ATOMIC TIME MACHINES: BACK TO THE NUCLEAR FUTURE

By Dr. Denis E. Beller
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Atomic Time Machines: Back to the Nuclear Future

Dr. Denis E. Beller[*]

I. BACK IN TIME

Have you ever felt as if you have experienced time travel (déjà vu)? After hearing my optimistic point of view, my opponent on a recent panel on the future of nuclear energy expressed just that sentiment.

When reading about or listening to present-day news items or speeches about the nuclear power industry, whether they are by or about industry leaders, nuclear scientists or engineers, or anti-nuclear individuals or organizations, some people might think they have been transported back in time in a time machine. Many people in the nuclear power industry and academia at the beginning of the twenty-first century have the same optimistic outlook as the founders did a half-century ago, and opponents of technology, especially nuclear technology, feel as if they're facing the same battles they fought in the 1970s and 80s. For a variety of reasons that will be explained in this essay, young nuclear proponents have what appears to be a brilliant future, which might mean opponents do as well. At the same time, opponents of all things nuclear—energy as well as nuclear medicine; use of nuclear reactors to eliminate weapons materials; recycling of used nuclear fuel; irradiation to sterilize consumer products, medical equipment, and food; industrial applications; etc.—may believe they are hearing the same overly optimistic projections and claims as in the distant past, when nuclear technology advanced rapidly and a nuclear construction boom produced most of the reactors that now provide 20 percent of U.S. electricity.[1] Those who have been the "pro" part of this battle for decades may feel like they are still hearing the same opposing arguments to which they have been listening for decades, akin to hearing the little boy cry "nuclear wolf" for thirty or forty years. But the little boy has grown old while the industry has proven itself to be the safest major source of electricity in the Western world; yet the old man is still crying.

One reason for the recent optimism in the nuclear industry is an ever-increasing worldwide demand for energy. Demand for electrical energy leads

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[*] Department of Mechanical Engineering, University of Nevada, Las Vegas. This paper was adapted from an oral presentation given at the Eighth Annual Wallace Stegner Center Symposium titled "Nuclear West: Legacy and Future" and for that reason does not include comprehensive citation of sources. It is grounded in Dr. Beller's extensive continuing experience both at Los Alamos National Laboratory and at the University of Nevada, Las Vegas, as well as his recent service as Chair of the Public Information Committee of the American Nuclear Society.

[1] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANNUAL ENERGY OUTLOOK 2004 WITH PROJECTIONS TO 2025, (DOE/EIA-0383(2003)) (2004), *available at* http://www.eia.doe.gov/oiaf/aeo/index.html (last visited Jan. 27, 2004).

that growth. Other recent trends and forces include demand for cleaner forms of energy in general and electricity in particular, as well as global pressure for sustainable development and reductions in carbon emissions, all of which support the need for increasing supplies of nuclear energy. Nuclear power is the only energy source that can be developed on a massive scale that will meet all the requirements for tremendous increases in generation. For economic and resource sustainability, new sources of energy must be clean, affordable, reliable, environmental,[2] safe and secure, and sustainable. Before describing why Western nuclear power meets these requirements, let me tell you why we need to use more clean electricity and other forms of energy, not less.

Those of us who have it use energy to benefit humankind. We naturally seek to use energy to multiply our labor, increasing our productivity. In developed nations energy is used to build and light grammar schools and universities, to run hospitals and police stations, to purify water and produce medicine, to power farm machinery and mass transit, to drive sewing machines and robot assemblers, and to store and move information. A particular form of nuclear energy, nuclear radiation, is also used to sterilize mail in the nation's capital, consumer products found on grocery store shelves and elsewhere, and medical equipment used in every hospital and clinic in the nation. For the betterment of the human condition, the world needs massive additions of clean and affordable energy supplies. Development depends on energy, we use it to fight poverty and disease, to create and administer medicine, to grow and distribute food, and to provide the means for people to learn their way out of poverty, which is the most dangerous "thing" on Earth.

II. ENERGY APARTHEID

Our global neighbors need much more energy to achieve the standards of living of the developed world. One-third of the six billion people on Earth today lack access to electricity.[3] Another two billion use just 1000 kilowatt hours (kWh) per year, which is barely enough to keep a single 100-watt light bulb lit.[4] In addition, one billion people have no sanitary water,[5] which could

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[2] "Environmental" implies more than clean, meaning not putting hazardous matter into our water and air. It also includes the responsible and ethical use of our resources, including land, water, and air. While not "dirty," activities like creating sinkholes, mountain top mining, release of toxic water from coal-bed methane extraction, and drowning millions of acres behind dams are certainly not environmentally sound practices.

[3] WORLD ENERGY COUNCIL, ENERGY FOR TOMORROW'S WORLD—ACTING NOW! (2000) *at* http://www.worldenergy.org/wec-geis/publications/reports/etwan/energy_goals.asp (last visited Jan. 27, 2004).

[4] DR. ALAN D. PASTERNAK, GLOBAL ENERGY FUTURES AND HUMAN DEVELOPMENT: A FRAMEWORK FOR ANALYSIS 16 (UCRL-ID-140773) 10 (2000), *available at* http://www.llnl.gov/tid/lof/documents/pdf/239193.pdf (last visited Jan. 27, 2004).

[5] DR. DENNIS B. WARNER, WORLD HEALTH ORGANIZATION, DRINKING WATER SUPPLY AND ENVIRONMENTAL SANITATION FOR HEALTH (1998) *available at* http://www.oieau.fr/ciedd/contributions/at1/contribution/warner.htm (last visited Jan. 27, 2004).

be provided easily and inexpensively if energy were available to operate desalination and/or purification plants. Energy is needed for development, prosperity, health, and international security. The alternative to development, which is easily sustained with ample energy, is suffering in the form of poverty, disease, and death. This suffering creates instability and the potential for widespread violence, such that national security requires developed nations to help increase energy production in their more populous developing counterparts.

The relationship between energy use and human well being is demonstrated by correlating the United Nations' Human Development Index (HDI) with the annual per capita use of electricity. The UN compiles the HDI for almost every nation annually. It is a composite of average education level, health and well being (average life expectancy), and per capita income or gross domestic product. One such correlation that was done a few years ago showed that electric consumption first increases human well being, then people who are well off increase their electric consumption.[6] Figure 1 illustrates this for almost every nation on Earth (the data includes more than 90 percent of the Earth's population). Note there is a threshold at about 4000 kWh per capita. Below this threshold, human development increases rapidly with increases in available electricity (there are, of course, exceptions to every rule). Above this threshold, use of electricity increases rapidly as people become more healthy, wealthy, and educated. A deeper investigation into the data underlying the HDI reveals the effects of what Dr. Eric Loewen, a delegate to the United Nations 2002 World Summit on Sustainable Development in Johannesburg, South Africa, now calls "energy apartheid."[7] People in the Western world, who have and use large amounts of energy, have a life expectancy of about eighty years, while those on the lower left side of this graph, undeveloped nations where most people have no access to electricity, will die decades earlier. Thus, billions of our global neighbors without sufficient electricity die decades before they should. Those who live in poverty live in the most dangerous of conditions.

