Preface to the Second Edition

After finishing the first edition in 2005, many new developments in the energy field have emerged which necessitates some additions and modifications to my book "The Nuclear Imperative – A Critical Look at the Approaching Energy Crisis". Several new books have also been written that address the threats to our society when oil runs out. One new book written during the US election campaigns of 2008 was titled "Physics for Future Presidents" by physics professor Richard A. Muller of UC-Berkeley. Because new government administrators and presidents tend to have much influence on national energy policy, I have expanded the subtitle of my book in this second edition to "More Physics for Presidents", hoping new presidents worldwide will inform themselves of at least what I wrote in Chapters 1, 2, and 9. By "presidents", I mean here to include all decision-makers in our societies, whether future (i.e. young students) or present, liberal or conservative, corporate or government, Christian, Islamic, Buddhist, Hindu, or other, and whether European, Asian, African, or other ethnicity. Our planet Gaia does not care, as long as mankind keeps it healthy.

This book is written with emphasis on the technology of modern nuclear power and aimed at new generations who must steer our civilization through difficult times with no more oil. Of necessity the presentation is not entirely technical because there are many non-technical factors that influence the subject matter. It is a "hybrid" textbook and correctly belongs in the publisher's TSRQ series (TSRQ = Topics in Safety, Risk, Reliability, and Quality) which emphasizes the need to blend technology with societal factors. The book identifies and analyzes major upcoming energy problems in areas that will see substantial changes in the not so distant future and suggests some obvious practical solutions. It is not a nuclear engineering reactor design book of which there are already many good ones. Instead I have delved into my 50 years of experience dealing with high-technology energy systems to present my best engineering analyses (and opinions) with as little prejudice as possible. Most technical books restrict themselves to technical matter and try to avoid societal issues. However, the subject of nuclear power technology has been heavily infiltrated by non-technical influences and it is impossible to discuss nuclear power without discussing some of these.

Many from the baby-boomer generation still find it paradoxical and counter-intuitive that nuclear energy can save our planet. While growing up in the 1960s, 1970s, and 1980s they were indoctrinated to reject anything with "nuclear" or "radiation" attached to it, since it stood for bombs, deaths, and danger. They have a difficult time shedding these feelings. But knowing that the survival of their children and grandchildren depends on them, I hope that those who think rationally will now push for expanded nuclear power. Those who are still opposed should ask themselves how we will replace oil energy when it is gone. Exhortations from anti-nuclear herds asserting that wind and solar energy can take care of all future needs and that nuclear energy is not needed, are filled with very serious miscalculations. The so-called "renewables", while helpful in supplementing small-quantity energy needs, can never sustain all future energy requirements of the world. An honest engineering study shows that at multi-gigawatt levels they are three times more costly than nuclear. Besides, one wonders why nature's scenery and ecosystems must be spoiled with millions of man-made windmills and solar panels spread over millions of acres, when a single perfectly safe nuclear power plant can be built on twenty acres to provide the same amount of energy. In the eyes of experienced utility engineers, the renewables-only scenarios trumpeted by a variety of anti-nuclear groups are impractical unrealistic fantasies and will be costly debacles if carried out. Worse than naiveté however is that later generations will see present anti-nuclear activists as being guilty of aiding and abetting the collapse of Western civilization, which too many of our enemies fervently desire. Without greatly expanded nuclear power the world will assuredly experience a calamitous depression by 2050 with worse consequences than an all-out nuclear war.

While finishing the first edition of this book, the great nuclear physics pioneer Hans Bethe died, whom I commemorated in my book and still do. During work on this second edition, another talented independent thinker departed: movie actor and producer Paul Newman. Like James Lovelock, a renowned naturalist from England, and Patrick Moore, co-founder of Greenpeace, Paul Newman concluded also that to rescue our children from future energy starvation we must take advantage of the atom. To keep Gaia (Mother Earth) from being despoiled by millions of scenery effacing, desert-smashing wind-mills and solar panels, only green nuclear power can save it. Paul came to that conviction after careful investigations and comprehension of the true dimensions of nuclear power and the pending oil-field depletions, even though in earlier days his pacifist nature had opposed the use of nuclear energy. I was much honored to share a page with him in the Nuclear Energy Institute's monthly circular "NE Insight" of June, 2007, which covered Paul Newman's tour of the Indian Point nuclear power plant, and a discussion of my book "The Nuclear Imperative".

