The Pursuit of Sustainable Energy Solutions and Systems[1]

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Abstract

This article concerns the application of a framework based on sustainable development that focuses on energy and the environment. It highlights how business enterprises, energy companies, and users can create sustainable solutions, develop innovative systems for achieving success, and enhance business value using energy efficiently and effectively. It indicates how leaders, professionals, and practitioners can realize growth and sustainable success by developing innovative solutions and more sophisticated systems that promote resource efficiency, enhance resource utilization, reduce resource depletion, and provide more beneficial outcomes. It highlights the challenges and opportunities to find more innovative ways to produce the required solutions for people across the world without depleting the key resources upon which the modern world depends. It proposes a framework that includes users as well as producers in developing innovations that improve efficiency, effectiveness, and outcomes.

Introduction

Energy is pivotal to the well-being of humankind and one of the most important underpinnings of modern industrial society. It impacts a significant portion of the global economy. It is a necessity for achieving sustainable lifestyles and for assuring economic stability. Energy is required for a myriad of applications, including heating and cooling, transportation, the generation of electricity, and the production of products. It is the quintessential ingredient in the development and deployment of a framework for the pursuit of sustainable solutions and systems.

For most of the twentieth century the quest for energy was relatively straightforward. Petroleum was the mainstay of the global energy landscape and the source of enormous wealth. Excepting the oil crises of the 1970s, petroleum was usually immediately available and affordable for an incredible number of users. Until the late twentieth century, products like gasoline, diesel, and kerosene were inexpensive, readily available, easy to use, and provided many benefits. Most importantly, producers and users alike usually focused on the positive attributes of such products.

As demand increased, when supply problems developed, the problem-solving approaches were generally based on finding more petroleum. Technological developments and favorable economics took precedent over social issues and environmental impacts. Billions of dollars were spent building offshore oil platforms and drilling for oil in the North Sea, Gulf of Mexico, and the Caspian Sea, as well as numerous other locations around the world. For the most part, the central question was how

[1] Rensselaer Polytechnic Institute Working Paper—June 18, 2013

to find more oil rather than how to more efficiently use the resources and how to create better systems.

Today, the focus is changing as people from all walks of life are thinking about the broader opportunities and challenges pertaining to energy. They understand that energy plays an essential role in their lifestyle, but they are beginning to realize that energy solutions should incorporate more social, political, economic, environmental, and technological considerations. The business environment of the early twenty-first century is far more complex than it was just two decades ago. The "economic elites" in the developed countries now have competition from a broader set of companies in the developing countries. Moreover, emerging companies in rapidly industrializing countries (RICs), such as China, India, and Brazil, are playing significant roles in producing goods and consuming resources and energy.

The prevalent view is that the business world is shrinking as technologies and innovative methods provide new ways to lower costs and make products and services more valuable and attractive for consumers. While there is no doubt that the geographic scale of the business world has shrunk, the number of existing and potential customers is growing. Homi Kharas and Geoffrey Gertz of the Wolfensohn Center for Development at Brookings estimate that the global middle class is expected to increase from 1.8 billion in 2009 to 3.25 billion in 2020.[1] This trend suggests more numbers and diversity of customers and therefore more opportunities for businesses. According to Kharas and Gertz:[2]

> Today, 1.8 billion people in the world are middle class, or 28 percent of the global population. About half of these people live in developed economies, with another fifth found in Brazil, Russia, India, and China – the so-called emerging BRIC economies. Less than 2 percent of the world's population is rich by our definition; a significant majority, 70 percent, is poor. Our scenario shows that over the coming twenty years the world evolves from being mostly poor to mostly middle class. 2022 marks the first year more people in the world are middle class than poor. By 2030, 5 billion people – nearly two thirds of global population – could be middle class.

While most of the attention to date has been on the more efficient use of labor to drive down costs, there are new challenges as well. With a more interconnected and fast-paced business world, strategic leaders must pay more attention to the availability and affordability of key resources, especially energy. Assuming that the middle-classes are the key drivers for the consumption of products and energy, the pressures on resources and energy are expected to increase dramatically over the next decade.

