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A True Sustainability Criterion and Its Implications

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1.1 Introduction

Within the context of today's technology development, the terms "sustainable" and "sustainability" refer to a concept that has become something of a buzzword on which different social, economic and political interests can (and do) hang some self-serving definitions. What these self-interested definitions have in common is their employment of terms to imply the acceptability of a process for some particular duration of time. True sustainability, on the other hand, cannot be a matter of such partial and subjective "definition", including the endless debates and interpretations that come with such subjectivity. Highlighting the importance of using the concept of sustainability in every model of technology development. This chapter attempts to clarify what is involved in elaborating a scientific criterion for determining sustainability. Far from being an idle preoccupation which at first blush, might look like "wishful thinking," the fundamental insight informing this particular exploration is that the economic arrangements needed for securing the benefits of such sustainability for all, can only be

realized if the underlying science and its engineering in various technological forms are themselves sustainable.

As argued in *Sustainable Energy Pricing* (the earlier companion volume to the present book), the only true model of sustainability to be found lies in Nature, the natural environment. Both in its root-source and in the pathway taken by its development, a truly sustainable process conforms to connected, and/or underlying, natural phenomena. Scientifically, what could this mean? In this book, it means that true long-term considerations of humans should include the entire ecosystem. Some label this inclusion "humanization of the environment" and have deemed its inclusion to be a precondition of true sustainability (Zatzman and Islam, 2007). Of course: the inclusion of the entire ecosystem becomes meaningful only when the natural pathway for every component of the technology is followed. Only such a design may assure that the process will produce both short-term (tangible) and long-term (intangible) benefits.

However, tangibles relate to short-term (and very limited) space — more like ∂s ("the rate of change of displacement") rather than plain old "pure and simple"s (displacement itself, as some fixed quantity). Intangible elements relate to either long-term elements or other elements of the current time-frame. Therefore, an exclusive or dominating focus on the tangible will obscure longer-term consequences from our collective awareness. Without including and properly analyzing intangible properties, of course, these consequences cannot be uncovered. According to Chhetri and Islam (2008), by taking the long-term approach, the outcome is reversed from the one that emerges from the shorter-term approach. As discussed *infra* in Chapter 2, by examining the efficiency (η) of different energy sources as delivered by various technologies, this distinction may be demonstrated almost graphically. By focusing on just heating value, for example, a ranking appears that diverges into what is observed today as the "global warming" phenomenon. On the other hand, if a long-term approach were taken, the current energy crunch would have been entirely avoided as none of the previously perpetrated technologies would have been considered "efficient" and replaced with truly, i.e., globally, efficient technologies. Such is the inherent importance of intangibles — and of how tangibles should link to them. Exploring many previously unremarked links between microscopic and macroscopic properties, this approach opens up a new understanding of the relationship between intangible-to-tangible scales.

It has long been accepted that Nature is self-sufficient and complete. This renders Nature the true teacher of how to develop sustainable technologies. From the standpoint of human intention, this self-sufficiency and completeness becomes a standard for declaring Nature perfect. "Perfect" here, however, does not mean that Nature is in one fixed unchanging state. On the contrary, it is the capacity of Nature to evolve and sustain itself which makes it such an excellent teacher. This perfection makes it possible and necessary for Humanity to learn from Nature — not to fix Nature, but to improve Humanity's own condition and prospects within Nature, in all periods and for any timescale. This holds a subtle yet crucial significance for such emulation of Nature. The most notable consequence is that technological or other types of development undertaken within the natural environment but lacking consciousness of Nature's "perfection," must necessarily end up violating something fundamental within Nature, even if only for some limited time. Understanding the effect of intangibles and the relations of intangibles to tangibles thus becomes extremely important for reaching appropriate decisions affecting the welfare both of human societies and the natural environment. A number of aspects of natural phenomena are explored in this chapter with the aim of further bringing out the relationships between intangibles and tangibles and the connection of that relationship to true sustainability. This provides an especially strong basis for the sustainability model argued for in this book. The mass-and-energy-balance equation, for example, is discussed here with the aim of further illuminating the influence of the intangible and the role of intention.

1.2 Importance of a Sustainability Criterion

Few in our post-Renaissance world would disagree over whether we have made progress as a human race. Empowered with the New Science led by Galileo and later championed by Newton, modern engineering is credited with having universally revolutionized human lifestyle. Yet, centuries after those revolutionary contributions of the New Science pioneers, modern-day leading scientists such as Nobel Chemistry Laureate, Robert Curl find such technology development more akin to "technological disaster" rather than a source of marvels. Today's engineering is driven by economic models that have been criticized trenchantly as inherently

unsustainable by Nobel Laureates Joseph Stiglitz, Paul Krugman and Mohamed Yunus. This would seem to position much of the contemporary engineering art itself as environmentally unsustainable and socially unacceptable.

Figure 1.1 shows the nature of the problem currently facing human habitat as a result. Value indices that would imply improvement of human social status have declined. At the same time, per capita energy consumption has increased. This figure thus clearly signals a problem of direction in technology development. If increasing per capita energy consumption is synonymous with economic growth, — in line with modern-day notions of gross domestic product (GDP) — then further economic growth could only mean an even worse decline in the quality of the environment. What appears on its surface to be a very difficult but essentially technological problem, therefore, is also a fundamental problem of the outlook that has come to prevail in modern society's evolution since the European Renaissance into the current-day Information Age.

Table 1.1 summarizes various man-made activities that have been synonymous with social progress and simultaneously responsible for much of the current global crisis. The current model is based on conforming to regulations and reacting to events. This response has remained purely reactive, ultimately rendering it ideologically and politically reactionary. Nowhere is any fundamentally proactive stance embraced or maintained with regard to environmental regulations among any of the developed countries. Conformity to

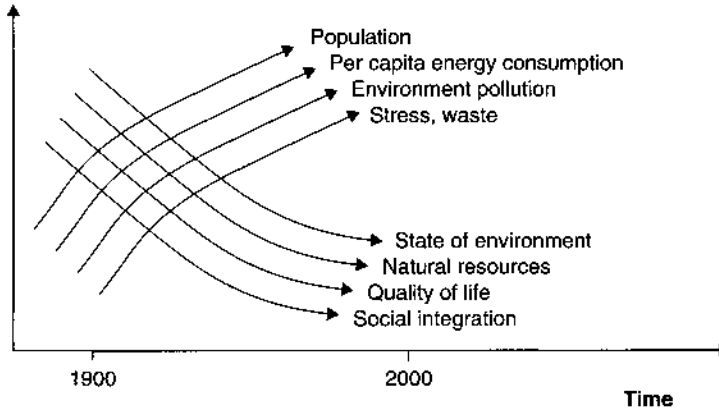

Figure 1.1 Rising costs and declining values during the post-Renaissance.

Table 1.1 Energy consumed by various human activities.

Activity	Btu	Calorie
Amatch	1	252
An apple	400	100,800
Making a cup of coffee	500	126,000
Stick of dynamite	2,000	504,000
Loaf of bread	5,100	1,285,200
Pound of wood	6,000	1,512,000
Running a TV for 100 hours	28,000	7,056,000
Gallon of gasoline	125,000	31,500,000
20 days cooking on gas stove	1,000,000	252,000,000
Food for one person for a year	3,500,000	882,000,000
Apollo 17's trip to the moon	5,600,000,000	1,411,200,000,000
Hiroshima atomic bomb	80,000,000,000	20,160,000,000,000
1,000 trans-atlantic jet flights	250,000,000,000	63,000,000,000,000
United States in 1999	97,000,000,000,000,000	24,444,000,000,000,000,000

regulations and rules that may themselves be utterly lacking any sustainable foundation can only increase long-term instability. This implies that conformity to law assures nothing in itself about sustainability — especially if those laws are based on something anti-nature.

Environmental regulations and technology standards today widely enjoy unquestioning acceptance, to the extent that fundamental misconceptions embedded in them (and discussed below) are frequently left unquestioned. The fact that many of these regulations and standards follow no natural laws is frequently concealed behind complete nonsense, sometimes put forward as cracker-barrel common sense, such as "dilution is the solution to pollution." No scientific-minded person could disagree that regulation that violates natural law has no chance of establishing a sustainable environment. With today's regulations, for example, crude oil is considered to be toxic and therefore undesirable in a water stream. Of course, from the standpoint of human consumption, crude oil is more or less indigestible and hence undesirable... but toxic it is not. Meanwhile, according to the current regulatory regime developed in the U.S. by the EPA and followed in many other countries, the most toxic additives — frequently byproducts of refining crude oil — are not considered toxic.[1]

The slogan, "Dilution is the solution to pollution" has become a popular slogan in the environmental industry. All environmental regulations are based on this principle. The tangible aspect — viz., concentration — is considered, but the intangible aspect, such as the nature of the chemical, or its source, is not. Hence, 'safe' practices initiated on this basis are bound to become quite unsafe in the long run. Environmental impacts, however, are not a matter of minimizing waste or increasing remedial activities, but of humanizing the environment. This requires the elimination of toxic waste altogether. Even non-toxic waste should be recycled 100 percent. This involves not adding any anti-natural chemical to begin with,

[1] A stunning example of the cloud-cuckoo-land this has unleashed in the regulatory environment may be gleaned from the detailed deconstruction (reproduced following Chapter 4 of this book) by members of the Environmental Defence Fund (EDF) and several other groups of the efforts of the U.S. Environmental Protection Agency to compel oil-refinery owners to clean up their onsite and landfill toxic waste. The EDF uncovered scores of examples where the EPA in league with oil refinery owners found ways to make the refinery owners' liability "disappear" by "tweaking" its inspection procedures. Referring to the fact that, until the late 1930s, the Third Reich defended its outrageous anti-people practices on the basis not of new laws but of a stretched interpretation of existing law and legal practice, the late Martin Luther King, Jr. famously pointed out that we should never forget that "everything Adolf Hitler did in Germany was 'legal'."What Martin Luther King Jr. would regard as "good" or "bad" law are what science would distinguish as sustainable (hence, true) law and false (hence, implosive) law, respectively. Thus, increasing numbers of environmental activists have become mightily exercised by the outrageousness of such hypocrisy. In the words of the late Malcolm X: "Don't stick a knife in me 10 inches, pull it out six, and tell me we've made progress."

then making sure each produced material is recycled, with value-addition taking place wherever possible. A zero-waste process thus has 100 percent global efficiency attached to it. If a process emulates nature, such high efficiency is inevitable.

This process is the equivalent of "greening" petroleum technologies (Islam, 2011). With this mode, no one will attempt to clean water with toxic glycols, remove CO_2 with toxic amides, or use toxic plastic paints as a "greening" process. No one will inject synthetic and expensive chemicals to increase "'enhanced oil recovery"' (EOR). Instead, one would settle for waste materials or naturally available materials that are abundantly available and pose no threat to the eco-system.

The role of a scientific sustainability criterion is similar to that of the bifurcation point shown in Figure 1.2. This figure shows the importance of the first criterion. The solid circles represent natural (true) first premises, whereas the hollow circles represent aphenomenal (false) first premises. The thicker solid lines represent steps that would increase overall benefits to the whole system. At every phenomenal node, there will be spurious suggestions that would emerge from some aphenomenal roots (e.g. bad faith, bottom-line driven, myopic models), represented by dashed thick lines. However, if the first premise is sustainable, no node will appear

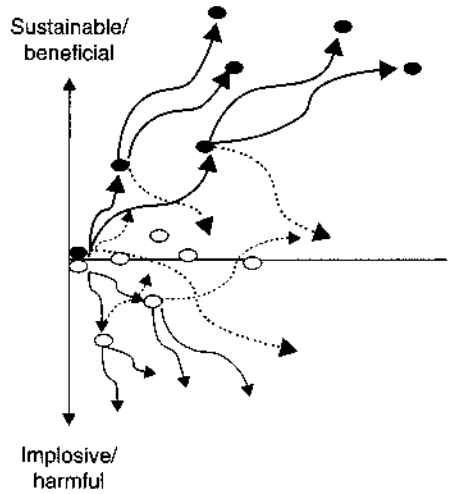

Figure 1.2 Role of first-criterion premise in determining a pathway to sustainability or implosion.

ahead of the spurious suggestions. Every logical step will lead to sustainable options. The thinner solid lines represent choices that emerge from aphenomenal or false sustainability criteria. At every aphenomenal node, there will be aphenomenal solutions. However, each will lead to further compounding of the problem, thereby radically increasing environmental costs in the long run. This process can be characterized as the antithesis of science (as a process). At every aphenomenal node, anytime a phenomenal solution is proposed, it is deemed spurious because it opposes the first criterion of the implosive model. Consequently, these solutions are rejected. This is the inherent conflict between sustainable and unsustainable starting points. In the implosive mode, phenomenal plans have no future prospect, as shown by the absence of a node.

Albert Einstein remarked that "the thinking that got you into the problem is not going to get you out." Figure 1.2 shows the two different thought processes that dictate diverging pathways. Once launched on the unsustainable pathway, there cannot be any solution other than returning to the first bifurcation point and relaunching in the direction of the sustainable pathway. This logic applies equally to technology development as well as economics.

1.3 Criterion: The Switch that Determines Direction at a Bifurcation Point

A decision-taking process involves asking "yes" or "no" questions. Usually, this question is expected to come at the end of a thought process or logical train. What is less often recognized is that the "yes" or "no" questions themselves cannot lead to a correct answer if the originating logical train of thought did not start from a correct first/major premise, and if the complete time domain (defining the logic of the train) is not fully considered.

To illustrate what this means, consider the following question: Is whole wheat bread better than white bread?