As is almost inevitable, there were some errors that sneaked into the first edition. With this new second edition, the necessary corrections were made. An entirely new chapter on "renewables" (Chapter 4) was added, mostly about solar and wind power. They have become quite popular in the last few years and cannot be ignored when one considers future energy sources. All later chapters from the first edition were moved up one notch but otherwise cover the same topics. Except they are largely rewritten and expanded. It must be emphasized again that I wrote this book entirely on my own without support from any special interests, whether private, commercial, or government.

October, 2009 Jeff W. Eerkens

Preface to the First Edition

Part of this book was originally written in 1976 when some thirty copies were printed and distributed to interested parties. A wider distribution was planned but never carried out. In re-reading the first edition written 30 years ago, I am struck by the fact that arguments for a nuclear-powered future and the need to develop portable synfuels have remained unchanged over all these years. Also interest in international weapons control and nuclear non-proliferation is still as strong today as it was in 1976. Some of my original comments on these issues (Chapter 8) still apply today and are independent of political persuasions.

This book can be used as a textbook in an introductory course on nuclear engineering. The subject matter is excellent for a first-year college class of students planning a career in engineering, economics, political science, law, and disciplines involving the structuring of future society. The book is also recommended reading for high-school seniors contemplating a higher education. Familiarity with high-school physics and chemistry is helpful, but "one does not have to be a rocket scientist" to understand the essential issues. All technical material is based on "hard" science, as opposed to dubious "pop" or "junk" science one often sees which distorts the facts and exploits people's predilection for the sensational.

The Three-Mile-Island (TMI) reactor meltdown in the US which occurred on March 28, 1979, and the Chernobyl reactor disaster that took place on April 26, 1986, caused an unfortunate slow-down and in some countries a moratorium on the construction of new nuclear power plants. However these accidents resulted in vastly improved safety measures in nuclear reactor operations. They also proved that a "maximum credible" reactor accident (a reactor meltdown) does not "kill thousands of people" as predicted by those opposed to the development of nuclear energy. In fact, the early safety measures built into American and West-European reactors, comprising a large steel and concrete containment vessel and other features, were shown to perform as designed. Thanks to TMI's containment vessel and pressurized water coolant system which provides a negative temperature coefficient of reactivity, the TMI accident in Pennsylvania did not harm a single person. However the Chernobyl reactor in the Ukraine had no containment vessel and used a graphite moderator with positive reactivity coefficient. Operator error induced a runaway reactor melt-down, causing the graphite to burn chemically with atmospheric oxygen. Non-nuclear-educated firemen from nearby cities who attempted to put out the fire, received serious overexposures of radiation. They had not been warned thereof due to bureaucratic territorialism and unnecessary secrecy. Ultimately 45 people died due to the Chernobyl reactor meltdown and 30 suffered permanent disabilities according to the International Atomic Energy Agency. Today's regulations require all nuclear power reactors to shut themselves down when they get too hot (= negative coefficient of reactivity) and to provide a containment vessel around the reactor, designed to hold all radioactive debris in case of a reactor melt-down accident.