It is clear the people living in both developed and rapidly developing countries want to enjoy the benefits of higher levels of consumption, including more convenient goods and greater access to energy-consuming applications such as automobile and air travel. Although the rise of the middle class and the reduction of people living in poverty are good for the global economy, these population projections provide startling insights. Within a decade or two, the availability of resources and energy may need to increase significantly to keep pace with rising needs and expectations. The recent turmoil in crude oil pricing may be a harbinger of the challenges to come in many other commodities and raw materials.

Solutions, Systems, and Sustainable Development

A solution is a multifaceted concept that includes the product, the service, the systems, the underlying technologies, all of the required resources, the means and mechanisms, and the tangible and intangible aspects that accompany it.[3] It also includes all of the complementary products, services, and energy provided by companies in related industries. A solution includes everything that people need and want to satisfy them and make them successful. People want high quality, affordability, longevity, reliability, ease of use, and carefree ownership. While solutions include products and services, simple product and service offerings are typically incomplete solutions. For instance, an automobile without fuel is just about worthless.

A critical factor for achieving success of a solution is the design of the supporting system. The system integrates supply networks, stakeholders, providers of complementary products, the infrastructure, and energy providers. That is, sustainable success is derived from optimizing the whole, not the pieces. It is the insights and creativity that address the interrelationships of technologies, products, processes, systems, and business models that assure success.

Sustainable solutions and systems require a mindset shift from exploring "what is" to "what could be." It is normative because the focus is on what ought to be. Solving human-related problems and eliminating environmental burdens and impacts are some of the most critical factors that can significantly contribute to sustainable success. Astute leaders, professionals, and practitioners provide solutions through integrated systems and structures. They build enduring relationships with customers and stakeholders, improve the well-being of people, lower the inherent risks of providing solutions, and increase confidence that the strategic direction and operations are performing as well as possible. In doing so, they enhance shareholder wealth and their own positions in the business environment.

Sustainable development is a holistic construct that focuses on developing and deploying solutions and systems that exceed the needs and expectations of humankind and at the same time protects the natural environment. It involves ensuring that future generations can continue to enjoy the benefits of social and economic well-being in harmony with the natural world. Sustainable development originated via the 1987 Brundtland Report, titled *Our Common Future*, which was prepared by The World Commission of Environment and Development for the General Assembly of the United Nations.[4] In the language of *Our Common Future*, sustainable development refers to the notion "that it [humanity] meets the needs of the present without compromising the ability of future generations to meet their own needs."[5]

From a business perspective, sustainable development is a methodology that leaders, professionals, and practitioners would adopt because they believe that the organization would achieve significantly better performance. Moreover, they would tend to believe that the company's reputation would be enhanced, along with its ability to create and sustain business value. They would also believe that customers, stakeholders, employees, and shareholders will have more favorable perceptions of the company. However, the notion of sustainable development is often misunderstood. Moreover, business scholars have difficulties articulating the requirements necessary for achieving sustainable development. Finally, because sustainable development involves intangibles and preventing difficulties before they have been realized, there is no consensus of what measures can be used to validate a company's progress toward sustainable development.

The Framework for the Pursuit of Sustainable Energy Solutions and Systems

The *Pursuit of Sustainable Energy Solutions and Systems* (PSESS) is a holistic perspective for improving the positive side of value creation. The PSESS seeks to develop and deliver sustainable solutions that maximize benefits and positive outcomes, while minimizing adverse effects and negative impacts. This perspective also includes reducing or eliminating resource depletion, environmental degradation, social and economic disruptions, and environmental wastes. The main goals are to ensure that natural, human, and economic capital (and all of the related resources and energy solutions) are produced and/or used efficiently, effectively, and appropriately. From a sustainable development perspective, the objectives are to identify, define, specify, develop, and apply resources and energy in beneficial ways and to mitigate the negative impacts to the extent possible. The primary concerns are:[6]

