Energy Reality

Something Worth Saving

Energy Reality

The Necessary Renaissance

by Rick Maltese

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> None of the world's problems will have a solution until the world's individuals become thoroughly self-educated.

- Buckminster Fuller

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Acknowledgements

Many thanks to the following people (listed alphabetically) who directly or indirectly provided me with assistance in putting this book together.

Meredith Angwin has been a mentor and colleague who has written Campaigning for Clean Air. It is full of good advice on advocacy for Nuclear Energy.

Wade Allison is a retired professor from Oxford University who has authored several books about radiation. You can get an education just by visiting his website named after his recent book Radiation and Reason.

Rod Adams has an excellent blog called Atomic Insights with a wealth of nuclear energy related posts and podcasts going back to the last century. Seriously.

Steve Aplin has been an energy consultant in Canada for a number of years and creates some excellent posts. Some that shed light on the power and energy density of various energy sources and others that help present a good picture of the energy scene. He also has up to date data statistics at Canadian Energy Issues.

Mathijs (Thies) Beckers is a prolific author, whom I happen to quote, that has a knack with numbers and statistics and has written three books in the last four years.

Christopher Bergan is a friend and moderator of Energy Reality Project Facebook group and provides a great service voluntarily like myself. He has also contributed many excellent posts as well as a few educational website posts.

Tom Blees wrote an important book called Prescription for the Planet

Barry Brook is an environmental scientist from Australia and is the founder of Brave New Climate which no longer makes posts but remains a good source of discussion from other scholars, scientists, engineers and advocates.

Stewart Brand has been a reminder that green environmentalists can change their mind about nuclear energy. He was the editor of the Whole Earth Catalog. More recently Whole Earth Discipline: An Ecopragmatist Manifesto 2009. Runs a series of lectures/interviews with the Long Now Foundation.

Alex Cannara has provided an unofficial forum for his members of Thorium Energy Silicon Valley, more recently called TESV Xero-Carbon, and has provided a regular newsletter Climate/Food/Energy that summarizes recent or topical references to current activity. It is an email based group relying on a committed bunch of advocates who write to members of congress, media outlets and NGOs who do not yet see the full picture, raising awareness and educating the decision-makers. I quote Alex in the "Energy Does It All" chapter and the background on Ocean Acidification. He also provided the analogy of the "pinky" sized pellet of uranium providing so much power.

James Conca is a devoted journalist and educator. Many of his articles cover the topics that interest followers of Energy Reality.

Mike Conley and Timothy Maloney are a good writing team who's biggest contribution so far is the http://RoadmapToNowhere.com.

Leslie Corrice is a former nuclear power plant operator, a member of Scientists for Accurate Radiation Information and keeps updates about the Fukushima Daiichi nuclear plant at his excellent http://hiroshimasyndrome.com

Gwyneth Cravens is an author of an excellent educational resource from her book called Power to Save the World: The Truth About Nuclear Energy where she engages on a journey of discovery with the help of an expert guide Rip Anderson.

Jerry Cuttler is a tireless advocate for fighting the misconceptions about radiation. He has worn many hats over his long career in various roles supporting nuclear energy including his own research and analysis on low dose radiation.

James Hansen is admired and respected for his advocacy for protecting the environment and as the leading Climate Scientist. His leadership in raising awareness has been unparalleled. From his first reports about climate change and global warming, he has delivered numerous testimonials and brought attention to human caused global warming. His numerous protest and arrests were widely publicized in all news outlets. He has no reservations about nuclear power as a necessary clean energy source that must replace coal and other fossil fuels. It was a big moment during the Paris Climate Summit when he was joined by leading climate scientists Dr. Ken Caldeira, Dr. Tom Wigely and Dr. Kerry Emmanuel to endorse nuclear energy.

Robert Hargraves is an author, professor and board member for Thorcon. His book Thorium: Energy Cheaper Than Coal has been an important contribution to the discussions concerning the future of energy world wide. His lecture and Ted Talk have been an important influence to myself and most other modern reactor enthusiasts. His concepts have been shared widely among nuclear energy advocates.

John Haugeland is the layout advisor and architect of the books components. John humbly calls himself an "average" citizen who does his best to advocate for an engineering-driven practical focus on nuclear energy, with a special emphasis on deploying things which already have factories and good safety records. John's primary interests are in dispelling safety myths, and helping clarify the need for short-term action on building what he believes are the world's safest, cheapest forms of power. John's sole actual interest is the prevention of climate change; his nuclear activism is a result of his belief that nuclear is the only non-future technology ready to meet this planet's near term needs. I happen to agree.

Lars Jorgenson is a lead architect of the Thorcon reactor. He is generous with his comments in the various energy forums.

John Kutsch is Exectutive Director of Thorium Energy Alliance which has provided a forum for entrepreneurs, engineers and scientists to present, collaborate and educate each other. He is also a board member of Terrestrial Energy. Some of my videos have been taken at his events. I gave a presentation at TEAC8 about his book. https://youtu.be/tNjZZzf5mFg

Jim Kennedy has a mining background and has partnered with John Kutsch to lobby for allowing rare earth mining and processing in the United States. The two of them have attended numerous meetings with congress. They hold key roles in the book Sellout by Victoria Bruce which highlights Jim Kennedy's efforts to revive the rare earths industry.

Gordon McDowell is a documentary film maker who deserves a lot of credit documenting the talks from the various conferences by Thorium Energy Alliance and others. He is best known for his extensive coverage of Kirk Sorenson and created the Thorium Remix. Whenever you see a video from TEAC you can assume Gordon did the editing plus mic and camera setups. My associates Eric Meyer, Scott Medwid have also contributed as camera people when more than just a tripod was needed.

Scott Medwid is a strong voice promoting nuclear energy and he runs a weekly radio broadcast at Oberlin College WOBC 91.5 FM.

Eric Meyers started up Generation Atomic. The team he created has generated a lot of positive public relations about nuclear plants and keeping them alive. Eric is known as the operatic advocate often singing at the various rallys for the environment. I have a lot of respect for his work. They are iconic in their efforts to educate and advocate for the future of nuclear energy.

Ed Pheil is the Co-Founder and Chief Technology Officer of Elysium Industries. Elysium is an advanced reactor design company seeking to develop and commercialize the Elysium Molten Chloride Salt Fast Reactor (MCSFR), representing the cross-section of nuclear energy and high-level waste management. Ed was born and raised near Three Mile Island, which inspired him to dedicate his life to nuclear reactors because he saw that no one was harmed after the casualty. In his thirty years at the NNL,he was involved in the design and construction of the US Navy's reactors for submarine aircraft carriers, and Jupiter spacecraft for propulsion and power. Ed devoted the majority of his career to reactor design. To this day, he has been involved in design and support for nine different reactors, including new reactors (Virginia & Columbia Class Subs, and Ford Carriers, new core startup testing for 15 reactors, as well as design studies for many types of Advanced Reactors technologies.)

Kirk Sorensen has become the most watched speaker on the topic of new nuclear research in the area of molten salt reactors. The tireless documenting skills of Gordon McDowell proved to be fruitful work making Molten Salt Reactors (MSR) the reactor of choice in Internet chats in social media worldwide. Gordon began his efforts at the Thorium Energy Alliance. The use of Thorium in an MSR attracted all kinds of engineers, scientists with rare specialties, students and nerdy environmentalists. Gordon's videos were posted to Thorium Remix on Youtube.

Robert Stone put out the film Pandora's Promise which educates the viewer by explaining how his guests had a reversal of their positions on nuclear energy. They included Stewart Brand, Gwyneth Cravens, Mark Lynas, Richard Rhodes and Michael Shellenberger.

Mare Tiido-Britton is a writer who I had many chats about the world's problems. I thank her for introducing me to Buckminster Fuller who I quote more than once and see him as the "luminary" (her word choice) he truly was. He lives on.

Alan Waltar is the author of Chapter Twelve. Dr. Alan Waltar was the Director of Nuclear Energy at the Pacific Northwest National Laboratory (PNNL) and is a past President and Fellow of the American Nuclear Society. He participated in the development of the report Nuclear Energy: Power for the 21st Century, which was put together by seven national laboratories.

Others I must mention as helpers either directly and indirectly: Asha Anand, Leslie Dewan, George Erickson, Jaro Franta, Bill Gates, Kirsty Gogan and her group Energy For Humanity, Ben Hammet, Robert Hargraves, Ben Heard, Jim Hopf, Gabriel Ignetti, David LeBlanc, James Lovelock, Mark Lynas, Mothers For Nuclear, Ripudaman Mahotra, Nnadir, Leigh Philips, Richard Rhodes, David Schumacher, Jeremy Whitlock and Dan Yurman.

Introduction

Prologue

(second half title)
(two page spread)

Prelude

In music, a prelude is a kind of musical form that can be structured or free, but nonetheless provides a way to prepare the listener for something more complex and important. The same can be said of an overture. Which label to use is a matter of scale and since the scope of this book is less like an opera but more like a Bach fugue let this be my prelude to a topic that is indeed important and it does indeed need some preparation.

Energy is fundamental to human survival and prosperity. It has been and always will be. It is a good thing that countries, who historically have lived in poverty and been ruled by leaders unwilling or unable to improve living conditions, have now finally started to grow economically. But the quality of life we experience depends on the kind of energy we use and how we regulate it. Coal is the dominant energy source and why that needs to change is what this book is about.

As a Canadian and resident of Toronto, Ontario I have a unique perspective on Energy. Being Canadian means getting used to weather extremes. Our winters require heat for months at a time. Our homes have undergone technological transitions keeping up with the pace of modernization, each time adapting to the kinds of energy used to heat them. Over a hundred years ago we relied on wood stoves and coal. Then advances in furnace design let us depend on oil and electricity. The fireplace or wood stove could always come to the rescue on cold nights. Now, if we have an extended power failure in the winter[0-1], most homes are not equipped with wood stoves or coal. Many of us could freeze to death. If we play too much with the energy mix, such as adding too much wind and solar, and shut down nuclear plants, as has happened in Germany, the scenario of winter blackouts is not so far fetched.

90% of Ontario's energy is emission free[0-2]. Nuclear provides 60% and hydro provides 25%. But wind and solar energy are not always available. We unfortunately have chosen natural gas to fill in the gaps. That releases large amounts of CO_2.

Can You Handle the Truth?

The truth is that CO_2 has been accumulating and increasing faster than the oceans can handle. Writing a book like this means I have a responsibility to share what I perceive to be true. Specifically, that we can no longer simply support any random green movement and think it is better than doing nothing. Our tipping point is rapidly approaching. To make our planet whole again means we can no longer simply stop emitting various greenhouse gases. We need to capture the excess accumulation of gases and convert them back to a solid so they no longer occupy the air or the oceans[0-3]

We are faced with a challenge as a human race. Indisputable evidence reveals that we have been too busy using the planet's resources to notice we have gone too far. Technology has given us toys that consume enormous amounts of electricity and fossil fuels. We have grown accustomed to abundant energy. Most people don't even question where their electricity comes from let alone what energy is best for the environment. When the question does come up there is little awareness of the actual energy mix.

Climate scientists and ecologists who endorse nuclear energy are calling on us to take action to reverse climate change. These environmentalists[0-4] have concluded that to prevent the threat to species extinction and quality of life issues that nuclear energy is the best solution. We need zero greenhouse gas emissions. Only nuclear can be scaled fast enough and robustly enough to be able to replace the abundant energy that coal currently provides. Clearly these pronuclear supporters are not afraid of nuclear reactors. How did they become supporters?

It is difficult to step out of the shadow of fear. They say the truth will set you free. Don't take my word for it. Research it yourself. Begin by looking up deaths per kWh (kilowatt-hour) for each energy source. Also look up half-lives and the inverse relationship of short half-lives to radiation intensity[0-5]; how short half-lives make for quicker decay and disappearance of the more radioactive elements. Then look up hormesis and the evidence that small doses of radiation above a certain amount[0-6] actually benefits us. Then try to understand how the excessive safety[0-7] requirement of nuclear plants drives up their cost. The nuclear industry in North America has been subjected to an unbearable amount of scrutiny and interference. Playing into the fears of the average citizen, corporate forces have lobbied to prey on the perceived weakness in nuclear energy. The radiation levels considered safe are based on false outdated information. I'll be explaining more about this in later chapters.

In order for wind and solar to take on the role of replacing coal it would require more raw materials than are available worldwide[0-8]. Also, natural gas has been known to leak. Being a much stronger green house gas it only takes a 4% leakage rate[0-9] to equal the CO_2 emissions of coal.

The effort to do anything resembling a Green New Deal is gargantuan and will likely bankrupt whoever invests. It would be much easier to reform the regulatory system and construction methodology for nuclear energy in order to bring costs down.

Now we have new companies like Ontario's Terrestrial Energy[0-10] showing us the potential of new designs that are even safer than already "very-safe" nuclear technology providing a way to take spent nuclear fuel as an excellent source of energy.

Refurbishing[0-11] reactors is really a complete upgrade, easily doubling their lifespan but also improving efficiency, the physics and the chemistry. No other energy source gets so thoroughly scrutinized. As a result they are the safest and cleanest long-lasting energy sources available. One big advantage is that their power easily equals that of coal, making our quest for an end to coal achievable. The remaining question is whether it will be cost competitive. The thinking process that manifests in very real negative results, is “fear" of radiation which results in an overburdened industry that is far more expensive than it needs to be. Fortunately the new companies have well understood this challenge and expect to build new reactors cheaper than coal.

Among the antinuclear citizens of Ontario there has been a push to seek replacing nuclear energy with Hydro power from Quebec. Recently my friend Steve Aplin of Canadian Energy Issues commented: “Has anybody asked Quebec if they are willing to create another lake the size of Belgium[0-12] to provide the hydro power needed by Ontario? The answer would be a polite no."

The Dalai Lama, James Hansen and countless scientists who support nuclear energy indicate that acceptance is a matter of education. Once we get over the irrational fears of radiation and false connections to nuclear weapons we can then consider how nuclear energy can make a better future.

Chapter 1

Collectively Preventing Self Destruction

One of the biggest surprises I've encountered in dealing with people when I want to share information about energy and the promise of nuclear energy, is that a strange thing happens after the conversation. The people seem happier.

It never occurred to me that in general there are an overwhelming number of people out there who have quietly given up, who think there are no good solutions. Scientifically literate people in particular take a dim view of getting out of this mess. Most people are not going around blissfully happy and totally ignorant of how serious things have gotten. The feeling usually goes unspoken and rarely gets acknowledged. I have concluded that most people expect doomsday scenarios for our future. But many have resolved themselves to the idea that the worst will happen after they die and choose not to share their thoughts about it and in other cases avoid thinking about it.

But if we want to be able to say we contribute, doing nothing is an unrewarding path and places you in the category of a wimpy, somewhat immoral and fatalistic position. With our American way of life, where societal change happens very gradually, it is easy to be convinced that any effort we make to change things is futile. With so many "God-fearing" christians, the real challenge they face is remembering that the lives that matter are the people who still remain when we are gone, and not our own place in heaven. What ever way you look at it, we know large numbers of people are already affected seriously by climate extremes. Most people, especially seniors, feel they will die before the worst happens. But if there was a way to reverse this path to catastrophe would you push for it? Don't you want the human race to thrive and prosper? I think that was the appeal of shows like Star Trek. Writing about a future when people have evolved and solved problems, the message live long and prosper has significant meaning, knowing our existence could continue with a high standard of living. The people in Energy Reality are full of those who thoroughly understand this. They respect the scientific method that has brought us the wonders of technology that has transformed our society. They also know the situation is urgent and choosing a renewable path is like trying to cure cancer with an aspirin.

Succeeding in preventing a disastrous future will be one tremendously big undertaking. The current plan of the people on the liberal side is not much of a plan. The outrageous Green New Deal wants to increase usage of renewable energy while eliminating coal by replacing it with some unknown energy source, presumably replacing it with natural gas. That's only the goal of the left in North America. The Republicans and Canadian Conservatives have a different agenda. With Donald Trump muzzling scientists and pretending climate change is not an issue and Doug Ford and his colleagues in Canada pushing for no carbon tax we have forces working against real change. I propose that nuclear energy provides the solution we've been looking for that both sides seek. Many countries say they want to stop emissions but coal continues to be used at an unacceptable rate[1-1]. As you will see reading on, this presents a serious lack of vision. We need to be much more analytical in prescribing solutions. The decision-makers are letting green entrepreneurs set the policy. I will attempt to clarify why this is a dangerous plan of action and how we can get back on the correct path, closer to a vision we held in the 1950s and 60s.

There are plenty of doomsday scenarios and it is not easy to recognize what needs to be done without closely studying the scope of the situation. It will involve dedicated people to push for extreme measures. We don't have the strong leaders like Winston Churchill anymore who understood how to motivate people into action. During the Second World War after Britain had witnessed the horrific bombings, the occupation of France and the retreat of the Canadians, Winston Churchill finished his long speech[1-2] about how effectively Hitler had defeated so many and seemed nearly unbeatable. Churchill wanted the bickering and the unproductive babbling from critics to stop.

> "... if we fail, then the whole world, including the United States, including all that we have known and cared for, will sink into the abyss of a new Dark Age made more sinister, and perhaps more protracted, by the lights of perverted science. Let us therefore brace ourselves to our duties, and so bear ourselves that, if the British Empire and its Commonwealth last for a thousand years, men will still say, 'This was their finest hour.'"

Our dark age is upon us. The "sinister aspect" is hidden in political agendas. Consequently, a similar kind of challenge exists for us. I hope to show that the path to remediate a sick system is not so unattainable. We humans, as a collective, need to prevent our existence from evolving into an irreversible path. As individuals we need to change the way we think. If governments or corporations want our support we can hold them accountable and insist that they contribute. So I'm after more than just "hope." I'm after giving some direction as to how to contribute to the cause, exactly what I hope you will gain after reading this book.

You might be surprised to find out how the things that really matter to us, like the future for our children, grandchildren and keeping ourselves employed, are also connected to this networking opportunity called the Energy Reality Project[1-3].

You may find that what's missing, the thing that could help you cope, is a sense of unity, a feeling that we're not alone, that when our focus is absent that somebody is still present pushing for the same basic needs. That's why we need to get real with energy and choose to become involved with the Energy Reality Project.

Chapter 2

Energy Reality Project

I started the Energy Reality Project (ERP) about six years ago when I realized that more action had to be taken on solving climate change. I had looked at what the biggest factors were contributing to inaction and realized that the average person was simply poorly equipped to make informed decisions or able to have a dialogue. I had also been inspired by Kirk Sorenson's videos on Thorium filmed by Gordon McDowell of Alberta. I was fascinated, as I learned about what was better about nuclear energy technology, that I was gaining a perspective as to how energy and the ways it was being used was the biggest contributing factor to Anthropogenic Global Warming. It was a true epiphany to see that energy usage was the biggest factor in how our futures unfold.

I was not the only one who realized this. Like everybody who is interested in science I had considered how the popular notions of conservation and lifestyle changes might contribute to reducing CO_2 emissions but I realized that the hardship of living without reliable energy was going to be too great and would be unacceptable to most people. With such drastic measures such as living without electricity, the conveniences we all love and take for granted would be one of the first things to go. We would need to regress. One prevailing thought shone through the doubt. I could see that it would take an enormous energy transition. The amount of abundant energy was the key.

The "reality" was staring me in the face. We have become gluttons for coal burning. What was needed was a tranformation. A renaissance. The unpopular choice would need to become our preferred choice, in fact, our only choice when it comes to solving the climate crisis.

The Canadian Encyclopedia states about energy:

> "Energy plays a unique and critical role in the world; no activity of any kind (no "work") can take place without the movement or conversion of energy. Energy use in society is a flow that begins with a source (eg, coal, uranium, petroleum, the sun) and passes through several intermediate processes for refinement or conversion to a different form (eg, electricity, diesel oil, methane), finally reaching a home, vehicle or industrial plant, where it is introduced into a consuming device (eg, furnace, motor)."

The Al Gore film "An Inconvenient Truth," a documentary made by the former Vice President, who has far reaching fame, did a decent job of explaining the climate change problem. But the organization he formed after the film's success, came to be called the "Climate Reality Project." Their strategy, advocating renewable energy and conservation, fell far short of true reality and solutions that would make a big enough difference. He is still training an army of recruits to go out and spread the word that is only half baked. He calls his trainees "climate leaders" which to anyone respectful of nature and aware of science realizes how arrogant and out of tune that sounds. What can you say about climate? Yes we affect climate. Now what? The message of Al Gore is actually harmful. The mission statement on the website[2-1] says

> “...Urgent action to cut greenhouse gas emissions and speed the global shift to renewables...[2-2]"

Trying to run the world on renewable energy alone, you will discover, is an exercise in futility. When you look at the popular wind and solar solutions more closely you will discover they appeal to those who trust the status quo. The "feel-good" aspect of their so-called "renewable" ability turns out to be a fantasy. Even the word "renewable" goes against the laws of physics. Looking at the origins of the universe we learn that everything originates from exploding stars. The sun is one of those stars that still has billions of years left before its natural cycle ends. Wind and solar are nothing but diffuse secondary energy that has lost much of its energy entering the Earth's atmosphere. Their output reflects their low density which is a small fraction of the world's electricity sources and probably always will be. (See Chapter Eleven on Energy Density)

I realized this when I started comparing wind turbines and solar panels, in terms of power and how much land and resources were needed, to nuclear energy.[2-3]. It was a real eye opener.

It wasn't until I had started the project that I discovered just how much Carbon Dioxide (CO_2) had accumulated. The oceans were our natural buffer without which we would have had warming much sooner. But the oceans are losing that ability. We have a surplus that won't stop doing damage until we return much of the trillion[2-4] tons of excess carbon back to the earth or ocean floor. This gave the project an even stronger sense of urgency. Stop the warming, sure, but also stop the probable mass extinctions[2-5], as if overfishing weren't bad enough. We will need to capture CO_2 from the air to make a significant difference.

It struck me that Gore's choice of words "Climate Reality" were alarmist. In order to recognize the problems facing our planet we need a far better set of words that encompasses a solution, something that also gives us hope. Right now we are given a task to educate ourselves and others. We need ready and willing individuals that need to know they have been fed misinformation. Yes training and self-education are requirements to begin this rescue operation.

Becoming an ERP Member

Energy needs to be discussed in a realistic way that takes into account what science has achieved. If the goal of science is to make a better future then we need to take the scientists and real experts[2-6] seriously and look at what is economical and what is healthy and achievable for the planet.

The energy policy set by Obama was pretty much an "all of the above" strategy that was more politically motivated than it was economical or even logical[2-7]. Now under Trump there is a more hands off approach leaving market forces to determine the outcome. Trump is a climate change denier which leaves fossil fuels like coal and natural gas as acceptable energy policy. There is good reason to collect professional expert analysis to explore what the reality is when it comes to an optimum energy balance and we must recognize how that balance might change. We need to understand how well each technology performs and their suitability to the geography, how much they need in terms of resources, their reliability, how the local weather patterns affect them etc.

The climate scientists and ecologists are calling us into action to prevent climate change. But equally important and perhaps easier to tackle are problems such as the threat to species extinction and quality of life issues. This is another way that attention to your local issues can help. The same actions that are being called upon to prevent species extinctions and other things like cleaner air will ultimately assist in the slowing down of global warming and eliminating the increase in drastic weather patterns and rising sea levels.

We need to develop ways to provide outreach. I think providing a context of where nuclear fits in the larger picture is very important. Yes nuclear scales well, but how well in comparison to renewables? I attempt to answer some of these questions in this book.

Being “proactive" is an important concept. Getting more people out into the public eye, away from their computers is both healthy and socially responsible. In our efforts to advocate for better understanding we need to ask questions. Many of those invited to the group have shared a lot about energy and we encourage more participation.

The Energy Reality Project seeks to help everyone better understand energy and the central role it plays in our lives. The reality is that in a variety of different forms energy is ultimately the thing that makes stuff happen. It is the master resource. It allows us to perform countless useful tasks such as the extraction and processing of raw materials, production of goods by industry, growing and processing food, and transporting ourselves from one place to another. It lights our homes. It allows water to reach our high rise apartments[2-8]. Saves us lugging supplies up stairways by powering elevators[2-9]. It keeps us cool in the summer and warm in the winter. An abundance of affordable, reliable energy is a necessary condition for us to live healthy, happy and prosperous lives. But the unreliable intermittent power sources we currently call "renewable" sources such as wind and solar conflict[2-10] with the smooth operation of reliable base load power.

It is because of these fundamental facts that access to energy and its productive use is what underlies economic systems that, in turn, govern politics and influence the destiny of nations. It is hard to overstate the importance of low-cost energy to our lives, indeed to all civilization. Energy matters. Through a better understanding of these truths we can make better decisions at all levels that will positively affect the future of our families, businesses, communities and country. So, let us roll up our sleeves, delve into the realities of energy!

Gaining Perspective

When we look at the most pressing issues of our time it is difficult to know which ones deserve the most attention. Some problems we can't ignore. There are teams of people who get paid to make reports on weather, power efficiency, demographics about populations affected by coal etc.

We can try and do the research and bury ourselves in data or we can attempt to discover what common solution exists for them all. This book will show how energy is the fundamental factor that ties all these issues together. See Chapter Eleven and Twelve to see how plentiful, cheap, clean energy can solve our biggest problems.

The weather is no longer the talk of idle conversation. It has become a topic of concern because more than ever our lives are affected by the disasters that are happening all over the planet. Everybody knows that something is wrong. Even a ten-year-old is aware that the climate is not as predictable as it used to be. Also most people don't have any idea we already have the technology that can save the planet from ruin.

Our goal is to try to educate as many people as possible about the urgency of making a difference now, before it is too late. Rather than feeling you are too insignificant to affect change, recognize the commonality you have with other equally concerned people, knowing that we can share a technological truth to fix much of what has gone wrong.

You will see in later chapters how the various energy sources fare handling the big problems such as energy shortages, climate change, ocean acidification, you name it. We need to consider what must replace coal plants and natural gas plants. The supplies of natural gas and coal are one factor. There is a limit. Other factors include a true carbon footprint that must look at the whole cycle. It will be important to look at economic analysis. Can we justify overspending for the sake of security and maintaing military power that affects international relations. We need to ask whether the cost is too high to push for inefficient, subsidy dependent intermittent energy like wind and solar and whether some costs are unnecessary such as very high licensing fees and the outrageously expensive application process for nuclear plants. We discuss why energy density makes a difference in Chapter Ten.

The existing coal plants in the US are still far too numerous[2-11] to continue with a "business as usual" mentality. Young people and future generations face a much more degenerate, unsustainable, uninhabitable world. The recent Clean Power Plan which Donald Trump wants to dismantle[2-12] does not go far enough to reduce and shut down coal plants. See Chapter Eight and Nine on a National Energy Policy[2-13].

U.S. and Canada's Energy Use & CO_2 emissions - World Bank[2-14]

2011 Energy Usage by Country		
Country	Energy Equivalent in Gallons of oil/yr/ capita.	Metric tons of CO_2 per yr. per capita
US	7,000 (Canada is slightly higher)	17
China	2,000	7
India	600	2

Information and Misinformation?

Headlines about the planet try to steal our focus while we seek solutions to our daily immediate problems of income and providing a support network for our immediate families and communities.

Problems of basic survival will get in the way of dealing with issues that are greater than each of us. The few moments we do get to ponder about what matters such as global warming, the melting ice caps, ocean chemistry and species extinction, they rarely get a few seconds of notice. If you also happen to be religious you also have your faith crowding your thoughts for their share of your attention.

Are You Part of the Solution?

In the absence of great leadership writers can attempt to enlighten the reader to sort out and simplify what factors will do the most good globally. But you might ask why should we choose a global perspective at all? But we in the west have a loosening of the security we assumed was part of our existence. The bubble is not so tightly bound anymore. We are more aware than ever of how much corruption exists and, apart from security, how many special interest groups are fighting for things many of us would rather not hear about. That, in addition to a weakening of our strength as a nation economically, technologically and socially leaves us in a numb state unable to sympathize with anything outside our personal lives. The global perspective has been simply that we never needed to worry about the whole planet until we made it too sick to sustain us. It really is not so different from cancer. The approach to cancer and other illnesses has been to treat the symptoms but not prevent the illness.

Should We Feel Guilty?

It depends on how much you connect to the pulse. It's not all lost if you occasionally take time out to manage your own life. The sphere of influence that any individual has over what gets attention in a democracy is local, at the community level, and that influence can reach higher levels. But it is the number of like-individuals that actually make the effort which enables the awareness to spread the actionable ideas, moving from municipal, to city, to state, to country, to continent, to various international treaty-bound nations etc. Buckminster Fuller said “Think globally. Act locally."[2-15]

About Becoming a Member of ERP

If you found yourself sympathizing with what I have been saying then that is all you need in order to qualify to be a member. You are already welcome. Share, inquire, reach out, be marginalized because chances are you are already shunned for other reasons. We humans like to pigeon hole others but in a world gone as bad as ours has I personally feel we all need to take action. There comes a point where taking a stand is more important than being accepted by your peers.

Chapter 3

Earth, Air, Water and Fire

> “We are not going to be able to operate our Spaceship Earth successfully nor for much longer unless we see it as a whole spaceship and our fate as common. It has to be everybody or nobody[3-1]." - Buckminster Fuller

One of the most profound discoveries I have made in my entire life is the benefit of holistic thinking. Looking at the history of medicine in the Western world we can truly see that it has been a long path to acceptance of an approach to health and well being that has been a tradition for centuries in Eastern medicine. If we look at the human body and its basic makeup, we are familiar with behaviour for example that recommends treating acne with creams or radiation rather than diet or lifestyle.

Looking at the big picture and preparing the body to harmonize with external factors such as the environment, food habits, sleep habits and cleanliness are more of an Eastern way of viewing traditional medicine. This is just one example of a microcosm of our body within a macrocosm being Earth.

Let's consider a larger microcosm vs. macrocosm relationship.

Earth's Amazing Balancing Act

Here's a thought exercise to make a rather startling point. These questions should get you thinking.

What do you think the chances are of us ever discovering life in our galaxy outside of Earth? During the lifetime of Earth's existence could life forms have been born and died somewhere in our own solar system? What factors gives Earth its unique advantage to be able to sustain life? Considering that we have not discovered life, does this indicate that conditions need to be just right to enable life? Does it not make sense that we have been very lucky to have reached these conditions and that it is quite possible we could join the other lifeless planets if something were to threaten the balance? The mechanisms that exist naturally seem to be intentionally designed to protect life. A reasonable argument for divine intervention.

We know Mars once had an atmosphere and magnetic field. The theory goes that millions of years ago meteors knocked out the magnetic field and solar radiation burned up the planet[3-2].

But something keeps the balance on Earth. There has been an ongoing, naturally occurring nuclear decay happening deep down in the Earth's core[3-3] that keeps it hot and in a constant state of flux that, besides being the source of volcanic eruptions and continental drift, manages to keep our magnetic field active. Naturally occurring shifts in the location, and shifts in polarity, of the poles are evidence of the Earth's constant core activity. But fortunately the magnetic field protects our planet from solar radiation. Ironically this radioactive decay of natural atomic elements, the same activity that antinuclear activists fear so much, is sustaining our planet, keeping us alive by deflecting solar radiation back into space.

But we take Earth's resilience for granted. We have been disturbing the balance of nature for far too long. If we are to learn about how to apply holistic thinking to the planet, we need to look at equilibrium, balance if you will, the microcosm within the macrocosm. For our purposes we'll stick to the Greek view of four elements rather than the Chinese five elements (wood, fire, earth, metal, water.) The natural elements Earth, Air, Water and Fire, as the ancient Greeks called them, still serve as a way to simplify and gain a broad perspective.

Buckminster Fuller in the quote above suggests that humans are piloting Earth and we can somehow determine the path or outcome. Cooperating in a unified manner fully aware of the goal and recognizing we all have a role to play is the only way to navigate Earth back to safety. Finding the harmony may not be possible without drastic measures. Again I'll compare the fictional vision of Star Trek's utopian view. This outlook by Fuller is not that different science fiction writers like Gene Roddenbury. Although some may think it naive, this is the right outlook no matter how unlikely getting humans to unite for a common cause may seem.

The earliest humans lived without the knowledge of Fire. Long before Fire, our more distant ancestors depended on the elements Earth, Air and Water and were happy without the knowledge of Fire. But when Fire was discovered it became such a valuable tool that a lot changed in profound ways. Cooking, processing steel and heating all contributed to improved lives and it genetically enhanced humans due to the better nutrition and health obtained from the cooking process. The handling or mishandling of fire would take many thousands of years before it would become a threat to our overall existence.

Burning coal for electricity and burning gasoline and diesel for cars now have new meaning in this modern era. What was once considered sustainable can no longer be taken for granted. Our growing population and our rate of consumption is offsetting Earth's balance.

Once our electricity supply became so reliable and commonplace nobody imagined it would be putting a strain on our environment. It was never a question in people's minds. The engineers did a good job of meeting a steady growing demand. This "out of sight. Out of mind." phenomenon decades later was going to come back to haunt us.

Of course we no longer think of "Earth" as an element but we know a surprising amount about how a planet's well being is dependent on what goes on below the surface. The steel alloys far below the surface have become magnetized by convection currents. The magnetic field shields the planet from solar radiation and that allows us to keep our precious atmosphere. Molten rock typically rises to the surface of our 4.5 billion year old planet as volcanic eruptions.

But why did the centre never cool? I first came across the following explanation in a book called Terrestrial Energy[3-4]. It explains that radioactive decay of uranium and other radioactive elements cause enough heat to melt the rock. Earth is bigger and warmer than Mars but evidence indicates Mars once had a magnetic field. Why Mars lost its atmosphere is directly related to the loss of a magnetic field. Our planet may be more stable with regard to a field. Also our planet has less violent storms than other planets, more moderate temperature extremes and a greater abundance of water which all seem naturally balanced in quantity and strength.

Our unique status as the only "known" planet with life does indicate that we have just the right ingredients in the right balance for life to thrive. If the margin of error for attaining that perfect mix of oxygen, temperature, weather were very wide then we probably would have observed life elsewhere by now. But, what we have discovered about the universe is that its immensity is much greater than we ever imagined and much of the unreachable regions we are capable of seeing are also a very distant history considering how long it has taken for light from those regions to reach us. So the odds are that among the numerous galaxies the conditions do exist somewhere among them to sustain life but the information, if they even have a modern technology, has not yet reached us.

