AC 2010-60: ACHIEVING ORGANIZATIONAL SUSTAINABILITY: AN ENGINEERING MANAGEMENT CHALLENGE OR OPPORTUNITY?

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Abstract

Organizational sustainability in terms of societal, environmental, and financial impacts may become the overarching success factor for technology-driven businesses in the global marketplace. This triple-bottom line has received considerable attention in the literature. However, the question of sustainability becoming an independent field is still being debated.[1]

Engineering management may become a major player in transforming compliance with legal regulations into an enhanced competitive business advantage by offering a total systems approach to achieving performance excellence. The applied research presented in this paper suggests a conceptual framework to guide the process of transforming the organization's products and services to improve performance in terms of the expanded definition of sustainability. The educational aspects of sustainability are emphasized throughout this article. This framework may also be helpful to those in higher education faced with the challenge of reforming engineering education in the Engineering Management graduate curriculum.

A mini case study is discussed to illustrate the framework and suggest several managerial implications. The mini case tells the story of an electrical power distribution organization that expanded their customer provided services to include broadband and telephone technologies. They currently have 10,000 broadband customers and are operating this business segment in the black. Now the organization is exploring smart grid approaches to level load electrical power system demands. The mini case discussed in this article does offer a potential contribution. When addressing sustainability for a single organization in the supply chain, a best strategy for the local organization may be destabilizing for the entire supply chain. This suggests that sustainability strategies should be evaluated from a total systems perspective. Extrapolating to managerial implications one might conclude that Systems Engineering and Engineering Management disciplines could make a significant contribution in resolving the "sustainability" debate in higher education.

Introduction

The purpose of this applied research is to: 1) Explore the emerging emphasis on the triple bottom line as organizations strive to survive in this turbulent decade; 2) Use relevant literature and the authors' practical experience to suggest a conceptual framework that could guide organizations through a revolutionary process that involves disruptive or discontinuous changes to processes and business models; 3) Reflect implications of these sustainability transformation on Engineering Management Programs; and 4) Use the case of Bristol Tennessee Essential Services (BTES) to illustrate the framework and show positive results for the discontinuous changes that have occurred. Throughout this discussion the authors strive to use the BTES experience as a benchmark for reinforcing the systematic approach to innovation suggested by the conceptual framework; and to suggest that the Engineering Management curriculum may need innovative changes to provide the skills necessary to excel.

Enhanced competitiveness in the global arena requires both a commitment to quality/continuous improvement and an expanded view of organizational sustainability. Engineers of the 21st century must understand globalization and sustainability to be professionally successful in the domestic and international dimensions of their careers.[2] Galloway goes on to say that such requirements demand that engineering education be reformed to include lifelong learning, ethics and sustainability; while continuing to teach the core undergraduate curriculum. Interestingly, results from the Peterson and Humble 2007 study of 28 graduate programs in Engineering Management, places Environmental Policy and Sustainable Development at the bottom of lists of courses taught ranked in order of importance.[3] This gap certainly creates a challenge for educators at institutions of higher learning teaching in Engineering Management Programs. Viewed through a Performance Excellence lens, this challenge may become an opportunity to enhance the engineering management skills by refining portions of the Engineering Management curriculum.

Hopefully, our applied research summarized in this article stimulates a dialogue that creates an opportunity for Engineering Management and Systems Engineering to play a larger role in the sustainability debate. We begin with a brief review of relevant literature to place our potential contribution in an appropriate context. Then we suggest a conceptual systems framework for guiding a revolutionary-discontinuous change process to promote longer range organizational stability. We suggest Engineering Managerial Implications and illustrate the conceptual framework with a mini case study.

Relevant Literature

Higher education is still debating the question of sustainability becoming an independent field. Redman[1] points out that several universities have established programs "dedicated to the study of sustainability and the environment." *"There is still a debate about whether sustainability is a genuine field, and that's why we use the word transdisciplinary – it isn't just that we're working across fields, but we're creating a field by working across fields,' says Redman, a professor of natural history and the environment and director of Arizona State University's School of Sustainability, which opened in 2007 and which this fall expects a class of 70 graduate students and 500 undergraduate majors*." We are suggesting in this article that Engineering Management and Systems Engineering are vital core competencies that could make a substantial contribution in clarifying central issues in this debate. From a commercialization perspective, using these core skills may be essential to creating innovative business models that view environmental and societal constraints and obligations as opportunities to profitably penetrate new markets.

