The GeoPolitics of Energy: Engaging the Public and Policymakers - 9557

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ABSTRACT

If the world is to attain global peace and prosperity in this century, a rational mix of energy sources must be achieved quickly, by about 2040. This mix should be about $^1/_3$–fossil fuel, $^1/_3$–renewables and $^1/_3$–nuclear, each source generating over 10 trillion kW-hrs/year, the amount generated by all fossil fuels in the world today. Without a comprehensive push for both renewables and nuclear, humanity will not avert environmental and economic catastrophe by mid-century, and we will not be able to prevent worldwide weapons proliferation. Public misperception of nuclear energy is probably the greatest hurdle to achieving a third of this mix by nuclear energy, while a similar but opposite overly optimistic perception of renewables may cause renewables to fail in achieving their third of this mix. This $^1/_3$-$^1/_3$-$^1/_3$ mix requires committed leadership among the nations of the world, and full understanding and support from their citizens, with an understanding that failure will result in developed nations losing their high standards of living and developing nations losing the opportunity to achieve such standards, while the planetary ecosystem teeters on the brink of collapse.

INTRODUCTION

In general, societies have failed to give their citizens an education that provides a broad understanding of science and technology, which would maximize productivity and economic output and raise standards of living while avoiding an unsustainable waste of resources. This is unacceptable and will prevent achievement of world peace and prosperity that humans have been dreaming of since before the Enlightenment.

It is a truism that hardship and survival favor understanding of natural processes and science. Water rationing in pre-Western Hawai'i was strictly enforced, punishable by death (Nakuina 1894). The understanding of the hydrologic realities of a growing population on an island with limited rainfall and groundwater resources was empirical, slowly developed over a thousand years of variable weather cycles followed by large population die-backs as fresh water periodically became insufficient to support agriculture and the population. Technological advancements, economic prosperity and rapid population movement in and out of modern Hawai'i has made strict water use less practiced by the present population there, although the environmental engineering community understands the problem very well.

The dramatic increase in the basic education of the population at large, and the increase in scientific and technological understanding at all levels in the United States in the mid twentieth century was fueled by WWII, Sputnik and the Cold War. In those days, there was a general feeling among private citizens that science and technology were inextricably linked to survival and prosperity, and there was a genuine desire to understand and employ technology in everyday life as well as on the national scale. Large technological enterprises had broad public acceptance. Since the early 1980's, when it was generally felt that the United States was superior technologically, economically and militarily, public interest in science has waned with a rise in actual anti-scientific sentiments. However, the recent energy crises of 2007-08 and the present economic crisis has shown those sentiments to be flawed and even fatal, and has again spurred aspirations for rational thought and action, along with a desire for advances in science and technology, especially with regard to energy.

In this present situation, it is possible to correct the public misperceptions about nuclear energy, and formulate a national long-term energy strategy that addresses our energy needs, economic recovery, national security and environment sustainability.

The best way to engage private citizens on nuclear issues is to put the issues into perspective. The success of various knowledge-based media outlets such as PBS, Discovery Channel, NOVA science series, the History Channel and others has been outstanding. The authors of these series have used the strategy of organizing specific data and events into a rational whole that addresses the big picture and leads the viewer or reader from no understanding to significant understanding by molding their sporadic, unconnected bits of knowledge into something whole. The fulfilling sense of accomplishment engendered by true understanding has been the basis of successful teaching, especially in science, and can be harnessed on the national level.

HOW MUCH ENERGY DO WE NEED?

Therefore, energy must be discussed in a holistic way that sets the foundation for what this country needs to achieve, with nuclear as just one of the components. We need to address the separate concerns not as a reactionary response to negative opinion, but as a rational set of building blocks to a complete and logical energy plan that addresses the concerns and fears of all citizens with respect to all issues, not just nuclear. In a transparent world it is difficult for critics to separate, misrepresent and vilify individual aspects of nuclear energy. There are two time frames on which this can occur: 1) the short-term, embodied by media outlets, advertising, TV and radio talk shows, books and periodicals, and 2) the long-term, involving public educational programs.

