

# Keeping the Lights On

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This is my second talk before the Diet. My first one was on sex and death. Tonight I will address the subject of energy. Apropos this subject, Artemus Ward, Mark Twain's predecessor, said: "It ain't the things we don't know that gets us into trouble. It's the things we know that just ain't so."

Our country uses fossil fuels, mainly coal and natural gas, to produce 70 percent of its electricity. Nuclear power generates 19 percent and hydroelectric dams the other 11 percent. Solar energy and wind turbines generate less than one-tenth of one percent of our electricity. The U.S. has a lot of coal, but 60 percent of it is strip-mined, at a rate of 65,000 acres per year, with over a million acres awaiting reclamation; and coal mining, the source of the rest, kills 100 miners per year. Burning coal also adds greenhouse gases, toxic metals, and a lot of pollutants to the atmosphere. Natural gas is cleaner, but our natural gas wells produce only one-third the amount of gas they did 30 years ago. Producing electricity consumes one-third of the energy we use (Figure 1).

Overall, the U.S. uses fossil fuels to produce 85 percent of the energy it consumes—about half from oil and the other half equally from coal and natural gas (Figure 2). Fifty years ago oil was used to produce 20 percent of the country's electricity. Now, as it grows scarcer, it is used mainly for transportation—to run our automobiles, trucks, airplanes, ships, and most buses and railroad trains. Before the discovery of oil in the 1800s, humans had just two main sources of energy: wood and animals. Today, rather than ride horses, teenagers compare the horsepower of their automobiles.

In 1950 the U.S. consumed 6 MBPD and produced one-half of the world's oil. Today the US produces 4 percent of the world's oil and consumes 20 MB, while the rest of the world consumes close to 60 MBPD (Figure 3).

China, with its 1.2 billion people, leads the race in growing oil consumption, and it has to import an increasing percentage of the oil that it consumes. India, with one billion people, is close behind (Figure 4).

Sixty percent of the known oil in the world lies within this triangle in the Middle East. Oil wells there pump 10,000 barrels per day, compared with wells in the U.S that pump an average of 300 barrels per day. U.S. oil reserves have now dropped to the point that if we were not able to import any oil we would exhaust our 22 billion barrel reserve and run out of oil in three years. The "War on Terror," as the Bush Administration has chosen to prosecute it, is designed to further American energy interests. It's "all about oil." In addition to our bases in Saudi Arabia and Kuwait, and the 14 new ones being built in Iraq, the U.S. now has military bases, known as "*power projection hubs*," in five other countries in this area. One in Qatar, particularly valued by the Air Force, has a three-mile long runway (Figure 5).

Iraq has 11 percent of the world's oil, five times as much as the U.S. now has. The only country with more is Saudi Arabia. This map, prepared by the National Energy Policy Development Group, chaired by Vice-President Cheney, shows the location and extent of Iraq's known oilfields and divides the western part of the country into nine exploration blocks (Figure 6).

This table, put together by the same group, catalogues the foreign suitors that are vying for Iraqi oilfield contracts, by country, firm, and project (Figure 7).

Central Asia is another important source of oil and natural gas. One of the Bush Administration's goals in occupying Afghanistan is to build a pipeline through that country to a port on the Arabian Sea, one that does not through Russia or Iran (Figure 8). With the Taliban running Afghanistan there was no hope that this pipeline would be built.

California is the leader in developing solar power. Solar Two in its Mojave Desert, shown here (Figure 9), has an annual peak output of 10 MW. In order for a plant like this to produce as much energy as a 1,000 MW nuclear reactor would require 127 square miles of mirrors

The Solar plant in Kramer Junction has an average output of 100 MW. It generates 90 percent of the world's direct solar electricity. Rows of mirrors focus sunlight onto a special fluid in tubes that run along the top of array. The solar-heated fluid turns water into steam that powers electricity-producing turbines. The mirrors have to be washed every five to ten days to maintain a reasonable (70 percent) optical efficiency. To make the electricity it produces economically feasible requires substantial government subsidies and tax credits. Thirty-three square miles of mirrors would be required to produce as much electricity as one nuclear power plant (Figure 10).

The Nine Canyon Wind Project in our state completed its Phase II expansion last year, adding 12 new wind turbines to the previously existing 37. On a windy day they have a peak output of 64 MW. It would take 50,000 wind turbines of this size positioned over a 300 square mile area to generate the same amount of electricity that a nuclear power plant produces (Figure 11).

Avian mortality is a major problem with windmills. They act as bait and executioner for birds because rodent populations multiply rapidly at the base of windmills, which protect them against these predators, and the birds get killed trying to get at them. The windmills on Altamont Pass east of San Francisco, for example, kill eight times as many bald eagles each year as those that died in the one-time Valdez oil spill in Alaska. This is also a problem with solar energy. Bird deaths per megawatt at Solar Two in California are ten times higher than at Altamont Pass, a result of their flying into them.