One cannot answer this question without some knowledge of past history. For instance, if organic flour (without chemical fertilizer additives, genetic alteration, pesticides, metallic grinders, and-or artificial heat sources) is employed, whole wheat bread is better. However, if the flour is not organic, then more questions need to be asked in order to determine the degree of insult caused to the natural process and to determine the actual composition of

the whole wheat bread if all ingredients (including trace elements from the grinder, chemical fertilizers, pesticides, heat sources, and others) were to be considered. In this analysis, one must include all elements in space at a given time. For instance, if trace elements from pesticide or a metallic grinder are neglected, the answer would be falsified. In this particular case, whole wheat non-organic bread is worse than white non-organic bread, but will not be shown as such if one doesn't include all elements in time and space (mass and energy). Summarizing these two points, one must consider the full extent of time from the start of a process as well as all elements in space (for both mass and energy sources), in line with the theory advanced by M.I. Khan *et al.* (2008). Each of these considerations will pose a question regarding the diversion of the process from a natural process. At the end, anything that is natural is sustainable.

Table 1.2a Rephrasing the question-sequence.

Q: *Is whole wheat bread better than white bread?*
The conventional answer sought would be either "Yes" or "No", or "True" or "False". However, without a proper criterion for determining "True" or "False", this question cannot be answered. In order to search for the knowledge-based answer to this question, the following question must be asked:
Q_k: *Are both white bread and whole wheat bread organic?*
If the answer is "yes", then the answer to Q is "YES". If the answer is "no", then the following knowledge-based question has to be asked:
Q_{k1}: *Are both non-organic?*
If the answer is "YES", then the answer to Q becomes "NO", meaning whole wheat bread is not better than white bread. If the answer to Q_{k1} is "NO", then a further knowledge-based question has to be asked:
Q_{k2}: *Is the white bread organic?*
If the answer is "YES", then the answer to Q becomes "NO", meaning whole wheat non-organic bread is not better than white organic bread. If the answer to Q_{k2} is NO, then the answer to Q is, "YES", meaning whole wheat organic bread is better than white non-organic bread.

In the above analysis, the definition of "organic" had been left to the reader's imagination. However, a 100 percent scientific organic white bread cannot be achieved. Scientifically speaking, throughout this book, "organic" means something in which anti-conscious intervention of human beings has been blocked or has not occurred. Obviously, nature itself being continuous in space and time, there is no possibility of having a 100 percent organic "product". However, this should not stop one from searching for the true answer to a question. At the very least, this line of analysis will raise new questions that should be answered with more research if deemed necessary. In the simple experimental outline that follows for this particular question, "Q", we have only presented the mass balance aspect. For instance, organic bread also implies such things as baked in a clay stove with natural fuel. What happens if this energy balance is not respected? This poses another series of questions. Here this series of questions are labeled as "energy-related" questions, or "QE". This question must be asked in the beginning (meaning, before asking any of the Q_{kx} series of questions).

As it becomes clear from the above analysis, many knowledge-seeking questions arise, and each question demarcates a bifurcation point. At each bifurcation point, the question to ask is: Is the process natural? The time frame to investigate often takes much more than the characteristic time of the process. For environmental sustainability, the characteristic time of the process is the duration of the existence of the human species. As originally proposed by Khan and Islam (2007), this can easily transform into infinity. The process,

Table 1.2b Further rephrasing of the question sequence.

QE: Are both whole wheat and non-whole wheat breads organically baked?
If the answer is "YES", then the previous analysis stands. If the answer is "NO", then the following knowledge-seeking question must be asked:
QE_k: Are both of them cooked non-organically, i.e. microwaves, using processed fuel, recombined charcoal, or baked in a steel stove?
If the answer is "YES", then the previous analysis stands. If the answer is "NO", then it is a matter of doing more research. To date, we do not have enough research to show how whole wheat flour would react with non-organic energy sources as compared to white flour.

then, involves taking the limit of a process as time goes to infinity. If the process is still sustainable, it can be taken as a natural process and is good for the environment. Otherwise, the process is unnatural and therefore, unsustainable. This analysis shows that the most important role of the time dimension is in setting the direction.

In Figure 1.2, we have seen that a phenomenally-based starting point would lead to actual knowledge, whereas a starting point lacking phenomenal reality would lead to prejudice. If the time dimension is not considered on a continu*ous* basis (continu*al* is not enough), even the logical steps cannot be traced back fully or reliably enough to verify the first premise. It is not enough to back up a few steps. One must back up to the first premise that led to the bifurcation between sustainable and implosive pathways. Zatzman *et al.* (2008) highlighted the need for such considerations of the time domain in order to utilize the time dimension as a switch. It turns out that without such considerations scientists cannot reliably determine the causes of global warming using the science that assumes all molecules to be identical. This assumption itself makes it impossible to distinguish between organic CO_2 and industrial CO_2, or, for example, to determine the cause of diabetes, absent a paradigm that would clearly distinguish the type of sucrose in honey from "sucrose" in Aspartame (Chhetri and Islam, 2007).

1.3.1 Some Applications of the Criterion

The same logic would indicate that unless science includes intangibles, the cause(s) of global warming also cannot be reliably determined. What remains uncharted is precisely the role of the pathways and the passages of time — something impossible to follow meaningfully in lab-controlled conditions — in transforming the internal basis of changes in certain natural phenomena. One such example given by Khan and Islam (2007b), discloses a deep problem in analyzing the consequences of the presence of reaction catalysts. Tangible science asserts catalysts play no role in the chemical reaction equation because they do not appear in the result/outcome. No mass balance can account for the mass of a catalyst lost during a certain reaction, and no chemical equation can account for what happens to the "lost" catalyst molecules when they combine with the products during extreme conditions enjoying neither origins nor a stable existence in the natural environment.

By using the science of tangibles, one can argue that the collection of patents listed in Table 1.3 is indeed a technological breakthrough. This patented technology separates mercury (Hg) from a

Table 1.3 El-Shoubary patents re: separating Hg from gaseous stream — Partial List.

6,524,371
Process for adsorption of mercury from gaseous streams
Feb 25 2003
(http://patft.uspto.gov/netacgi/nph-Parser?Secto-PTOi&Sect2-HITOFF&d-Pall& p-i&u-%2Fnetahtml%2
FPTO%2Fsrchnum.htm&r-i&f-G&l-50&si-652437i.PN.&OS-PN/652437i)
6,533,842
Adsorption powder for removing mercury from high temperature, high moisture gas stream
March 18, 2003
(http://patft.uspto.gov/netacgi/nph-Parser?Sectr-PTOi&Sect2-HITOFF&d-PALL& p-i&u-%2Fnetahtml%2
FPTO%2Fsrchnum.htm&r-i&f-G&l-50&si-6533842.PN.&OS-PN/6533842&RS-PN/6533842)
6,558,642
Method of adsorbing metals and organic compounds from vaporous streams
May 6, 2003
(http://patft.uspto.gov/netacgi/nph-Parser?Secti-PTOi&Sect2-HITOFF&d-PALL& p-i&u-%2Fnetahtml%2
FPTO%2Fsrchnum.htm&r-i&f-G&l-50&si-6558642.PN.&OS-PN/6558642&RS-PN/6558642)
6,5824,97
Adsorption powder for removing mercury from high temperature high moisture gas stream
June 24, 2003
(http:/patft.uspto.gov/netacgi/nph-Parser?Secti-PTOi&Sect2-HITOFF&d-PALL& p-i&u-%2Fnetahtml%2
FPTO%2Fsrchnum.htm&r-i&f-G&l-50&si-6841513.PN.&OS-PN/6582497&RS-PN/ 6582497)
6,589,318
Adsorption powder for removing mercury from high temperature, high moisture stream
July 8, 2003
(http://patft.uspto.gov/netacgi/nph-Parser?Secti-PTOi&Sect2-HITOFF&d-PALL& p-i&u-%2Fnetahtml%2FPTO
%2Fsrchnum.htm&r-i&f-G&l-50&si-6589318.PN.&OS-PN/6589318&RS-PN/6589318)
6,841,513
Adsorption powder containing cupric chloride
Jan 11,2005
(http://patft.uspto.gov/netacgi/nph-Parser?Secti-PTOi&Sect2-HITOFF&d-PALL& p-i&u-%2Fnetahtml%2FPTO
%2Fsrchnum.htm&r-i&f-G&l-50&si-6841513.PN.&OS-PN/6841513&RS-PN/6841513)

contaminated gas stream using copper chloride ($CuCl_2$) as the main catalyst. At a high temperature, $CuCl_2$ would react with Hg to form a Cu-Hg amalgam. This process is effective when combined with fire-resistant Teflon membranes. Going by the science of tangibles which ascribes the mass balance within the confines of the reactor, this is indeed an effective technology. The table provides a partial listing of patents (all with El-Shoubary as the inventor) on various aspects of this process.

This high level of recognition of the technology is to be expected. After all, what happens to Teflon at high temperatures and what happens to any Cu-Hg amalgam in general, are matters of long-term concern, or at least over a duration of time beyond the "time of interest" (Khan {M.I.}, 2006). This is described as "time t = right now".

However, if longer-term time is used for the analysis and a bigger area is considered for the mass balance, it becomes clear that the same process has actually added more waste to the environment in the form of dioxins released from Teflon and Cu-Hg—both being in a more harmful state than their original states in Teflon, $CuCl_2$, and gas streams, respectively. In the efficiency calculation, nearly 90 percent efficiency is reported within the reactor. This figure makes the process very attractive. However, if the efficiency calculation is conducted, including the entire system, in which the heater resides, the efficiency drops drastically. In addition, by merely including more elements, the conversion of Hg in the natural gas stream and Cu in $CuCl_2$ solution into Cu-Hg sludge, as well as the addition of chlorine in the effluent gas, poses a difficult question as to what has been accomplished overall.

Another example can be given from the chemical reaction involving honey and Aspartame®. With the science of tangibles, the following reactions take place:

$$\text{Honey} + O_2 \rightarrow \text{Energy} + CO_2 + \text{Water} \tag{1.1}$$

$$\text{Aspartame} + O_2 \rightarrow \text{Energy} + CO_2 + \text{Water} \tag{1.2}$$

In fact, a calorie-conscious person would consider Aspartame a better alternative to honey, since the energy produced in Aspartame is much less than that of honey for the same weight consumed. An entirely different picture emerges, however, if all components of honey and Aspartame are included. In this case, the actual

composition of water as a product is very different for both cases. This difference cannot be observed if the pathway is cut off from the analysis and if the analysis is performed within arbitrarily set confines. Similar to confining the time domain to the "time of interest" or "time = right now", this confinement in space perverts the process of scientific investigation.

Every product emerging after oxidation of an artificial substance will come with long-term consequences for the environment. These consequences cannot be included within the existing science of tangibles. Zatzman and Islam (2007) detailed the following transitions in commercial product development and argued that this transition amounts to an increased focus on the tangible in order to increase the profit margin in the short-term. The degradation in quality is obvious, but the reason behind such technology development is murky. At present, the science of tangibles has proven incapable of lifting the fog.

As a third instructive example, consider the example of lemon and vitamin C. Lemon has both culinary and medicinal functions in ancient cultures, ranging from the Far East to Africa. However, in European literature, there is a confusion that certain fruits (e.g., oranges, in the following example) are only for pleasure (culinary) and others are for medicinal applications (e.g., lemon). Apart from this misconception, the point worthy of noting here is that lemon was known to cure scurvy, a condition arising from lack of Vitamin C. So, this becomes the first premise: lemons can cure scurvy.

Reference to this premise begins in centuries-old literature (Ferrari, 1646). Ferrari described numerous medicinal preparations based upon citrus blossoms or fruits. He noted that the orange is usually eaten for pleasure alone, while the lemon, citron and pomegranate are used as medicine. He mentions in passing the use of citrus to cure scurvy. By the 18th century, the British Royal Navy and merchant marine, whose seamen were expected to spend months at a time at sea without making landfall, were keen to alleviate the scurvy menace by adding Vitamin C to the diet in the form of lemon juice. James Lind's experiments on seamen suffering from scurvy in 1747 established the efficacy of this approach (Website 29).

Eventually, it emerges that only 5 percent of lemon juice is ascorbic acid. With this isolated aphenomenal first premise, one can easily proceed to commercialization by producing ascorbic acid with techniques that are immediately proven to be more efficient and therefore more economical. This is because when ascorbic acid is

manufactured, the pills have much higher concentration of ascorbic acid than lemon juice ordinarily would have. In addition, the solid material that is used to manufacture Vitamin C pills are also cheaper than lemons, and are definitely more efficient in terms of preservation and commercialization. After all, no lemon would last for a year, whereas Vitamin C pills will last. Overall, if Vitamin C is ascorbic acid, then manufactured Vitamin C can be marketed at far lower cost than Vitamin C from lemons. Now, if a clinical test can show that the manufactured Vitamin C indeed cures scurvy, no one can argue that real lemons are needed and would, in fact, obviously be a waste of money. This is the same argument put forward by Nobel Laureate Chemist, Linus Pauling, who considered that "synthetic" Vitamin C is identical with "natural" Vitamin C and warned that higher-priced "natural" products are a "waste of money." Some thirty years later, we now know "synthetic" Vitamin C causes cancer while "natural" Vitamin C prevents it (Chhetri and Islam, 2008). How could this outcome be predicted with science? By removing the fundamental misconception that lemon juice is always and everywhere 5 percent ascorbic acid, indifferent to the passage of time and thus independent of its source or pathway.

The litany of false conclusions just catalogued, derived through conventional New Science, could be avoided by using a criterion that distinguishes between real and artificial. This can be accomplished with a science of intangibles that includes all phenomena that occur naturally, irrespective of what might be detectable. With respect to catalysis, for example, it can be said that if the reaction cannot take place without the catalyst, clearly the catalyst is playing a role. Just because at a given time (e.g., time = "right now"), the amount of catalyst loss cannot be measured, does not mean catalyst loss and/or some other related role does not exist. The loss of catalyst is real, even though one cannot measure it with current techniques. The science of intangibles cannot wait for the time when one can "prove" that catalysts are active. Because nature is continuous (without boundary in time and space), considerations are not focused on a confined "control volume". For the science of tangibles, on the other hand, all that the absence of molecules of the catalyst in the reaction products means is that one would not find that role there.

Tangible science says: if it cannot be found in the reaction product, it does not count. The science of intangibles says: obviously it counts, but just as obviously — not in the same way as what is

measurable in the tangible mass-balance. This shows where the existing conventional science of tangibles remains incomplete. Precisely to the extent that it remains incomplete, on this basis of disregarding or discounting qualitative contributions that cannot yet be quantified in ways that are currently meaningful, this kind of science is bound to become an accumulating source of error.

