From Green Computing to Sustainable IT: Developing a Sustainable Service Orientation

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Abstract

The primary goal of the emerging discipline of IT sustainability is to enable firms to use computing resources more efficiently while maintaining or increasing overall performance. The first wave of these efforts is commonly identified as "green computing" where the emphasis has been primarily minimizing power usage for datacenters and technical equipments (such as desktops, projectors). The benefits of green computing in terms of reducing power consumption and corporate carbon footprints are direct and relatively rapid to achieve. However, to move beyond internally focused green-computing initiatives to the realm of competitive advantage and corporate sustainability, more attention needs to be directed to how a second wave of sustainable IT practices can align with and enable corporate sustainability strategy. Moreover, sustainable IT strategies need to accomplish this while delivering on core IT performance requirements to drive business productivity. Increasingly, sustainable IT will be impacted by the shift away from product strategies to embrace an integrated service-science and IT-service orientation that has the potential to redefine how customer value is created and how quality of life is improved with service. This paper will explore the dimensions of sustainable IT, discuss its development as a service, and provide criteria for improving its alignment with corporate sustainability strategy.

1. Introduction

The first wave of sustainable IT strategies has been focused on minimizing the costs and environmental impacts of datacenters. Over the last decade as datacenters have become an integral part of IT strategy, green computing methods which recognize the linkage between IT-related energy use and overall corporate carbon generation have become widely utilized. Enterprise-scale datacenters account for approximately half of corporate energy use and resulting carbon footprint [15] [26]. With power consumption of datacenters exceeding a combined $10 billion in the EU and U.S. in 2007 and expected to double again by 2011, and global purchases of IT goods and services are equal $1.66 trillion in 2009 [5], it is easy to see why green computing methods are a high priority [18].

Therefore, it is likely that efforts to reduce energy costs while improving the performance of data centers and desktop computers will remain a primary focus for IT organizations. Green computing also includes the goals of controlling and reducing the environmental footprint of computing by minimizing the use and discharge of hazardous materials, conserving water and other scarce resources, and reducing waste throughout the value chain [1]. Green computing encompasses IT product use over its lifecycle, and the recycling, reuse, and biodegradability of obsolete products. These goals seek to minimize the ecological footprint of IT products and services for companies and their customers. But, much more effort in terms of improving product and service design, rethinking the value chain, and reengineering IT processes will be needed to enable the IT organization to align with overall corporate environmental and social responsibility efforts [29] [33] [41] [8].

As beneficial as green computing strategies are, they are unlikely to dissuade customers, governments, activist nongovernmental organizations (NGOs), the media, and other stakeholders from demanding that companies commit more resources to mitigate the social consequences of their business activities [26]. "Sustainable IT" is the emergent second wave of strategies that is moving IT and ICT sustainability beyond the datacenter. The focus is on innovation and on improving alignment with overall corporate social responsibility (CSR) efforts [27]. This broader approach to sustainability will require changes in the nature of how value is conceived and delivered if competitive advantage is to be realized at the corporate and societal levels [34] [12]. The second wave will necessitate the development of sustainability strategies that spur innovation, create new markets, redefine processes, and require changes in IT organizations and corporate culture in order to integrate sustainable IT with global sustainability and social responsibility requirements [10] [33]. These changes reflect a shift in customer requirements from a primary focus on tangible cost-benefits of IT as a product (e.g. reduced energy usage) to the more intangible green benefits of sustainable IT as a service for implementing socially responsible business models [41].

The purpose of this paper is to explore the evolution of sustainable IT as it transitions from a product to a service and to provide a framework for integration with corporate sustainability strategies. Sustainable IT as a service holds the promise for enabling the IT

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organization to fulfill a much broader societal mission than just developing and provisioning computing services. The paper is organized as follows: Section 2 explores the value dimensions that are foundational to the development of sustainable IT as a service. Section 3 reviews the literature on the development of first wave approaches to green computing and looks at the issues driving the development of second wave sustainable IT strategies. Section 4 suggest a framework for the integration and alignment of sustainable IT as a service with corporate sustainability strategy in order that it can become a source of opportunity, innovation, and competitive advantage that benefits both the company and society. Lastly, Section 5 identifies issues and questions to motivate future research.