- *Destruction and Damage*: Waste streams from products, production processes, and the applications can destroy the chemical, physical, and biological equilibrium of nature and have significant adverse local, regional, or global effects. It is often difficult to assess and mitigate the destruction of the natural environment and its potential to provide natural resources like trees and water in the future.
- *Degradation*: Pollution of the air, water, and land, and deposits of solid and hazardous wastes in the natural environment degrade the availability and quality of natural resources. Pollutant volume, concentration, and duration of releases are significant factors in determining the long-term viability of using many of the resources in current uses.
- *Depletion*: Resource availability plays an important role in the economics of products and production processes. As resources become scarce, they tend to become more costly and more difficult to acquire. As resources are used faster than they are replenished, the viability of the products and processes that depend upon them becomes questionable. The depletion of petroleum is one of the most critical social, economic, and environmental concerns.
- *Disruption*: Nature is complex, and therefore the introduction of an industrial activity, a manmade product or waste stream, or altering the ecosystem can have major consequences. For example, although hydroelectric power plants were once viewed as renewable sources of energy, the current assessment is not as positive given the negative effects on the waterways and the land downstream.
- *Defects and Burdens*: Defects lead to uncertainties, risks, and liabilities that result in compromised solutions that may not be reliable or sustainable. Burdens are the negative impacts caused by products and processes. All materials have the potential to be hazardous or toxic. However, there are certain materials, such as heavy metals and certain manmade organic compounds, which are inherently toxic and therefore impose burdens that should be mitigated.

Today, global corporations and small- and medium-size enterprises (SMEs) depend on external relationships to produce and deliver solutions, create value, and sustain success. The PSESS requires these organizations to integrate all of social and economic participants associated with its extended enterprise. It includes the corporation with all of its internal strategic business units and their internal and external value delivery systems (i.e., suppliers, alliances, partners, etc.). It also includes all of the relationships with customers, stakeholders, and the broader elements of

communities and society. The PSESS necessitates that all inputs, ideas, concepts, suggestions, and decisions are in concert with creating value and achieving sustainable success. This necessity is especially important for dealing with energy and developing more energy efficient solutions and systems.

The PSESS implies an implicit assumption that every member of a society impacts the social, economic, technological, environmental, and energy challenges. Thus, everyone has a shared responsibility to help find better approaches for meeting the needs and expectations of people without degrading the planet, the ecosystems, or the well-being of humankind, or depleting the available resources. As such, it requires a state in which all facets of the company are in harmony with the markets, the business environment, the social world, and the natural environment. In the PSESS, although it is proper and just to use resources and energy to satisfy needs of the present, it is unacceptable and unwise to overuse or waste resources and energy, or to create pollution and wastes that require future generations to clean up or suffer the negative consequences. As discussed earlier, these perspectives are sensible from an economic perspective and can lead to enhanced and sustainable competitive positioning.

Opportunities and Challenges

Given the legacies of the past, the realities of the present, and the desires for the future, the PSESS must include measurements of the critical elements of both lifestyles and enterprises. However, there are few, if any, generally agreed upon measures. Traditional measures generally focus on the economic aspects of production and consumption. More sophisticated measures must be more holistic and include elements related to solutions, systems, and sustainable development. Thus, the PSESS requires measurements that assess the viability of sustainable solutions, determine the efficiency, effectiveness, and appropriateness of human activities and business actions, and evaluate outcomes. The intent is to quantify opportunities and challenges in sufficient detail to ensure that positives are being encouraged and that the potential for future problems will be minimized. Table 1 presents opportunities and challenges that require careful consideration. It offers some suggestions pertaining to the specifications/criteria.[7]