An holistic approach was outlined in Wright and Conca (2007) where the first step is to place energy in its historical and sociological context. Paul Collier (2007) discusses the problems and social injustices of the 1.6 billion people who live in abject energy poverty with no access to electricity, the *bottom billion*. An additional 2.4 billion people burn wood and manure as their main source of energy. And another 3 billion people will be born between now and 2040. These 7 billion people will, and should, get electricity by 2040. It is this group that is responsible for the huge growth estimated in global energy demand (Deutch and Moniz 2006). The remaining 2 billion alive today already have access to sufficient or plentiful energy resources, and their population will remain fairly steady.

In a just and ethical energy future we cannot, and should not, prevent all of Earth's citizens from having access to energy. Access to energy is the single most important factor in achieving a safe and secure life. It is a recognizable fact that as people live longer, and know that their children will live longer, overall population declines and stabilizes. This has occurred in every industrialized nation and is reflected in population projections that show a drop in worldwide human population from almost 10 billion in 2050 to about 5 billion in 2100. Achieving a sustainable world population is another reason to achieve a just and sustainable energy distribution for all people.

The concept of safety and security in life is embodied in the United Nations Human Development Index (HDI), shown in Figure 1. Over 75% of the world's population of over 6.5 billion people is below 0.8 on the HDI. It is no coincidence that this is the region of the world's greatest social problems. In order to have a good life, with an expectation that you will live to age 40 and that your children will live to age 40, requires about 3,000 kWhrs per person per year. Overall, there is a zone between 3,000 and 6,000 kWhrs per person per year that is a just and sustainable region for humans and the planet. The United States and the industrialized world are in the energy fat region, well over 0.9 HDI with between 7,000 and 15,000 kWhrs per person per year. Citizens in these countries can afford to conserve, buy compact fluorescents, switch to hybrid electric cars, recycle and change their lifestyles so as to drop back to the