2. Developing a Service Orientation

Recently, Vargo and Akaka [47] clarified the differentiation of the service-dominant (S-D) logic paradigm from the goods-dominant (G-D) logic paradigm. A principle distinction is the type of value that is created and how it is delivered. G-D logic views "services" from a product perspective as "add-ons" or intangible products that may be offered on an after-sale basis [48] [49]. Services are designed and conceptualized as output, essentially intangible products, that "add value" that is created and then delivered to the consumer for compensation. Therefore, G-D logic is based on a value-in-exchange conceptualization.

Alternatively, S-D logic envisions service to be product independent, although goods can play a role in service provisioning [48]. Service value is always co-created with customers. It is based on the value-in-use concept. Co-creation involves the process of proposing value, the acceptance of the proposal, and the realization of the proposal by two service systems [43]. These systems engage each other to apply and integrate resources in order to co-create value and realize the service experience (V&E). Since the customer is actively engaged with the "provider" in the co-creation of value, the outcome of the service experience should, by definition, be more customer-oriented and satisfying.

The distinctions between G-D logic and S-D logic are useful for assessing the evolving nature of sustainable IT from a product and services orientation to a service orientation. The first wave of sustainable IT with its focus on green computing is an artifact of G-D logic that focuses on the product dimensions of business value to reduce costs (energy in this case) and increase benefit (lower carbon footprint) without directly engaging customers or other service systems on a co-creation of value basis. Green computing by nature is design-build-sell value-in-exchange. Conversely, if the emerging second wave sustainable IT is to be successful, IT organizations must engage both internal and customers and other members of its business ecosystem on a co-creation of value basis by offering value propositions that address environmental stewardship issues on a value-in-use basis. In short, for sustainable IT to be viable it must become a true service that can create sustainable customer value.

2.1. Business Value, Customer Value, and Societal Value

IT organizations are required to demonstrate the impact of their operations on the bottom line of the corporation. Accordingly, business value may be defined as the overall value delivered to the enterprises that result from IT projects and services [45]. Business value requires that IT spending be aligned with the business goals of the corporation in order to better meet customer requirements. Evidence that business value is being created includes increases in revenue and or decreases in costs that can increase ROI that can be derived from successful investments in innovative IT solutions [2] [45]. Although this definition does implicitly recognize the necessity for creating value for the customer, the overall focus of business value is generating returns for the corporation. Therefore, business value tends to focus on short-term, cost-based solutions that are relatively easily quantifiable. For example common metrics include cost reductions, headcount reduction, productivity increases, discounts, uptime, risk avoidance, and cost avoidance that can overlook the long-term best interests of the customer, society, and resultantly, the business as well.

Business value is based on G-D logic principles. IT products and services (not service) are created, some with customer input, and then delivered to customers. It is value-in-exchange in action. Value that recognizes customer requirements may be co-produced in this manner, but it is not co-created. The first wave focus on green computing, with its primary emphasis on cutting energy costs, can certainly increase business value, while increasing customer and societal value (carbon reductions). However, the short-term focus on costs and the lack of sustained engagement and collaboration with stakeholders cannot ensure that benefits to the customer and society will continue to be realized over the long term. A sole focus on creating business value is not sufficient for a sustainable IT service orientation.

Customer value may be defined as the overall benefit derived from a product or service, as the customer perceives it, at the price the customer is willing to pay [21] [22] [42]. A focus on customer value requirements enables IT organizations to look outside their organization to engage the customer both individually and collectively (as markets) as the true focus of

business activity. The type and degree of engagement is critical. From a G-D logic perspective, engagement might mean periodically asking customers what they want in terms of new products and services, delivering the output, and then conducting customer satisfaction surveys to gage the customer's reaction to the experience. This situation would describe co-production and the exchange of value—IT *services* not IT *service*. It leaves lots of room for the development of gaps between expectations and reality. Alternatively, from an S-D logic perspective a sustainable IT service could be envisioned as continuous engagement between two service systems (provider and customer) to propose, accept, and realize value by integrating their resources to co-create value to meet economic, ecological, and societal requirements. This situation describes the co-creation of value-in-use for an IT service [47]. However, a short-term focus on customer value, co-created or not, which is the default approach given short product lifecycles and competitive pressures, may not be sufficient for a sustainable IT service orientation. Some customers may be willing to look at their long-term needs in a societal context, but for most IT consumers cost and performance are dominant value drivers [10].