Criteria	Implications	Comments/Concerns
	Material Resources	
Less is better	Using less mass in the product or the process means less resource depletion and usually less waste generated.	The product or process may be less robust and have a tendency to fail prematurely.
Higher yields that reduce inputs per outputs	The more efficient the process, the less mass and energy has to be consumed to obtain the product.	More efficient processes may cost more or be more complex. They may have higher failure rates.
Avoid toxic substances	Toxic materials create complexities and downstream impacts that take time and money to mitigate. There may be hidden defects that cause problems in the future.	All material and energy sources have the potential to have negative sides. The alternate may be more problematic than the original design or specification.
Reuse resources and materials	Reusing scrap and used products reduces the need for virgin materials and the effects of wastes and their disposal.	Reused material may require special cleaning and handling that are costly and add to waste streams and the complexities of the processes.
	Product Perspective	
Improve product viability	Product viability in the market is a function of customer preferences, perceptions, quality, technology, and economics. Enduring products save on design costs and resources.	The viability of a product in the market depends on competition, customers, the availability of support products, etc. Technology plays a key role in the life cycle.
Increase life span	Expanding the useful life of a product means that its replacement and all of the resources and negative impacts of its replacement can be reduced or avoided.	Products may be obsolete long before their useful life is exhausted. If the product outlasts its technological life, it may result in wastes anyway.
Develop easy-to-use products and processes	Because of the diversity of applications and users, products and processes have to be relatively easy to use. Simplicity of the applications is most crucial when there is less control over outcomes.	Products are becoming more complex as technologies and economics force better and more cost-effective solutions. It may be necessary to increase the complexity of products and processes to mitigate other factors.
Increase shelf life	Increased shelf life reduces the amount of product that spoils or has to be discarded due to time restrictions.	For food products, increased shelf life may require more packaging or more complex technologies like composites.
	Energy	
Improve energy efficiency	The more efficient the process, the less mass and energy is consumed in obtaining the products and using them over time.	Energy efficient devices are typically more expensive to produce and may create more wastes during production.
Reduce energy losses/conserve energy	Saving energy through conservation and insulation eliminates the need to produce energy and transport it.	Insulation and conservation may cost money to implement and may not be cost effective unless usage is reasonably large.
Use renewable sources or those that can be replenished	Renewable energy sources tend to have the fewest impacts, especially solar energy. Energy sources that can be replenished tend to be stable and viable.	Care has to be exercised to ensure that energy sources are reducing impacts. For capital-intensive processes, the applications may have low impacts, but have significant upstream impacts.
Increase energy density	Higher density energy sources take less space and often require less mass to achieve the desired outcomes.	Devices with high energy density are often more costly and occasionally more dangerous.
	Resource Recovery	
Enhance secondary use	Refurbishing and reclaiming products and parts eliminates the need for new ones, avoiding all of the associated resources and impacts.	Secondary applications may not be as safe or beneficial as primary ones. Users may lack the information necessary for sound use.
Recover products, parts, and materials with the highest value	Recovery of those products, parts, and materials with the greatest economic value achieves the greatest benefits. Early intervention in the recovery process captures more materials and resources efficiently.	Certain products and parts may have hidden defects that decrease their value or may have exceeded normal life expectancy thereby increasing risks and potential future impacts.
Create a recovery infrastructure	Creating the means to recycle and reuse scrap and other discarded materials is imperative for the effective recovery and reuse of resources.	Creating an infrastructure is complicated and requires the input and support of many partners and related entities.
Enhance recycling and material recovery	The recovery and reuse of scrap from manufacturing or post-customer use has to be designed into products and processes.	Creating product take-back systems is complicated and costly. The best options are not always clearly identified.

Waste Streams		
Prevent pollution and avoid degradation	Avoiding pollution at its source is one of the most effective means of reducing impacts and improving product and process efficiencies.	Pollution prevention is not always cost-effective in the short term. It may take an investment of time and money to reap future rewards.
Keep waste streams homogeneous	It is easier and less expensive to enhance the recovery, reuse, and recycling or treatment of homogeneous waste streams.	Managing separate waste streams may increase the amount of equipment necessary to produce the product or treat the waste streams.
Prevent leaks, spills, and accidents	Leaks, spills, and accidents generally mean a loss of resources, turning assets into liabilities and expenses. Preventing such events saves money and avoids impacts.	Avoiding these unintended events is often costly and requires up-front investments and training. It becomes more difficult to reduce the potential for spills as processes improve.
Avoid the transfer of wastes from one media to another	Cleaning one process at the expense of another is not effective and is generally a waste of resources.	There may be government mandates calling for such protocols. Often cleaning one waste transforms one form of pollution into another.
Informational		
Promote communications of information/data	Encouraging the proper use of products reduces incorrect applications. Disclose the positives and the negatives.	Information and data have to be accurate and validated. The marketing methods have to provide both the positives and negatives.
Educate employees, customers, and stakeholders	Knowledge is powerful and helps mitigate potential risks and impacts. Educating people about the products and processes reduces the potential for mistakes and misapplications.	Creating effective educational programs and materials requires significant investments. Care has to be taken to ensure that the knowledge conveyed is correct and appropriate.
Enhance feedback	Communications are a two-way street. It is imperative that designers listen to their customers and use their suggestions when feasible.	Customer and stakeholder inputs are complicated and often difficult to interpret. Constituents do not always say what they mean.