Consider that life thrives on Earth. It makes this seemingly accidental fine-tuned system seem even more amazing when you also consider that Earth has two naturally occurring systems in place to protect us from harm. First, the atmosphere protects us from objects that burn up in the atmosphere before hitting the surface. We call those events shooting stars. If the atmosphere were not full of oxygen the falling objects (stars) that normally heat up from friction and catch fire would otherwise crash and destroy whatever lie in its path. Second, the Earth's magnetic field deflects solar radiation that would otherwise strip our planet of life and its atmosphere. What we call the solar winds are "naturally" prevented from heating our atmosphere and slowly eroding it away. We should be thankful for this "natural" equilibrium. But what would it take to knock it off balance? Can we gamble with our future? I have heard from experts that the chances of true catastrophic climate change are high. That's a forever event. Does it make sense to ignore the solutions?

It is hard not to mention James Lovelock when discussing Earth. The scientist, inventor, environmentalist who predicted serious setbacks in the "Revenge of Gaia[3-5]" later changed his mind about the extremes of his first book's predictions of severe devastation. At 101 years of age he says it makes more sense to engineer cities to manage the air locally and that trying to fix the whole planet is just too difficult. His view is an extreme view. However he also supports nuclear energy.

The idea of not interfering with nature has had a resurgence with an interesting document titled "The Ecomodernist Manifesto[3-6]." which suggests we should not return to a low tech society dependent on farming and a more simple life but quite the opposite. We need to remember and respect the best values of the indigenous peoples yet unlike environmentalists who romanticize the idea of living off the land we would be wise to consider embracing technology.

The Ecomodernist Manifesto speaks about "decoupling" from nature. The goal we must focus on is using technology to avoid harming nature. Cities are ideal for that since human activity is confined to the city.

> "...we affirm one long-standing environmental ideal, that humanity must shrink its impacts on the environment to make more room for nature, while we reject another, that human societies must harmonize with nature to avoid economic and ecological collapse."

Technology can solve many problems and cities are better ways to organize humans. Again Lovelock uses the examples of ants and bees as understanding how to organize to survive. The hives evolved out of necessity.

Essential to understanding ecomodernism is that we as a planet have been knocked off balance by our own abuses and that “harmonizing" with nature is not enough. We must reverse the effects brought about by our constant insatiable need for electricity and transportation fuels. It will take innovation and technology breakthroughs to do this.

Examples of practical uses of technology are vertical farming. Dickson Despommier sees vertical farms as environmentally sound[3-7] and would allow more manageable controlled conditions for growing food and prevent overusing land that will become more scarce with expanding populations.

We now have living examples of the vertical farm concept in America. The new urban agriculture will provide resilient food systems and minimize the need for land, water, energy and pesticides. The environmental impact will be very low, and their products will be delivered directly to consumers in the city, lowering the costs of transportation. Fresh, local vegetables can be delivered daily directly to consumers at more affordable prices.

Air

We have learned to live with self abuse as a species. Polluted air has been threatening lives from the first locomotives and steamships followed by the first coal plant designed by Edison. The direct current (D.C.) coal fired plant in New York city in 1882 was designed to handle street lamps[3-8].

When the first alternating current (A.C.) plant was developed by Tesla for the Niagara Falls hydro plant in 1885 A.C. was a more efficient long distance carrier of electricity[3-9] and it's use started to spread more rapidly. Hydro power would prove to be a superior method to getting electricity than coal.

With expansion of hydro worldwide we have come full circle and witnessed that we have outpaced ourselves and started to see a decline in available waterways. Dams in the US are drying up. The suitable water sources and land formations that could exploit hydroelectric power have mostly been used up. But hydro is the real success story of the renewable energy sources despite it being limited by topography and weather patterns. Our air has been spared significantly for the number of coal plants their energy has prevented.

London Smog Event - 1953

The idea that coal kills is understood yet the degree and scope of what specific lives are being threatened is not widely understood. The emissions of sulphur dioxide plus soot (particulate matter) mercury, arsenic, lead, cadmium, NO_X and nitrous oxide (ozone) are the worst contributing pollutants. But coal was out of control in London in 1953:

> “...smog begins to hover over London, England, ... in 1952. It persists for four days, leading to the deaths of at least 4,000 people."

> "It was a Thursday afternoon when a high-pressure air mass stalled over the Thames River Valley. When cold air arrived suddenly from the west, the air over London became trapped in place. The problem was exacerbated by low temperatures, which caused residents to burn extra coal in their furnaces. The smoke, soot and sulfur dioxide from the area's industries along with more from cars and consumer energy usage caused extraordinarily heavy smog to smother the city. By the morning of December 5, there was a visible pall cast over hundreds of square miles."

> "The smog became so thick and dense that by December 7 there was virtually no sunlight and visibility was reduced to five yards in many places. Eventually, all transportation in the region was

halted, but not before the smog caused several rail accidents, including a collision between two trains near London Bridge. The worst effect of the smog, however, was the respiratory distress it caused in humans and animals, including difficulty breathing and the vomiting of phlegm. One of the first noted victims was a prize cow that suffocated on December 5. An unusually high number of people in the area, numbering in the thousands, died in their sleep that weekend."

"It is difficult to calculate exactly how many deaths and injuries were caused by the smog. As with heat waves, experts compare death totals during the smog to the number of people who have died during the same period in previous years. The period between December 4 and December 8 saw such a marked increase in death in the London metropolitan area that the most conservative estimates place the death toll at 4,000, with some estimating that the smog killed as many as 8,000 people."

> "On December 9, the smog finally blew away. In the aftermath of this incident, the British government passed more stringent regulations on air pollution and encouraged people to stop using coal to heat their homes. Despite these measures, a similar smog 10 years later killed approximately 100 Londoners."[3-10]

Despite the fact that some will remain skeptical about CO_2 affecting climate, it would benefit us all to recognize its effects on the oceans, whether a temperature catastrophe happens or not we need to fix the air and the water in order to save species extinctions and give us back the quality of life we once had.

Pollutants from Coal Plants

A coal plant emits on average 3.5 million tons of Carbon Dioxide per year. Airborne particles from coal plants have harsh substances that are poisonous such as mercury, arsenic and even uranium. It is estimated pollution from coal causes one million deaths a year worldwide, about 24,000 a year in the US, and that is just humans at a quarter of which are children[3-11].

Sulfur dioxide (SO_2) becomes acid rain damaging crops, forests, soils, lakes and streams. The average coal plant emits 7,000 to 14,000 tons of SO_2 a year. Nitrogen oxides (including nitrous oxide - N2O, Nitrogen Dioxide - NO_2 or ozone - NO_x): NO_x pollution causes ground level ozone, or smog, which can burn lung tissue, exacerbate asthma, and make people more susceptible to chronic respiratory diseases. The average coal plant produces 3,300 - 10,300 tons of NO_x per year[3-12].

Particulate matter can cause chronic bronchitis, aggravated asthma, and premature death. A typical coal plant emits 500 tons of small airborne particles each year and uses 40 traincar loads of coal a day (4000 tons/ day). That leaves behind 500 tons toxic ash per day[3-13].

Baghouses installed inside coal plant smokestacks can capture much of the particulates. But this is not widely accepted or practiced. Coal plants are responsible for more than half of the U.S. human-caused emissions of mercury, a toxic heavy metal that causes brain damage and heart problems. Just 1/70th of a teaspoon of mercury deposited on a 25-acre lake can make the fish unsafe to eat. The average uncontrolled coal plant emits 170 pounds of mercury each year. Activated carbon injection (ACI) technology can reduce mercury emissions by up to 90 percent when combined with baghouses. A baghouse is a type of filtering technology designed to remove most of the particles emitted from coal burning. It is costly and the law does not require it. ACI technology is currently found on just 8 percent of the U.S. coal fleet.

There is also Pacific Northwest National Labs developing several technologies that look promising for dealing with CO_2 and specifically toxic mercury using a method they call SAMMS (Self Assembled Monolayers on Mesoporous Supports[3-14].)

Coal plant emissions

- 114 pounds of lead, 4 pounds of cadmium, other toxic heavy metals, and trace amounts of uranium.
- 720 tons of carbon monoxide, which causes headaches and places additional stress on people with heart disease.
- 220 tons of hydrocarbons, volatile organic compounds (VOC), which form ozone.
- 225 pounds of arsenic, which will cause cancer in one out of 100 people who drink water containing 50 parts per billion

We recently passed the 400 parts per million (ppm) point of carbon dioxide. James Hansen has estimated that we need to return to a balance of 350 ppm to live sustainably [3-15]

Water:The Twin Tragedies

When we say "climate change" we need to understand that it also has a twin and that is "ocean acidity." High carbonic acid levels (CO_2 from coal plants) are killing off the tiny creatures such as pteropods that are vital for the food chain which if they disappear and go extinct would have a devastating effect on other dependent creatures.

(See chapter 5 section 1 on ocean acidity.)

Why do we let the oceans become less and less inhabitable? Fish in some regions are being banned because of their high levels of mercury[3-16] caused mostly from coal emissions.

> "The Eight-hundred-pound gorilla behind virtually all of the 'sustainability challenges' is you and me, the consumer. The problem is not that we are bad but that we have been blind to the impacts of our everyday choices. New information technologies and growing public concern are awaking our intrinsic desire to do what is right to shape a healthier world for our children and grandchildren[3-17]." - Peter Senge

What seems pretty evident about human nature is that if we can't see it, feel it or smell it, that we tend to ignore it. This is evident by our lack of treatment of sewage. In Canada we have 400 cities and towns[3-18] that dump their sewage directly into the local lakes, oceans and rivers. People just flush the toilet and forget about it. That needs to change.

In an article[3-19] on the Global News website dated May 13, 2013 it says:

> “Last year, Environment Canada announced new federal regulations that say primary treatment plants don’t cut it anymore. Now, cities must use secondary wastewater treatment or better to remove bacteria and other things that have dissolved in our wastewater. Similar wastewater standards have been in place in the U.S. for almost 40 years..."

> “...Cities across Canada have been given a deadline of 2040 to upgrade their plants, but many are left wondering how they will pay for costly upgrades required to meet the new standards."

This kind of lenience is a sign of the times. The sense of urgency about stopping the abuse of the land, water and air is far too slack.

One recommended treatment is a small reactor that handles waste and gives electricity to the grid[3-20]. There are two ways a reactor can assist. One is the process heat from a small modular reactor and the other is using Cesium to irradiate the sludge that can later be used in agriculture.

Fire

Fire is known to have been commonly used as recent as 400,000 years ago. The marvels that were accomplished and the tragedies that fell are numerous and not the goal of this chapter to discuss. But as technology advanced, skipping ahead several hundreds of millennia, fire became replaced by electric stoves and microwave ovens. Such possessions became commonplace to people of the affluent nations[3-21]. Meanwhile the overpopulated poor in countries such as India are scrambling for cheap energy based on fire by burning dung and scraps of wood when their income status gives them little choice. How many die a year from indoor fumes?

Now there are 7.3 billion people with most countries knowing that fire and nuclear power are common ways to get power yet many of their people are without electricity. It has been estimated that with the current rates of production that Earth is overpopulated by 5 billion people[3-22]. Mathematically the maximum sustainable population, if resources were used properly, would be 4.1 billion which suggests we have gone past the emergency levels by 3 billion people. Africa (1.1 billion), India (1.2 billion) and China (1.3 billion) all have populations adding up to about half of the world's people. While the west's standard of living lowers and the disappearing middle class seems to be evident, the east is beginning to prosper. We are seeing their poverty quickly being replaced by a working class and examples of wealthy business owners in communist China. But progress has its challenges. In China where prosperity is growing the fastest, coal plants were being built at a rate of two coal plants per week in the first years from 2000-2004 and has reduced to two coal plants per month in more recent years with so-called committment to reduce their emissions. [3-23] This causes serious health issues and deaths.

Meanwhile CO_2 is causing global warming and a serious pH imbalance in the oceans. India is slower moving toward prosperity with the top 10% holding 75% of the wealth. But the United States has a similar distribution of wealth the top 10% hold 65% of the wealth but the extremes are greater in India since their highest 10% holds 370 times as much as the lowest 10% whereas in the United States that separation is much lower roughly 12 times[3-24]. Clearly India has a much bigger problem enabling their masses to rise out of poverty.

There is a way to answer our problems that makes sense in a world gone out of control. The answer lies in the form of an emissions-free, abundant, responsible and practical energy choice, nuclear energy. Our group has paid special attention to molten salt reactors or MSRs (more later) which had their introduction back in the late 1950s and went through several stages of prototypes at Oak Ridge National Laboratory under the leadership of Alvin Weinberg.

But the promise of the atomic age has been slow (See YouTube video "A is for Atom"[3-25].) Nuclear energy can do a lot. With enough nuclear plants we can clean up the air, the oceans, the abuses to the land (whether it be the destruction of habitats from mining, methane release from fracking or steel monstrosities erecting wind "turbines" or habitat destruction by solar farms), improve education, lower populations and eliminate poverty. You don't believe me? Read on.

The New Fire[3-26]

There are many misconceptions about nuclear energy. Some anti-nuclear people want to blame science, painting it as evil for creating nuclear energy that in their narrow view can explode like a weapon. This a totally false perspective. Just because we can create nuclear weapons using our knowledge of nuclear forces does not mean that nuclear power plants can explode[3-27]. We return to this in Chapter 4.

Tracing the origins of the universe we now know that nuclear forces existed billions of years ago before the earth was formed 4.5 billion years ago. The elements we are made of were born in those early stellar explosions. Radiation was born long ago, along with the big bang, at the beginning of this universe (it apparently took a while before radioactive elements formed but it was close enough to the beginning), and it is still all around us. What we call background radiation comes both from the skies and the ground which was born long before the birth of our planet.

Recently it was announced that natural gas just passed coal as the biggest provider of electricity in the USA[3-28]: 33% natural gas, 31% coal, 19% nuclear and 13% non-hydro renewables. (add pie chart clarify hydro and renewable) This is a baby step forward.

Nuclear fission as an energy source has had a slow start since the technology first arrived. The excitement over nuclear energy precedes WWII. There was hope that an atomic age would provide limitless power and therefore comforts and wealth.

For example, the reality of science explains that nuclear energy is an abundant and carbon free energy source that outperforms all other energy sources per unit of fuel, as well as power plant longevity. It has many other advantages we will look at. If you are skeptical, please suspend your disbelief until later.

There are 20,000,000 lives per year[3-29] saved by using medical procedures that use radiation. There has been 1.8 million lives saved because of the zero emission nuclear plants that replace carbon dioxide and other pollutants from dirty coal plants and James Hansen predicts saving 7,000,000 by 2050 if we replace carbon emitting power plants with nuclear power[3-30].

Unlike what most people think, nuclear energy is not closely related to the production of nuclear bombs[3-31] and people falsely imagine mysterious radiation to be threatening our existence. The only thing in common between nuclear plants, nuclear bombs and nuclear medicine is the science of atoms but all three are totally separate fields and disciplines. See Chapter 14 for more details. Throughout the book we will return to discuss whether fear of all things nuclear are justified.

Fear of phantoms, ghosts, shadows all have to do with fear of the unknown. The truth is that radiation is a fundamental necessity to keeping our planet alive. The film called Independence Day had the aliens defeated because their immune systems were not designed to handle Earth viruses. We have plenty of invisible activities occurring in our bodies every second. We are equipped to deal with a lot of tiny invasions on our cells. One of the ways our body defenses works is DNA repair and surprisingly it is chemical activity that does the most damage. Radiation will also damage DNA but it happens to a much lesser degree. Read Chapter 12 to read about the wonders of nuclear science and radiation.

The following is taken from an article by a creative thinker who calls himself NNadir, a writer about the science, chemistry and power related to nuclear energy:

> "If we note that the upper mantle constitutes about 10% of the mass of the earth, generally taken to be about 5.97 × 1024 kg, and allowing for the decay of uranium since the formation of the rock, the value given in reference 2 for the uranium content of the mantle 4.5 billion years ago, 0.0117 ppm, suggests that about 3 trillion tons of uranium now exist in the upper mantle, never mind the planetary lower mantle, never mind the outer and inner cores. Moreover the existence of this uranium, along with thorium and radioactive potassium, provides almost all of the Earth's internal heat, an enormous amount of heat, the heat that drives plate tectonics and thus accounts for all the earth's land mass on which the human race evolved.

> If this planet had not formed containing a vast amount of uranium, neither the text here nor the

eyes that read it could exist, since without it, human beings would not exist, and not existing, would be thus deprived of their ability to fear their own extinction. As a result of the heat generated by the decay of uranium, thorium and radioactive potassium — said heat dominated by the former — all of the layers of the earth experience convective flow and we may presume — we know this to be true for the mantle-crustal interface — elements exchange between layers as if the each of planet's layers were continuous extraction devices. The energy content of the uranium in upper mantle, were it converted to plutonium and fissioned — the heat it generates comes not from nuclear fission but from the far more inefficient process of alpha decay — is roughly equivalent to the energy output at current levels, 520 exajoules per year, to about a trillion years of human energy consumption, although neither humanity nor the planet will survive that long.

“A little less than 5 billion tons of this uranium, at little more than 0.1% of what's in the Earth's upper layers, has leached into the earth's oceans, limited only by the solubility of uranium in seawater. Any attempt to remove this oceanic uranium would be futile, again, since volcanism and weathering of crustal rocks continuously cycles mantle and crustal uranium to the oceans. Seawater is thus probably the most sustainable resource for supplying uranium indefinitely"[3-33].

Chapter 4

An Uncompromising Reality

"The discovery of nuclear reactions need not bring about the destruction of mankind any more than the discovery of matches.[4-1]"

- Albert Einstein

The Obstacles

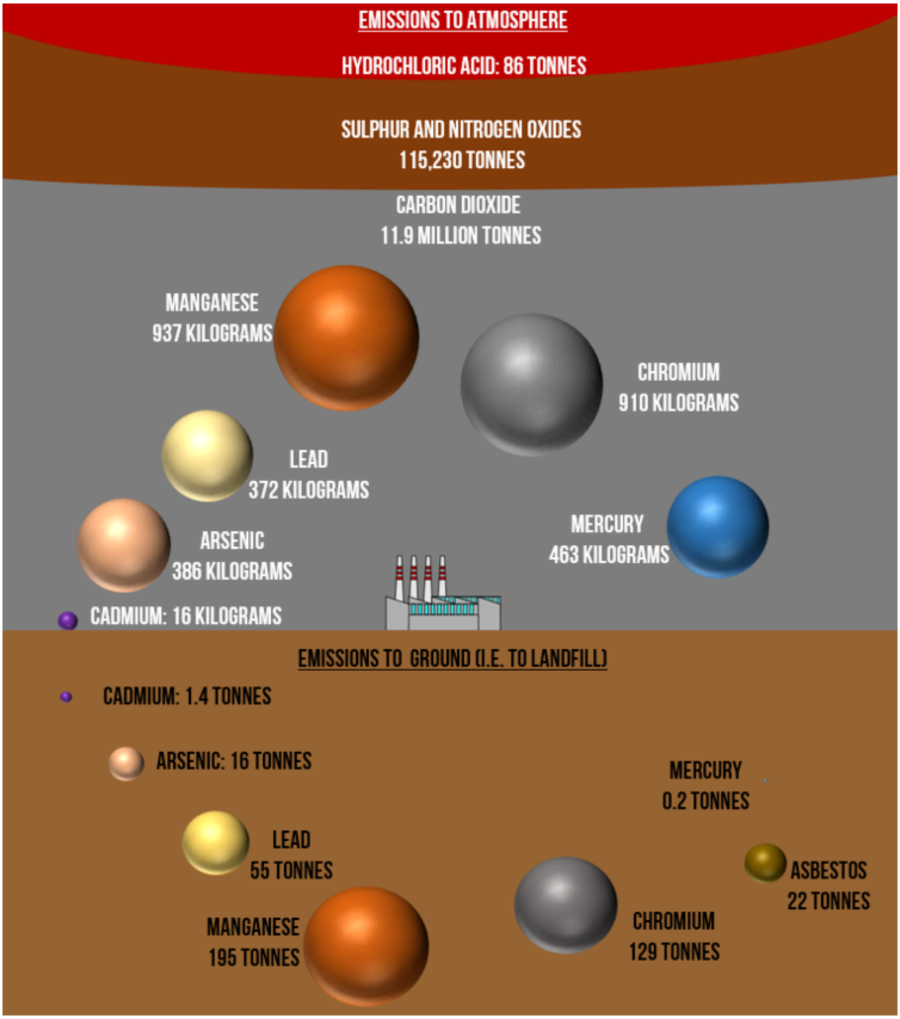
There are many reasons that this miracle of science has not flourished despite the wishes and intentions of people like John F. Kennedy and others.[4-2] The lack of a standard nuclear reactor type. The decentralized political system. The uninformed public. The antinuclear lobby. A strict regulator. Political interference. Construction costs. The list goes on. But central to most of the road blocks is a lack of public awareness and fear of the unknown.

Einstein was intensely aware of his role in the creation of the atom bomb[4-3], however indirect, but also of the benefits that this new science entailed, whether it be medical breakthroughs or the generation of electricity. To his horror his discoveries not only held great promise harnessing of the atom for humanitarian benefits generating electricity and providing isotopes for medicine but also the atom bomb. In the quote above he is saying it's what we do with technology that becomes either destructive or beneficial. The choice is ours. Einstein also has been quoted about the capacity of human stupidity and I'm sure he would be sad to see how we have brought about climate change and its twin tragedy ocean acidification (more on this later) and plethora of other Earth maladies.

Our biggest problem is collective blindness. The willful ignorance is frightening. In terms of the probability for self destruction, it need not be nuclear weapons that destroys us, more likely, it will be our contribution to these Earth illnesses that finishes the job. The path we have taken is one of willful ignorance, neglect and indifference. As a civilization we continue to behave in the manner to which we have become accustomed, the same lifestyle that brought about climate change. Summing it up, our attitude of neglect, wastefulness, selfish pursuits of instant gratification, exploitation of resources, consumerism and hedonism have had an impact that seriously threatens human existence.

The role humans have played in affecting climate change and ocean acidification is pretty clear. We have all heard the warnings [4-4] and shrugged off responsibility. It has taken us a while to recognize the basic cause and effect of global warming. Mostly it is the direct result of fossil fuel burning. We have been asleep at the wheel. The burning of dirty coal is high on the list and transportation fuel not only produces CO_2 but toxic substances and other greenhouse gases.

Ground and Air Pollutants from burning coal in Saskatechewan



Also, burning gasoline and heating our homes with natural gas and oil seem like innocent activities to most, but they also emit CO_2 and adds up collectively. As a greenhouse gas CO_2 is accumulating the fastest and is understood to be the most prevalent greenhouse gas. We are to blame because we continue to use these fuels. They have contributed to the constant building up of Carbon dioxide. CO_2 is the most plentiful of various greenhouse gases in the atmosphere (over 400 parts per million). The oceans have absorbed a lot of CO_2 acting as a buffer. The natural ability of the oceans has prevented an otherwise much faster global warming, and consequently a lowering of the ocean's pH level. This lowering of the ocean's pH and global warming has begun the process of massive sea life extinctions.

Awareness of the problem created by greenhouse gases is common knowledge but news of the backlog and future effects have snuck up on us.

A CO_2 backlog?

Even if humans stopped causing CO_2 emissions today the existing excess CO_2 and the backlog in the air and oceans would take centuries[4-5] or millenia to complete its natural cycle where it is returned to solid form in the ground and ocean floor. If by some incredible cooperative effort we somehow managed to stop burning stuff and stopped contributing to the existing trillion tons of CO_2 not yet dissolved in the seas tomorrow, the warming it causes will not stop. Stopping all combustion would mean stopping coal and natural gas plants, commercial airlines, automobiles, industrial processes that use combustion, even your reading light by your bed could be powered by combustion if the energy comes from coal. It is not good enough to cut back. A reversal is what's needed. All the coal, gasoline, coke, oil, biofuel, cement and steel production require combustion and that is exactly what needs to stop.

But many of these processes could be sustainable if they used nuclear power for electricity that would charge car batteries and the molten salt reactor possibilities of industrial heat to produce low carbon fuel and create better ways to accomplish common industrial activities.

Raise the alarm bells!

Some scientists warned us. In fact one scientist who will come back to our story again. Alvin Weinberg, the inventor of the light water reactor and the molten salt reactor, predicted that our over use of coal could have serious consequences back in 1974.

The obvious early warning signs of the effects of climate and ocean change are rising sea levels. Parts of New York city have started flooding due to the constant rising. Sea levels have risen 70% more rapidly since 1993.[4-6]

In a video news release President Obama spoke of his plans for attending GLACIER[4-7], a conference held Aug 30th, 2015.

"Climate change once seemed like a problem for future generations, but for most Americans it's already a reality – deeper droughts, longer wildfire seasons, some of our cities even flood at high tide," he said...In Alaska glaciers are melting… the hunting and fishing upon which generation have depended for a way of life and their jobs are being threatened."

But the politicians are still playing politics. They can count on the fact that the public does not fully understand how extreme the problem has become. It is right to take action but the size of the problem continues to be swept under the carpet. U.S. diplomacy has failed in winning allies regarding fighting climate change. Stating that the problem is serious and then proposing countermeasures that amount to very little is a typically political maneuver. The reality is a pandora's box, too big to confront and not within the scope of even one election cycle. To be set on a course of extreme action is just too big an issue for any future political leader to dare handle. However we have seen for the 2020 election campaign a more daring election platform for both election reform and a promise to implement nuclear energy by Andrew Yang and Cory Booker.

James Hansen of NASA Godard Institute for Space Studies started officially recording global temperatures on 1981. His most well known testimony before congress in 1988 did the most to raise awareness of global warming. He also wrote a paper in 2003 called "Can We Defuse the Global Warming Time Bomb?"[4-8]

How We Measure Success

Most people would agree that technologically we, as a civilization, have come a long way. But if we were to measure how much of a difference any particular technology has made to our lives, nuclear technology might be the greatest of them all.

The engineers who designed and built the first nuclear reactors learned to apply science that was based on layers of engineering in many disciplines never seen before. They built the ultimate machine that could transform a "rock" into immense power. Power that could be extended, controlled and sustained for decades refueling once a year with some designs (i.e. CANDU) that never needed to shut down[4-9] during refueling. The largest plants are strong enough to supply all the electricity needs of an average city. That rock was no ordinary rock. Some of the proposed 4th generation reactors we will see next decade will only need refueling every 4-7 years.[4-10]

The irony is that the same science that led to the atom bomb is the same science that could lead to a solution that saves us. We already know that nuclear medicine is a field that has saved millions. Nuclear power plants have been a very important substitute for polluting coal plants. That alone goes a very long way to providing part of the solution. The atomic age is here but not nearly at the level it could be. Looking at the science of using uranium for bombs and the science of using uranium for creating energy are two distantly related and very distinct disciplines. We can't let our fear of nuclear bombs affect our path forward with nuclear power and nuclear medicine. (See Chapter Fourteen)

Effects of Resource Wars

When you compare spending on defense and military between countries we can see that most of the biggest countries feel the need to protect their sovereignty. The US spends trillions on defense, spending that could otherwise go far towards solving the energy crisis for example or replacing coal with nuclear. The misguided funding of the government military and defense sucks the life out of the economy and the competing government departments who get stuck with comparably pitiful amounts.

Overcoming Irrational Fear

The way James Lovelock describes the fear is that nuclear radiation is mistakenly connected to cancer[4-11]. We have all witnessed the effects of the disease. We live with a contradiction and most of us have witnessed that radiation can even cure cancer. We have been told it can cause cancer but, in truth, not so easily. Our bodies have evolved from a time when radiation was even greater than we now deal with in our modern daily existence. Remember that we have radiation around us all of the time. Our bodies deal with far more chemical assaults than radiation assaults. In fact many scientists have concluded that radiation below a certain level is actually beneficial. The common items we come in contact with daily do not harm us even though they emit radiation.

Things like bananas (any foods with potassium), granite, marble, the sky, the sun, the earth, the sand on the beach, the ocean we swim in all have radiation. You remember the nuclear bomb tests that took place in the ocean, the air, underground? (Some exceptions of course took place but even expert Richard Rhodes says its the fires that do the most harm[4-12]) But, how is it possible that we have not had massive illnesses from radiation exposure to fallout? The reason is that the radiation is diluted to levels that we already routinely deal with on a daily basis so it has no consequence. This is also true of rarely occurring nuclear accidents. In fact coal plants are far worse. Coal emits all kinds of toxins including, you guessed it, radiation. Keep in mind radiation has a halflife. It disappears eventually. The chemicals like mercury, sulphur and arsenic that are emitted by coal plants are forever.

Innocence to Disillusionment

A lot happened in nuclear science while we were not looking (See Benefits of Nuclear Science in Chapter Twelve). It does raise some questions. What happened? What caused the industry to forge ahead scientifically without making the science and mathematics more accessible? How did the public's grasp on the science become so distant?

Our fears have affected the outcome of the dream of an atomic age[4-13]. Even the medical world has been affected by the attitude towards nuclear plants. Such a slowdown was triggered by unfortunate circumstances. As a result of misunderstood mechanical failures in two nuclear plants (three if you count the more recent Fukushima) the industry became heavily regulated, over politicized and over scrutinized in an already over-regulated industry.

The Boomers

The 1950s expanded and ushered in a real consumer and commercial age. It was a baby boom era that created a market frenzy that flaunted the products and lifestyle of the American dream. Images of stay-at-home housewives and the working husband became a frequent part of the ads in magazines and on sponsored television. Symbols of prosperity, innocence and hope clashed with those of the civil rights movement and the witch hunts against communists.

The depiction of the Russian adversary in films and news about a growing arms race heightened the fears. The rapid scientific advancement and military expansion on both sides as well as attempts to justify aggression both abroad and against the so-called communist sympathizers produced deep psychological damage that would have repercussions in more than just America. The Middle East, Korea and Vietnam all became the stage to play out the drama of building American military might and the policing of the free world against communist expansion.

Lessons Learned?

A lot of traditional values slipped away when mass media started to dominate our daily routine. At first it felt good economically because people had plenty of disposable income. But a lot started to change as the period of innocence gave way to cynicism. We started to recognize hypocrisy. We had been raised on a phony ideal. What was labeled the "me" generation emerged. Divorces skyrocketed and children with single parents became quite common.

The ideal of being wholesome, law abiding and self sacrificing was the message coming from the establishment as to the best path to follow, but after experiencing a lack of similar sentiments in return we began to feel betrayed. The preaching and the doing has not been consistent. It has eroded our confidence in the system. But the system is supposed to be democratic. Do we let democracy perform as it should? How might our wishes be better represented? More on this later.

What Stifled Progress?

In order to see how silence, secrecy and the Cold War we need to go back to the root of the problem which produced a generation of anti nuclear citizens. It began with the second world war, the Manhattan Project (1939-1946). It was a project to develop the atomic bomb. Done in secret, the best scientists from around the world were assembled.

How it happened and why it happened is generally understood. It was wartime. But that secrecy is what drove a wedge between public understanding and scientific advancement.

A great deal was accomplished in those few years. A very large body of scientific discovery was known by only a limited number of people and kept secret for several decades.

Glenn Seaborg had started to report on the properties of thorium and uranium in 1939. His big breakthroughs in 1942 were with thorium and plutonium. Seaborg knew that he had made a startling discovery and saw its potential for powering electricity for peaceful purposes. But his discovery that Thorium could create Uranium 233 was overshadowed by his discovery of Plutonium.

Thorium had the promise of being used for peaceful purposes but the bomb fuel, plutonium, became the focus till after the war. Thorium became the motivating purpose for the molten salt reactor over a decade later under Alvin Weinberg's Molten Salt Reactor Experiment (MSRE).

Ironically the military quest intervened once more in the late 40s when it was requested that a nuclear powered airplane be designed.

The years following the 2nd World War were generally positive about the prospects of an atomic age. The public had visions of a very modern and affordable future. But the contingent of an uncertain future with an aggressive Russian leadership kept the US military leadership on a continuous R&D effort to hold onto its military advantage. The next goal was the Nuclear Energy Powered Aircraft

(NEPA) under General Curtis. He had commanded the bomber attacks on Japan during the war. Conceptually the idea was to be able to keep a nuclear bomber aircraft airborne indefinitely, unrestricted by fuel limitations. There were several designs being considered. The idea was tested for a short time and it was dropped and picked up again later.

Weinberg had a long standing position as administrator at the Oak Ridge National Laboratory from 1945 to 1973. Just like many of his colleagues he had worked on the Manhattan Project.

In Weinberg's The First Nuclear Era he says "as I think back on Wigner's design of the Hanford plutonium-producing reactors, I can think of only one analogy: Mozart, who would compose a piano concerto in a few days. The whole thing was accomplished in about four months...the entire conception was mind-boggling- a chain-reacting pile producing 500 megawatts at a time when no one had operated a critical pile at any power… we can hardly imagine the sense of strangeness that pervaded the enterprise in 1942."

A smaller reactor was now being considered for flight. Weinberg knew it was not a smart idea for a few reasons but he welcomed a chance to develop the technology to become a better reactor than his first invention the Light Water Reactor (LWR) which eventually became a huge success on submarines and aircraft carriers and eventually civilian commercial reactors.

Since the light water reactor had been declared too heavy for flight a new design was requested and that is when the MSRE was born. What was called the Thorium cycle that produced ^{233}U had been determined to be unsuitable for nuclear weapons.

But the design concept was radically different from any previous reactors. The fuel was blended with a molten salt mixture and it so happens that uranium 233 was the fuel of choice but prepared in a separate research reactor. The eventual development of thorium processing would depend on getting the green light to develop a commercial reactor. The thorium cycle produced ^{233}U, a fuel much less desirable for weapons, and it held the promise of a cheaper to build, more efficient and even safer reactor. Alvin Weinberg's focus on reactor safety and his strong preference for the molten salt reactor designs went against the more favored nuclear design, the Light Water Reactor. It was what led to his being fired.

Much of the library at Oak Ridge National Laboratory (ORNL) consists of thousands of pages that remained classified until the 1990s. This whole field of science had stayed secret while a new generation of engineers and scientists knew very little about it. Glenn Seaborg referred to the secrecy of the time as "small islands of technical information sealed off from the rest of society."

In a book titled "Neutron's Children: Nuclear Engineers and the shaping of identity" Sean F. Johnston states "Previous studies of secrecy in the nuclear field have focused on those vocal and visible members of the 'atomic scientists movement' who actively promoted internationalism and progressive ideals during the post-war period, or on contemporary weapons designers. By contrast, the effects of secrecy on their cousins the engineers, technicians, and other skilled nuclear specialists, who arguably were even more affected, kept them relatively voiceless and unexamined." … "Like medieval monasteries, wartime and post-war national laboratories in the USA, UK and Canada promoted distinct regional variations, they were not founded primarily with economic motivations, but on locally nuanced and isolated intellectual foundations; they combined idealism with pragmatic duties; and they served a strong central authority."

The knowledge gained from developing and processing the fuel for weapons during those early war years prepared the way for commercial reactors. But the secrecy caused a gap in understanding which led to the myths about nuclear energy and atomic science. This grew into a backlash that prevented us from benefitting from the full potential that nuclear technologies capability promised.