Societal value calls upon organizations to build social responsibility and sustainability into their business practices [39] [41]. Business for Social Responsibility, a leading CSR business association, defines societal value for businesses in terms of achieving commercial success in a manner that honors ethical values, and respects people, communities, and the natural environment [34]. Business should meet their market goals in such a way that enhances the customer's and the society's long-term well being. These goals are often perceived to be in conflict when they are actually interdependent and they are seldom aligned with the corporation's business strategy [34]. Efforts to improve societal value are not as productive as they might be. Most efforts have been relatively unfocused G-D logic approaches that mitigate risk, lower cost, or try to enhance corporate reputations without really engaging stakeholders. It is unfocused value-in-exchange, generally without consideration of co-production of value. What is needed is an S-D logic approach that genuinely engages stakeholders on sustainability as a service basis to co-create value-in-use that not only enhances society, but brings business success as well. Table 1 summarizes the value discussion as it maps to green computing and sustainable IT service. Green computing can generate all three types of value. However, its short-term, low engagement dimensions map best with a business value G-D logic orientation. Green computing can generate considerable customer and societal value as well. However, the low engagement approach which lacks co-creation can lead to a lack of understanding on how to align strategy with customers and society. Alternatively, the long-term, high engagement, co-creation, S-D logic dimensions that characterize sustainable IT service are best for creating sustainable customer and societal value.

Table 1. The Dimensions of Value

Value Dimension	Green Computing	Sustainable IT Service
Business Value	Primary driver of adoption G-D logic Products and services Co-produced Value-in-exchange Low engagement Short term	NA
Customer Value	Secondary driver of adoption G-D logic Products and services Co-produced Value-in-exchange Low engagement Short term	Primary driver of adoption S-D logic Service Co-created Value-in-use High engagement Long term
Societal Value	Secondary driver of adoption G-D logic Products and services Co-produced Value-in-exchange Low engagement Short term	Primary driver S-D logic Service Co-created Value-in-use High engagement Long term

3. The Evolution of Sustainable IT

The IT industry epitomizes the Vargo and Lusch definition of a service as "the application of competences for the benefit of another" [47]. However, IT has historically operated in a product-oriented paradigm of developing and deploying IT equipment and services to meet what IT perceived its customers' requirements to be. The emphasis has been on providing sufficient capacity and capability to meet business demand.nInfrastructure issues, energy consumption, cooling, and space for data centers were given scant attention since they were thought to be always available and affordable. Unfortunately, these issues, especially energy costs and environmental concerns, have become limiting factors for deploying new IT systems [51].

3.1. Green Computing

Large enterprise-scale datacenters may cost from $500M to $1B, account for 25% of total corporate IT budgets and 50% of overall corporate greenhouse

emissions [15]. On average, operating costs are increasing at 20% per year with annual energy costs alone nearly matching the costs for new equipment. Datacenter expenses threaten budgets for new products and reduce overall operating margins, which makes data center efficiency an important strategic issue [15]. Table 2 lists the factors that are impacting data centers, and to a lesser degree, desktop computers, and driving the adoption of green-computing practices.

Green computing strategies have largely been focused on lowering power costs in datacenters which reduces the carbon footprints IT organizations. The transitioning to a green data center involves a mix of integrating new approaches for power and cooling with energy-efficient hardware, virtualization, software, and power and workload management [11]. Table 3 summarizes the major green computing strategies.

Tables 2 and 3 indicate that green computing is overwhelmingly product-oriented in nature. All of the key drivers impact energy costs and operations efficiency which are subsequently reflected in product and service costs. High energy consumption and inefficient products and services threaten IT's viability as a generator of value. The solutions to these energy and efficiency problems are similarly product driven. All of the mitigation strategies are designed to reduce energy use and improve efficiency.

