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Introduction

1.1 The Science of Change: How Will Our Epoch Be Remembered?

Energy policies have defined our modern civilization. Politicizing energy policies is nothing new, but bipartisan bickering is new for the Information Age. The overwhelming theme is "change" (similar to the term "paradigm shift"), and both sides of the "change" debate remain convinced that the other party is promoting a flat-earth theory. One side supports petroleum production and usage, and the other side supports the injection of various "other" energy sources, including nuclear, wind, solar, etc. This creates consequences for scientific study. The petroleum industry faces the temptation of siding with the group that promotes petroleum production and continuing usage with only cosmetic change to the energy consumption side, namely in the form of "energy saving" utilities. The other side, of course, has vested interest in opposing this move and spending heavily on infrastructure development using renewable energy sources. Both sides seem to agree on one thing: there is no sustainable solution to the energy crisis, and the best we can do is to minimize the economic and environmental downfall. This book shows, with scientific arguments, that both sides are wrong, and there is indeed a sustainable solution to petroleum production and operations. With the proposed schemes, not only would the decline of the economic and environmental conditions be arrested, but one could improve both these conditions, launching our civilization onto an entirely new path.

This book is about scientific change that we can believe in. This is not about repeating the same doctrinal lines that got us in this modern-day "technological disaster" mode (in the word of Nobel Laureate Chemist Robert Curl). The science of true change is equated with the science of sustainability. This change is invoked by introducing both a natural source and a natural pathway. This book summarizes an essential, critical distinction between the outcomes of natural processes and the outcomes of engineered processes that conventional science discourse and work have either missed or dismissed. In contrast to what defines a change in a natural process, the outcomes of engineered processes can change if there is a change in only the source or only along the pathway, and there may be no net change in outcome if changes at the source cancel out changes along the pathway or vice-versa.

Today, the entire focus has been on the source (crude oil in petroleum engineering), and the role of the pathway has been completely misunderstood or deliberately ignored. Numerous schemes are being presented as sustainable alternatives – sustainable because the source has been replaced with another source while keeping the process intact. This mode of cognition has been a very typical philosophy for approximately the last 900 years and has many applications in other disciplines, including mathematics (theory of chaos). This book deconstructs this philosophy and presents truly scientific analysis that involves both the source and the pathway. As a result, all the analyses are consistent with the first premise, and no question remains unanswered.

1.2 Are Natural Resources Finite and Human Needs Infinite?

Over a decade ago, Lawrence Lerner, Professor Emeritus in Physics and Astronomy at the University of Chicago, was asked to evaluate how Darwin's theory of evolution was being taught in each state of the United States (Lerner 2000). In addition to his attempt to find a standard in K-12 teaching, he made some startling revelations. His recommendations created controversy, and many suggested that he was promoting "bad science" in name of "good science." However, no one singled out another aspect of his finding. He observed that "some Native American tribes consider that their ancestors have lived in the traditional tribal territories forever." He then equated "forever" with "infinity" and continued his comment stating, "Just as the fundamentalist creationists underestimate the age of the earth by a factor of a million or so, the Black Muslims overestimate by a thousand-fold and the Indians are off by a factor of infinity." (Lerner 2005). This confusion between "forever" and "infinity" is not new in modern European culture. In the words of Albert Einstein, "There are two things that are infinite, human stupidity and the Universe, and I am not so sure about the Universe." Even though the word "infinity" emerges from a Latin word, *infinitas*, meaning "unboundedness," for centuries this word has been applied in situations in which it promotes absurd concepts. In Arabic, the equivalent word means "never-ending." In Sanskrit, similar words exist, and those words are never used in mathematical terms as a number. This use of infinity to enumerate something (e.g., infinite number of solutions) is considered to be absurd in other cultures.

Nature is infinite – in the sense of being all-encompassing – within a closed system. Somewhat paradoxically, nature as a system is closed in the sense of being self-closing. This self-closure property has two aspects. First, everything in a natural environment is used. Absent anthropogenic interventions, conditions of net waste or net surplus would not persist for any meaningful period of time. Secondly, nature's closure system operates without benefit of, or dependence upon, any internal or external boundaries. Because of this infinite dimension, we may deem nature – considered in net terms as a system overall – to be perfectly balanced. Of course, within any arbitrarily selected finite time period, any part of a natural system may appear out of balance. However, to look at nature's system without acknowledging all the subtle dependencies that operate at any given moment introduces a bias that distorts any conclusion that is asserted on the basis of such a narrow approach.