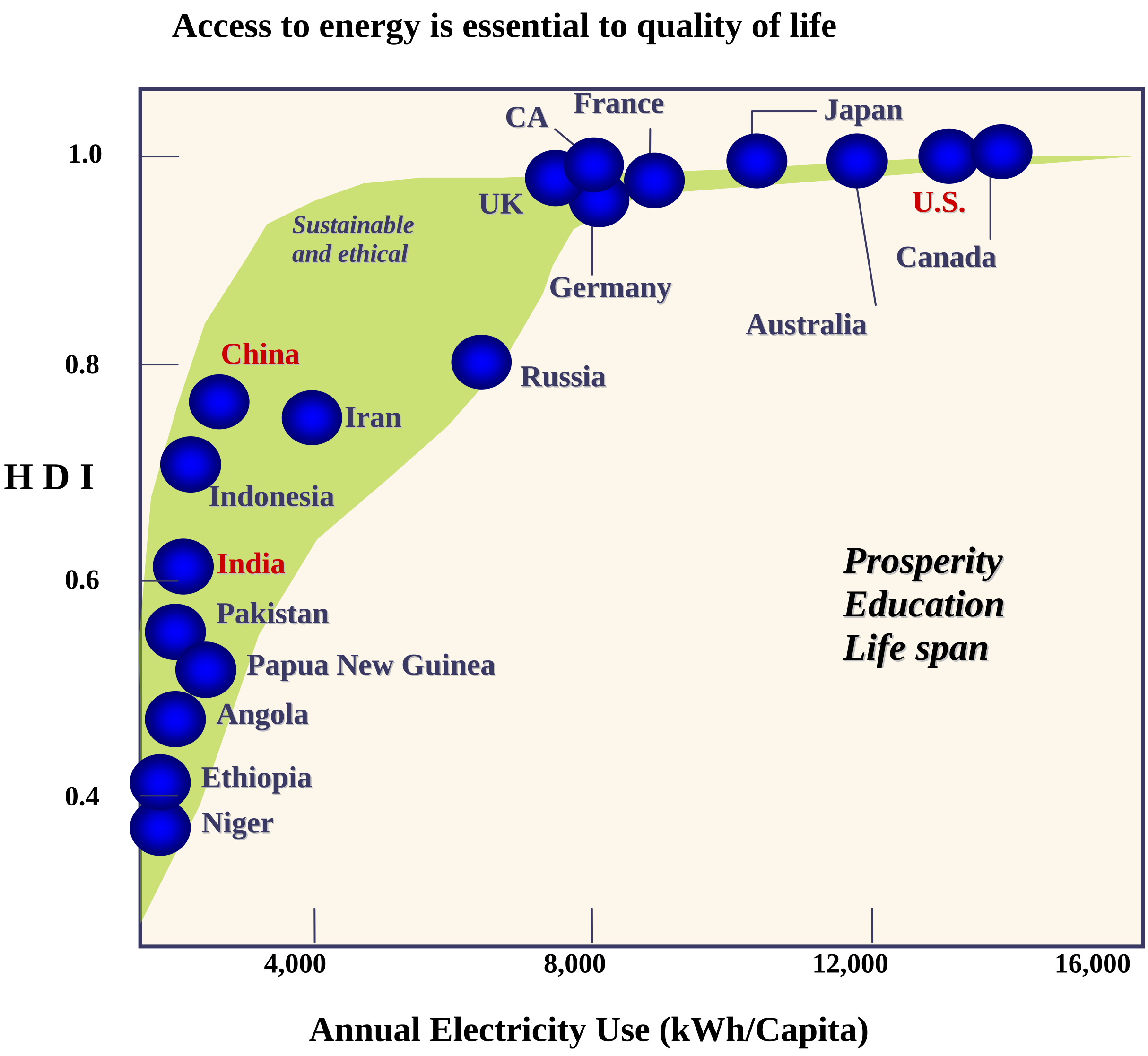


Fig. 1. The United Nations Human Development Index (HDI). Source: UN Development Program.

region of about 6,000 kWhrs per person per year, the region that the U.K, Germany and France are fast approaching, a fairly efficient region overall. Concerted efforts in conservation, increased efficiencies and advanced technologies could bring the entire developed world down to 6,000 kWhrs per person per year. This would save over 4,000 kWhrs per person per year in Japan and Australia, and over 8,000 kWhrs per person per year in the U.S. and Canada, a total savings of over four trillion kWhrs per year, almost 40% of all present fossil fuel use worldwide today.

But there are only a billion people in this energy fat zone. Dropping their use to 6,000 kWhrs per person per year will result in a total energy requirement of about 6 trillion kWhrs per year. Four billion people are in the lowest zones below 0.8 on the HDI, and they should and will achieve 0.8 HDI. An additional 3 billion people will be born by 2040 and will also require energy. Therefore, out of about 9 billion people alive in 2040, raising 7 billion of them up to 0.8 HDI will require about 3,000 kWhrs per person per year, or about 21 trillion kWhrs per year. If the remaining 1 billion stay at about 3,000 kWhrs per person per year, then the total world power consumption would be leveled at 30 trillion kWhrs per year (Table 1), the amount of energy we need for a just and sustainable future worldwide.

A sharp decline, almost an end to, war, terrorism and poverty occurs when societies rise above 0.8 HDI comes a. But achieving an additional 15 trillion kWhrs per year while at the same time decreasing the developed world's over-use and meeting global environmental goals, will be extremely difficult and will require global coordination beyond anything ever achieved by human society. **This is the context in which to engage the public and policy-makers.**

Nuclear energy is just one essential energy source used to achieve 30 trillion kWhrs per year. Note that nuclear weapons are not part of this gestalt. In addition to an energy discussion, the scientific community must succeed in separating nuclear weapons from nuclear energy in the minds of the public. Interesting and transparent discussions of weapons and how they are different from energy are essential to reducing the fear, e.g., we don't care if Iran has a nuclear power plant, we care if they have an enrichment facility.