Table 2. Factors Driving the Adoption of Green Computing. Adapted from [20]

1. The rapid growth of the Internet	• Heavy use of Internet drives datacenter growth in size and number, 20% CAGR [55]. • Internet communications, financial services, media, gaming, music, and video • Computerization of business processes and applications, legal requirements, and disaster recovery backups • Sarbanes Oxley increases storage demand by 50% [52] • Rapid growth in e-government [13]
2. Increasing equipment power density	• More servers installed with higher performance processors with more memory [44][51]. • Server form factors are much smaller, shrinking by more than 70% through the use of blade servers. • Packaging density is matched by increases in the power density of data centers. Increases more than 10X from 300 watts per sq. ft. in 1996 to over 4,000 watts 2007 [13][44][46][51].
3. Increasing cooling requirements	• Increase in server-power density increases data center heat density. • Servers require approximately 1 to 1.5 watts of cooling for each watt of power used [17][25][40]. • The ratio of cooling power to server power requirements will continue to increase as data center server densities increase.
4. Increasing energy costs	• Datacenter power costs can exceed equipment expenses over the life of a server. • The ratio of power costs to equipment expenses increased from 0.1 to 1 in 2000 to 1 to 1 in 2007 [51]. • The advent of a carbon cap-and-trade scheme will significantly increase datacenter energy costs [28].
5. Restrictions on energy supply and access	• Large companies such as Google, Microsoft, and Yahoo may not be able to find power at any price in major American cities [14]. • New data centers are built near the Columbia River for direct access to low-cost hydroelectric power and avoid dependence on the overtaxed electrical grid. • In California, Illinois, and New York, old electrical infrastructure and high power costs can slow or stop data center construction and limit the operations of existing centers [25]. • In some crowded urban areas utility power feeds are at capacity and electricity is not available for new data centers at any price [12].
6. Low server utilization rates	• Data center efficiency is a major problem in terms of energy use. • The server utilization rates average 5-10 per cent for large data centers [15]. • Low server utilization means that companies are overpaying for energy, maintenance, operations support, while only using a small percentage of computing capacity [10].
7. Growing awareness of IT's impact on the environment	• Carbon emissions are proportional to energy usage. • In 2007, approximately 44 million servers worldwide consumed 0.5% of all electricity. • Data centers in the server-dense U.S. use more than 1% of all electricity [12]. • Collective annual carbon emissions are 80 metric megatons of CO2, equivalent of the Netherlands and Argentina [15]. • Carbon emissions from operations are expected to grow at more than 11% per year to 340 metric megatons by 2020. • Carbon footprint of manufacturing the IT product is largely unaccounted for [15].

Cloud computing is a notable exception in that it also provides a bridge to an entirely new business model that serves to not only increase efficiency and lower costs, but holds the promise for moving IT in the direction of becoming a service. It brings computing services to customers that can be accessed in an on demand subscription environment with no requirement to invest in infrastructure or other up front expenditures.

Table 3. Green Computing Strategies. Adapted from [20]

1. **Data center infrastructure**	• Infrastructure equipment includes chillers, power supplies, storage devices, switches, pumps, fans, and network equipment. • Many data centers are over ten years old. They typically use 2 or 3 times the amount of power overall as used for computing, mostly for cooling [12]. • Strategy is to invest in new energy efficient datacenters or retrofit existing centers.
2. Power and workload management	• Power and workload management software could save $25-75 per desktop per month and more for servers [54]. • Adjusts the processor power states (P-states) to match workload requirements. It makes full use of the processor power when needed and conserves power when workloads are lighter. • Some companies are shifting from desktops to laptops for their power-management capabilities.
3. Thermal load management	• Technology compaction in data centers has increased power density and the need for efficient heat dissipation. • Thermal load management strategies include variable cooling delivery, airflow management, raised-floor data center design, more efficient air conditioning equipment, ambient air, liquid heat removal systems, heat recovery systems, and smart thermostats [12][40].
4. Product design	• Microprocessor performance increased at approx. 50% CAGR from 1982 to 2002, but performance increases per watt over the same period were modest. • Energy use by servers continued to rise relatively proportionally with the increase in installed base [13]. • The shift to multiple cores and the development of dynamic frequency and voltage scaling technologies hold great promise for reducing energy use by servers. • Energy proportional computing concept takes advantage of the observation that servers consume relatively more energy at low levels of efficiency than at peak levels [3].
5. Virtualization	• Data center virtualization affects four areas: server hardware and operating systems, storage, networks, and application infrastructure. • Virtualization enables increased server utilization by pooling applications on fewer servers. Through virtualization, data centers can support new applications while using less power, physical space, and labor. This method is especially useful for extending the life of older data centers with no space for expansion. Virtual servers use less power and have higher levels of efficiency than standalone servers [3]. • Multiple operating systems can run concurrently on a host server which can be segmented into several "virtual machines", each with its own operating system and application. • For large data centers, server usage ranges from 5-10 percent of capacity on average. With virtualization, server workloads can be increased to 50-85 percent where they can operate more energy efficiently [3]. Less servers are needed which means smaller server footprints, lower cooling costs, less headcount, and improved manageability [31][38].
6. Cloud computing and cloud services	• The term "cloud computing" refers to a computing model that aims to make high-performance computing available to the masses over the Internet [30]. • Cloud computing enables developers to create, deploy, and run easily scalable services that are high performance, reliable, and free the user from location and infrastructure concerns [32]. • The "cloud" has long been a metaphor for the Internet. When combined with "computing" the definition turns to services [24] [36]. • As cloud computing continues to evolve it has increasingly taken on service characteristics. These services include utility computing, software as a service (SaaS), platform as a service (PaaS), and infrastructure as a service (IaaS) [8] [9].