Table 1: Selected Specifications and Criteria for Improving Energy Efficiency

Determining opportunities and challenges is intended to provide an understanding of current levels, achievements, and outcomes, and where the innovations are heading over the next forty years. The measures are informed by the expected outcomes in the social world and the natural environment. The overall aims are to objectively evaluate potential solutions and systems and monitor the progress being made and the need for further advancements and achievements.

Determining the guidelines that will be used to obtain, analyze, and interpret the information and data is critical. Some of the areas to be examined include:

- *Users and applications*, which involve consumption in multiple dimensions. Segmenting consumption by geographical, demographical, behavioral, and other schemes is necessary. This area examines the whole while delving into the details of each market segment. It includes potential and emerging markets, especially in developing countries in which there are latent requirements (i.e., potential demand) for products and services. Moreover, it considers scenarios where existing products and services are not suitable for social, economic, or cultural reasons.
- *Lifestyle aspects*, which involve people and their communities. It includes where and how they live, work, and develop, and how affairs between individuals, groups, local communities, nations, and the global community are conducted. It also encompasses how people interact with the natural environment. Some of the most important aspects are the general well-being of people, the protection of human rights, and what society expects from businesses.
- *Natural world considerations*, which are the effects and impacts of products. They encompass impacts during production and consumption in the broadest sense, including air emissions, wastewater discharges, solid and hazardous wastes, the use and disposal of toxic chemicals, accidents and spills, and the health and safety of workers and contractors. Energy

consumption, process inefficiencies, poor yields, life cycle problems, wastes, and discards are only a few of the concerns both upstream and downstream of the value system(s).

- *Cultural aspects*, which are the specific ways in which people live and behave based on their ethnic and/or religious backgrounds. They include social norms, beliefs, and how one is expected to behave in their society. Cultural aspects are often taken for granted since the population in one's home country often appears to be somewhat homogeneous, especially in developed countries. However, there are usually cultural differences among people, even those who reside within the same region or country.
- *Talent/Labor*, which involves the availability capable and educated people. These individuals create and carry out the strategic and operational requirements of the company. Although there may be hundreds, if not thousands, of people trying to get jobs, the most effective talent pool is not always available. This is especially true as the business environment and the associated management constructs become broader and more sophisticated.
- *Innovation aspects*, which have broad implications that change market demand and competition. Innovation provides new ways of achieving desired outcomes. Technological forces drive change in the business environment through technological innovations that involve the discovery, development, and deployment of new technologies, knowledge, and mechanisms. Technological innovation is the systematic creation of new technologies that are superior to their predecessors and improve existing technology portfolios.

Improving Efficiencies and the Role of Innovation

Understanding the flow of materials and energy from the raw material extraction to the end-of-life considerations can help leaders, professionals, and practitioners reduce the consumption of energy and resources. Knowledge of energy impacts, both direct and indirect, can provide insights into opportunities for efficiency improvements. The actual quantities of energy and materials used often vary with the quantity of the product being produced and the services being provided. Generally, processes are less efficient at low-process utilization than at full or nominal output. Most production processes measure the consumption of energy, raw materials, parts, and components and relate that to the nominal production output. If a process is stable and operating at a consistent rate, the calculations are straightforward. However, if there are significant swings in production rates, and if the efficiency of the process depends on output (more efficient at full capacity), the actual energy and material utilization per unit of production may be higher than the design specifications would indicate. Thus, it is incumbent on management to keep processes stable and operating at the expected efficiencies.

Innovation can play an important role because the most crucial way to improve efficiencies is during the design and development of products and processes. Here, decisions made about product specifications and applications that usually directly affect the energy consumption and resource impacts. If a designer fails to focus on ways to maximize efficiencies, the opportunity to make substantial improvements is often lost.