From where do the imbalance and unsustainability that seem so ubiquitously manifest in the atmosphere, the soil, and the oceans originate? As the "most intelligent creation of nature," men were expected to at least stay out of the natural ecosystem. Einstein might have had doubts about human intelligence or the infinite nature of the Universe, but human history tells us that human beings have always managed to rely on the infinite nature of nature. From Central American Mayans to Egyptian Pharaohs, from Chinese Hans to the Mannaeans of Persia, and from the Edomites of the Petra Valley to the Indus Valley civilization of the Asian subcontinent, all managed to remain in harmony with nature. They were not necessarily free from practices that we no longer consider (Pharaohs sacrificed humans to accompany the dead royal for the resurrection day), but they did not produce a single gram of an inherently anti-nature product, such as DDT. In modern times, we have managed to give a Nobel Prize (in medicine) for that invention.

Chapter 2 examines how our ancestors dealt with energy needs and the knowledge they possessed that is absent in today's world. Regardless of the technology these ancient civilizations lacked that many might look for today, our ancestors were concerned with not developing technologies that might undo or otherwise threaten the perceived balance of nature that, today, seems desirable and worth emulating. Nature remains and will remain truly sustainable.

1.3 The Standard of Sustainable Engineering

Beginning in the 20^{th} century about four generations ago until the Great Depression about three generations back, alcohol was placed under Prohibition in the United States even for medicinal purposes. Today, the most toxic and addictive form of alcohol is not only permitted but is promoted as a part of a reputedly "refined" life style. Only about four to six generations ago in the mid- to late 19^{th} century, interracial marriages and marriages between cousins were forbidden (some still are, e.g., Paul and Spencer 2008), women and African-Americans did not have the right to vote in elections, and women (after marriage) and slaves (after sale) were required to change their surname and identity. In many parts of rural Quebec, well into the 20^{th} century, women were required to replace all their teeth with a denture as a gift to the groom. Today, as part of the reaction to the extreme backwardness of these reactionary social practices, same-sex marriage is allowed in Canada, much of USA, and Europe. Marriage among siblings is even allowed in some "enlightened" parts of Europe, and changing one's surname has become a sign of backwardness. Although the religious establishment's various sanctions surrounding these relationships, not to mention the status of these various relations themselves, have actually changed very little, a vast propaganda was loosed nonetheless upon the world proclaiming the alleged modernization of all human and social relations represented by such "reversals." However, all that has "changed" is the standard as to what is acceptable. Similarly, about one to two generations ago, organic food was still the most abundant and most affordable food. Then, along came the notorious "Green Revolution," fostered mainly in Third World countries by U.S.-based agribusiness interests often acting through governments. "Productivity" reportedly doubled and tripled in less than a decade. Today, organic food in general costs three times (200% increase) more than non-organic. In this process, the actual quality of the food declined. Yet, the standard had been shifted again, rendering possible an extensive widening of profit margins in the most powerfully positioned sectors of food production and distribution. When, where, and how does such a reversal in the trend of quality and pricing start, like the reversal in the trend of the quality of certain social relations and the value placed on them? In either case, investigating and establishing true sustainability entails a deep analysis of the entire matter of what constitutes a standard, what social forces are in a position to shift standards, how the process of rewriting standards operates, and where and when may people intervene to empower themselves and put an end to being victimized in such processes?

Chapter 2 discusses and discloses the problem inherent in the standards that we use today – standards or ideals that are not natural. Chapter 3 explains that by forcing a non-natural standard or ideal in all engineering calculations all subsequent conclusions are falsified.

Nature exists in a state of dynamic balance both in space and time. In its attempts to comprehend fundamental changes of state within a natural environment, the conventional science of tangibles hits a wall, especially when it comes to the treatment of time's role at such bifurcation points. Why? Such a situation follows from the fact that the actual rate at which time unfolds at such points within a natural process is itself part of that process. This means that time cannot be treated as varying independently of that process. Very much akin to the problem of standards falling under the dictate of special, usually private, interests, the mathematics used by the science of tangibles becomes hijacked. For centuries, this mathematics warned its users about the falsehoods that will arise when differentiating a discontinuous function as though it were continuous, or integrating over a region of space or time that is discontinuous as though it were continuous. In practice, meanwhile, pragmatism has often prevailed, and the reality of a natural system's output often bearing little or no relationship to what the theoretical mathematical model predicted is treated as an allowable source of error. However, what could be expected to eventuate if the standpoint of the science of intangibles, based on a conception of nature's system as one that is perfect (in the sense of complete and self-contained), were adopted instead? Many of these howling contradictions that emerge from retaining the conventional science of tangibles in areas where its modeling assumptions no longer apply would turn out to be removable paradoxes.