The most serious, important, and significant litmus test of a proposed scientific characterization or analysis of any phenomenon is that it should account for everything necessary and sufficient to explain the phenomenon — its origin, its path and its end-point — thereby rendering it positively useful. The same criterion was used in previous civilizations to distinguish real from artificial. M.I. Khan & M.R. Islam (2007) introduced a criterion that identifies the end-point, by extending time to infinity. This criterion avoids scrutiny of the intangible source of individual action (viz., intention). However, Zatzman and Islam (2007a) pointed out that, although the end-point at time $t = \infty$ can be a criterion, it will not disclose the pathway unless a continuous time function is introduced. In the assessment of all these deductions, it is the science of intangibles that offers some hope. It is important to note that the insufficiency just mentioned is not overcome, and indeed cannot be overcome, by doing "more" science of tangibles "better". It is already evident that what is not being addressed are intangible components that cannot be ferreted out or otherwise measured by existing means available within the realm of the science of tangibles.

1.4 Current Practices in Petroleum Engineering

In a relatively short time — "short" relative to the history of the environment — the oil and gas industry has become one of the world's largest economic sectors, a powerful globalizing force with far reaching impacts on the entire planet humans share with the rest of the natural world. Decades of continuous growth in oil and gas operations have changed, and in some places even transformed, the natural environment and the way humans have traditionally organized themselves. The petroleum sector draws huge public attention due to the environmental consequences of its activities. All stages of oil and gas operations generate a variety of solids, liquids and gaseous wastes (Currie and Isaacs, 2005; Wenger *et al.*, 2004; Veil, 2002; Wiese *et al.*, 2001; Rezende *et al.*, 2002; Holdway,

2002). Different phases of petroleum operations, their associated problems and the challenge posed to sustainable development are discussed in the next several sections.

1.4.1 Problems of Current Operations

In petroleum exploration and production operations, different types of wastes are generated. They can be categorized broadly as drilling wastes, human-generated wastes, and other industrial wastes. A detailed list of wastes generated during different phases of petroleum operations is presented in Table 1.4 *infra*. There are also accidental discharges, such as air emissions, oil spills, chemical spills, and blowouts.

During the drilling of an exploratory well, several hundred tonnes of drilling mud and cuttings are commonly discharged into the marine environment. And, even though an exploratory activity, such as seismic exploration, does not release waste, it nevertheless also has a potential negative impact (Cranford *et al.*, 2003; Putin, 1999). According to reports (SECL, 2002; Putin, 1999), seismic

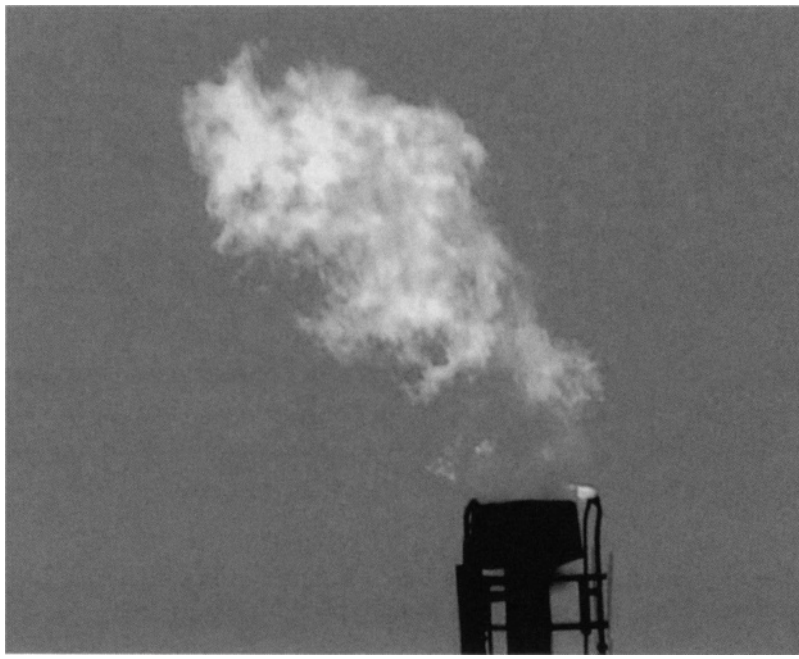

Figure 1.3 Oil refinery flaring off.

shooting kills plankton, including eggs and larvae of many fish and shellfish species and juveniles that are very close to the airguns. The most important sub-lethal effects on adult organisms exposed to chronic waste discharges, from both an ecological and a fisheries perspective, are the impairment of growth and reproduction (GESAMP, 1993; Putin, 1999). Growth and reproduction are generally considered to be most vulnerable to the sub-lethal effects from chronic contaminant exposure (Cranford *et al.*, 2003). Seabirds aggregate around oil drilling platforms and rigs in above average numbers due to night lighting, flaring, food and other visual cues. Bird mortality has also been documented from impacts these structure as well as from from oiling of the waters and from incineration by flares. (Wiese *et al.*, 2001).

M.I. Khan and Islam (2005) report a large quantity of water emissions — primarily the result from the discharge of produced water — which include fluid injected during drilling and high saline water. Produced water contains various contaminants, including trace elements and metals from formations through which the water passed during drilling as well as additives and lubricants necessary for proper operations. Although typically treated these days prior to discharge, such was historically not usually the case (Ahnell and O'Leary, 1997).

Based on the geological formation of a well, different types of drilling fluids are used. The composition and toxicity of these

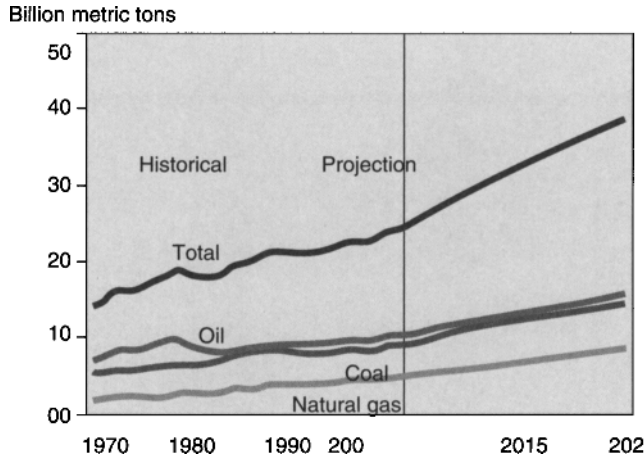

Figure 1.4 World CO_2 emissions by oil, coal and natural gas, 1970–2025 (adapted from EIA, 2004).

drilling fluids are highly variable, depending on their formulation. Water is used as the base fluid for roughly 85 percent of drilling operations internationally while the remaining 15 percent predominantly use oil (Reis, 1996). Spills make up a proportionately small component of aquatic discharges (Liu, 1993).

Carbon dioxide (CO_2) emissions are a pressing issue in the hydrocarbon sector. There are direct emissions from production sites caused by flaring and the burning of fossil fuels. During exploration and production, emissions take place due to control venting and/or flaring as well as the use of fuel. Based on 1994 British Petroleum figures, emissions by mass were 25 percent volatile organic compounds (VOCs); 22 percent CH_4; 33 percent NO_x; 2 percent SO_x; 17 percent CO; and 1 percent particulate matter. Data on CO_2 are not provided (Ahnell and O'Leary, 1997). Flaring continues to be used as a production and refining technique, even as it wastes huge amounts of valuable resources through burning. The air emissions during petroleum processing are primarily due to uncontrolled volatilization and combustion of petroleum products in the modification of end products designed to meet consumer demand (Ahnell and O'Leary, 1997). Oils, greases, sulphides, ammonia, phenols, suspended solids, and chemical oxygen demand (COD) are commonly discharged to water during the refining process (Ahnell and O'Leary, 1997). Natural gas processing generally involves the removal of natural gas liquids (NGLs), water vapour, inert gases, CO_2, and hydrogen sulphide (H_2S). The by-products from processing include CO_2 and H_2S.

The oil sector contributes a major portion of CO_2 emissions. Figure 1.5 presents the world historical and the projection of CO_2 emissions from different sectors. About 29 billion tonnes of CO_2 are released into the air every year by human activities while 23 billion tonnes come form burning fossil fuels and industry (IPCC, 2001; Jean-Baptiste and Ducroux, 2003). This is why this sector is blamed for global warming. The question is, how might these problems best be solved? Is there any possible solution?

Throughout the life-cycle of petroleum operations, there are accidental discharges. There are, for example air emission, oil spills, chemical spills, and blowouts. The spilled oil released to terrestrial and aquatic environments has different impacts. Figure 1.6 shows the annual total amount of oil releases in the marine environment. Crude oil is one of the major toxic elements released into the marine environment. On average, 15 million gallons of crude

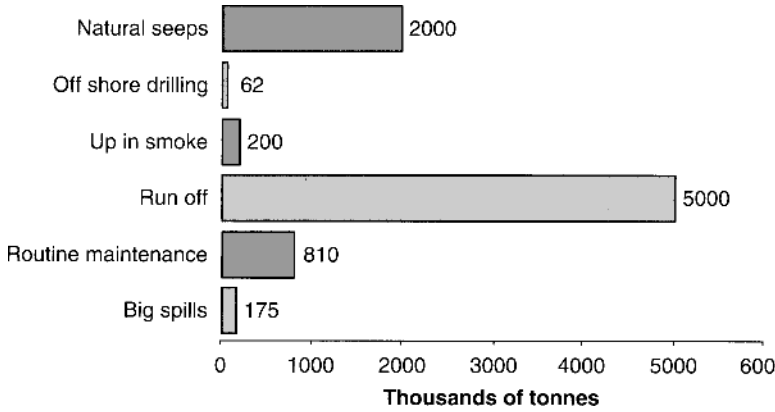

Figure 1.5 Annual total amount of oil release in the marine environment (Data source: *Oil in the Sea*, 2003).

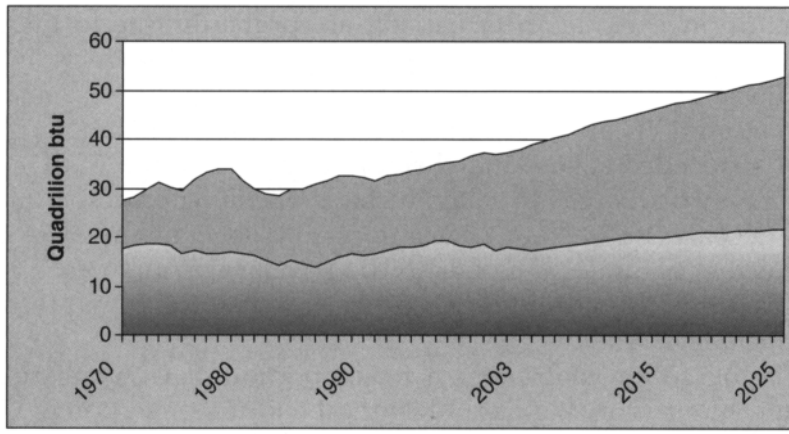

Figure 1.6 Estimated Total World Production and Demand of Oil (Data source: EIA, 2003).

oil are released yearly from offshore oil and gas operations into the marine environment. There are also some 700 million gallons of oil discharges into the sea from other sources (United States Coast Guard, 1990; Khan [M.I.] and Islam, 2004). These include routine maintenance of shipping, domestic/urban runoff, smoke and natural seepage.

The above mentioned examples are but a few within the current technology development mode that could be pointed out. As discussed previously regarding Enron (in Chapter 1 of the earlier

companion volume, *Sustainable Energy Pricing*), it is hard to find a single technology that does not have such problems. In addition to the use of technologies that are unsustainable, the corporate management process itself is based on a structure that resists sustainability.

There are enormous environmental impacts arising from current petroleum operations, but there is high market demand and technological advances in exploration and development with petroleum operations spread all around the world. These include even more remote and deeper oceans to help capture these markets to the maximum in the shortest possible turnaround times (Wenger *et al.*, 2004; Pander, 2001). Due to the limited supplies of oil and gas reserves onshore — including the fact that these reserves have already been under exploitation for a long time and are probably well past their peak — the available data suggest that there has been increasing pressure since the 1990s to explore and exploit offshore reserves. This phenomenon has gone global within the past two decades (Pinder, 2001) to include many reserves previously believed to be marginal. Typically, such reserves include Canada's Scotian Shelf deposits which were found unsuitable and unfeasible in the 1970s, but became economically attractive since 1996 (Khan and Islam, 2006).

1.4.2 Problems in Technological Development

As mentioned earlier, technologies promoted in today's post-industrial revolution are based on the aphenomenal model (Islam, 2005), which grossly linearizes nature. ("Nature" in this context includes Humanity in its social aspect.) This model's assumption that whatever appears as $\Delta t \to 0$ (or time = "right now") represents the actual phenomenon is clearly an absurdity. How can there be such a thing as a natural phenomenon without a characteristic duration and/or frequency? When it comes to what defines a phenomenon as truly natural, time in one form or another is of the essence.

The essence of modern technology development is the use of linearization or reduction of dimension. Linearization has provided a powerful set of techniques for solving equations generated from mathematical representations of observed physical laws – physical laws that were adduced correctly and whose mathematical representations as a symbolic algebra, have proven

frequently illustrative, meaningful and often highly suggestive. However, linearization has also made the "solutions" inherently incorrect. Any solution for time "t = right now" represents the image of the real solution, which is inherently opposite to the original solution. Because this model lacks a basis in phenomenal reality, any approach that focuses on the short-term makes one travel down the wrong path. This path does not intersect with the true path at any point in time other than at "t = right now". Thus, the divergence begins from the outset. Any natural phenomenon or product always travels an irreversible pathway that is nowhere emulated by the currently employed aphenomenal model of technology development because *by definition*, nature is non-linear and "chaotic" (Gleick, 1987). Any linearized model can therefore represent *only* the image of nature at a time "t = right now" (from which, as already mentioned, their pathways necessarily diverge). It is therefore safe to state that in this crucial yet generally overlooked sense, *all* modern engineering solutions, in which there are always linearized elements, are anti-Nature to some greater or lesser degree.