The quest for military power and the propaganda machine was certainly an obstacle. Various leaders and men in positions of power took on roles that were strategic for developing a superior military force and providing a technical knowledge that unintentionally became a part of a knowledge resource for positive change. President Harry Truman back in 1946 wanted nuclear research out of the hands of the armed forces and switched to civilian hands. This was a controversial issue and remained a divisive issue for decades to come. The Eisenhower years also started an initiative around the need for expanding nuclear energy with the Atoms for Peace program. Kennedy, Johnson, Nixon and Reagan had positive outlooks for nuclear energy. But not enough to stay the course.

There were other factors, such as the hubris that accompanies any specialized field, that played a role in causing the delay of nuclear science advances reaching the public as well as contributing to a growing mistrust of scientists.

Science has grown and fragmented into an unimaginable number of fields and specialties. This trend has blossomed to a point where any member of the public is challenged to keep up. But energy is fundamental just like food and money. So the basics of energy need to be learned early. Now more than ever nuclear energy must play a role in restoring Earth to an ecological balance.

In light of this we need to understand what other obstacles also prevented acceptance of nuclear energy. These obstacles have their roots in anti nuclear groups and individuals. The original antinuclear groups never confused the two technologies of nuclear weapons and nuclear energy. They simply wanted to ban the bomb. But with growing consumerism and personal possessions adding two or more cars per household began to make the oil companies very wealthy. They were so huge and wealthy that they made the nuclear companies seem commercially insignificant. But for the oil companies it was the prospect of nuclear energy taking some of their valued business away.

So joining the propaganda effort were the corporations who saw nuclear energy as a threat. On one hand you had the propaganda justifying the war machine and on the other you had a rationale designed to slow down or stop nuclear energy in order to ensure continued profits from oil and coal.

In conclusion a lot of the blame for the sins against the environment sits with corporate greed, the military complex and the growing gap between the public and scientific community. We can begin to see that turning a blind eye to important trends had repercussions. To ignore the warnings of people like Alvin Weinberg who wanted a better nuclear reactor that was potentially cheaper and safer and therefore more able to bring on the atomic era was a sensible vision in retrospect. Knowing that climate was changing was not a major concern for very many.

Walk the Walk, Talk the Talk

We have had it lucky in North America. We have been the envy of many nations. Our comforts seem to have come easily. Credit goes to the engineers and designers for their clever innovations and inventions. But still, we are spoiled with energy.

Most people take energy for granted. The first big lesson we need to learn is getting a sense of what it's like to have energy poverty. We understand very well what it's like to have energy wealth. Televisions, computers, stereos, microwave ovens, dishwashers, giant freezers, heating, air conditioning, battery chargers and the list goes on and on. If you live in a city you have traffic lights, sports bars running eight or more giant TV screens with different games being broadcast, elevators, escalators, coffee makers, electric trains, electric pumps to send water into all those high rise buildings and the list goes on.

The United States and Canada have been the biggest energy consumers in the world per capita. According to World Bank[4-14]:

Equivalent of Gallons of oil/yr/capita. (2011)

- US - 7,000 (Canada slightly higher)
- China - 2,000
- India - 600

The metric tons/yr/capita of carbon dioxide emissions:

- US 17
- China 7
- India 2

In the next 20 years power demand in developing countries is expected to increase by more than 250%, in industrialized countries, however, only by 37%. That's a growth rate of more than double for developing countries and not much more than a third for localities in North America.

Per capita energy consumption for India shows you what energy poverty looks like. Blackouts and brownouts are normal in India but even more common is no electricity at all.

Blackouts are pretty common across the U.S. as well. Facts on blackouts from Issues in Science and Technology magazine:

"The average U.S. customer loses power for 214 minutes per year. That compares to 70 in the United Kingdom, 53 in France, 29 in the Netherlands, 6 in Japan, and 2 minutes per year in Singapore. These outage durations tell only part of the story. In Japan, the average customer loses power once every 20 years. In the United States, it is once every 9 months, excluding hurricanes and other strong storms.

Despite decades of sober technical reports written by investigation teams in the aftermath of blackouts, the frequency of electric power outages in the United States is no less today than it was a quarter-century ago. Whether measured in terms of city-sized blackouts or smaller events, the statistics show that reliability has not improved. Indeed, if the data shows any trend in the past few years, it is toward lower reliability.

The causes of outages in the United States show there is considerable room for improvement. If outages from major storms are excluded, the causes of each hour of outage include equipment failure (24 minutes), as in the 1965 Northeast blackout; untrimmed trees near power lines (6 minutes); and mistakes by power company personnel (4 minutes), as in the 1977 New York blackout and the 2005 Los Angeles outage. This history of blackouts creates ample public demand to increase reliability, opening a window of opportunity for the industry[4-15]."

Quick Facts

Government has always played a role in energy supply. This is a handy list to keep when accusations fly about expensive nuclear power getting subsidies:

Subsidies in the US

Subsidies from 1950 – 2006 (56 yrs)

- Nuclear energy > nine percent ($65 billion),
- Renewable energy > six percent ($45 billion) (~30 yrs)
- Coal > thirteen percent ($94 billion)
- Hydroelectric > eleven percent ($80 billion)

- Provided by NEI

The components of a wind turbine are not as clean as you imagine.

- 200-378 Tonnes of steel
- 1 tonne of coal used to make 1 tonne of steel (we know coal kills)
- 1000 tons of concrete for the base
- 200 kg of coal per tonne of cement
- 200 tonnes of coal for the concrete base
- 400 tonnes or more of coal for a single wind turbine
- 131 tonnes of coal kills one person
- before the windmill even begins to operate it has effectively killed 3 people based on how much coal is used to complete.(my own calculation)

- for the same amount of electricity produced, wind turbines require 50 times more steel and 60 times more concrete than nuclear reactors.
- Seven hundred lbs of coal will keep a 100 watt light bulb glowing for a year
- A ball of thorium the size of a golf ball can supply one person's energy needs for a lifetime.(assuming it is a molten salt reactor)
- One ton of natural uranium can produce more than 40 million kilowatt-hours of electricity. This is equivalent to burning 16,000 tons of coal or 80,000 barrels of oil.

Chapter 5

Energy Does It All The Most Urgent Problems

The claim that nuclear power can solve our biggest problems may sound far fetched but let me share my thoughts. Before the predictions of harnessing the atom for power, as far back as 90 years ago, any such claims of energy providing solutions may have seemed dubious. What's changed since the advent of nuclear reactor design circa 1950 is a shift toward what's called Gen IV designs where reactors now have potential to be specifically used for applications that, up until now, required fossil fuels to provide economical production. Figuring out ways to use the byproduct heat, stimulates the imagination. It has the potential to provide numerous solutions where either heat or electricity can be applied in areas that previously were too carbon intensive and costly to satisfy new emerging clean industrial standards. The capability for new reactors or retrofitted old reactors totally changes industrial processes. They no longer need to be carbon intensive. The problems outlined below are solvable largely because nuclear reactors provide, directly or indirectly, a way to meet our ecological and economical needs.

Ocean pH and Ocean Warming

Part of growing up over the last 60 years included, for most people, watching nature specials on TV. We caught some spectacular scenes of underwater life that demonstrated how wondrous and alien-like life in the oceans can be. More recently the internet has added vast numbers of video clips and images. One of my more memorable recent visual moments was that of the adorable tiny creature known as the Sea Butterfly also called a Pteropod. One of the endangered species caused by the oceans absorbing CO_2 and changing the pH balance.

The world of home video and advances in photography have brought us high resolution and brilliant images bringing the incredible world of underwater sea life to large monitor screens. The sad part about it is that we are seeing much of this life for the first time and yet their very existence is seriously under threat of extinction in the near future.

We never imagined that during our growing up days that we had been contributing to the decline of the oceans. Over the last sixty years there has been a serious decline of ocean diversity at continuously accelerated rates. Extinctions have taken place at an alarming rate. Coral graveyards exist where life once thrived. Pteropods, Krill and Plankton are quickly disappearing. We really do have a tendency to ignore things we can't see unless we are told they pose a direct threat. The reality is that we have it backwards. Not only are we causing climate change but we are a direct threat to the oceans. We are the invasive species. Seeking more and more energy as cheap as possible unfortunately comes at a cost to the environment because it leads to coal usage. This unfortunate choice rather than nuclear power has become a destructive invasive habit. The nearly zero risk of radiation is a very small problem by comparison. And we add to the problem with our overindulgent lifestyles. We have become pests of the Earth.

Triple Threat

As a result of increased carbon dioxide caused by human consumption there are three things affecting near-surface life. 1) Warming, 2) acidification and 3) reduced oxygen called deoxygenation. The creatures affected most, initially, are tiny but vital to the food chain. But just as important their life cycle provides natural carbon sequestration.

Warming of the Oceans

The most obvious effects of ocean warming will be the loss of ice and therefore the creatures who thrive in these icy regions. Polar bears and penguins will go extinct.

Warmer seas also lead to melting from below of polar ice shelves, compromising their structural integrity and leading to spectacular shelf collapses. Scientists also worry that warmer water could interrupt the so-called ocean conveyor belt, the system of global currents that is largely responsible for regulating Earth's temperature. Its collapse could trigger catastrophically rapid climate changes.

Warm seas increase the spread of invasive species and marine diseases. Temperature changes affect stability. Ecosystems that become warmer enables species or bacteria to thrive where they were once excluded leading to migrations and species extinctions.

Acidification is the Twin Tragedy of Global Warming

Ocean acidification is caused by the abundance of carbon dioxide in the air that flows from both land to coastal waters and through the air via various complex behaviours eventually absorbed into the ocean. Coal emissions and other carbon dioxide sources have already begun a mass extinction of sea life that, if left unmitigated, will potentially cause human starvation and societal collapse to countries that have become dependent on seafood.

These ocean extinctions will happen due to the increased ocean acidity and higher ocean temperatures with both being caused by carbon emissions. The harm we have been causing has barely registered in human consciousness. We can't recognize our own neglect. We fail to see that we can make a difference by the policies we support and the habits we develop. Our perspective about energy in the west is out of touch. We have an abundance of energy, food, commodities, gadgets, etc. and going without them is rarely a concern.

In the U.S. and Canada getting employment or finding a place to live is within reach for most people, especially the educated. People raised in the west are largely unaware of how different our abundance of energy compares to the hardship in places like China, Brazil, India and Africa. They are unprepared for the kind of hardship that will eventually happen in the west too.

The outcome we all gamble with is human extinction itself. This prediction, however dark, is necessary to discuss, even if the prediction turns out to be an exaggeration. Science leads us to conclude that serious consequences will bring severe hardship for much of the planet. The hardest hit will be the poorest most populated countries. Environmentalists are saying these countries must cut back on fossil fuel usage yet our economy still depends on fossil fuel while we largely ignore nuclear power. It's not acceptable to allow future generations to pay for our neglect nor expect emerging developing countries to sacrifice their standard of living just to avoid fossil fuels.

Ocean pH is Now 8.1 – What is pH?

To get an idea of how bad current pH levels are you need to understand what pH means. pH has a scale that ranges from 0 to 14.

14 is the most basic (alkaline) and 0 is the most acidic. An example soap is basic (pH of 9 or 10). Lemon juice has an acidity pH of 2.2. The pH scale is logarithmic so a small change is quite significant. Pure distilled water has a pH of 7. But the oceans need to be above 7 on the alkaline side to sustain life. The closer it gets to neutral or acidic in the lower numbers, the worse it gets for sea life.

The oceans have been absorbing carbon dioxide at an accelerated rate. Estimates are between 25% and 40% of all airborne CO_2 since the beginning of the industrial age. The current ocean pH level is still considered basic(alkaline). When you hear that ocean acidity has gotten worse it simply means that the pH has moved lower on the scale closer to the acid levels below 7.

The current ocean pH is 8.14.

Wikipedia says back in 1751 it was 8.25. That change is 0.11 which might seem small but actually in logarithmic terms it is quite large. That represents a 29% increase in hydrogen ions. It is estimated that at current rates by 2100 it will reach .3 to .5 which would be as low as 7.64 pH. Hydrogen, which happens to be the smallest atom is the ingredient that makes water acidic by forming a compound. When carbon dioxide (CO_2) combines with hydrogen it becomes carbonic acid. Once the ocean reaches a pH of 8.1 it kills shelled creatures that are vital to the food chain.

The tiny sea snails called Pteropods (sea snails or sea butterflies) are threatened with extinction in as few as 20 years at the current rate of acidification, deoxygenation and warming. They are an important food source for all larger species such as pacific salmon, whales and different kinds of ocean birds.

Liming of the Oceans

The average pH is now half way down toward the extinction point. Ocean acidity hasn't been this high (lower pH) in 200 million years. Hydrogen, which happens to be the smallest atom is the ingredient that makes any liquid acidic by forming a compound. When carbon dioxide (CO_2) combines with hydrogen it becomes carbonic acid. Carbonic acid once it reaches a pH of 8.1 kills shelled creatures that are vital to the food chain.

One proposed solution to ocean acidity is to extract a lot of lime by heating up limestone. Adding lime to the oceans is a proposed solution to use a natural cycle to sequester carbon from the oceans. The idea of lime is that it is rich in calcium and magnesium and the Energy abundance from dedicated nuclear reactors could provide heat needed to fix acidity by producing enough lime, when added, it would allow creatures who need the calcium to absorb it into their skeleton. The formation of their bones and shells naturally extracts the carbon from the water. When they die they take the carbon with them to the ocean floor. The ideal reactors would be the proposed modular factory made kind similar to what we see occurring in the assembly of the jumbo jet or shipbuilding industry. The molten salt reactors will provide an ideal versatile application-specific power source that can also double as an electricity provider where needed. This would be the first commercial application-specific reactor design to come into the market. Canada's Terrestrial Energy and the American Thorcon are both ideal candidates.

We emit more than 30 billion tons of CO_2 per year, and have an inventory of more than 1.5 trillion tons already in the air. About 1/3 has yet to be dissolved, acidifying waters. Limestone is about 1/2 CO_2 and 1/2 lime. Heating it separates them and we get a ton of lime + a ton of CO_2 using ~300kWHrs of heat energy.

The following quote is from Alex Cannara who has researched the subject of reversing the effects of CO_2. The least invasive and ecologically friendly way to mitigate ocean acidification is described in a document he shares among his peers.

> "Fuels and chemicals from oil are about equal to coal as carbon sources, but the amount of actual chemical feedstock carbon is very small compared to all the emissions from combustion. And, being carbon neutral means something… But it doesn't help ocean chemistry — it's fine only after we address deteriorating ocean chemistry.
>
> Limestone consists of about 1/2 CO_2 and 1/2 lime. Heating 2 tons of limestone separates them and we get a ton of lime + a ton of CO_2 using ~300kWHrs of heat energy. So, if we're thinking we're going to use a lot of CO_2 from lime making, we're dead wrong — not enough for chemicals and vehicles is too small.
>
> We thus must sequester the CO_2 from limestone, permanently, as some groups in Iceland & WA are researching. That gives us a ton to sequester for every 300 kWHrs we make available to heat the limestone we mine. If we just compensate for our present amounts, >30 gigatons of CO_2 emissions, we need to generate, with no emissions, 300 x 30 billion = 9000 GWH/year with 0 emissions.

> That's 9 teraWatt Hours, or half of the entire world's present power use.
>
> If we want to start biting into the 1500 gigatons already emitted, with ~500Gt already in seas, then we obviously need to generate a bit more to process a bit more limestone, etc.
>
> Carbon-neutral fuels for aircraft are probably unavoidable, but all other vehicles must be moved without emissions."
>
> Therefore, we must sequester nearly all the CO_2 that comes out of limestone at the rate of 1 ton per 300 kWHrs and 2 tons limestone input. Trying to capture CO_2 from air, in which it's not ~50% (as in limestone), but 0.04% is ridiculous, to quote Harry Potter.

Dr. Cannara is essentially saying that the drastic situation calls for drastic action. It's not enough to simply stop emitting carbon. The current ocean chemistry is not hospitable to life.

It is also important to consider that warmer oceans means less carbon absorption. Warming of the planet includes increased warming in both the air and sea. Another tipping point will occur when the ocean temperature is too high to accept more CO_2. Since water temperature and reduced oxygen are also factors that are negatively affecting ocean life this is not a positive outcome. But we humans will start seeing more greenhouse effect as a result.

Trying to remove it from coal-stack exhaust, which is mostly nitrogen, may be good if the energy is available, but still a far less effective method than getting CO_2 from limestone, where it was naturally sequestered long ago, and putting it back into CO_2 absorbing rock permanently, while using the lime to counteract more recent emissions that are dissolving in oceans. We're simply using the natural process of the lime cycle that's been implemented by life forms for millions of years.

To supply the heat needed for the liming process will require a lot of energy. Nuclear energy happens to be the cleanest and most economical way and currently the only way to meet the required energy needs to create enough electricity for the kilns typically used for such operations.

Unfortunately, we're now in a war on carbon that could have been avoided, had nuclear power been allowed to grow, as JFK instructed in 1962.

Unfortunately many of the tiny aquatic animals such as plankton and coral are hypersensitive to small temperature changes.

Coral bleaching is one of the consequences. Temperature change slows coral growth, making them susceptible to disease which can devastate ecosystems that are sustained by coral reefs.

Krill reproduce in smaller numbers at higher temperatures. This can also seriously disrupt the food chain.

Deoxygenation

The reduced oxygen is referred to as “aNO_xic." This condition has not happened in the oceans for millions of years when mass extinctions ocurred. Regions called “dead zones" currently exist in over 400 locations around the world from the east coast of the United States to the Black Sea to New Zealand.

> “the world's oceans have lost about two percent of their oxygen in just 50 years, while the amount of water that's completely free of oxygen has increased fourfold, according to the new study. Scientists now can identify 500 sites along the coasts where oxygen is exceedingly low. Fewer than 10 percent of those were known before the mid-20th century."[5-1-1]

When Phytoplankton disappears so does a major oxygen source. They produce more oxygen than the land. What we don’t realize is that the ocean makes up a huge part of the life support system of the Earth. 99% of Earth’s livable space is the oceans. It should not come as a surprise that 80% of breathable oxygen comes from plankton.

> “Scientists say the pH level of the world’s seas have already dropped—on average from 8.2 to 8.1 on the pH scale (lower numbers are more acidic). That’s a 26 percent drop in the past century (because the pH scale is logarithmic). But as the ocean absorbs more industrial emissions of carbon dioxide, its pH is expected to double to 7.7 pH units by the end of the century, according to Aleck Wang, professor of marine chemistry at the Woods Hole Oceanographic Institution."[5-1-2]

Fish like the Blue Marlin are known for deep diving. In warmer areas like Guatamala and Costa Rica they have been observed to be staying closer to the surface to avoid suffocation due to the lower oxygen content of the deeper water.[5-1-3]

> “In fact, the world's oceans have lost about two percent of their oxygen in just 50 years, while the amount of water that's completely free of oxygen has increased fourfold, according to the new study. Scientists now can identify 500 sites along the coasts where oxygen is exceedingly low. Fewer than 10 percent of those were known before the mid-20th century."

Sea Levels

Sea levels are affected by melting ice from icebergs, ice caps, land ice and glaciers. Rising sea levels affect coastal habitats, disappearing shoreline, coastal erosion and disrepair from storms. “Sea level has risen 4.5 cm from 1993 to 2008 at a rate of approximately 3 mm/yr." 5-1-4

“Rising seas is one of those climate change effects. Average sea levels have swelled over 8 inches (about 23 cm) since 1880, with about three of those inches gained in the last 25 years. Every year, the sea rises another .13 inches (3.2 mm)."

Expanded water molecules from temperature increase also plays a role in sea rise.

Stronger Storms

Higher ocean temperatures create stronger and more frequent tropical storms, hurricanes and cyclones. These stronger storms not only affect human habitats but wildlife habitats and the more frequent storms mean less time to recover.

Other Consequences

Generating electricity contributes 31% of carbon dioxide and transportation is a close second at 27%. That means that human activity has a lot to do with CO_2's creation. The chart on the right indicates part of the reason why CO_2 is the main focus of controlling climate change. But we can't ignore that, although methane is 14% of the total content, it is 25 times more powerful in trapping heat in our atmosphere.

2013 sources of CO_2 by sector in USA

World Greenhouse Gases by percentage

In 2014 it was estimated that 40 billion tons of CO_2 were released (~36 billion metric tons).

Will It Continue?

As the oceans increase in temperature they lose their ability to absorb carbon dioxide. This is another tipping point we must expect and try to prevent. The only way to reduce ocean temperatures is to dramatically reign in our emission of greenhouse gases. However, even if we immediately dropped carbon dioxide emissions to zero, the gases we've already released would take centuries or longer to level off temperature increases.

Weather Extremes

How energy policy is getting it wrong. - It's about reliability

The "all of the above" policy chosen by President Obama is far too simplistic. With more extreme weather events happening all the time now keeping within the required indoor temperature depends on whether electricity is available. Thinking about the naive environmrntalist who is seduced into believing that renewable energy can do it all worries me. What happens to a community that depends totally on wind or solar when the weather does not provide enough wind or sun. Here's where energy abundance can save lives from freezing cold or over heating.

What is Baseload Power?

Baseload power is something we take for granted. Power that is available twenty-four-seven. If you follow the news you will notice some regions (that frequently experience weather extremes) have been fighting to eliminate nuclear energy (their main sources of baseload power) and replace them with renewable energy. Nuclear energy, coal, natural gas, oil, wood and biofuel are all source of baseload power. They all contribute energy around the clock where-ever they are used. Yet if we are to eliminate CO_2 we need more nuclear power, not less. Places like California, Germany, Wisconsin and Quebec have all shut down perfectly good nuclear reactors.

Nuclear energy comes from a fuel that is not fossil-based, is of relatively low cost, and is abundant. U.S. nuclear energy plants use a low-enriched form of uranium (^{235}U) for fuel. Canada can function on low enriched fuel with their enhancement of using heavy water. Uranium is a relatively abundant element that occurs naturally and that is about as common on Earth as is tin. In 2002, 16 countries produced more than 99 percent of the world's uranium, with Canada and Australia counting for about half of the world's production.

Recently it has been reported that we can effectively extract uranium from ocean water. In fact there is so much of it that all of Earth's needs could be met until the Earth ends it's remaining 7.5 billion years.[5-2-1]

Compared to natural gas, uranium is relatively low in price and is less sensitive to fuel price increases—only 20 percent of the overall production cost is due to the cost of uranium, while 83 percent of the cost of electricity from gas is due to the cost of natural gas. It does not take much uranium to power a plant from a volume standpoint: one pellet of uranium—the size of the tip of an adult's little finger—is the equivalent of 17,000 cubic feet of natural gas, 1,780 pounds of coal or 149 gallons of oil. Nuclear energy is not dependent on unstable foreign suppliers; North America has abundant sources of uranium.

Nuclear plants are not vulnerable to weather fluctuations or climate conditions. These large units, which run for extended periods, supply electricity—called "baseload generation" — day and night, often only shutting down for refueling every 18-24 months. (note: CANDUs can refuel without shutting down) While nuclear plants are as environmentally clean as plants driven with wind and solar power, nuclear plants do not rely on wind conditions or on the sun shining to do their jobs, and they occupy much less land based on comparable generation output. Continued plant modernization means there is no such thing as an “old" plant.

Although the oldest existing U.S. commercial plant went online in 1969 (In Canada 1971), there is no “old" nuclear plant. Systems are constantly upgraded or replaced to ensure all plants operate with the highest reliability. Additionally, nuclear power plants are valuable assets to their owners because their initial license period can be extended. The initial license period of 40 years can be renewed for an additional 20 or more. This means that operators have incentives to keep their plants in top operating shape and maintain safety margins.

Nuclear plants survive hurricanes, tornadoes, freezing rain, sudden rain-induced floods, dry spells, heat waves, cold spells, blizzards, you name it. The increase in extreme weather makes choosing nuclear energy a smart choice. However there are no guarantees the grid will be operating as smoothly.

Hurricane Sandy, Katrina, Hazel

My earliest memory of a hurricane was Hurricane Hazel in 1957. If you were one of the unlucky ones your home was flooded and in a few cases whole households swept away.

Hurricanes and tornadoes have been striking in the usual places but also in places you don’t normally hear about. In 2009 three unlucky

Americans from Oklahoma were fishing at a cottage in Georgian Bay, Ontario. Not unheard of, but strangely ironic, a tornado caused the deaths of three friends, away from their tornado ridden home turf, when the entire cottage was dragged into the water by the severe freak weather.

The Growing Need for Cooling and Heating

As two opposing movements grow, we are seeing on one hand the West's preoccupation with renewable energy which is poised to bring us blackouts, and on the other hand the East's and the developing world's quest to modernize and gain economic freedom. As a result we are seeing, ironically, more usage of fossil fuel for energy. Both situations are bringing about the growth of coal and natural gas.

Another contradiction is that places like Toronto and New York are seeing the Polar Vortex that shifts erratically where cold weather occurs. We are witnessing places like Toronto getting zero Celsius weather and Yellowknife having 22 Celsius. This puts a demand on electricity at times when they are not normally expected.[5-2-3]

The West has a preoccupation with wind turbines and solar panels which are proving to provide far less power than was once predicted. The shortfall of power from their unreliability has forced some countries such as Germany to build more coal plants and mine for more coal, especially since the imposed shutdown of several of their nuclear reactors. While we should be thankful the Trump administration supports Nuclear Energy they also are promoting coal and Natural Gas all in the name of energy independence.

India and China have been proliferating numerous comparatively cheap coal plants for decades in an unprecedented effort to bring the poor out of poverty.

“For billions of people life is already too hot, so the artificial cooling of humanity will proceed regardless of climate change or decarbonization goals. A key part of that will be supplying electricity to run (and build) air conditioners; India’s soaring AC demand will necessitate some 300 new power plants over the next two decades. [28] Here too there’s a tension between necessary development and green sustainability doctrine, with its emphasis on reducing energy use and relying on intermittent wind and solar generators. Cooling requires a lot of electricity that is reliably available when demand is greatest; given the limitations of wind and solar, much of that electricity will have to come from new nuclear and, for now, fossil-fueled plants. High-quality power will take precedence over intermittent energy austerity as a strategy for beating the heat."[5-2-4]

Summer 2006 Issue (Energy Reality)

We get some spectacularly cold January and February weather in Canada and northern parts of the U.S. We need to heat our homes to survive. We have been getting freak winter storms in recent years. My story was before the worst cold but still pretty bad.

Diary of an Ice Storm Blackout (from Energy Reality Blog Dec 23/14) **Toronto needs reliable power. Apply pressure at all gov. levels to upgrade. Recent power outages are outrageous.**

I'm not sure what is worse. Sitting alone at a table for two in a very noisy bar waiting for my phone to charge or going home to a dark apartment with a flashlight and candles.

I am sitting at one of the noisiest bars in Toronto. I am here on a Sunday night two days before Christmas because the power is out for the 4th time in 3 years. Yet this lively bar, across the street from where I live has had all its power all day. Why do the stores along Bloor on both sides all have power? The power infrastructure in Ontario is seriously out of date.

The temperature is hovering around freezing but will get colder tomorrow. Many of the locals have so much ice on their cars that they gave up on de-icing. I spoke to Steve Foster, my new friend from Barrie, who has power yet 300 thousand others need to wait a few days while Christmas is around the corner. Steve said Barrie has no visible power lines (meaning they have been wisely buried underground). Why we continue to suffer 19th century style inconveniences has to do with mismanaged government at all levels.

Extreme weather is no longer a freak event. We should expect these events to happen. I see no reason why we should suffer or worse, have our lives threatened. The cold, if not prepared for properly, can be lethal.

We also need to update our power facilities so that they don't flood in extreme weather like what happened July 2013. What is really ironic is that I'm sitting right across from a wall of 100 year old enlarged black and white photos of my neighbourhood. If it was 1913 I might have electricity right now.

1913 - King and Yonge – Toronto

Jacques Boissinot/CP PHOTO

How much business is lost on account of power failures?

Each year the US loses over $100 Billion due to power failures[5-2-5]. Ontario's losses must be in the $billions. Besides robbing us of our rights to normal comforts we also lose business.

Our power infrastructure is also expensive and less reliable because we are forced by law to include wind and solar energy into our grid. We need to subsidize the unreliable, "natural gas" dependent so-called "renewables" because of a perceived need for an "all of the above" energy mix. Our energy bills are higher because of this idealist yet proven-to-fail method of powering the grid has become the norm.

Germany now has the highest electricity rates in Europe because they have decided to go "green" and discontinue nuclear energy. Germany has been forced to increase the building of coal plants to make up for the lost nuclear energy. Italy will face the same consequences. Just like California who shut down San Onofre Nuclear Plant over irrational fears over a possible accident their energy bills have gone sky high. An interesting fact is that the worst ice-storm in Ontario's history did not affect the nuclear plants at all.

It is always a good time to put pressure on all three levels of government to upgrade our power system. i.e. put power lines underground and make the power stations flood proof and allow new build of nuclear to replace the plants that will be decommissioned because of age. However refurbishing nuclear plants have been very successful in Ontario. (end of blog post)

Nuclear Energy and Energy Efficiency

The usual argument in favour of reduced energy consumption is the reduction of fossil fuels. There are several things that appear environmentally friendly but when you follow the energy source they provide little benefit in carbon reduction. The electric vehicles are, to some, an environmental dream but in reality they are only beneficial if they are charged with non-emitting electricity produced from nuclear energy or hydro.

Required indoor temperature control can be better controlled with improved upgrades to air leaks and insulation. Home fortification also makes sense in view of an increase in powerful storms. While we consider reducing our energy usage you might want to look into the government (provincial or state) that assists in paying for environmentally beneficial home improvements.

Energy abundance will not only save lives from freezing cold or overheating but eventually end energy poverty.[5-3-1]

Highest temperature ever recorded on Earth was 59 C. 54 C occurred in August 2015 at a city in the Middle East called Bahsra.

The toll on health is complicated by disease and clean water shortages. The costs of damages from hurricanes and other events.

What is arguably the most controversial fact when discussing renewable energy is that Nuclear Plants use Uranium. Uranium is viewed by many as the demon ingredient by those who don't investigate the facts. It has been a concern in the recent past that we will run into Uranium shortages. But now we have a technique for extracting Uranium from seawater. This makes it renewable for as long as the Earth shall live.[5-3-2]

Water Scarcity

Water, like air, is a limited resource on the planet. It is logical that we keep it free of pollution as much as possible. But we are witnessing severe droughts with record high temperatures springing up all over the world. Droughts mean there are shortages of water for basic household living, industry, public spaces, sewage etc. Typically droughts follow extreme temperatures.

Over 30 U.S. states are now very close to drought conditions. California needs to ration water and there are legal restrictions on how often they flush their toilets. Texas is now the driest region.

The Green Blue Book by Thomas M. Kostigen is a guide to saving fresh water. In the book you will see dozens of estimates of how much water is used in the process of getting various products to market to wisely handle how to conserve fresh water.

> "The average person needs about 13 gallons of water a day to drink, wash, and eat. We in America use almost 10 times that. In fact, the global population may have tripled in the 20th century but water consumption went up sevenfold.[5-4-1]"

Water Supply and Water Quality

Exploration of underground wells began and the water table became widely used. Groundwater is normally replenished by rain. Many American states depend heavily on groundwater. Water usage has been strained and is not being replenished fast enough both from overuse and dry spells. Fracking has started to affect the water quality[5-4-2] nationwide in the United States.

Drought in California

California has a number of farms that require large amounts of water. Being on the ocean makes desalination seem like an obvious solution. But it is a power intensive process and for both economic and environmental reasons we want the production of fresh water to be clean and affordable. However, desalination has been a part of Diablo Canyon Nuclear Power Plant's desire for their own fresh water until drought became a serious need. Additional supply was in the plans to supply a few thousand homes. Oddly the NIMBYs (groups who say "not in my backyard") and other special interest groups interfere with these solutions from taking place. Congressman Jordan Cummingham has proposed that the planned closing of Diablo Canyon Power Plant (Nuclear Power Plant) be reversed to take advantage of the much needed shortage of fresh water. The plant already supplies a significant amount of desalinated water. Cunninham also has introduced legislation to redifine nuclear power as renewable as Idaho has done.

When Americans settled in the interior there were vast areas that had no access to water. They learned to access the water table which is now in danger of drying up. Diablo Canyon Nuclear Plant, the last Nuclear plant in the State of California has been producing fresh water through a reverse osmosis process. General Electric runs the plant.

You can supply 2.5 million people with fresh water using a 200MWe reactor to desalinate ocean water.

Droughts / Flooding

The World Health Organization says that floods are the natural disasters having the greatest impact on human health. The activities of the climate summits puts on a humanitarian face. They explore ways to mitigate the effects of climate change. Things like preventing the spread of disease, better evacuation procedures etc. Probably more than finding solutions. One of modern civilizations signs of broken down too little too late solutions.

How can energy stop that? Many people don't get the seriousness of global warming. The carbon dioxide has already accumulated and is in a constant process of doing its damage. We see it in the form of weather extremes. If we want less drought and less flooding we need to not only stop the rise of CO_2 but reverse it. That will require geoengineering.[5-4-3]

We discussed desalination and we discussed lime creation these are both types of geoengineering but what about our behavior towards responsible sustainable behavior.

Freedom to farm, mine, manufacture, distribute and profit from commerce are factors that have played a role. But we are seeing resources becoming more significant. Climate change has made matters worse. The middle east is becoming a drought zone. Water is scarce.

Poverty, Literacy and Population

Smaller gap between rich and poor.

India compared to US.

Robert Hargraves makes a convincing argument that MSRs will lower the worlds population by first bringing prosperity and therefore education.

Aim High: Using Thorium Energy to Address Environmental Prob (video)[5-5-1]

energy=>industry=>jobs=>education=>birth control=>population control

> “Safe, inexpensive energy from the liquid fluoride thorium reactor can stop much global warming and raise prosperity of humanity to adopt US and OECD lifestyles, which include lower, sustainable birth rates."

> “Oak Ridge first developed molten salt reactor technology in 1958-1976. Thorium fuel is transformed to uranium-233 which fissions, producing heat and electric power at a cost less than that from coal power plants — the only way to

> dissuade developing nations from burning coal. Thorium produces less than 1% of the long-lived radioactive waste of today's nuclear power plants. Existing nuclear power plant waste can be consumed. One ton of plentiful thorium costing $300,000 provides 1 GW-year of electric energy, enough for a city. A 5-year NASA-style shoot-the-moon project can complete technology development of this inexpensive, safe, clean power."