The conundrum arises in the first place mainly (and/or only) because the tangible aspects of any phenomenon do not go beyond the very small element in space, i.e., $\Delta s \rightarrow 0$, and even a smaller element in time, i.e., $\Delta t = 0$ (meaning, time t = "right now"). Within the space-time of a purely mathematical universe, Newton's calculus gives reliable answers concerning the derivative of a function based on taking the limit of the difference quotient of the function as change in any selected variable of the said function approaches zero. However, regardless of that fact, is the underlying first assumption correct? That is to say, what fit may be expected between the continuity of processes in a natural system and the continuity of mathematical space time that undergirds whether we can even speak of a function's derivative? In general, the results in the mathematical reality and the natural reality don't match, at least not without "fudging" of some kind. Is it reasonable to consign such a mismatch to "error," or is something else at work here? The authors believe the incompatibility has a deeper source, namely in an insurmountable incompatibility between the continuum of mathematical space-time and the essentially dynamic balance of natural systems.

Since the dawn of the Industrial Revolution, the only models used and developed continually have been based on what we characterize in this work as the science of tangibles. This book reviews the outcome of these models as manifested in the area of energy management. The prejudicial components of "steady state" based analysis and assumptions have begun to emerge in their true light mostly as an unintended byproduct of the rise of the Information Age. From this perspective, it becomes possible to clarify how and why modeling anything in nature in terms of a steady state has become unsustainable.

The unexpected fallout that we are ascribing to the emergence of the Information Age is simply this: in light of the undreamt-of expansion in the capacity to gather, store, and manipulate unprecedented quantities of data on anything, the science of tangibles calling itself "New Science," that developed out of the European Renaissance has turned out to be a double-edged sword. All its models are based on the short term – so short that they practically eliminate the time dimension (equivalent to assigning $\Delta t = 0$). However, these models are promoted as "steady state" model with the assertion that, as Δt approaches ∞, a steady state is reached. This syllogism is based on two false premises: (1) that there is such a state as steady state and (2) that nature is never in balance.

Proceeding according to a perspective that accepts and embraces the inherent overall dynamic balance of natural systems as given, it soon emerges that all these models are inherently flawed and are primarily responsible for transforming the truth into falsehood. That is because their continued promotion obscures key differences between real (natural) and artificial (created by violating natural process). Models based on steady-state have been developed and promoted by all the great names of natural and social science over the last 400 years, from Sir Isaac Newton and Lord Kelvin to the economist John Maynard Lord Keynes. However, although presented as the only acceptable bridging transition from natural science to engineering, all such models are in fact freighted with the enormous baggage of a Eurocentric cultural bias. A most glaring feature of technological development derived on the basis of this "steady state" bridging transition from theory to practice has been its denaturing of how time actually operates, reducing the meaningful sense of time to whatever exists "right now."

Thus, for example, in medical science this has strengthened the tendency to treat symptoms first and worry about understanding how disease actually works later. In economic development, it amounts to increasing wasteful habits in order to increase GDP. In business it amounts to maximizing quarterly income even if it means resorting to corruption. In psychology it means maximizing pleasure and minimizing pain (both in the short-term). In politics it amounts to obliterating the history of a nation or a society. In mathematics it means obsessions with numbers and exact (and unique) solutions. In technology it means promoting comfort at the expense of long-term damage. In philosophy it means positivism, behaviorism, and materialism. In religion it means obsession with ritual and short-term gains. This steady state doesn't exist anywhere and contradicts fundamental traits of nature, which is inherently dynamic. When it was recognized that steady states were non-existent, the time function was introduced in practically all analysis, this time function being such that as $t \rightarrow \infty$, and the aphenomenal steady state emerged. That should have triggered investigation into the validity of the time function. Instead, it was taken as a proof that the Universe is progressively moving toward a state of heat death – an aphenomenal concept promoted by Kelvin.