Without substantial increases in electricity generation, the proportion of the Earth's population without sufficient electricity will increase in the next fifty years as it grows by 50 percent to near 9 billion people.[8] Preventing global conflict will require even more addition of electricity. The product of increased population and increased per capita energy usage by people who today have access to nearly none is a great growth in global electricity usage. Estimates

[6] PASTERNAK, *supra* note 4, at 16.

[7] Eric Loewen, Global Energy Apartheid: The Disparity Between the Haves and Have-Nots, Address at Director's Special Seminar, Advanced Photon Source, Argonne Nat'l Laboratory (Jan. 28, 2003).

[8] John Ritch III, *Nuclear Energy at a Moment of Truth: Six Reasons Behind the Case for Nuclear Power*, 44 INT'L ATOM. ENERGY ADMIN. BULL., 30-35, (2002), *available at* http://www.iaea.or.at/worldatom/Periodicals/Bulletin/Bull442/article6.pdf (last visited Jan. 27, 2004).

for future increases in energy and electricity use, even with substantial efficiency improvements and conservation efforts, range between doubling and tripling in the next fifty years.[9] Even with conservation, "energy star" appliances and homes, mandated fuel economy, massive government purchases of "renewables," and energy saving and efficiency measures, our use of electrical energy has been growing faster than total energy usage; electricity use in the United States increased 57 percent between 1980 and 2000, while total energy use increased just 27 percent.[10]

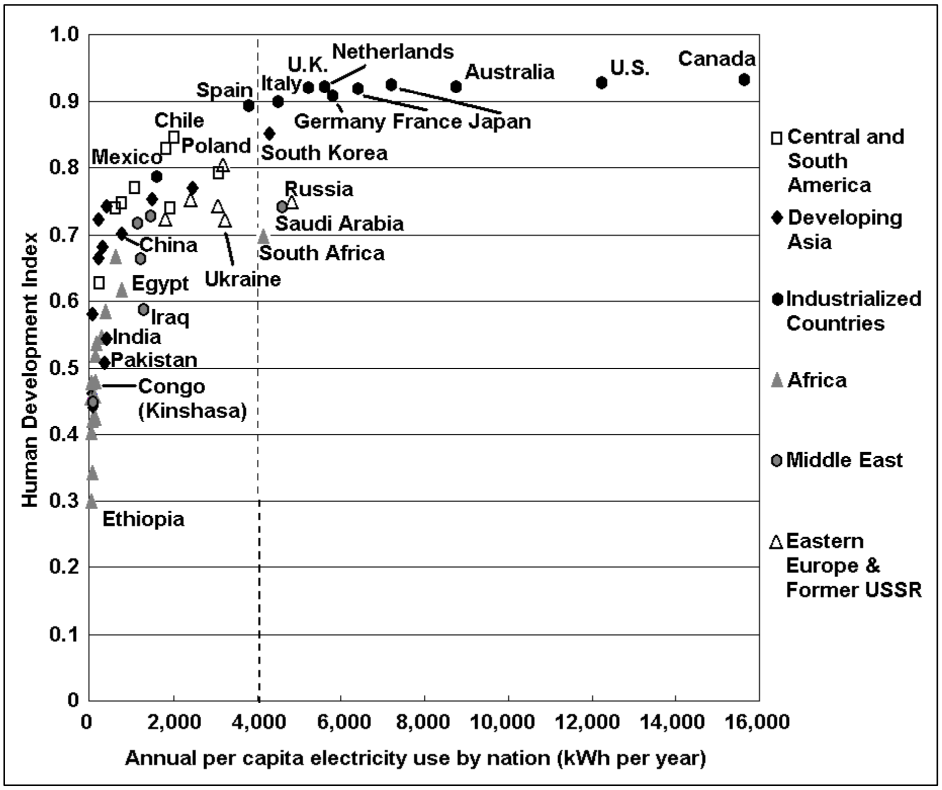

Figure 1. The United Nations' Human Development Index and electricity use for 60 countries (1997).[11]

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[9] *Id.*; Amanda Griscom, *Power to the People: Plugging Developing Nations into Renewable Energy*, GRIST MAG. (Oct. 8, 2002), *at* http://www.gristmagazine.com/powers/ powers100802.asp (last visited Oct. 28, 2003); THE ROYAL SOCIETY & THE ROYAL ACADEMY OF ENGINEERING, NUCLEAR ENERGY: THE FUTURE CLIMATE 3 (1999), *available at* http://www.royalsoc.ac.uk/policy/fullnuclearreport.pdf (last visited Jan. 27, 2004).

[10] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANNUAL ENERGY REV. 2001 38 (DOE/EIS-0384(2001), 2002), *available at* http://www.eia.doe.gov/aer/pdf/multifuel/03842002.pdf (last visited Jan. 27, 2004).

[11] PASTERNAK, *supra* note 4, at 20.

III. FUTURE ENERGY SCENARIOS

The International Energy Agency (IEA) of the Organization for Economic Cooperation and Development (OECD) projects 65 percent growth in world energy demand by 2020, two-thirds of that coming from developing countries.[12] That is near-term growth of 65 percent, and it is in the future you and I can influence. This view of the future presents us with an immense challenge: how can we meet the global demand for energy without unsustainable long-term damage to the environment? The damage could include sinkholes, acid-mine runoff, mountaintop removal for coal extraction, pollution of our waters, earth, air, and possibly global warming. Will we get that energy from fossil fuels, nuclear power, hydroelectric, or renewables? The answer is unquestionably "yes, we must" instead of a restrictive choice of one or a few of these options. To meet the world's demand for energy, we must use every available resource; but international conflict, economic prosperity, and local, regional, and global pollution will all be influenced by our future energy choices.

Economic and energy growth have historically gone hand in hand in the United States and the rest of the world. During the first year of the current recession, when the U.S. economy actually declined, so did the annual use of electricity. As the nation recovers and our economy again expands, we will see electricity usage grow rapidly again, with a projected increase of more than fifty percent between 2001 and 2025.[13] That growth is equivalent to 250 new large power plants like today's 1-gigawatt nuclear or coal-fired plants, or equivalent to construction of seventy to ninety smaller plants each year in the United States for the next twenty years.

If this growth were all to be supplied by wind or solar plants (e.g. one million 1-megawatt windmills covering fifty million acres), a major part of our electricity supply would be highly intermittent and undependable, which is harmful to electricity markets.[14] Electricity will then become unaffordable for millions of Americans. If, instead, those new plants are distributed according to the current mix, in twenty years we'll be using much more coal, oil, and natural gas, generating more acid rain, leveling more mountains, filling in

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[12] INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK 19 (1998), *available at* http://www.worldenergyoutlook.org/weo/pubs/weo1998/WEO98.pdf (last visited Jan. 27, 2004).

[13] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, ANNUAL ENERGY OUTLOOK 2004 WITH PROJECTIONS TO 2025, (DOE/EIA-0383(2003)) (2004), *available at* http://www.eia.doe.gov/oiaf/aeo/index.html (last visited Jan. 24, 2004) [hereinafter ANNUAL ENERGY OUTLOOK 2004] (the value was calculated from tbl. 8, line 822).