While the electric power industry suffered a set-back in the public acceptance of nuclear energy, the reasons for expanding construction of new nuclear power plants three decades ago have not changed and in fact have become more urgent. After demise of oil and gaseous petrofuels from the earth, only coal and uranium (perhaps deuterium/tritium in the next century) are left as prime sources to provide us with large-scale quantities of energy. Large quantities of prime energy are needed in the future to synthesize hydrogen, ammonia, hydrazine, and other portable "synfuels" to move our transportation fleets (cars, trucks, trains, ships, aircraft, etc.), and to energize our heavy industries (steel-production, ship-building, auto manufacturing, etc.). Uranium can satisfy this demand for at least 1,000 years with much less waste and real estate problems and with vastly better economics than "renewable" solar-cells and wind-farms ever could. In the USA, coal-fired power plants presently produce 52%, uranium fission generates 21%, natural gas and oil-burning units contribute 15%, and hydro + geothermal + others yield 12% of all electricity (3.5 billion MWh(e)/year). Burning of coal, oil, or natural gas produces heat. In a power plant this heat vaporizes water into high-pressure steam which is converted into electricity by steam turbines. In a nuclear plant, water is heated by fissioning uranium; otherwise the same electric generation is used as in coal-fired plants that is with steam turbines. However coal, oil and natural gas pollute the atmosphere enormously when burnt with atmospheric oxygen (O_2), since they produce globe-warming gaseous carbon dioxide (CO_2). In theory, without oil and uranium, coal could supply the world with all needed energy for some 100 years. But it would be insanity not to generate electricity for the next 1,000 years utilizing non-polluting fissioning of uranium instead of burning coal, knowing that uranium has little other use. When oil is gone, only coal (and wood) can still provide raw material for making plastics and other carbonaceous compounds widely used today; it should not be burnt! The oft-quoted "problem of radioactive waste" produced by reactors is highly exaggerated. "The problem" is nonexistent for nuclear engineers who have no difficulty concentrating and packing solid oxidized fission products from one hundred US nuclear power plants in a few hundred drums yearly for underground storage.

This book is not the first nor will it be the last one that warns of an impending energy crisis. The annotated bibliography lists books giving similar serious warnings, which seem to be unheeded by mal-informed governments. The main message of this book is that doom of our civilization due to depletion of oil is not inevitable if the correct measures are taken. Current government energy policies seem influenced by dogmatically anti-nuclear lobbyists who believe only "renewable" wind and solar farms can solve future energy problems. Nuclear and coal power plant experts should be consulted instead when making policy decisions. The sun provides a year-averaged 500 W of light energy per square meter, and most strong winds blow only 20% of the time. No amount of legislation can alter those facts. Also in round numbers, the earth once possessed 4 trillion barrels of oil and 20 quadrillion cubic feet of natural gas (natgas) from fossil remains, including oil from tar-sands and natgas from sea-beds. Of these, 2.5 trillion barrels of oil and 15 quadrillion cubic feet of natgas are left today. In addition earth also possesses 6 trillion tons of coal and 10 million tons of exploitable uranium at present. With average energy consumption leveling to 1.3 kW(e) per person and a stabilizing world population of 7 billion people, it would take 17 years to deplete all oil, 18 years for all natgas, 153 years for all coal, and 1,000 years to burn up all uranium, *assuming* each were the *only* prime energy source for electricity and portable fuel production. Presently (2005), world consumption is 0.7 kW(e) per person, but Asia is expected to raise this to 1.3 kW(e) in 10 years. The U.S., with 4.5% of the world population, consumes 4.4 kW(e) per capita at present. However roughly 1.2 kW(e) is spent on the electricity-intensive manufacture of exported goods (aircraft, autos, bulldozers, ships, etc) and only 3.2 kW(e) is self-consumed. Here 1 kW(e) of high-grade electrical energy is assumed to equal approximately 3 kW of heat energy.

It is important to point out that the per capita energy consumption includes each person's share of the fuel energy consumed by transportation fleets (cars, buses, aviation, etc.), by the manufacture of goods (automobiles, trains, television sets, etc.), by agriculture, by food distribution, etc. The oft-quoted figure of 0.6 kW(e) per person (2.4 kW(e) per home) applies only to the average electric grid energy consumed in rural households of North America, and does not include their consumption of petrol energy or their share in energy for the production of goods or foods they use. The latter energies must be added to their "electric bill" since primary electricity must manufacture all portable synthetic fuels when oil is gone.