Chapter 3 presents a comprehensive theory that can answer all the questions that remain unanswered with the current engineering tools. This theory combines mass and energy balance to demonstrate that mass and energy cannot be treated in isolation if one has to develop sustainable energy management schemes. This theory exposes the shortcomings of New Science on this score and is a powerful tool for deconstructing key spurious concepts, such as the following. The concept that "if you cannot see it, it doesn't exist" denies all aspects of intangibles, yet it forms the basis of environmental and medical science. The concept that "chemicals are chemicals," originally promoted by Linus Pauling, a two-time Nobel Laureate, assumes that the pathway of a chemical doesn't matter and is used in the entire pharmaceutical, chemical, and agricultural industry. Numerous physicists, including Einstein, Rutherford, and Fermi, believed the notion that "heat is heat," which was originally inspired by Planck.

With the above formulation, two important fallacies at the core of currently unsustainable engineering practice are removed: (1) the fallacy that human need is infinite and (2) the fallacy that natural resources are finite.

These notions were not only accepted, but they were presented as the only knowledge. Yet, they clearly violate the fundamental trait of nature. If nature is perfect, it is balanced. It is inherently sustainable. However, it does not follow that it can be artificially sustained. If human beings are the best creation of nature, it cannot be that the sustainability of nature is being threatened by human activities, unless these activities are based on flawed science. In Chapter 3, the core reasons behind this apparent imperfection of nature are analyzed, and science that prompted the fallacious conclusions is deconstructed. It is shown that within the core of current engineering design practices lies a fundamentally flawed notion of ideal and standard. This ideal is mentioned as the first premise of Newton's work, followed by the first premise of Lord Kelvin. Both used the first premise that is aphenomenal. In philosophical terms, this first premise is equivalent to saying that nature is imperfect and is degrading to a lower quality as time progresses, and in order to remove this degradation, we must "engineer" nature. Chapter 3 shows that, by making a paradigm shift (starting from the first premise), if "nature is perfect' is used as the first premise, the resulting model can answer all questions that are posed in the wake of the environmental consciousness in the Information Age. This approach has been long sought-after but has not been implemented until now (Yen 2007).

1.4 Can Nature Be Treated as If It Were Static?

The most significant contribution of the previous section has been the recognition that the time function is the most important dimension in engineering design. If this is the case, one must then ask what the duration of this time function is in which one should observe the effect of a certain engineering design. It is of utmost importance to make sure that this duration is long enough to preserve the direction of the changes invoked by an engineering design. Philosophically, this is equivalent to saying that at anytime the short-term decisions cannot be based on an observation that is not absolutely true or something that would be proven to be false as a matter of time. This notion is linked to the concept of sustainability in Chapter 4.

The term "sustainable" has become a buzzword in today's technology development. Commonly, the use of this term infers that the process is acceptable for a certain duration of time. True sustainability cannot be a matter of arbitrary definition, nor can it be a matter of a policy objective lacking any prospect of physical achievement in reality. In this book, a scientific criterion for determining sustainability is presented. The foundation of this criterion is "time-testedness."

In Chapter 4, a detailed analysis of different features of sustainability is presented in order to understand the importance of using the concept of sustainability in every technology development model. A truly sustainable process conforms to natural phenomena both in its source, or its root, and in its process, or pathway. However, as applied to resource engineering nominally intent on preserving a healthy natural environment, the science of tangibles has frequently given rise to one-sided notions of sustainability. For example, a phenomenal root, such as natural gas supplies, is addressed with principal attention focused on whether there will be a sufficient supply over some finite projected duration of time. Such a bias does not consider which uses of the said resource should be expected to continue into the future and for how long into the future. For example, should natural gas production in the Canadian province of Alberta be sustainable to the end of being used for (1) feedstock for heavy-oil upgraders, (2) export to residential and commercial markets in the U.S., (3) a principal supply for Canadian residential and commercial markets, or (4) some combination of two or more of the above?

Of course, absent any other considerations, sufficient supply to meet future demand can only be calculated by assuming that current demand continues into the future, including its current rate of growth, and, hence, is utterly aphenomenal. Both the origin and destiny of this source of natural gas and the mechanics by which it will enter the market are matters of speculation and not science. However, consciousness of this problem is obscured by retrofitting a pathway that might attain all potential projected demands targeted for this resource. Inconvenient facts, such as the likelihood that nuclear power is being strongly pushed to replace Alberta's natural gas as the fuel for future upgraders *in situ* at the tar sands, are not taken into account. Whatever the pathway, it is computed in accordance to a speculated prediction and, hence, is utterly aphenomenal. Meanwhile, whether that pathway is achievable or even desirable, given current engineering practices, is neither asked nor answered. The initial big "plus" supposedly in natural gas' favor was that it is "cleaner" than other petroleum-based sources. Given the quantity of highly toxic amines and glycols that must be added in order to make it commercially competitive for supplying residential markets, however, this aspect of its supposed sustainability would seem to raise more uncomfortable questions.