[14] *See* COUNTRY GUARDIAN, UNPREDICTABLE WIND ENERGY—THE DANISH DILEMMA (outlining intermittent power in Denmark resulting from heavy dependence on wind energy) *at* http://www.countryguardian.net/denmark.htm(last visited Jan. 27, 2004).

more valleys and springs, drilling tens of thousands more gas wells in Wyoming and Montana, and polluting our earth, air, and waterways even more than we do today. Why? Because today more than 85 percent of U.S. energy comes from the combustion of fossil fuels accompanied by these environmental assaults.[15]

Of our electricity, in 2002 72 percent was produced by combustion, 21 percent by nuclear power, 6.5 percent by hydroelectric, and about 0.6 percent by non-hydro, non-combustion renewables.[16] This fact may surprise some readers of this essay: in 2002 more than 82 percent of our non-hydro renewable electricity was produced by combustion, mostly of waste, not from the wind or sunshine.[17] Combustion of waste releases pollutants into our air and water and recycles CO_2, just one of the global warming gases, back into our atmosphere. We do not actually get much of our renewable energy from windmills and solar cells.[18] In spite of many tens of billions of U.S. dollars of research and development and taxpayer subsidies, renewable electricity generation has declined since the peak year of 1997. It was 33 percent less in 2001, a dry year in the west, and it was still down by 23% in 2002.[19] Is this decline in renewable generation what the U.S. taxpayer believes is happening in the U.S.? The story is about the same for non-hydro renewables (geothermal, biomass, solar, and wind combined), which in 2002 had declined by 33% since the U.S. DOE began compiling this data in 1990.[20] On the other hand, non-emitting nuclear power has increased, and it now supplies more than 75 percent of emission-free electricity in the United States.[21] Lesser fractions are hydro at 22 percent, 1.4 percent geothermal, 0.7 percent wind, and finally the insignificant solar, which provides less than one-tenth of one percent of our emission-free electricity.[22] Nuclear power has also provided almost 50 percent of the pollution reductions reported since the beginning of the voluntary system in the 1990s.[23] All of these energy sources are sustainable for our lifetimes, but

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[15] ENERGY INFO. ADMIN., UNITED STATES DEP'T OF ENERGY, ELECTRIC POWER MONTHLY, MAY 2002 WITH DATA FOR FEBRUARY 2002, (DOE/EIA-0226 (2002/05)) 10 (2002), *available at* http://tonto.eia.doe.gov/FTPROOT/electricity/epm/02260205.pdf (last visited Jan. 27, 2004).

[16] ANNUAL ENERGY OUTLOOK 2004, *supra* note 13, at tbl. 8, 17.

[17] *See* ENERGY INFO. ADMIN., UNITED STATES DEP'T OF ENERGY, RENEWABLE ENERGY ANNUAL 2002, Table 4. Electricity Net Generation From Renewable Energy by Energy Use Sector and Energy Source, 1998-2002, *available at* http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/table4.html (last visited Jan. 24, 2004).

[18] *Id.*

[19] *See* ENERGY INFO. ADMIN., UNITED STATES DEP'T OF ENERGY, *Electric Power Monthly – December 2003* at 10, DOE/EIA-0226 (2003/12) Net Generation by Energy Source: Total (All Sectors), 1990 through September 2003 *available at* http://www.eia.doe.gov/cneaf/electricity/epm/epm.pdf (last visited Jan. 26, 2004).

[20] *Id.*

[21] *See* ENERGY INFO. ADMIN., UNITED STATES DEP'T OF ENERGY, *supra* note 16.

[22] *Id.*

[23] NUCLEAR ENERGY INSTITUTE, POWERING THE FUTURE WITH ENVIRONMENTALLY SOUND NUCLEAR ENERGY: THE ECOLOGICAL STEWARDSHIP OF THE NUCLEAR INDUSTRY 2 (2003), *available at*

although oil and coal still dominate global primary energy, coal's market fraction began declining many decades ago, and oil's market share peaked in the 1980s.[24]

IV. BACK TO THE PRESENT

Today's nuclear power industry is performing at an incredible level. A consolidated, streamlined, and efficient U.S. nuclear industry now leads the world in economic production of electricity.[25] The United States is the world leader with 103 of the world's 441 operating power plants (as of 2002).[26] Whereas 17 percent of global electricity is produced by nuclear power, it supplies more than 20 percent of that used by Americans and 35 percent in the European Union.[27] The U.S. is not constructing new plants, but production has been growing as fast as electricity demand because the industry has increased performance as well as increased capacity through plant upgrades and uprates. In 2002, U.S. nuclear power industries generated more than 780 billion kilowatt-hours, which was worth more than $50 billion.[28] Last year, the reliability of nuclear plants averaged more than 90 percent, compared to less than 60 percent just 20 years ago.[29] Compare that to the capacity factors for other sources of electricity: coal (69 percent), natural gas (between 14 and 50 percent depending on the type of plant), heavy oil steam turbine (26 percent), hydro (29 percent), wind (29 percent), solar (21 percent), and geothermal (77 percent).[30] Fuel cycle, operations, and maintenance costs dropped again, so that nuclear power now has a lower marginal production cost than 90 percent of our electricity supply.[31] An existing plant that has been amortized can produce electricity 24 hours a day at less than two cents per kWh.[32] The median total production cost in 2002, including fuel cycle, operations, maintenance, and

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http://www.nei.org/documents/Ecology_Book_2003.pdf (last visited Oct. 28, 2003) [hereinafter POWERING THE FUTURE].

[24] Cesarre Marchetti, Infrastructures for Movement, 32 *Technological Forecasting and Social Change* No. 4 373, 388-89, Figs 18-19. (1987).

[25] *World List of Nuclear Power Plants*, NUCLEAR NEWS, Mar. 2003, at 41-67.

[26] *Id*.

[27] *Id*.

[28] NUCLEAR ENERGY INSTITUTE, NUCLEAR FACTS (2003), *at* http://www.nei.org/index.asp?catnum=2&catid=106 (last visited Jan 26, 2004) (reporting the value of electricity is based on the average retail price of electricity nation-wide, from DOE-EIA; nuclear energy is actually more valuable than many other forms because of its reliability) [hereinafter NUCLEAR FACTS].

[29] ENERGY INFO. ADMIN December 2003 Monthly Energy Review 117, tbl. 8.1 (2003) *available at* http://www.eia.doe.gov/emeu/mer/pdf/pages/sec8.pdf (last visited Jan. 24, 2004).

[30] NUCLEAR FACTS *supra* note 28.

[31] See Larry R. Foulke, *the Status and Future of Nuclear Power in the United States*, NUCLEAR NEWS, Feb. 2003 at 34, and *Nuclear Maintains Lowest Production Cost,* NUCLEAR NEWS Feb. 2003 at 20.

[32] NUCLEAR FACTS *supra* note 28.

waste disposal, was just $16 per megawatt hour (MWh) (1.6 cents per kWh, compare that to the wholesale cost on your electric bill).[33]

United States nuclear generation has set new records every year since 1997, and that trend is continuing in 2003.[34] In fact, during the last decade of the twentieth century, U.S. nuclear generation increased by more than 30 percent, which was equivalent to building more than twenty new commercial reactors.[35] Safety performance improved, worker exposures to radiation decreased, and emergency shutdowns dropped to near zero per reactor.[36] Nuclear power is alive and thriving in the United States, at least for existing power plants. The industry is increasing capacity, increasing capacity factor, and making even more clean and affordable electricity for America. With additional capacity uprates currently under consideration by the U.S. Nuclear Regulatory Commission (NRC), I expect the nuclear power industry will set new records again in the near future. With license renewals, we can now expect many of these plants to run until mid-century.

