A Recipe for a Sustainable Future, Part II

Will our children and grandchildren inherit a world that has adequate food and clean energy resources to offer quality of life? In Part I of this essay (see *Agora* for fall 2011), we addressed the issue of adequate food and endorsed modern agriculture rooted in molecular biology as the best path forward. Here we examine the need to find a clean and abundant energy source to replace fossil fuels. We also consider the premise that clean and cheap fuel may offer a glimmer of hope for disarming the population bomb. The debate over nuclear power will be a major focus.

Electric Power Changes Lifestyles

The transition from lighting the kerosene lantern to flipping on the light switch was the end result of a series of political decisions about creating the Rural Electric Administration. It began at the voting booth and made its way through the politics and bureaucracy of the mid 1930s. I have many memories of the major change in lifestyle on the farm I grew up on in South Dakota that were brought about by rural electrification.

Life without electricity is very different and more difficult than having power at one's finger tips. For my first thirteen and a half years, until November 1948, I lived in a world that lacked modern conveniences at home, at school, and at church. Even Dahlberg, a village 4.5 miles from our farm had no electricity. Its dimly lit general store had no fresh meat, milk, butter, frozen foods or cold soda pop. Dahlberg also had a town hall, a cream station, and a grain elevator. The centrifuge in the cream station was hand cranked, as was the Emerson Kicker dockage separator at the elevator. A large one cylinder engine powered the elevator lag and the hydraulic pump for the lift that lifted the front of trucks or wagons before unloading. The engine starting procedure was really exciting for this boy to watch. It began with heating the glow plug with a blowtorch

by **JOHN TJOSTEM**

This essay is the second installment of the piece John published in our fall 2011 issue. John is a Concordia graduate and earned his MS in microbiology and PhD in botany with a focus on plant physiology from North Dakota State. He taught his first classes at Luther in 1962 and became professor emeritus of biology in 2000. He regularly taught microbiology, cell biology, and immunology and conducted research on well water contamination and on cellulosic ethanol production from alfalfa.

JOHN TJOSTEM

The Tjostem farm in South Dakota lacked modern conveniences, including electricity, until November 1948.

for what seemed like an eternity. Cranking the engine began when the engineer climbed up on one of the two big fly wheels, then rode it down hoping that fuel combustion in the large cylinder would start. He climbed up and rode the fly wheel down repeatedly until the engine came to life.

The biggest technological change in my lifetime was the implementation of the Rural Electrification Act (REA). I can still recall the night in November 1948 when the dark landscape was lighted for the first time by dozens of yard lights. Nearly every yard light was turned on that clear autumn night.

Within a couple of years the flush toilet replaced the outhouse and I had my first bath in a real bathtub. It had been my winter chore to keep the copper boiler on the top of the cook stove filled with snow. The water from melted snow was needed on washday when the washing machine with the kick start engine occupied a place in the middle of the kitchen floor. I still have that washing machine engine in my shop. The serial number on a brass plate affixed to the engine let me to find the date of manufacture—it was made in June of 1935—my month and year of birth. It was my mother's first washing machine, purchased after her first born arrived. The end of the engine's flexible exhaust pipe was placed in the ash drawer of the cook stove. At times one of my mother's arms bore burn marks from coming in contact with the hot exhaust pipe.

Electricity took a lot of drudgery out of my mother's life. Hot water on tap from the electric water heater was a wonderful change. Washday included ironing. Mother always dreaded lighting the white gas iron and the electric iron was among her favorite improvements to come with electricity.

