvered in a number of oil and natural gas deals recently, which has sparked a mad scramble to secure supply. The ETR maintains the increases in fossil fuel prices thus far are as much a reflection of monetary inflation and excess liquidity as increased global demand; when the third element of supply shortage is eventually factored into the equation, the price increases will astonish. This is currently being underestimated by the powers that be in Washington but promises to keep a bid under oil prices, indeed all energy prices, for the foreseeable future. Add in the premium attached to oil prices due to political instability, terrorism, monetary inflation, and the threat of pre-emptive invasion and regime change, and higher prices begin to assume a more permanent nature. Indeed, at the moment, the only way the ETR can envision energy prices retreating significantly would be as a result of a global recession induced by runaway energy costs.

DETAIL 2: "It was as clear as mud but it covered the ground...."¹⁶

Aside from conservation, for which the American culture appears to be singularly ill-suited, there is little we can do to lessen our dependence on imported oil for transportation purposes simply because there are presently no alternatives. Thankfully, relatively little oil is used in the generation of electrical power in the US. That is not to say oil does not factor in a discussion of base load electrical generation for strangely enough it is still a driving force. Increases in the price of oil shift emphasis to sibling fossil fuels, natural gas and coal, and when their prices increase sufficiently, there is cause for a re-evaluation of nuclear energy. If Energy Security and Global Warming are indeed considerations, no discussion can legitimately exclude nuclear energy simply because, for all of its faults, it has few drawbacks in these regards.

Unfortunately, nuclear energy is the most polemic issue of our time. Entire careers, indeed the founding and rise of entire organizations, have been built on debunking or promoting nuclear energy. The issue is highly charged not least because of the staggering "inherent economic stakes,"¹⁷ as James Hansen puts it: electrical power generation in the United States in 2004 produced gross revenues of more than 193 billion dollars,¹⁸ a sum greater than the gross national product of Denmark.¹⁹ With so much money on the table, spurious as well as specious claims abound. Dueling experts and biased polls present agendas as facts or popular opinion. The politics of fear are applied

¹⁵ Heinberg, Richard: "Energy Geopolitics 2006"; Energy Bulletin: 22-06-2006.

<http://www.energybulletin.net/16393.html>

¹⁶ Belafonte, Harry and Rollins, Jack K: "Man Piaba"; RCA: 1954.

¹⁷ Hansen, James: "Defusing the Global Warming Time Bomb"; Scientific American: pp. 68-77, March 2004.

¹⁸ Energy Information Administration: "Electric Power Annual 2004"; Department of Energy: DOE/EIA-0348(2004), p. 6, November 2005.

<http://www.eia.doe.gov/cneaf/electricity/epa/epa.pdf#page=13>

¹⁹ Central Intelligence Agency (CIA): "The World Factbook: 'Rank Order-GDP'"; CIA: undated.

<http://www.cia.gov/cia/publications/factbook/rankorder/2001rank.html>

with equal vigor by either side. The levels of mis- and disinformation are such that getting a grasp on nuclear energy is akin to trying to tackle a greased pig.

Although the Emerging Trends Report (ETR) is hardly in a position to provide a definitive resolution to the debate, we feel it is vital to point out some of the more egregious myths, claims and counter-claims promulgated by the opposing sides as much in order to demonstrate the tactics being used as to facilitate something approaching a rational discussion of nuclear energy.

Chernobyl is the fulcrum used to lever public opinion. There is no arguing Chernobyl was a horrific accident. But it is important to understand that the type of reactor used at the Chernobyl facility was graphite moderated and the core was not housed inside a containment vessel. When the core overheated, due to human error, a steam explosion ignited the graphite which burned for days, releasing massive amounts of radioactivity directly into the atmosphere for lack of said containment vessel. By comparison, the US employs light water moderated reactors which cannot burn as Chernobyl did, houses these reactors in containment vessels, and by all accounts has far superior safety standards to those in operation at Chernobyl.