Table 1. The amount of energy needed to achieve a just and sustainable world.

Subpopulation group		***Energy/capita needed to raise HDI to >0.8 or maintain at 0.9***	***Approximate subpopulation***	***Annual energy requirement***
Industrialized world -	**cut to**	**6,000 kWhrs/yr**	**1,000,000,000**	**6 tkW-hrs**
Intermediate -	**maintain**	**3,000 kWhrs/yr**	**1,000,000,000**	**3 tkW-hrs**
Developing world -	**increase to**	**3,000 kWhrs/yr**	**4,000,000,000**	**12 tkW-hrs**
Those born by 2040 -	**achieve**	**3,000 kWhrs/yr**	**3,000,000,000**	**9 tkW-hrs**
		Total Annual Global Energy Requirement		**30 tkW-hrs**

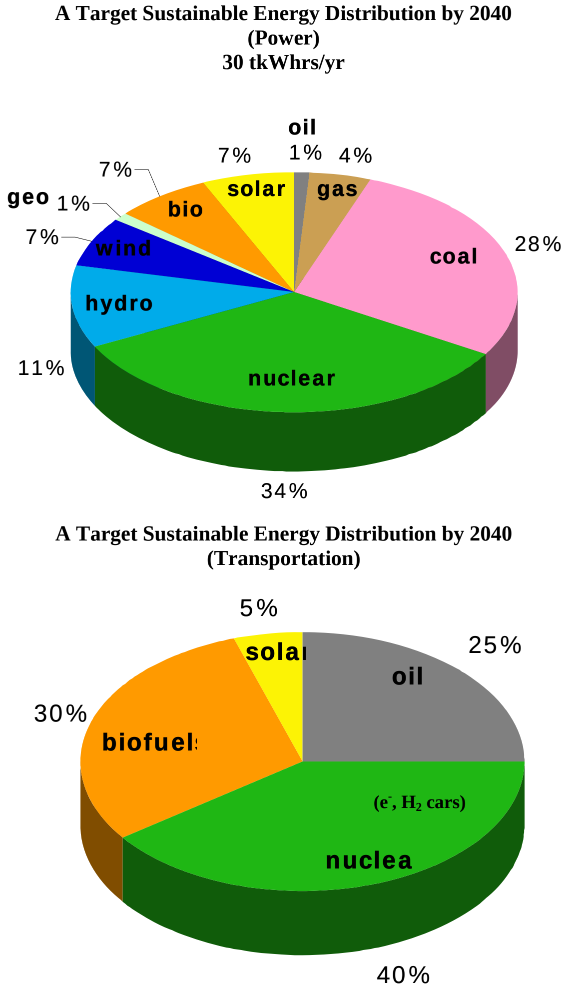
A DIFFERENT ENERGY MIX

Unless global strategies change, the difference between the present global energy consumption of 15 trillion kWhrs and the goal of 30 trillion kWhrs by 2040 will be produced primarily by burning fossil fuel, effectively tripling fossil fuel use. All alternative energy sources, including nuclear, must make up this difference if there is any chance of reaching a goal of sustainability, reducing CO_2 emissions, or preventing other serious environmental and economic effects. It will not be easy, and cannot be forced, but will require cooperation, diplomacy, and global leadership, as well as a genuine sense of fairness in the distribution of this planet's resources.

What is needed, then, is a leveling of the total consumption and a change in the distribution, or mix, of energy sources (Stix 2006). But what energy mix can sustain such a huge consumption rate? Since all fossil fuel use today generates 10 trillion kWhrs/yr world-wide, if we level consumption at 30 trillion kW-hrs/yr without increasing CO_2 levels much above the present (about 380 ppm), then *two-thirds of production must come from non-fossil fuels, and only one-third can come from fossil fuels.* But this means that fossil fuel production will continue on at present rates, and not decrease as is assumed by Kyoto-type protocols. Rather than cutting production, advances in carbon sequestration and dramatic increases in efficiency will have to be used to reduce CO_2 levels below those of today.