Facilities that use geothermal energy generate up to 35 MW of electricity. Beneath most of the world rocks hot enough to boil water can be found three to six miles below the surface. Someday, perhaps, we can better harness this source of energy (Figure 12).

Hydroelectric dams produce 85 percent of the electricity our state generates. The Federal government, however, owns most of them, and its Bonneville Power Administration sells the electricity to customers in multiple states. Washington consumers get 60 percent of their electricity from its dams, 20 percent from coal, 10 percent (2,000 MW) from California, and 4 percent from its one nuclear power plant (Figure 13).

The Columbia River is 1,200 miles long. Its main Snake River tributary drains 40 percent of the Basin and contributes 20 percent of its flow. Construction of first dam on the river, the Rock Island Dam, began in 1929. In 1932, the Army Corps of Engineers submitted a study to the Roosevelt Administration identifying ten promising locations for dams on the river—for hydroelectric power, flood control, and irrigation. It began work on the Bonneville Dam in 1933, and the Bureau of Reclamation started construction of the Grand Coulee Dam the same year. Between 1933 and 1975, these two federal agencies built 30 major dams on the Columbia and Snake River system (Figure 14).

The Grand Coulee Dam is the largest concrete structure in the world. Its reservoir drowned 12 towns with 1,200 buildings, and it blocks salmon access to more than 1,000 miles of productive river (Figure 15). Called the “cesspool of the New Deal” (by a New York newspaper), a governor of an eastern state, complaining about the dam’s cost, said, “The Columbia runs through four states and drains forty-eight states.” The Bureau hired folk singer Woody Guthrie to promote the dam, and he wrote songs about it that contained lyrics such as “all this here water just a going to waste.”

In 1937, the Grand Coulee Fish Maintenance Project sought to lessen the impact of the dam on salmon by establishing fish hatcheries. One of the first ones constructed is just upriver from my place in Leavenworth. It releases 1.5 M Chinook salmon each year for their 500 mile trip across seven dams to the Pacific (Figure 16). Hatcheries, however, are one reason why wild salmon runs in the Columbia River Basin have declined so drastically. 10 to 16 million salmon used to come back up the Columbia River each year to spawn. Now less than 200,000 wild salmon do so, a 98 percent decline. In his book *King of Fish*, David Montgomery, a Professor of Geomorphology at the UW, identifies four things that have caused this decline, each beginning with the letter “H:” harvest, hydropower (i.e., dams), habitat, and hatcheries. Hatchery-bred fish have hastened the decline of wild salmon because they compete with them for food, transmit diseases they acquire in the hatchery, and, by interbreeding with them, dilute and weaken the genetic characteristics of wild salmon.

Salmon gain 90 percent of their body weight at sea and carry vast quantities of nutrients obtained from eating crustaceans and plant life in the ocean back to their home stream. Eliminating most of this salmon-provided source of nutrients has had a disastrous effect on the ecosystem of the Columbia River Basin. Grizzly bears, for example, obtain up to 90 percent of the nitrogen in their bones and hair from the salmon they eat. The impact of the decline of salmon on this ecosystem is reflected in these Washington Department of Fish and Wildlife estimates: the basin’s population of fur-bearing mammals has declined from 13,000 to 500; game birds dependent on this landscape, from 120,000 to 2,000; and winter songbirds, from 95,000 to 3,000.

But, to paraphrase Woody Allen, we need the electricity. This graph shows why (Figure 17). It helps to keep us alive. Life expectancy, literacy rate, and GDP per capita, combined into what is called the Human Development Index, is a function of annual per capita electricity use. People in countries that use more than 5,000 kilowatts—5 megawatts—of electricity have an average life span of 70 years or greater. The people in countries that have lesser amounts of electricity have a lower index and shorter life span. The life span of people in Ethiopia it is 47 years.

This is our state’s only commercial nuclear power plant (Figure 18). It produces 1,150 MW of electricity. There are also two partially completed reactors on the site.

Worldwide, there are 442 nuclear reactors that produce electricity. 35 are under construction, 24 of them in Asia. France uses nuclear energy to generate 77 percent of its electricity. In the U.S., no nuclear power plants ordered after 1974 have been completed and none have been ordered since 1978. Eight have been shut down since 1990—103 remain in operation (Figure 19).

Our media, led by the New York Times, has a bias against nuclear energy. This survey, done by social scientists at Columbia and Smith College, shows that nuclear scientists voice strong support for nuclear energy; whereas TV journalists, who know the least about this subject and who have a much greater influence on public opinion, reject it (Figure 20).