Comparing Chernobyl to the American nuclear industry is, for this very reason, not valid. Likening the accident at Chernobyl to something that could happen at American reactors, even by implication, is a blatant invocation of fear rather than fact to further an argument. *It is akin to using the design shortcomings of the Ford Pinto²⁰ to condemn Volvos as firetraps.*

Even the number of deaths at Chernobyl has become propaganda:

“How many (people) have died to date from the (Chernobyl) disaster is a controversial question. According to government agencies in the three former Soviet States affected, about 25,000 "liquidators" have died so far. Estimates provided by the liquidator associations in the three countries are well in excess of the official figures. The Chernobyl Forum's 2005 Report, on the other hand, attributes a far lower number of liquidator deaths to the reactor disaster.”²¹

“A total of up to 4000 people could eventually die of radiation exposure from the Chernobyl nuclear power plant accident...*however, as of mid-2005, fewer than 50 deaths had been directly attributed to radiation from the disaster.*”²²

While certainly not intending to downplay the death and misery resulting from Chernobyl, the ETR suggests that we try to maintain some perspective on this critical issue rather than allowing ourselves to adopt black and white views based on sensationalism. By way of safety comparison, coal mining deaths, which are the leading cause of death within the industry, in the US alone averaged 45 fatalities per year for the 1990's, the best decade on record,²³ while the civilian nuclear

²⁰ Engineering.com: “Ford Pinto”; Engineering.com: undated.

<http://www.engineering.com/content/ContentDisplay?contentId=41009014>

²¹ Greenpeace: “The Disaster”; Greenpeace website: undated.

<http://www.greenpeace.org/usa/campaigns/nuclear/chernobyl-anniversary/disaster>

²² World Health Organization: “Chernobyl: the true scale of the disaster”; WHO: Geneva, 05-09-2005.

<http://www.who.int/mediacentre/news/releases/2005/pr38/en/>

²³ Mine Safety and Health Administration: “Injury Trends in Mining”; Department of Labor: undated.

<http://www.msha.gov/MSHAINFO/FactSheets/mshafct2.HTM>

industry in the US has not suffered a fatality since the Wood River Junction criticality accident in 1964.²⁴

If the liberal organizations vilifying the nuclear industry are prone to exaggeration and hysteria, the conservative organizations profiting from it are equally prone to secrecy and reductionism; it may well have ever been thus.

The stellar safety record of the nuclear industry does not mean that it is without incidents, for they are far more common than the public generally believes. Earlier this year, for example, it was revealed that Exelon, an operator of nuclear power plants in Illinois, had experienced eight leaks over a period of ten years without ever bothering to disclose the fact to the public. In 1998, its Braidwood plant discharged three million gallons of water containing radioactive tritium that was still measurable eight years later.²⁵ Litigation fears do not constitute a legitimate excuse when dealing with public safety and trust: omission simply is a sin.

Of course, Cockroach Theory²⁶ allows such practices may be industry-wide.

This serves to underscore the shortcomings of Nuclear Regulatory Commission (NRC) oversight. Years of being undermanned and overstretched has amounted to the industry being for all intents and purposes self-policing—a conflict of interest that should alarm the general public. As Wall Street amply demonstrated in the 1990's, industry regulation should not be left to those who stand to profit the most from abusing the system, no matter how much they promise they won't. This lack of oversight certainly alarms the Union of Concerned Scientists (UCS), who point out that since 1984 there have been 27 nuclear reactors shut down for repairs to safety equipment that required more than a year of downtime to remedy,²⁷ few of which drew media scrutiny.

The issue of the oversight and regulation ensuring public safety is not something that should be minimized or dismissed. The nuclear industry is confronting a whole new set of challenges it has not faced before, namely aging reactors which are by their very design parameters nearing the last phase of their operational lives. This presents new safety concerns that are especially worrying in light of the extensions being granted to the nuclear industry to effectively increase their plant lives by as much as 50%.

The situation is perhaps best visualized by the Bathtub Curve,²⁸ which was developed by the National Space and Aeronautical Administration (NASA) to depict the operational lifespan of, well, just about everything from a simple tool to a complex machine. Basically, when the rate of failure of an item such as a machine (or an animal for that matter) is plotted over a period of time it regularly takes the shape of a bathtub (see chart below), albeit of varying sizes.