Black-box representations have been created for every technology (Figure 1.7). Such formulations keep "outsiders" ignorant of the linearization process that renders the greater part of all such solutions as spurious. However, of even greater interest in the context of the current discussion, it is probably crucial and the least remarked feature, that the model itself has nothing to do with knowledge. In a typically repetitive mode, the output (B) is modified by adjusting input (A). The input itself is modified by redirecting (B). This is the essence of the "feedback effect" that has become very popular in our day. Even in this mode, nonlinearity may arise as efforts are made to include a real object in the black box. This nonlinearity is expected. Even a man-made machine would generate chaotic behavior which becomes evident only if we have the

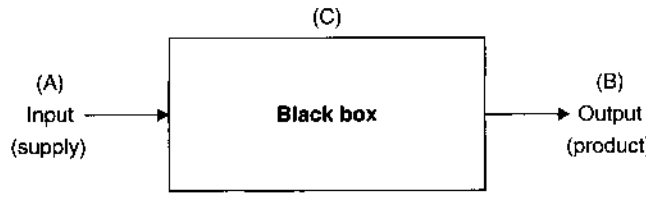

Figure 1.7 Classical "engineering" notions (redrawn from Islam, 2005a).

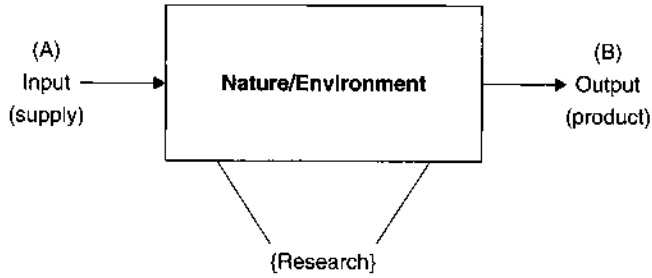

Figure 1.8 Research based on observing Nature intersects classical "engineering" notion (redrawn from Islam, 2005a).

means of detecting changes over the dominant frequency range of the operation.

What is needed are quantum improvements to our knowledge of this process. Before claiming to emulate nature, we must implement a process that allows us to observe nature (Figure 1.8). Research based on observing nature is the only way to avoid spurious solutions due to linearization or elimination of a certain dimension.

Sustainable development is characterized by certain criteria. The "time" criterion is the main factor in achieving sustainability in technological development. However, in the present definition of sustainability, a clear time direction is missing. To better understand sustainability, we can say that there is only one alternative to sustainability, viz., unsustainability. Unsustainability involves a time dimension, only very rarely implying any immediate existential threat. Existence is threatened only in the distant future, perhaps too far away to be properly recognized. Even if a threat is understood, it may not cause much concern in the present, but will work its effect cumulatively over a wider period of time, as depicted in Figure 1.9.

In Figure 1.9, the impact of the wider time scale is shown where 'A' and 'B' are two different development activities that are undertaken over a certain time period. According to the conventional environmental impact assessment (EIA) or sustainability assessment process, each project has insignificant impacts in the environment in the short time scale. However, their cumulative impacts will be much higher and will continue under a longer time scale. The cumulative impacts of these two activities (A, B) are shown as a dark line.

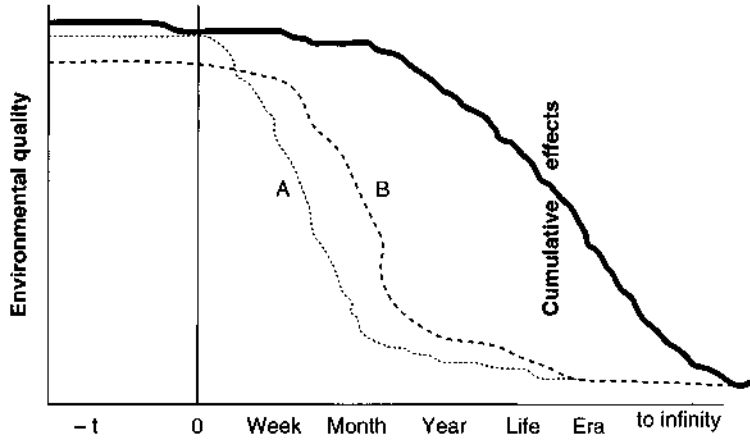

Figure 1.9 Cumulative effects of activities A and B within different temporal periods.

1.5 Development of a Sustainable Model

The sustainability model developed by Khan and Islam (2007a) provides the basis of the direction of sustainable technology. According to this model, a process is sustainable if and only if it travels a path that is beneficial for an infinite span of time. Otherwise, the process must diverge in a direction that is not beneficial in the long run. Pro-nature technology is the long-term solution. Anti-nature solutions are all that will come from schemas that comprehend, analyze, or plan to handle change on the basis of any approach in which time changes, i.e., Δt, are examined only as they approach 0 (zero).

Of course, in nature, time "stops" nowhere, and there is no such thing as a "steady state." Hence, regardless of the self-evident tangibility of the technologies themselves, the "reality" in which they are supposed to function usefully is itself non-existent, i.e. "aphenomenal,"and may neither be found within nor placed upon the graph (Figure 1.10). "Good" technology can be developed if, and only if, it travels a path that is beneficial for an infinite span of time. In Figure 1.10, this concept is incorporated in the notion of "time tending to infinity", which (among other things) also implies that time changes — instead of approaching zero — could instead approach infinity; i.e., $\Delta t \rightarrow \infty$. In this study, the term "perception" which was found important at the beginning of any process, was introduced. Perception varies from person to person: it is subjective. There is no way to prove if a perception is true or false. Its effect is immediate. Perception shapes the individual's personal

opinion, without necessarily incorporating any other appropriate or earlier acquired knowledge. That is where over-reliance on perception may mislead. If perception is used in the model developed in the previous figure, the model would now look like Figure 1.11.

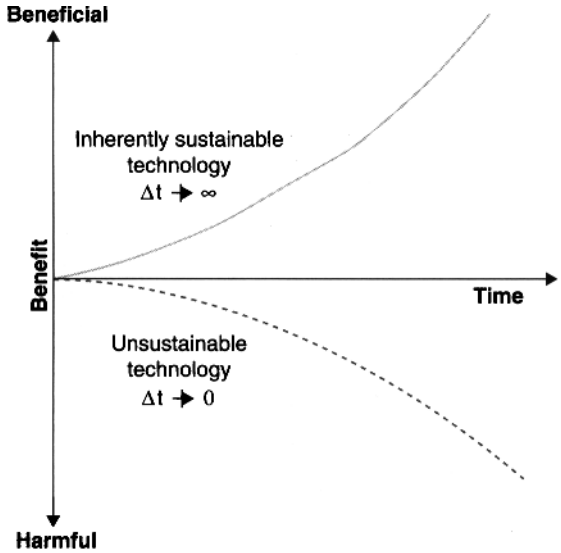

Figure 1.10 Direction of sustainability (Redrawn from Khan and Islam, 2007a).

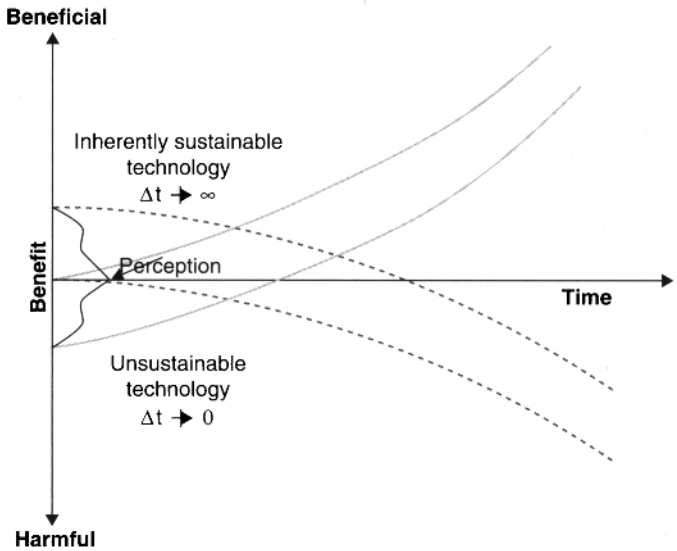

Figure 1.11 Direction of sustainability, incorporating perception (Modified from Khan and Islam, 2007a).

1.6 Violation of Characteristic Time

Another problem with current technology is its violation of natural characteristic time. A natural phenomenon's characteristic time is similar to the natural life cycle of living beings. Like the latter's cytologically-clocked "death," this time is not some precise constant, although it is possible to statistically average a value for this characteristic. For example, in industrialized societies today, most men may be expected to die in their late 70s and most women in their early 80s. However, just as human death by so-called misadventure (e.g., through murder, wars etc.) is heavily discounted by such an averaging procedure, characteristic time does not include any modification of life-cycle time due to non-natural, and especially, human intervention. Thus, the life span of an unconfined natural chicken can be up to 10 years, yet table fowl or broilers reach adult size and are slaughtered at six weeks of age (PAD, 2006). In effect, this human intervention has violated the characteristic lifespan for broiler chickens. The present study emphasizes characteristic time because of its pro-nature definition. Anything found in nature, grown and obtained naturally, has tangible and intangible elements in its contents. Consumption of anything produced either by internal genetic intervention or external application of chemical fertilizers and/or pesticides, on the other hand, cannot be assumed to provide the same source of both long-term and short-term benefits as poultry raised without such intervention. Indeed, very much like decisions not to feed cattle stock with natural untreated grasses, such violations of the chicken's natural characteristic growth time and cycle are consciously intended to give rise to greater short-term tangible benefits, e.g., production of more chicks per square unit area of hennery space. This results in a tradeoff against certain other intangible benefits which are actually often more important, such as ensuring the healthiest chicks possible.

Nature is directly observed and recorded in tangible aspects, detectable with current technologies. While this in itself is no mean feat, it must not be assumed to be the be-all and end-all. Much of what could only be taking place as a result of intangible, but very active orderliness within nature is promoted – according to this standard – as being "disorder". The greatest confusion is created when this misapprehension is then labeled "chaotic," and its energy balance is portrayed as headed towards "heat death", "entropy", or even possibly, the complete dissipation of any possibility of extracting "useful work".

Reality is different. In nature, there is no single entity that is linear, symmetrical or homogeneous. There is no process that is steady or even periodic. Natural processes are chaotic, but not in the sense of being either arbitrary or inherently tending towards entropy. Rather, they are chaotic in the sense that what is essentially orderly and characteristic only unfolds with the passage of time within the cycle or frequency that is characteristic of the given process at some particular point. **What the process looks like at that point is neither precisely predictable before that point nor necessarily amenable to being precisely reconstructed or reproduced after that point.** The path of such a process is defined as chaotic on the basis of its being aperiodic and non-linear; however, this does not mean that it is arbitrary or possibly not fitting the pattern of an order beyond our current means of detection and measurement. Indeed, for anything to occur within the natural environment on any basis, this would undoubtedly have to be the case.

Nature is chaotic in this way. The laws of motion developed by Newton cannot explain this chaotic motion of Nature, since key assumptions underlying these "laws" themselves contradict precisely this reality of Nature. The experimental validity of Newton's laws of motion is limited to describing or accounting for instantaneous macroscopic and tangible phenomena. However, microscopic and intangible phenomena are ignored. Classical dynamics, as represented by Newton's laws of motion, emphasize fixed and unique initial conditions, stability, and equilibrium of a body in motion (Ketata *et al.*, 2007). However, the fundamental assumption of constant mass alone is enough by itself to confound Newton's laws of motion. Ketata *et al.* formulated the following relation to describe the body in continuous motion in one space:

$$m = \frac{F}{\left((6t+2)+(3t^2+2t+1)^2\right)ce^u} \tag{1.3}$$

where F is the force on the body; $u = t^3 + t^2 + t + 1$ and c is a constant.

The above relationship demonstrates that the mass of a body in motion depends on time, regardless of whether F varies over time or not. This absolutely contradicts Newton's First Law of motion. Similarly, the acceleration of a body in motion is not proportional to the force acting on the body because mass is not constant. This contradicts Newton's Second Law.

Here it is found that time is the biggest issue which, in fact, determines the correctness (or incorrectness) of Newton's laws of motion. Considering only instantaneous time ($\Delta t \rightarrow 0$), Newton's laws of motion will be experimentally valid with some error. However, considering an infinite time span ($\Delta t \rightarrow \infty$), these "laws" cannot apply. That is why sustainable technologies which include short-term to long-term benefits cannot be explained by Newton's laws. To overcome this difficulty, it is necessary to break out of '$\Delta t \rightarrow 0$' in order to include intangibles. Here is where the essence of pro-Nature technology development is to be found.

In terms of the well-known laws of conservation of mass (m), energy (E) and momentum (p), the overall balance, B, within Nature may be defined as some function of all of them:

$$B = f(m,E,p) \tag{1.4}$$

The perfection without stasis that is Nature means that everything that remains in balance within it is constantly improving with time. That is:

$$\frac{dB}{dt} > 0. \tag{1.5}$$

If the proposed process incorporates all elements concerned such that each element is following this pathway, none of the remaining elements of the mass balance discussed later will present any difficulty. Because the final product is being considered as time extends to infinity, the positive ("> 0") direction is assured.

Pro-Nature technology, which is non-linear, increases its orderliness on a path that converges at infinity after providing maximum benefits over the intervening time. This is achievable only to the extent that such technologies employ processes as they actually operate within nature or use materials whose internal chemistry has been "refined" entirely within the natural environment and whose subsequent processing has added nothing else from nature in any manner other than its characteristic form. Any and every other technology is anti-nature. The worst among them are self-consciously linear, "increasing" order artificially by means of successive superpositions that supposedly take side-effects and negative consequences into account as they are detected. This often enables the delivery of maximum power, or efficiency, etc. for some extremely short term, without regard to coherence or overall sustainability.