Our diet changed with the addition of a refrigerator in the kitchen. For the first time we could have store-bought

ice cream at home. No more sour milk and cream and no more smelly swill pail in the entry. This small unheated porch contained a kerosene stove for summer cooking and also the hand cranked cream separator which separated the cream from milk. I participated in hand milking the cows and cranking the cream separator was my regular chore. Large Redwing crocks filled with brine for curing meat in the cellar were emptied and no longer used. Dozens of jars of canned meat on the shelf in the cellar were consumed and not replaced. In their place was a large deep freezer. I missed the slab of dried beef which hung from a hook in the pantry. With a really sharp knife one could sneak into the pantry slice off thin slices of dried beef without removing the slab from its hook. Whole hams hung from a ledge in the stairwell to the unheated upstairs. The large wooden butter churn was no longer cranked and buttermilk was no longer served. Smaller batches of butter were churned in the new G. E. Mix Master. It also replaced the hand potato masher and the hand cranked egg beater. The toaster was wonderful; we could have toast for breakfast every day. No more toasting homemade bread over an open fire of the cook stove. I think milktoast dropped out of our diet with the end to open fire toasting.

A lot of salt went out of our diets when the refrigerator came to our house. Heavily salted cod in a white sauce that did not require refrigeration came in the small wooden boxes with mitered corners. The salted creamed cod served over toast also became a rare item on our menu after electrification came to our home. We are still using that 1948 G. E. refrigerator in the basement of our cabin where it expands our refrigerator space when the whole family is at the lake.

Electricity is the commodity that separates developed countries from the rest. Access to electric power is a key component of alleviating poverty and "an indispensable element of sustainable human development," according to the International Energy Agency (IEA). "Without access to modern, commercial energy, poor countries can be trapped in a vicious circle of poverty, social instability and underdevelopment."

One point that needs to be made is the fact that one third to forty percent of all the food produced on the planet is lost to spoilage. Lack of refrigeration is the main cause of that loss. Since refrigeration requires electricity, expanding electric power to unserved populations would certainly increase the available supply of food. Nearly twenty five percent of the world population, or 1. 6 billion people, still lack electric power. Electrification brings a huge jump in life expectancy.

Prosperity and Urbanization Cause Birth Rates to Drop

Rather than buying into gloom and doom and skimping on energy, we should concentrate on making affordable energy available in developing nations. Currently coal is the most affordable energy source and at present world-wide industrialization is driven mainly by energy from coal. Referring to coal, Freeman Dyson, professor of physics at Princeton, wrote, "The humanistic ethic accepts an increase in carbon dioxide in the environment as a small price to pay, if world-wide industrial development can alleviate the miseries of the poorer half of humanity."

JOHN TJOSTEM

John's farm chores included milking cows and cranking a hand-powered cream separator pictured here.

We need to accept the present use of coal for world-wide industrial development, but at the same time we should for the sake of our environment and our collective health, increase our national investment in research and development to replace coal with advanced generation nuclear power. The people who want to maintain the deception that there is something bad about developing clean, safe, incredibly abundant, and emission free nuclear power to share with as many of the world's people as possible, need to be challenged. If clean, cheap energy is available developing nations can manufacture goods for bettering their standard of living and also their environment. Developing countries gain wealth by selling goods to the rest of the world. The only clean energy source that is abundant and cheap is nuclear fission. It is not a sin to embrace nuclear fission power or to have a growing economy.

The world is experiencing a slowing of population growth. The actual annual growth in the number of people fell from a peak of 88.0 million in 1989 to a low of 74.6 million in 2009, and is projected to fall steadily to about 41 million per annum in 2050. "The world reached peak child before peak oil," says Hans Rosling, an epidemiologist at the Karolinska Institute in Stockholm. That is mostly because family size in the majority of poorer nations has been shrinking for decades, thanks to economic growth, improved family planning, and decreased child mortality. Much of the developing world is closing in on the population-replacement fertility rate, which is about two children per woman.

Migration to the city brings opportunities including opportunities for education. Education for girls has been found to be a really important determinant of family size. Stewart Brand makes the point that with urbanization, women who leave the farm, gain freedom and choose to have small families. The internet and cell phones are showing people of the devel-

oping world that a better lifestyle is possible. Stewart Brand projects that by mid-century 80% of the world's population will be urban. On the farm, children are a labor source and provide insurance there will be a caretaker for their parents in old age. In the city, however, children are expensive. The result is that urbanization is followed by a birth rate below replacement.