Because so much misinformation has been disseminated about nuclear power generation, after the introduction, the book starts out with a review of facts and fables about nuclear energy in Chapter 2. Chapter 3 is perhaps the most important part of the book. It gives the reasons why everyone, including anti-technology environmentalists, should endorse uranium-fueled power generation lest they want to be responsible for globe-warming CO_2 from burning coal and coal-derived synthetic fuels in the next decades. If they abandon nuclear power and do not wish to burn coal either, they must be prepared to eliminate 90% of the world's population after oil runs out. Chapter 3 reviews current energy consumption rates by humans on planet earth and the finite reserves of the world's prime energy sources. The numbers show irrefutably that if we want to reduce global warming and save coal for making plastics and synthetic hydrocarbons, only full exploitation of nuclear energy can save mankind from economic collapse when fossil fuels run out. Wind and solar electric power generation is helpful but only a band-aid (Chapter 4). It could never provide the enormous quantities of energy needed to replace all oil-derived fuel with synthetic fuels to sustain our transportation fleets (cars, airplanes, etc.). Similarly, saving energy by better home insulation and improving auto engine efficiencies, is useful and should be encouraged. But they cannot change the fact that oil will still run out, as more people on the planet consume it. Chapter 5 reviews propulsion techniques using portable fuels synthesized with the help of primary nuclear electricity. The synfuels should be tested and available by 2020 to start the massive replacement of petrol in order to avoid serious economic upheavals 25 years from now. We *can* survive 2030, but planning and preparations must be started *now*. If replacements of present propulsion technologies and new synfuel productions are not initiated in time, we may see endless wars to control the last remaining oil fields and terrorist activities that make Al Qaeda's atrocities pale by comparison.

Following the first five chapters, back-up material is presented on key features of nuclear reactors, environmental concerns, radiation physics, and security issues, which have been questioned by so many. Factual material for this book was gathered from numerous reports, books, and journal articles written by nuclear professionals worldwide. With the exception of a few always-present contrarians, the vast majority of some 250,000 professional engineers in the nuclear energy field are in agreement with the material presented in this book.

In summary, this book is an admonition that the world must stop vilifying nuclear energy and rapidly expand this unique energy source so we can overcome the pending out-of-oil crisis. Nuclear proliferation concerns and nuclear security issues can be and must be resolved. We don't have any choice if we want to survive oil depletion and stop burning globe-warming coal. Some recent books acknowledging the up-coming energy crisis, project it as inescapable and forecast gloom and doom for our progeny. This book refutes such a scenario and shows a workable solution based on proven technology and scientific facts. Nuclear power should be supported by everyone, in particular by environmentalists. Providence is giving mankind one clear (and clean!) way out of the predicaments it faces when oil is no longer available.

Most derived numbers in the book are scientifically reasonable estimates. But because no one can predict exactly how many people will populate our globe in the next 30 years or how much energy each will consume, and no one knows the precise cost of (future) hardware, there are minor variations of some numbers in different chapters, with which some "preciseniks" may find fault. They do not invalidate the main conclusions of the book however. Most of this book was written in 2003 and 2004, but at the publisher's request a discussion on Risk Analysis was added as Section 1.2 in 2005. As this book was readied for publication, my attention was called to J.H. Kunstler's recent book titled *The Long Emergency*, and Alan E. Waltar's *Radiation and Modern Life; Fulfilling Marie Curie's Dream.* Kunstler expresses the same concerns about the pending energy crisis as I do, but offers no solution to overcome this crisis. My prognosis is more optimistic, *provided* the public listens to hands-on nuclear energy engineers, and ignores anti-nuclear armchair philosophers who use fictitious science. Waltar's opus complements this book and shows how important and unavoidable nuclear energy already is in our daily life.

November, 2005 Jeff W. Eerkens

http://www.springer.com/978-90-481-8666-2

The Nuclear Imperative
A Critical Look at the Approaching Energy Crisis (More Physics for Presidents)
Eerkens, J.
2010, XX, 212 p., Hardcover
ISBN: 978-90-481-8666-2