Campus sustainability resources were dramatically increased in 2008 and the trend appears to be accelerating in an upward direction.[4] Engineers of the 21st century must understand globalization and sustainability to be professionally successful in today's global arena.[2] Galloway goes on to say that such requirements demand that engineering education must be reformed to include livelong learning, ethics and sustainability; while continuing to teach the core undergraduate curriculum. As we ponder the future of higher education's role in

Engineering Management, it may be helpful to start with a baseline of those courses that form a graduate program. An initial cut at the Engineering Management Body of Knowledge was provided by Peterson and Humble.[3] They sampled 28 programs of higher learning ranked by number of students and examined their graduate program of study. They indicated that although their data was incomplete patterns began to emerge. They generated two lists of courses in terms of importance to the Engineering Management Body of Knowledge. Then, they concluded that " four topics (a) Engineering Economics/Financial Management, (b) Management in Technical Organizations, (c) Project Management, and (d) Operations Research" were important to most programs with "two additional topics common to the five to eight positions in both lists: (e) Strategic Management and (f) Organizational Behavior." Interestingly, Environmental Policy and Sustainable Development were at the bottom of both lists at 28th and 22nd place respectively. This finding suggests that sustainability education was of minor importance for graduate engineering management programs prior to 2007. Some things may have changed. However, there is still an apparent gap between courses being taught and the need to revamp the curriculum to help our engineering managers thrive in the 21st century.

What if we were to apply our systems engineering technology to the business models discussed in the Engineering Management courses listed in the Peterson and Humble study and suggest a conceptual framework for redesigning business models to achieve better performance as measured by the triple bottom line? [3] For clarification, systems engineering is defined by the International Council of Systems Engineering to be: ". . . an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem…" In the context of this applied research, the Systems Engineering discipline is applied to suggest that the organization's business model be redesigned to identify innovative approaches to achieving organizational sustainability measured in terms of the triple bottom line. These changes may become disruptive or discontinuous. Hence, by systems approach we mean that changes in organizational processes and are evaluated from a total system perspective that strives to achieve mutually beneficial outcomes as measured by the triple bottom line of financial, environmental, and societal impacts.

With such an approach several benefits might accrue: 1) The resulting framework could guide organizations in changing their approach to sustainability with a possibility of improving financial performance and increasing market share; 2) Engineering management and systems engineering might play a larger role in sustainability education; and 3) Business leaders might change their view of compliance with regard to regulations and take a total systems approach to sustainability. This is an objective of the applied research described here. But first we need to clarify how sustainability is defined, then revisit some tools described in the business literature, and suggest the use of the National Baldrige Criteria for Performance Excellence.

So how is sustainability defined? Allenby, as well as many others in the literature refer to a triple bottom line comprised of financial, environmental, and societal factors.[5] Hitchcock offers a guide for creating and implementing sustainability plans.[6] When Dr. Harry Hertz gave his presentation at the 2009 Excellence in Tennessee Conference, the lead author was frustrated by the "simple" change in the Baldrige definition of sustainability in the 2009-2010 "Glossary of

Key Terms"; because Dr. Hertz went on to say that there was no corresponding change in the criteria themselves.[7] In a hallway conversation, Dr. Hertz was kind enough to explain that the "triple bottom line" had been around for a long time. The literature certainly substantiates this claim. However, there is an apparent gap between the Baldrige definition and the criteria that describe the processes that generate the bottom line results. In Boyd's "Destruction and Creation" discussion Boyd cites the famous German mathematician Kurt Gödel to conclude "you cannot prove the consistency of a system within itself."[8] Imagine if the change in definition of sustainability was a change in the organization's output without corresponding changes in the organization's processes that generate that output. Such a statement could be challenged by Boyd's interpretation of Gödel's system consistency theorem. Such a gap suggests that a total systems approach might be beneficial. Furthermore, in the journal article reporting their National Science Foundation sponsored research, Kumar et al. discuss benchmarking results from several mechanical engineering schools.[9] One observation from Kumar's study is: "Like ethics, sustainability should not be viewed just as a constraint, but rather as an underlying principle that serves as a key driver in the design of systems, components, and processes". Perhaps treating sustainability as an overarching objective function might be helpful in taking a total systems approach to re-designing the business model. We take such an approach in this article.

Traditional business tools are applicable to this discussion and are core competencies suggested in some of the Engineering Management courses listed in the Peterson and Humble study.[3] Many authors have used the SIPOC (Supplier, Input, Process, Output, and Customer) chart shown in Figure 1 to investigate process improvements, quality, and performance excellence requirements. See De Koning and De Mast for example.[10] A Balanced Score Card, see Kaplan and Norton,[11] reflecting financial viability, customer-focused outcomes, marketplace performance, work force and process effectiveness is often employed to measure success. If we adopt Kumar's suggestion cited above, the Kaplan and Norton Score Card may need to be rebalanced to reflect sustainability objectives and results. An innovative approach may be necessary to fully address the impacts of the expanded definition of sustainability. Sawhney et al. use the radar chart in describing how companies innovate and could shed some light on the innovations being sought here.[12] Armed with these tools we are still confronted with a challenge noted by Hall and Johnson.[13] Process standardization must be overcome with an artistic dimension to create a disruptive change in an organization's business model. We suggest an Imagine step as a starting point with a blue sky- green field (Thibaudeau[14)] approach to approximate the outer boundary of what might be. Next a "spring board" storytelling approach suggested by Denning[15] could be helpful. By springboard storytelling we mean that the teller communicates a complex idea in simple terms to spark action that could achieve extraordinary results. Over time such an approach can be helpful in transforming human behaviors to drive the organization to discontinuous positive changes in performance. With this augmented tool set and we are ready to outline a conceptual framework and illustrate the resulting framework with a mini-case study.