Robert Hargraves' Aim High. Book on Amazon – less than $10.00

Additional Links[5-5-2]

Economic Drivers

As we've been saying, the benefits of building nuclear plants has many parallel benefits. The number of jobs they provide is enormous. Apart from being clean energy the surplus of heat can be diverted for industrial purposes. Besides providing jobs by creating spinoff industry there is cheap electricity and process heat to be used for the community and industry benefit.

Food Supply

Oceans provide 20% of the world's protein. As discussed, huge quantities of energy are needed to make lime that can reduce ocean acidity.

Mentioned earlier fish that are a significant supply of the world's food supply may go extinct without mitigation into the ocean's pH levels. Lowering the carbonic acid content can be done with adding lime and nutrients such as iron that helps algae thrive.

Vertical farms with controlled environments can produce high yields of food. But these farms require a lot of energy. Nuclear is well suited.

Vertical farms are easily scalable and distributable

Vertical farms exist around the world and demonstrate that there will be local produce in controlled conditions. With predictions of mass movement into cities because of the uninhabitable rural life brought about by climate change it will become harder to live and even survive. The idea was proposed by architects and some of the ideas were developed by futurists like Despommier. Ecomodernists and visionaries like James Lovelock and Buckminster Fuller have contributed to the concepts being adapted for modern living.

GaMOs are another trendy thing to hate but it has been shown that instead of GMOs China has started using controlled radiation (irradiation) for grain that will grow better crops.

Deforestation

Half the forests can be saved because burning wood is not needed if abundant cheap energy is available.

Deforestation is affecting CO_2. Deforestation is typically done to make more land available for housing and urbanization, timber, large scale cash crops such as soy and palm oil, and cattle ranching. The World Wildlife Fund reports that much of the logging industry that contributes to deforestation is done illegally (about half of it used for firewood).

The use of firewood for heat is essential to regions with no power lines to deliver electricity. The population density makes introducing a grid for all a huge challenge and expense.

<<Deforestation has decreased global vapor flows from land by 4% (3,000 km^3/yr), a decrease that is quantitatively as large as the increased vapor flow caused by irrigation (2,600 km^3/yr). >>

Recent sensationalistic news headlines have bold headlines about how the Amazon rainforest are lungs of the world. Bolsonaro has eased up on regulations which has led to farmers burning the forests in order to clear land for soy bean crops and cattle grazing. There is also a reduction in policing of the indigenous habitats that have resulted in abuses of the habitats and it's people.

There is photosynthesis and the activity that breathes the opposite direction analogous to breathing. Carbon dioxide capture by day and carbon dioxide release by night.

How nature provides the natural rhythmic cycles is yet another built-in protector of life. It's not just the deliberate burning of forests that takes a toll but also the way the land is used.

About half of the trees illegally removed from forests are used as fuel. It is not clear what the numbers are in the Amazon however the struggle for survival has everything to do with it. The farmers clear the land more now because Bolsonaro has lifted the ban on clearing forests.

What about the legally removed ones?

An estimated 18 million acres (7.3 million hectares) of forest worldwide, which is roughly the size of the country of Panama, are lost each year (permanently). Countries with significant deforestation include Indonesia, Brazil, Thailand, Congo and other parts of Africa and parts of Eastern Europe.

Indonesia has lost at least 15.79 million hectares of forest land. Ninety percent of the continental United States' indigenous forest has been removed since 1600. The world's remaining indigenous forests are located in Canada, Alaska, Russia and the Northwestern Amazon basin. Forest loss contributes between 6 percent and 12 percent of annual global carbon dioxide emissions. About 36 football fields worth of trees lost every minute. Deforestation is the second largest anthropogenic (human-caused) source of carbon dioxide to the atmosphere, ranging between 6 percent and 17 percent. (Van Der Werf, G. R. et al., 2009)

The added water vapor from trees although significant as a short lived greenhouse gas also has a cooling effect.[5-7-1]

Polar Ice Caps Melting

What about the ice caps and glaciers melting? Can we bring back freezing of the polar ice caps by stopping the CO_2? Reverse warming?

The logic here is simple. Fix the CO_2 problem and by default we reduce warming.

Cold water holds more CO_2 than warm water. Significance? Sealife will die whenever CO_2 is added or oxygen is depleted.

Are the polar bears dying or moving south? Polar Bears live in 19 different areas within five countries Canada, the USA, Greenland, Norway and Russia which all share parts of the Arctic Circle. Eight of the those groups are in decline, three are stable and several others have not been observed close enough to say.

Some radical ideas have been suggested such as putting white dye in the ocean to reflect sunlight.

Cleaner Air, Cleaner Water

Air pollution kills. What are the worst offenders? Coal burning releases numerous toxins. Mercury, sulphur dioxide, carbon moNO_xide, nitrous oxide (ozone)

One of the worst offenders of air pollution happens where the poor have limited access to electricity and heat. Deaths are common from indoor air pollution where they are burning dung that is processed in square packages at prices much lower than any other burnable fuel.

"Arguably most importantly, our planetary atmosphere is currently showing the effects of about two centuries of use as a vast dump for dangerous fossil fuel waste, agrochemical waste, halogenated organic compounds and other chemical wastes. The capacity of the atmosphere to absorb this waste, or lack thereof, has impacted, is impacting and will impact not only every human being on the earth, but almost every living thing on the planet as well." by David Jones – Sustaining the Wind Part 1 – Is So Called "Renewable Energy" the Same as "Sustainable Energy?"

"The crisis has, however, spurred intense research in water de-contamination techniques. How to ensure tens of millions of people arsenic-free drinking water when their water supply comes from wells, many of them rich in arsenic."[5-9-1]

How many Bangladeshi are exposed to a high level of arsenic? Estimates vary from a low of 28-35 million to a high of 77 million, more than half the population of the country. The Bangladeshi are being poisoned by drinking well water, usually without knowing it.

Only three decades ago health and development experts, and small local contractors, dug between 7-11 million deep tube wells throughout Bangladesh. The experts encouraged the whole nation to drink well water because it was safe. It was free of the bacteria that caused water-borne diseases such as diarrhoea and other intestinal maladies that have long plagued tropical Bangladesh.

Bill Gates set up a foundation to address the problem in Kafar. He discovered that using a western approach that requires massive plumbing installation will not be affordable.

Ironically, the people of Bangladesh exchanged water-borne diseases for arsenicosis. In the 1970s public health specialists and government policy-makers did not think of arsenic. It was only in 1993 that the "clean" well water was discovered to contain dangerous quantities of the poison.

Arsenicosis can cause skin cancer as well as cancers of the bladder, kidneys and lungs, and diseases of the blood vessels of the legs and feet, and possibly diabetes, high blood pressure and reproductive disorders.

WHO's most recent guideline for a maximum amount of arsenic in drinking water recommends 10 parts per billion (ppb). That was in 1993 when it was lowered to that level from 50 ppb. A new guideline is anticipated in 2003. But most water that is drunk in arsenic affected areas in Bangladesh has substantially higher levels, frequently far above 50 ppb.

Arsenic-contaminated water is not restricted to developing countries. In the western states of the United States of America about 13 million people drink arsenic-tainted water, albeit less contaminated than the well water in Bangladesh. Australia, too, has arsenic-contaminated water. So do Argentina, Brazil, Chile, Hungary, Mexico, Taiwan (Province of China), Thailand, Viet Nam, and the eastern areas of India in Bengal.

“Unfortunately," says WHO sanitary engineer, Hiroki Hashizume, a Japanese expert on arsenic, “it is virtually impossible, with present measurement techniques, especially in the developing world, to measure quantities below 10 ppb. When drinking water guidelines or national standards are established, careful attention has to be paid to analytical capability, arsenic removal technology, etc., to ensure that the levels are really achieved. Since the principal health gain comes from targeting those most exposed to arsenic poisoning, using an intermediate target of 50 ppb, until a lower target can be achieved, would already improve people's health given Bangladesh's limitations.

“Another unfortunate and complicating fact about arsenic poisoning," Hiroki Hashizume adds, “is that it generally takes from seven to 10 years, sometimes longer, for the disease to be recognized. When it finally is, it may be too late to treat."

Again we must consider means to providing clean water. Israel successfully turned their economy and well being by building water desalination plants.

Water treatment in wells and rivers etc.[5-9-2]

Preparing, planning and training staff will be a priority for health and welfare. Their priorities need to be ready since the diasters are increasing and really happening.

Preventing Resource Wars and Mass Migration

Poverty explains why such civil discontent is tied to freedoms and rights abuses. The Arab Spring was triggered mostly by human rights abuses but a lesser known cause is the government's disregard of it's own people who faced record high temperatures with no attempt to solve water shortages. The uprisings, protests and battles spread rapidly. Yet you would think that the wealth of some of the middle eastern countries would be able to provide for their countries what is needed. Clearly class, privilege and religion matters. Priorities by governments serve the privileged like many places.

How Abundant Energy Can Lessen Wars, Militarization and Terrorism

In The Middle East Israel has set the standard for a state of the art desalination facility. They unfortunately have chosen fossil fuels to power the facility.

But most of the middle east needs desalination plants. Nuclear power provides the way. The Arab Spring had a lot to do with the lack of effort going into safeguarding the people from the extreme heat and drought to most of the area.

If we're not able to reform our ways how do we justify telling other countries they can't follow our path to prosperity? It was fine for us but not for them? In global politics I hear often "who are we to interfere?" Its true that we would be hypocrites to try and stop their progress. But since we have a karmic debt to pay and the US and Canada have both contributed more per capita to climate change than most countries it makes sense that we help with the transition to an atomic power era.

Defense, Budget, Weapons

Weapons will be less needed if the earth has less overall resource wars.

The logic here is simple. Abundant, low cost nuclear energy from nuclear reactors such as MSRs will provide more independence for nations making them more self sustaining. Weapons will be less needed if the earth has less overall problems.

Chapter 5 covers the history of nuclear weapons and nuclear energy in parallel.

When you read about wars a lot of speculation about the purpose behind the wars is given but often missing the real cause of wars. There is no doubt that war provides profits and cash flow for USA and Russia. When places like Syria, Iraq and Turkey enter into regime wars we know that the guns, ammunitions and other weapons have two main suppliers.

Terrorism is rarely justified but its roots lie in the discontent of citizens feeling abused, restricted, dominated or enslaved.

We have been having fewer battles with the military in recent years but this lull is probably temporary. The real shortages are just starting. Water, oil, food, electricity, jobs, farm land, commodities and lifestyle is mounting as frustration increases.

We have seen the “weapons of mass destruction" as a fabrication to invade Iraq. The Gulf wars happened for several reasons.

Interesting bit of history on how nuclear plants can be dual purpose.

There was the now closed Stade Nuclear Power Plant in Germany that provided heat to extract salt from sea water.[5-10-1]

More recently and still active, but to be shut down in 2025, is the Diablo Canyon Nuclear Power Plant Desalination Plant.

Note that Stade excess heat was used to extract the salt however in the case of Diablo it is electricity that powers the pumps for reverse osmosis using membranes to filter the sea water.

Industrial Applications

The possibilities for expansion of various industries to will both provide employment and boost the economy when they come into play.

Pulp and Paper is Energy Intensive

Pulp and paper need huge amounts of energy. The U.S. DOE reports, "In 2002, the paper manufacturing industry consumed over 2.4 quads (quadrillion or 1015 Btu) of energy … and represented over 15% of U.S. manufacturing energy use."[5-11-1] Purchased electricity and on-site use of coal, gas, and fuel oil are major costs often needed. With the likely charges for carbon emissions, world demand for energy might surpass available power. Nuclear could clearly come to the rescue.

Steel and Concrete

When the 2030s prove to be booming years of economic growth it will be partly due to Small Modular Reactors being employed as hybrid or dedicated energy or process heat providers for essential industries like steel and coal. One of the false arguments anti-nuclear environmentalists often claim is the idea that supposedly we need to look at the full life cycle of Nuclear Power Plants to get a fair estimate of their carbon footprint. They typically cite the need for carbon intensive construction using steel and concrete. The argument is very weak considering that the energy that would otherwise be needed are also equally carbon intensive, or much worse in the case of wind and solar, on a Kwh to Kwh basis. But at least they understand that concrete and steel require coal for processing. In the case of using scrap metal Electric Arc Furnaces have become popular.

> “To produce a ton of steel in an electric arc furnace requires approximately 400 kilowatt-hours per short ton or about 440 kWh per metric tonne; the theoretical minimum amount of energy required to melt a tonne of scrap steel is 300 kWh (melting point 1520 °C/2768 °F). Therefore, a 300-tonne, 300 MVA EAF will require approximately 132 MWh of energy to melt the steel, and a "power-on time" (the time that steel is being melted with an arc) of approximately 37 minutes. Electric arc steelmaking is only economical where there is plentiful electricity, with a well-developed electrical grid. In many locations, mills operate during off-peak hours when utilities have surplus power generating capacity and the price of electricity is less."[5-11-2]

As you may conclude, any high demand electricity process benefits from abundant, clean, carbon-free energy source such as nuclear energy. Glass, cement, iron, hydrogen, ethylene, styrene,petroleum refineries, low octane fuel for jets, cargo and cruise ships, desalination,

Emission absorbing concrete

Italian company Italcementi designed a kind of cement that is supposedly alleviating air pollution by breaking down pollutants that come in contact with the concrete, through the use of titanium dioxide absorbing ultraviolet light. Some environmental experts nevertheless remain skeptical and wonder if the special material can 'eat' enough pollutants to make it financially viable. Jubilee Church in Rome is built from this kind of concrete.[15]

Another proposed method of absorbing emissions is to absorb CO_2 in the curing process. Recent research has proposed the use of an admixture (a dicalcium silicate y phase) that absorbs CO_2 as the concrete cures. With the use of coal ash or another suitable substitute, this concrete could theoretically have a CO_2 emissions below 0 kg/m^3, compared to normal concrete at 400 kg/m^3. The most effective method of production of this concrete would be using the exhaust gas of a power plant, where an isolated chamber could control temperature and humidity.[16] Even besides the use of advanced additives, carbonation naturally occurs within concrete, thus causing it to absorb CO_2 in a process that is effectively the reverse of cement production. While concerns about corrosion of reinforcement and alkalinity loss remain, this process cannot be discounted.[17]

In August 2019, a reduced CO_2 cement was announced which "reduces the overall carbon footprint in precast concrete by 70%."[5-11-3]

Solutions and Conclusions

“The free market has a glaring blindspot it ignores the cost of commerce’s destruction or consumption of nature itself, the planet’s common." – Daniel Goleman – Ecological Intelligence

The common obstacles to fixing all of these problems are a lack of cooperation and a lack of awareness. Turn it around you can say education and unification are missing. We are victims of the intrusion of corporate and elite interests and we have come to learn that our opinion matters if any change for good is at all possible.

The voting system needs reform too because people vote like they bet on the horse races. It should not be the candidate that has the best chance of winning but the candidate that you believe is best for the job. But politicians still care about getting support so if more people express their wishes to make nuclear energy a priority they will start to listen.

One of the least explored topics about climate change is the existing backlog of CO_2. That is sort of like credit card debt. Hard to reverse when you’re poor. It sits there like a threat that will possibly force you into bankruptcy. You could view it as the climate change equivalent of bankruptcy. Perhaps it would be more productive to compare it to the national debt. Cutbacks on spending and fixing inflation are the only ways to reverse it. When enough of the CO_2 finally converts to carbonic acid passing 8.1 pH you could call that going past your credit limit. The debt ceiling and the cliff come to mind.

The twin tragedies of climate change and ocean acidification are epic problems and they need to be tackled in all ways possible. However we should not exclude solutions at the expense of others. We need to recognize what solutions are the most effective and focus on them if we can.

Unfortunately we have learned that getting cooperation to work on solutions is very difficult however necessary. With government spending being strained by weather disasters and the effects of climate change there is more need for cooperation than ever. We are discovering that the fabric of society is being challenged by capitalism and the corporate model because the absence of profit prevents action. Couple that with a widespread western trend of austerity limiting government spending and you have a potent mix of destabilizing influences. The need for cooperation and leadership is becoming paramount.

Affordable emission free energy that is also abundant and reliable comes in only one kind of package right now and that is nuclear power. It can contribute a lot to making these problems smaller. It is affordable and plentiful, reliable energy that can double as industry apps for things like desalinization, lime creation, sewage treatment, low emitting liquid fuels. Nuclear energy is the most scalable and easy to adapt to industrial process as well as electricity. Generation IV reactors have been held back for far too long. They could start within 5-7 years.

77 million have-nots in India use kerosene for lighting their homes. The problem is in rural areas where 44 percent of the households don't even have electricity.

Energy is so important that in my view failure to engage all people about the future of energy is failure to save the planet.

Chapter 6

Need a Little STEAM?

Everybody needs a little STEAM. STEAM not STEM. The missing ingredient is Art, too often overlooked. Science, Technology, Engineering, Arts, Math (S.T.E.A.M.)

We need to catch up on biology, chemistry and physics that belong to S.T.E.A.M.[6-1] and make the effort to evaluate energy. We need to be certain about what kind of decisions can make a difference in the remaining time left to do so.

What about learning complex science? Is Nuclear Physics so hard to learn? How much do we need? It is complex at the deeper levels but what you need to know is not so far away or hard to find. Between truth and fear lies a lot of fact finding to clear up the misconceptions about nuclear. Once the truth comes out then we can see how the big fossil fuel energy players care more about profits than about the environment. Getting a grasp on the science will also help to lighten your view of what is possible and what is not. Common myths like "all radiation is dangerous" can easily be seen to be false by looking at data that compares exposure levels and knowing that radiation is everywhere.

The documentary film Pandora's Promise[6-2] uses a powerful analogy right in the title. What "promise?" Robert Stone did a good job of finding a title that represented a journey of discovery. In a Greek myth, Pandora, the first woman, is endowed with seductive charms and when given a gift box labeled "do not open", she opens it anyway. Out comes all sorts of evil. She manages to close the box before the last item escapes. That last item is "hope."

The film shows how five environmentalists with an antinuclear outlook discover "hope" in the form of nuclear energy. All the previous myths they held started to disappear after inquiring into the real nature of atomic science. The myths were debunked one by one and the future outlook appeared less bleak in the face of climate change.

Nuclear power was a path they never considered until they understood the more immediate danger posed to the planet by climate change and ocean acidification. The fact that China will have double the carbon emissions that the US is projected to have in 30 years and also the fact that wind and solar are totally inadequate to bring poor countries out of poverty indicates it is imperative, if there is any "hope", that it must be nuclear energy that will replace coal.

The unwillingness of so many protesters to actually try to understand the science and relative value both economically and environmentally is another example of the human failure. Several nuclear reactors in the US have recently been shut down due to market driven factors. Kewaunee[6-3] in Wisconsin[6-4] and Vermont Yankee[6-5] were forced out of business partly because of the existence of cheap natural gas. But the other factor is lack of public awareness. Too many people see the closing of a nuclear power plant as a victory. I am one that feels both angry and sad that fear of radiation, and I mean any radiation is very much part of the North American psyche. There is a huge difference between the reality and the perception. We need to close this gap.

But the need for the general public to be informed and educated about nuclear energy has never been acknowledged by those who could make a difference. The need for public awareness is still not a phenomenon discussed or explored. Hence the purpose of this book.

Now it makes sense to bring the public, including the gamers, up to speed on the subject of atomic science and how it led to nuclear energy because nobody should be left in the dark worried and confused. At this level governments fail. They don't properly mandate what is being taught. This chapter will try to be your orientation. Let the politicians catch up later.

What About the Science?

Let's start by observing our planet. Have you ever wondered how the center of the earth stays hot and keeps molten lava flowing? The planet is billions of years old. Why has it not cooled in that time? It is the presence of uranium, thorium changing from one state to another perpetually releasing energy and heat from radioactive decay [6-6] that causes the rocks to melt. This was only discovered in the last 60 years or so.

The age of planet Earth was first calculated in 1956 using nuclear science by an American geologist Clair Patterson to be 4.5 billion years old[6-7] and it was using a method known as radiometric dating based on comparing different isotopes of lead. Another trick discovered in the 1940s was carbon dating. It takes the ratio of two different isotopes of carbon (carbon 12 is constant and carbon 14 decays at 50% every 5,730 years) and is used to accurately measure the age of things up to a maximum of 50,000 years. These techniques would not be possible without the advances in nuclear science.

The story of energy can't be told without understanding the role the chemists and physicists. In fact the two types of reactors that dominates current research and development could be described as requiring a marriage of the two disciplines.

The Early Chemists

When Marie Curie decided to do experiments in the late 1800s with a strangely behaving unknown substance, it's high incidence of activity was brand new territory. Little did she know that she was carrying around radium[6-8] in her pockets. The handling of the materials without protection would lead to her eventual death 30 years later of aplastic anemia at age 66. But her accomplishments give women a reason to be proud. She was the first person and only woman to win the Nobel prize twice[6-9]. She did the world a great service by dedicating her life to understanding radioactive elements, specifically discovering, naming and adding radium (origin of the words "radioactive" and "radiation") and polonium. (named after her Polish heritage) to the table of elements.

Her relatively long life and the long lives of other nuclear scientists show that radiation is not as bad as people imagine. Marie Curie handled the substances of varying purity and quantity daily without protection yet she lived to be a senior. Radium is only found at trace levels (produced by decaying uranium) because natural radium has largely vanished due to natural decay. What are called the primordial elements are still found if their half lives happen to be older than 2 billion years or so. The longer the half life the lower the radioactivity. The real damage is done if you eat it or breathe it but otherwise our skin is a reasonable block to the radiation that is emitted through the air. The overwhelming majority of nuclear scientists live to an old age without cancer incidence. No matter where a person lives, it would be extremely rare to ever encounter high dose radiation.

But even if you work with it or near it daily it is manageable and safe when the right procedures for handling it are made. You may recall the safety gear that visitors were asked to wear in news features about Fukushima. The measures being practiced reflect the attitude of public officials exercising caution that is an over-reaction in an over-regulated safety culture. Those safety suits were completely unnecessary.

Historically, the elusive invisible and atomic universe had been viewed as composed of individual elements that existed alone and unable to bind and create compounds. Discovering properties of natural elements had been a French tradition going back to 1789 when Antoine Lavoisier catalogued 33 of the atomic tables elements[6-10]. His insights led to the understanding of compounds that had specific molecular structures.

Swedish chemist Jöns Jacob Berzelius would further expand that in 1818 calculating the atomic weights of 45 of the known 49 elements including his personal discovery of Thorium[6-11], element 90. Dmitri Mendeleev of Russia in 1869 had developed what became known as a periodic table of 66 elements[6-12] ordered according to their chemical properties. This was developed without the knowledge of electron shells or orbitals which did not arrive until 1919.

French chemist Marcellin Berthelot published an important thesis on compounds in 1860 when most chemists believed compounds from organic substances could not be recreated in the lab. Berthelot proved them wrong thus ending the notion of vitalism[6-13]. He is considered the greatest chemist ever. He was also able to observe something frightening about the power of the atom when he said

“Within a hundred years of physical and chemical science, men will know what the atom is. It is my belief when science reaches this stage, God will come down to earth with His big ring of keys and will say to humanity, ‘Gentlemen, it is closing time [6-14].’"

The Early Physicists

The breakthroughs regarding atomic structure made real progress after Albert Einstein's several discoveries and the proposed models of mathematical modeling based on Brownian motion discovered 28 years earlier by Robert Brown[6-15] who observed the motion of dust grains in water. Theories formed by John Dalton 100 years earlier[6-16] would be proven true by Jean Baptiste Perrin who used Einstein's equations to help prove Dalton was correct. Perrin later was awarded a Nobel prize[6-17] in 1926. Einstein got his Nobel prize in 1921.

Such a web of discoveries and interconnected thoughts led to advancements that would allow us to send pictures back to the earth from Pluto in 2015 and Mars for the past several years. The space travel technology depends on RTG[6-18] devices that are a type of nuclear battery.

Einstein’s Famous Equation

Nuclear energy was not new it was just new to humans. Although we discovered it about 100 years ago nuclear energy was around when the first stars were born and the big bang occurred. But this knowledge is relatively new. Einstein lived in a time when nobody understood this yet. That's why his insights are all the more incredible.

$E = \gamma mc^2$ means “Energy" is equal to some specific mass at rest[6-19] multiplied times the speed of light squared. The speed of light is so fast that it is typically a given distance per second. That is 186,000 miles per second. That speed could be expressed as 671,000,000 miles per hour. The Lorentz factor, gamma, γ, says that the faster the objects are moving with respect to one another, the higher the energy is.

Mass vs. Speed of Light

This incredible formula was discovered by Einstein before it was even possible to prove. It does follow that since c is already a very big number, based on the speed of light, that being squared makes it an extra huge amount. Therefore the change in mass must be a small amount but still very significant. So this formula is an equation that demonstrates that it is possible to get a huge amount of energy from a small change in mass. That small change in mass is in fact measurable at the atomic level.

Somehow Einstein also figured out that nothing could go faster than light. He calculated that any mass to reach the speed of light would require a certain number of joules of energy. So when the big less-stable atoms split and change their atomic weight there is a measurable amount of energy released. That energy is expressed as $E = \gamma mc^2$. When Einstein produced his equation atoms were not known to be splitting so his anticipation of what was coming was prophetic, to say the least.

A Little Nuclear Physics

The study of nuclear physics is not everybody's idea of fun. But some basics are essential to getting a grasp of why nuclear energy is not only a dense energy source but it can be and has been made safe to give nuclear plants the best safety records of all power plants[6-20].

One of the polarizing factors in the nuclear industry is the variety of nuclear plants that have been created and the numerous schools of thought that accompanies each design. The versatility of the technology is both a blessing and a curse. But they all have common factors we can summarize here.

Reactors require what is called a fissile element from the periodic table. If an element is fissile it is fissionable. Basically, fission is essential to creating nuclear energy.

Many of the heavier elements in the periodic table no longer exist naturally but have been recreated in the laboratory. The elements in existence are the lighter more stable elements. That means most of them are not decaying. If they are decaying it is at a very slow pace.

The only naturally occurring source of nuclear fuel is Uranium and most of the uranium we find is in trace amounts that have been transmuted from plutonium (the uranium we dig up is a low purity daughter element from decaying plutonium - now essentially gone). Thorium has a unique advantage as a power source but it is not a fuel, technically, but later I'll explain the Thorium Cycle[6-21] which produces fissile fuel[6-22]. We'll come back to this.

Uranium is found in trace amounts and needs processing to be as pure as needed. The ability to create man made isotopes[6-23] of radioactive elements is partly what is keeping the nuclear industry alive. And although expensive to build, Nuclear Reactors are still the cleanest, most efficient electricity producers ever by a long shot and the availability of uranium is not at risk. The economics of nuclear plants needs demystifying. They don't need to be expensive. For the most part they are expensive as a direct result of pressure from lobbyists and peer groups who fight for greater safety measures for the already very safe reactors. Any pronuclear advocates worth their salt will tell you that nuclear reactors are over-engineered and currently lack a standardized design.

Out of all the different types of reactors available there are three kinds of reactors we need to consider. For the sake of keeping the investigation into the science within our grasp let's simplify our effort and look at the most popular reactors, the Canadian designs, American designs and next generation Molten Salt Reactors[6-24]. The first two represent the majority of existing reactors that are now in 31 countries: France, Slovakia, Hungary, Ukraine, Belgium, Sweden, Switzerland, Slovenia, Czech Republic, Finland, Bulgaria, Armenia, South Korea, Spain, United States, Russia, Romania, United Kingdom, Canada, Germany, South Africa, Mexico, Pakistan, Argentina, Netherlands, India, Brazil, China, Iran, Japan and Taiwan and very recently the Arab Emirates. Egypt is serious about getting them while having a test reactor for years.

The Canadian Reactors are located in Ontario and New Brunswick. These commercial designs are CANDU reactors[6-25]. They require a much lower concentration of pure Uranium than American Light Water Reactors (LWR)[6-26]. Bruce Nuclear Generating Station, west of Toronto, is the biggest nuclear power plant (NPP) worldwide employing 3800 workers. It consists of 8 CANDU reactors all in the 730 MW to 813 MW range totalling over 6,000 MW. There is a thriving nuclear industry of CANDU reactors abroad in six countries: Argentina, China, India, Pakistan, Romania and South Korea.

The biggest difference between the CANDU and varieties of LWR reactors is the kind of fuel required for their operation. CANDUs do not need to enrich the fuel to high purity whereas LWRs need slightly higher purity. CANDUs use pressurized heavy water to control the reactivity rate. LWRs are a simpler design which are actually a slightly newer innovation that started around 1950 after Alvin Weinberg's design[6-27] allowing untreated water as a moderator. The uranium needs to be 3% to 5% pure ^{235}U for LWRs[6-28] and less than 1% ^{235}U for CANDUs[6-29]. By the way, nuclear weapons require 90% pure ^{235}U[6-30].

When we discuss the actinide elements (numbered 89-103) that are naturally radioactive we are referring to the heavy elements in the periodic table where we get the fuel for nuclear power plants. Let's look at some of the actinide properties. We discussed Marie Curie's experiments with radium and radioactive decay that cause elements to transmute. Radium-236 is one of several radium (element 88) isotopes. It decays to radon gas. Thorium (element 90) and Uranium (element 92) are less radioactive, in fact you can hold thorium and uranium 238 without any risk of harm[6-31]. Our bodies can easily handle the low radiation levels much to the shock of many antinuclear folks.

Transuranic elements are also actinides but heavier than Uranium (elements 93 and higher) and more unstable than the lighter elements but they no longer exist naturally. They must be created in the lab. Over Earth's history they all decayed or converted to other substances and gradually vanished. An unstable element is typically “radioactive." The elements that decay faster and have a significant level of decay are more “radioactive" and their decay rate is measured by the amount of time it takes to decay by half. Thus its called the half life and the elements with short half-lives are usually the most toxic elements[6-32].

More on Physics

Uranium was thought to be getting scarce in the early years of the nuclear industry. That view has changed as the methods for extraction and reprocessing has been successfully performed. The industry has come up with some creative ways to collect fissile Uranium including breeder reactors and the dismantling of nuclear bombs[6-33]to use the Uranium for fuel. There are even methods proposed to extract uranium from seawater[6-34]. This method has inspired some people to reclassify nuclear energy as renewable because the oceans have an inexhaustible supply of dissolved uranium.

We've all heard of Plutonium.[6-35]. The word is very familiar to us. It is generally man made by using nuclear fission. Because these elements are unstable they will convert to stable or unstable isotopes meaning they will have an atomic weight more or less near the natural weight plus or minus a few neutrons. For instance ^{238}U is the normal atomic weight of Uranium but they have some ^{235}U and ^{234}U mixed with it. Just trace amounts can weaken Uranium's fissile ability therefore Uranium is processed by chemical means either into its useful concentrated ^{235}U or into Depleted Uranium (^{238}U) which is not fissile but used in weapons ammunition. (note: ^{238}U can be used as a fertile fuel just like Thorium in Molten Salt Reactors[6-36], ^{240}Plutonium is also fertile but not fissile.) The important thing is that a fissile element is able to convert to a new element and in the process releases energy. Note: $E = \gamma mc^2$ explains where the energy comes from in a nuclear reaction.

One of the challenges to learning about the science behind nuclear energy is the surprisingly unintuitive realities of how fission works[6-37].

All nuclear reactors need fission. Typically they use ^{235}U (Uranium), ^{239}Plutonium (Pu) or ^{233}U as fuel. They are all radioactive. These elements are called fissile because they can be used for fission. They can respond to neutron particles converting to daughter products. Thorium and ^{238}U are not fissile but are called fertile since they respond well to neutron bombardment creating daughter products that are fissile. Thorium undergoes two transformations. ^{232}Th that undergoes neutron bombardment, in the presence of fissile elements, converts to Protactinium and Protactinium decays naturally to ^{233}U. Similarly fertile ^{238}U, also in the presence of fissile elements converts to plutonium-239? The main reason to be excited about these two commonly found elements and because of the fact that they are both very mildly radioactive ^{232}Th and ^{238}U promise to be the fuels of the future. The Molten Salt Reactor with all of its advantages will perform well with both and once this proven 1960s technology is scaled up to commercial nuclear reactor sizes and modernized to withstand high temperatures they will catch on quickly.

To understand what is meant by energy density and why nuclear power is so important you need to take a look at the abundant energy acquired from coal plants. When a Uranium atom splits it releases 100 million times more energy than a carbon atom that combusts[6-38]. This explains why Einstein's equation is such a big deal and what is meant by density and why the oil industry feels threatened. It also explains why wind and solar could never do it alone. It is clear that the support given to renewable energy by fossil fuel companies is a diversion to make themselves appear green knowing fully that renewable energy is not a threat to their dominance of the market share.

Brush up on your STEAM and when you are ready you can start making a difference.

Fission Explained

"A single fission event can yield over 200 million times the energy of the neutron which triggered it [6-39]!"

The word fission is derived from the Latin word findere which means to split apart. The components of an atom are made up of a nucleus and electrons. All nuclei (plural for nucleus) consist of protons and neutrons. The largest atoms, consisting of many protons, neutrons and electrons can reach a size that makes them less stable and more vulnerable to collisions with neutrons from other atoms. The best conditions for a controlled series of collisions have been discovered from experiments that have been well established for over 40 years. Pioneers like Enrico Fermi and Glenn Seabourg did much to develop the techniques needed for controlled fission. The collisions cause a split in the atom which releases heat. That heat is captured and directed to a water supply that converts to steam and creates electricity by spinning a turbine.

The nucleus of an atom is about 10^{-13} cm. That means if you could line up 10 trillion nuclei beside each other it would equal one centimeter. But the electron's orbits are at quite a distance relatively speaking. The entire size of an atom would equal approximately 10^{-8} cm. Fissile [6-40] Uranium has the natural ability to release neutrons which are needed for fission. Uranium is inserted into a fuel assembly inside the reactor core. Fission is dependent upon the certain elements being struck by a neutron that eventually, when struck at the right angle and velocity, produces, after splitting, new atom isotopes. This splitting or breaking apart is due to the nuclear fuel, usually Uranium, being able to absorb the uncharged neutrons. Uranium fuel is set up under ideal conditions in order to maintain a continuous rate of fission called a chain reaction. There is a moderator added that stops the chain reaction from going out of control. The cycle produces more neutrons which in turn are captured by other uranium atoms. The controls in place allow fission to produce a steady source of heat that heats up water and converts it to steam.

Natural uranium comes out of the ground as a mix of 99.3% uranium 238 (^{238}U) and 0.7 % uranium 235 (^{235}U) and is mined in places like Cameco Mines[6-41] in Saskatchewan and the actual uranium content in the ore is between 2% and 20%[6-42]. For CANDU reactors uranium does not need enrichment. It does need to go through a milling[6-43] process and gets delivered to a uranium refinery. Processing takes place at one of the two known facilities in Ontario. These are designated facilities that convert either to uranium dioxide[6-44], for the CANDU, or uranium hydroxide (Uranyl Hydroxide)[6-45] for LWR fuel.