Fear of radiation is based on the “Linear No-Threshold Hypothesis” or “model.” This model postulates that there is no threshold below which the deleterious effects of radiation cease to appear. Consequently, exposure to any amount of ionizing radiation, no matter how small, is harmful—and thus no amount of radiation can be proclaimed safe. Regulators and the radiation protection industry use this model to predict the number of cancer deaths that low doses of radiation are assumed to cause and then cite these predictions to justify their very strict radiation limits.

This is how it works: After we developed the atom bomb, tested it, and dropped two of them on Japan, investigators found that people exposed to 600 rem—600,000 millirem—of radiation all die; and 50 percent of people exposed to 400 rem will die of radiation sickness. Overt signs of radiation sickness are seen when a person receives 100 rem. This model calculates, in a linear fashion, the mortality rate of small doses of radiation. It extrapolates, for example, that people exposed to a 500 mrem dose will have a 0.0625 percent mortality rate. While a low rate, but when applied to a large population it gets scarier. In a city the size of New York, if 10 million people are exposed to this dose, regulators assume 6,250 deaths from cancer will occur (Figure 21).

The ALARA regulation—As Low As Reasonably Achievable—follows this model, with its linearly extrapolated predictions of cancer at low doses. This “knowledge,” to paraphrase Artemus Ward, has caused us a lot of trouble, and it turns out not to be true (Figure 22).

The average American is exposed to 200 millirem of natural and medical radiation each year. But the government’s statutory limit on radiation emitted from an operating nuclear power plant is a 5 millirem (Figure 23).

Two-thirds of the radiation we receive is natural background radiation—from cosmic rays, isotopes of uranium and thorium in the bricks, plaster, and concrete in our buildings, and from radioactive potassium. Each person emits about 25 mrem of radiation per year from potassium-40, a naturally occurring radioactive isotope that is in our bodies (Figure 24).

The Environmental Protection Agency and the Nuclear Regulatory Commission limits for public exposure to radiation are 15 and 100 mrem/year respectively. This is the level of cleanup radioactive sites have to achieve, for example, before they can be released for public use. The original safety standard for radiation was 36 rems (36,000 millirems) and there were no documented injuries or deaths using that standard.

The residents of Ramsar, Iran, a resort on the Caspian Sea, are exposed to 79 rem, 79,000 mrem of radiation each year. The river and streams there have a high concentration of radium. Its 2,000

residents do not have an increased incidence of cancer, as the linear hypothesis would predict, and their life span is no different than that of other Iranians. A park in Santa Fe, Fountainhead Rock Place has radioactive rock of volcanic origin that emits 760 mrem of gamma radiation, 14 times the amount allowed by the EPA. This table, in an article titled “Disabling the terror of radiological dispersal,” i.e., dirty bombs, was published in Nuclear News last year (Figure 25). Even the most potent one wrapped with cobalt-60 would deliver only a few hundred millirem within a half mile radius, less radiation than that park in Santa Fe has. If government agents follow EPA regulations, people will be ordered to evacuate the city where the bomb goes off and the city will be shut down. It will be completely unnecessary and serve only to further the terrorist’s aims.

The perceived truth, based on the linear hypothesis, is that any amount of radiation is harmful. The actual truth is just the opposite. Not only are low doses *not* harmful, they have a beneficial effect on one’s health. Looking carefully at the evidence, one finds that atom bomb survivors in Nagasaki who received 1,000 to 19,000 mrem of radiation have a lower incidence of cancer, especially leukemia and colon cancer, than a matched group of Japanese people not exposed to radiation. And they live longer (Figure 26).

Another important epidemiological study has tracked the cancer mortality in people exposed to radiation from a thermonuclear explosion in 1957 in Russia. Investigators followed 8,000 people who were irradiated in that test for 30 years. The group exposed to 12,000 mrem and 50,000 mrem had a statistically significant decrease in cancer mortality compared with a non-irradiated control group (Figure 27). The same kind of thing is seen with shipyard workers. Those that work on nuclear powered ships have a lower all cause mortality than non-nuclear workers.

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The most definitive study that shows just how good low dose radiation is for you has just been published. In Taiwan, 180 apartment buildings were built with recycled steel that was accidentally contaminated with Cobalt-60. 4,000 people lived in them for more than 10 years before their radioactive state was discovered. The amount of radiation they received exceeded 1,500 mrem per year—100 times the EPA limit. These apartment dwellers, over a 20-year period, had *97 percent* fewer deaths from cancers than the general population of Taiwan (3.5 as compared with 116 deaths per 100,000 person years). Even the incidence of congenital malformations in the children radiated mothers bore was reduced (Figure 26). Low doses of radiation have a stimulating and protective effect on cell function, mediated through a process known as radiation hormesis. Radiation stimulates the immune system and checks oxidative DNA damage, and thereby *prevents* cancer. Two leading scientists that study radiation hormesis and have been instrumental in disproving the linear hypothesis are Bernard Cohen, Professor Emeritus of Physics at the University of Pittsburgh and Myron Pollycove, Professor Emeritus of Nuclear Medicine at the UCSF. I have had the opportunity to meet with both of these scientists and discuss their work with them.