Conceptual Framework

Guided by Systems Engineering techniques and Optimal Control theory we begin with the SIPOC (Supplier, Input, Process, Output, and Customer) chart shown in Figure 1. We have added the Managerial Influence transfer function to suggest that such leadership is necessary to control or modify the business process to achieve desired results. The inputs, outputs and transfer functions shown in Figure 1 can be related to the Baldrige Criteria for Performance Excellence (2009-2010)[17]. In particular we focus on Category 7. A Balanced Score Card, see Kaplan and Norton[11], reflecting financial viability, customer-focused outcomes, marketplace performance, work force and process effectiveness is employed to measure success. It is significant to note that two of the three triple bottom line parameters are almost buried in Baldrige category 7.6.a (1) and a (3). Furthermore, treating compliance as a constraint as is indicated in 7.6 a (3) may inhibit an organization's ability to maximize triple bottom line outcomes, since optimal solutions often tend to ride the constraint boundary. Hence we suggest that the triple bottom line be viewed as an overarching objective function and that innovative system solutions are evaluated using an iterative process comprised of both art and science. See Hall and Johnson[11]: "Ironically, process standardization can undermine the very performance it's meant to optimize." In this context, standardized processes judged successful with regard to the Baldrige Criteria may not be capable of generating the triple bottom line results necessary to ensure organizational sustainability. To address this apparent shortfall we introduce the 13 step iterative approach shown in Figure 2. The detailed version of this framework would have ovals representing outputs from each transfer function. However, to describe the methodology, we'll focus on the major transfer functions.

The lead author has served on the Tennessee Center for Performance Excellence (TNCPE) Board of Examiners and Panel of Judges for the past seventeen years. During this time period, several hundred organizations have been reviewed using the National Baldrige Criteria for Performance Excellence. (Please see Exhibit 1 for a summary of the Baldrige Criteria.) Current performance is assessed and major strengths and major opportunities for improvement are identified. The same criteria have been successfully utilized to evaluate performance for organizations in education, manufacturing, healthcare, service, government and not-for-profit. This experience suggests that the framework offered in Figure 2 could have applicability to the task of deploying sustainability considerations across a wide spectrum of organizations.

Starting on the left hand side of Figure 2 we begin with the organization's strategic plan, Step 1. Based upon the TNCPE experience cited above, most strategic plans are evolutionary rather than revolutionary. Hence action plans in Step 2 tend to be for achieving continuous rather that discontinuous improvement. So we proceed across the top portion of the framework first. The organization's response to the action plans can be described by the baseline, Supplier, Input, Process, Output, Customer transfer functions shown in Step 3. Generally, these actions are more managerial in nature because they represent incremental changes to the current baseline. Exceptions occur when significant capital investments are made to support growth and/or new markets; or joint ventures, mergers and acquisitions are pursued. In Step 4 a balanced score card can be utilized to capture financial, internal operational efficiency, external strategic effectiveness, and organizational learning results. Step 5 consists of conducting an assessment using the criteria in the seven Baldrige Categories. These are Leadership; Strategic Planning; Customer Focus; Measurement, Analysis, and Knowledge Management; Workforce Focus; Process Management; and Results. Although organizations are encouraged to conduct self assessments, additional value is often realized when external reviews are conducted. This step is very similar to academic accreditation approaches that are moving more towards being mission driven. The output from Step 5 is a feedback report summarizing the organization's major strengths and major opportunities for improvement. In Step 6 the organization evaluates the feedback report and generally feeds the information back to the leadership team and their strategic planning committee. Everything in the first six steps is straight forward. Building upon Kumar's previously cited observation we suggest that sustainability be the overarching objective function applied to the design of the business and engineering management systems as well.[9] In this context, managerial influence could be viewed as a control variable (presumably moving with faster dynamics) than the business processes they are influencing. With this in mind we move to Step 7.

The innovation begins with Step 7. Here we suggest that sustainability be introduced as a weighted combination of financial, societal, and environmental factors. Appropriate measures would be established for each parameter. To focus on the difference between a balanced score card and the objective function being suggested, let's examine the Baldrige Results category, which represents 45% of the total score for all seven categories. From control systems theory one might conclude that some of the "states" associated with processes necessary to generate the sustainability outputs are neither observable nor controllable. Hence when the output from Step 7 goes to the Strategic Planning Committee they are stymied. When the Baldrige criteria undergo a major revision in 2011 we predict that sustainability will be much more visible throughout all seven categories. Hence, the framework's steps eight through thirteen might enjoy broad applicability. We are suggesting that the Strategic Planning process accept sustainability as a revolutionary, disruptive, discontinuous change and form a task force to explore innovative changes in the organizations' SIPOC model. Such an approach could be triggered in Step 8.