It appears that prosperity and urbanization can defuse the population bomb. Bringing power to developing nations may be the solution to world overpopulation. Countries with GDPs above $7500 per capita have birthrates below zero population growth. This fact supports the notion that promoting growth of economies in countries with GDPs below $7500 per capita will turn our world's population growth rate negative.

We do not want the developed world to significantly slow consumption. The developing world needs our markets to grow their economies. Our goal should be to maintain our standard of living and to assist the developing world obtain affordable energy. Bill Gates suggests the minimum amount of energy that a person in a developing country should have for a reasonable standard of living is a level that is about half of current European usage and one quarter of current U. S. usage.

Nuclear Fission is a Sustainable Replacement for Fossil Fuels

"The Earth was endowed from its initial creation with all the energy fuel that mankind could ever desire."—Rod Adams

This terrestrial fuel—uranium—releases it energy through nuclear fission. It will keep humanity out of the Malthusian trap for millions of years to come. Alvin Weinberg (recalling a 1943 conversation with Manhattan Project physicist, Philip Morrison), wrote: "Phil Morrison could hardly contain his excitement as he showed me his calculations. If uranium were burned in a breeder [reactor], the energy released through fission would exceed the amount of energy required to extract the residual 4 ppm of uranium from granite rock." Weinberg was an American nuclear physicist, a patent holder of our current reactor design, the Light Water Reactor, and administrator at Oak Ridge National Laboratory during and after the Manhattan Project period. Harrison's insight was that uranium in granite represents an essentially inexhaustible energy supply. We can burn rocks! It has been shown that uranium can be extracted from sea water at modest cost. Not only can we burn rocks we can also burn water! In addition, fertile thorium, also reactor fuel, is believed to be four times more abundant than uranium in the Earth's mantle. Weinberg calculated that thorium resources on Earth could power a civilization of seven billion people at a U. S. level of energy use for approximately thirty billion years.

Charles Barton, Jr., science historian and son of a Manhattan Project nuclear chemist, observed, "The deployment of nuclear power is not a liberal / conservative issue. Nuclear power will be the primary source of future human wealth. Without that wealth, it will be impossible to meet either liberal or conservative socio-economic goals."

Nuclear fission is the only non-emitting energy source currently capable of replacing fossil fuel. Advance generation reactors which operate at ambient pressure, have a strong possibility of producing power that is cheaper than dirty coal. There is growing interest in smaller size breeder reactors that can be factory built and delivered to site by train or truck for set up in weeks or months rather than years. Since they operate at near ambient pressure, no billion dollar dome or 1000 ton reactor vessel is needed. They are meltdown proof and they produce very little radioactive waste. Unlike our current reactors, these advanced reactors do not require water as they are cooled by liquid metal and they can generate power using a gas turbine rather than a steam turbine.

We can burn rocks! It has been shown that uranium can be extracted from sea water at modest cost. Not only can we burn rocks we can also burn water!

An ideal way to improve efficiency of nuclear power generation is to invest waste heat in the production of potable water through the process of desalination. Also, reactors can remain at full power when grid demand is low as the portion of energy not needed by the grid can be diverted to desalination. In our Recipe for a Sustainable Future, fresh water is as much a necessity as food and energy. Potable water is in short supply in many parts of the world. It is estimated that one fifth of the world's population does not have access to safe drinking water, and this proportion will increase due to population growth relative to water resources. Where it cannot be obtained from streams and aquifers, desalination of seawater or mineralized groundwater is required. The microbiologist in me knows that lack of clean water is the main cause of human diseases and childhood mortality. The feasibility of cogeneration in integrated nuclear power/desalination plants has already been proven in several countries with a total of over 150 reactor-years of experience.