This comes at the cost of manifold detrimental consequences, carrying on long after the "great advances" of the original anti-nature technology have dissipated. Further disinformation is spread by declarations about the resulting product being "affordable", "inexpensive", "necessary", and other self-serving and utterly false attributes while increasing only very short-term costs.

If long-term costs are included, any product that is anti-nature would turn out to be prohibitively costly. One case in point is the tobacco technology. A decade ago in the Canadian province of Nova Scotia, for example, whose general health statistics fall in the median range of Canada in which the death toll from cancers due to smoking, has remained steady for the past 15 years, some 1,300 individuals, already registered as patients within the hospital system were dying each year of cancer due to smoking (Islam, 2003). According to standard medical market valuations of human body parts, these deaths alone cost some $60 billion. This poses once again — albeit in a novel way — the question: Just how expensive should cigarettes be? As already demonstrated elsewhere in this book, the fact is that if intangibles are included in any economic analysis, a picture very different from what is conventionally portrayed will emerge.

Any linearized model may be limited or unlimited, depending on the characteristics of the process (Figure 1.12). The "limited linearized model" has two important characteristics: more tangible features than intangible, and a finite and therefore limited amount of disorder or imbalance. Because only linearized models are man-made, nature has time to react to the disorder created by this limited model. It may therefore be surmised that such models are unlikely to cause irreparable damage.

The unlimited linearized model is characterized by long-term effects little understood but far more damaging, with more intangible features than tangible ones, and an unlimited degree of disorder or imbalance. This disequilibrium penetrates and pervades territory far beyond the laboratory or the classroom. Contemporary policy-making processes, for example, enable broad-spectrum concealment of actual or potential imbalances from immediate view or detection, generating the following exemplary classic problem that arises with introducing new pharmaceuticals. Since a drug has to pass the test of not showing allergic reactions, many such drugs make it into the market after being "tweaked" to delay the onset of what are euphemistically called "contra-indications". An

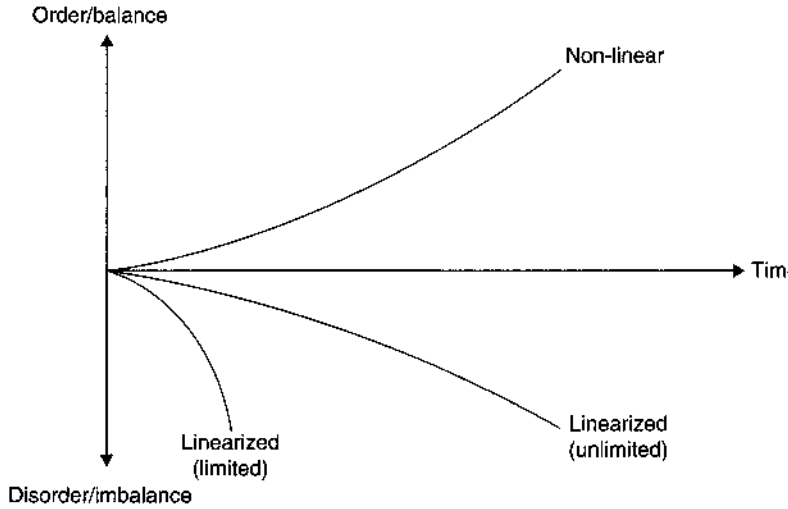

Figure 1.12 Pathway of nature and anti-nature (Modified from Khan and Islam, 2006).

elaborate and tremendously expensive process of clinical trials is unfolded to mask such "tweaking", mobilizing the most heavily invested shareholders of these giant companies to resist anything that would delay the opportunity to recoup their investment in the marketplace. The growing incidence of suicide among consumers of Prozac® and other SSRI-type anti-depressant drugs, and of heart-disease "complications" among consumers of "Cox-2" type drugs for relief from chronic pain, may represent evidence of the consequences of the unlimited linearized model and of how much more difficult any prevention of such consequences is (Miralai, 2006).

Here is a homelier example: if food is left outside, in two to three days, it will cause food poisoning, thereby provoking diarrhea. However, if food is placed in artificial refrigeration, the food will retain some appearance of "freshness" even after several weeks, although its quality will be much worse than the "rotten" food that was left outside. Another more exotic but non-industrial example can be seen in the reaction to snake venom. The initial reaction is immediate. If the victim survives, there is no long-term negative consequence. Used as a natural source or input to a naturally-based process, snake venom itself possesses numerous long-term benefits and is known for its role as an anti-depressant natural medication.

Repositioning cost-benefit analysis away from such short-term considerations as the cheapness of synthesized substitutes, etc., to

the more fundamental tangible/intangible criterion of long-term costs and benefits, the following summary emerges: tangible losses can be very limited, but intangible losses are not.

1.7 Analogies with Physical Phenomena

Mathematicians continue to struggle with the two entities, '0' (zero), and '∞' (infinity), whose full meanings and consequences continue to mystify (Ketata *et al.*, 2006a; 2006b). However, these two entities are most important when intangible issues are counted, as the following simple analogy from well-known physical phenomena (Figure 1.13) serves to demonstrate. As "size" — space occupied (surface area or volume) per unit mass — goes down, the quantity of such forms of matter goes up. This quantity approaches infinity as space occupied per unit mass heads towards zero. However, according to the Law of Conservation of Mass and Energy, mass can neither be created nor destroyed; it only can transform from one form to another form. This immanent contradiction was resolved in the early 20th century, when it was proven that as mass decreased, its quantity could increase (as particles of mass were converted into quanta of energy).

By "infinity", we usually actually intend some quantity too large to count exactly, but that enjoys practical existence. Conventionally,

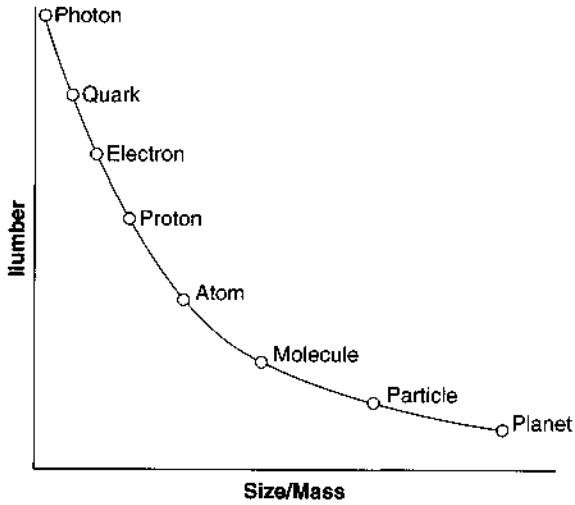

Figure 1.13 Relation of Size/Mass to number.

zero on the other hand denotes non-existence, posing another paradox that is nonetheless removable when the intangible aspect is considered. Something that is infinite in number is present everywhere but has no size. As Figure 1.13 shows, mass turns into the energy at the end, losing "size", a transition of the tangible into the intangible. This also signifies that the number of intangibles is much more than that of tangibles. We can measure the tangible properties but intangible properties, by definition, cannot submit to direct measurement. Yet, this constraint hardly justifies treating intangible properties as non-existent. Happiness, sorrow, etc., are all clearly intangible, and, however tangible their causes, possess no directly measurable properties themselves. As Figure 1.13 suggests, the scale of the intangible is potentially far more consequential than that of the tangible.

1.8 Intangible Cause to Tangible Consequence

Short-term intangible effects are difficult to understand, but consideration of the treatment procedures employed by homeopathic practitioners may serve to illuminate what is going on beneath the surface. One of the characteristic principles of homeopathy is that the potency of a remedy can be enhanced by dilution — an inconsistency with the known laws of chemistry (Tschulakow & Klimek, 2005). In some cases, the dilution is so high that it is extremely unlikely that one molecule of the original solution would be present in that dilution. As there is no detectable mechanism accounting for this, the effect of the molecule cannot always be understood. For this reason, in the realm of the modern science of tangibles, homeopathy remains controversial. However, the trace ingredient of dilution cannot always be ignored. Rey (2003) has studied the thermoluminescence of ultra-high dilution of lithium chloride and sodium chloride and found the emitted light specific to the original salts dissolved initially. The dilution was less than one part per Avogadro's Number (i.e., one atom in every 6.0×10^{23} atoms per mole), yet its effect was visible. In other words, when concentration of a substance descends below detection level, it cannot be ignored, as its effects remain present.

This is where greater care needs to be taken in addressing the harmful potential of chemicals in low concentrations. Lowering the concentration cannot escape the difficulty — a significant

consideration when it comes to managing toxicity. Relying on low concentration as any guarantee of safety defeats the purpose when the detection threshold used to regulate as to what is "safe" is itself higher than the lowest concentrations at which these toxins may be occurring or accumulating in the environment. Although the science that will identify the accumulation of effects from toxic concentrations before they reach the threshold of regulatory detection remains to be established, the point is already clear: tangible effects may proceed from causes that can remain intangible for some unknown period of time. In other words: for some unknown period, a tangible effect or symptom can seem to have an "unknown," i.e., intangible, cause. This places a large question mark over the soundness or completeness of the reasoning process that insists on determining a tangible cause for every recorded tangible effect irrespective of the passage (and/or ravages) of time.[2]

Cellphones are considered one of the defining inventions of modern life. So far, the alarms about using them have limited their sphere of concern to human brain damage arising from possible overexposure to non-natural electromagnetic frequencies. An official Finnish study found that people who used cellphones for more than 10 years were 40 per cent more likely to get a brain tumor on the same side as they held the handset (Lean and Shawcross, 2007). However, it has been observed that cellphone frequencies also cause serious problems for other living beings of the natural world that happen to be particularly important for maintaining the balance of the ecological system. "Colony collapse disorder" — the abrupt disappearance of the bees that pollinate crops — has been noticed especially in the United States as well as some European countries (Lean and Shawcross, 2007). One potentially plausible explanation of this disappearance, is that radiation from cellphones interferes with bees' navigation systems, preventing the famously home-loving species from finding their way back to their hives. Most of the

[2] Many reasoning processes rely to some degree or another on the Aristotelian logical principle known as the Law of the Excluded Middle. This law says that, at some point, every phenomenon 'A' may ultimately be isolated and/or distinguished from any and all other phenomena, which are classifiable as 'not-'A'. What is missing here is the reality of how time actually operates in Nature at all levels as a fourth dimension. Aristotle's injunction that everything is either 'A' or 'not-A' is true only at all points of two-dimensional or three-dimensional phenomenal reality. As discussed *supra* in the footnote to the Introduction's subsection on the "the basis of change and the conditions of change," this is deeply connected with the problem of humans' incapacity to experience time physically, perceptibly, as a 4th dimension.

world's crops depend on pollination by bees.[3] Massive food shortages have been anticipated due to the extinction of these bees due to radiation given off by mobile phones. Albert Einstein once said that if the bees disappeared, "man would have only four years of life left" (Lean and Shawcross, 2007). This exemplifies almost classically how a non-natural hi-tech instrument can pose a disastrous tangible effect in the longer-run due to causes or sources that were intangible in the moment of their actual environmental impact.[4]

1.9 Removable Discontinuities: Phases and Renewability of Materials

By introducing time spans of examination unrelated to anything characteristic of the phenomenon itself being observed in nature, discontinuities appear. These are entirely removable, but they appear to the observer as finite limits of the phenomenon itself. As a result, the possibility that these discontinuities are removable is not even considered. This is particularly problematic when it comes to the matter of phase transitions of matter and the renewability or nonrenewability of energy.

The transition between solid, liquid and gas in reality is continuous, but the analytical tools formulated in classical physics are anything but. Each P-V-T [= 'Pressure-Volume-Temperature'] model applies to only one phase and one composition, and there is no single P-V-T model applicable to all phases (Cismondi and Mollerup, 2005). Is this an accident? Microscopic and intangible features of phase transitions have not been taken into account, and as a result of thus limiting the field of analysis to macroscopic, entirely tangible features, modeling becomes limited to one phase and one composition at a time.

[3] In March 2012, CNN popularized the most current research that correlates the disappearance of bees in many rural areas to the cumulative environmental effects of herbicides and pesticides breaking down after application.

[4] Here we can glimpse some deeper elements of this problem: "intangible" does not necessarily mean unknowable or unpredictable. On the contrary, electromagnetic [EM] radiation — for example — is a familiar concept. So how could the necessary and appropriate attention to its potential impacts not have been paid during the development of the cellphone? It is widely accepted that tangibility implies perceptibility, and perception is assumed to be the basis of all knowledge. The buried falsehood is the implication that there is no knowledge without perception! EM radiation in the cellphone frequency band, while measurable, is not humanly perceptible.

When it comes to energy, everyone has learned that it comes in two forms: renewable and nonrenewable. If a natural process is being employed, however, everything must be "renewable" by definition in the sense that, according to the ""Law of Conservation of Energy, energy can be neither created nor destroyed. Only the selection of the timeframe misleads the observer into confounding what is accessible in that finite span with the idea that energy is therefore running out. This is hardly a minor verbal quibble. The dead plant material that becomes petroleum and gas trapped underground in a reservoir is being added to continually, but the rate at which it is extracted is set according to an intention that has nothing to do with the optimal timeframe in which the organic source material could be renewed. **Thus, "non-renewability" is no kind of absolute fact of nature. On the contrary: It amounts to a declaration that the pathway on which the natural source has been harnessed is anti-Nature.**

1.10 Rebalancing Mass and Energy

Mass and energy balance, inspected in depth, disclose intention as the most important parameter as the sole feature that renders the individual accountable to, and within, nature. This is rife with serious consequences for the black-box approach of conventional engineering because a key assumption of the black-box approach stands in stark and howling contradiction to one of the key corollaries of that most fundamental principle of all—the "Law of Conservation of Matter".

Conventionally, the mass balance equation is represented as "mass-in equals mass-out" (Figure 1.14). In fact, however, this is only possible if there is no leak anywhere and no mass can flow into the system from any other point – thereby rendering the entire analysis a function of tangible measurable quantities, a "science" of tangibles-only.

Figure 1.14 Conventional mass balance equation incorporating only tangibles.