3.2. Sustainable IT

The emergence of sustainable IT strategies is driving sustainability solutions beyond energy use and product and services considerations. Existing green computing strategies, which have been mostly inward looking and cost driven, would only indirectly impact sustainable IT strategies since they are not focused on benefitting

others. However, even those companies at the forefront of IT sustainability leadership define the concept in product terms. For example, Intel Corporation has defined IT sustainability as "encompassing the study and practice of using information and computing technology resources efficiently and effectively in ways that the planet can support indefinitely" [53]. This definition may imply engagement with and action for the benefit of stakeholders; but it more likely reflects Intel's product-oriented DNA that has a distinct green computing flavor. But it does open the door to services in a G-D logic way.

IBM's approach is more oriented toward sustainability as a service. IBM does not directly offer a definition for sustainable IT, but it does highlight the dependence of corporate sustainability strategies on the ability to leverage information from operations, supply chain, and customers [37]. They view customers as "partners in sustainability" and state that "collaboration with stakeholders, customers, and even competitors, is key in both setting standards for sustainability and in enabling the necessary transparency [37]. Since sustainability is a complex discipline the authors conclude that insight and engagement are necessary if effective action is to be taken. There approach is more consistent with S-D logic.

In addition to Intel's and IBM's corporate IT sustainability, there are many initiatives. For example, Dell's approach is producing energy-efficient products [7] to demonstrate their commitment to environment. Establishing basic compliancy programs is another step. ENERGY STAR is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy helping us all save money and protect the environment through energy efficient products and practices [50]. The Ecoleaf program in Japan which measures many more aspects of computer production [23]. For example, a label for a Fujitsu LifeBook laptop computer runs to two detailed pages full of sustainability data. The label shows an executive summary of "Life Cycle Impacts" and a breakdown of "Global Warming Impact" [16].

Moving toward an S-D logic related definition, we define sustainable IT as the application of IT knowledge and technologies for the benefit of customers and other stakeholders that enhances long-term mutual economic, environmental, and social well being. This definition encompasses the long-term importance of IT to the business organization, its customers (internal and external), other stakeholders, and society at large. To implement a sustainable IT orientation as defined would require a rethink of how IT organizations operate. IT would have to be much more interactive with its customers in terms of value co-creation and alignment with their business strategies.

4. Conceptualizing a Framework for Sustainable IT

When developing IT solutions, few IT organizations consider the full environmental impact of their product and service designs. One reason for this is the short-term orientation that puts emphasis on costs and business value. If reducing costs also has a beneficial environmental impact, such as the relationship between reducing power costs and carbon emissions; that will be given priority. However, organizationally, it is unlikely the IT organization itself can drive the sustainability priorities of other departments without the full support of top management. An integrated corporate-wide sustainability strategy is necessary for IT as a service to be truly sustainable. Then, it is possible for IT, facilities, supply chain management, manufacturing, finance, and marketing to all be acting in an integrated fashion.