The Traveling Wave Reactor (TWR) represents what is coming in reactor technology. TerraPower is a company founded by Bill Gates for the express purpose of building TWR reactors that have the potential to produce electricity cheaper than dirty coal plants. The plan is to combat global warming, which Gates sees as humanity's greatest threat. By making energy cheaper than coal, coal will become an obsolete fuel, but will be preserved for use as a feedstock in the future. Gates' goal is zero carbon emissions globally by 2050. He is seeking an affordable, safe energy source for use in developing countries. He says that high operating temperature of the TWR means that it puts out a lot of energy for its size. It is designed to use the spent fuel (nuclear waste) from our current Light Water Reactors and it will be loaded with enough fuel to operate for 60 years without refueling. The reactor requires no operator and can be buried underground where it is safer from terrorist attack. He is looking to partner with China. BBC News reported that on December 8, 2011, Mr. Gates was in China to talk to the government. Terrapower is collaborating with Chinese scientists on the fourth generation (4G) reactor. China is set to start work on the novel design.

"The idea is to be very low cost, very safe and generate very little waste," said Gates in a talk at China's Ministry of Science and Technology during which he confirmed the tie-up with Terrapower. "Research into the 4G reactor over the next five years could top $1 billion," said Gates.

Bill Gates' hope is to complete his reactor by 2020. He has given up placing his reactor in the USA. Our regulatory structure is too slow and cumbersome. He sees little chance of getting any new nuclear-related technology approved.

Nuclear Reactors Can Replace the Energy from Liquid Fuel

Nuclear generated power for electrified mass transit systems and plug-in electric cars are two ways to replace liquid fuel with emission-free energy. But can nuclear power give us liquid fuel for our tractors, combines, trucks, buses, and airplanes? Yes. High temperature nuclear reactors can split hydrogen from water at high efficiency. Synthetic fuels can be produced by chemically reducing carbon dioxide with reactor produced hydrogen. The Los Alamos National Lab has explored a highly efficient method for making synthetic hydrocarbon fuels from atmospheric carbon dioxide and hydrogen. They project an operating cost (Nov. 2007 equivalents) of $0.65/gal. for methanol and $1.40/gal. for syn-gasoline. Add on five billion dollars for construction of a plant and the cost goes to $4. 60 for gasoline and $1.65 for methanol. They suggested that with improvements costs could drop to $3.40/gal. and $1.14/gal. I suspect that the high temperature reactor hydrogen production would lower those costs considerably more. Getting a highly efficient hydrogen production system could lower the consumption of natural gas by 5%, since that is the percentage of natural gas currently used to make hydrogen, most of which is used to synthesize anhydrous ammonia fertilizer. Cheaper reactor generated hydrogen for fertilizer could trickle down to making food more affordable.

Iceland's synthetic fuel facility is even more exciting because it is beyond the concept stage, since it is under construction and scheduled to open in 2014. It will produce dimethyl ether from carbon dioxide and hydrogen. Dimethyl ether is a clean fuel for diesel engines. They expect that the new plant will reduce their petroleum fuel imports by one third. Unlike fossil fuels, synfuels do not increase greenhouse gases in the atmosphere. Our government should invest in R&D to make synthetic fuel. It would create jobs and reduce our dependence on foreign fuel.

Legislation for More Department of Energy R&D Funding

Energy is the base upon which economies are built. It appears that the transition from fossil fuel to a replacement fuel cannot occur fast enough to prevent a continued drop in our standard of living. This lower living standard can be minimized if government makes a major investment in R&D to develop the most economically viable replacement energy sources. The American Energy Innovation Council, (AEIC), calls for a national energy policy that would increase U.S. annual investment in energy research from $5 billion to $16 billion. Bill Gates, a member of the AEIC, said that

UNITED STATES DEPT. OF ENERGY PHOTO

The first production of usable nuclear electricity in Idaho National Laboratory, December 20, 1951: four light bulbs were lit with electricity generated from the EBR-1 reactor.

he was stunned that the DOE budget for R&D was only $5 billion; by comparison the National Institutes of Health invests a bit more than $30 billion. To pay for more R&D, Gates favors a 2% tax on energy. He does not favor cap and trade or a tax on carbon, but he favors a timetable for closing coal power plants so that each utility can have a dependable long range plan.