Step 9 now becomes the idea generation phase of the process. This is an artistic dimension to create a disruptive change in an organization's business model. We suggest an Imagine step as a starting point with a blue sky- green field (Thibaudeau[14]) approach to approximate the outer boundary of what might be. The key is to recognize that Steps 9, 10, and 11 forms an iterative loop designed to Imagine new possibilities in Step 9, Synthesize new SIPOC models in Step 10 and analyze potential payoff in terms of sustainability in Step 11. In Boyd's "Destruction and Creation" he argues that a "deductive destruction" is necessary before a new system can be created. The difficulty is that "sea of anarchy" with uncertainty and disorder is a management situation that few CEO's would embrace. However, an artistic process step with prescribed boundaries to the disruptions caused by our innovations might be more palatable. In other words, a series of non-linear jumps in the business system might allow the system to evolve and improve over time without incurring the penalty of anarchy in the process. With this guideline in mind we move from the iterative loop to Step 12. Promising non-linear jumps in the SIPOC model can be fleshed out with detailed commercialization and return on investment analyses and plans. Then appropriate pilot projects are implemented in Step 13. During this step assumptions are evaluated and appropriate adjustments are made. At this point another Baldrige assessment is suggested to evaluate the risk-reward equation. Values for each parameter are generated and plotted on the innovation radar chart with forecasted and actual results for each pilot project. See Sawhney et al. for a business use of the radar chart in describing how companies innovate.[11] Our suggestion is to remove regulatory constraints and treat sustainability as the overarching objective function. Then the business system is designed to maximize sustainability. Effectively this determines the value of the innovation in the business model. The gaps in the current values displayed on the radar chart and the potential for further achievement triggers the next iteration. Here a phased approach with incremental improvements could be attractive unless current legislation prohibits such action.

Outcomes for non-linear discontinuous changes in the SIPOC model are illustrated in the mini case discussed in a later section of this article. Ways to tailor these results to Engineering Management education are suggested below.

Implications for Engineering Management Education

Should Sustainability become an independent field or could Systems Engineering and Engineering Management become the integrating factors that achieve the overarching sustainability objective? Recognizing that sustainability resources are trending in an accelerated upward direction, graduate education and applied research programs may be encouraged to increase emphasis here. Although positive in nature, such a change would be disruptive and non-linear in nature. When viewed through a Performance Excellence lens, this challenge may become an opportunity to enhance the engineering management skills by refining portions of the Engineering Management curriculum. Let's pick an example and walk through the Conceptual Framework offered in this article.

President Obama awarded $3.4 Billion this past October to "spur the transition to Smart Energy Grid technology". (See www.doe.gov/8216.htm). Institutions of higher learning are exploring strategic questions on the type of research their faculties should pursue as well as new curriculum to support future economic development in this arena. Just imagine what an Engineering Management curriculum might look like if those who hire our graduates wanted them to be able to manage sustainability projects of this type.

The "Accreditation Board for Engineering and Technology" (ABET) prides itself on a history of "leadership and quality in accreditation". Although primarily focused at the undergraduate level, their review, assessment and continuous improvement process could be inserted into Step 5 of the Conceptual Framework shown in Figure 2. All other transfer functions could be tailored to reflect the appropriate functions for undergraduate education in engineering. Graduate programs in Engineering Management could also be evaluated using a program review format. However, care must be taken to avoid viewing the chosen criteria as being the absolute norm. When the potentially revolutionary changes caused by treating sustainability with higher priority are envisioned, allowance for breakthrough thinking must become a major factor. Here is where Steps 7 through 13 in the Conceptual Framework dominate, and may become the fundamental contribution for this article.

Just imagine if Sustainability and the Performance Excellence framework were used to guide our thinking in this arena. For several years the Baldrige Criteria for Performance Excellence has embraced the notion of customer-driven quality as a strategic concept implemented from the top down and a score card with a balance between financial and other internal and external performance indicators. However, day-by-day the triple bottom line enters into the evaluation of an organization's sustainability. Customers are more willing to pay green back dollars and Euros for value measured in social and environmental terms. The disruption caused by what might on the surface appear to be a minor change, may in fact become the ultimate success factor when the pace of change in technology and ever increasing global competition become driving considerations. Leaders personally play a major role in the creation of strategies, systems, and methods for achieving success. Well deployed, fact-based improvement processes become key management tools. Conversely, today's leaders are more often confronted with the challenge of achieving results when they do not have traditional power and control. Employees become empowered, share the company vision, and play vital roles in achieving both quality and operational performance goals and objectives. Personal lifestyle often trumps professional accomplishment. Management by fact is still the culture, and improvement trends are measured against relevant competitors and appropriate benchmarks. Nonetheless, closed loop, root cause, corrective action systems must be adapted to consider the impact of leadership by influence rather than by control. Culture is not only measured by geographic parameters. System Engineering, Engineering Management and business problem solving approaches also form a culture that must be balanced in terms of time to market and risk of early deployment with underdeveloped technology. New partnerships and strategic alliances with former competitors and/or new start up ventures may emerge as a strategy to balance Research and Development investments with marketing milestones identified to share risks and rewards. Although the role of Engineering Management is somewhat clearer in high technology companies, the challenge to reform engineering education posed by Galloway, must be addressed.[2] Such a discontinuous change in the Engineering Management graduate curriculum suggests that sustainability strategies be evaluated from a total systems perspective. Extrapolating to managerial implications one might conclude that Systems Engineering should become part of the subject matter "sustainability" debate.[1]

The Case of Bristol Tennessee Essential Services

Bristol Tennessee Essential Services (BTES) has been used as a benchmark in developing the Conceptual Framework discussed in this paper. The second author has used a personal story format to share the BTES experience in the subsection below.