The NRC has given twenty-year license extensions to 23 reactors to accompany record performance and safety levels and reductions in waste production.[37] The U.S. nuclear industry has applied for license extensions for seventeen more reactors,[38] has notified the NRC that they will apply for twenty more during the current Bush administration, and has announced plans to extend the licenses of almost all reactors. Unknown to most, new U.S. nuclear pioneers are in the midst of a renaissance.

V. IS NUCLEAR POWER REALLY CLEAN?

When questioned on whether it was time to start building nuclear plants, former Clinton-Gore Secretary of Energy Bill Richardson said at the National Press Club on October 4th, "Nuclear Energy is Clean."[39] He said this because nuclear power plants do not emit acid rain, arsenic, mercury, lead, cadmium, selenium, boron, chromium, copper, fluorine, molybdenum, nickel, vanadium, zinc, beryllium, chlorine, cobalt, manganese, tin, antimony, or radioactive elements thallium, thorium, uranium, radium, radon, or polonium.[40] These

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[33] *Latest News this Month: U.S. Nuclear Plants Reported Record Efficiency Gains in 2002,* NUCLEAR NEWS, Sept. 2003, at 56.

[34] ANNUAL ENERGY OUTLOOK 2004, *supra* note 13 at 147 tbl. A9.

[35] NUCLEAR FACTS *supra*.

[36] *Nuclear Power Industry Keeps on Improving,* NUCLEAR NEWS, Jul. 2003 at 29, 29-30.

[37] U.S. NUCLEAR REGULATORY COMMISSION STATUS OF LICENSE RENEWAL APPLICATIONS AND INDUSTRY ACTIVITIES (2004), http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html (last visited Jan. 24, 2004).

[38] *Id*.

[39] Sec. of Energy Bill Richardson, Address at the National Press Club Luncheon (Oct. 4, 2000) *available at* http://www.npr.org/ramfiles/exrad/001044.brichardson.ram (last visited Jan. 27, 2004) (audio recording).

[40] *See* TRACE ELEMENTS IN COAL §§2.2-2.4, at 6-14 (Dalway J. Swaine & Fari Goodarzi, eds., 1995).

materials are all toxic in large amounts, and thousands of tons are placed into our environment because we burn coal.[41] Some are released at the mines, some in stack gases and fly ash, and some as solids for landfill waste or to be used in construction materials.[42] All energy technologies, including nuclear, have some of this burden because all manufacturing in the United States gets half its electricity from the burning of coal. For already constructed nuclear power plants however, this burden is infinitesimal compared to any other energy source including renewables. Of all sources of energy, nuclear plants generate 75 percent of America's non-emitting electricity.[43]

All sources of energy mentioned—oil, coal, natural gas, hydroelectric, nuclear, and non-hydro renewables—have environmental impacts, some of which are hidden from the public. Only nuclear power internalizes all the costs of its environmental impacts, which means the ratepayer, not the taxpayer, pays for storage and disposal of used nuclear fuel.[44] Although these sources have inconsistencies, prejudices and drawbacks, all are needed for national security, energy diversity, and economic prosperity.

VI. NUCLEAR POWER IS SAFE AND SECURE

No caveats, no explanation, not from this engineer/scientist. It's just plain safe! All sources of electricity production result in health and safety impacts. However, at the National Press Club meeting, Energy Secretary Richardson indicated that nuclear power is safe by stating, "I'm convinced it is."[45] Every nuclear scientist and engineer should agree with that statement. Even mining, transportation, and waste from nuclear power have lower impacts because of the difference in magnitude of materials. In addition, emissions from nuclear plants are kept to near zero.[46] If you ask a theoretical scientist, nuclear energy does have a potential tremendous adverse impact. However, it has had that same potential for forty years, which is why we designed and operate nuclear plants with multiple levels of containment and safety and multiple backup systems. Even the country's most catastrophic accident,

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[41] H. Josef Hebert, *EPA Refuses to Regulate Coal Waste*, AUGUSTA CHRONICLE, Apr. 27, 2000, *at* http://www.augustachronicle.com/stories/042700/tec_LA0831-5.shtml (last visited Jan 27, 2004).

[42] Richard Rhodes & Denis Beller, *The Need for Nuclear Power*, 79 FOREIGN AFF. Jan./Feb. 2000, 30 at 38 at 38.

[43] POWERING THE FUTURE *supra* note 23.

[44] NUCLEAR ENERGY INSTITUTE, NUCLEAR DATA, NUCLEAR ELECTRICITY: A KEY TO SUSTAINABLE DEVELOPMENT (Sep. 2000) *available at* http://www.nei.org/index.asp?catnum=3&catid=589 (last visited Jan. 26, 2004).

[45] Richardson, *supra* note 39.

[46] No technology is truly zero emitting, including renewables, but if any technology can call itself "non-emitting," nuclear power certainly can.

the partial meltdown at Three Mile Island in 1979, did not injure anyone.[47] The fact is, Western-developed and Western-operated nuclear power is the safest major source of electricity production. Haven't we heard enough cries of "nuclear wolf" from scared old men and "the sky is radioactive" from nuclear Chicken Littles? We have a world of data to prove the fallacy of these claims about the unsafe nature of nuclear installations.

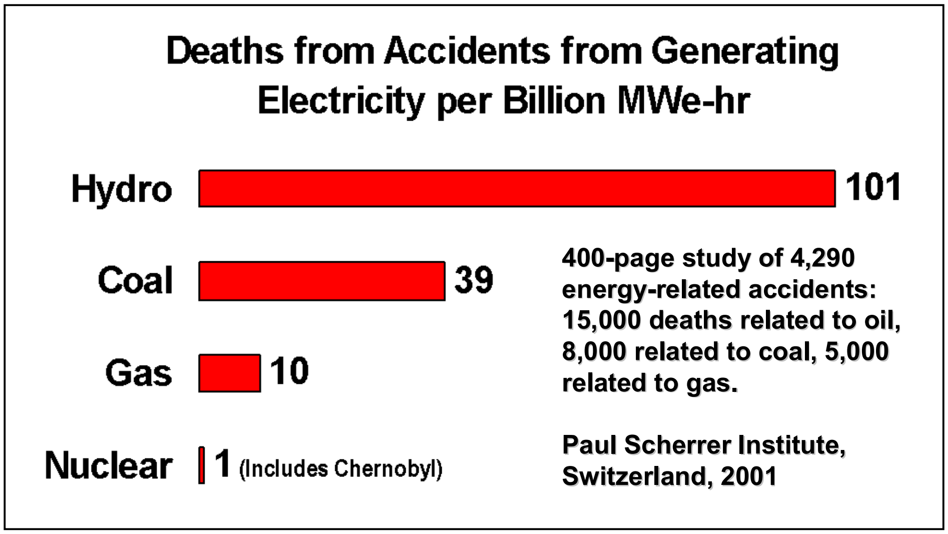

Figure 2. Deaths caused by accidents related to generating electricity.[48]

Figure 2 shows the results of an ongoing analysis of the safety impacts of energy production from several sources of energy. Of all major sources of electricity, nuclear power has produced the least impact from real accidents that have killed real people during the past 30 years, while hydroelectric has had the most severe accident impact. The same is true for environmental and health impacts.[49] Of all major sources of energy, nuclear energy has the least impacts on environment and health while coal has the greatest.[50] The low death

[47] Douglas M. Chapin et al.(eighteen other members of the National Academy of Engineering), *Nuclear Power Plants and Their Fuel as Terrorist Targets*, 297 SCIENCE 1997 (2002).