I had given thought to funding more R&D for energy before I saw Gates' ideas. My thought was that energy subsidies should be phased out and the government investment in subsidies be placed in the DOE's R&D fund. I felt that the first subsidy to go should be the 45 cent per gallon ethanol subsidy which will pay out $5.4 billion in 2011. I was pleasantly surprised when Congress voted to remove the ethanol subsidy starting in 2012. Removing this subsidy will not have a big affect on the amount of ethanol blend (gasohol) produced because by law the EPA requires a minimum production quota for 2011 of 12 billion gallons and a gradual increasing quota in subsequent years. There is no need for the federal government to both mandate and subsidize a commodity.

About a quarter of our corn crop and five percent of our soybean crop is currently turned into fuel. Organizations with the mission to alleviate world hunger charge that our use of corn and soybeans for fuel is evil, because it has the effect of increasing the cost of food for the poorest of the poor. Higher food prices means starvation for the very poor. As an owner of farmland upon which corn and beans are grown, I regretfully plead guilty as charged.

The subsidy of a $1.59/megawatt hour (MWH) for nuclear power is not justified. Our 104 nuclear power plants are now paid for and the operation and maintenance cost is about two cents/kilowatt hour (kWh). Nuclear plants have the lowest generating costs of all generating sources. Renewable subsidies are more than an order of magnitude larger (wind $23.37/MWH and solar $24.34/MWH). Wind and solar would not be competitive without these subsidies plus an added subsidy covering 30% of construction costs. I will tender a generalization: Subsidies do not encourage innovation and they often do not favor the most cost effective strategy.

Monies spent on R&D, education, and infrastructure are investments that pay back big dividends. Over regulation kills innovation and runs up construction costs. Our regulatory infrastructure needs to be streamlined.

Comprehending Energy Density of Fuels

The energy density of nuclear fuel is 50 million times that of coal on a volume basis. This example may help us conceptualize the tiny amount of nuclear fuel needed to run a typical 1000 megawatt (MW) reactor for a year. The energy density of nuclear fuel (uranium or thorium) is 2 to 3 million times that of coal on a weight basis. Uranium or thorium is 19 times heavier than coal, so when compared on a volume basis we must multiply the 2 to 3 million times 19, which gives us about 50 million times more energy than coal.

One ton of coal fills my Nifty Fifty pickup truck bed to a depth of one foot. That coal fed into a coal fired power plant will generate about 2400 kWh which is the amount of electricity used in two months in the average American home. One ton of uranium or thorium loaded into a breeder reactor that burns up 100% of the nuclear fuel will last for one year producing 8 billion kilowatt hours (kWh,) which is the annual amount of electricity used by the city of San Francisco. Since nuclear fuel is 19 times heavier than coal, my pickup box filled to a depth of one foot would contain 19 tons, enough nuclear fuel to power San Francisco for 19 years. The accumulation of radioactive waste produced in 19 years would also fit in my pickup box!

Choices of Energy Sources Matter

Forget about renewables—they will always be bit players because they are too diffuse to be economical and too intermittent to be dependable. If we are serious about decarbonizing our world we must not allow ourselves to be diverted from the goal of producing emission free energy that is cheaper than dirty coal. Renewables are competitive only because of government subsidies and they show little promise cost-wise for out-competing coal. Renewables do provide diversity in clean energy sources, but they cost too much, take up too much space, and too much of our earth's resources must be invested in their construction and maintenance. The wind varies from calm to too strong for use by wind turbines. The rated capacity or 100% output occurs only with optimal wind velocity. Worldwide, the mean wind capacity is only 27% of rated capacity. Due to variability, wind power needs a backup much of the time. Solar's capacity factor is even worse than wind. Denmark produces the equivalent of 20% of its total electric power needs from wind, but it is only able to provide between 5 and 10% of Denmark's annual electric power generation to the grid. More than half of the wind generated energy must be sold at bargain basement prices to their neighbors. Denmark, at 38 cents/kWh, has the highest priced electricity in Europe. Denmark has one of the largest carbon foot prints in Europe because it lacks hydro power and wind supplies only a small portion of its electricity generation, so fossil fuels make up most of its electricity generation. So much for wind's poster child!