²⁴ Wikipedia: "List of civilian nuclear accidents"; Wikipedia: undated.

http://en.wikipedia.org/wiki/List_of_civilian_nuclear_accidents

²⁵ Ferkenhoff, Eric: "The Right Kind of Nuclear Leak": Time.com: 23-02-2006.

<http://www.time.com/time/nation/article/0,8599,1167105,00.html>

²⁶ Cockroach Theory: if you find one cockroach, the odds are good there are others lurking unseen.

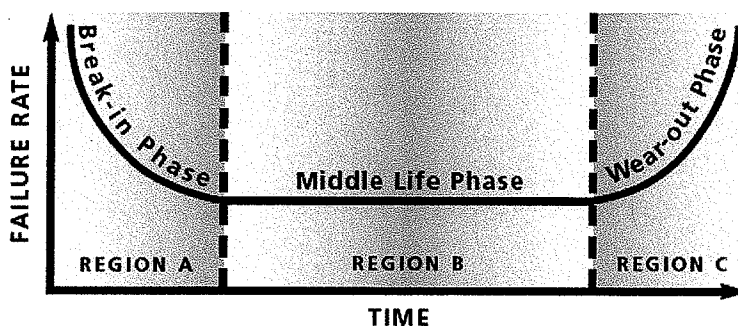
²⁷ Lochbaum, David: "U.S. Nuclear Power Plants in the 21st Century: The Risk of a Lifetime"; Union of Concerned Scientists: p.12, May 2004.

http://www.ucsusa.org/assets/documents/clean_energy/nuclear04fnl.pdf

²⁸ Lochbaum, David: "U.S. Nuclear Plans in the 21st Century: The Risk Of A Lifetime"; Union of Concerned Scientists: p.4, May 2004.

http://www.ucsusa.org/assets/documents/clean_energy/nuclear04fnl.pdf

Figure 1 The Bathtub Curve



Source: NASA, 2001.

As far as the nuclear power industry is concerned, the relevancy of the Bathtub Curve is in understanding the periods during which systems are most likely to encounter problems or to fail. The most notorious nuclear power station failures, from Fermi Unit 1 in 1966 to Three Mile Island Unit 2 in 1979 to Chernobyl Unit 4 in 1986, have occurred during the "Break-in Phase" on the above chart, generally within the first thirty months of operation.²⁹

With time, the overall performance kinks are worked out and a nuclear power plant enters its Middle Life, or peak operational, Phase. This is where most US plants find themselves today, which is reflected by the increased load factors and decreased electrical production costs of the last decade.³⁰

As nuclear power plants near the end of their Middle Life Phase, it is axiomatic that increased vigilance will be required to anticipate the problems sure to arise from age and fatigue preceding eventual retirement. Whether a recent spate of incidents at nuclear power plants is a statistical aberration or an indication that many of these plants are entering the Wear-out Phase remains to be seen.³¹ How these plants will perform during their extended life spans is anyone's guess; however, considering the nuclear industry's reluctance to disclose safety breaches, the de facto ceding of such NRC duties at a time monitoring clearly needs to be intensified is troubling enough that even the Government Accountability Office has expressed misgivings about it.³²

With most American nuclear reactors now well into their peak operational phases, the low cost of nuclear-generated electricity is regularly being trotted out as proof positive of how competitive the industry is. This is misleading to say the least. By far the largest cost associated with a nuclear power plant is its construction and financing, which is generally assumed to account for between half and two-thirds of total costs, but this cost is not reflected in the price of nuclear electricity today because those costs have long been written off.³³ *So what the nuclear energy*

²⁹ Ibid: p. 5.

³⁰ Hore-Lacy, I.: **Nuclear Electricity**; Uranium Information Centre: seventh edition, Ch. 3, 2003.

³¹ Lochbaum, David: "U.S. Nuclear Plans in the 21st Century: The Risk Of A Lifetime"; Union of Concerned Scientists: pp.19-21, May 2004.

http://www.ucsusa.org/assets/documents/clean_energy/nuclear04fnl.pdf

³² Ferkenhoff, Eric: "The Right Kind of Nuclear Leak": Time.com: 23-02-2006.