Although innovation is generally considered the responsibility of the producer, users play a critical role once products are purchased and used. For example, users often reuse, redeploy, and recycle,

which typically involves downstream processes to mitigate the residual effects of products, parts, components, or materials. They also impact end-of-life efforts to deal with some of the negative aspects. Such efforts are especially important if the residuals are inherently undesirable or dangerous. The most powerful approaches are those that positively influence the upstream processes. For instance, due consideration should be given to replacing inefficient products such as incandescent light bulbs, which require electric utilities to generate more electricity than what would be necessary if everyone used LEDs. Reuse can be implemented with recycling to improve the utilization of materials and reduce energy generation, thus making the overall systems more efficient.

Improvement initiatives and innovation efforts should lead to positive social, economic, technological, and environmental outcomes and allow the producers and users to build momentum toward even greater improvements. The following examples are simple initiatives that can reduce the impacts:[8]

- Reducing the amount of energy and materials required to produce the products including reducing the size and weight of the products
- Increasing the life of products, thus making the inputs and outputs more efficient and effective on a per-unit basis
- Improving the quality, reliability, and longevity of products and processes so that there are fewer premature failures and fewer resources are necessary to satisfy customer demand over time
- Improving the efficiency and effectiveness of processes so that process yields are higher, more output is achieved, and less waste is generated
- Increasing the integration of supply networks and customers to minimize inefficiencies, losses, and wastes and improve applications
- Substituting benign materials for toxic substances as well as using materials that are easily reused, recycled, and repairable
- Enhancing the material life cycle through closed-looped recycling, thus getting more value from the inputs and outputs and reducing resource utilization
- Improving the public and market awareness about the proper use and applications of products and processes through effective communications and disclosure of technical information

Ultimately, conservation is an effective technique. Avoiding using energy and resources through alternative solutions is among the best approaches for reducing depletion and ensuring the availability of energy and resources in the future. While conservation often implies sacrificing comfort, satisfaction, and/or convenience to obtain the desirable outcomes, conservation also means using the energy and resources more wisely to obtain the same desired results. Conservation can be preferred over the development of renewable energy sources because it can expand economic development without an expansion of energy requirements. Such development involves economic and social benefits for people without a huge growth in resource utilization. In the article, "Towards a Sustainable Energy Balance: Progressive Efficiency and the Return of Energy Conservation," the authors argue that:[9]

> For these programs, incorporating criteria from consumption, as well as efficiency, offers a path for energy experts, policymakers, and the public to begin beginning consensus on energy policies that recognize the limits of resources and the global carrying capacity. Ultimately, it is both necessary and, we believe, possible to manage energy consumption, not just efficiency, in order to achieve a sustainable energy balance. Along the way, we may find it possible to shift expectations from perpetual growth and toward satisfactions and sufficiency.

Integrating Producer-Driven and User-Driven Innovation

The development of sustainable energy solutions cannot be achieved in the context of producer-driven innovation that solely resides within the design and development departments or research and development centers of business enterprises. Rather, these innovations must be the result of collaborative processes that are primarily driven by users rather than producers. This shift in focus is non-trivial, because it takes the power away from the entity that will ultimately produce and distribute products, then maintain responsibility for end-of-life considerations. The PSESS framework will need to incorporate a much more inclusive, interactive collaboration. In this way, communities and societal needs will be incorporated into the sustainable solutions.

Figure 1 provides a simplified illustration of the two innovation routes that would need to be integrated into a comprehensive system. Although examples exist of user-generated innovations, these innovations generally involved a producer observing or otherwise interacting with users to determine their particular needs (i.e., it only considers the "application" section of the construct). The proposed framework will go beyond just applications, to encompass the entire vertical flow and, as such, includes innovations driven from lifestyle and societal needs, along with the needs and wants (demand) of individual users. Hence, in this context, users become key contributors to innovation in a most comprehensive way.