Power cheaper than coal is our only hope for turning the world away from dirty coal. Coal is implicated in climate change and pollution induced heath issues. If we can develop and export a nuclear technology that is cheaper than coal, we address both our economic problems and the climate change threat.

On the other hand, if we make poor decisions about our energy sources, other nations will out-compete us with lower power costs. Russia has two of seven planned floating reactors under construction. Situated on large towable rafts they will supply electricity to coastal Russian cities. The first floating reactor has been launched and is scheduled to commence power production in 2012. Russia has a 30 year head start with their breeder, the BN 600. We need to worry that our labor force will remain underemployed while our utilities buy power from Russia. Our power could be delivered to us from floating reactors placed along our coasts. If we choose not to buy their power, our more expensive power will negatively affect the price of our exports. I recall when Oregon Plywood mills closed their doors because Japan made plywood from our trees cheaper on ships that were positioned off our west coast. Will it be *déjà vu*?

The Myths Associated with Nuclear Power's Dangers Need to be Exposed as Mostly Frauds

Our species evolved in a world that had much higher levels of radiation. Radiation, like vitamins, is good for us in small amounts but toxic in large quantities. Animal studies provide evidence that ionizing radiation is not only good for us its presences in our bodies is a necessary requisite for health. The scientific literature is filled with some 3000 studies that show a moderate increase in radiation improves our health and decreases our risk of cancer.

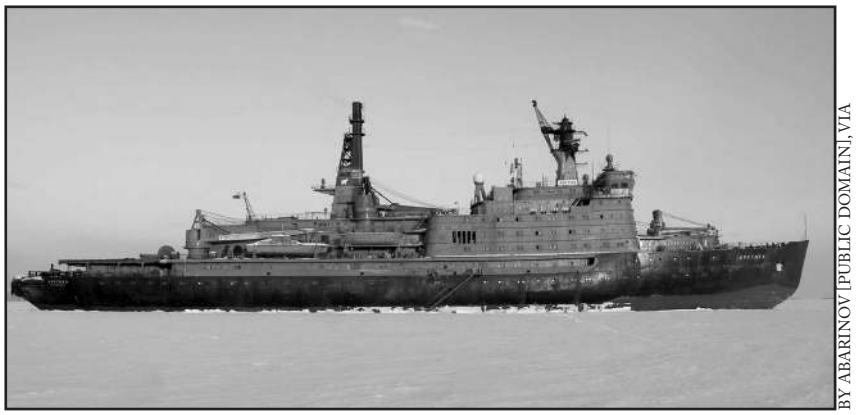
Immunologists have found that additional moderate radiation exposure induces several mechanisms in the immune system which function to improve our defenses against diseases. We now know that a process, "radiation hormesis," mediates beneficial effects on health in humans. Benefits of radiation stimulation to the immune system's damage-control is much greater than its direct damage done to DNA molecules. The increase in the amount of DNA damage caused by moderate levels is relatively trivial—orders of magnitude less than the benefits from immune stimulation. Additional radiation turns on the synthesis of DNA repair enzymes and enzymes capable of destroying reactive molecules which have the capacity to cause mutations. Additional radiation also stimulates an arm of immune defense that rids the body of DNA damaged cells which could potentially turn malignant.

More than forty-five years ago, I introduced a lab exercise that demonstrated an ultraviolet radiation induced DNA repair process in bacteria. Over the years this interesting demonstration was successfully replicated by microbiology students many times. I regret that I did not have the foresight to postulate similar mechanisms discovered years later for ionizing radiation in human cells.

Naturally occurring radiation varies greatly depending on locale. Worldwide the annual individual exposure to natural radiation from the Earth's mantle and cosmic origin expressed in milliseiverts (mSv), ranges from 1 mSv to 260 mSv. Residents in Ramsar Iran are exposed to 260 mSv annually. Studies

found no increase in cancer incidents, birth defects or other health issues in Ramsar residents as compared with Iranian neighbors where natural radiation is low.