[48] Dr. Stefan Hirschberg, et al., Comparison Of Severe Accident Risks In Fossil, Nuclear And Hydro Electricity Generation 10-11 (2001) (invited paper from the International Conference on Ecological Aspects of Electric Power Generation in Warsaw, Poland, Nov. 14-16, 2001); see also Hirschberg et al., SEVERE ACCIDENTS IN THE ENERGY SECTOR, PSI REPORT NO. 98-16, (1st ed., Paul Scherrer Institute, 1998) (providing a full safety report including non-nuclear accidents).

[49] Rhodes & Beller, *supra* note 42, at 38-40.

[50] *Id*.

rate from nuclear power accidents in the figure includes the Chernobyl accident in the Former Soviet Union.[51]

Our nuclear plants are also among the most secure industrial facilities in the nation. In a recent report on homeland security, U.S. nuclear plants were given the only "A" grade.[52] According to the *Los Angeles Times*, in California, emergency planners recently evaluated potential targets, categorizing them and giving point scores for various aspects.[53] While highly visible places like the Golden Gate Bridge, the Los Angeles Airport, and Disneyland were at the top of the list, they thought nuclear plants were not worth attacking, rating the San Onofre Nuclear Generating Station less than 400th.[54]

VII. THE WORLD WILL CARESS NUCLEAR ENERGY

Nuclear power meets many future energy criteria

Clean (non-emitting, compact waste)
Affordable today
Reliable (nearly 100% when not refueling)
Environmentally acceptable (land, trees)
Safe & Secure for more than 40 years
Sustainable for the 21st Century

To benefit mankind without imposing unacceptable burdens, new sources of energy need to provide a number of attributes. The best would provide all of the following. They should be **clean**, which means non-emitting with compact wastes that can be easily and inexpensively controlled. They should be **affordable**, especially for the impoverished, but they should not be cheap. As Californians demonstrated during the recent electricity crisis and blackouts, economics is the best incentive for conservation. New sources of electricity must also be **reliable**. No one wants the power to fail while their children or grandchildren are on the operating table, and electricity disruptions have crippled California's, and probably the nation's, economy in the past two years. Energy has in the past become more and more **environmental** (not the same as clean),[55] and it must continue to do so. In addition to these attributes, massive new sources of energy must also be **safe**, **secure**, and **sustainable**. The initials of these attributes—clean, affordable, reliable, environmental, safe and secure,

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[51] Hirschberg, et al., *supra* note 50.

[52] PROGRESSIVE POLICY INST., AMERICA AT RISK: A HOMELAND SECURITY REPORT CARD 18 (2003), *available at* http://www.ppionline.org/documents/HomeSecRptCrd_0703.pdf (last visited Apr. 19, 2004).

[53] Steve Hymon, *LAX Ranks No. 1 on State List of Terrorist Targets*, LOS ANGELES TIMES, February 22, 2003, at B1.

[54] *Id.*

[55] *See supra* note 2.

and sustainable—make up the acronym CARESS. It is obvious from a review of recent global activities and proclamations that the world is now CARESSing nuclear energy as a top choice to meet global demand for new sources of electricity.

VIII. A FUTURE FOR NEW FOREIGN NUKES

Nuclear plants are under construction abroad, and many more are planned. Most of this nuclear construction, both planned and current, is concentrated in Asia.[56] This includes China, Japan, North and South Korea, Taiwan, India, Pakistan, Iran, and Vietnam. Korea, Japan, and China have the most ongoing construction, and they are making plans to build much more nuclear capacity in the next fifteen to twenty years. The Republic of Korea (South Korea) currently operates sixteen reactors, six are under construction, and eight more are planned for completion by 2015—implying a 100% increase in nuclear generation by 2015.[57] The Korean Atomic Energy Research Institute (KAERI) is also working with U.S. researchers and the U.S. State Department to develop a new fuel cycle to "recycle" used fuel from light water reactors into heavy-water CANDU (Canadian Deuterium Uranium) reactors.[58]

In Japan, which has more than fifty reactors, new construction is ongoing and more has been approved recently despite widely publicized problems in their nuclear industry.[59] Japan is also working on recycling used nuclear fuel, where they are constructing plants for partitioning the used fuel into waste, uranium, and other actinides and for manufacturing mixed fuels for their reactors.[60] The most significant global nuclear story is in central and southeast Asia.

More than one-third of the Earth's people live in China, Pakistan, and India. Growing energy use in these nations, which are all on the far left of the earlier HDI-versus-electricity graph, could have devastating global implications. In China, aggressive growth depends on the availability of capital. China has eight operating nuclear power reactors, four are under construction, and they plan to continue to expand their nuclear industries even

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[56] URANIUM INFORMATION CENTER, ASIA'S NUCLEAR ENERGY GROWTH (Nov. 2003), *at* http://www.uic.com.au/nip02.htm (last visited Jan. 28, 2004).

[57] STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE, SOUTH KOREA COUNTRY PROFILE, *available at* http://projects.sipri.se/nuclear/cnsc5kos6.htm (last visited Jan. 24, 2004).

[58] URANIUM INFORMATION CENTER, NUCLEAR POWER IN SOUTH KOREA (Jan. 2003), *at* http://www.uic.com.au/nip81.htm (last visited Jan. 28, 2004).

[59] URANIUM INFORMATION CENTER, NUCLEAR POWER IN JAPAN (Jan. 2004), *at* http://www.uic.com.au/nip79.htm (last visited Jan. 28, 2004).

[60] *Id.*

further.[61] India has fourteen operating reactors, several are under construction, and they are in the process of developing a complete fuel cycle industry.[62]

Nuclear power is seldom thought of in conjunction with Central and South America, but many nations have nuclear programs, and some even have nuclear power plants. Brazil, with two operating reactors and one on hold,[63] recently restarted their Angra-3 reactor construction project, with a $1.8 billion price tag and a projected completion date of 2008.[64] With recent heavy rains, a recession, and a national surplus of hydroelectricity, however, they have once again halted the project. In Argentina, Atucha-1 has been upgraded and Atucha-2 is 85 percent complete, and the Government has approved a design and a site for a new prototype reactor.[65] Peru announced that they expect to need nuclear power between 2012 and 2016, and Mexican authorities stated that when the United States begins construction of new nuclear plants, Mexico would follow.[66] In addition, the International Atomic Energy Agency began a multi-national project to develop a waste repository for use by many of these countries.