The mass conservation theory indicates that the total mass is constant. It can be expressed as follows:

$$\sum_{0}^{\infty} m_i = \text{Constant} \tag{1.6}$$

where m = mass and i is the number from 0 to ∞.

In the true sense, this mass balance encompasses mass from the very macroscopic to the very microscopic and detectable to the very undetectable; i.e., from tangible to intangible. Therefore, the true statement should be as illustrated in Figure 1.15:

"Known mass-in" + "Unknown mass-in"
= "Known mass-out + "Unknown mass-out"
+ "Known accumulation" + "Unknown accumulation".

The unknowns can be considered intangible yet essential to include in the analysis as they incorporate long-term and other elements of the current timeframe.

In nature, the deepening and broadening of order is continually observed, with many pathways, circuits and parts of networks being partly or even completely repeated and the overall balance being further enhanced. Does this actually happen as arbitrarily as conventionally assumed? A little thought suggests this must take place principally as a result and/or in response to human activities and the response

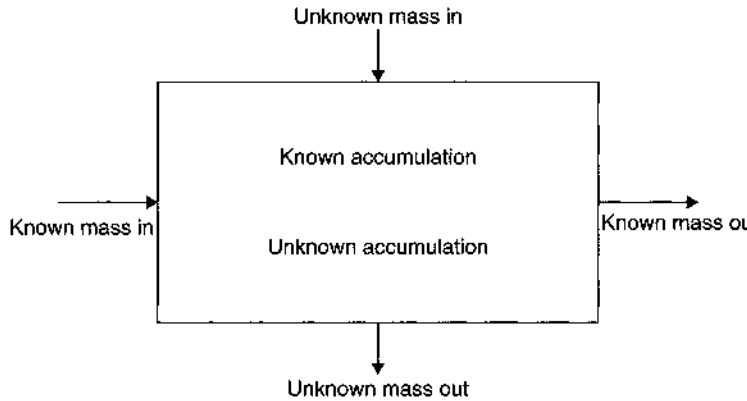

Figure 1.15 Mass-balance equation incorporating tangibles and intangibles.

of the environment to these activities and their consequences. Nature itself has long established its immediate and unbreachable dominion over every activity and process of everything else in its environment. There is no other species that can drive nature into such modes of response. In the absence of the human presence, nature would not be provoked into having to increase its order and balance, and everything would function in the "zero net waste" mode.

An important corollary of the "Law of Conservation of Mass", that mass can be neither created nor destroyed, is that there is no mass that can be considered in isolation from the rest of the universe. Yet, the black-box model clearly requires just such an impossibility. Since, however, human ingenuity can select the timeframe in which such a falsified "reality" will be exactly what the observer perceives, the model of the black box can be substituted for reality and the messy business of having to take intangibles into account no longer arises.

1.11 Holes in the Current Energy Model

There are a number of theories developed in the past centuries to define energy and its characteristics. However, none of the theories are enough to describe energy properly. All of the theories are based on idealized assumptions which never exist in practice. Consequently, the existing model of energy and its relation to others cannot be accepted with confidence. For instance, the second law of thermodynamics depends on the Carnot cycle from classical thermodynamics whereas none of the assumptions of Carnot's cycle exists in reality. The definition of an "ideal gas," of reversible processes and adiabatic processes used in describing Carnot's cycle are all imaginary. In 1905, Einstein came up with his famous equation, $E = mc^2$ which states an equivalence between energy (E) and relativistic mass (m), in direct proportion to the square of the speed of light in a vacuum (c^2). However, the assumptions of constant mass and the concept of a vacuum do not exist in reality. Moreover, this theory was developed on the basis of Planck's Constant which was derived from black body radiation. A perfectly black body is not available in reality. Repeatedly, it is found that the development of every theory depends on a series of assumptions that do not, and indeed cannot, exist alongside the reality of mass-energy-momentum conservation.

1.11.1 Supplementing the Mass Balance Equation

For whatever else remains unaccounted for, the mass balance equation, which in its conventional form necessarily falls short of explaining the functionality of nature coherently as a closed system, is supplemented by the energy balance equation.

For any time, the energy balance equation can be written as:

$$\int_0^\infty \sum a_i = \text{Constant, } i \text{ going from 1 to infinity} \qquad (1.7)$$

where "a" is the activity equivalent to potential energy.

In the above equation, only potential energy is taken into account. Total potential energy, however, must include all forms of activity, and here once again a large number of intangible forms of activity, e.g., the activity of molecular and smaller forms of matter, cannot be "seen" and accounted for in this energy balance. The presence of human activity introduces the possibility of other potentials that continually upset the energy balance in nature. There is overall balance, but some energy forms, e.g., electricity (either from combustion or nuclear sources), which would not exist as a source of useful work except for human intervention, continually threaten to push this into a state of imbalance.

In the definition of activity, both time and space are included. The long-term is defined by time being taken to infinity. The "zero waste" condition is represented by space going to infinity. There is an intention behind each action and each action playing an important role in creating overall mass and energy balance.

The role of intention; i.e., direction, is not to create a basis for prosecution or enforcement of certain regulations. It is rather to provide the individual with a guideline. If the product or the process is not making things better with time, it is fighting nature – a fight that cannot be won and is therefore not sustainable. Intention is a quick test that will eliminate the rigorous process of testing feasibility, long-term impact, etc. Only with "good" intention can things can improve over time. After that, other calculations can be made to see how fast the improvements will take place.

In clarifying the intangibility of an action or a process (with reference to the curve of Figure 1.13), the equation has some constant which is actually an infinite series:

$$a = \sum_0^{\infty} a_i = a_0 + a_1 + a_2 + a_3 + \ldots\ldots \tag{1.8}$$

If each term of Eq. 1.8 converges, it will have a positive sign, indicating intangibility. Hence, the effect of each term becomes important for measuring the intangibility overall. On this path, it should also become possible to analyze the effect of any one action and its implications for sustainability overall as well.

It may be inferred that man-made activities are not enough to change the overall course of nature. Failure up to now, however, to include an accounting for the intangible sources of mass and energy has brought about a state of affairs in which, depending on the intention; i.e., direction, attached to such intervention, the mass-energy balance can either be restored and maintained over the long-term, or increasingly threatened and compromised in the short-term.[5]

The main obstacle to discussing and positioning the matter of human intentions within the overall approach to the Laws of Conservation of Mass, Energy and Momentum, stems from notions of the so-called "heat death" of the universe predicted in the 19th century by Lord Kelvin and enshrined in his Second Law of Thermodynamics. In fact, however, this idea that the natural order must "run down" due to entropy eliminating all sources of "useful work," naively attempts to assign what amounts to a permanent and decisive role for negative intentions in particular without formally fixing or defining any role whatsoever for human intentions in general. Whether they arise out of the black box approach of the mass-balance equation or the unaccounted missing potential energy sources in the energy balance equation, failures in the short-term become especially highly consequential when they are used by those defending the status quo to justify anti-Nature "responses".

[5] Would it not be far better to develop the habit of investigating Nature and the prospects and possibilities it offers Humanity's present and future by considering time t at all scales, going to infinity? No doubt: the habit of resorting to time scales that appear to serve some immediate ulterior interest in the short-term, but have nothing to do in fact with the natural phenomena of interest, is fine for bean-counters and fast-buck artists. Such an approach would doom science and engineering, on the other hand, to reproducing something that will be anti-Nature in the long-term and the short-term.

1.12 Tools Needed for Sustainable Petroleum Operations

Sustainability can be assessed only if technology emulates nature. In nature, all functions or techniques are inherently sustainable, efficient and operational for an unlimited time period. In other words, as far as natural processes are concerned, "time tends to infinity". This can be expressed as:

$$\partial t \text{ (or, for that matter, } \Delta t) \rightarrow \infty \tag{1.9}$$

By following the same path as the functions inherent in nature, an inherently sustainable technology can be developed (Khan [M.I.] and Islam, 2005b). With regard to the sustainability and virtually infinite durability of natural functions, the "time criterion" is a defining factor. Figure 1.16 shows the direction of nature-based, inherently sustainable technology, as contrasted with an unsustainable technology. The path of sustainable technology is its long-term

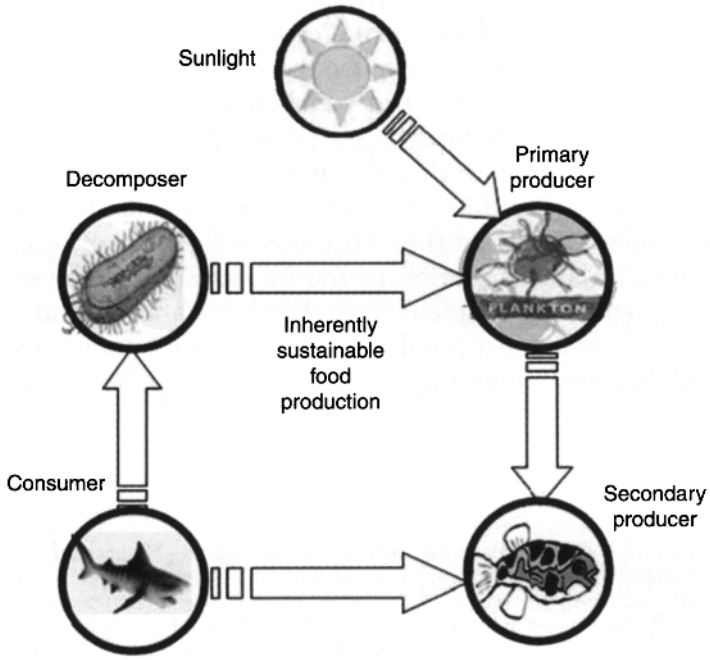

Figure 1.16 Inherently sustainable natural food production cycle.

durability and environmentally wholesome impact, while unsustainable technology is marked by Δt approaching 0. Presently, the most commonly used theme in technology development is to select technologies that are good for t = "right now" or $\Delta t \rightarrow 0$. In reality, if we seek sustainability for economic, social and environmental purposes, such models are devoid of any real basis and should not be applied in technology development.

Considering "pure time," so to speak, (or time tending to infinity) in terms of sustainable technology development raises thorny ethical questions. This "time tested" technology will be good for Nature and good for human beings. The main principle of this technology will be to work towards, rather than against, natural processes. It would not work against nature or ecological functions. (In this long-term sense, all natural ecological functions are truly sustainable.) We can take a simple example of an ecosystem technology (natural ecological function) to understand how it is time-tested (Figure 1.16).

In nature, all plants produce glucose (organic energy) by utilizing sunlight, CO_2 and soil nutrients. This organic energy is then transferred to the next higher level of organisms which are small animals (zooplankton). The next higher (tropical) level organism (high-level predators) utilize that energy. After the death of all organisms, their body masses decompose into soil nutrients which again help plants to keep the organic energy loop alive (Figure 1.16). This natural production process never falls into dysfunction, remaining viable for an infinite time. It can be defined as a time-tested technique.

This time-tested concept can equally apply in technology development. New technology should be functional for an infinite time. This is the only way it can achieve true sustainability (Figure 1.17). The triangular sign of sustainability in Figure 1.17 is considered as the most stable sign. In this, a triangle is formed by different criteria which represent a stable sustainability in technology development. This is the idea that informs the new assessment framework that is developed in Figure 1.18. Any new technology could be evaluated and assessed by using this model. There are two selection levels: One is primary and the other secondary. A technology must fulfill primary selection criteria before being taken to the next level of selection. The primary selection criterion is "time".

For a simulation test, we imagine that a new technology is developed to produce a product named "Ever-Rigid". This

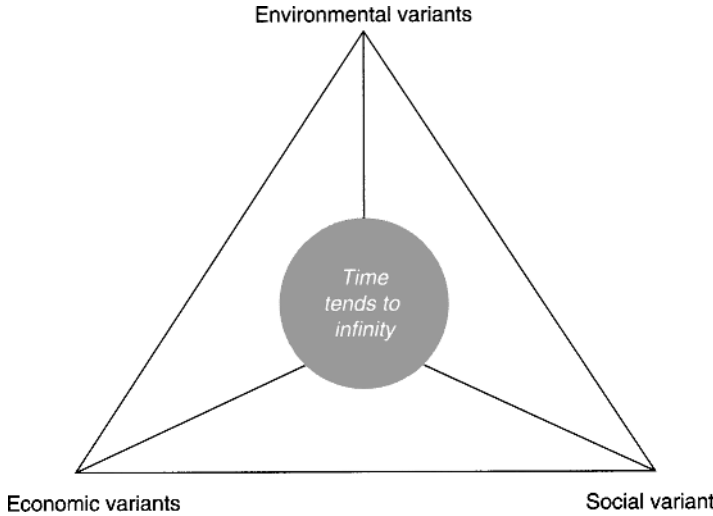

Figure 1.17 Pictorial view of the major elements of sustainability in technology development.

product is non-corrosive, non-destructive and highly durable. The "Ever-Rigid" technology can be tested using the proposed model to determine whether it is truly sustainable or not. The prime first step of the model is to find out if "Ever-Rigid" technology is "time-tested." If the technology is not durable over an infinite time, it is rejected as an unsustainable technology and would not be considered for follow-up testing. For, according to the model, time is the prime criterion for the selection of any technology.

If the "Ever-Rigid" technology is acceptable with respect to this time criterion, then it may be taken through the next sorting process to be assessed according to a set of secondary criteria. The initial set of secondary criteria analyzes environmental variants. If it passes this stage, it goes to the next step. If this technology is not acceptable with respect to environmental factors, then it might be rejected, or further improvements might be suggested to its redesign. After environmental evaluation, the next steps involve technological, economic and societal variants analyses, each of which follows a pathway similar to that used to assess environmental suitability. At these stages also, either it will ask for improvements to be made to the technology, or it might be rejected as unsustainable.