Study Setting

Back in 1977, when BTES was still Bristol Tennessee Electric System, a municipally-owned electric utility; the building was hit by a tornado. Our office phones were out, but our main mission was to get the power back on. We called the phone company and they dispatched crews to help get our phones working again. We have a Supervisory Control and Data Acquisition system, or SCADA, which is used to monitor and control substation breakers. For just over 20 years, it was the main view of the status of our power system. In 1998, an ice storm hit and we lost communications to all 18 of our substations at one time or another. We called the phone company, but this time we spoke to someone in another state who was not very familiar with what was going on in Tennessee. They said it would take three days to get someone out there because they could not get out due to the ice storm. At the same time, our linemen were out working to get the power back on.

As a result of this, we decided we needed a way to control our own communications network.

Fiber was the best option, so we studied networking and fiber optics in order to make the best decision. In 2001, we began pulling a 216-fiber cable as our backbone and connected our first substations to our own network. “We” refers to our own linemen, who learned how to construct the fiber backbone. It also refers to our own meter and substations crew, who learned how to splice fibers. By the time we were done, we had pulled 125 miles of fiber and spliced over 10,800 fibers. About the same time we were pulling our backbone up for our internal use, Bristol Virginia Utilities (BUV) Board entered into the telecommunications business. The incumbent cable company lowered rates on the BVU side of town but refused to do the same in Tennessee.

In 2004, three students from BTES were taking the lead author’s course in innovative entrepreneurship and the second author was one of these students that developed a significant innovation. The team’s idea was that the fiber optics could be used for more than just responding to power outages. The team’s “school project” was presented first to the CEO and then the Board. Plan for success and don’t outrun our capital commitments became a theme. Over time the Board made more than a twenty-five million dollar investment, facilitated a change in Tennessee Legislation permitting Electric Systems to enter the broadband business, and changed its BTES name to Bristol Tennessee Essential Services.

In 2005, BTES connected their first customer. We saw competitors’ rates drop. This was a win for all the citizens of Bristol, whether they took our services or not. Our goal, however, was to be the best. Since we began, we have added several TV channels, including 23 more HD channels. We have increased the speed of our Internet offerings without raising rates. By 2009, we had surpassed our goals. In four years we had provided the infrastructure so that all of our customers were connected or ready to be connected with fiber optics cable. We had connected over 10,000 customers to our service. We were operating in the black, which was not estimated until the year 10 of our plan.

On the path forward, the BTES team has examined potential changes in the TVA’s pricing of electrical power. They asked what might be possible if the broad band capabilities were utilized to help level load the demand. Inspired by Smart Grid technology, see Lightner[16] for example, they are further evaluating their journey towards sustainability. A smart grid is a power system that takes advantage of digital and communications technology to increase reliability, save energy, and reduce cost. Utilizing current infrastructure, BTES is already setup to create a smart grid network for demand response and energy efficiency and signaling variable pricing to customers can be utilized by smart end-use devices that will modify their operation during high-peak demand periods.

Now in the era of smart grid technologies, we can see how we can really make the network “work” for everyone. Each customer has an optical network terminal (ONT) that connects to the fiber network. The ONT provides the customer’s Internet, phone, and cable TV connection. During discussions with the hardware vendor, we learned that the ONT sends an alarm whenever it loses power. This created quite a bit of excitement – instant power outage notification. We found the value of this early when a subdivision lost power late at night. There were two ONTs in that subdivision. When the power went out, they sent the alarms. Our dispatcher relayed the information to our linemen and we fixed it before we received the first call.

When we connect a customer to our fiber network, we install a smart meter that can both power the ONT and read the customer's meter. Beyond that, it can also send voltage and power usage data on demand. The system can also control other devices using wireless. Currently, BTES maintains over 14,000 water heaters for our customers, and in exchange for maintaining them we have a radio controlled switch that allows us to turn the water heaters off during peak load times. This system has worked for cutting water heaters off for short times, but there is no way of knowing the status of the water heater. Using the wireless technology in the smart meter system, we can actually read the temperature of the water at the top and bottom of the water heater. If the temperature is still hot, we can leave the water heater off for longer intervals – up to 5 hours. As the temperature drops, the individual water heater can begin heating again. We have estimated that if all the power systems in the Tennessee Valley were using this system, it could save TVA from building four 500MW combined cycle generation plants at a cost of $2 billion.

The smart metering system is only the start. We are working with vendors to create a smart distribution and transmission system that will inform us of where a fault occurs on an electric line. Using the concept of a spring board story, we can just imagine the positive impacts on the environment and the corresponding benefits that will accrue for society. The fiber network has created a sustainable platform on which we use SCADA for our substations, provide services for our customers, and pursue new smart grid initiatives.

So, from the quest for reliability, we have brought our customers new services, better prices, and new ways to increase reliability. These technologies allow us to provide comfort, convenience, entertainment, and productivity. It has also shown that as we connect more customers, the power of our network creates more opportunities to provide better service from all BTES business units to all of our customers.