Attitudes are mixed in Europe, where only France, Finland, the Czech Republic, and Romania are currently going against the "Green" tide. France has publicly announced plans to build a new generation of nuclear plants, and recently extended the lifetimes of their reactors by 10 years or 33 percent, from 30 years to 40 years.[67] The nuclear industry in Finland, already with legislative approval, plans to build a fifth reactor at the Olkiluoto plant with scheduled operation beginning in five years.[68] The Finnish are also currently building an underground repository for permanent disposal of used nuclear fuel.[69] In the Czech Republic the commissioning of two new reactors is progressing, with both operating at 100 percent power.[70] In Romania, one reactor is under construction with Canadian financing and Italian partnership, another is in the approval process for beginning construction, and the Romanians recently commissioned a nuclear waste storage facility.[71] Although Germany is in the

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[61] URANIUM INFORMATION CENTER, NUCLEAR POWER IN INDIA AND CHINA (Sep. 2003) *at* http://www.uic.com.au/nip80.htm (last visited Jan. 24, 2004).

[62] *Id*.

[63] *See* ENERGY INFO. ADMIN., UNITED STATES DEP'T OF ENERGY, BRAZIL COUNTRY ANALYSIS BRIEF, *at* http://www.eia.doe.gov/emeu/cabs/brazil.html (last visited Jan. 28, 2004).

[64] NUCLEAR NEWS *Americas Nuclear Energy Symposium-2002,* Feb. 2003, at 40, 41.

[65] *Id.*; *Argentina May Finish Atucha in a Hurry*, 44 NUCLEONICS WEEK 1, 1 (Sept. 25, 2003) *at* http://www.platts.com/nuclear/products/nw.pdf (last visited Jan. 28, 2004).

[66] *Americas Nuclear Energy Symposium-2002 supra* note 64.

[67] *Late News: Construction of a Demonstration EPR Has Been Endorsed,* NUCLEAR NEWS, Dec. 2003, at 17.

[68] *Late News: TVO's Preferred Alternative for its Fifth Nuclear Plant,* NUCLEAR NEWS, Nov. 2003, at 18.

[69] URANIUM INFORMATION CENTER, NUCLEAR ENERGY IN FINLAND (Dec. 2003) *at* http://www.uic.com.au/nip76.htm (last visited Jan. 28, 2004).

[70] *International: Temelin-2 Completes Testing, in Trial Operation,* NUCLEAR NEWS, June 2003, at 41.

[71] *International Briefs*, NUCLEAR NEWS, Sept. 2003, at 46.

midst of a phase-out of nuclear energy,[72] few outside observers expect it to stand when it comes time, in the distant future, to actually shut down all but a couple of small, poor performing, uneconomical nuclear plants. In addition, four German states are assessing whether to challenge the constitutionality of the phase-out agreement in court.[73] Belgium is also in the midst of a phaseout, with the first plant shutdown scheduled for 2015.[74] However, Sweden has called a halt to its phase-out, and a survey in 2003 showed that pro-nuclear opinions had risen to 84 percent of the public.[75] In Switzerland, two referenda against nuclear energy were handily defeated this summer.[76] Despite the mixed attitudes, the European Commission (EC) formally recognized the need to keep nuclear's 35 percent share of electricity generation to meet goals of reducing carbon dioxide emissions.[77] A European Commission Green Paper stated that nuclear power is an important factor for achieving carbon emission reductions in developed countries: If existing nuclear plants were phased out and replaced with other conventional generating plant[s], the Green Paper states that it would become impossible to achieve Kyoto [emissions-reduction] objectives.[78] The Green Paper also stresses the role of nuclear power in European Union (EU) security, and the EC concluded that they must reverse the downward trend in nuclear power in the EU.[79]

In Eastern Europe, Russia continues its use of nuclear power and its plans for growth. They are planning to open a repository for storage of used nuclear fuel from international partners, they are marketing nuclear energy internationally, and they are working with the United States to destroy plutonium and highly enriched uranium from the weapons program.[80] Uranium from more than a seven thousand nuclear warheads has already been recycled into fuel for U.S. commercial nuclear reactors.[81] Bulgarian officials recently announced that they would need a second nuclear power station in six years.[82]

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[72] URANIUM INFORMATION CENTER , GERMANY'S NUCLEAR ENERGY (Nov. 2003) *at* http://www.uic.com.au/nip46.htm (last visited Jan. 28, 2004).

[73] *Briefs*, NUCLEAR NEWS, Dec. 2003, at 37.

[74] *International: Lower House Adopts Nuclear Phaseout Bill,* NUCLEAR NEWS, Feb. 2003, at 46.

[75] URANIUM INFORMATION CENTER , NUCLEAR ENERGY IN SWEDEN, (Jan. 2004) *at* http://www.uic.com.au/nip39.htm (last visited Apr. 19, 2004).

[76] *Late News: Swiss Voters Firmly Rejected Initiatives to Scrap Nuclear Power,* NUCLEAR NEWS, Jul. 2003, at 22, 22, 63.

[77] EUROPEAN COMM'N, GREEN PAPER: TOWARDS A EUROPEAN STRATEGY FOR THE SECURITY OF ENERGY SUPPLY annex 1 64 app. at 82, 83 (2000), *at* http://europa.eu.int/comm./energy_transport/doc-principalpubfinal_en.pdf (last visited Jan. 30, 2004).

[78] *Id*.

[79] *Id*.

[80] *Late News: The Growing Threat to the Global Non-proliferation Regime*, NUCLEAR NEWS, Oct. 2003, at 63.

[81] *Id*.

[82] *Bulgaria Will Need New Nuclear Power Station in 2009: Official,* BULGARIAN NEWS NETWORK, June 27, 2003, *at* http://www.bgnewsnet.com/story.asp?st=1401 (last visited Jan. 30, 2004).

IX. BACK TO THE FUTURE OF NUCLEAR POWER

Visionaries in U.S. nuclear power industries are planning "New Nukes" for us as well. The Tennessee Valley Authority (TVA) decided to choose nuclear power over too costly coal, so they are recovering a reactor that has been shut down for more than a decade.[83] The recovery of Brown's Ferry Unit 1 follows by many years the restart of Unit 2 and Unit 3, which are rated among the top 25 percent performers.[84] Those earlier restarts taught TVA management valuable lessons, so the current $1.8 billion project is now partially complete, with progress ahead of schedule and spending on track.[85] The re-start project is self-financed by TVA large customers with no need to borrow at high interest rates.[86]

While all of this has been going on, the nuclear industry in the United States has also been planning to build new Advanced Light Water Reactors. The U.S. NRC granted licenses to reactor designs by General Electric, Combustion Engineering, and Westinghouse, [87] and they are considering a second Westinghouse design at this time.[88] A license should be issued in the next year or two, just in time for construction at one of several pre-licensed sites. The federal government also initiated a new licensing process designed to avoid historical delays in starting new reactors.[89] To test this new licensing process, on Sept. 25, 2003, Exelon (Illinois) and Dominion (Virginia) filed Early Site Permit (ESP) applications with the U.S. NRC: Exelon for a second reactor at its Clinton, Illinois, plant, and Dominion for another reactor at its North Anna, Virginia, plant.[90] A third power company, Entergy, applied for an ESP October 21, 2003 for a second reactor at its Port Gibson, Mississippi, plant. [91] These three licenses could be the beginning of the nuclear construction renaissance in the United States. According to the Nuclear Energy Institute, the industry has a vision of increasing generating capacity by 50 percent, or about

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[83] *Clean Power: TVA Should Choose Nuclear Option*, THE PADUCAH SUN, July 23, 2003, at A4.