What happens when observing the binding forces in order of the smallest atomic weights to the largest? There is an inverse relationship to an atoms stability to its size. The atoms actually reverse their ability to bind and these atoms are described as too large to remain stable. The ideal binding elements are, no surprise, iron and nickel. But really the study of the elements properties are the key. The elements instability are caused by their size. It's actually the opposite relationship in gravitational forces of large bodies where we observe the larger the object the greater the attractions. Gravity is ignored at the atomic level. The size of the particles are immune individually. Collectively of course they are indeed influenced by gravity.

Warning! You can skip this section if you are not interested in the details.

Isotopes[6-46] are regular atoms plus or minus a neutron or two and for the most part retains the original properties. Depending on the balance of neutrons, protons and electrons an isotope can be radioactive or non-radioactive. Isotopes of Uranium and, much less commonly, Plutonium are the most used in Nuclear Power plants. The atomic number like the 233 in ^{233}U indicates the number of protons in an element. Every proton in an atom is matched by at least as many neutrons. The order starts at a lower atomic weight - elements 89-103 plus the heavier elements 104-118. The transuranics 93-118 are unique because of the fact that they no longer occur naturally on Earth.

Neutrons are uncharged and very useful. Here's where the clever idea came from to manipulate[6-47] the isotopes. Being uncharged they have the ability to penetrate an atom more deeply. The neutrons released by the radioactive elements ^{235}U or $P^{239}U$ are typically too fast to be absorbed efficiently by ^{235}U (^{235}U is uniquely configured to absorb slow neutrons) but if moderators such as water, heavy water or graphite are added then a chain reaction can be sustained[6-48].

Theoretically, when we fission a heavy nucleus, we are really just taking energy that was stored as mass in a proverbial tiny ball under immense gravity and pressure before the Big Bang. When it exploded billions[6-49] of years ago all kinds of elements were created. Stars eventually formed, aged and subsequently exploded again in super novas. These kinds of activities produced many of the heavy elements that still exist. Many of them transmuted to other elements and those with shorter half lives disappeared. Since the short range nuclear force can only hold such a big atom together for so long, all we ever find naturally that can be fissioned and that has not already decayed is Uranium.

Nobody really knows what causes that short range nuclear force but if the big bang really did happen then that bang of the universe changing from a condensed tiny area then massively exploding would retain some of its original properties. Hence the strong binding force by definition is likely related to that unique primordial moment of unmatched extreme density.

The Thorium Cycle.

When discussing alternative reactor designs it is the Molten Salt Reactor (MSR) that has been making a return from obscurity. Now it's gained a cult status around the world. One of the MSR designs provides a means to breed fissile fuel from fertile elements such as ^{238}U and ^{232}Th. The thorium cycle takes advantage of Glenn Seaborg's discovery that Thorium can produce the isotope ^{233}U. Seaborg with the help of his lab assistant observed that Thorium, when in the presence of ^{235}U or ^{233}U, converts to ^{233}Protactinium and then decays after 27 days to become Uranium 233 which is not found naturally in significant concentrations.

Thorium has 90 protons and is element 90. In it's natural state it has an equal number of protons and electrons. Since Thorium is not fissile it must offer other benefits to gain this cult status. Through neutron capture in the presence of other fissile material it will convert to Protactinium. Protactinium consequently naturally decays to Uranium-233 which is certainly capable of fissioning .

Thorium fuel has favorable properties that improve performance in a MSR. Compared to the uranium dioxide(), thorium dioxide (ThO_2) has a higher melting point, higher thermal conductivity, and lower coefficient of thermal expansion. ThO_2 also exhibits greater chemical stability and, unlike UO_2, does not further oxidize. Aqueous Molten salts melt at a higher temperature at normal atmospheric pressure unlike the high pressures that Light Water Reactors and

CANDU reactors need just to keep the cooling water in a liquid state that would otherwise become steam.

Fluoride salt has some very stable qualities. Fluoride is the salt of choice for Thorium LFTR's. For those interested in chemistry Fluoride is chemically stable but Fluorine is not.

One benefit from using the Thorium cycle is that there is an inevitable quantity of ^{232}U that gets produced during fission. This quantity is sufficient to make it impractical to create weapons grade fuel. It essentially poisons the ^{233}U nuclear fuel therefore it is inherently proliferation resistant. ^{232}U cannot be chemically separated from ^{233}U and has several decay products that emit high-energy gamma radiation making it easy to detect.

These high-energy photons are a radiological hazard that necessitate the use of remote handling of separated uranium and aid in the passive detection of such materials. ^{233}U can be denatured by mixing it with natural or depleted uranium, requiring isotope separation before it could be used in nuclear weapons.

Chapter 7

Getting out in the field

“I don’t want to belong to any club that will accept me as a member."
Groucho Marx

Clubs, clubs, clubs. Advocacy groups and special interest groups have their own clubs. Environmentalists, human rights activists, health organizations, political parties, philanthropists all have their own clubs. Some clubs raise money to finance lobbyists and often sway opinions that affect election outcomes. Trading party favors, in what is called cronyism, also becomes a conduit for getting bills passed and supported. The most powerful clubs are also the wealthiest ones. Investors and shareholders have their own clubs. These realities chip away at our democracy. In recent years polls increasingly show public support that rarely matches government legislation.

Plus, there are flaws in the way our governments are formed. The electoral system does not demand quality leadership, skills or knowledge; The elections are steered by popularity contests. It's a bad idea, the fact that government consists of a variety of people who typically get shifted around based on qualifications that would normally be viewed as a poor match. Too often we see that merit is not based on qualifications or a suitable job portfolio. The selection criteria puts more weight on values like loyalty, diplomacy, and the number of years of service. Consequently, politicians can make really bad decisions. How governments manage themselves are often disconnected from the public. In fact it has become an election issue. They call it transparency. The idea of being somewhat secretive is for self preservation. If the majority of ministers act incompetently, keeping the blunders from being exposed or covered up is easier to accomplish when it is part of the political culture to cover each other's backs.

Back in 1980 the handling of various government departments got so bad that they started to remove the responsibility of running them. Departments such as Nuclear Energy and Public Utilities were declared as open for corporate tender. First it was Margaret Thatcher privatizing nuclear plants[7-1] and more recently it was Prime Minister Stephen Harper[7-2]. In the U.S. it was the Public Utilities[7-3] that became deregulated in the 1990s.

Because the electoral system has been left to votes by a public that does not know what is happening behind closed doors we see groups forming for a common goal. Advocates, groups or clubs are a natural consequence of people who are not satisfied to let an uninformed public make their decisions. In order to influence change it is easier with a group. Besides, voters only carry influence at election time.

There have been forces that seem to deliberately encourage apathy. If we look at Republican behaviour since President Barack Obama took office, they deliberately encouraged division. Polarizing seemed to be their goal at any cost. This kind of behavior goes against our instincts. What did they gain? It's frightening to imagine that apathy is what they are trying to encourage. We don't know why they do it but when you consider the effect it has we can guess that it is to manipulate the votes.

What clubs can we join as members of the public? We have special interest groups. No other country has so many. Statistically, over half the population joins one sometime in their life. In fact many of them have agendas that are driven by perceived injustice or perceived need for change. Many of them are intruders and time wasters with profit and control as their main goal. They block progress and prevent positive change. There are good ones too of course like Unicef and the Cancer Foundation. We need to question the motives of some of the environmental groups that support natural gas and renewable energy, but do not nuclear energy; like the Sierra Club, NRDC, Union of Concerned Scientists, Physicians for Social Responsibility, Friends of the Earth, Mothers for Peace, Greenpeace, 350.org and The Climate Reality Project.

But how do we sift through the noise and recognize what really matters? A psychoanalyst puts us on a couch to say "Tell me the first thing that enters your mind." It takes a while to cut through the brain chatter but with repeated visits people eventually discover what is blocking their growth or their ability to move on. When we finally do discover what matters to us we become ready to deal with the outside world. We move past the petty emotional blocks of childhood or marital breakup or job loss and get on with living.

All of those young people who play or have played video games and spent countless hours mastering the world they escaped into and conquered have been, ironically, preparing themselves for the fight we now face. This society, like the games they play, has plenty of obstacles - cliques, special interest groups, human rights organizations and lobbyists steering our planet off course. So instead of remaining disillusioned, marginalized, victimized and misunderstood the gamers can get off the antidepressants and give up their escapist habits in favor of fighting a real battle with the goal of doing what's right for our common home Earth. Barry Brook the climatologist cowrote a post at Brave New Climate suggesting that the same thinking that went into

Pokeman Go be implemented in a new ecology game[7-4] where the game encourages acts that respect and improve the environment.

Even if we can't be superheroes we need to recognize that there are stewards we can call upon to solve the problems we face. Maybe our individual efforts seem futile but identifying and supporting those stewards will be essential to solving our challenges. Those stewards are the scientists and engineers. Among them are people with vision. See Chapter Thirteen. We need to empower them. But first we need to learn their language well enough to identify them as the best problem solvers.

Knowledge is Power

When we finally do decide to wake up and take advantage of the "democratic" process, how will we discover how to verify information when we are given it? Our network will be an important information source, but it will be important to learn which websites are legitimate. Some of these website domains are set up for the sole purpose of misrepresenting the facts. Not all of them know they misrepresent the facts. They are simply part of an unofficial group that reinforces their beliefs. It does not take much effort to lead the gullible astray by spreading and sharing sources of misinformation.

So, how do we learn to recognize when information is reliable. If you are committed to getting the facts there are many sources of reliable information. Wikipedia.org is one of my favorite sources for getting to the bottom of a topic (but I have found bias there too.) Their pages often give external links and citations and references. You need to be detectives to uncover unjustified bias.

Carl Sagan devoted a chapter in one of his well known books titled “The Demon Haunted World: Science as a Candle In the Dark[7-5]." The chapter is called “The Fine Art of Baloney Detection." Sagan outlines steps that make a lot of sense and helps us navigate to the truth.

Many of the members of Energy Reality spend time commenting on some of these websites that allow the misinformation. We try not to encourage debate but simply provide information that is accurate often giving links to places that are more credible.

Are There Dark Forces Out There?

Do you want controversy? Darkness, just like beauty, is in the eye of the beholder. If we took all conspiracy theories seriously we could fill a book on that topic alone. For example there is plenty of evidence that some corporations are in the habit of backing political parties. The super pac is a perfectly legal way to try to subvert or topple the government:) Failing that, you can start a special interest group, fund your lobbyists, seek donations and deliberately set policy based on the wish to continue getting donations from corporations. When financial support is involved revealing information about a company's investments or behind the scenes activities are an inconvenience to corporations who have profit as a bottom line.

Even the Google search engine has been challenged to provide accurate data. But that conflicts with the search engine optimization techniques. I go to the Scholar search engine provided by Google and see all kinds of articles, reports and papers cited but many are, unfortunately, only available for sale.

Given our limited choices to make a difference to our world do we continue to resent how little opportunity is given to us or do we stop the self doubt and start relating to people that are similar to ourselves, who care about the quality of living and share our ideas. We have a common goal to stop letting corporations and banking institutions rule. We can't just climb into our cocoons and relinquish all of our responsibility.

The press and media outlets succeed in turning the elections into a fake race between only two opponents when the real issue is that corporations rules both parties.

Think of Howard Beal from the fictional film Network when he says “I’m Mad as Hell and I’m not going to take it anymore[7-6]." We have reason to be angry. But what can we do about it? We have to be smart. Nobody can save us but ourselves. We need to use our numbers to make a difference. We can learn from the groups that do succeed. If you can’t beat’em, join‘em. The press and media are, to a large extent, controlled by the corporations. Knowing this can help us use the media to our advantage. But beware, if we get the media to speak for us the corporations can instruct the media to follow up and target us for ridicule as they did with the Occupy Movement.

Chapter 8

Exploring a National Energy Plan

“Oh, What a tangled web we weave." Walter Scott

The Clean Power Plan[8-1] set out by Obama has undergone a reversal in many ways. Trump’s policy is Libertarian in the sense that he follows their mantra “less government." The idea of “energy dominance" and reduced restrictions on coal and other fossil fuels indicates how he views energy as an economic opportunity. Exporting coal and liquified natural gas are just two examples of how the strategy is unfolding. But support for nuclear energy seems even more pronounced than the lip service Obama’s energy plan preached. Trump’s policy is looking like a shift away from an “all-of-the-above" approach and away from renewable energy. The support for wind and solar under Obama had much more subsidized support.

It was starting to look like the kind of plan we saw happen in Germany that has gone backwards in their attempts to reduce emissions. But if Trump has his way the US will start to resemble China with a focus on economic growth at the expense of the environment. Where German and US policy Obama-style were a kind of deal that could only be made by naive environmentalists, with a little help from deceptive business executives, Trump’s plan is an openly crass approach to the point of gross negligence. But where Obama’s plan had very little to encourage nuclear energy there is evidence that nuclear energy is beginning to be taken seriously. The importance of energy begins to reveal itself in relation to the economy, the environment and in politics when Trump states that he wants to "make America great again" or that he wants the U.S. to dominate in energy and when he chooses to spend so much on the military. It becomes clear that energy plays a vital role in prosperity, independence, the environment and geopolitical battlegrounds.

There have been a number of rebuttals[8-2] as far back as 2010 from top scientists and analysts debunking the claims that we could move to 100 percent renewable energy. In addition nuclear plant closures have been reversed in New York and Illinois with the help of pronuclear environmental activists like Environmental Progress led by Michael Shellenberger and Generation Atomic led by Eric Meyer. A recent announcement by the Department of Energy under Secretary Rick Perry stated that the US needs to make Nuclear Energy “cool again" and that clean energy goals must include nuclear energy.

Developing a national energy policy for a country like the United States does have significant challenges. Obama’s Clean Energy Plan has been viewed by most as "comprehensive" but from a checks and balances perspective it has placed far too much emphasis on renewable energy and conservation. Whereas "renewable" wheels have been in motion for a few years, that trend is changing and coal plant closures are expected to slow down under Trump.

While some state moratoriums block new nuclear plants and Renewable Portfolio Standards require a minimum percentage of renewable energy, the current policies are making the outlook for nuclear energy less dim. The insanely lopsided American Recovery and Reinvestment Act of 2009 is a stimulus package, again, mostly ignoring nuclear energy.

"A massive $800 billion economic stimulus package aimed at job creation and the promotion of investment and consumer spending Included $4.3 billion in tax credits to homeowners for energy efficiency improvements in 2009-2010, $300 million for reducing diesel engine emissions, $21.5 billion for energy infrastructure, $27.2

billion for energy efficiency and renewable energy research and investment, \$2 billion in research for DOE, \$600 million in research for NOAA."[8-4]

This development was meant to be a stimulus package to assist in economic recovery from the crash of 2008. It defines several initiatives in a lot of detail but misses the point. Nuclear energy is not even mentioned. This one fact alone is the kind of fact that justifies the whole purpose for writing this book.

Our biggest challenge is that nuclear power is viewed negatively mostly from sensationalized media and outright propaganda. But, in reality it is an econòmy driver and environment saver. Nuclear plants provide more jobs than any other type of power plant and there are quite a number of related industry jobs too.

"The Brattle Group has determined that nuclear plants operating in Pennsylvania contribute approximately \$2.36 billion to state gross domestic product (GDP) (\$3.56 billion in gross output), account for 15,600 in-state full time jobs (direct and secondary), help keep electricity prices low, and are responsible for \$81 million in net state tax revenues annually."

The public needs to grow up about their fears; and not just about nuclear energy. The nuclear industry has been punished long enough. The blatant truth is that few people really get it. The biggest misconception is about the scope. Its about what we call energy density and energy capacity. Wind, solar, tidal, geothermal and biofuel are simply not able to contribute enough to make a big enough difference. They are comparatively wasteful economically and draw unsustainably on available resources of land and materials in order to meet the required demand. Investors need to understand this when making decisions to finance such energy sources. Investing in a company that is developing a new type of nuclear reactor is possibly the most important investment anybody could make not only financially but morally.

Tidal has it's predictability factor advantage so using tidal may eventually work better than wind and solar however to be effective requires a large coastal region at billions of dollars in construction costs.

What Factors Need to Be Considered Before Making a Policy?

1. The survival issue reminding people of the urgency before the irreversible happens triggering mass extinction.

2. The capacity issue of increasing nuclear power usage and it having a power density several orders of magnitude greater than any other available source.

3. the issue of good-for-the-environment, emissions-free nuclear plants (80% of America's clean energy) being built despite people's perceptions and fears

4. the issue of weaning people off of an unhealthy Amerocentric view that ignores the emerging economies like China and India who are not going to slow down just to meet carbon emissions limits.

5. the cost issue that prevents further nuclear expansion. Costs can be lowered if people's perception viewed nuclear energy with a more rational point of view. They are a privilege not a burden.

Nuclear power is our best hope. The majority of people around the world fail to recognize the urgency of our current need to stop CO_2 emissions and the U.S. government and all policy makers need to take a global perspective on CO_2 emissions. While the U.S. is committed to gradually reducing coal (far too gradual) the growing economies in China and India have a rapid expansion of coal burning power plants taking place.

Clearing up the misconceptions and myths will help with making a set of guidelines for a diverse set of regions and jurisdictions. It is a challenge. Not every guideline will be a perfect fit. Energy policy in our case needs to make the case that nuclear energy has the most potential to do the most benefit. Windy regions should explore wind power and sunny regions should explore solar but all locations will benefit from nuclear power.

Keep in mind that current models of reactors are still feasible but that new sizes need to be considered to more effectively deal with making transitions more affordable and adaptable to less populated regions. The model we aim for would ideally be well-suited for anywhere in the world. The Small Modular Reactor (SMR) will play a role and it should be any leader's priority to clear a path for the over regulated nuclear industry.

Currently there are 11 states that have a moratorium to stop new builds of nuclear power plants. As of 2010, 104 reactors at 65 nuclear power plants delivered 20 percent of the nation's electricity. Since then three plants have been closed before the end of their useful lifetime partly due to public pressure over minor issues and the fact that under-regulated natural gas is cheaper to buy. Thankfully there are a few new reactors nearing completion.

The biggest reality check about wind and solar energy is that they cannot compete with what is called base load power. There is very little similarity between the commonly held "champions" of the green movement and base load power. Comparing the availability and reliability is the first dramatic difference.

Several nuclear plants have recorded performance times as lasting well over a year without a shutdown. Base load is also the fundamental type of energy that we have been running for over a century that has rarely disappointed us for extended periods of time. Much more reliable base load such as nuclear energy has not given us much grief for its steady performance over the long term. We have a fairly dependable grid infrastructure. Some aspects need upgrades and more challenges have been added such as severe weather.

The electricity system in the U.S. is a huge web of interconnected power cables mostly above ground. The combined regional grids make up the wide area synchronous grid. But "grid" can mean local or a widespread area. Even microgrids exist to support small communities. Four major regional grids exist across Canada and the United States. They are the Western Interconnection[8-7], Eastern Interconnection[8-8], Quebec Interconnection[8-9] and Electric Reliability Council of Texas (ERCOT)[8-10]. Some people refer to them generally as "the grid."

Each regional grid consists of an Independent System Operator (ISO) (In Ontario - Independent Electricity System Operator (IESO)) that run within each state or province and the larger organizations that encompass several states called a Regional Transmission Organization (RTO). Ontario has Hydro One Incorporated an electricity transmission and distribution utility. The remaining provinces have their own.

Transmission lines can have shared ownership that includes investor-owned utilities, rural cooperatives and government agencies.

The control of a national grid is dependent on what are a mix of utility companies including rural utility cooperatives as well as public utility companies. They all have regulators. The NERC is the widest regulator covering The US, Canada and Mexico. FERC is the US regulator that governs the US power providers. To deal with the reliability and availability of power a number of “power pools" have been formed that merge their resources to improve reliable distribution.

To get a better idea of performance factors let’s look at the three classifications of power transmission defined by function.

1) Base load power is provided by coal, hydro and nuclear power.

2) Intermittent power is provided by wind, solar, wave and tidal power.

3) Peaking Power is provided by natural gas. Also called load following reactors natural gas plants have flexibility to ramp up and down more quickly than nuclear or coal plants.

Most nuclear reactors in the U.S. do not load follow however Chicago's Boiling Water Reactor (BWR) models do. France and Germany have LWRs that operate in constant load follow mode designed for that purpose. The CANDU reactors have some that can handle load following in urgent situations but they simply redirect the steam to the sky which is not an efficient way to handle it. They will need to be upgraded for better load following where power fluctuation is designed into the reactor. If Ontario continues to add intermittent wind and solar then this kind of engineering into a CANDU is not so difficult. It would involve a redesign of the control rod system. However new reactor designs will inevitably have load follow capability given that renewables are now contributing more of the energy mix.

Some of the other power sources not mentioned such as geothermal, biofuel, wood and liquid natural gas could theoretically provide base load power if their availability were in large enough quantities, reliable and affordable but so far they have none of these attributes.

Consideration for reliable power needs to be part of the decision process. Choosing to eliminate base load power sources to make room for subsidized renewable is a mistake. The only way governments can deal with removal of base load is to import base load from remote sources like neighboring regions or to extend the reach of dispatchable power. This requires more transmission lines and is prohibitively expensive.

Why We Pay Twice as Much For Wind and Solar

The subsidies needed for the otherwise unprofitable wind and solar business cause electric bills to climb out of control and to make matters worse the system becomes unreliable. When the wind does not blow and the sun does not shine natural gas plants kick in and attempt to do their job load following. The U.S. is happy about energy independence from Middle Eastern Oil but have been closing a blind eye to the fact that leakage of methane is being reported wherever fracking occurs. Varying levels have been recorded as low as 1.5% and as high as 2.5% which makes natural gas just as bad as coal regarding CO_2.

As a result of the subsidies granted for wind and solar the consumer ends up paying twice: once for the subsidy that guarantees the wind or solar company payment as if they were run twenty-four-seven. And second when natural gas load follows. In fact wind and solar run only 20% to 30% of the time and natural gas must be running full time even when they are not needed. The need for load following is the handicap of "renewable" wind and solar. I am not opposed to wind and solar but spending becomes wasteful when redundant power is created simply to accommodate the overrated power sources of wind and solar.

In addition to a poor distribution network of natural gas pipelines the cold weather states have more complications when pipes freeze.

This forces businesses that need reliable steady power to relocate. Governments keep consulting the wrong people. If they attempt to eliminate nuclear power it will be the slow path to disillusionment when the hopes and dreams of replacing coal and nuclear will be impossible without ruining the economy. The idealists that make up the supporting fans of renewable energy could save themselves time by learning about energy density.

We have the failed experiment of Germany as a perfect example. When their government chose to close down their most reliable non-polluting power sources (nuclear power) they discovered that renewable power was disruptive. Many companies were forced to leave the country. Public utilities were unable to make a profit and nuclear power was imported from France. Ironically the riddled-with-green policy of Germany's Energiewende discovered the hard way that it was necessary build coal plants to replace that precious base load nuclear power.

When Japan shut down its 52 nuclear reactors they were forced to import large quantities of liquified natural gas to replace the lost power.

How dense energy fits into the discussion has already been touched upon. One uranium pellet is the equivalent of 3 barrels of oil, 1 ton of coal, 17,000 cubic feet of natural gas.

Land Footprint by Type of Energy

1000 MWe (typical size) nuclear power plant is 0.8 square km

1000 MWe Wind Farm uses 572 square km

1000 MWe Biomass Farm uses 4002 square km

1000 MWe Solar farm uses 177 square km

Our energy policy includes educating people to draw their own conclusions based on comparing the options which I hope this book and, eventually, our website will provide.

But we need to make it clear why nuclear energy and nuclear science is so important to everyone. It's true that we need more scientists and engineers to fill the jobs but we also need the general public to embrace nuclear so the jobs can be created and the remediation applied.

Part of the problem is that most people feel that it is too complicated to understand nuclear. We can change that perception. It is not so esoteric. It can be made into a more easy to digest subject by starting with the numerous non-energy benefits of nuclear. For this point to be understood simply look at the wide range of benefits nuclear science has given us beyond energy and weapons. See YouTube video The Future of Nuclear Technology … After Fukushima with Alan E. Waltar[8-6]

Times have changed. We used to be able to ignore what science and industry were doing. We could get on with our lives in particular areas of self indulgence. It was a lesson of democracy, freedom of choice and laissez-faire. But what has changed is that now the balance has been tipped. The paradise is sick. The responsibility to correct the problem needs to be shared by all of us, from our grandparents to our grand children.

The chances of a nuclear accident in North America any time soon are very, very remote. Yet after the Fukushima accident of 2011 the agencies assigned to the job of making sure we stay as safe as possible are at it again.

In Canada where restrictions are not as rigid the introduction of a mandatory supply of iodine pills has been suggested for the areas near the nuclear plants in Ontario. This ruling should not be a deterrent and cause for fear. But it is. (See: Toronto Star: Article) It is important to be prepared but the thinking behind such decisions need to be understood in the larger context. We know how this vital technology can help a society progress. We need to advocate that we should learn to accept the hidden world of nuclear, make it a part of education and general knowledge and being prepared for a very low probability of an accident is responsible and not cause for alarm.

There is going to be that time when observing such rules as making a full stop at a stop sign will seem relatively insignificant when chaos surrounds us and scenes of local street signs being washed away by floods and storms will not surprise us. Let's hope not.

Acceptance of nuclear would also allow its cost to come down. Politicians listen to the voters. When politicians realize there is more acceptance and support they can push for reforms. Replacing coal won't happen until it becomes acceptable to use nuclear and when the costs come down again. We must question the framework of a democracy when smart decisions are so needed and profit motive becomes the deterrent from success but if we can persuade public opinion through education and promotion then we must. Only then, can we begin to reverse the momentum of increased CO_2 and consequently global warming and growing ocean acidity which will kill the oceans and bring about many calamities.

The biggest obstacles to nuclear energy acceptance are irrational fear and the energy competitors know this and play it up. Our focus in delivering an energy policy is to make sure the majority of the people understand why nuclear is the best energy choice. Although explaining and comparing the various energy sources is beneficial it is not so beneficial to stress one kind of reactor over another. All nuclear reactors are better in the sense that a car is better than a bicycle. Striving to reduce CO_2 should be a priority commitment for us all.

The product we already believe in, is great in all current commercial reactor configurations. What's left to explain are the limits, the margins, the deceptions, the misconceptions, the probabilities and therefore whether current policies are problematic and need changing. In North America we would not welcome a leader who believed the Earth was flat. Why should we welcome leaders who view nuclear energy as too dangerous. We could also impose limits on car emissions that would entirely eliminate combustion engines but we don't for practical reasons. The same should be true for nuclear energy. Practical reasons suggests we should not impose such extreme safeguards on nuclear plants the one power source we know is emission-free.

Nuclear Power Plants

We want to keep all, or most, of the current operating reactors running as long as their useful lives last. It is wise to keep these power horses going. Nuclear energy is dense, carbon free, and affordable with many economic and environmental advantages. Upgrades to reactors every 20 years or so essentially make the old reactors into new reactors.

There are huge savings made keeping the original infrastructure in place. We know new nuclear plants are currently very expensive but if upgrades can be made at a fraction of the price of building a new one then it should be done. That's why it has it is tragic when a useful power plant is forced to shut down for economic reasons because the "free" market allows competition from unregulated natural gas.

We have witnessed one plant in particular who could not compete with natural gas. That is the Kewaunee Nuclear Power

The Molten Salt Reactor (MSR) technology is available now but some legal regulatory obstacles still remain. There is no doubt, the NRC and the EPA has been antagonistic toward the nuclear industry and have made reversing rules and regulations a long drawn out process called ratcheting. But an informed public is what is needed to begin to reverse the process. In this case rather than "trickle down" economically it would be a "trickle up" effect intellectually that would motivate the leadership to make sweeping decisions that would bring about the reform and new policy-making that is so desperately needed.

For example the coal plants which have given China it's much needed power at a rate of one coal plant a week are being delayed in

India for political and corrupt business reasons. The way I would play that “civilization game" would be to add nuclear R & D to the local schools, promote nuclear energy with a focus on Molten Salt Reactors. I know India is creating ads that promote nuclear energy. Good first steps.

The newest US reactors, the AP-1000, most limiting factor to growth is the expense but still we need to encourage awareness of the long term benefits and the eventual return on investment. This is a good example of economies of scale. There is no other energy source other than hydro that gives back so much and for so long. Reactors that cost up to 20 Billion dollars or more are still a safe long term investment.

We also support North American initiatives such as Molten Salt Reactors and Small Modular Reactors (SMRs) with commercial roll-outs in 7-10 years.

SMRs we encourage especially the designs that are passively safe and will help allay the common fears about reactors. Non-pressurized reactors in particular are the safest for future reactors. All current reactors have aspects that, although engineered very well, still scare people. Pressurized water explosions (or even nuclear detonations – tell them not possible) and the potential for subsequent widespread contamination are likely the biggest fears.

So-called “Renewables"

The word “renewable" is an over-used and inappropriate term that has won the hearts of too many. What good is renewable energy if they are only available twenty percent of the time as is the case for wind. (see article: Wind Farms Generate Below 20 Percent of Their Supposed Output…2014 Nuclear Issues Vol 37 No 7 September) It is not yet a feasible technology. Wind, waves and solar may have their place but not as a grid source for dependable electricity. The wind and solar farms are not ready for prime time. In fact they are harmful to industry and existing full time energy sources. It's called resonance or sub-synchronous power that because of their intermittent, unreliable supply actually cause wear and tear on the system. Keep in mind that the politicians are the ones who put pressure on the utilities for what energy mix to make. So just as misconceptions affect the outcome for nuclear they also affect the outcome for renewables.

The economics of renewables is tied in with the load following energy sources of power that replace wind and solar for during their downtime, which is most of the time. They are referred to by utility people as negative load sources. Here's the catch 22. Add renewables to the mix and you are automatically going to need backup. No city can survive with intermittent power. So more than half (the inconvenient truth) of wind and solar are not producing so the void is filled with natural gas, coal or nuclear.

Renewables are also land-intensive. Trying to compare them to nuclear is futile. They lose on so many levels that it's just plain silly to compare. Again it is like a car compared to a bicycle. Simply not a fair comparison. But it is the farms we mostly are against because they can have sudden spikes of power that traditional grids are not designed to handle.

Wind has the most money spent for electrical power gained disrupting smooth grid transmissions. The economics of renewables are such that the consumer pays more for electricity because of the subsidies that guarantee rates whether there is wind or sunlight available. The impact is that the consumer is paying twice. Once for the gas and once for the stalled wind and solar.

Solar can be less disruptive if spread out and installed & used by local home rooftops, schools, or businesses because they have not yet reached saturation where they can be disruptive. The personal rooftop's output is buffered by immediate use of the owner. One proposal to dealing with intermittent unreliable sources is to create an independent grid of their own letting the cities prime functions alone.

But more importantly Wind and Solar and other intermittent energy sources need to be rethought and the separation of baseload dependent electrical use and less critical electrical use, so that renewable energy sources can be applied locally and coupled with storage and not a part of the same grid that carries baseload. One such beneficial example is using solar power to keep batteries for low wattage voltage heat pumps that are part of a geothermal installation.

If energy policy includes making responsible decisions about how we spend and the environmental impact from the development to the final installation, then a whole range of factors that go beyond merely delegating what power sources to use but also considering what materials from rare earths that come from China are part of the wind mill's and solar panel's design. They are long term hazards. Other unfriendly hidden factors such as desert solar farms require preparation that kills any wildlife or vegetation near the solar farm that could possibly allow growth or interference with the unmanned panels. How much thought has gone into disposal of end-of-life panels and wind turbines. There is indeed an inversely proportional amount for how much land and construction materials are needed and how much energy is produced when comparing small footprint nuclear energy to renewables.

Fossil Fuels - Coal

The worst offenders by far are Coal Plants! Coal generates 40% of Earth's electricity and about 25% of its carbon dioxide emissions. London's Great Smog of '52 is a perfect example. Read about it here:

www.metoffice.gov.uk/education/teens/case-studies/great-smog

There are states that still have over 50% of their power from coal. But it is true that the US burns less coal than they once did but that is a deception. The coal they mine is still being burned but just not in the US. We need to consider creating more coal gasification plants to keep the coal business alive which means less exporting and more developing. But the long term goal should be to phase out coal mining for fuel. Again energy awareness needs to take the big picture into account. We can't ignore that China is building a new coal plant every week to meet their expanding economic needs. We export coal but we used to export knowledge too. Somehow we fell behind. Catching up to our once proud position as the most technologically advanced country will begin when we accept nuclear science as part of our reality.

Fossil Fuel - “Natural" Gas

Because of what appears to be some bad apples, fracking has got a bad name. There is satellite evidence that shows more methane escape than is being reported from the wells. This under-regulated industry has examples of abusing, disfigurinand despoiling the land and water tables but there are sources that indicate it has had a positive impact on reducing CO_2. On the one hand America is thankful for natural gas for helping the US to become more independent of Arab countries but on the other it is a threat to the environment in several ways. Water, wildlife and landscape have all suffered from the invasion of once pristine and relatively untouched countryside. The economics of natural gas is strongly connected to big business and the deep pockets give those companies more leverage to artificially keep prices low to make nuclear less able to profit. The utilities are forced to buy the cheapest energy sources.

What about labeling methane as “natural gas"? Does calling it “natural" accurately describe it’s function and properties? Methane is a much stronger greenhouse gas than CO_2. It will stay in the atmosphere for 29 years before converting to CO_2 which still remains. In addition, methane is explosive and has killed far more people than nuclear. So if explosions are natural then the name works but the intent of labeling it “natural" implies that it is unspoiled by human intervention. We know now that human intervention in the fracking sense is very un-natural. In an article titled “Hydrofracked: One man's quest for answers about natural gas drilling" the author Abrahm Lustgarten states:

"...Between 200,000 and 6 million gallons of water are mixed with a cocktail of solvents, surfactants and acids -- about 1 percent by volume -- and pumped into the well under thousands of pounds of pressure per square inch. The intense pressure cracks open the deep rocks, releasing the gas. Sand or other particles mixed with the fluids prop open the artificially created fractures so that gas and fluids can flow freely. Sometimes the drilling is turned to run horizontally -- deliberately angled to reach across thin layers of gas- and oil-bearing rock. When horizontal wells are fracked, they use vastly more fluid and chemicals…"

"In a typical fracked gas well, vertical or horizontal, it's unclear exactly how far these man-made cracks extend, or whether they connect with natural faults and fissures to create rogue pathways for gas and chemicals. The oil and gas industry has long insisted that fracking is harmless..."