Such operations can include dimming or turning off non-essential lighting, and shifting appliance operations such as dishwashers, washers, and dryers from peak periods. A forecast for high demand could be established so preconditions can be set for hot-water heaters and HVAC operations prior to high demand so they will not operate during peak demand. During this time, the thermostat temperature could be increased by two degrees to prolong operation.

Illustrating the Conceptual Framework

Bristol Tennessee Essential Services sustainability journey is illustrated in Figure 4. In 1996 BTES informally followed Steps 1 through 5 in the Conceptual framework and submitted a Level 4 (highest level achievement) application to the then Tennessee Quality Award, now Tennessee Center for Performance Excellence (TNCPE). BTES won the Level 4 award, at that point in time, called the Governor's Quality Award. In 1996 the BTES SIPOC chart looked something like what is shown in Figure 3. Their journey from 1977 through today discussed above in some detail is summarized in Figure 4. BTES remained actively engaged in the Performance Excellence Process from its inception in 1993 until today.

In 2004 BTES approximated Steps 9 through 13 with a chain of entrepreneurship described as idea generation, innovation-practical implementation, and real opportunity-a customer is willing to receive the value produced by the innovation. The result was both a non-linear change in services provided and a dramatic change in the BTES SIPOC chart. Although the change in suppliers, customers, and competitors was very clear to the BTES team the SIPOC chart was never formally documented. Since the fiber optics also enhanced the electrical system's performance, outside examiners might think of the BTES SIPOC chart as the one shown in Figure 3. Although other utilities chose BTES as a benchmark process when they pursued their fiber optics networks, BTES was not given credit because these other utilities were using the fiber to improve their internal efficiencies, not enter the broadband market. In 2008 BTES submitted a Level 4 application to the TNCPE. Imagine their disappointment when they did not win.

During the ensuing year BTES implemented action plans to close all performance gaps, conducted a holistic review to ensure strategic alignment and submitted another Level 4 application to the TNCPE. When they fell short again we conducted an analysis that resulted in refining the Conceptual Framework by adding Steps 7 through 13. Idea generation is comprised of silent brainstorming as individuals, followed by a group brainstorming session. Then ideas are filtered using Timmons' guide.[18] The Steps 9, 10, and 11 start with a "spring board" storytelling step suggested by Denning.[15] Just imagine if the regulatory requirements were removed and we could become a provider of broadband services. Steps 9, 10, and 11 are iterative in nature and evaluate a phased approach to mitigate risks.

Here is the key finding. Since the Baldrige Criteria do not explicitly evaluate sustainability in the broader sense of the definition in the 2009 – 2010 glossary, seasoned examiners are inclined to drill down into lower levels of indenture and offer improvement suggestions that have little or no value to organizations implementing discontinuous improvements. The more examiner training focuses on the criteria and the more experience the examiners have, the less likely they are to recognize discontinuous innovations and revolutionary processes from which others can learn. It is analogous to taking a Taylor Series expansion of a non-linear function and focusing on the third order terms while neglecting first and second order terms. In reality things are much more complex.

This finding raises a caution flag for higher education. Engineering Management programs reviewed against the current Body of Knowledge may find resistance when they respond to Galloway's call to reform engineering education by including sustainability and other factors. Perhaps the Conceptual Framework illustrated here can prove helpful in addressing this challenge.

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Figure 1: Supplier, Input, Process, Output, Customer