[84] *Power: TVA Earns Industry's "Best of Best" Honor,* NUCLEAR NEWS, Jul. 2003, at 18-19.

[85] Interview with Lucha Ramey, Media Relations Manager, Tennessee Valley Authority, Oct 23, 2003.

[86] *Id*.

[87] NUCLEAR ENERGY INSTITUTE, ADVANCED-DESIGN NUCLEAR POWER PLANTS (2003), *available at* http://www.nei.org/doc.asp?docid-132 (last visited Jan. 24, 2004).

[88] U.S. Nuclear Regulatory Commission Design Certification Application Review – AP1000 *available at* http://www.nrc.gov/reactors/newe-licensing/license-reviews/design-cert/ap1000.html (last viewed Jan. 24, 2004).

[89] Office of Nuclear Energy, Science, and Technology, DOE Announces Public-Private Partnership to Demonstrate Streamlined Licensing Process for New Nuclear Power Plants (Mar. 4, 2002), *at* http://www.ne.doe.gov/home/03-4-02.html (last visited Jan. 28, 2004).

[90] *Power: Exelon, Dominion are First to Test Waters,* NUCLEAR NEWS, Nov. 2003, at 12.

[91] *Late News: An ESP Application for the Grand Gulf Site,* NUCLEAR NEWS, Nov. 2003, at 17.

50 plants or 50,000 megawatts, by 2020.[92] In addition, the U.S. DOE is preparing to construct a new, high-temperature, gas-cooled reactor for developing the technology to generate hydrogen instead of (or in addition to) electricity by using heat from nuclear power.[93]

Internationally, medium-term plans include a new reactor concept called the Pebble Bed Modular Reactor (PMBR), which is being developed by South Africa's Eskom, the fifth largest utility in the world.[94] The PBMR is a small, modular, helium gas-cooled reactor that will not require emergency core cooling systems because it physically cannot "melt down."[95] A very low power PBMR research reactor is already in operation in China.[96] The South African Government gave the green light for a prototype to be built at Koeberg, north of Cape Town.[97] They also approved environmental impact studies for a plant to be built at Pelindaba to supply nuclear fuel for the new reactor.[98]

Long-term plans are international, with the United States leading a program to develop advanced "Generation IV" (Gen IV) nuclear plants.[99] The Gen IV International Forum (GIF) includes countries in North America, South America, Africa, Asia, and Europe. National laboratories, university faculties and students, and nuclear power industries are developing six concepts for modular, proliferation resistant, affordable nuclear plants to generate electricity and supply high-temperature heat for alternate applications, including the production of hydrogen, clean water, and industrial heat.[100]

Alternate applications for existing and advanced nuclear reactors include industrial processes such as hydrogen generation, desalination, and recycling used nuclear fuel and transmutation of nuclear waste. Desalination plants can provide clean water for the billion people who do not have safe water supplies.

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[92] Joe F. Colvin, *From Renaissance to Reality—Vision 2020***,** Address at the Nuclear Energy Assembly (May 23, 2001), *available at* http://www.nei.org/index.asp?catnum=3&catid=671 (last visited Apr. 19, 2004).

[93] M. P. LaBar, et al., *The Gas-Turbine Modular Helium Reactor,* NUCLEAR NEWS, Oct. 2003, at 30.

[94] Melanie Gosling, *Green Light for New City Nuke Plant*, CAPE TIMES, June 27, 2003, *at* http://www.capetimes.co.za/index.php?fSectionId=271&fArticleId=177905 (last visited Apr. 19, 2004).

[95] *Id*.

[96] *China's First HTGR Was Connected to the Grid*, NUCLEAR NEWS, Feb. 2003, at 46.

[97] *Id*.

[98] *Id*.

[99] OFFICE OF NUCLEAR ENERGY, SCIENCE, AND TECH., THE U.S. GENERATION IV IMPLEMENTATION STRATEGY 3 (2003), available at http://www.ne.doe.gov/reports/Gen-IV_Implementation_Plan_9-9-03.pdf (last visited Jan. 24, 2004).

[100] *Id*.

Several nations have demonstrated the use of nuclear energy for desalination including Kazakhstan, Japan, and others.[101] China will soon begin construction of a nuclear-powered desalinator project in Yantai City in east China's Shandong Province, with a designed capacity of producing approximately 35 million gallons of fresh water per day.[102] India has a desalination plant in development, which by the end of the year will be capable of producing 1.7 million gallons of fresh water per day.[103] The desalination plant is coupled to two 170 megawatt pressurized heavy water reactors at the Madras Atomic Power Station in Kalpakkam.[104] Other nations investigating or developing nuclear desalination plants include Egypt, Russia, Morocco, Pakistan, Tunisia, Algeria, Iran, South Korea, Indonesia, and Argentina.[105] Nuclear energy can also provide heat for industrial applications and heat and electricity for the production of hydrogen. These provide clean electricity production, transportation, and industrial fuels. Finally, nuclear power can be used to take care of its own one remaining problem: waste. Research for nuclear transmutation—the use of nuclear reactions to eliminate radioactive and radiotoxic isotopes—is being conducted in the United States, Europe, Russia and many other nations.[106] Transmutation may one day be able to reduce the toxicity of waste bound for repositories and eliminate the eternal storage of plutonium in repositories. It could also generate 10-20 percent more nuclear power.[107]

Used nuclear fuel is mostly uranium and, if buried, the long-term hazards would arise from just 1.1 percent of the used fuel.[108] Of the thousands of tons of used nuclear fuel from commercial electricity generation, about 96 percent is uranium and 4 percent are byproducts of the fission process.[109] The uranium can be separated cleanly and disposed as Class C low-level waste, or it can be

[101] WORLD COUNCIL OF NUCLEAR WORKERS, NUCLEAR DESALINATION: AN ANSWER FOR A KEY POINT FOR SUSTAINABLE DEVELOPMENT, *at* http://www.wonuc.org/desalination/ (last visited Feb. 2, 2004). *See also* Mohamed M. Megahed, *An Overview of Nuclear Desalination History and Challenges, at* http://www.wonuc.org/desalination/conf_01.htm (last visited Apr. 19, 2004).

[102] *China to Build Nuclear-Powered Desalinator Project*, PEOPLE'S DAILY ONLINE, July 24, 2003, at http://english.peopledaily.com.cn/200306/24/eng20030624_118813.shtml (last visited Feb. 2, 2004).

[103] WORLD NUCLEAR ASSOCIATION, ISSUE BRIEFS: DESALINATION (2003), *at* http://www.world-nuclear.org/info/inf71.htm (last visited Feb. 2, 2004).

[104] *Id.*

[105] *Id.*

[106] OFFICE OF NUCLEAR ENERGY, SCIENCE, AND TECH., REPORT TO CONGRESS ON ADVANCED FUEL CYCLE INITIATIVE: THE FUTURE PATH FOR ADVANCED SPENT FUEL TREATMENT AND TRANSMUTATION RESEARCH III-3 (United States Dep't of Energy, 2003), *available at* http://www.ne.doe.gov/reports/AFCI_CongRpt2003.pdf (last visited Apr. 19, 2004).