Cost optimization was the primary emphasis of the first wave of green computing. Problems and solutions associated with green computing are well known. The second wave, which we call sustainable IT has a much broader focus on the role of IT in the society. The primary driver of sustainable IT is corporate social responsibility (CSR), especially as it applies to firm's impact on the economy, environment, and society at large [56]. These are three areas of responsibility are associated with "triple bottom line" or TBL reporting. The key tenet of corporate citizenship recognizes that an organization should ensure that its organizational objectives are in consonance with economic, environmental, and social goals of key stakeholders [39] [56].

4.1. A Strategy Oriented Framework for Sustainable IT

It has taken some time for an appreciation of the need for sustainable IT as a key element for aligning the IT organization with society and the overall corporate CSR strategy to develop. One reason for this is corporate approaches to CSR are fragmented and disconnected from business strategy [34]. This means CSR initiatives are often not effective and the greatest opportunities to benefit society and the company are not readily apparent. What is needed is an approach to CSR, and specifically sustainability in this instance, that uses the same framework that guides business strategy. Uncoordinated initiatives to reduce energy use, carbon footprints, limit pollution, and save water, may be great for the environment and look good on the annual report, but may not have much business impact if they are uncoordinated and lack an integrated approach.

For sustainable IT to be successful, an appreciation of the interrelationship between the IT organization and society must be strongly aligned with the strategies and activities of the corporation. So, there is a need for IT to not only align its efforts with business strategy, but for business strategy to be aligned with sustainability requirements. For this to be accomplished, the corporation must integrate a sustainability perspective into the same strategic framework used to identify new markets, develop new technologies, understand competition, and establish partnerships and alliances. This is not easily done, however the following steps adapted from Porter and Kramer should be considered [34]:

a. **Identifying points of intersection.** First, the points in the value chain of the IT organization and the corporation that are impacted by sustainability issues in the normal course of business need to be identified. These are called *inside-out linkages* where IT strategy impacts the environment. This could include everything from datacenter design, emissions, water use, and the application of IT to protect the environment. *Outside-in linkages* indicate where and how the external environment impacts the IT organization in terms opportunities, constraints, and risks. These factors impact a company's competitive context.
b. **Understanding the competitive context.** Competitive context refers to the quantity and quality of business inputs, the rules that govern competition, the size and sophistication of demand, and the availability and capability of business ecosystem members, especially members of the firm's value chain. The IT organization needs to understand the relationships and the how and where sustainability issues will impact.
c. **Choosing sustainability issues to address.** It would be impossible to deal with all potential sustainability issue facing the IT organization. The cost would be prohibitive and the likely results suboptimal. Alternatively, IT must select high impact issues that intersect with its key business initiatives. The choice should be influenced by the opportunity to create shared value that provides a meaningful benefit for the environment while providing value for the business. There is a continuum of sustainability issues that might be addressed. *Generic sustainability issues* might be important to society, but are not affected by or affect the IT organization. *Value-chain sustainability issues* impact the IT organization directly in the course of business. *Competitive context sustainability issues* are external factors that can significantly affect the competitiveness of the IT organization [35]. The goal here is to classify sustainability issues into these categories and then rank them in terms of potential impact.
d. **Creating a sustainability agenda.** The agenda should engage stakeholders to identify opportunities to achieve economic and sustainability benefits simultaneously. The sustainability agenda must choose between *responsive* sustainability and *strategic* sustainability. Responsive sustainability means being a good citizen by responding to stakeholder demands. Responsive sustainability typically deals with generic issues of little strategic value and value chain issues to mitigate risk. It does not impact the competitive context. Strategic sustainability raises the bar to focus on issues that directly impact the competitive context and transform value chain activities to enhance sustainability while supporting business strategy.
e. **Creating a sustainability dimension to the value proposition.** Sustainability cannot be a "bolt on" addition to the IT value proposition. To be successful it must be a core dimension of every activity that IT does. For example, a sustainable IT value proposition might include products and services that were developed using processes and materials that minimize their environmental impact. Or, an IT service might enable customers to work collaboratively on demand from any location, thereby minimizing travel and upfront infrastructure costs. Creating a sustainable IT as a service value proposition would be the logical extension of sustainable IT. Working collaboratively with customers to co-create new platforms and applications that create value-in-use that benefits the IT organization, the customer, and the environment would be an application of an S-D logic approach at its best.