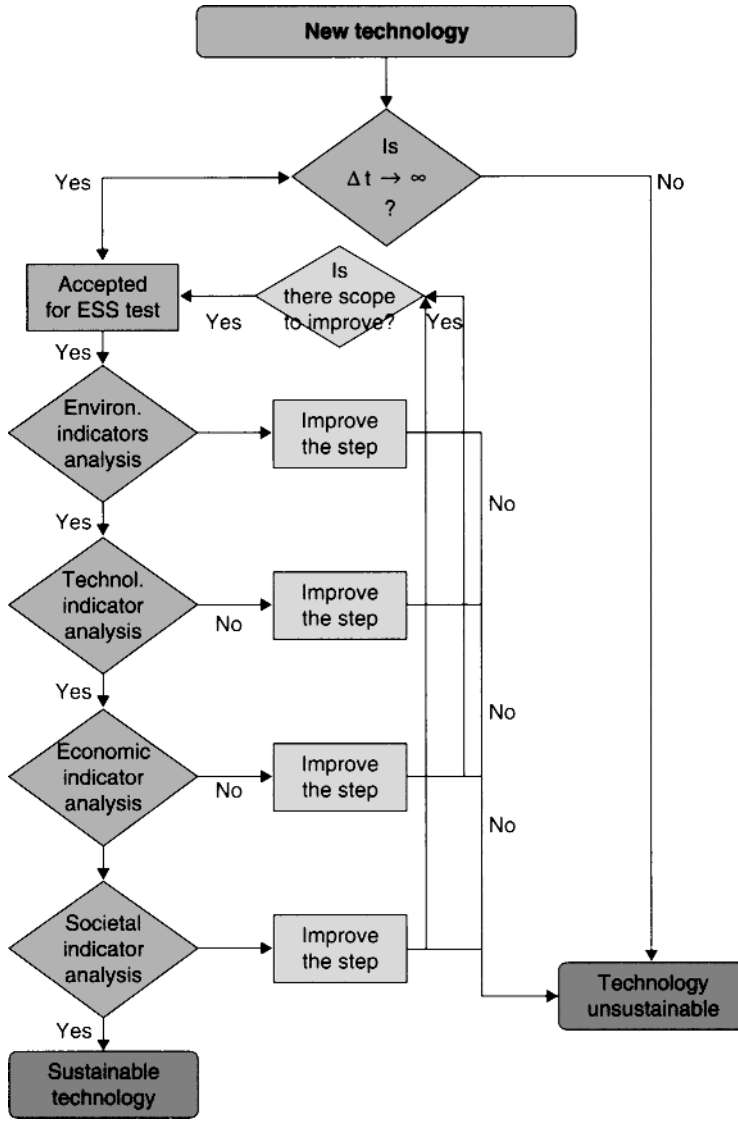

Figure 1.18 Proposed sustainable technology flowchart (modified Khan and Islam, 2005a).

1.13 Conditions of Sustainability

In order to consider a technology for use in petroleum operations, a method that is inherently sustainable is needed for purposes of conducting evaluation. This evaluation method should be based on the principle of true sustainability as defined and flowcharted in

Figure 1.18 above. Based on this newly developed method, a practical tool is proposed. For the sake of sustainability, in this evaluation process, the totality of critical natural resources should be conserved throughout. As well, the amount of waste produced in the process of using the technology should fall within the assimilative capacity of a likely-to-be-affected ecosystem. This entails ascertaining an intra- and inter-generational ownership equity of natural resources on which the technology depends (Daly, 1999; Costanza *et al.*, 1997). Daly (1999) points out that all inputs to an economic process, such as the use of energy, water, air, etc., come from natural ecology and all the wastes of the economic process are sunk back into it. In other words, energy from the ecological system is used as throughput in the economic process, and emissions from the processes are given back to the larger overall ecology. In this sense, an economic system is a subsystem of the ecology and, therefore, the total natural capital should be constant or increasing. Man-made capital and environmental capital are complementary, but are also substitutable or interchangeable. As such, any energy system should be considered sustainable only if it is socially responsible, economically attractive and environmentally healthy (Islam, 2005c).

To be considered sustainable, a petroleum operations system should fulfill certain basic criteria with respect to environment, social, economic and technological aspects of society (Pokharel *et al.*, 2003 and 2006; Khan [M.I.] and Islam, 2005b and 2005c; Khan [M.M.] *et al.*, 2005c; Khan [M.I.], 2006). In the present work, the following criteria are taken into consideration:

$$C_N + C_E + C_S \geq K_\infty \tag{1.10}$$

or (translated into words): "natural (environment) capital (C_N) plus economic capital (C_E) plus social Capital (C_S) is greater than or equal to some positive constant (K_∞) for all time horizons." In addition, $(C_N + C_E + C_S)_t \geq$ constant for any time t, provided only that

$$\frac{d}{dt}Cn_t \geq 0, \frac{d}{dt}Ce_t \geq 0, \text{percent}\frac{d}{dt}Cs_t \geq 0$$

1.14 Sustainability Indicators

Indicators can be used to measure the state, or degree, of sustainability of petroleum operations. A sustainable operation is envisioned

as something that plays some managing role, with respect to time, in the interaction between the natural environment and social and economic progress. However, at the moment, there is no suitable or widely-agreed method or system for measuring the sustainability of petroleum operations. Experts continue to wrestle with the practical problem of how to measure it. The *Centro d'Estudi D'Informaci Ambiental* (CEIA, 2001) stated that "the move towards sustainability would entail minimizing the use of energy and resources by maximizing the use of information and knowledge". In effect, in order to develop sustainable technology and manage natural resources in a sustainable manner, policy makers need to improve the application of knowledge gained from information. However, there remains generally a large gap between the provision of data and the application of knowledge gleaned from the data.

Sustainability indicators represent one method of providing information in a format that policy and decision makers can use. An *indicator* may be defined as a parameter that provides information about an environmental issue with a significance extending beyond the parameter itself (OECD, 1993 and 1998). Indicators have been used for many years by social scientists and economists to explain economic trends; a typical example is the Gross National Product (GNP). NGOs, government agencies and other organizations are also using indicators for addressing sustainable development. Among these are: the World Resources Institute; the World Conservation Union-IUCN; United Nations Environmental Program; the UN Commission on Sustainable Development; European Environmental Agency; the International Institute of Sustainable Development (IISD); and the World Bank (IChemE, 2002).

Indicators for addressing sustainable development are widely accepted by development agencies at national and international levels. For example, Agenda 21 (Chapter 40) states that "indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to the self-regulating sustainability of integrating environmental and development systems." (WCED, 1987). This development has encouraged acceptance of sustainability indicators as a basic tool for facilitating public choices and supporting policy implementation (Dewulf and Langenhove, 2004; Adrianto *et al.*, 2005). The selection of a suitable indicator is crucial for generating information needed on relevant issues; for identifying problems with and perspectives

on development potential; for providing analysis and interpreting possible roles of potential conflicts and available synergies; and for assisting implementation of policies (including assessment of impacts).

With regard specifically to technology development and oil and gas operations, Khan and Islam (2005a and 2006) have developed sets of indicators, including indicators for the environmental, societal, policy, community and technological variants illustrated Figures 1.19(a–d). Analyzing these sets of indicators, they have also been able to evaluate the sustainability of offshore operations and technologies associated with such activity.

1.15 Assessing the Overall Performance of a Process

To break out of the confines of conventional modes of analysis introduced through the science of tangibles, some salient features of the time domain must be made conscious. The aim here is to

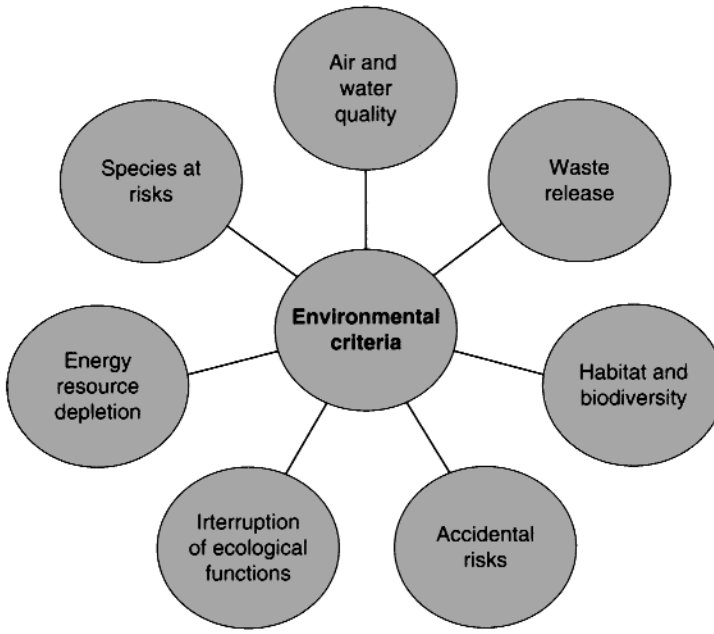

Figure 1.19(a) Environmental criteria for sustainable development.

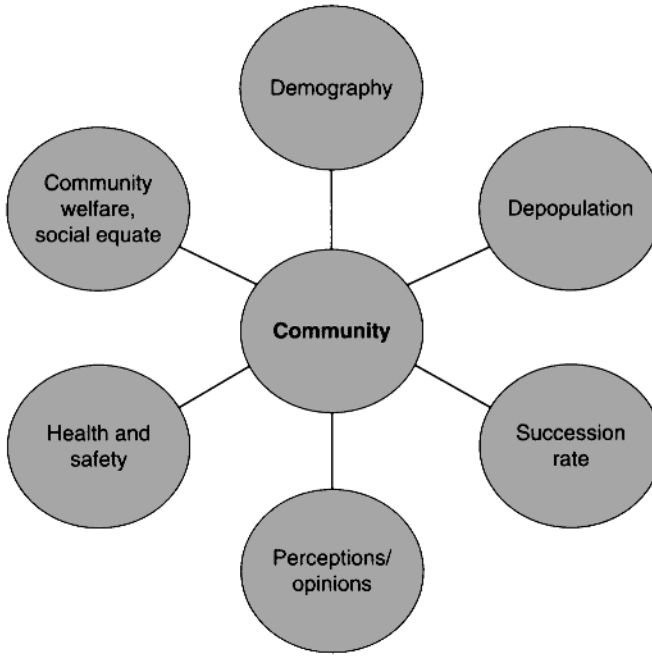

Figure 1.19(b) Community criteria for sustainable development.

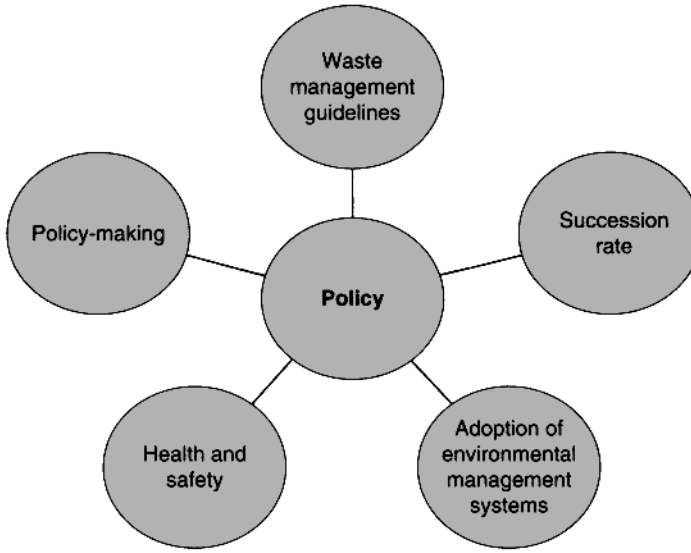

Figure 1.19(c) Policy criteria for sustainable development.

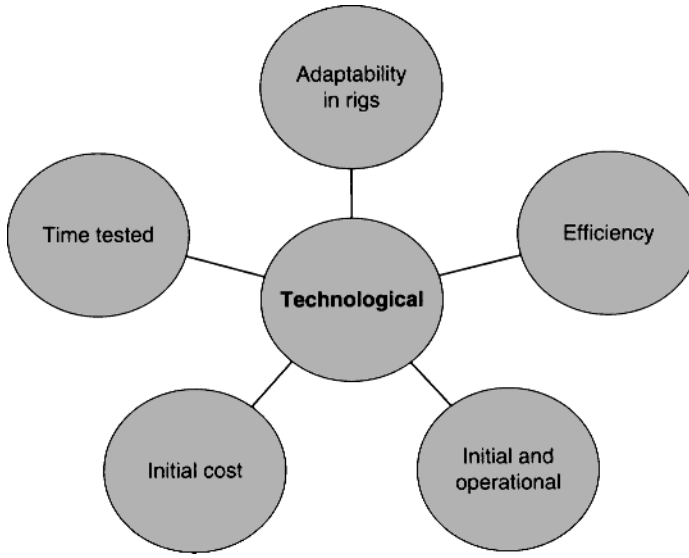

Figure 1.19(d) Technological criteria for sustainable development.

assess overall performance of a process using time t as a true 4th dimension. Here time t is not orthogonal to the other three spatial dimensions. However, it is no less a dimension for not being mutually orthogonal. Socially available knowledge is also not orthogonal either with respect to time t, or with respect to the other three spatial dimensions.[6]

Between input and output, component phenomena can be treated as lumped parameters.[7] This is not such an alien or fanciful idea. In the economic theory of commodity transactions, for example, relations of exchange in the market lump all "supply" with the seller and all "demand" with the buyer — even though, in reality, there is also a serious question of a "demand" (need for money) on the part of the seller and a certain "supply" (of cash) in the hands of the buyer.

[6] Despite the training of engineers and scientists in higher mathematics that hints, suggests, or implies that dimensionality must be tied up "somehow" with the presence of orthogonality, orthogonality is not in itself a relationship built into dimensionality. It applies only to the arrangements we have invented for rendering two or three spatial dimensions simultaneously visible; i.e., tangible.

[7] The following illustrates the idea of a "lumped-parameter." just as, for example, in electric circuit theory, resistance/reactance is lumped in a single resistor; capacitance in a single capacitor; and inductance in a single inductor. Electromotive potential/force and current of the entire circuit are also lumped at a power supply or at special gated junction points (such as between the base and emitter of a transistor), etc.