[107] *Id.*

[108] *Id.* at II-2, fig. II-1 (1 percent actinides and 0.1 percent technetium and iodine)

[109] Gregory J. Van Tuyle et al., *A Roadmap for Developing ATW Technology: System Scenarios & Integration*, 38 PROGRESS IN TECHNOLOGY 3 (2001) (based on calculations with the ORIGEN code for "average" fuel that yields 45,000 MW-thermal-days of energy per metric tonne (ORIGEN can be obtained from the Radiation Sciences Information and Computing Center, Oak Ridge, TN)).

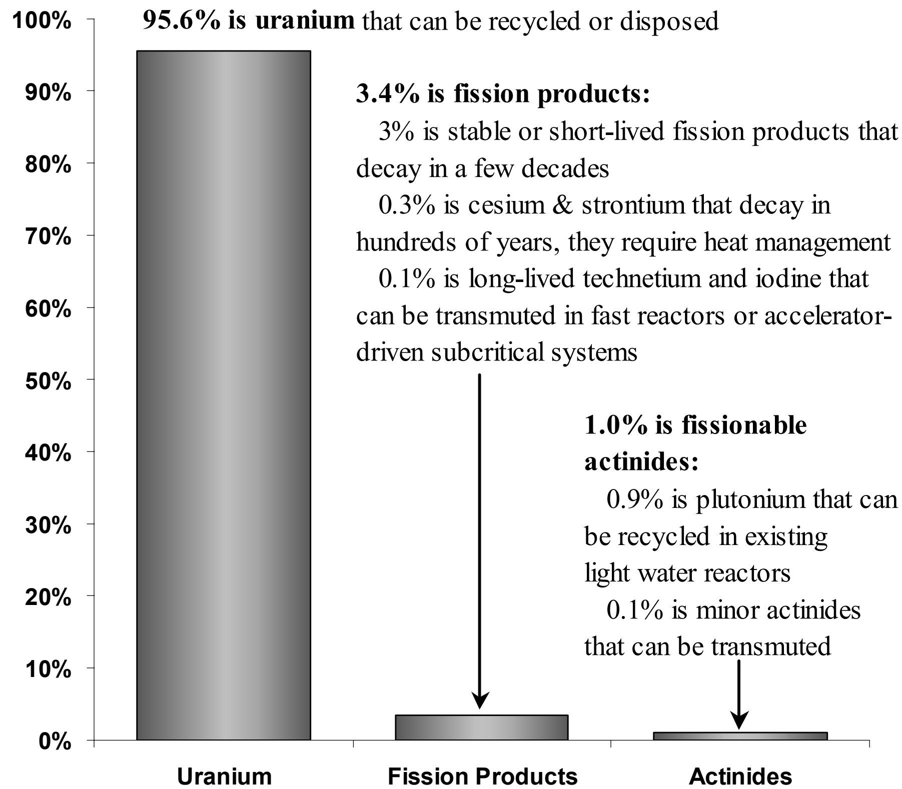

Figure 3. The Composition of Used Nuclear Fuel. [110]

safely stored for later recycling from a few decades to a century from now.[111] In 2002 the U.S. DOE demonstrated the capability to produce almost 99.99 percent pure Class C uranium after separating it from used nuclear fuel.[112] The product was so clean it could be safely held in your hand. Most of the byproducts of the fission process (about 75 percent of the byproducts or about 3 percent of the used fuel) are stable or short-lived fission products that do not pose major disposal challenges.[113] This process of separating the waste stream is called "partitioning." If we can separate the 96 percent reusable uranium from the 4 percent waste products, then partition the easily treated portion (75 percent of the waste) from the rest, we need to treat a comparatively small amount of material.

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[110] *Id.*
[111] OFFICE OF NUCLEAR ENERGY, SCIENCE, AND TECH., *supra* note 106, at I-6.
[112] *Id.*
[113] *Id.*

Another 0.3 percent of the used fuel is cesium and strontium that decays in a few centuries.[114] This more highly radioactive material is a source of much of the thermal energy, or heat, that must be considered when designing deep geological repositories for high-level waste. During the partitioning of the used fuel, cesium and strontium can be captured and stored in extremely stable waste forms while they decay to inert materials in a few hundred years. In the unlikely event it was released from a repository, the remaining 1.1 percent of the used fuel would create a long-term hazard.[115] Of that, 0.9 percent is plutonium that can be fissioned to produce energy in a wide variety of existing and conceptual nuclear reactors; 0.1 percent is minor actinides that can be fissioned efficiently only in fast spectrum reactors; and 0.1 percent is long-lived iodine and technetium that can be transmuted to stable, non-radioactive, non-toxic elements.[116] Thus, nuclear transmutation can take care of both the minor actinides and the long-lived fission products in the right kind of facility or facilities.

Through the Advanced Fuel Cycle Initiative (once called the Advanced Accelerator Applications Program),[117] the United States joined long-standing and widespread international efforts in other nations to evaluate the potential of Partitioning and Transmutation along with advanced nuclear fuel cycles.[118] The other nations include Spain, France, Italy, Great Britain, Germany, Poland, Netherlands, Switzerland, Russia, South Korea, China, Belgium, the Czech Republic, India, Hungary, and Japan.[119] Scientists in the rest of the world are working hard to develop advanced nuclear technologies including accelerator-driven transmutation, in which a charged-particle accelerator and target system provides the neutrons needed to initiate fission chain reactions in waste elements in sub-critical reactors.

X. CONCLUSION: NUCLEAR ENERGY'S FUTURE IS AGLOW

Diversity and redundancy are important for safety and security. Thus, all sources of energy should retain a place in the energy economy of the century to come. For workers, the public, and the environment; for energy reliability,

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[114] *Id.* at III-3.

[115] *Id.* at III-2.

[116] Denis E. Beller, et al., *The U.S. Accelerator Transmutation of Waste Program,* 463 NUCLEAR INSTRUMENTS AND METHODS IN PHYSICS RESEARCH, SECTION A: ACCELERATORS, SPECTROMETERS, DETECTORS, AND ASSOCIATED EQUIPMENT 468, 469 (2001) (also report LA-UR-00-2106, Los Alamos National Laboratory, NM, 2000).

[117] OFFICE OF NUCLEAR ENERGY, SCIENCE, AND TECH., *supra* note106 at I-1.

[118] *Waste Incineration CRP Underway*, NUCLEAR NEWS, Mar. 2003, at 81.

[119] *Id.*

diversity, sustainability, and security; and to fight energy apartheid, we need to use more, not less nuclear energy. As Pulitzer Prize-winning historian Richard Rhodes wrote in the conclusion of the *Foreign Affairs* essay "The Need for Nuclear Power":

> [N]uclear power should be central. Despite its outstanding record, it has instead been relegated by its opponents to the same twilight zone of contentious ideological conflict as abortion and evolution. It deserves better. Nuclear power is environmentally safe, practical, and affordable. It is not the problem—it is one of the best solutions.[120]

If the affluent, caring citizens of the world would CARESS nuclear energy, we could all look forward to a better world, especially for the billions without access to electricity or clean water. A time traveler returning from the distant future might observe that early twenty-first century engineers and policy makers had the foresight to make the right choice for both people and their environment.

[120] Rhodes & Beller, *supra* note 42, at 30.