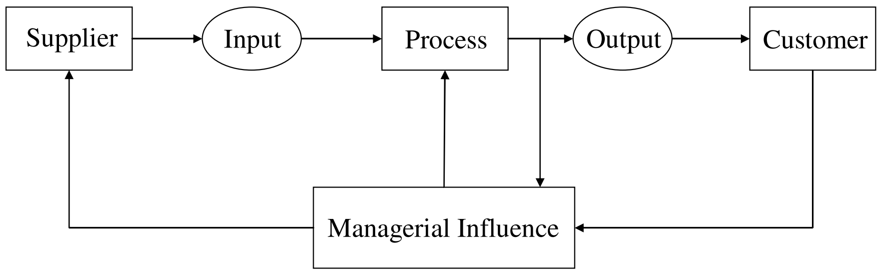


Figure 2: A Conceptual Framework for Assessing Sustainability Impacts

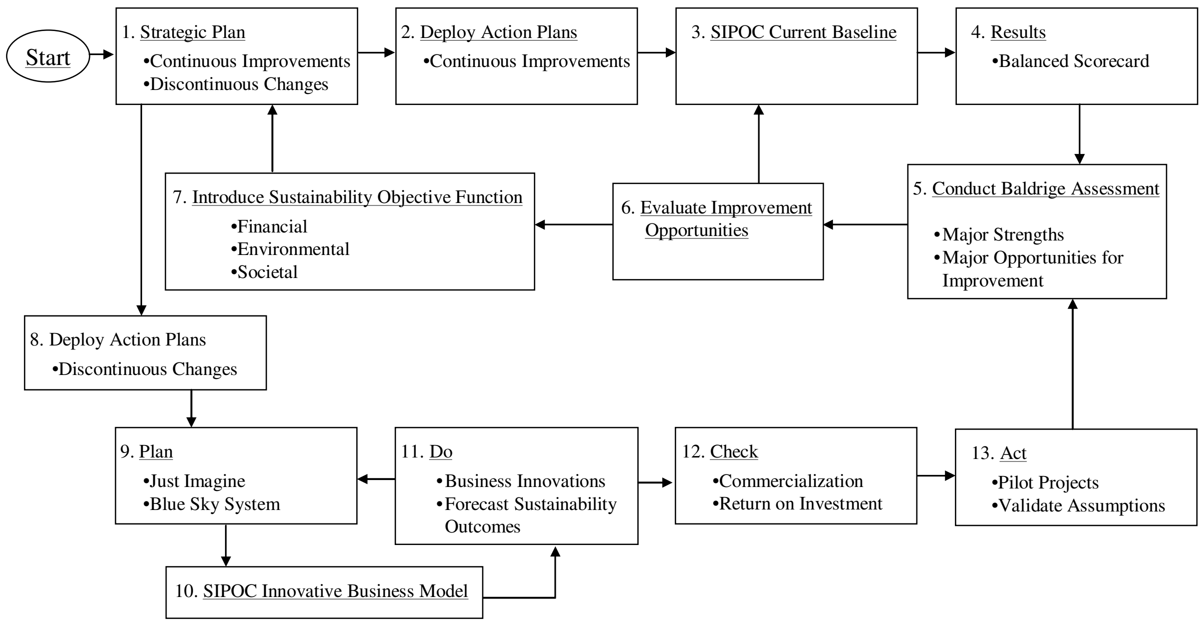


Figure 3: A Systems Engineering Management View of BTES