At the same time, because of its focus on the tangible to the exclusion of the intangible, the lumped-parameter approach is neither silver bullet nor panacæa. In Nature, or even within certain highly-engineered phenomena, such as an electric circuit in which human engineering has supplied all the ambient conditions (source of electrical energy, circuit transmission lines, etc.), even after assuming certain simplifying conditions like a near-zero frequency and virtually direct current flow and very small potential differences, we still have no idea whether the current is continuous or how continuous. Nor do we have any idea how stable or uniform the voltage difference is at any point in the circuit. The lumped-parameter approach enables us to characterize the overall result/difference/change at output compared to the input without worrying about the details of what actually happened between the input and the output. At the same time, when natural processes are being considered, such an approach still leaves a great deal unexplained and unaccounted for. Nor does the lumped-parameter approach ensure that gross errors will be avoided. So long as the computed result matches the difference measured between the input and the output, this approach opens the door to imposing any interpretation to account for what happened.

Closely related to the technique of characterizing the operation of a process by means of lumped parameters is the technique of assessing or describing overall performance of the process under study (or development), according to objective, external, uniform "standards" or norms. In the MKS system of SI units, for example, the meter is standardized as a unit of distance according to the length of some rod of a special element maintained in a vacuum bell at a certain temperature and pressure in some location in Paris, France. Similarly the National Institute of Standards and Technology (NIST) in Washington DC standardizes the duration of the "second" as the fundamental unit of time according to an atomic clock.

The problem with such standards is that the question of the standard's applicability for measuring something about the process-of-interest is usually not asked beforehand. Consider the known, and very considerable, physical difference between the extremely high-frequency [tiny-wavelength] EM waves on the one hand, and much lower-frequency [much-greater wavelength] audible sound waves on the other hand, propagate. The meter may be quite reasonable for the latter case. Does it follow, however, that the nanometer

(based on subdividing the meter into one billion units) is equally reasonable for the former case? The physical reality is that the standard meter bar in Paris actually varies in length by a certain number of picometres or nanometres just within an earth year. If the process-of-interest is EM radiation traversing light years through space, however, variation of the standard metre by 1 nanometre or even 1000 picometres will make nonsense of whatever measure we assign to something happening in the physical universe at this scale.

What the objectivity, externality and uniformity of standards enables is a comparison based on what the human observer can directly see, hear, smell, touch or taste — or, more indirectly, measure, according to standards that can be tangibly grasped within ordinary human understanding. Once again this begs the question, however, of whether science is reducible to that which may be tangibly grasped within ordinary human understanding. If science were so reducible, we could, and should, have spent the last 350-plus years since Galileo fine-tuning our measurements of the speed of bodies falling freely towards the earth. This feature might then be catalogued for different classes of objects, according to Aristotle's principle. While seemingly quite reasonable and perfectly tangible, Aristotle's principle was that the speed with which objects fall freely towards the earth is a function of their mass. This view is utterly erroneous, but the Spanish Inquisition was prepared to burn at the stake anyone who challenged its scientific authority.[8]

This example hints at the solution to a major conundrum. Once the principle of gravity as a force — something that cannot be directly seen, heard, smelt, touched or tasted — acting everywhere on earth was grasped, measuring and comparing the free fall of objects according to their mass had to be given up because it was the attraction due to gravity that was the relevant common and decisive feature characteristic to all of these freely-falling objects — not their individual masses. So, standards of measurement applied to phenomena and processes in Nature should cognize features that are characteristic to those phenomena and processes, not externally applied regardless of their appropriateness or inappropriateness.

[8] Galileo's experimental program demonstrated neither the existence of gravitational force nor its magnitude or direction, at least not directly. (By other methods, it was Isaac Newton who, two generations after Galileo, would assert and demonstrate the existence of the force of gravity.) What Galileo's experiments decisively refuted was the idea since Aristotle that the rate at which a body of any magnitude would fall freely to earth was in any way, or to any degree, a function of its mass.

Instead of measuring the overall performance of a process or phenomenon under study or development according to criteria that are characteristic, however, statistical norms are frequently applied. These compare and benchmark performance relative to some standard that is held to be both absolute and external. Public concern about such standards — such as what constitutes a "safe level of background radiation" — has grown in recent years to the point where the very basis of what constitutes a standard has come into question. Zatzman (2008) countered the conventional approach with the idea of using units or standards that exist naturally, that are "phenomenal" as opposed to aphenomenal. For those who want a science of nature that can account for phenomena as they actually occur or appear in nature, standards whose constancy can only be assured outside the natural environment — under highly controlled laboratory conditions, such as "in a vacuum" — are in fact entirely arbitrary. Phenomenally-based standards, on the other hand, are natural in yet a deeper sense: they include the notion of characteristic features that may be cognized by the human observer. These are standards whose objectivity derives from the degree to which they are in conformity with nature. The objectivity of a natural standard cannot and must not be confounded with the vaunted neutrality of position of some external arbiter.

For all the work on intangibles (the mathematics of, the science of, etc.), one must establish:

1. Actual, true source.
2. Actual, true science, pathway.
3. Actual, true end-point, or completion.

Knowledge can be advanced even if the "true object" is not the entire truth. In fact, it is important to recognize that the whole truth cannot be achieved. However, this should not be used as an excuse to eliminate any variable that might have some role, but whose immediate impact is not "measurable". All of these potential variables that might have a role should be listed right at the beginning of the scientific investigation. During the solution phase, this list should be discussed in order to make room for possibilities where at some point one of the variables will play a greater role. This process is equivalent to developing the model that has no aphenomenal assumption attached to it. There is a significant difference between that which tangibly exists for the five senses in some finite portion

of time and space, and that which exists in Nature independently of our perceptual functioning in some finite portion of time and space. Our limitation is that we are not able to observe or measure beyond that which is tangible. However, the models that we are comparing, should not suffer from these shortcomings.

If we grasp the latter first, then the former can be located as a subset. However, errors will occur if we proceed from the opposite direction, according to the assumption that what may be perceived about a process or phenomenon in a given finite portion of time and space contains everything typical and/or characteristic of the natural environment surrounding and sustaining the process or phenomenon as observed in some given finite portion of time and space.

Proceeding according to this latter pattern, for example, mediaeval medical texts portrayed the human fetus as a "homunculus", a miniaturized version of the adult person.

Proceeding according to the former pattern, on the other hand, if we take phase [or "angle"] x as a complex variable, de Moivre's Theorem can be used to readily generate expressions for $\cos nx$ and $\sin nx$, whereas (by comparison) if we struggle with constructions of right triangles in the two-dimensional plane, it is a computationally intensive task just to derive $\cos 2x$ and $\sin 2x$, and orders of magnitude more difficult to extend the procedure to derive $\cos nx$ and $\sin nx$.

In technology development, it is important to take a holistic approach. The only criterion that one can use is the reality criterion. A reality is something whose features, while it exists, do not change with time going to infinity. This is the criterion that Khan (2007) used to define sustainability. If the ranking of a number of options is performed based on this criterion that would be equivalent to the real (phenomenal) ranking. This ranking is absolute and must be the basis for comparison of various options. This ranking is given in the left most column of Table 1.4. In technology development, this natural (real) ranking is practically never used. Based on other ranking criteria, most of the ranking is reversed, meaning the natural order is turned upside down. However, there are some criteria that would produce the same ranking as the nature-based criteria, but that does not mean that the criterion is legitimate. For instance, the heating value for honey may be the highest. However, this does not mean the process is correct because, on this particular point, it only reaffirms something we knew all along.

Table 1.4 Synthesized and natural pathways of organic compounds as energy sources, ranked and compared according to selected criteria.

Natural (real) Ranking ("top" rank Means Most Acceptable)	Aphenomenality Ranking by Various Criteria			
	Bio-degradability	Efficiency[a] e.g., η = [output ÷ input] x 100	Profit Margin	Heating Value (cal/g)[b]
1. Honey	2	4 "sweetness/g"	4	1
2. Sugar	3	3	3	2
3. Sacchharine	4	2	2	3
4. Aspartame	1	1	1	4
1. Organic wood	1 Reverses depending on applic'n, e.g., durability	4 Reverses if toxicity is considered	4 Reverses if organic wood treated with organic chemicals	4
2. Chemically-treated wood	2	3	3	3
3. Chemically grown, Chemically treated wood	3	2	2	2
4. Genetically-altered wood	4	1	1	1

(Continued)

Table 1.4 (Cont.) Synthesized and natural pathways of organic compounds as energy sources, ranked and compared according to selected criteria.

Natural (real) Ranking ("top" rank Means Most Acceptable)	**Bio-degradability**	**Efficiency[a], e.g., η = [output ÷ input] x 100**	**Profit Margin**	**Heating Value (cal/g)[b]**
1. Solar 2. Gas 3. Electrical 4. Electromagnetic 5. Nuclear	Not applicable	5 4 3 2 # # Efficiency cannot be calculated for direct solar	5 4 3 2 1	5 4 3 2 # # - Heating value cannot be calculated for direct solar
1. Clay or wood ash 2. Olive oil + wood ash 3. Veg oil + NaOH 4. Mineral oil + NaOH 5. Synthetic oil + NaOH 6. 100% synthetic (soap-free soap)	1 3 4 5 6 2 Anti-bacterial soap won't use olive oil; volume needed for cleaning unit area	6 5 4 3 2 1 Reverses if global is considered	6 5 4 3 2 1	4 6 5 3 2 # # 1 cannot be ranked

(Continued)

Table 1.4 (Cont.) Synthesized and natural pathways of organic compounds as energy sources, ranked and compared according to selected criteria.

1. Ammonia 2. Freon 3. Non-Freon synthetic	1 2 3	Unknown	3 2 1	Not applicable
1. Methanol 2. Glycol 3. Synthetic polymers (low dose)	1 2 3	1 For hydrate control 2 3	3 2 1	Not applicable
1. Sunlight 2. Vegetable oil light 3. Candle light 4. Gas light 5. Incandescent light 6. Fluorescent light	Not applicable	6 5 4 3 2 1	6 5 4 3 2 1	Not applicable

Notes:

[a] This efficiency is local efficiency that deals with an arbitrarily-set sample size.

[b] Calories/gm is simultaneously a negative indicator for 'weight watchers' interested in minimizing calories, and a positive indicator for energy drink makers interested in maximizing calories.

In engineering calculations, the most commonly used criterion is efficiency, which relates output to input. Ironically, an infinite efficiency would mean someone has produced something out of nothing – an absurd concept as an engineering creation. However, if nature does that, it operates at 100 percent efficiency. For instance, every photon coming out of the sun gets used. So, for a plant the efficiency is limited (less than 100 percent) because it is incapable of absorbing every photon with which it is coming into contact. (It will become 100 percent if every photon is accounted for.) This is why maximizing efficiency as a man-made engineering practice is not a legitimate objective. However, if the concept of efficiency is used in terms of overall performance, the definition of efficiency has to be changed. With this new definition (called "global efficiency" by M.I. Khan *et al.*, 2005d), the efficiency calculations will be significantly different from conventional efficiency that only considers a small object of practical interest. As an example, consider an air conditioner running outdoors. The air in front of the air conditioner is indeed chilled while air behind the device will be heated. If cooling efficiency calculations are performed on an air conditioner running outdoors, the conventional calculations would show finite efficiency, albeit not 100 percent, as determined by measuring temperature in front of the air conditioner and dividing the work by the work done to operate the air conditioner. Contrast this to the same efficiency calculation if all-round temperature is considered. The process will be proven to be utterly inefficient and it will become obvious that the operation is not a cooling process. Clearly, the cooling efficiency of a process that is actually heating is absurd. Consider now an air conditioner running with direct solar heating. An absorption cooling system means there are no moving parts and solar heat is being converted into cool air. Solar heat is not the result of an engineered process. What would then be the efficiency of this system and how would this cooling efficiency compare with the previous one? Three aspects emerge in the answer. First, global efficiency is the only one that can measure the true merits of a process. Second, the only efficiency that can be used to compare various technological options is global efficiency. Third, if one process involves natural options, it cannot be compared with a process that is totally "engineered". For instance, efficiency in the latter example (as output/input) is infinity, considering no engineered energy has been imparted on the air conditioner.

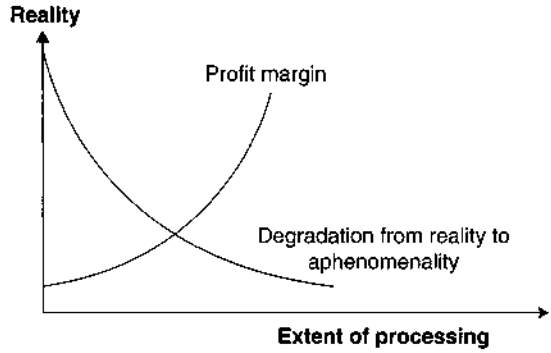

Figure 1.20 The profit margin increased radically with external processing.

No engineering design is complete until economic calculations are performed. Therein lies the need for maximizing profit margin. Indeed, since the dawn of the Industrial Revolution, profit margin has been the single most used criterion for developing a technology. As Table 1.4 indicates, natural rankings are reversed if the criterion of profit maximization is used — affirming, once again how modern economics turns pro-Nature technique upside down. This is the onset of the economics of tangibles, as illustrated in Figure 1.20. As processing advances, the quality of the product decreases. Yet, this process in its economic aspect, at least, is called value-*addition*. The price rises in inverse proportion to the change in real value (as opposed to *perceived* value promoted through advertisement). Here, the value is fabricated, similar to what is done in the aphenomenal model discussed in *Sustainable Energy Pricing*.[9] The fabricated value is made synonymous with real value or quality (as proclaimed by advertisements) without any further discussion of what constitutes quality, thereby further perverting the entire value-addition concept and falsifying the actual mechanisms of commodity economics. Inevitably, the "science" behind this disinformation is beginning to surface (Shapiro *et al.*, 2007).

[9] The mechanism of the following syllogism, discussed extensively in that work, illustrates one of the commonest forms in which the Aphenomenal Model expresses itself. Two false premises are combined to affirm a conclusion whose truth content may be confirmed independently, as in: "All Americans speak French; President Hollande is an American; therefore, President Hollande speaks French."