Chernobyl is the only accident in the history commercial nuclear power where any radiation-related fatalities have occurred—134 employees had acute radiation disease and 28 died. An estimated 70 extra cases of thyroid cancer arose in children as a result of the accident, which could have been prevented by timely ingestion of potassium iodide. Chernobyl’s main victims were 200,000 pregnant women in Europe who, caught up in a wave of radiophobic hysteria, feared that their fetuses would be damaged by radiation from the fallout and had their pregnancies terminated. Radiation-exposed fetuses that were not aborted, however, delivered normally and did not have an increased incidence of congenital abnormalities or genetic defects. An accident like this will not

happen anywhere else because all the reactors currently in operation are placed within a containment building, which Chernobyl did not have (Figure 29).

The reactor core meltdown at Three Mile Island in 1979 happened when its cooling system failed, and, like at Chernobyl, it produced a lot of radiation. The containment building the reactor was housed in, however, kept it from being released into the atmosphere, and there were no deaths. People living next to the reactor received a maximum dose of 80 mrem, much less than the people living in those apartment buildings in Taiwan got, on a yearly basis, which kept them from getting cancer (Figure 30).

Uranium is the heaviest of all naturally occurring elements, and it is present in most of the earth's crust. One pound of uranium yields 20,000 times more energy than the same amount of coal. Coal, in fact, has uranium in it in a concentration of 1 to 2 parts per million. This is the reason why coal-fired plants release up to 50 times more radioactivity as nuclear plants. In the U.S., the amount of uranium we have far surpasses our fossil fuel resources, as this block diagram shows (Figure 31).

All the nuclear power plants in the U.S. are second-generation reactors, based on designs derived from those made for naval use. Third generation reactors, with an output of 600 MW, are simpler, smaller, more rugged, and reduce substantially the possibility of a core meltdown accident, to 1 in 800,000 reactor years. They have, for example, 80 percent fewer control cables and 60 percent less piping; and they are standardized to expedite licensing and reduce construction time. Fourth generation fusion reactors, like this one, are being developed and should be in operation in fairly soon (Figure 32).

There is another way to get oil for our automobiles and airplanes, which would make it possible for the U.S. not to import any Middle Eastern or Central Asian oil. American entrepreneurs are marketing a new technology called a "thermal conversion process" that can make oil out of various agricultural, industrial, and municipal wastes; and nuclear power is the best source of energy to run it. The process employs a technique known as thermal depolymerization, which in essence mimics the geothermal process that created our fossil fuels, notably oil. Wastes subjected to temperatures of 500 degrees F and pressures of 600 pounds per square inch will produce light oil that is half diesel oil and half gasoline. You can put most anything in it—sewage sludge, plastic bottles, old tires, turkey offal, wet bandages and needles. If a 175 lb. person accidentally fell into the process, it would turn him into 38 pounds of oil, 7 pounds of purified minerals, 7 pounds of methane gas, and 123 pounds of water. Putting all of the country's agricultural wastes through this process would produce 4 billion barrels of oil, the amount we currently import from OPEC each year (Figure 33).

When Lewis and Clark arrived at the junction of the Snake and Columbia Rivers 200 years ago, Clark wrote in his Journal, "The river is remarkably clear and crowded with salmon in many places, [and] the number of dead salmon on the shores and floating in the river is incredible." To have any hope of restoring the ecosystem of this region we will need to start removing its dams, beginning with these four on the lower Snake River, and replace the electricity they generate with nuclear power plants (Figure 34).

The many billions of dollars our government is spending occupying Iraq and Afghanistan would be better spent building third and fourth generation nuclear power plants, like China and other Asian

nations are doing, and fostering new technologies like the thermal conversion process that can make the oil that can serve our transportation needs..

We need to bring our troops home. The War on Terror will not be won, with our adversary employing fourth-generation-warfare suicide attacks on civilians in one's homeland, until our country pulls its stick out of the hornet's nest. The only way Muslim terrorists are going to leave us, and our soon-to-be former allies like Spain alone is if we pull all of our troops out of the Middle East, and leave them alone.

This is perhaps the greatest advantage of nuclear power, coupled with new technologies like thermal depolymerization. It will get our country to follow the advice its first President gave us in his Farewell Address—to conduct dealings with other nations in the marketplace, not on the battlefield. Building more nuclear power plants will help end the War on Terror, in addition to keeping our lights and computers on.