A target distribution, or energy mix, that would provide two-thirds of the world energy consumption from non-fossil fuels by 2040 is shown below on the left in Figure 2. It is about $^1/_3$, $^1/_3$, $^1/_3$: a third fossil fuels, a third renewables and a third nuclear. **This is the goal to present to the public and policy-makers.**

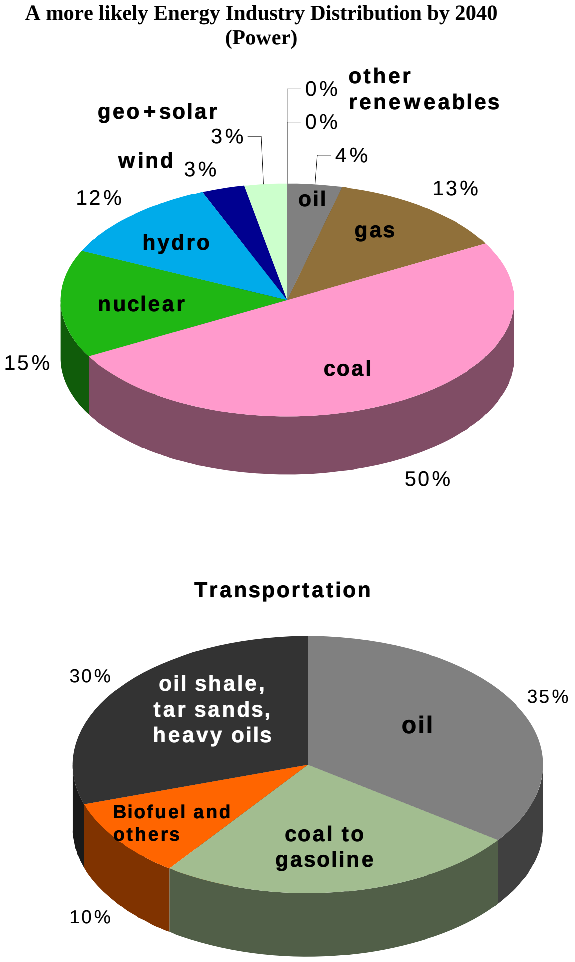
The lesson here is that we are being too timid in our plans for developing non-fossil fuel energy sources, and this lack of urgency will condemn us to a greatly expanded use of unconventional fossil fuels and technologies such as coal-to-gas (Figure 3). If you extrapolate present energy development worldwide, fossil fuel industry investments, central planning of countries such as China, India and Indonesia, Figure 3 is more likely to be achieved than Figure 2, with drastic economic and environmental consequences. **This is the consequence that needs to be presented to the public and policy-makers.**



A Target Sustainable Energy Distribution by 2040
(Power)
30 tkWhrs/yr

A Target Sustainable Energy Distribution by 2040
(Transportation)

Fig. 2. How We Achieve a $^1/_3$, $^1/_3$, $^1/_3$ - Energy Distribution: a third fossil fuel, a third renewables and a third nuclear



A more likely Energy Industry Distribution by 2040
(Power)

Transportation

Fig. 3. A more likely Energy Distribution: almost twice as much fossil fuel as present, and about four times as much as in Figure 2.

MUCH ADO ABOUT NUCLEAR

Policy-makers think that the public favors renewables but does not support nuclear energy. However, this is not true. Recent public surveys show an overall 74% favorability rating of nuclear energy nationwide (Bisconti 2008). Surprisingly, these same respondents think they are in the minority, which is why such a supermajority does not translate into political support. In addition, misunderstanding of nuclear still leads to general suspicion and ill-ease that permeates all discussions of nuclear energy even though the person may overall favor it in the abstract. Finally, as with many complex problems, a vocal minority dominates the discussion and acts as unelected spokespersons for the public. Therefore, fears must be addressed even though the majority personally supports nuclear.