The mean annual exposure to natural radiation for Americans is three mSv. The Rocky Mountain States residents get six mSv, the highest radiation exposures in the country. Cancer rates among people living in the seven Rocky Mountain States are one third lower than the rest of the nation. Conversely, the Louisiana delta has the lowest exposure to radiation and the highest cancer rates in the country.



BY ABARINOV [PUBLIC DOMAIN], VIA WIKIMEDIA COMMONS

The 25,000 ton Russian nuclear icebreaker Arktika *travels through more than 400 miles of pack ice on only one pound of uranium fuel, demonstrating the incredible energy density of nuclear fuel.*

In January of 2012, the US Nuclear Regulatory Commission granted first reactor construction license in thirty-four years. The aftermath of anti-nuclear hysteria from the Three Mile Island accident in 1979 created a nuclear exceptionalism that led to over-regulation of nuclear power plant construction driving up construction costs several fold. The nation turned to coal power plants. Ironically, coal power plants cause much more loss of life than nuclear plants. Over its lifespan, a coal plant will claim 3000 lives from the pollution it puts into our environment. Also, our coal mine accidents claims thirty or more miner's lives per year. Nuclear power plants produce 20% of our electricity and their radiation has not claimed a single American life in the fifty-four years that nuclear generated power has been in service.

In response to hysterical fear of radiation, unrealistically low radiation limits are enforced world-wide by the International Commission on Radiological Protection (ICRP). The conservative ICRP adheres to the flawed linear non-threshold hypothesis (LNT) and promotes the standard, "as low as reasonably achievable" (ALARA). Their recommended safety level for a person is radiation exposure of only 1 mSv per year.

British radiation expert, Wade Allison, author of *Radiation and Reason: The Impact of Science on a Culture of Fear* (2009), addressed the people of Japan on television, October, 2011. He proposed that radiation limits be set the same way other such limits are set—not by seeing how little we can obtain, but what is the maximum we can tolerate, including a generous safety factor. The answer he gets is a 1000 mSv per year, or 1000 times the ICRP permissible limit. He says his proposed limit is still well under the clinical data on which he bases his proposal. A cancer risk from a 1000 mSv per year for chronic exposure or a one time exposure of 100 mSv is so low you cannot measure it. He bases this conclusion partly on life span survivor studies of the victims of Hiroshima and Nagasaki. The bomb survivor study included a population of approximately 100,000 people monitored carefully for more than fifty years. Professor Allison states that it is difficult to conceive of a larger or more well followed study group. Victims of Hiroshima and Nagasaki are living longer than their countrymen not exposed to radiation from the bombs.

We need to recognize the difference between levels of radiation that are actually dangerous and levels that we have been illogically taught to fear. The incidence of cancer deaths among all the Hiroshima and Nagasaki survivors was one-half of one percent higher than in a similar size cohort of Japanese people not exposed to radiation from the bombs. This increase in cancer cases has occurred mainly among survivors subjected to high radiation dosages above 1000 mSv while those exposed to a moderate amount of radiation, 180 mSv or less, had a lower incidence of cancer than the general public in Japan.

In March of 2011, Japan suffered its worst earthquake in centuries and a direct hit on nuclear plants by a tsunami. Ted Rockwell in a November 17, 2011, *Atomic Insights* guest editorial wrote,

> Amid tens of thousands of deaths from non-nuclear causes, not a single life-shortening radiation injury has occurred. Not one. And while some people in the housing area are wearing cumbersome rad-con suits, filtered gas-masks, gloves and booties, there are people living in other places like Norway, Brazil, Iran, India where folks have lived normal lives for countless generations with radiation levels as much as a hundred times greater than the forbidden areas of the Fukushima homes.
>
> At Fukushima this is no abstract issue. People are being told they cannot return home for an indeterminate period—perhaps years. And efforts to decontaminate their home sites may require stripping off all the rich top-soil and calling it RadWaste. People formerly living there have been reduced to economic poverty, clinical depression, and even suicide.
>
> It's time this draconian situation is resolved. A simple declaration of the facts about radiation protection from the proper authorities would be a good first step.
>
> Signed: Ted Rockwell