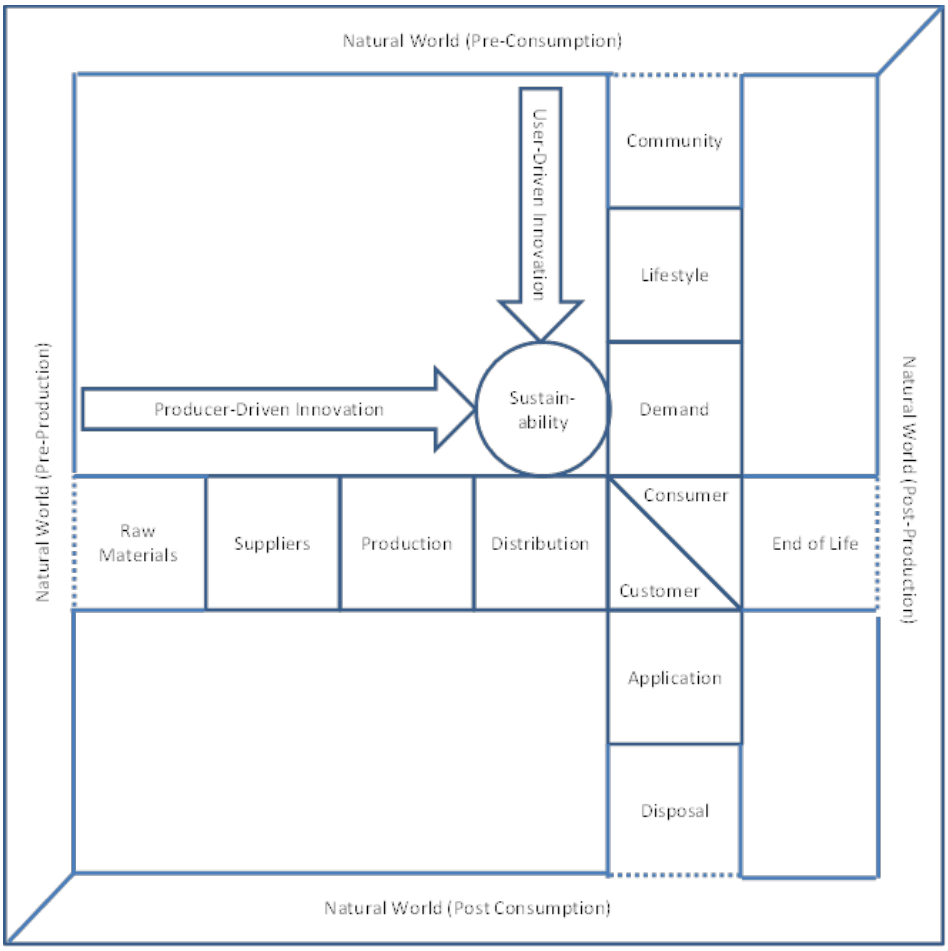

Figure 1: The Framework for the Pursuit of Sustainable Energy Solutions and Systems

The process of innovation is complex, even though traditional design and development activities are based on well-established elements of the value chain (i.e., the producer's activities in Figure 1). For example, it is generally well understood where the need for innovation is identified, where decisions to go ahead with the ideas are made, and at what point the innovation is incorporated into the technologies, products, and services. However, the innovation process relevant to the comprehensive user scale is relatively less understood and defined.

User-oriented (i.e., society, community, consumer, stakeholder) research and analysis is necessary to identify important features of innovations that would apply to users. The result will be the identification and documentation of pathways for the consumer and the community to communicate their ideas and needs to the producer so that the innovations will meet consumer and societal wants.

The particular focus should be the leveraging of today's technologies, including social networks, the Internet, and other information and analytical technologies, to bring together users and producers in ways that are conducive to innovation. The emphasis will be on proactive users. It will be useful to consider a number of case studies of entrepreneurial activities, where individuals found mechanisms for satisfying latent improvements that had great benefits to the whole of society. The focus will be on innovations that will have minimal impact on the natural world post- versus pre-production and consumption.

Reflections and Conclusions

The PSESS involves making transitions and transformations to assure that energy solutions and systems are on the cutting edge and they are in concert with the business environment, market spaces, and all of the affected entities. It involves producing and using energy and resources that are socially responsible, economically viable, technologically advanced, ethically proper, and environmentally sound. The key to success is to increase opportunities, decrease challenges, reduce risks, and eliminate vulnerabilities.