Lack of understanding of nuclear energy by the public is the biggest hurdle to nuclear achieving its third of the mix. Not only do these perceptions affect siting of nuclear power plants and cause regulatory delays, but they also affect many peripheral areas such as access to loan guarantees, funding of public educational programs, and vulnerability to dirty bomb attacks the primary destruction of which comes from fear and not the radiological material dispersed (Conca and Reynolds, 2006).

The reasons nuclear energy did not expand after 1970 in North America and elsewhere fall into five categories: capital costs, operational risks, proliferation, waste disposal, and public fear. The first four are no longer the insurmountable challenges they once were, as will be discussed below. They must be discussed with private citizens in an open and inclusive way. It is best to focus on the safe and productive history of nuclear energy in this country instead of refuting each issue individually and becoming mired in the traditional negative debate. On the other hand, there must be answers to each issue. Finally, public fear can only be dealt with by addressing the first four issues with open and honest discussion in venues from public school curricula to the national media.

Cost

Actual costs for nuclear power have come down since designs have become more standardized and the industry learned to operate reactors more efficiently. Every reactor in the U.S. is a different design, because they were all designed before 1980 when we were still learning. We have been unable, and unwilling to build the new design reactors, although other nations have with great success. The other part of the high cost is an artifact of the fear. Financial institutions take advantage of the fear to charge exorbitant interest rates to finance nuclear plant construction. Even though every other form of energy, including fossil and renewable is subsidized by the government, nuclear is actually penalized, not subsidized. Remove that penalty and the costs are lower than for any source except wind and geothermal.

Standardizing units, removing punitive financing and regulatory delays, providing loan guarantees and streamlining the permitting process, cuts costs dramatically. Because nuclear and renewable costs are mainly up front, they appear larger than for fossil fuel, but the continuous need to fuel fossil fuel plants with increasingly costly fuel quickly overwhelms any reasonable projections of nuclear and renewable costs. Even so, for nuclear to produce 10 trillion kW-hrs/yr by 2040 will require investments upwards of $8 trillion. But the same power production from renewables will require about $9 trillion, and simply fueling existing fossil fuel plants to produce 10 trillion kW-hrs/yr from now to 2040 will require over $20 trillion depending upon fossil fuel cost projections. As large as these investments appear, if nuclear and renewables fail to significantly exceed 5 trillion kW-hrs/yr by 2040, then just fueling existing fossil fuel plants will exceed $50 trillion between now and 2040.

In other words, as costly as the almost $20 trillion investments in nuclear and renewable over the next 30 years will be, not investing in nuclear and renewable to this degree will cost much more in the long run.

Indirectly coupled to costs are environmental effects, another type of cost. Certainly, an obvious advantage to nuclear energy is the lack of emissions. Nuclear produces little CO_2, less than solar or biomass, and almost as low as wind. Fossil fuels produce 30 billion tons of CO_2 each year. Nuclear energy worldwide has saved over 100 billion tons of CO_2 from entering the atmosphere since 1975, more than any other emissions strategy could achieve in the next 20 years, including the rise in renewables, carbon taxes or cap & trade. Only significant national, corporate and individual conservation can do as well, and is needed just as much as increased development of nuclear and renewables.

France, which is about 80% nuclear, decreased its CO_2 emissions by almost 30% in the 1980s, when, in response to the oil embargo of 1973, it decided that new power plants would be nuclear instead of fossil fuel. This drop in CO_2 emissions is more than any country has achieved with any other strategy. As a result, France has the best air quality in Europe, and exports energy to other European countries, helping them achieve their CO_2 targets. In fact, worldwide nuclear energy saves more than twice the Kyoto Accord carbon targets each year. It is the only strategy that has significantly reduced CO_2 emissions.

Risk

Risk is a subject that should be a basic part of public education as it determines not only people's fear and their actions, but also the overall cost to society. With respect to nuclear energy, it is imperative that private citizens are able to separate weapons from energy, and then look at nuclear energy in terms of its history in this country. As an example, how do most people rank the following list of activities from most dangerous to least dangerous?

alcohol
automobile accidents
coal use
construction
contraception
mining
hunting
iatrogenic
nuclear industry
police work
smoking
food poisoning

Almost everyone knows that smoking is unhealthy, but most also put nuclear near the top of the dangerous list. Looking at the actual deaths over the last five years (Table 2) shows that, yes, smoking is bad, but smoking was passed a few years ago by iatrogenic death, a simple definition being *medicine gone wrong;* not abuse or mistakes, just that the person inexplicably dies. It is now the leading cause of death in the United States.