In addition, the natural criterion alluded to above means that true long-term considerations of humans should include the entire ecosystem. Some have called this inclusion "humanization of the environment" and have put this phenomenon as a pre-condition to true sustainability (Zatzman and Islam 2007). The inclusion of the entire ecosystem is only meaningful when the natural pathway for every component of the technology is followed. Only such design can assure both short-term (tangible) and long-term (intangible) benefits.

1.5 Can Human Intervention Affect Long-term Sustainability of Nature?

It is commonly said that any set of data doesn't reach statistical significance unless several cycles are considered. For instance, if the lifecycle of a forest is 100 years, a statistical study should cover at least several centuries. Then, one must question what the duration of the life cycle of humans is since they started to live in a community? Past experience has shown that putting 10,000 years on the age of Adam (the alleged first human) was as dangerous as calling the earth flat. Recent findings show that it is not unreasonable that the humans lived as a society for over a million years. What then should be the statistically significant time period for studying the impact of human activities? In Chapter 4, the focus lies on developing a sustainability criterion that is valid for time tending toward infinity. This criterion would be valid for both tangible (very large number) and intangible (no-end) meanings of the word infinity. If this criterion is the true scientific criterion, then there should be no discontinuity between so-called renewable and non-renewable natural resources. In fact, the characterization should be re-cast on the basis of sustainable and non-sustainable. After this initial characterization is done, only then comparisons among various energy sources can be made. Chapter 5 offers this characterization.

It is shown in Chapter 5 that sustainable energy sources can be rendered fully sustainable (including the refining and emission capture), making them even more environmentally appealing in the short-term (long-term being already covered by the fact they meet the sustainability criterion). In order to characterize various energy sources, the concept of global efficiency is introduced. This efficiency automatically shows that the unsustainable technologies are also the least efficient ones. It is shown that crude oil and natural gas are compatible with organic processes that are known to produce no harmful oxidation products.

1.6 Can an Energy Source Be Isolated from Matter?

The most important feature of human beings is their ability to think (*homo sapiens* literally meaning the thinking man). If one simply thinks about this feature, one realizes that the thinking is necessary to decide between two processes. In that sense, our brain is just like a computer, the option always being 0 or 1. The history of philosophy supports this cognition process, as evidenced by Aristotle's theory of exclusions of the middles. Even though dogmatic application of this theory to define enemies with tangible features (the with us or against us syndrome) drew severe criticism from people of conscience, this theory indeed was instrumental throughout history in discerning between right and wrong, true and false, and real and artificial. This is not just a powerful tool. It is also an essential and sufficient decision-making tool because it provides one with the fundamental basis of "go" or "no go." This has been known as *Al-furqan* (the criterion) in Arabic and has been used throughout Qu'ranic history as the most important tool for decision makers and revolutionaries (Zatzman and Islam 2007b).

Aristotle considered the speed of light to be infinity. Father of modern optics, Ibn Al-Haytham (also known as Al-Hazen) realized that this theory doesn't meet the fundamental logical requirement that a light source be an integral part of the light particles. Using this logic, he concluded that the speed of light must be finite. Many centuries later, Satyendra Nath Bose (1894–1974) supported Al-Hazen's theory. In addition, he added that the speed of light must be a function of the media density. Even though he didn't mention anything about the light source being isolated from the light particles, he did not oppose Al-Hazen's postulate. Until today, Bose's theory has been considered to be the hallmark of material research (see recent Nobel prizes in physics that refer to the Bose-Einstein theory), but somehow the source has been isolated from the light particles. This was convenient for promoting artificial light as being equivalent to real light (sunlight).

Chapter 5 characterizes lights from various sources and based on their sources. It shows that with such scientific characterization it becomes evident why sunlight is the essence of life and artificial light (dubbed as "white light") is the essence of death. The problems associated with artificial lights, ranging from depression and breast cancer to myopia (Chhetri and Islam 2008), are explained in terms of the characterization done in this chapter. It is shown that a natural light source is a necessary condition of sustainability. However, it is not sufficient as the process of converting the energy source into light must not be unsustainable.