"Politicians who supported the industry had tried for years to exempt fracking from the Safe Drinking Water Act, the 1974 law that regulates the injection of waste and chemicals underground. The EPA's 2004 study was used to justify that effort. With the help of then-Vice President Dick Cheney — the former head of Halliburton — President George W. Bush's landmark energy legislation, the 2005 Energy Policy Act, included a provision that prohibited the EPA from regulating fracking under the Safe Drinking Water Act. Regulation would be left to the states, many of which had underfunded agencies, looser standards and less manpower than the federal government..."

"Fracking works like this: First, a well is drilled thousands of feet into the earth, passing through layers of rock and water until it reaches the place where the gas is trapped -- in shale, tight sands or some other geological formation. The well bore, which narrows as it gets deeper, is partially encased in steel pipe, and concrete is pumped into the space surrounding it, extending deep enough to seal off the drinking water aquifers. The concrete and steel are supposed to separate the well from everything except the target zone at the bottom."

The Misinformed Green's Are Unwitting Accomplices in Slowing Economic Recovery and Preventing Ecological Recovery

There have been a few cases where antinuclear protests and lobbyist efforts have forced the closing of nuclear plants such as Vermont Yankee and San Onofre plants and successful efforts to cancel nuclear projects. Lawyers, who belong to the profession we most love to hate, really take advantage of the under-educated green movement by working with nuance and counting on the fact that the judges and jury are not well informed on nuclear energy and they help bring about the closings of perfectly good productive nuclear power plants.

The outcome is almost always an increase in use of fossil fuel to replace this energy. The pollution affects the air and ocean acidity and the utility bills go sky high. We must continue to give examples of how much carbon dioxide is being added by removing nuclear energy from the equation. If the "greens" want to pretend to be concerned about the quality of life as a so-called "environmentalist" it is a must to know the facts. You can't play it both ways. It is tantamount to superstition. Have we really regressed that far as a civilization?

Chapter 9

A Hypothetical National Energy Policy

How we use Energy is the single most significant factor affecting Climate and Global Ocean Chemistry. Seeing how release of greenhouse gas, particularly carbon dioxide, has such a profound effect on the average global temperature and ocean acidity it becomes necessary to factor that into the decision process of choosing the best energy mix.

Designing and using an energy mix which works in tandem with sustainable, natural processes is a noble goal. Such a holistic eco-system is not so easy to achieve mostly because of a lack of shared knowledge, political will and a lack of public awareness. The technology exists today to create conditions globally for all people to thrive and prosper, but the main obstacle is ignorance and fear.

Why Nuclear Power Plants Matter

Keeping all, or most, of the world's currently operating reactors is a necessary strategy. In fact we need many more. See how China has stepped up their energy plan with nuclear power.[9-1] Senator Lamar Alexander understands the need for more reactors. "I have proposed that we build 100 new reactors, which may seem excessive, but not with the Center for Strategic and International Studies saying up to 25 of our 99 nuclear reactors could close by 2020."[9-2]

Dense, carbon free, nuclear energy gives many economic and environmental advantages that satisfy a fundamental need for reliable and steady power.

How All Commercial Nuclear Power Plants Serve Humanity

We have taken for granted almost a century of reliable electricity reaching our homes. The demand for electricity is continually growing, especially in places like China, India and Africa. They know that the cheapest and most reliable way to create electricity is the same as it has been for nearly a century and that is dirty coal.

When nuclear plants started to flourish in the 1960s and 70s the demand for coal shrunk very significantly. The economics of nuclear was very competitive with coal. For over thirty years France has had a thriving economy. Over 70% of their energy comes from nuclear power. In the U.S. its 20%. The number of coal plants that did not need to be built prevented more dirty emissions from happening. Since its inception "Nuclear power may have saved 1.8 million lives otherwise lost to fossil fuels, may save up to 7 million more..."[8-4] over the next 40 years. (blog Scientific American - April 2, 2013) The numbers are boggling how much carbon dioxide we could have prevented but did not and now we are paying the price.

So-called "Renewables" Are Unreliable and Not Renewable

The term "renewables" has taken on a legal definition designating specific technologies that may be used to meet quota goals and/or be eligible for subsidies. This word "renewable" unfortunately is used to discriminate against new and existing hydro and nuclear power plants although both are arguably more "renewable" than wind or solar.

"Sustainable" is our preferred term and has more relevant meaning and no legal entanglements. Although this word is also misused. You rarely see nuclear praised as being sustainable but it gives the most energy for the smallest amount of fuel. This demonstrates that a significant bias does exist. Nuclear waste is viewed as somehow unacceptable when, if you have read this far, you will know the waste is well managed and safely stored in dry casks and will serve as a future power source for new reactors. Yes, what we call waste is perfectly good fuel for producing electricity. That's because only 5% of the fuel that goes into current reactors gets utilized. A handful of companies expect to have nuclear reactor prototypes that will consume used fuel ("nuclear waste") in less than 10 years.

Wind and Solar are intermittent energy sources. That's a very significant fact. It means that other sources of energy and/or storage capacity are needed in order to provide energy through the periods when wind and solar cannot function. So how is wind and solar renewable? It's only renewable if it's available. In a 24/7 world that's not good enough. The capital investment and the environmental costs of compensating for the intermittency of wind and solar should be included in the estimates of the cost for comparison purposes.

Can Distribution of Electricity Solve the Intermittency Problem?

The theory goes that if you have in place enough wind turbines and solar panels over a wide enough land area, that there will always be enough wind or enough sun available. But we all know that the entire continent goes dark for several hours every day. And, yes, there is never a completely still day over the continent, but that does not really matter because what counts is that the power lines needed to even test this theory would be in far greater quantities than we could afford to build and the manpower needed to actually mine the copper would not be feasible. See Mathijs Beckers report, book and video.

Wind has the most money expended for electrical power gained and is known for disrupting smooth grid transmissions. Solar can be less disruptive if installed locally, meaning, used by local homes, schools, or businesses for non grid applications such as heating water or recharging batteries for low power devices.

Reclassifying Nuclear as Renewable

Ohio, Arizona, Idaho and Missouri have initiatives to classify nuclear as renewable. This is a positive step towards making this a true nuclear energy era. On the other hand scrapping the use of renewable on the grid might be what's needed. Perhaps the various types of power should be considered on their own merits. Perhaps keeping renewable energy off the grid should be made a legal requirement for renewable energy use in some locations.

Wind and Solar and other intermittent energy sources need a new strategy. Separation of base load dependent electrical use and less critical electrical use is needed so that renewable energy sources can be applied locally and coupled with storage and not made part of the same grid that carries base load.

Feeling Good Can Be Expensive

Most of us are seduced by the idea of clean renewable energy until we realize that feeling good is expensive. When we deploy wind turbines (wind mills) and solar we are building what can be described as a very diffuse energy supply. In other words it takes a lot of them to create useful electricity. But since they cannot do that in any reliable way we need to have natural gas, coal plants or nuclear plants to replace them when they are down. But that disadvantage comes with a price. Ironically “renewable" energy is heavily subsidized. The structure of that agreement that subsidizes renewable guarantees that they get compensation as if the wind is blowing 24/7. But when they are not running (which is frequently) we need to pay for the power that replaces them. That means the power utility company charges you twice. Once for the inflated costs of temporary stretches of wind and solar energy and again for the replacement energy needed when the wind and sunlight are missing.

When Is Solar OK?

Solar on rooftops, in areas where it is frequently warm and sunny, can be used for local power to reduce energy needed from grids powered with fossil fuels. There is one distinct advantage over solar farms. The power that is harnessed goes into the local users home or business and it acts as a buffer that would not occur if the electricity came from a solar farm. But if the grid is powered by enough nuclear there won’t be a need for renewable energy. Wherever Nuclear Energy is located it does not make sense to add wind or solar to those regions but since policy often dictates and is hard to change we must give into political pressure and build reactors that can load follow wind and solar. If the leadership were to learn these facts a lot of expense could be spared. What's needed to make a much needed transition is a promotional campaign to sing the praises of nuclear power.

When President Obama says let's use "all of the above" he really means he doesn't have the will to make nuclear a platform issue. He does not fully understand how serious our situation really is.

When is wind OK?

Wherever there is a windy remote community that does not have nuclear then wind makes sense in a limited way. The problem is that adding wind farms (also true for solar farms) to a grid near a large city will destabilize and cause damage to the infrastructure. And perhaps the worst effect of all is the cost of maintaining a system that has too many surges to the system. Energy Reality is not totally against renewable we just view the flawed technology as bad timing when nuclear already does such a good job. The demand is too great to expect renewables to be sufficient. The remediation of damage to our oceans and atmosphere needs to start immediately.

Myths about Nuclear Power Plants

It is impossible for a nuclear reactor to have a nuclear detonation. The kind of explosions that are possible are non-nuclear and the result of extreme temperature. Pressurized water and/or hydrogen explosions are possible but they occur in only the rarest circumstances. In fact the evacuations have done more harm than good.

Pressurized reactors that currently exist have been known to have hydrogen explosions. These have been damaging mostly to the local plant and would not cause widespread contamination although Chernobyl did spread radiation it serves as the absolute worst case scenario that no reactor that has been built outside Soviet run Ukraine would ever be capable of. Fukushima did release much smaller amounts of radiation in the first days but subsided quickly. Both examples happened in old reactors where human error had a greater potential and the operators failed to follow recommended procedures.

Living near a nuclear plant is not a radiation risk. “We are surrounded by naturally occurring radiation. Only 0.005% of the average American's yearly radiation dose comes from nuclear power; 100 times less than we get from coal , 200 times less than a cross-country flight, and about the same as eating 1 banana per year."

We need to put our support toward North American initiatives and the newest trend that is gaining traction is the Small Modular Reactor (SMR). This is a trend that would speed up how quickly we build power plants and bring down the costs.

https://piaterdaro.files.wordpress.com/2015/10/handbook-of-radiation-measurement-and-protection.pdf

Fossil Fuels

Coal plants are the worst offenders by far! London's Great Smog of 1952 is a perfect example.

www.metoffice.gov.uk/education/teens/case-studies/great-smog

But all fossil fuel plants produce carbon dioxide. We already have an inventory of CO_2 that recently passed the 400 ppm mark. CO_2 will need to be removed from the air and oceans if we expect to reverse the effects of global warming and climate change and at the same time save all the species of fish and mammals from going extinct.

Natural Gas

This under-regulated industry has been abusive and treated with abuse. There are sources that indicate it has had a positive impact on reducing CO_2 that coal would otherwise produce. Yet other indications of methane leaks lead us to believe the rewards are not big enough. Studies indicate that there is effectively no green house gas reduction.

thebreakthrough.org/index.php/voices/energetics/us-exports-have-little-discernable-impact-on-massive-global-coal-growth

More details are here:

thebreakthrough.org/index.php/issues/natural-gas/faqs-on-natural-gas

But satellite data reveals a high level of methane release across the U. S. Whenever any fossil fuels are involved it comes with a price. Fracking has been doing its damage to the water table, the local wildlife, the destruction is an invasion of the landscape and has literally invaded adding earthquakes to the list of growing concerns.

Gas plants in Dakota flare off between 30% and 40%[9-3] of the methane they gather. That combustion is a problem! How much CO_2, anybody? Is that part of the calculations done in studies on their contribution?

The average person views the water of the oceans as a limitless and indestructible resource. Part of our policy needs to adapt a view on the precious resources of water and oxygen. Water and air are not replaceable. We must ensure these are properly preserved. Our children and grandchildren will be affected by the degree to which we keep these resources pure & clean.

Safety Concerns about Nuclear Power Plants

www.nei.org/Issues-Policy/Safety-Security/Operational-Safety

New Perspective and Prospects for so-called Nuclear Waste

If there's anything useful to know about nuclear waste is that the next generation of reactors we will likely start using it as nuclear fuel (not waste at all) for converting to energy. It is also easily managed simply because the fuel does not change its physical size and takes up very little room to start with.

Molten Salt Reactors (MSRs) Show Great Promise With Many Advantages.

The Molten Salt Reactor is a Generation Four technology and is under development in several countries. Those who are advocates of MSRs recognize that it solves a great number of issues but also provides new opportunities that never existed for existing nuclear technology.

With commercial roll-outs of MSRs in 6-9 years. MSRs are encouraged but only if they are passively safe (walk away safe) and all indications suggest that MSRs solves the common fears about reactors. All current reactors have aspects that, although engineered well, still scare people.

MSRs are not only passively safe but offers additional safety by having no pressurized containment. Traditionally a worse case scenario for current reactor designs has the possibility (although highly unlikely to happen) of spreading radioactive particles for miles. This is not the case with Molten Salt Reactors. Since the fuel is in a high temperature liquid state with no steam to carry radioactive elements it will simply harden when exposed to cooler surroundings.

Chapter 10

Perception Versus Reality

If we try to stay current with what's going on in the world we find ourselves constantly faced with the task of sorting out how others fail to see reality. But of course, depending on your sources, getting to the truth is harder than ever because within the explosion of information that's available, there is a deluge of misinformation. But, finding the full truth can set you free. I will limit my writing to my own personal experiences.

A big eye opener I had, not too long ago, was in a Facebook chat with a passionate young man who called himself a human rights activist. I was trying to persuade him that Ontario's energy bills were higher because of subsidies for renewables such as wind and solar. He was clearly very smart and articulate. Still, he disagreed.

He wanted to inform me that nuclear energy was bad because the uranium mining[10-1] it required was doing harm to the environment. His take on it was that nuclear power was run by the big bad corporations and that they were interested in profits at the expense of the people, especially the first nations people. I could not help but wonder if his point of view was outdated. I knew for instance that there is only one uranium mine still functioning in Canada and that is Cameco in Saskatchewan. I explained to him about the enormous benefit Ontario experiences as a result of our nuclear plants and that the good that nuclear plants do, far outweighs the harm the mining does.

Later, after digging more into the subject I discovered that mines and power plants have consequences and their proximity to valued natural habitat going back just 25 years has a dark history with regard to the wishes of the First Nations people. Consultation has been missing from the process of establishing mining and power plant operations.

As recent as 50 years ago consultation with First Nations, Inuit and Métis regarding mining activities was nonexistent. There has been a significant improvement, especially in recent years. For example there are clear indications from Ontario Power Group (OPG) that dialogue has improved. The world's biggest uranium mines are in Kazahkstan, Canada and Australia. Canada's worst health impacts to the indigenous people go back to the 1930s right up to 1962 in Deline, Northwest Territories.

It is a violation when you show up in someones backyard uninvited. It is invasive when you start digging without permission and without any attempt to educate the people about the dangers or benefits. All of that has changed and the rules were laid out in 1995. Now that protocols have been established and consultation has been started. What needs to be communicated more often is that the benefits of uranium mining and nuclear energy far outweigh the costs. That means economically, environmentally and humanely. The risks may be small but when the perception of the risks are high then dialogue is needed and the First Nations groups were not getting that information or communication. Who handles marketing for the nuclear industry?

From the Canadian Nuclear Safety Commission (CNSC) website they say (see endnote pdf):

"

> "...Uranium exploration poses the same low risks to public health or the environment, as any exploration methods (such as drilling small core samples). It does not significantly modify the natural environment. Uranium exploration presents a very low risk of increasing radiation or radon exposure to the public and to the environment…"

> "...The CNSC ensures streams, lakes and rivers downstream of uranium mining projects are safe for people, plants, fish and other animals…"

> "...The CNSC assesses monitors and tracks licensees' environmental performance to verify that releases to the environment are not harmful and are below regulatory limits. Since 1994, an ongoing monitoring study in northern Saskatchewan has assessed the cumulative impacts of radon, radionuclides and heavy metals on the local environment. Results have shown that uranium mines have no effect on radon levels, and that uranium, radium-226, lead-210 and polonium-210 levels in fish were often below detection levels. When measurable, these levels were no different

> around mine sites when compared to those at both nearby and remote reference sites..."

In recent years Quebec, British Columbia and Nova Scotia have placed moratoriums on uranium mining after investigations into Uranium Mining practices appeared largely based on pressure from human rights groups. These groups demand inquiries and reports are made but typically lack the scientific inquiry and they ignore the properly conducted scientific studies of already existing reports made by the CNSC.

There has been successful antinuclear activity in affecting change. Canada and the US both have their share of opposition to all things nuclear. The majority of cases where restrictions have occurred are due to emotional reactions based on outdated information and antinuclear rhetoric that ignores the successes in upgrades and regulations that apply to all current uranium mining in North America in effect since the 1990s.

Clearly the discussion with the young activist had a positive effect on me. I researched the topic. But I scored a few points too. He agreed that closing down all the coal plants in Ontario was something to be proud about. The point he did not grasp was that nuclear power was the main reason that stopping coal was even possible. He also failed to realize that Ontario would not be able to maintain its low carbon footprint without nuclear plants. He kept throwing at me the line about keeping this sustainable. I tried to explain that wind and solar farms are not sustainable. That was a tough one to crack.

If the wind stops blowing or the sun stops shining in the idealistic world of renewable energy lovers what energy source comes to the rescue? Well in Ontario it happens to be natural gas. The same is true for other parts of the world especially where natural gas is easy to come by.

What is interesting is that nuclear power could do it all alone. But to humour the pro-renewable camp let's try to understand why Europe has had load following reactors and North American reactors don't. The punitive attitude towards nuclear would never let modifications take place without a massive review process. Consequently we don't even try for new designs. So, carbon emitting natural gas wins by default because our system is still out of date and bases their decisions on a dogmatic approach to radiation dangers that have been proven to be overly conservative.

In Germany coal is winning that role where they foolishly started shutting down their nuclear reactors. But the hardest part to grasp is that if wind and solar were not part of the strategy to start with you would not need to find energy to replace the frequent losses of wind and solar power. So the perception that a significant risk exists outweighs the facts and decisions are made that have serious consequences economically and environmentally.

I noticed that my adversary and I resorted to our areas of expertise and I eventually realized our agendas had completely different foci and prevented us from winning each other over to our own side. It was clear to me that this individual was more concerned about the rights of individuals than about the best way to save the ecology of the planet. I did have a moment where I got him to recognize that nuclear might have a role in keeping things sustainable. I guess that was an accomplishment.

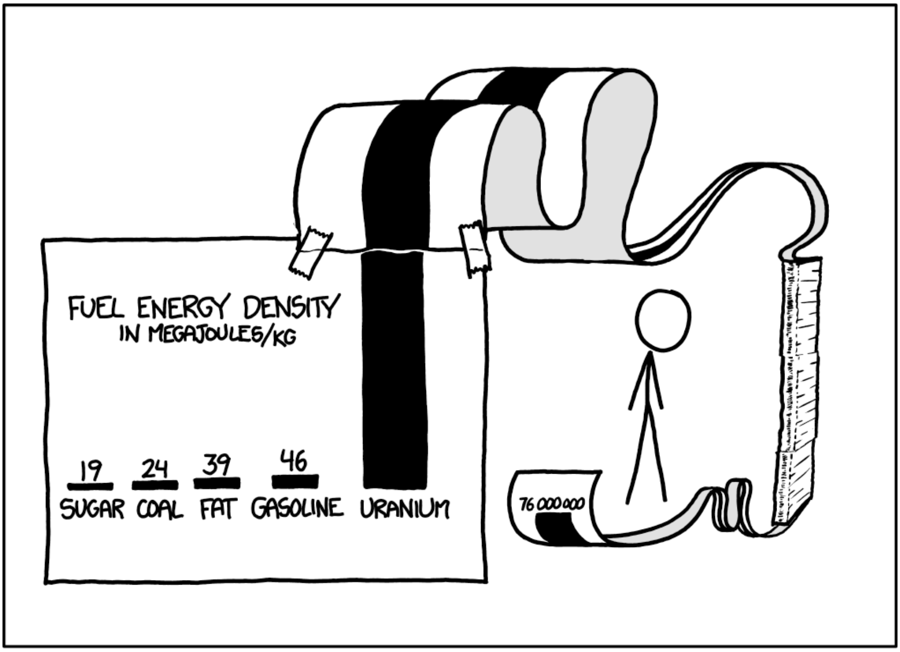
There was a lesson here. If your adversary calls themselves an activist you better be prepared to anticipate their bias and try to frame any new arguments you have from a perspective that they understand. I realized that my argument should have been that clean water and clean air are human rights and that nuclear energy happens to be one of the best ways to accomplish the goals of keeping the air and water clean.

Chapter 11

Energy Density

The energy stored in atoms has been hypothesized as beginning before the big bang that has continuously expanded ever since. The theory states that before the big bang all matter was compressed into a tiny sphere and that the pressure exerted on each atom, created properties that remained thereafter. Hence the mysterious force that keeps atoms glued together although still unproven have become useful to us billions of years later.

If there could ever be a lesson learned that can make a person recognize why we need nuclear power, it is the case for energy density. All of the energy choices have a small power output compared to nuclear. We are going to look at how various energy forms differ by the quantity of fuel per unit and in the case of wind, solar and hydro their energy footprint that needs to factor in efficiencies and dependencies.



SCIENCE TIP: LOG SCALES ARE FOR QUITTERS WHO CAN'T FIND ENOUGH PAPER TO MAKE THEIR POINT *PROPERLY.*

Energy Density measures how much heat is released in an second of time. A **joule** is the energy dissipated as heat wh current of one ampere passes through a resistance of one o second.

<u>MegaJoules per Kilogram</u>

<u>MJ/Kg</u>

Sugar is 19 MJ/Kg

Coal is 24 MJ/Kg

Fat is 39 MJ/Kg

Gasoline is 46 MJ/Kg

Uranium is 76,000,000 MJ/Kg

See[11-1]

There are two ways to look at energy density.
One is by looking at how much energy is produced per unit of fuel. Nuclear fuel is as compact as you can get. The power contained in several pellets of Uranium is literally very dense.
Two is by looking at how much energy is produced by the resource equivalent whether that be wind, sunlight or water. The energy produced per unit of fuel is easy to calculate. The energy produced by wind, sunlight and hydro are trickier values to calculate. Wind and solar are more of a problem to sort out because they are dependent on things that are less predictable like the weather or daylight. Their dependencies are also hard to ignore. Both wind and solar energy depend on other energy types whenever the wind stops blowing or the sun stops shining.

(Wind Turbine Density: 0.03 MJ/Kg)
(Solar Panel Density: 0.0000015 MJ/Kg)
But which type of energy source will replace the missing wind and solar energy?

Table 1 Energy Densities
see image of table

Medium	Energy Density MJ/m³	Electrical Energy Density kWh/m³	Conv. Effic.	Comments
Natural uranium (Fast)	150,000,000,000	12,500,000,000	30%	Fast reactors
Natural uranium LWR	950,000,000	80,000,000	30%	Thermal
Black coal	24,000	2,300	35%	-
Brown coal	15,000	1,000	25%	-
Dry wood	10,000	970	35%	Biomass
Natural gas	38	5	45%	CCGT

Energy density is expressed in megajoules (MJ) per cubic meter (m^3). There is always some loss in converting the stored energy to electrical energy, so the table shows the typical conversion efficiency and the electrical energy recovered per cubic metre of fuel.

In the U.S. its natural gas. Other places that find natural gas too expensive are more likely to use dirtier sources of energy like coal. If the local land formations allow it pumped storage power plants can be used but they are not available everywhere.

The Levelized Cost of Electricity (LCOE) helps compare their value.

“The levelized cost of electricity (LCOE) is a measure of a power source which attempts to compare different methods of electricity generation on a comparable basis. It is an economic assessment of the average total cost to build and operate a power-generating asset over its lifetime divided by the total energy output of the asset over that lifetime. The LCOE can also be regarded as the minimum cost at which electricity must be sold in order to break-even over the lifetime of the project."

Wikipedia: Cost of Electricity by source

“Roadmap to Nowhere" is a chapter from a book called “Power to the Planet" by Mike Conley and Timothy Maloney that helps illustrate what the problem is with so-called renewable energy.

Four bottom lines up front:

- It would cost over $29 Trillion to generate America’s baseload electric power with a 50 / 50 mix of wind and solar farms, on parcels of land totalling the area of Indiana. Or:
- It would cost over $18 Trillion with Concentrated Solar Power (CSP) farms in the southwest deserts, on parcels of land totalling the area of West Virginia. Or:
- We could do it for less than $3 Trillion with AP-1000 Light Water Reactors, on parcels totalling a few square miles. Or:
- We could do it for $1 Trillion with liquid-fueled Molten Salt Reactors, on the same amount of land, but with no water cooling, no risk of meltdowns, and the ability to use our stockpiles of nuclear “waste" as a secondary fuel.

One estimate by my colleague Mathijs Beckers is that if the U.S. were to go 100% renewable the rest of the world would have no resources left to do the same. That’s how much we would need in materials such as steel, concrete, aluminum and copper wire. China and India would be stuck burning fossil fuels.

Despite Germany’s plans to shut down nuclear power plants they will have trouble shutting them down. They boast about their plans to make renewable energy the dominant energy source regardless of the fact that they have achieved only a 15% share in the energy mix. Misguided intentions considered, they are not tsunami prone like Fukushima was in Japan. Energiewende cannot shut down nuclear power easily because currently they provide so much of the missing energy. Unlike the U.S. natural gas is more expensive in Europe because they don't have the geological conditions for natural gas. What they do have ironically is coal which has been added to their energy mix. The dirtiest kind of coal fleet called lignite is now expanding in Germany. In fact it makes up over 50% of their electricity in the country cited as being largely renewable.

Energy density of nuclear energy is precisely why it is by far the most significant factor in reducing Carbon emissions. We all know that nuclear power is mighty. We think of phrases like "harness the atom" and "split the atom." What is hard to grasp about nuclear energy is just how much energy is contained in uranium, plutonium or thorium. It is because of this huge amount of energy created per unit of fuel that makes it so appealing and after comparing you will see that it is necessary.

Being energy literate you will begin to see why nuclear energy is so desperately needed. Being painfully aware of the threat carbon dioxide has become and being energy literate we realize its the facts that matter.

We know coal is by far much more harmful and deadly than nuclear. The nuclear safety record is the best. To illustrate the point let's try to imagine an impossible scenario that for all the planet's nuclear plants we managed to produce one chernobyl accident a day. First remember that depending where you heard about Chernobyl the numbers will vary. But we would still be doing better than the current damages being done by coal pollution. Coal kills 1 million people a year worldwide. That's 2700 a day worldwide. Looking at just the U.S. that's 24,000 a year or 67 a day. Considering Chernobyl's official death toll is 60 people it is fair to say that nuclear energy in a worse case scenario is still a better choice than coal. Also consider that nuclear accidents are very rare. Count the coal mine accidents, the natural gas explosions, the oil spills, the hydro dams bursting, even the repairing of wind turbines and installation of solar panels has had more accidents than nuclear plants. But everyone remembers the three nuclear plant accidents over the entire history of commercial nuclear plants that killed less than 100 people combined and that was all in Chernobyl.

The countries of China and India dwarf our North American countries. They are desperate to come out of poverty. Will they listen to the brats marching for green power. Those who march in the name of renewable energy and conservation have never lived without energy for any length of time that matters.

https://en.wikipedia.org/wiki/
Environmental_impact_of_the_coal_industry

Why can't weather dependent wind and solar solve our problems?

Wind and solar power are diffuse and unpredictable. We know when the sun shines if there's no cloud cover. And there are regions that have more wind and there are regions that have more sun but they are not the norm. Last century the countries that had power mostly ran on reliable power. Our grid is geared to handle reliable power. We call reliable power base load power like nuclear, hydro, natural gas, oil and of course coal. Over 400 coal plants exist in the U.S. and we keep saying we need to stop coal plants. 60% of American electricity comes from coal.

Does running a lemonade stand in front of your house as a child prepare you for the retail business? Hardly.

A uranium pellet the size of your finger tip produces (with zero emissions) the same energy as 1,780 pounds of coal.

Here is a quote from Alex Cannara who keeps his group members primed for encounters and this is a simple to understand explanation:

"Ok gang, here's the pinky story: Hold up a pinky. If the top two joints of your pinky were Uranium 235, it would run your profligate American life for 10 years. That would give you two pinkies of 'waste' including a teeny amount of the long lasting kind like Plutonium.

That "waste" is usable in advanced reactors and they decay to ordinary elements taking anywhere from seconds to a few centuries. So every decade, that individual would have to find a pill bottle to put the waste in and bury it next to the prior decade's bottle in their back yard. Each bottle could indicate when it can come back out.

Wade Allison & some other sensible Brits in an attempt to show their confidence of the safety of such stored waste offered their gardens as a place for the "waste."

One pinky's worth of pure fissile Uranium produces enough energy to supply a single person for 10 years leaving behind two pinky sized pellets of so-called "waste" fission products (much of it is reusable). Producing the same amount of energy from coal would take 286 refrigerator loads to produce 20 refrigerator loads of coal ash. "

From Booklet on IAEA website Energy density comparisons (fuel and land requirements)

The quantity of fuel used to produce a given amount of energy - the energy density - determines in a large measure the magnitude of environmental impacts as it influences the fuel extraction activities, transport requirements, and the quantities of environmental releases and waste. The extraordinary high energy density of nuclear fuel relative to fossil fuels is an advantageous physical characteristic.

One kilogram (kg) of firewood can generate 1 kilowatt-hour (kW•h) of electricity. The values for the other solid fossil fuels and for nuclear power are:

One kilogram of:	kilowatt hours (kWh)
firewood	1
coal	3
oil	4
uranium	50,000 (3,500,000 kW•h with reprocessing)

Consequently, a 1,000 MW(e) plant requires the following number of tonnes (t) of fuel annually:

Plant Fuel	No. of Tonnes (t) per year	How much space it occupies
coal	2,600,000 t	2,000 train cars (1,300 t each)
oil	2,000,000 t	10 supertankers
uranium	30 t	reactor core (10 cubic metres)

The energy density of fossil and of nuclear fuel allows relatively small power plant areas of some several square kilometers (km^2). The low energy density of renewables, measured by land requirements per unit of energy produced, is demonstrated by the large land areas required for a 1000 MW(e) system with values determined by local requirements and climate conditions (solar and wind availability factors ranging from 20 to 40%):

Type of Power Plant	**Area (km^2)**
Fossil and nuclear sites	1–4 km^2
Solar thermal or photovoltaic (PV) parks	20–50 km^2 (a small city)
Wind fields	50–150 km^2
Biomass plantations	4000–6000 km^2

Comparing the energy output difference of Uranium to Coal

Comparing the energy output difference of Thorium in Molten Salt Reactors to Uranium to coal

Who's the Fairest of them All

There was a time when Nuclear Energy was the cheapest going by the accounting. In fact it still is over long periods of time.

Looking at figures from 1982 page 98 The Environmental Case for Nuclear Power

Kirk Sorensen explains how energy dense a Thorium Molten Salt Reactor based on his LFTR design would be.

“A mere 6,600 tonnes of thorium could provide the energy equivalent of the combined global consumption of 5 billion tonnes of coal, 31 billion barrels of oil, 3 trillion cubic meters of natural gas, and 65,000 tonnes of Uranium"

Hydro uses kinetic energy from the flow of water. Wind uses kinetic energy from the flow of air. Solar uses electromagnetic radiation from the fusion reactions on the sun.

The different fuels we use as energy sources are either combustible or fissionable. The combustible type is the breaking of chemical bonds called an exoergic or exothermic reaction. 95 percent of the world’s energy is created from combustion of coal, oil and natural gas.

That leaves us with nuclear energy which relies on another type of energy release from breaking a nuclear binding force. The reaction depends on using uranium or plutonium. Thorium is still experimental but could prove to be an indirect fuel that goes through the thorium cylcle to produce uranium. Thorium has advantages based on its abundance 4 times more plentiful than Uranium, better fission products than Uranium. As Kirk Sorensen explains the real advantages of Thorium are a real game changer when the reactor is using the molten salt reactor as it's design. It is the fluid that makes all the difference. Hot fluid mixture allows nearly full utilization of the fuel.

Chapter 12

Nuclear Technology's Numerous Uses

This is the 2004 article by Alan E. Waltar (alan.waltar@pnl.gov) is director of nuclear energy at Pacific Northwest National Laboratory in Richland, Washington. Original article was published in "Issues in Science and Technology, Vol. XX, No. 3, Spring 2004"

We should not let unjustified fear of radiation create obstacles to continued progress and benefits.

In his 1953 "Atoms for Peace" address to the United Nations, President Dwight D. Eisenhower challenged scientists and engineers to harness the atom for humanitarian purposes in medicine, agriculture, and other non-power aspects of direct benefit. Half a century later, nuclear technology has had astounding economic and job impacts in the United States (see Table 1). The totals in terms of dollars and jobs are impressive, but perhaps the biggest revelation is that the atom has a substantially larger impact outside the nuclear power sector than in it.

Perhaps the most significant success story over the past half-century in harnessing radiation to serve modern humanity is found in the field of medicine.

Sterilizing medical equipment. Radiation in high enough doses can kill microorganisms, so gamma radiation is used to sterilize dressings, surgical gloves, bandages, and other equipment routinely used during medical procedures. Today, well over half of all sterilized medical equipment used in modern U.S. hospitals has had radiation treatment. This is safer and cheaper than most other methods (such as steam) because it can be done after the item is packaged. Its sterile shelf life is practically infinite as long as the package is not opened.

New drug testing. Substantial testing must be done before new drugs are approved. This includes detecting how a product attacks a targeted disease and any possible side effects. Radioisotopes, because of their unique imaging characteristics (via particle emission), are ideally suited to deal with such questions–including material uptake, metabolism, distribution, and elimination of unwanted residues from the body. For at least 80 percent of the new drugs approved by the U.S. Food and Drug Administration (FDA) for medical use in the United States, radiation was a crucial component of their success in making it through the approval process. The International Atomic Energy Agency estimates that some 100 to 300 radiopharmaceuticals are in routine use throughout the world, and most are commercially available.

Diagnostic techniques. The earliest use of radiation in the medical field occurred in World War I, when portable x-rays helped field surgeons save many lives. Today, dental x-rays, chest x-rays, mammograms, and numerous other tests are used routinely in the medical and dental professions.

But x-rays, useful as they are, provide only a snapshot of a particular piece of the anatomy. The imaging properties of radioisotopes allow modern nuclear medical specialists to measure the activity of some specific physiological or biochemical function in the body as a function of time. Two of the most common technologies are single photon emission computed tomography (SPECT) and positron emission tomography (PET), which are used to detect cancer. Nuclear diagnostic techniques are now routinely used throughout the industrial world to determine anomalies in the heart, brain, kidneys, lungs, liver, breasts, and thyroid glands. Bone and joint disorders, along with spinal disorders, also benefit directly from this routine use of radioisotopes.