<http://www.time.com/time/nation/article/0,8599,1167105,00.html>

³³ Economist, the (not attributed): "Climate change: The nuclear answer?" Economist.com: 07-07-2005.

http://economist.com/research/articlesBySubject/displayStory.cfm?story_ID=4151435&subjectid=821240

industry is submitting as electrical generation costs bears no more resemblance to the truth than a hacker bragging about his golf score—if you but disregard the times he shot over par.

If is this not enough to make you skeptical of nuclear claims regarding cost, it should be remembered that the industry has a 30-year history of promising one price and then delivering another, passing its cost over-runs on to customers via rate increases. “The nuclear industry has never delivered a project on time and on budget,” claims Alan Noguee of the UCS.³⁴ In 2005 dollar terms, 75 of our 103 nuclear power plants exceeded their budgets by nearly two billion dollars apiece³⁵—approximately the same amount the Energy Information Agency (EIA) now estimates a new reactor would cost to build (see below).

Studies by the Massachusetts Institute of Technology (MIT), and Britain’s Royal Institute of International Affairs in 2003 both concluded that nuclear energy is not “economic without subsidy.”³⁶ Anecdotal support for this conclusion comes from the fact that no new nuclear plants have been ordered in the US since 1978,³⁷ suggesting that when government subsidies ended, so did plans to build them.³⁸ Indeed, in inflation adjusted terms, the Economist magazine points out that the nuclear energy industry has “already received half of all subsidies lavished on the energy industry in OECD countries over the past fifty years.”³⁹

The issue of cost is central to the energy debate in the US today, but it is far from a simple matter of price comparisons. For it has to be pointed out that mis- and disinformation is not just the province of anti- and pro-nuclear camps—it’s prevalent throughout the Electrical Industry.

Coal and natural gas are touted as being the cheapest electrical energy sources in the US without ever having to make any accounting whatsoever for the millions and millions of tons of carbon dioxide and other waste they are responsible for pumping into the atmosphere each year (see below). In terms of cost accounting, it’s as if they are not producing any. The US Electrical Industry, as represented by the Bush administration⁴⁰ (and previously by the Clinton administration), is adamantly opposed to any kind of carbon accountability simply because the cost is horrendous, with some estimates running as high as \$200-250 per ton.⁴¹ In contrast, the nuclear industry had put aside \$22.5 billion as of 1998 to cover decommissioning costs and another \$18 billion for waste disposal as of 2002.⁴²

Typically, the cost of a nuclear power plant is two to four times that of a fossil fueled plant⁴³—if it has no provisions for cleaning emissions in the pricing. What the ETR has done in the following comparison is to take the data from the Energy Information Agency’s (EIA) “Assumptions

³⁴ Murawski, John: “Putting a Price on Nuclear Power”; The News & Observer: 19-02-2006.

http://www.redorbit.com/news/science/398986/putting_a_price_on_nuclear_power/index.html?source=r_science

³⁵ Ibid.

³⁶ Economist, the (not attributed): “Nuclear power: The shape of things to come”; Economist.com: 07-07-2005.

http://economist.com/research/articlesBySubject/displayStory.cfm?story_ID=4149623&subjectid=821240

³⁷ Lake, Jmaes, A., Bennett, Ralph, G., & Kotek, John, F.: “Next-Generation Nuclear Power”; Scientific American: pp73, January 2002.

³⁸ Lewis, Judith: “Green to the Core?—Part 1”; Los Angeles Weekly: 10-11-2005.

<http://www.laweekly.com/general/features/green-to-the-core-part-1/151/>

³⁹ Economist, the (not attributed): “Climate change: The nuclear answer?” Economist.com: 07-07-2005.

http://economist.com/research/articlesBySubject/displayStory.cfm?story_ID=4151435&subjectid=821240

⁴⁰ the Economist, (not attributed): “Nuclear power: The shape of things to come”; Economist.com: 07-07-2005.

http://economist.com/research/articlesBySubject/displayStory.cfm?story_ID=4149623&subjectid=821240

⁴¹ Anderson, J.W.: “Coal: Dirty Cheap Energy”; Resources For the Future: p. 33, Winter 2005.

http://www.rff.org/rff/Documents/RFF_Resources_156.pdf

⁴² Hore-Lacy, Ian: **Nuclear Electricity**; Uranium Information Centre: seventh edition, ch.5, 2003.