Table 2. The number of deaths by activity in the United States over the past five years.

Activity	**Number of Deaths in U.S. over the past 5 years**
iatrogenic	**950,000**
smoking	**760,000**
alcohol	**500,000**
automobile accidents	**250,000**
coal use (~ 50% of U.S. power)	**30,000**
food poisoning	**25,000**
construction	**5,000**
hunting	**4,100**
police work	**800**
mining	**359**
nuclear industry (~ 20% of U.S. power)	**0**

But no one dies from nuclear energy or nuclear waste. Radiological deaths and environmental effects are from weapons not energy. Note the dramatic effects from coal, which produces two-and-a-half times as much power as nuclear, but many more deaths. What is confounding is that this list of almost 3 million deaths in America over 5 years is acceptable to our society, but it is nuclear, with no fatalities, that causes such fear. Why? Is it just its association with weapons? Is it the lack of under-standing of radiation effects? Political agendas? MoveOn.org? The scary old movies? The Simpsons?

Even when looking at OSHA data for non-lethal injuries like falling off a ladder, jobs in nuclear energy are still the safest ones available, safer than sitting at a desk trading stocks, safer than being a realtor, safer than any job anyone in any likely audience has ever held (U.S. Bureau of Labor Statistics). And that level of safety has cost more. Because of the *sturm und drang* of the cold war during the 1950s, 60s, 70s and into the 80s, finally ending in 1991 with the *glasnost* and *perestroika* of Mikhail Gorbachov, great pressure was placed on the Nuclear Regulatory Agency, the EPA, the DOE and their predecessors to do their jobs better, making nuclear the safest, cleanest, most efficient energy source known to humans. This result, more than is generally realized, achieved with nuclear in environmental and health safety what no one has achieved with fossil fuel, or even with solar. These requirements should not be lost in discussions on energy sustainability. But when the job has been done this well, it needs to be acknowledged, and not presented as if nothing has been accomplished in the last thirty years. And the other energy sources need to be held to as high a safety and environmental standard as nuclear energy.

Proliferation

It is imperative that private citizens are able to separate weapons from energy, and then understand that decisions about nuclear energy in this country have never had any effect on proliferation, but have served to isolate us and remove our influence in this area. However, greater understanding of nuclear and its rise on the world stage is necessary to address proliferation. The only effective way to address proliferation is by controlling nuclear materials, removing the need for each country to develop enrichment, fabrication, recycling or disposal capabilities. This strategy is the driving force behind various global nuclear energy partnership concepts, such as GNEP in the U.S. or GNPI in Russia, and multiple-country repository concepts and world nuclear fuel banks in Europe (McCombie 2007; Conca and Wright 2009, this volume). In these types of nuclear energy partnerships, nuclear fuel is provided to non-nuclear-capable countries by nuclear countries thereby removing the need of non-nuclear countries to develop their own enrichment capabilities that can also be used to produce weapons-grade material. this allows the non-nuclear-capable countries to invest in the power plant itself, which is much less expensive than the entire cycle of enrichment, fabrication, recycling, and disposal. This strategy also allows the world to slow down on its fossil fuel power plant production, allowing countries to meet emissions targets without sacrificing their standard of living.

Nuclear Waste

Finally there is nuclear waste, the easiest issue to handle scientifically. First, there is not much of it. In the United States, where 20% of our power comes from nuclear, only 2,000 tons of solid waste are generated each year. Coal-fired power plants, where 50% of our power is generated (only two-and-a-half times more power than nuclear provides), produces millions of times more waste, several hundred million tons of solid waste and over 2 billion tons of CO_2. Coal even produces more radioactive waste (25,000 tons/yr) than nuclear (600 tons/yr) because of the uranium, thorium and daughter products in coal that are released when burned.