Therapeutic approaches. Until recently, the use of radiation to actually cure diseases was rather limited. One of the first therapeutic applications involved using iodine-131 (^{131}I) to cure thyroid cancer. Since the thyroid has a special affinity for iodine, it is a relatively simple and straightforward matter to have a patient drink a carefully determined amount of ^{131}I in a chemically palatable form of solution. The ^{131}I then preferentially lodges in the thyroid gland, and the beta-emitting properties of this radioisotope subsequently target and destroy the thyroid malignancy. Since ^{131}I has a half-life of eight days, it effectively disappears within a few weeks. Radiation is now used widely in the treatment of other cancers as well.

Most of the current therapeutic procedures deliver radiation to the patient externally. Accelerators are used to deliver either protons to the target or beta particles, which are normally directed onto a target that secondarily produces x-rays. Although this can have substantial benefits, it is impossible to keep the radiation from killing or impairing healthy tissue in the immediate vicinity, especially if the beam must pass through healthy tissue to reach the malignancy.

Table 1. Overall Impact of Nuclear Technology in the United States.				
	1991		1995	
	Sales (billion dollars)	Jobs (million)	Sales (billion dollars)	Jobs (million)
Radiation	257	3.7	331	4.0
Nuclear Power	73	0.4	90	0.4
Total	330	4.1	421	4.4

[a]Using a multiplicative economic model that includes secondary revenue and jobs created by the primary source

There are three principal ways to minimize injury to healthy cells from radiation therapy: (1) rotating the external beam around the patient, (2) creating radioisotopes only at the site of the malignancy, and (3) developing a method to deliver appropriate radioisotopes directly to the cancerous tissue.

An example of the first approach is the "gamma knife," where the radioactive source is delivered from many directions, with the beam continuously focused on the targeted abnormality but with only small amounts of radiation passing through healthy tissue.

An example of the second approach is boron-neutron capture therapy. Boron is introduced into the patient as part of a special chemical carrier, so that it preferentially concentrates at the tumor site. A neutron beam is then focused on the boron, producing alpha particles that destroy the malignant cells only in the immediate vicinity of the concentrated boron. Because alpha particles are typically stopped within one human cell from their point of origin, the intense radiation damage is quite localized.

An example of the third approach is cell-directed radiation therapy. In order to have just localized damage, either beta or alpha emitters are needed. For solid tumors, one method of getting the radioisotope to the target is direct injection, assuming that the tumor is accessible. Brachytherapy, for instance, is used to treat prostate cancer: Several "seeds," each containing a small amount of a radionuclide such as I125 or palladium-103 within a titanium capsule about the size of a grain of rice, are placed directly into the prostate gland, where they remain for life. Another cell-directed method involves attaching the radioisotope to a chemical that has a special affinity for the malignancy. This is called the monoclonal antibody (or "smart bullet") approach. It is particularly suited for treating malignancies that are not confined to a particular spot, such as leukemia and non-Hodgkin's disease.

Although many of these therapeutic applications of radiation are still in relatively early trial stages, the potential for success is enormous.

AGRICULTURE

There remains a huge need to find new ways to increase food production and deliver food without spoilage to the growing global population.

Greater crop production. By attaching radioactive tracers to known quantities and varieties of fertilizers, it is possible to directly determine nutrient efficiencies as the labeled products are absorbed at critical locations in the plant. This can help to substantially reduce the amount of fertilizer required to produce robust yields.

Water is becoming quite scarce in many areas of the world. Neutron moisture gauges can measure the hydrogen component of water in both the plant and the surrounding soil. Thus, they are ideal instruments to help farmers make the best use of limited water supplies and are now found on many large U.S. farms.

Another effective way to improve crop production is the development of new species–varieties that can better withstand heat or storm damage, have earlier maturing times to escape frost damage and allow crop rotation, resist diseases and droughts, provide better growth and yield patterns, deliver improved nutritional value, allow improved processing quality, and so on.

Specialized radiation techniques–either directly bombarding seeds to alter DNA structures or irradiating crops to induce variations in the resulting seeds–can greatly accelerate the selection process. Radiation was the key element in the development of 89 percent of about 2,250 new crop varieties in the past 70 years; three-quarters of these irradiation-induced varieties were food crops, and the rest were ornamental flowers.

To date, China has benefited the most from using radiation to improve crop species. As of 2002, nearly 27 percent of the crops grown in China were developed this way. The equivalent figure elsewhere ranges from 11.5 percent in India and 9.3 percent in Russia to 7.8 percent in the Netherlands, 5.7 percent in the United States, and 5.3 percent in Japan. Indeed, the application of radiation techniques to the development of new crop varieties has probably provided the greatest global economic value of any form of harnessing radiation.

Improving Animal Health. Farm animals have likewise benefited from the application of radiation techniques. One key area concerns the optimal use of natural pastures or commercially prepared feeds. This is accomplished by labeling feed with specialty radioisotopes, such as carbon-14, and then tracing the paths of the food within the animal's digestive system to determine where and how quickly it is broken down into body tissues or milk. This helps determine food's nutritional value.

Radioisotopes have also been used to develop vaccines that are effective against certain animal diseases. For example, rinderpest ("cattle plague")–a dreaded disease that has killed millions of cattle on African farms over the past four decades–has been eliminated using radiation-produced vaccinations in 16 of the 18 African countries previously infested.

Eradication of pests. One proven way to use nuclear technology in controlling or even eradicating unwanted insects is the sterile insect technique. This involves mass "factory breeding" of large numbers of the target insects and sterilizing the males by exposing them to gamma irradiation. When the sterilized males are released into infested areas and mate with wild females, no offspring are produced; if the sterilized males greatly outnumber the wild males in the area, the pest will be eradicated. Perhaps the largest success to date in using this technique occurred in Mexico.

The Mediterranean fruit fly (the medfly) was knocked out entirely by 1981, and a screwworm eradication program yielded some $3 billion in benefits to the Mexican economy by 1991.

Food processing. Tragically, infestation and spoilage prevent one-fourth to one-half of the food produced in the world from reaching people. In addition, the food that does reach them can become unsafe to eat because of contaminants such as insects, molds, and bacteria. The U.S. Centers for Disease Control and Prevention estimated in 1999 that some 5,000 Americans die each year from food-borne diseases, and about 30 million others become sick, with about 300,000 of them requiring hospitalization.

Food irradiation involves subjecting food to carefully controlled amounts of ionizing radiation, such as beta particles or gamma rays, to break the DNA bonds of targeted pathogens. This is especially effective in destroying the reproductive cycle of bacteria and pathogens. It can eradicate unwanted organisms and specific nonspore-forming pathogenic microorganisms such as salmonella. It can also interfere with physiological processes such as sprouting in potatoes or onions. Thus the shelf life of many foods can be extended appreciably, and the presence of food-borne disease organisms such as Escherichia coli can be dramatically reduced. It is important to note that food processed by radiation does not become radioactive. At the doses used, it is impossible for beta, gamma, or x-rays to make food radioactive.

One of the prime advantages of food irradiation is that it sterilizes food without altering its form or taste. Older methods of food processing, which rely on heating or freezing, extreme drying or salting, or chemical treatments, generally do change the way food tastes and/or looks.

Widespread acceptance of food irradiation by the general public has been slow, but there are several signs–particularly in the United States–that consumer acceptance is not far away. Major supermarkets have signed on to offer irradiated meat at some stores. And the 2002 Farm Bill approved by Congress mandated that commodities such as meat and poultry that are treated by any technology approved by the U.S. Department of Agriculture and the FDA for improving food safety must be made available to the National School Lunch Program. Food irradiation is included in this mandate.

INDUSTRY

Although modern factories are the source of most of the products that we use daily, harnessed radiation in industry likely constitutes the most hidden use of this technology to ordinary citizens.

Process control and plant diagnostics. Because radiation has the ability to penetrate matter, industrial measurements can be made using radioisotopes without direct physical contact with either the source or the sensor. This allows online measurements to be made nondestructively while the material being measured is in motion. Measurements that are typically made in production lines include liquid levels, the density of materials in vessels and pipelines, the thickness of sheets and coatings, and the amounts and properties of materials on conveyor belts.

Radioisotope "thickness gauges" are unequalled in performance and are used extensively in almost every industry involved in producing sheet material (such as sheet metal or paper). It is highly unlikely that automation in such industries would be possible without the use of radioisotopes. Modern steel mills use such gauges to measure the thickness of rolled metals accurately at every moment during production. Paper mills use them to measure the density of wet pulp accurately in the first stages of paper production. These gauges are also frequently used in the food industry (such as in filling cereal boxes) and the oil industry, where determining the density of liquids, solids, or slurries is important.

Many radioactive tracer techniques have been used to investigate the reasons for reduced efficiency in modern plant operations. Tracers are now routinely used to measure flow rates, study mixing patterns, and locate leaks in heat exchangers and pipelines.

Materials development. Changes in molecular structure, including the inducement of desired chemical reactions, can be created in certain materials by appropriate exposure to radiation. For example, some polymers whose cross-linkage is induced by radiation can be tailored to shrink when heated. "Heat-shrink" products are now widely used in the packaging industry. Wire and cable insulated with radiation-cross-linked polyvinylchloride exhibit excellent resistance to heat and chemical attack and are widely used in the automobile, aerospace, and telecommunications industries. This process is being used increasingly to cross-link foamed polyethylene for thermal insulation and wood/plastic composites cured by gamma irradiation. The latter are gaining favor for flooring in department stores, airports, hotels, and churches because of their excellent abrasion resistance, the beauty of natural grains, and low maintenance costs. Many tire companies are now using radiation to vulcanize rubber for tire production as an improvement over the conventional use of sulfur.

Materials testing and inspection. One of the earliest industrial applications of radiation was to measure engine wear in the automotive industry. Irradiating the surface of an engine part under investigation (such as a ring or a gear) makes that portion of the metal radioactive. In tests to see which materials hold up best during operation, any wear on that part results in some radioactive material being deposited in the oil lubrication stream, where it can be readily measured.

Corrosion in pipes is a common problem in the industrial world. By moving a gamma source on one side of the pipe and a detector on the other, precise analyses can be made of the corrosion patterns. The activation property of radiation is used extensively to determine precise layers of special coatings, such as metal coatings to produce galvanized or tin-plated steel. The penetrating property of radiation is routinely used to check welds in crucial places such as airplane wings, housings for jet engines, and oil and gas pipelines.

Police and firefighters should be trained to deal with the real dangers of nuclear materials rather than perceived ones.

Energy The coal industry benefits directly from using neutron gauges to measure and control the moisture content in coal and coke. And gamma sources are used to assay ash content as well as the combustion gases that go up the stack. It is important to determine the sulfur and nitrogen contents of coal, which are of considerable interest because of their contributions to acid rain. A new radiation technique called electron beam processing has been developed to remove both sulfur and nitrogen oxides from flue gas effectively and allow the products to be converted into a commercially viable agricultural fertilizer.

The oil industry also depends heavily on the use of radiation to conduct business. Borehole logging often employs nuclear probes to determine the potential for economically viable oil deposits in test wells. Radiation monitors are also widely used to determine malfunctions in refinery operations.

Personal care and conveniences. Anyone who wears either contact lenses or glasses benefits directly from radiation. The saline solution used to clean and store contact lenses is sterilized by gamma radiation. Neutron probes are used to ensure the proper moisture content during the making of the high-quality glass for eyeglasses. Cosmetics often use gamma radiation to rid products of any microbes before the product is packaged for public consumption. One helpful feature of radiation is that it changes the molecular structure of some materials to allow them to absorb huge amounts of liquid. Useful products that rely on this include air fresheners, disposable diapers, and tampons.

OTHER FIELDS

Radiation has an increasing role in public safety, including airport screening, crime solving, and the deterrence of terrorism at points of entry. The use of americum-241 in smoke detectors has undoubtedly saved thousands of lives and prevented untold property damage.

Radiation is also a key component for archaeological dating and the enhancement of precious gems. It is likewise used extensively for measuring and controlling sources of contamination to our environment.

Advanced space exploration would not be possible without radiation technology. Plutonium-238 is widely used as both a heat source to keep instruments from freezing and a source of electricity to run instruments and communication devices. Propulsion that uses nuclear-reactor rockets will be needed for manned voyages to other planets or their moons.

Finally, radiation technology provides a powerful fleet of tools to probe and unravel the mysteries of the basic structure of materials. From electron microscopes to very-high-energy accelerators, researchers have one of the best sets of technologies available to both explore existing matter and to synthesize new materials with highly desirable properties.

OBSTACLES TO FURTHER PROGRESS

It is not a given that these impressive applications of nuclear technology will continue to expand. The public's sometimes overriding fear of radiation has historically thwarted progress in many areas.

This fear has worked its way into numerous rules and regulations among federal and state agencies that have stymied progress and added considerable cost in several areas. For instance, the intense degree of regulation of almost anything having a nuclear component forces practitioners to use time-consuming and expensive accounting practices. Is the cost of such detailed recordkeeping really warranted when the expense of such attention to detail is ultimately passed on to the public? Some medical practitioners have reacted by moving into other areas of practice.

Perhaps a larger issue facing the nuclear medical industry is the disposition of low-level radioactive waste (LLW). There are currently only two U.S. sites licensed to receive this waste material: Richland, Washington, and Barnwell, South Carolina. Efforts to dispose of LLW in other areas have met strong public resistance, even though detailed scientific studies have shown such sites and associated operations to be much safer than essentially any other waste commodity. As a result, long-distance hauling of LLW from hundreds, if not thousands, of sites clearly adds to the cost of waste disposal today and hence to the cost of using this technology.

A significant impediment to the medical community is the limited availability of new radioisotopes. Currently, the United States imports at least 90 percent of the radioisotopes used in daily commerce. Further, the U.S. Department of Energy has reduced its research budget for producing and developing the use of new radioisotopes to zero. Some clinical studies to use new radioisotopes in curing cancer and other life-limiting diseases have been halted because of the lack of isotopes. Of perhaps greater concern, there are very few sources of alpha emitters, which have enormous potential for curing several types of cancer. Without a major change to revitalize the U.S. radioisotope program, nuclear medicine could stagnate. New techniques such as gene therapy will likely play an increasing role in the future, but even these often require the concurrent use of radiation technology in order to be successful.

Concern over radiation dangers is also thwarting progress in areas other than medicine. A classic case is food irradiation. This technology has been studied for more than four decades in several countries and has been declared safe and effective by essentially every relevant international scientific body. Yet only recently have U.S. federal approvals been given for its use on major food items. Irradiated foods sold in bulk, such as chicken or strawberries, are designated with the "radura" symbol on the package. Approval of the irradiation of seafood commodities is still pending, but efforts to gain it are under way. This is important because spoilage is quite high for many of these products. In a less visible aspect of agriculture, many thousands of acres of stubble are burned every year to cleanse fields of insects and other undesirable pests; gamma irradiation might provide a better soil-cleansing operation.

Even though radioisotopes are widely used in industry for gauges, the automation of processing, the manufacture of new materials, and so on, there is still reluctance in some quarters to use radiation because of concern that the public may be unwilling to accept products from a company utilizing radiation technology.

The U.S. space program has stagnated somewhat over the past decade or two because policymakers have been exceptionally cautious about developing nuclear propulsion engines. Fears of minute quantities of radioactive materials falling back to Earth after a mishap in space have sometimes overshadowed the fact that deep space exploration with sizable payloads simply cannot be accomplished without nuclear propulsion. The United States has launched only one nuclear reactor into space to date, but there are now plans to build and launch a substantially larger reactor as a key part of the Jupiter Icy Moon project.

Since the 9/11 tragedy, public fears have risen about terrorists' possible use of a radiation dispersal device (RDD) or "dirty bomb." Although this is clearly possible, the actual health effects from such a detonation would almost certainly be far less than imagined by a frightened public. Several scores of radioisotopes are being used to supply the benefits described throughout this article, but only a handful of radioisotopes pose a real potential hazard in an RDD. Hence, it is important that police and firefighters be trained to deal with real dangers rather than perceived ones, so that unnecessary panic does not take place if someone threatens to use such a device or actually sets one off.

It is clear that President Eisenhower's challenge to use the atom for peace has been ably met. The benefits achieved over the past 50 years are nothing short of astonishing. One out of every three patients who enter a U.S. hospital or medical clinic, for instance, benefits directly from nuclear medicine. This translates into over 10 million nuclear medical procedures per year. Even broader beneficial impacts are possible, such as the successful adoption of food irradiation in normal commerce.

But there are significant obstacles to overcome whenever radiation is used, mainly because of lingering public fears. Perhaps the most significant success that the scientific community could strive for in this field in the next 50 years is to effectively engage the public and political leaders in a dialogue to eliminate unnecessary fears of radiation. Making people more aware of the enormous daily benefits of radiation is an important first step. If we could accomplish this, the dream of a better world that President Eisenhower set before us could be achieved many times over.

Chapter Twelve Endnotes

Recommended reading

1. S. Ahloowalia, M. Maluszynski, and Karin Nichtertein, “Global Impact of Mutation-Derived Varieties," Joint FAO/ IAEA Division of Nuclear Techniques in Food and Agriculture,

International Atomic Energy Agency, Vienna, February 2003.

International Atomic Energy Association (IAEA), *Induced Mutations and Molecular Techniques for Crop Production*, proceedings of a symposium jointly organized by IAEA and FAO, Vienna, June 19 to 23, 1995.

Management Information Services, *Economic and Employment Benefits of the Use of Nuclear Energy to Produce Electricity* (1994).

Management Information Services, *The Untold Story: Economic and Employment Benefits of the Use of Radioactive Materials* (1994).

Management Information Services, *The Untold Story: the Economic Benefits of Nuclear Technologies* (1996).

“Irradiated Food, Good; Food-Borne Pathogens, Bad," *Nuclear News*, July 2003, p. 62.

Jihui Qian, and Alexander Rogov, “Atoms for Peace: Extending the Benefits of Nuclear

Technologies" (2003) (http://www.iaea.or.at/worldatom/Periodicals/Bull371/qian.html).

Uranium Information Centre, Australia (2003) ().

Kazauki Yanagisawa et al., "An Economic Index Regarding Market Creation of Products Obtained from Utilization of Radiation and Nuclear Energy (IV)," *Journal of Nuclear Science and Technology* 39, no. 10 (October 2002): 11201124.

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Chapter 13

Proliferation Concerns

No internationally-regulated commercial nuclear plant can make nuclear-weapons materials. They are under constant surveillance. Those who try, face serious challenges. Nuclear-power reactors are unsuitable for making nuclear bombs. North Korea is a poster child for their defiance of the law enforcement attempts. They have been ruthless in their disregard of the entire country's population unable to meet their basic human needs. Their people suffer both economically with food shortages and politically with sanctions that keep them both isolated and shunned. Partly because they chose a path of obtaining a production reactor to acquire the weapons-grade fuel in order to make nuclear weapons.

With regard to geopolitical affairs the definition of the word "weapon" has been pushed to the unthinkable. Take, for example, the commercial airliners used as weapons to crash into the Twin Towers of the 9/11 terrorist attack. Let's set the record straight. A nuclear reactor cannot have a nuclear explosion. The dilute mix of nuclear elements makes a nuclear explosion impossible. The purity levels of the specific isotopes are far too low. Very rarely relatively small hydrogen gas explosions have been known to happen but with minimal threat beyond the nuclear plant's perimeter.

Nuclear plants are very resistant to acts of sabotage or natural disaster and built to handle earthquakes, floods and terrorist attacks.

Because of the degree of specialized knowledge and resources needed for a large team from many disciplines, no single individual could ever build a nuclear weapon or a nuclear reactor. The monitoring of nuclear facilities is aided by the fact that the detection of even the smallest levels of radiation are now possible. Let's just say the probabilities are extremely low that a reactor or a bomb would be built undetected. The numerous challenges are listed below.

Economic Challenge

The cost of obtaining the weapon is most likely the first consideration. The pursuit of nuclear weapons is so costly that only strong economies can even consider doing it and maintaining, forever, whatever they build. It would involve a multi-disciplinary team of experts all at the top in their fields. Then collecting the required amount of fissile material for processing to the correct enrichment is a long and tedious process that could take years.

Legal Challenge

With safeguards in place to monitor and detect any kinds of irregular activity as well as the treaties of international law that have been negotiated, there are serious penalties a country faces if they break those laws. Any hint of foul play and the country suddenly becomes the focus of numerous law enforcement agencies such as the United Nations Security Council.

The IAEA sets the guidelines for enforcement by the security council and other agencies. But the IAEA has defined it's objective as follows: "The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose."

Political Challenge

When such weapons are so destructive that whole populations are threatened the greatest opposition will be from neighboring countries. But most countries will protest any country wanting nuclear weapons. So there is a risk of creating new enemies and hostile relations with the many countries that would be affected.

Intellectual Challenge

The team required to create a nuclear weapon would need people from several very different disciplines that would need to be highly skilled and knowledgeable. Depending on the kind of nuclear weapon there would be varying levels of complexity. If it is a missile with guidance capability, that has specific rocket design capability, very specialized detonators, precise chemistry and nuclear engineering and fuel source that will require maintaining a balance of ingredients without impurities.

Because the challenges are so great, it is far more likely that a conventional means of creating weapons fuel would be used such as gas centrifuges or specially designed non-commercial research reactors. Next generation reactors have built-in advantages for improved safety and proliferation resistance.

Reactors are Resistant to Terrorist and Military Threats

A plot to steal fuel from a conventional reactor is a very difficult task and would very likely fail. They are both well guarded and monitored. The elements available for bomb creation from a reactor are quite limited. Uranium is the most likely target since the plutonium that exists in reactors does not provide the essential balance of isotopes.

Generation IV Reactors are more Resistant to Terrorist or Military Threats

Any attempts to steal fuel from the new reactor designs that are in the development and design stages called molten salt reactors, would be particularly challenging due to high heat and high levels of radiation.

Providing detailed explanations of the various types of next generation reactors is beyond the scope of this article but one point is worth mentioning. The two types of molten salt reactors that can be classified into general categories are the single fluid and the dual fluid designs. The industry will most likely see the first Generation IV licenses for a single fluid design molten salt reactor. This provides an advantage of having the fuel mix prepared by mixing in what's referred to as denatured elements of specific isotopes such as ^{238}U and U232. This has a poisoning effect to the mixtures ability to be used as weapons fuel.

Chapter 14

Conclusion

The topic of proliferation is complex and providing an in-depth analysis is a daunting exercise that goes against common sense for the average person and beyond the scope of our target reader. Anybody with the knowledge to understand such a breakdown of information would be educating themselves to be potential practitioners of making bombs. So asking the question "are bombs possible?" is tempting when the myth is so often repeated by the antinuclear groups as being feasible. The fact is that it is highly improbable as outlined in each of the five challenges mentioned above. The probability of success in eliminating all the challenges is compounded mathematically at each level. So put your mind to rest because after all we have the more immediate threat of things like car crashes, and coal ash ponds sliding into rivers, and toxic chemical plants leaking into rivers and exploding oil trains.

Chapter 15

Glossary

ACR 1000: Advanced CANDU Reactor (wikipedia)
ADS: accelerator driven system (wikipedia)`
ADTR: Accelerator Driven Thorium Reactor (Developed by Carlo Rubbia)
AGR: advanced gas-cooled reactor (British successor to Magnox) (wikipedia)
AHWR: advanced heavy-water reactor (Indian PHWR that burns thorium) (wikipedia)
AEC: Atomic Energy Commission (1946-1974) replaced by NRC
AECL: Atomic Energy of Canada Limited (wikipedia)
AP600: 600 MWe nuclear power plant designed by Westinghouse Electric Company (wikipedia)
AP1000: 1154 MWe nuclear power plant designed by Westinghouse Electric Company (wikipedia)
APWR: Advanced Pressurized Water Reactor (wikipedia) by Mitsubishi
ARE: Aircraft Reactor Experiment
ART: Aircraft Reactor Test ("Fireball")
BED: Banana Equivalent Dose – radiation from one banana (roughly 520 picocuries per 150g banana)
BNL: Brookhaven National Laboratory (BNL website)
BWR: Boiling Water Reactor (external link)
BWRX-300 SMR: recent Small Modular Reactor variant of BWR - General Electric Hitachi (GEH) now proposed for Estonia
CANDU: CANadian Deuterium-Uranium (Reactor) (James Whitlock has done an excellent page)
CANDU 6:
Capacity Factor (CF) : a ratio of an actual electrical energy output over a given period of time to the maximum possible electrical energy output over that period

CAPEX: capital expenditure
CEAA: Canadian Environmental Assessment Agency
CEFR: China Experimental Fast Reactor (see posting) (wikipedia)
CNSC:Canadian Nuclear Safety Commission
CNP-600: Chinese indigenous LWR
CPR-1000: Chinese standard 3-loop PWR design and Chinese "improved Chinese PWR"
CTBT: Comprehensive Test Ban Treaty
DOE: Department of Energy formerly called ERDA
DMSR: Denatured Molten Salt Reactor
ENHANCED CANDU 6:Wikipedia (external link)
EBR-1: Experimental Breeder Reactor-1 (external link)
EBR-2: Experimental Breeder Reactor-2 (external link)
EPR: Evolutionary (European interchangeable) Pressurized Reactor (external link)
ERDA: Energy Research and Development Administration (1975-77)now DOE
ESBWR: Economic Simplified Boiling Water Reactor (external link) by General Electric
FBR: fast breeder reactor

fertile: refers to the ability of a radiactive element to produce fissile elements by neutron bombardment $^{238}U, ^{232}Th$: Uranium-238 and thorium-232 are known as fertile materials, and the production of fissile materials from them after capturing a neutron is known as breeding. When these fertile materials capture neutrons, they are converted into fissile plutonium -239 and uranium-233, respectively."

fissile: means that an element is capable of experiencing fission

FP: fission product
FUJI: Japanese MSR concept

Generation IV Reactors: : "The most developed Gen IV reactor design, the sodium fast reactor, has received the greatest share of funding over the years with a number of demonstration facilities operated. The principal Gen IV aspect of the design relates to the development of a sustainable closed fuel cycle for the reactor. The molten-salt reactor, a less developed technology, is considered as potentially having the greatest inherent safety of the six models.[2][3] The very-high-temperature reactor designs operate at much higher temperatures. This allows for high temperature electrolysis for the efficient production of hydrogen and the synthesis of carbon-neutral fuels.[1]

The majority of the 6 designs are generally not expected to be available for commercial construction until 2020–30.[4] Currently the majority of reactors in operation around the world are considered second generation reactor systems, as the vast majority of the first generation systems were retired some time ago, and there are only few Generation III reactors in operation as of 2014. Generation V reactors refer to reactors that are purely theoretical and are therefore not yet considered feasible in the short term, resulting in limited R&D funding." Wikipedia: Generation IV Reactor

HWR: heavy water reactor
IAEA: International Atomic Energy Authority (external link)
IFR: Integral Fast Reactor (external link)
GFR: Gas-Cooled Fast Reactor

HEU: Highly enriched Uranium about 90% Uranium 235
HTGR: High-Temperature Gas-cooled Reactor
IFR: Integral Fast Reactor
IMSR: Integrated Molte Salt Reactor. Currently being pursued by Terrestrial Energy led by David Leblanc of Canada
INL: Idaho National Laboratory est. 1949 Arco 1st nuclear powered city
LANL: Los Alamos National Laboratory (external link)
LCOE: Leveleized Cost of Energy calculated over the design lifetime of a plant, which is usually 20 to 40 years, and given in the units of currency per kilowatt-hour or megawatt-day, for example AUD/kWh or EUR/kWh or per megawatt-hour
LLNL: Lawrence Livermore National Laboratory (external link)
LCFR: Liquid Chloride Fast Reactor
LEU: Low Enriched Uranium Less than 20% Uranium 235
LFR: Liquid-Fluoride Reactor (see also Lead Cooled Fast Reactor)
LFTR - Liquid Fluride Thorium Reactor is the Molten Salt reactor design favored by FLIBE Energy chief technology officer is Kirk Sorenson
LMFBR: Liquid-Metal Fast Breeder Reactor
LNT: Linear, No Threshold
LWR: Light-Water Reactor
MA: minor actinides
MCSFR: molten chloride salt fast reactor. Currently being pursued by Elysium Industries under the direction of Ed Pheil
MOLTEX: company from the UK with a design following traditional LWR configuration but using MSR technology with a new acronym SSR (Stable Salt Reactor). Currently targeting Canada and UK
MOX: mixed oxide fuel (U + Pu oxides) – reactor fuel, developed

by the French, is made from uranium oxide and plutonium oxide. Usually the plutonium is sourced from reprocessed used nuclear fuel and has the isotopic profile known as 'reactor grade', indicating it is high in plutonium-240. The exact composition in the American program, in collaboration with AREVA ,to start in 2016 in South Carolina, is different because the plutonium is sourced from dismantled US nuclear warheads, meaning it is 'weapons grade' and high in plutonium-239 instead and has a correspondingly different operational signature. (wikipedia)

MSR: Molten-Salt Reactor

MSBE: Molten-Salt Breeder Experiment

MSBR: Molten-Salt Breeder Reactor

MSRE: Molten-Salt Reactor Experiment

MWd: megwatt-day (1 MW * 1 day)

MWe: 1 Mega watt of electricity (1,000,000 watts)

MWt: megwatt thermal (=of heat) (vs. MWe)

NGNP: Next Generation Nuclear Plant (wikipedia)

NEI: Nuclear Energy Institute (lobbing group on behalf of Congress)

NNSA: National Nuclear Security Administration

NPT: Nuclear Non-Proliferation Treaty

NRC: National Regulatory Commission (opened in 1975)

NREL: Nation Renewable Energy Laboratory – Facility of the US Department of Energy (DOE)

NSG: Nuclear Suppliers Group

= OPEX: Operating Expense. Often found with CAPEX Capital Expense

ORNL: Oak Ridge National Laboratory (external link)

PBMR: Pebble-Bed Modular Reactor

PBR: pebble bed reactor (vs PBMR)

PHWR: pressurized HWR
process heat- the heat from a nuclear reactor that can be used for industrial or other practical purposes in addittion to electricity. There is also a very likely outcome that new Gen IV reactors could be dedicated exclusively for industrial purposes. The benefit being that the energy used creates zero emissions.
PUREX: Pu + U extraction, standard reprocessing chemical process
PWR: Pressurized Water Reactor (external link)
RBMK: reaktor bolshoy moshchnosti kanalniy [graphite-moderated nuclear power reactor] (external link)
ROI: Return on investment
SFR: Sodium-cooled Fast Reactor
SLOWPOKE: Safe Low-Power Kritical Experiment (external link)
SNF: Spent Nuclear Fuel
SONE: Supporters of Nuclear Energy
SYSTEM 80: Pressurized Water Reactor by Westinghouse
TerraPower: Company led by Bill Gates was on course to collqaborate with China. Now back in US with a new plan.
ThorCon: name of the reactor being pursued by Thorcon scales up the MSRE concept currently targeting Indonesia
Thorium: Th is element number 90 is an actinide and metal
Thorium Bank: Part of a proposal laid out by Jim Kennedy and John Kutsch to enable storage of thorium for future use opening the possibility of rare earth industry in North America currently illegal due to unfair regulations
Travelling Wave Reactor: TerrPower's initial favored design
THTR-300: a former thorium PBR in Germany
==TRISO: a PBR fuel pebble design
TRU: transuranic element

VHTR: very high temperature reactor
VVER: a Russian PWR design

Endnotes:
Prelude Citations:

0-1 Wikipedia: December 2013 North American storm complex

Energy Reality Project: Toronto Needs Reliable Power. Apply Pressure at all Gov Levels to Upgrade

0-2 Independent Electricity System Operator Releases 2016 Electricity Data for Ontario

0-3 Atomic Insights: Caldeira, Emanuel, Wigley and Hansen Statement at COP21, December 4, 2015

0-4 Wikibooks.org: The Radioactive Decay Law

0-5 Atomic Insights: Positive Effects Low Dose Radiation - Dr. Jerry Cuttler - via Go-Nuclear/

0-6 Nuclear Townhall: Ted Rockwell

0-7 Google Books: Developments and Innovation in Carbon Dioxide (CO_2) Capture and Storage - edited by M. Mercedes Maroto-Valer

> "Carbon dioxide capture and storage (CCS) represents a key component of a larger porfolio of advanced energy technologies and climate policies needed to mediate the rise in atmospheric CO_2 concentration. Geologic CCS systems are specifically designed to remove CO_2 from various point sources and safely deposit CO_2 in secure storage sites deep underground..."

The experiments for ocean CCS still needs greater investigation.

Woods Hole Oceanographic Institution: The socioeconomic costs of ocean acidification.

0-8Book: Non-Solutions Project: Here are a few quotes from Mathijs Beckers' book. He does an excellent job of projecting the amount of materials needed to run a so-called 100% renewables scenario. Beckers does an admirable job of laying it all out using graphs, equations, numbers and analysis:

> "Copper has many uses: wiring; in semiconductors as circuitry; in piping and plumbing; as a building material; in electric motors; we even use it as a hull material for boats, but renewables have only had a marginal share of all available copper. However, that will change if we

choose to implement the 100%WWS Roadmap. Copper use for wind and solar is currently only 3.3%, but if we adopt the roadmap plan it could rise to 75~80%. The limitations of copper production might just be the straw that will break the camel's back..."

"It is important to note that known reserves are roughly 720,000 thousand metric tons. Suppose we could reach 100,000 TWh of annual energy production on Wind and Solar, and it would require 200,000 thousand metric tons of copper, we would have extracted more than one-fourth of all the copper known to be available. It is not so much the amount of copper required that makes this challenge so big, it is about the increase in copper production growth required, that makes it hard to achieve..."

"Even if we keep production as high as possible, we wouldn't be able to build all the wind turbines and solar panels required before 2050 due to the deficit in copper. Also note that we are already behind 1500 GW of annual required wind and solar additions (which is about 15 times more than we currently add)..."

"Shortages of rare earths already plague the renewable industry. Research institutes confirm that there's a tremendous strain on resources already and foresee a shortage of materials in the not-so-distant future. I doubt that we can sustain the raw material production levels that are needed to facilitate this rapid growth in wind and solar as required in the 100%WWS Roadmap. And research and development on raw material recovery is lagging, so we may conclude that the 100%WWS Roadmap is already facing serious startup problems..."

"If we want to do an all-out build-off bonanza as required in the 100%WWS Roadmap, we will be faced with massive shortages so long as mining capabilities trail behind the demand. Lake Baotou in China, which is a dystopian place, is one of the shady sides of rare earth mining. Once the rare earth materials have been mined, you have to separate them from the ore, which is done by a

> host of different chemical processes with hazardous tailings and other valuable elements going to waste..."

> "The people who work in the mines and live near the refineries pay the price for our technologies. So let's go for the technologies that are most efficient in terms of materials used. As long as we fail to clean up our mining and purification practices, 'clean energy' will be an oxymoron..."

> "However, we already have a safe, efficient, environmentally friendly technology for generating electricity—nuclear energy, especially when produced by modern plants that can "burn" our stored nuclear waste as fuel..."