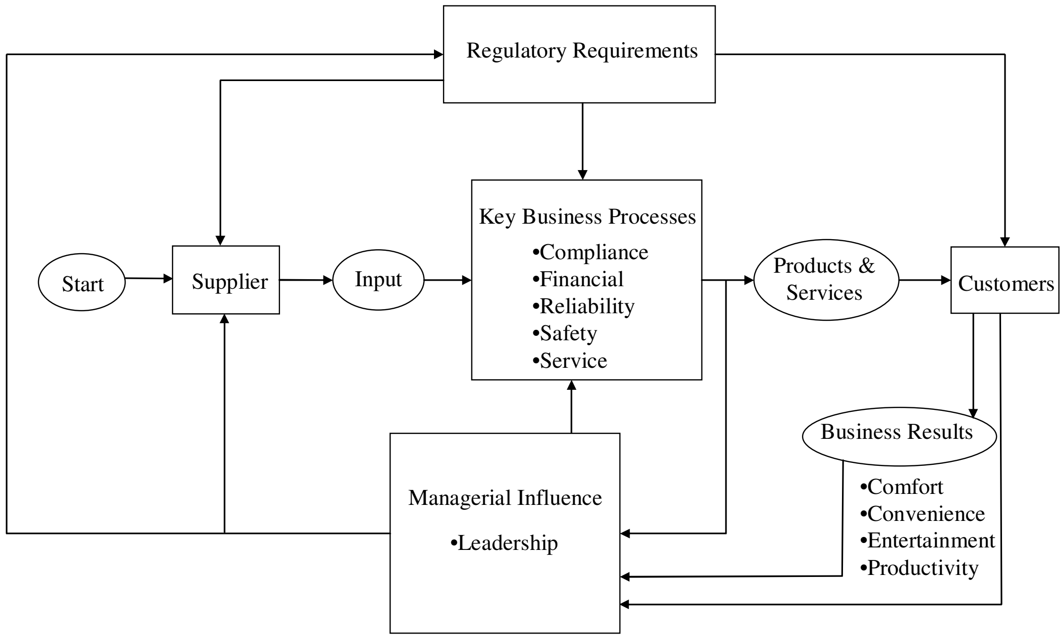


Figure 4: Discontinuous Improvements in BTES Services

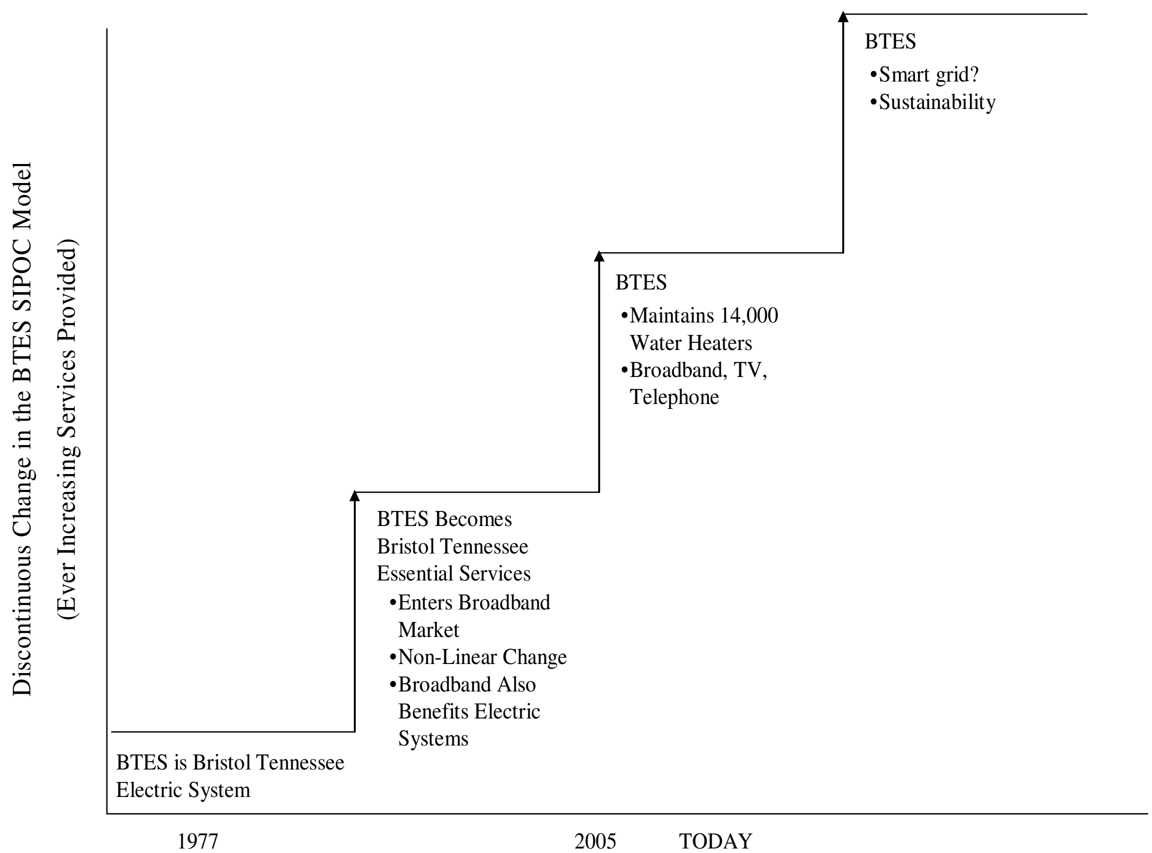
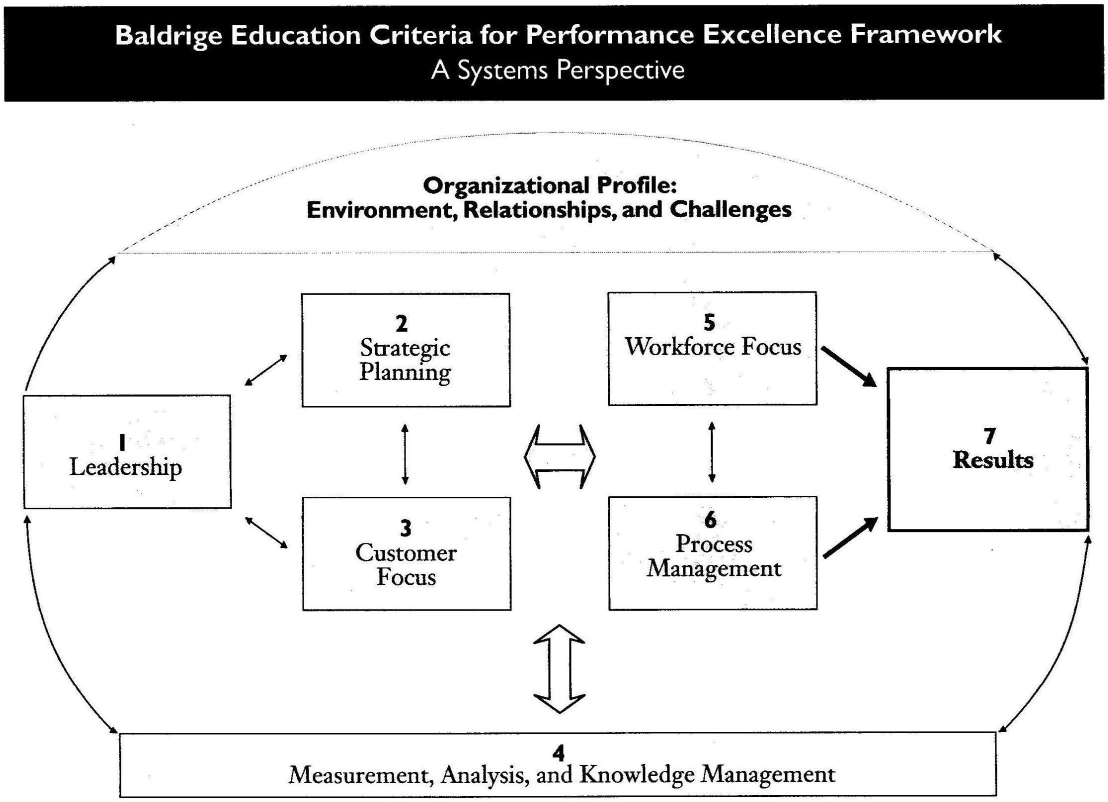


Exhibit 1



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