1.7 Is It Possible That Air, Water, and Earth Became Our Enemy?

For thousands of years of known history, air, water, fire, and earth matter were considered to be the greatest asset available for the sustainability of human civilization. On the same token, humans (earthlings, in English inhabitants of the "earth," which comes from old English, *earthe*, old German *erda*, and is very close to Arabic, الأرض (*al-ardha)* that means "the natural habitat" of humans) were the greatest assets that a family, a tribe, or a community could have. Land was the measure of worldly success, whereas organic earth contents, produces, and derivatives (e.g., crops, vegetation, domestic animals) were the symbol of productivity. Ever since the reign of King David (CNN 2008a), non-organic minerals also joined the value-added possessions of humans. Never in history were these natural resources considered to be liabilities. The natural value addition was as follows:

Air → land → water → organic matter earth matter → non-organic earth matter

In the above path, air represents the most essential (for human survival) and abundant natural resource available. Without air, a human cannot survive beyond a few minutes. Land comes next because humans, who have the same composition as earth matter, need to connect with the earth for survival. This is followed by water, without which humans cannot survive beyond a few days. Water is also needed for all the organic matter that is needed for human survival as well. Organic matter is needed for food, and without it humans cannot survive beyond weeks. Non-organic earth matter is least abundant (readily available), but its usefulness is also non-essential for human survival.

In the quest of survival and betterment of our community, the human race discovered fire. Even though the sun is the root energy source available to the earth, fire was not first discovered from solar energy. Instead, it was from natural wood, which itself was a naturally processed source of energy and matter. Nature didn't act on energy and matter separately, and both energy and mass do conserve with inherent interdependency. No civilizations had the illusion that energy and matter could be created. They all acted on the premise that energy and matter are interrelated. The discovery of coal as an energy source was another progression in human civilization. There was no question, however, that the direct burning of coal was detrimental to the environment. Coal was just like green wood, except more energy was packed in a certain volume of coal than in the same volume of green wood. Then came the petroleum era. Once again, a naturally processed source of energy was found that was much more efficient than coal. Even though petroleum fluids have been in use for millennia, the use of these fluids for burning and producing heat is relatively new and is a product of modern times. There is no logical or scientific reasoning behind the notion that the emissions of petroleum products are harmful and the same from wood is not. Yet, that has been the biggest source of controversy in the scientific community over the last four decades.

Ironically, the scientists who promoted the notion that "chemicals are chemicals," meaning carbon dioxide is independent of the source or the pathway, are the same ones who became the most ardent proponent of the "carbon dioxide from petroleum is evil" mantra. How could this be? If carbon dioxide is the essence of photosynthesis, which is essential for the survival of plants, and those plants are needed for sustaining the entire ecosystem, how could the same carbon dioxide be held responsible for "destroying the planet?" The same group promotes that nuclear energy is "clean" energy, considers that genetically modified, chemical fertilizer- and pesticide-infested crop derivatives processed through toxic means are "renewable," and proclaims that electricity collected with toxic silicon photovoltaics and stored with even more toxic batteries (all to be utilized through most toxic "white light") is sustainable. In the past, the same logic has been used in the "I can't believe it's not butter" culture, which saw the dominance of artificial fat (transfat) over real fat (saturated fat).

Chapter 7 demystifies the above doctrinal philosophy that has perplexed the entire world, led by scientists who have shown little appetite for solving the puzzle, resorting instead to be stuck in the Einstein box. This chapter discusses how the build-up of carbon dioxide in the atmosphere results in irreversible climate change and presents theories that show why such build-up has to do with the type of CO_2 that is emitted. For the first time, carbon dioxide is characterized based on various criteria, such as the origin, the pathway it travels, and the isotope number. In this chapter, the current status of greenhouse gas emissions from various anthropogenic activities is summarized. The role of water in global warming is also discussed. Various energy sources are classified based on their global efficiencies. The assumptions and implementation mechanisms of the Kyoto Protocol are critically reviewed. Also, a series of sustainable technologies that produce natural CO_2, which does not contribute to global warming, are presented.

1.8 The Difference Between Sustainable and Unsustainable Products

The history of this modern age tells that we cannot trust the doctrinal definition of truth and falsehood. This book is an attempt to describe fundamental principles from an entirely scientific stand. It is established in this book that truth is based on a true first premise, followed by the natural process of cognition. If this is the case for the thought process or the abstract notion of the truth, what is the case for products? Based on the explicit first premise that natural = real, Chapter 8 establishes that a sustainable product is an outcome of (1) a natural source and (2) a natural process.