Here are a couple of sentences from Ted Rockwell's biography: "Dr. Rockwell has spent over 60 years in nuclear technologies. He is a Fellow of the American Nuclear Society and recipient of its first Lifetime Contribution Award, now known as the Rockwell Award. He has Distinguished Service Medals from

both the Navy and the U. S. Atomic Energy Commission, and is a member of the National Academy of Engineering. He was Technical Director of Admiral Hyman Rickover's program to build the nuclear Navy and the first commercial atomic power station. He has written numerous books and technical papers, including the widely-used text, *Reactor Shielding Design Manual*."

The World Nuclear Association confirms some of Rockwell's claims, reporting that as of February 27, 2012, there have been no deaths or cases of radiation sickness from the Fukuskima nuclear accident. Two workers received radiation burns on their feet from beta emission while standing in contaminated water. Beta radiation is not deeply penetrating and the total body exposure did not exceed the allowable dose for either of the two clean up workers. So far over 3500 of some 3700 workers at the damaged Daiichi plant have received internal check-ups for radiation exposure, giving whole body count estimates. The level of allowable maximum short-term dose is within the international dose standard for all of the emergency clean-up workers receiving check-ups.

Chernobyl was the worst possible nuclear power plant disaster. It was a total meltdown. A steam explosion and ensuing fire sent radiation fallout over a wide area. Acute radiation exposure accounted for twenty-eight early deaths among fire fighters. An additional nineteen deaths among fire fighters in the following seventeen years came from variety of causes. Approximately fifteen deaths from thyroid cancer in children were attributed to drinking milk contaminated with radioactive iodine in the weeks immediately after the Chernobyl nuclear accident. The enormous political, economic, social and psychological impact was mainly due to deeply rooted fear of radiation induced by adherence to the linear non-threshold hypothesis (LNT). Based on the LNT assumption, large numbers of radiation causalities and increased incidence of cancer should have occurred. The opposite happened; evidence suggests that radiation from the Chernobyl accident actually reduced the incidence of cancer among those most heavily exposed to radiation.

In 2006 the United Nations Chernobyl Forum Proceedings, Zbigniew Jaworowski, chairman of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) stated in "Chernobyl Accident Appendix 2," "The standardized incidence ratio (SIR) for all cancers combined ranged from 0.30 to 0.69 (i. e. 30% to 69% of the normal incidence in Belarus), from 0.89 to 0.98 in Russia, and from 0.80 to 0.82 in Ukraine. Hence, the incidence of all cancers appears to have been lower than it would have been in a similar but unirradiated group. The only real adverse health consequence of the Chernobyl catastrophe among about five million people living in the contaminated regions is the epidemics of psychosomatic diseases. These diseases were not due to irradiation with Chernobyl fallout, but were caused by radiophobia, induced by years of propaganda before and after the accident, and aggravated by improper administrative decisions."

UNSCEAR also reported that no increase in birth defects, congenital malformations, stillbirth or premature births could be linked to radiation exposures caused by the Chernobyl fallout.

Conclusions

Replacement of fossil fuels with nuclear fuel is the only way to retain a livable planet without lowering our living standard. Cheap, clean nuclear energy provides hope for the Third World to raise their living standard, which in turn may stem population growth thereby disarming the population bomb. Nuclear energy does not add carbon dioxide to our atmosphere. It's just that simple and it's our only real hope—no other options are available. We will move forward with nuclear fission, or it will be coal and gas, with costly environmental and health consequences.

We have not yet probed the depth of the Earth's abundance. Wonderful new developments are spawning in the minds of future scientists and engineers. The key to sustainable economies in all the nations of the world and a sustained decent standard of living for all the people of the world is abundant affordable emission-free energy. Increasing our national support for education and scientific research is the best way to insure a sustainable world for our children, grandchildren, and all the other children of the world. *Agora*

Recommended Reading

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