The creation of value while minimizing energy and environmental impacts necessitates ongoing innovations by users and producers alike. It necessitates investments to develop new solutions, new approaches, new capabilities, and new energy technologies before they become apparent and necessary. Going forward, value creation based on user-driven innovation may be a critical factor for achieving success. This approach enhances the ability of a business to practice sustainable development. The aim is to create the best possible solutions for customers, stakeholders, communities, and society. It seeks to identify solutions that maximize benefits and gains, and minimize failures and losses, using the capabilities and resources of the extended enterprise.

The PSESS depends on a number of factors, including (a) insightful, creative, and courageous leaders, professionals, and practitioners; (b) knowledge of how to discover, develop, and produce more fruitful benefits and outcomes; and (c) consideration of all stakeholders, including customers, shareholders, employees, and society. At the same time, the PSESS seeks to use fewer resources and generate less waste. The approach involves significant changes in how solutions are provided and systems are managed. It involves all of the people affected by the enterprise and focuses on achieving the best outcomes and sustainable success. Some of the key perspectives include:[10]

- Resources should be deployed in the most effective and efficient means possible given their availability, costs, the processes, and best practices.
- Resources should be used in a manner that minimizes the potential for environmental degradation, depletion, disruption, and destruction.
- Materials used in products and processes should be non-toxic and safe to obtain and use during extraction, processing, manufacturing, transportation, application, and disposal.
- The quantity of waste generated in processes should be close to the theoretical minimum with plans to further reduce the amount of waste produced.
- Products should be designed and produced in ways that provide the highest level of quality, reliability, safety, longevity, durability, maintainability, serviceability, and disposability.

- Communications with customers and stakeholders should provide the full factual information needed for the safe and effective use, reuse, recycling, retirement, and disposal of the products. It is the responsibility of the primary producers to create and articulate solutions for the safe and effective discard of end-of-life residuals.
- The impacts of the technologies, products, processes, and operations should not adversely affect the quality of life in the local, regional, and global communities or the natural environment.
- Products should be designed and produced to maximize the ability to reuse, recycle, remanufacture, and refurbish the products, component, parts, and materials.
- Safety and human health should be primary considerations when designing and operating facilities, plants, and processes and when designing and producing products.

The challenges presented by the global economy are enormous as more and more countries, companies, and people are competing for the scarce energy and resources in their quest to achieve their economic goals and sustain growth. To achieve economic development and to have sufficient resources that are affordable and stable require innovative solutions that are much more efficient and effective in using resources. Leaders, professionals, practitioners, and people in general must develop the ability to be in concert with the definition of sustainable development: growth and development that "meets the needs of the present without compromising the ability of future generations to meet their needs."[11]

Notes

[1] Homi Kharas and Geoffrey Gertz, "The new Global Middle Class: A Cross-Over from West to East," the Wolfensohn Center for Development at Brookings, 2010, p5.
[2] Id.
[3] David L. Rainey,
[4] The World Commission of Environment and Development (WCED) for the General Assembly of the United Nations, *Our Common Future*, The Brundtland Report (Oxford, UK: Oxford University Press, 1987, p8).
[5] Id. WCED was under the direction of G. H. Brundtland, the Prime Minister of Norway.
[6] David L. Rainey, Sustainable Business Development: Inventing the Future through Strategy, Innovation and Leadership (Cambridge, UK: Cambridge University Press, 2006, p561).
[7] Id, pp587-589.
[8] Id, pp630-631.
[9] Jeffry Harris, Rick Diamond, Maithili Iyer, Christopher Payne, Carl Blumstein and Hans-Paul Siderius, "Towards a sustainable energy balance: progressive efficiency and the return of energy conservation," Energy Efficiency, 2008, p1.
[10] David L. Rainey, Sustainable Business Development: Inventing the Future through Strategy, Innovation and Leadership, p525.
[11] The World Commission of Environment and Development (WCED) for the General Assembly of the United Nations, *Our Common Future*, The Brundtland Report, p8.