Other types of waste are even more stunning in volume. Five hundred million tons of chemical and sanitary waste are generated each year causing much more damage to our environment than any possible effects from nuclear, and over two quadrillion gallons of wastewater has to be treated each year. In contrast, all the waste ever generated from nuclear energy in the United States would only fill one landfill. There is not much waste from nuclear energy and the fear of it is stopping us from seriously addressing global warming and other environmental and economic problems.

Second, nuclear waste is easy to handle and easy to detect, even from a distance. Radioactive waste can't sneak up on anyone like anthrax, melamine or diethylene glycol. For 70 years it has been easy and inexpensive to measure radioactivity, which is the reason why no one has ever been killed by waste from nuclear energy. We know how to package it, ship it, and dispose of it (Figures 4 and 5). There has never been a transportation accident where nuclear waste has been released. This is not the case with other hazardous materials.

Third, there is WIPP. Most people have never heard of the Waste Isolation Pilot Plant, shown in Figure 4. It is a deep geologic nuclear waste repository in a massive, tight, bedded salt deposit a half-mile below the surface of the earth in southeastern New Mexico. This massive salt is relatively plastic for a rock, is easy to mine, and creeps slowly closed over time, so that it cannot sustain a fracture or any other pathway for water or contaminants to get in or out. This creep closure property is rare, and unlike fractured hard rock (volcanics, limestones or granitics) provides a perfect enclosure for any waste, especially nuclear. The Salado Salt is so isolating that intact macrobiomolecules such as DNA, bacterial husks and cellulosics from cell walls have been preserved (Griffith et al., 2008). WIPP, near Carlsbad, New Mexico has been operating for almost ten years, since 1999, and as of this writing, has disposed of about 60,000 m^3 of waste in over 100,000 containers, equivalent to about 300,000 fifty-five gallon drums (Figure 5, see also http://www.wipp.energy.gov). WIPP is licensed to accept only defense transuranic waste, but this was a bureaucratic decision. Scientifically and physically WIPP can accept any nuclear waste. In fact, the National Academy of Sciences made the decision in 1957 that the Salado Salt should be the primary disposal site for all nuclear waste. Political decisions made in the 1970s separated nuclear waste into several arbitrary categories and mandated that only defense transuranic waste could be disposed at WIPP. This must be changed.

Fig. 4. The Waste Isolation Pilot Plant (WIPP), the only operating deep geologic nuclear waste repository, is excavated 700 meters below the surface in the massive salt of the Salado Formation, and has operated successfully since 1999.

Fig. 5. Over 10,000 nuclear waste drums and standard waste boxes filling 1 of 56 rooms to be filled at WIPP over a 20-year period. Almost 25 rooms have been filled as of June 2008. Note the higher activity remote handled waste plunged into boreholes in the wall to the right and plugged with four-foot metal-wrapped cement.

Private citizens and policy-makers are invariably surprised to learn: a great volume of nuclear waste has been stored at WIPP safely without incident; the actual exact costs and logistics are lower than other energy sources; the Salado Salt Formation has the capacity to hold all the nuclear waste we could ever produce in a thousand years; and the isolation time period for the stored nuclear waste is over 200 million years. This is probably the best information there is to diffuse the fear of private citizens about nuclear energy.

CONCLUSIONS

Although it is easy to provide huge amounts of data and information concerning the safety and effectiveness of nuclear power, the best way to engage private citizens and policy-makers is to frame the problem in the larger context of socioeconomics and ethics, that nuclear is just one component of our long-term energy solution, and to then have meaningful and realistic discussions of how to address the larger energy, environmental and economic crises that face the world. The magnitude of these crises should allow a more rational discussion of nuclear power than has been possible in many decades. We will not end global poverty, war, genocide or terrorism until everyone is above 0.8 HDI and this will require a total sustainable energy budget for the world of about 30 trillion kWhrs by 2040.

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