<http://www.uic.com.au/ne.htm>

⁴³ Jackson, Bob: “Nuclear Power: and option for Australia?”; Engineers Australia: vol. 78, no 1, p. 23, January 2006.

to the Annual Energy Outlook 2006⁴⁴ and adjusted it numerically in order to present uniform production capacities and construction estimates. By this we mean that because the EIA presented estimates for the costs of power stations ranging from 160 to 1000 megawatts (mW) capacity, we adjusted the figures to reflect the uniform cost of building a plant of 1000 mW capacity of each type; we made no adjustment to the estimated lead times.

PLANT TYPE (1000 mW capacity)	COST (\$Billions)	Lead times (years)
Scrubbed Coal	2.081	4
Integrated Coal-Gasification Combined Cycle (IGCC)	2.623	4
IGCC with Carbon Sequestration	5.431	4
Conventional Gas/Oil Combined Cycle (CCGT)	2.336	3
Advanced CCGT	1.438	3
Advanced CCGT with Carbon Sequestration	2.867	3
Advanced Nuclear	2.014	6
Conventional Hydropower	2.904	4

Source: Department of Energy, report #DOE/EIA-0554, table 38.⁴⁵

Although useful for comparison purposes in pointing out how utterly changed the cost structures for fossil fuel plants are expected to be by carbon capture and sequestering, the ETR would be loath to rely on these estimates. Because no nuclear plants have been built for nearly 30 years, we also find it doubtful that anyone can accurately assess the true costs of building one today, but history suggests cost over-runs will be the norm. Similarly, carbon capture and sequestration are new technologies that are as yet undeveloped in the commercial sense (see next section), so we would expect unanticipated problems to increase costs. However, and for what it's worth at this juncture, where the estimated cost of a nuclear plant is remarkably consistent with estimates from experts not aligned with the nuclear industry,⁴⁶ the estimate for an IGCC coal plant with Carbon Sequestering is considerably higher than a similar increase Sasol has recently quoted the Chinese to build a coal-to-liquid fuels plant with carbon sequestration.⁴⁷

With time and experience, the price of all this technology would be expected to come down considerably, but *the clear take-away from all of this is that energy will not be cheap in the future.* The energy source we choose today for tomorrow's world clearly cannot be based on cost alone because those costs in light of Energy Security and Global Warming are simply unknowable at present. This leads the ETR to the conclusion the focus should not be on costs but on policy—we have to find a better energy policy, one we can live with for generations to come. And in this regard, nuclear energy holds far more promise than either coal or natural gas.

⁴⁴ Energy Information Administration: "Assumptions to the Annual Energy Outlook 2006 With Projections to 2030"; Department of Energy report #DOE/EIA-0554; March 2006.

[http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554\(2006\).pdf](http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554(2006).pdf)

⁴⁵ Ibid.: table 38, p.73.

[http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554\(2006\).pdf#page=77](http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554(2006).pdf#page=77)

⁴⁶ the Economist, (not attributed): "Nuclear power: The shape of things to come"; Economist.com: 07-07-2005.

http://economist.com/research/articlesBySubject/displayStory.cfm?story_ID=4149623&subjectid=821240

⁴⁷ Salgado, Ingrid: "Sasol, China set date for coal plant project"; Business Report: 23-06-2006.

<http://www.busrep.co.za/index.php?fArticleId=3305588&SectionId=612&fSetId=662>

In the following sections for subscribers, the Emerging Trends Report continues its assessment of the viability of natural gas, coal and nuclear energy as primary sources of base load electrical power in the US as well as our investment approach to nuclear energy, our stock recommendations, and our substantial Sources/Further Reading section.

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