0-9 KCET Programming: SoCalGas' Aliso Canyon Leak a Disaster For Climate by Chris Clarke - Nov. 24, 2015

Atomic Insights: The Worth-It Threshold – When gas or gas + renewables is as bad for climate as a coal plantBy guest authors Mike Conley and Timothy Maloney - Apr. 9, 2016

0-10 See Terrestrial Energy: Clean Sustainable Energy/ re: Spent Nuclear Fuel

0-11 Bloomberg News: Exelon said to seek license to run nuclear plant for 80 years Jun. 6, 2016

Nuclear FAQ: Candu Refurbishment by Jeremy Whitlock

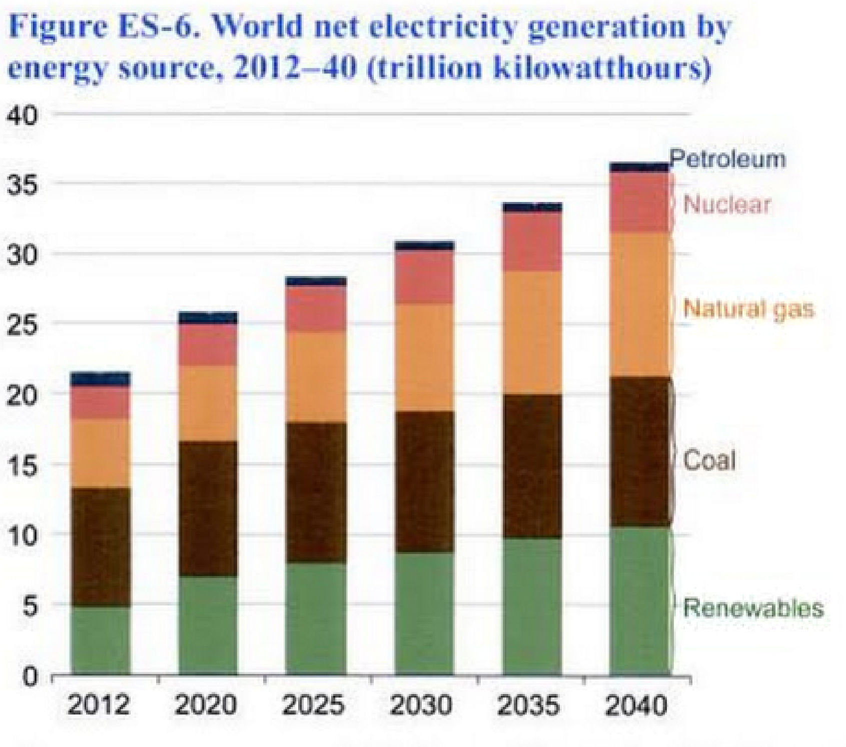
0-12 Energy Reality Project: Thanks to the power of Pickering Nuclear Plant we replaced coal.

IAEA Statute

Youtube: Gordon McDowell's rebuttal to claim by Dr. Arjun Makhijani – "Nuclear Reactors Create 30 Bombs of Plutonium Every Year"

Atomic Insights: Rod Adams' rebuttal to Makhijani claims

Ch. 1 Endnotes: (Collectively Preventing Self Destruction)
1-1



Energy Sector Growth

[Google Books: International Energy Outlook: 2016 with Projections to 2040 by EIA (Energy Information Administration)]

1-2 [Winston Churchill Speech: Our Finest Hour]

1-3. [Energy Reality Project] [Facebook Group for Energy Reality]

http://www.facebook.com/groups/energyreality

Ch. 2 Endnotes: (Energy Reality Project)
2-1 [Climate Reality Project: Our Mission]

2-2 Wikipedia: The Climate Reality Project

2-3 Website as a Free Book: Roadmap to Nowhere by Mike Conley and Timothy Maloney

Youtube: "Nuclear Humanist Series" by Thies Beckers

2-4 Our World in Data: CO_2 and Other Greenhouse Gas Emissions - How do we measure or estimate CO_2 emissions?

2-5
Youtube: Alex Cannara's talk at the 7th Thorium Energy Alliance Conference (TEAC7)

2-6 Popular Science talking "authorities" are not qualified to judge the role of nuclear energy
Michio Kaku - Degrees in Theorietical Physics, Quantum Mechanics and String Theory has not presented a paper in over 30 years.

Quora.com: Is Michio Kaku a credible scientist?

Bill Nye the Science Guy - is only a mechanical engineer
Medium.com: Why Bill Nye is not a scientist and why it matters

2-7 UC Davis School of Law: A Sustainability Critique of the Obama "All-of-theAbove" Energy Approach by Albert C. Lin

2-8 Canadian Energy Issues: What do an 80 year old retiree and an Olympic athlete have in common? Neither carries their own water to a 15th floor high rise condo by Stve Aplin - Dec. 3, 2012

2-9 Quote from article by Steve Aplin:

> "Could you imagine getting onto an elevator and seeing a sign that reads "This elevator is 100 percent wind powered"? Would you press the button?"

Canadian Energy Issues: What runs Toronto? An instructive snapshot from the last few days by Steve Aplin - Jun. 6, 2013

2-10See section titled "Gridmasters of the 21st-and-a-half century"
Roadmap to Nowhere: Chapter Six (free online book)

2-11Record of existing and retired coal plants
Sourcewatch.org: Existing U.S. Coal Plants

2-12Architectural Digest: 236 Climate Mayors to Scott Pruitt: Don't Repeal the Clean Power Plan by Tim Nelson Feb. 21, 2018

2-13see Chapter Eight

2-14World Bank: Data for CO_2 emissions

2-15LA Times: Futurist Provides Fuller Explanation for Passengers on Spaceship Earth by Dennis McLellan, Jul. 7, 1989

Ch. 3 Endnotes:(Earth, Air, Water, Fire)

Terrestrial Energy: How Nuclear Power Will Lead the Green Revolution and End America's Energy Odyssey by William Tucker

History.com: Smog Kills Thousands in England

3-1Buckminster Fuller Quote: Dialogue, 3, 1989, p.10. Ecological Poetry: Its Contribution Towards a New View of the World (PDF) by Karlheinz Goller (University of Regensburg)
3-2Loss of magnetic field on Mars caused loss of atmosphere: ABC Science:How Mars lost its warm, wet atmosphere. by Dani Cooper Mar. 31, 2017 Australia News
3-3Earth's core has molten iron to create magnetic fieldNational Geographic: Education: Resource Library Encyclopedia: Core
3-4Bartleby: Terrestrial Energy/ **Terrestrial Energy: How Nuclear Power Will Lead the Green Revolution and End America's Energy Oddysey by William Tucker** **ISBN-10: 0910155763 ISBN-13: 978-0910155762**

3-5 Article from The Guardian about James Lovelock's "Revenge of Gaia" by Robin McKie: Life on Earth, but for how much longer? - 2006

How to save humankind (according to James Lovelock) | The Economist (video) The Economist
3-6Read the Essay: An Ecomodernist Manifesto
3-7Read about Dickson Despommierre's Book: The Vertical Farm: Feeding the World in the 21st Century
3-8Online Book: Thomas Alva Edison: THOMAS ALVA EDISON and

THE INCANDESENT LAMP by Brian Roberts, CIBSE Heritage Group

3-9War of Current

Tesla vs Edison: The AC DC Current Wars

3-10BBC:Choking fog spreads across Britain (1962)

3-11Researchers have estimated that between 300,000 and 630,000 children are born in the U.S. each year with blood mercury levels high enough to impair performance on neurodevelopmental tests and cause lifelong loss of intelligence.

3-12Excerpt: (from same article above)

> "Pollutants produced by coal combustion act on the respiratory system to cause a variety of respiratory ailments. Air pollutants such as nitrogen oxides (NO_x) and fine particulate matter (i.e. PM2.5) adversely affect lung development, reducing forced expiratory volume (FEV) among children. Reduced FEV often precedes the subsequent development of other pulmonary diseases."

> "Air pollution triggers attacks of asthma, which now affects more than 9% of all U.S. children, who are particularly susceptible to the development of pollution-related asthma attacks. Asthma exacerbations have been linked specifically to

> exposure to ozone, a gas produced when NO_x reacts with volatile organic compounds in the presence of sunlight and heat. The risk to children of experiencing ozone-related asthma exists even when ambient ozone levels fall within the limits set by the EPA."

3-13Sourcewatch: Coal Waste: Coal Ash and Scrubber Sludge

3-14EPA Article: EPA's Contaminated Site Clean-up Information Pages: Applications for environmental remediation

3-15Article from The Guardian:What's climate scientist James Hansen's legacy?

Coal and Air Pollution
3-16Wikipedia: Mercury in Fish

3-17Book: Ecological Intelligence by Peter Senge

3-18 Article headlined as "Canada is full of crap" in the sun also showed up in the Daily Observer with the heading Not a s pretty as they seem on sewage.

Toronto Sun:Canada is full of crap: When it comes to sewage, many places aren't as pretty as they seem by Greg Weston Feb. 25, 2010

3-19 Global News article: Canada's method of water treatment a national embarrassment (May 13, 2013)

3-20 High Energy Electron Beam Irradiation of Water, Wastewater and Sludge

3-21 Wikipedia article: Control of fire by early humans

3-22 Article: Business Insider: The World Is Overpopulated By 5 Billion People April 2012

3-23 Bloomberg News: China's Far From Done With Coal as Regulator Eases New Plant Ban - Apr. 19, 2019

3-24 CNN: Money: US: The richest 10% control 76% of the wealth

3-25Animated Short Film from 1953 Youtube: "A is for Atom"

3-26The New Fire Movie

3-27Duke Energy: Common Myths About Nuclear Energy Jun. 12, 2013

> "You will not see a nuclear power plant erupting into a mushroom cloud."

> "It is physically impossible for a U.S. commercial reactor to explode like a nuclear weapon. The reactor fuel does not have enough uranium to be explosive, and all reactors are built with many layers of safety controls and self-limiting features."

> "For example, if the reactor temperature reaches a certain level during power operations, the fission process is naturally suppressed to guarantee the power level can't spike under any conditions. It is not possible for a person to intentionally, or unintentionally, modify a commercial nuclear reactor, its controls, or its fuel to cause an explosion. "

3-28 Talk Nuclear: Top 10 Myths about Nuclear Energy

Washington Post: Mapping how the United States generates its electricity by John Muyskens, Dan Keating and Samuel Granados - Updated Mar. 28, 2017

> "Coal was responsible for a majority of electricity generation at the start of the century and

> was still the source for nearly half in 2008 but has fallen steadily, accounting for 30 percent last year. Natural gas powered 34 percent of the country's electricity last year, passing coal as well as nuclear."

3-29 Society of Nuclear Medicine and Molecular Imaging: SNMMI and Safe/Beneficial Medical Uses of Radiation

> "**Does Nuclear Medicine Save Lives?** Yes. More than 20 million Americans benefit each year from nuclear medicine procedures used to diagnose and treat a wide variety of diseases. The use of radiation in these procedures—with low risks—offers a safe and cost-effective means to provide doctors with information that would otherwise require exploratory surgery, necessitate more costly and invasive procedures or simply be unavailable. The risks of not performing a needed medical exam are usually much greater than the risks of the radiation exposures associated with the exam."

> "Nuclear medicine can be used to:

- determine whether or not organs are functioning normally,
- show whether the blood supply to the heart is adequate,
- detect cancers at an early stage,
- determine the extent of cancer and assess the response of cancer to treatment,
- discover whether the heart can pump blood adequately,
- identify abnormal brain lesions without exploratory surgery,
- detect whether the brain is receiving an adequate blood supply and if brain cells are functioning or not,
- check whether or not kidneys are functioning normally and whether the stomach is emptying properly,
- ascertain lung function and bone density and
- locate a bone fracture before it can be seen on an X-ray."

3-30Scientific American: Nuclear Power May Have Saved 1.8 Million Lives Otherwise Lost to Fossil Fuels, May Save up to 7 Million More. - By Ashutosh Jogalekar on Apr. 2, 2013

3-31Scientific American: Richard Rhodes on the Need for Nuclear Power - by Ashutosh Jogalekar on Jul. 23, 2013

Physics Today: Nuclear weapons vs. nuclear energy by Ralph Moir - Nov. 1, 2015

Ralph Moir comments on an interview regarding nuclear weapons and nuclear power plants:

"

> "...In the book, the authors make strong arguments about the virtue of taking every possible measure to ban or make illegal the use of uranium enriched above 20% ^{235}Uranium and other isotopes that are usable to make nuclear bombs."

> "It is hard to argue against the virtue of trying to undo history as the book and the interview suggest: Restrict or eliminate the use of uranium enriched above 20% and other fissile isotopes that are weaponizable. The ultimate goal is the elimination of all nuclear weapons. Who could say that is not a good goal?...

3-32Forbes: Uranium Seawater Extraction Makes Nuclear Power Completely Renewable by James Conca - Jul. 1, 2016

3-33Atomic Insights: ***On Plutonium, Nuclear War, and Nuclear Peace*** by Nnadir (guest article) - Nov. 5, 2013

Ch. 4 Endnotes:(An Uncompromising Reality)

4-1Einstein Quotes by Subject

4-2Glenn Seaborg's report to John F. Kennedy

Energy From Thorium: Civilian Nuclear Power (PDF)

Atomic Insights: JFK's "Best of the Above" speech at Hanford, WA on September 26, 1963

4-3Einstein's discovery of $E = \gamma mc^2$ provided the foundation but it was quite a large hurdle conducted by other scientists before that could be tranlated into a bomb.

American Museum of Natural History:The Manhattan Project -see source (Federation of American Scientists: Einstein) for the following quote:

> "Dear Friend,

> I write to you for help at the suggestion of a friend.

> Through the release of atomic energy, our generation has brought into the world the most revolutionary force since prehistoric man's discovery of fire. This basic power of the universe cannot be fitted into the outmoded concept of narrow nationalisms. For there is no secret and there is no defense; there is no possibility of control

except through the aroused understanding and insistence of the peoples of the world.

> We scientists recognize our inescapable responsibility to carry to our fellow citizens an understanding of the simple facts of atomic energy and its implications for society. In this lies our only security and our only hope -- we believe that an informed citizenry will act for life and not death.

> We need $1,000,000 for this great educational task. Sustained by faith in man's ability to control his destiny through the exercise of reason, we have pledged all our strength and our knowledge to this work. I do not hesitate to call upon you to help.

> Faithfully yours,

> [A. Einstein]"

4-4**Alvin Weinberg's** Warnings from 1977 -

Revolvy: Alvin M. Weinberg

> "In June, 1977, Weinberg testified at a congressional hearing of the House Subcommittee on the Environment and the Atmosphere concerning the impact of increasing carbon dioxide emissions on global average temperatures. He stated that a doubling of global carbon dioxide emissions by 2025, which some scientists predicted would occur, would lead to a two-degree Celsius increase in global average temperature."

James Lovelock's warnings from 1965
-The Guardian: Science of Climate Change March 1, 2008

James Hansen's warnings from 1988
New York Times: Global Warming Has Begun Expert Tells Senate
James Hansen - June 4, 1988

Edward Teller warned the oil industry in 1959
The Guardian: On its 100th birthday in 1959, Edward Teller warned the oil industry about global warming.

"Ladies and gentlemen, I am to talk to you about energy in the future. I will start by telling you why I believe that the energy resources of the past must be supplemented. First of all, these energy resources will run short as we use more and more of the fossil fuels. But I would [...] like to mention another reason why we probably have to look for additional fuel supplies. And this, strangely, is the question of contaminating the atmosphere. [....] Whenever you burn conventional fuel, you create carbon dioxide. [....] The carbon dioxide is invisible, it is transparent, you can't smell it, it is not dangerous to health, so why should one worry about it?

"Carbon dioxide has a strange property. It transmits visible light but it absorbs the infrared radiation which is emitted from the earth. Its presence in the atmosphere causes a greenhouse effect [....] It has been calculated that a temperature rise corresponding to a 10 per cent increase in carbon dioxide will be sufficient to melt the icecap and submerge New York. All the coastal cities would be covered, and since a considerable percentage of the human race lives in coastal regions, I think that this chemical contamination is more serious than most people tend to believe."

"At present the carbon dioxide in the atmosphere has risen by 2 per cent over normal. By 1970, it will be perhaps 4 per cent, by 1980, 8 per cent, by 1990, 16 per cent [about 360 parts per million, by Teller's accounting], if we keep on with our exponential rise in the use of purely conventional fuels. By that time, there will be a serious additional impediment for the radiation leaving the earth. Our planet will get a little warmer. It is hard to say whether it will be 2 degrees Fahrenheit or only one or 5."

"But when the temperature does rise by a few degrees over the whole globe, there is a possibility that the icecaps will start melting and the level of the oceans will begin to rise. Well, I don't know whether they will cover the Empire State Building or not, but anyone can calculate it by looking at the map and noting that the icecaps over Greenland and over Antarctica are perhaps five thousand feet thick."

4-5 Wikipedia: Carbon Dioxide in Earth's Atmosphere

> "Excess CO_2 emitted since the pre-industrial era is projected to remain in the atmosphere for centuries to millennia, even after emissions stop. Even if human carbon dioxide emissions were to completely cease, atmospheric temperatures are not expected to decrease significantly for thousands of years."

4-6American Geophysicists Union: Humans Caused Nearly 90 Percent Sea Level Rise Warming Upper Ocean Study Says/
4-7LA Times: President Obama to visit Alaska's Arctic region in bid to fight climate change by Christi Parsons - Aug. 13, 2015
Obama visits receding glacier in Alaska to highlight climate change Sep. 1, 2015 4-8James Hansen: Climate Bells Ringing (pdf)

4-9Canadian Nuclear FAQ - CANDU Nuclear Power Technology http://www.nuclearfaq.ca/cnf_sectionA.htm#e2
4-10WikiVisually: Integral Molten Salt Reactor Terrestrial Energy: Technology The IMSR is a Reactor Design by Canadian David LeBlanc that has a 7 year refueling model.

The Energy Collective: Thorcon's Nuclear MSR Design Gains Momentum by Dan Yurman

Thorcon Website: Production Thorcon is another MSR design. This one has a 4 year refueling model.

4-11Huffington Post: Why You Should Stop Worrying About Nuclear Radiation by Capt. Trevor Greene - Apr. 29, 2014
4-12Video: Twilight of the Bombs with Stewart Brand interviewing Richard Rhodes - Sep. 21, 2010

4-13The Energy Collective:Let's Create Awareness For All the Benefits That Nuclear Technology Brings to Mankind by David O. Woodbury

George Mason University - History Matters: 'The Utopian Promise of the Peacetime Atom': Predictions and Hopes for Atomic Energy

4-14World Bank Data ***Energy use (kg of oil equivalent per capita)***
4-15 Issues in Science and Technology: Power Play: A More Reliable U.S. Electric System by Jay Apt, Lester B. Lave, M. Granger Morgan
ABC Science News: Majority of mars atmosphere lost in space

Ch. 5 Endnotes:(Energy Does It All)

5-1-1National Geographic: Climate Change Suffocating Low Oxygen Zones

5-1-2Springer Link: Is Ocean Acidification an Open-Ocean

Syndrome? Understanding Anthropogenic Impacts on Seawater pH
5-1-3National Geographic: Climate Change Is Suffocating Large Parts of the Ocean
5-1-4National Geographic: Sea level rise, explained by Christina Nunez

5-2-1Forbes: Uranium Seawater Extraction Makes Nuclear Power Completely Renewable by James Conca - Jul. 1, 2016

5-2-2National Geographic: The Ocean Is Getting More Acidic — What That Actually Means - June 2018

5-2-3Forbes: Polar Vortex: Nuclear saves the day - Jan. 12, 2014

5-2-4Progress and Peril: The Conquest of Climate by Will Boivert - Feb. 23, 2018

5-2-5Our Energy Policy: Climate Central: "BLACKOUT:Extreme Weather, Climate Change and Power Outages" (PDF) by Alyson Kenward, PhD, and Urooj Raja - 2014

5-3-1IAEA: Nuclear district heating in CMEA countries: A number of approaches have been developed for using nuclear plants as sources of heat (PDF) by V.L. Losev, M.V. Sigal, and G.E. Soldatov

5-3-2Forbes: Uranium Seawater Extraction Makes Nuclear Power Completely Renewable by James Conca - Jul. 1, 2016

5-4-1The Green Blue Book: The Simple Water-Savings Guide to Everything in Your Life by Thomas M. Kostigen (quote shows on Amazon listing)

5-4-2APM Reports: EPA reverses course, highlights fracking contamination of drinking water by Tom Scheck and Scott Tong - Dec. 13, 2016

5-4-3 Forbes: Why Solar Geoengineering May Be Our Only Hope To Reverse Global Warming by James Conca - Sep. 10, 2019

5-5-1 Youtube: Robert Hargraves TEAC presentation May 2009
Slideshare: Aim High Slides Robert Hargraves

5-5-2 The Hindu: Nuclear power is our gateway to a prosperous future A.P.J. Abdul Kalam, Srijan Pal Singh - Nov. 6, 2011

5-7-1 LiveScience:Deforestation: Facts, Causes & Effects by Alina Bradford Apr. 4,2018

5-9-1 World Health Organization: Arsenic - Mass poisoning on an unprecedented scale Mar. 2002

5-9-2World Health Organization Report: Gadjah Mada University:Climate Change and Health

5-10-1Wikipedia: Stade Nuclear Power Plant

5-10-2This article explains how it works

World Ocean Review: Ocean Chemistry - CO_2

Fertilizing the ocean with iron The ocean as a sink for anthropogenic CO_2

> "As soon as CO_2 migrates from the atmosphere into the water, it can react chemically with water molecules to form carbonic acid, which causes a shift in the concentrations of the hydrogen carbonate (HCO3-) and carbonate (CO32-) ions, which are derived from the carbonic acid. Because carbon dioxide is thus immediately processed in the sea, the CO_2 capacity of the oceans is ten times higher than that of freshwater, and they therefore

can absorb large quantities of it. Scientists refer to this kind of assimilation of CO_2 as a sink. The ocean absorbs human-made atmospheric CO_2, and this special property of seawater is primarily attributable to carbonation, which, at 10 per cent, represents a significant proportion of the dissolved inorganic carbon in the ocean. In the ocean, the carbon dissolved in the form of CO_2, bicarbonate and carbonate is referred to as inorganic carbon. When a new carbon equilibrium between the atmosphere and the world ocean is re-established in the future, then the oceanic reservoir will have assimilated around 80 per cent of the anthropogenic CO_2 from the atmosphere, primarily due to the reaction with carbonate. The buffering effect of deep-sea calcium carbonate sediments is also important. These ancient carbonates neutralize large amounts of CO_2 by reacting with it, and dissolving to some extent. Thanks to these processes, the oceans could ultimately absorb around 95 per cent of the anthropogenic emissions. Because of the slow mixing of the ocean, however, it would take centuries before equilibrium is established. The very gradual buffering of CO_2 by the reaction with carbonate sediments might even take millennia. For today's situation this means that a marked carbon disequilibrium between the ocean and atmosphere

> will continue to exist for the decades and centuries to come. The world ocean cannot absorb the greenhouse gas as rapidly as it is emitted into the atmosphere by humans. The absorptive capacity of the oceans through chemical processes in the water is directly dependent on the rate of mixing in the world ocean. The current oceanic uptake of CO_2 thus lags significantly behind its chemical capacity as the present-day CO_2 emissions occur much faster than they can be processed by the ocean."

Huffington Post: The Myth of U.S. Democracy and the Reality of U.S. Corporatocracy by Bruce E. Levine

5-11-1Department of Energy: Energy and Environmental Profile of the U.S. Pulp and Paper Industry Dec. 2005

5-11-1Department of Energy: Energy and Environmental Profile of the U.S. Pulp and Paper Industry Dec. 2005

Ch. 6 Endnotes:(Everybody Needs a Little S.T.E.A.M.)

6-1Wikipedia: S.T.E.A.M. Education
6-2Nuclear For Climate: No other choice than nuclear Robert Stone explains the title

> "The title for a film is always a complex thing. You want the title to capture people's imagination in some way and hopefully to be a bit poetic. Given the subject matter, I wanted the title to acknowledge the fact that the splitting of the atom has had negative effects, specifically in the development of nuclear weapons. That aspect has been widely associated with the Greek myth of Pandora's Box. Since my film was both acknowledging the evil that sprang from the discovery of this technology, as well as its promise, Pandora's Promise seemed like an apt and somewhat poetic title. It also didn't telegraph the meaning of the film too directly, as would have happened if I had used the word 'nuclear' in the title. So I'm happy with it."

6-3 Wikipedia: Electricity Market

6-4 Closing of Kewaunee explained
Kewaunee Power Station - Wikipedia
6-5Meredith Angwin's Yes Vermont Yankee Blog - Jan/2011
6-6Using neutrinos to probe Earth's hot core
6-7https://en.wikipedia.org/wiki/Age_of_the_Earth
6-8Encyclopedia Britannica: Marie Curie: Biography
6-9Wikipedia: List of Nobel Laureates
6-10www.audit.web.id/IT/884-781/chemical-

elements_1225_audit.html

6-11en.wikipedia.org/wiki/J%C3%B6ns_Jacob_Berzelius

Superfuel by Richard Martin pg. 34 on Google Books

6-12Wikipedia Biography of Dmitri Mendeleev

A Well-Ordered Thing: Dmitrii Mendeleev and the Shadow of the Periodic Table ... By Michael D. Gordin - Google Books p. 180

6-13The discreet charm of eighteenth-century vitalism and its avatars - http://philsci-archive.pitt.edu/11546/ (see download)

6-14A Philatelic Ramble Through Chemistry

6-15Chemistry - By John S. Holman, Phil Stone - Google Books

6-16Jean Baptiste Perrin Biography

6-17Jean Baptiste Perrin (Extended Biography)

6-18Atomic Insights:"The Martians" RTG science includes jarring errors - Rod Adams - July 6, 2016

Wikipedia: Curiosity Rover

6-196-19

6-20What is the Safest Form of Energy?

6-21ThoriumMSR.com About Page (Inactive Website Created by Rick Maltese)

6-22Fissile Material

6-23Synthetic Elements - Wikipedia

6-24

- Terrestrial Energy's Integrated Molten Salt Reactor
- Thorcon molten salt fission reactor
- Elysium's Molten Chloride Fast Reactor

6-25Canadian Nuclear FAQ by Jeremy Whitlock - www.NuclearFAQ.ca

6-26Nuclear Power Reactors - www.world-nuclear.org
6-27The Second Fifty Years of Nuclear Fission by Alvin Weinberg - www.cns-snc.ca/media/history/fifty_years/weinberg.html
6-28https://www.world-nuclear.org
Uranium found in nature consists largely of two isotopes, ^{235}U and ^{238}U. The production of energy in nuclear reactors is from the 'fission' or splitting of the ^{235}U atoms, a process which releases energy in the form of heat. ^{235}U is the main fissile isotope of uranium.

Most reactors are light water reactors (of two types – PWR and BWR) and require uranium to be enriched from 0.7% to 3-5% ^{235}U in their fuel. This is normal low-enriched uranium (LEU). There is some interest in taking enrichment levels to about 7%, and even close to 20% for certain special power reactor fuels, as high-assay LEU (HALEU).

^{235}Uranium and ^{238}U are chemically identical, but differ in their physical properties, notably their mass. The nucleus of the ^{235}U atom contains 92 protons and 143 neutrons, giving an atomic mass of 235 units. The ^{238}U nucleus also has 92 protons but has 146 neutrons – three more than ^{235}U – and therefore has a mass of 238 units.

The difference in mass between ^{235}U and ^{238}U allows the isotopes to be separated and makes it possible to increase or "enrich" the percentage of ^{235}U. All present and historic enrichment processes, directly or indirectly, make use of this small mass difference.

6-29https://www.world-nuclear.org
"Natural uranium contains 0.7% of the ^{235}U isotope. The remaining 99.3% is mostly the ^{238}U isotope which does not contribute directly to the fission process (though it does so indirectly by the formation of fissile isotopes of plutonium). Isotope separation is a physical process

to concentrate ('enrich') one isotope relative to others. Some reactors, for example the Canadian-designed Candu and the British $MagNO_x$ reactors, use natural uranium as their fuel."

6-30(For comparison, uranium used for nuclear weapons would have to be enriched in plants specially designed to produce at least 90% ^{235}U.)

6-31Thorium-232 is safe if you don't eat or inhale it - Dr Looi Hoong Wah

6-32Half Life and Activity

6-33Megatons to Megawatts

6-34Why nuclear power can be considered renewable energy

6-35Wikipedia on Plutonium

6-36Wikipedia on Fertile Material

6-37The 10 weirdest physics facts from relativity to quantum physics

6-38Fission releases 100 million times more energy per atom than the chemical energy that's released in a combustion reaction.

6-39Quote from hyperphysics.phy-astr.gsu.edu/hbase/NucEne/fission.html

6-40"^{235}U is naturally occurring. It is possible to breed ^{233}U and ^{239}Pu from more common naturally occurring isotopes (Th-232 and ^{238}U respectively) by single neutron capture. The others are typically produced in smaller quantities through further neutron absorption."

6-41Cameco Mines - Wikipedia

6-42What is Enriched Uranium - Smithsonian

6-436-43 Milling explained on Cameco Website

6-44Conversion explained from Cameco Website
Uranium Processing - Encyclopedia Brittanica

6-45Uranyl Hydroxide - Wikipedia

6-46BBC Bitesize Guide - "Atoms, isotopes and ions - AQA"

6-47Enrico Fermi's discovery of Fission

6-48Fueling Our Future: An Introduction to Sustainable Energy by By Robert L. Evans - Page 116 - Google Books

6-49"The famous astronomer and astrobiologist Carl Sagan popularized the concept of a cosmic calendar about three decades ago. In his 1977 book *The Dragons of Eden: Speculations on the*

evolution of human intelligence, Sagan wrote a timeline for the Universe, starting with the Big Bang about 15 billion years ago. Today, we think that it all started about 13.7 Billion years back."
Sagan used the twelve months of the year to span all of time since the Big Bang. Using this scale life did not emerge until the last month.

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http://gridwatch.ca/ http://teachnuclear.ca/all-things-nuclear/canadas-nuclear-history/candu-reactors-worldwide/

http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html
Ch. 7 Endnotes:(Getting Out in the Field)

7-1How We Happened to Sell Off Our Electricity by James Meek, London Review of Books = Vol. 34 No. 17 · 13 September 2012 https://www.lrb.co.uk/v34/n17/james-meek/how-we-happened-to-sell-off-our-electricity
7-2AECL sold for $15M to SNC-Lavalin - CBC News, June 29, 2011 https://www.cbc.ca/news/business/aecl-sold-for-15m-to-snc-lavalin-1.985786
7-3"Electricity market" from Wikipedia.org
https://en.wikipedia.org/wiki/Electricity_market

7-4Article: Pokecology posted by Barry Brook for the website Brave New Climate
https://bravenewclimate.com/2016/09/14/pokecology/
7-5"A Baloney Detection Kit: The Demon-Haunted World by Carl Sagan" a review in NewScientist March 16, 1996
https://www.newscientist.com/article/mg14920215-000-a-baloney-detection-kit-the-demon-haunted-world-by-carl-sagan-hodder-

headline-18-99-isbn-0-7472-1554-5/
7-6Quote from the film Network from 1976
https://en.wikiquote.org/wiki/Network_(film)

Ch. 8 Endnotes:(Exploring a National Energy Plan)

8-1Clean Power Plan Resources
8-2Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar
8-3'Atomic Humanism' and the Eco-Modernist Campaign to Promote Nuclear Power

Why renewables can't save the planet by Michael Shellenberger

8-4Scientific American: Nuclear power may have saved 1.8 million lives otherwise lost to fossil fuels, may save up to 7 million more. By Ashutosh Jogalekar Apr. 2, 2013

8-5Nuclear Matters: Pennsylvania Nuclear Power Plants' Contribution to the State Economy by The Brattle Group Sep. 9, 2015

8-6Youtube: The Future of Nuclear Technology ... After Fukushima with Alan Waltar

8-7 Western Interconnection

8-8 Eastern Interconnection

8-9 Quebec Interconnection

8-10 Electric Reliability Council of Texas (ERCOT)

Ch. 9 Endnotes:(A Hypothetical National Energy Policy)

9-1China hopes to take prominent role in international collaboration designed to develop fourth-generation technology - by Alice Shen - Jan 10, 2019
9-2

9-3North Dakota Flared Off 1 Billion Worth of Natural Gas Last Year

Ch. 10 Endnotes:(Perception Versus Reality)

140. Nuclear Safety Fact Sheets: Uranium Mining and Milling the Facts on a Well Regulated Industry (PDF) - July 2012

Ch. 11 Endnotes:(Energy Density)

Diagram explained
Ch. 12 Endnotes:(Nuclear Technology's Numerous Uses by Guest Author Alan Waltar)

Recommended reading

1. S. Ahloowalia, M. Maluszynski, and Karin Nichtertein, “Global Impact of Mutation-Derived Varieties," Joint FAO/

IAEA Division of Nuclear Techniques in Food and Agriculture,

International Atomic Energy Agency, Vienna, February 2003.

International Atomic Energy Association (IAEA), *Induced Mutations and Molecular Techniques for Crop Production*, proceedings of a symposium jointly organized by IAEA and FAO, Vienna, June 19 to 23, 1995.

Management Information Services, *Economic and Employment Benefits of the Use of Nuclear Energy to Produce Electricity* (1994).

Management Information Services, *The Untold Story: Economic and Employment Benefits of the Use of Radioactive Materials* (1994).

Management Information Services, *The Untold Story: the Economic Benefits of Nuclear Technologies* (1996).

“Irradiated Food, Good; Food-Borne Pathogens, Bad," *Nuclear News*, July 2003, p. 62.

Jihui Qian, and Alexander Rogov, “Atoms for Peace: Extending the Benefits of Nuclear

Technologies" (2003) (http://www.iaea.or.at/worldatom/Periodicals/Bull371/qian.html).

Uranium Information Centre, Australia (2003) ().

Kazauki Yanagisawa et al., “An Economic Index Regarding Market Creation of Products Obtained from Utilization of Radiation

and Nuclear Energy (IV)," *Journal of Nuclear Science and Technology* 39, no. 10 (October 2002): 11201124.

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> "Nuclear technology, the basis for well-known energy production via nuclear power, has also been harnessed to serve a plethora of humanitarian functions in the fields of in agriculture, medicine, electricity generation, modern industry, transportation, public safety, environmental protection, space exploration, and even archeology and the arts. This talk explores continuous improvement in many areas of science, industry,

> and medicine through tapping the incredible potential of nuclear technology."

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1. The First Nuclear Era by Alvin Weinberg

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