If this is the case, then the sustainability criterion (established in Chapter 3) will require that the sustainable product emit products that continue to be beneficial to the environment. If the sustainable product is exposed to unsustainable medium (e.g., microwave heating), then the product reacts with the medium to minimize the damage of the unsustainable medium. On the other, an unsustainable product continues to emit harmful products even if it is exposed to a sustainable environment (e.g., sunlight and natural atmosphere), and it emits much more toxic products if exposed to unsustainable medium (e.g., microwave). This chapter establishes a protocol that can answer why no amount of unsustainable product or process can be allowed as standard practice in sustainable engineering.

Chapter 9 moves the argument one step further and uses two sets of products to highlight the scientific difference between sustainable and unsustainable products. It is shown that the only feature common between sustainable and unsustainable products lasts only an infinitesimally short period of time, i.e., $\Delta t \rightarrow 0$. This chapter serves as a verification of the theory advanced in this book that any decision making process that is based on short-term observation, i.e., most tangible features, will be inherently wrong. This chapter provides one with engineering protocol of discerning between sustainable and unsustainable products.

1.9 Can We Compare Diamonds with Enriched Uranium?

Engineers are always charged with the task of comparing one scheme with another in order to help decide on a scheme that would be ideal for an application. It is commonly understood that a single-criterion analysis (e.g., fuel efficiency for energy management) will be inherently skewed because other factors (e.g., environmental concerns, economic factors, and social issues) are not considered. The same engineers are also told that they must be linear thinkers (the line promoted even in the engineering classroom being "engineers love straight lines"). This inherent contradiction is very common in post-Renaissance science and engineering.

Chapter 10 demystifies the characterization principle involved in energy management. Various energy systems are characterized based on 1) their sustainability and 2) their efficiency. This characterization removes the paradox of attempting to characterize diamonds (source being carbon) and enriched uranium (source being uranium ore), inherently showing that diamonds are a less efficient energy source than enriched uranium. This paradox is removed by including the time function (essence of intangibles), which clearly shows that a sustainable energy source is also the most efficient one. This characterization is an application of the single-criterion sustainability criterion of Chapter 3.

After the energy systems are classified under sustainable and unsustainable, energy sources are ranked under different categories. Among sustainable ones, the classification led to improvements of design in order to achieve even better performance (in terms of immediate benefits – long-term benefits being embedded in the sustainability criterion). For the unsustainable energy systems, it is shown how the long-term environmental impacts snowball into truly disastrous outcomes. This relates to the "tipping point" that many environmental pundits have talked about but that until now has not been introduced with a scientific basis.

1.10 Is Zero-waste an Absurd Concept?

Lord Kelvin's theory leads to this engineering cognition: you move from point A to point B, then from point B to C, then back to point A. Because you came back to point A, you have not done any work.

However, what if a person has actually worked (W) and spent energy (Q) to make the travel? Modern thermodynamics asserts that the claim of work is absurd and no *useful* work has been done. This is the engineering equivalent of stripping conscience participation of a worker. Rather than finding the cause of this confusion, which is as easy as saying that the time function to the movement should be included and that you have actually traveled from Point A (time 1) to Point A (time 2), what has been introduced is this: because you didn't do any *useful* work, W, the energy that you have spent, Q, is actually 0.

The above example is not allegorical, it is real and anyone who attempted to design an engineering system using conventional thermodynamics principles would understand this. That's why any attempt to include real work (as opposed to *useful* work) or real heat (as opposed to heat to produce *useful* work) would blow up the engineering calculations with divisions by zero all over the place. This is equivalent to how economic calculations blow up if the interest rate is written equal to zero[1].

Truly sustainable engineering systems require the use of zero-waste. This, however, would make it impossible to move further in engineering design using the conventional tool that has no tolerance to zero-waste (similar to zero-interest rate in economic models). This is why an entire chapter (Chapter 11) is dedicated to showing how petroleum engineering design can be done with the zero-waste mode. The scientific definition of a zero-waste scheme is followed by an example of zero-waste with detailed calculations showing how this scheme can be formulated. Following this, various stages of petroleum engineering are discussed in light of the zero-waste scheme.

1.11 How Can We Determine Whether Natural Energy Sources Last Forever?

This would not be a valid question in the previous epochs of human civilization. Everyone knew and believed that nature was infinite and would continue to sustain itself. In the modern age, we have been told that human needs are infinite, humans are liabilities,

1. The standard practice of financial organizations that are using softwares is to put a small number, e.g., 0.1% interest rate, to simulate 0% interest rate.

and nature is finite. We are also told that carbon is the enemy and enriched uranium is the friend. We are told that carbon dioxide is the biggest reason our atmosphere is in crisis (yet carbon dioxide is the essence of photosynthesis) and organic matter is the biggest reason our water is polluted (yet organic matter is the essence of life). If we seriously address the questions that are asked in previous questions, the above question posed in this section becomes a matter of engineering details. These engineering details are provided in Chapters 12 through 14.

Chapter 12 identifies root causes of unsustainability in refining and gas processing schemes. It is shown that refining, as used in modern times, remains the most important reason behind the toxic outcome of petroleum product utilization for natural gas, liquid petroleum, and solid final products (e.g., plastics). Alternatives are proposed so that refining is done in such a way that the refined products retain real value yet do not lose their original environmental sustainability (as in crude oil).

Chapter 13 identifies root causes of unsustainability in fluid transport processes. It is shown that the main causes of such unsustainability arise from the use of artificial chemicals in combating corrosion, hydrate formation, wax deposits, aspheltene deposition, etc. The pathway analysis of these chemicals shows clearly how detrimental they are to the environment. For each of these chemicals, alternate chemicals are proposed that do not suffer from the shortcomings of the artificial chemicals and prevent the flow assurance problems that prompted the usage of artificial chemicals.

Chapter 14 proposes a host of sustainable enhanced oil recovery (EOR) techniques. Historically, EOR techniques have been considered the wave of the future and are believed to be a major source of increasing petroleum production in the upcoming decades. However, to-date all EOR techniques adopt unsustainable practices, and if these practices are not rendered sustainable, an otherwise sustainable recovery scheme will become unsustainable. Earlier chapters establish the criteria for rendering such schemes sustainable, and Chapter 14 shows how the most promising aspect of petroleum recovery can become sustainable.

1.12 Can Doing Good Be Bad Business?

Chapter 15 removes all the above paradoxes and establishes the economics of sustainable engineering. This chapter shows that doing good is actually good business and deconstructs all the models that violate this time-honored first premise. This chapter brings back the pricing system that honors real value, replacing the artificial pricing system that has dogged the petroleum industry for the longest time. Despite the length of this chapter, it doesn't cover all the details because that would be beyond the scope of this book. However, it provides enough details so that decision makers can be comforted with enough economic backing. After all, engineering is all about practical applications of science. No practical application can take place without financial details. This is true even for sustainable engineering.

1.13 Greening of Petroleum Operations: A Fiction?

This book is all about true paradigm shift – a paradigm shift from ignorance to knowledge. A true paradigm shift amounts to revolution because it challenges every concept, every first premise, and every process. No revolution can take place if false perceptions and misconceptions persist. Chapter 2 begins with highlighting the misconceptions that have been synonymous with the modern age. In Chapter 16, the outcomes of those misconceptions are deconstructed. It shows how Enron should have never been promoted as the most creative energy management company of our time, not unlike how DDT should not have been called the "miracle powder," and we didn't have to wait for decades to find out what false claims were made. Most importantly, this chapter shows that we must not fall prey to the same scheme.

Chapter 16 discusses how if misconceptions of Chapter 2 were addressed, all the contradictions of modern times would not come to deprive us of a sustainable lifestyle that has become the hallmark of our current civilization. In particular, this chapter presents and deconstructs a series of engineering myths that have been deeply rooted in the energy sector with an overwhelming impact on modern civilization.

Once the mythical drivers of our energy sector are removed, it becomes self evident that we have achieved complete reversal of slogan – a true paradigm shift. Chapter 17 summarizes all the changes that would take place if the sustainable schemes were implemented. Reversing global warming would just be icing on the cake. The true accomplishment would the reversal of the pathway to knowledge, like with the scientific meaning of *homo sapiens* in Latin or *insan* in Arabic[2]. If we believe that "humans are the best creation of nature," then the expectations of this book are neither unreal nor unrealistic.

2. The Arabic word, *insan*, is derived from root that means sight, senses, knowledge, science, discovery by senses, and responsible behavior. It also means the one that can comprehend the truth and the one that can comprehend the creation or nature.