4.2 Sustainable IT Strategy Dimensions

Few companies have developed a sustainable IT strategy that rises to an enterprise-level or focuses on social responsibility goals [30]. Although organizations are changing their policies and practices to minimize their environmental impact, such efforts are generally not well organized or integrated. Many environmental projects have been undertaken due to customer safety concerns, legal action, legislation, regulation, community pressure, and to protect the brand. A sustainable strategy should be one that is complementary to both the business and the environment. Table 4 shows strategy dimensions that should be considered for developing strategy for sustainable IT.

Table 4. Strategy Dimensions of Sustainable IT.

Sustainable organizational culture	• An organizational culture based on environmental sustainability can drive sustainable solutions throughout the organization. By fostering a common culture employees will become aware of issues, opportunities, actions required to achieve a desired result [30].
Sustainability goals and objectives	• Clear enterprise-level sustainability goals and objectives will enable the IT organization to align decisions with corporate business strategy. Companies should be able to strengthen their competitiveness while simultaneously protecting the environment [30].
Products and services design issues	• Clean technology is new technology that addresses environmental problems. It differs from "end-of-pipe" greentech" clean up technology. Cleantech segments include green energy, transportation, water and wastewater, air and environment, materials, smart manufacturing, agriculture, recycling, and waste (www.cleantech.com). • Design for environment (DfE) priorities are energy efficiency, water and air management, materials innovation, and the reduction of toxic elements [4][10]]. • Design for recycling (DfR) requires that products that use modular and intelligent designs to facilitate upgradeability, reuse, dismantling, and recycling [4][6][19]. • Asset decommissioning. When products no longer are needed by a firm they should be easily decommissioned and recycled. They might also be re-manufactured and remarketed or redeployed [4][6]. • E-waste minimization and disposal. Strategies include product take-back programs, waste management and recapture of critical materials, and secure disposal [19].
Sustainable processes	• A sustainable IT strategy must extend throughout the value chain to include the supply chain, distribution channels, manufacturing, operations, and marketing. All of these functions rely on IT and their processes can affect IT's environmental impact. A holistic collaborative approach is needed to ensure that IT and all the other functional areas of the firm are all working toward the overall enterprise sustainability goals [4].
Corporate social responsibility (CSR) road map	• The IBM Institute for Business Value has developed the CSR Value Curve [33] which provides a road map to CSR-driven business growth. IT depicts the milestones on the maturation curve as businesses move up the CSR continuum from low-value compliance activities to the high-value CSR growth platform. • Legal and compliance. The organization adheres to CSR-associated requirements for production, operations, and distribution. • Strategic philanthropy. Charitable activities are aligned with social issues to support business objectives. The purpose it to make stakeholders aware of the company's efforts and reinforce its social commitment. • Values-based self regulation. The company's value system becomes more aligned on environmental and social responsibility. A code of conduct typically guides business activity. • Efficiency. Companies look for major cost savings through efficient scenarios. • Growth platform. CSR strategies provide access to new markets, partnerships, and product/service innovations that generate revenue and profit.
Reporting	• Engagement with stakeholders is essential for an effective sustainability strategy. Information transparency provides customers, employees, business partners, investors, community members, non-governmental organizations (NGOs), and the government with a report card on how the company is doing with its sustainability commitments. It is through continuing engagement with stakeholders that this information helps form long-term relationships. Trust-based relationships informed by good public relations and customer satisfaction can build superior brand power.

5. Conclusions

The first wave of green computing strategies focused on increasing data center efficiency. Infrastructure costs, power and workload management, thermal management, product design, virtualization, and cloud computing strategies remain the central focus of business value oriented strategy and tactics that have had the desired effect of lowering costs and environmental impact in terms of energy use. The emerging second wave of sustainable IT services is not well defined. It undoubtedly will require the integration of IT sustainability initiatives with the enterprise's overall CSR and especially the corporate sustainability strategy. It will involve establishing a roadmap and baseline metrics, redesigning business processes, encouraging engagement with customers and various stakeholders, and adapting the organization's culture to new ways of thinking and doing things [53]. As can be seen in Figure 1 below, IT strategy will be subject to influences that are numerous and complex. IT strategy will need to become more transparent and more integrated with corporate strategy.

This paper has argued that sustainable IT strategy should move from its current focus on green computing products and services and the emphasis on the creation of business value to a service orientation that focuses on full engagement and collaboration with the customer and various other stakeholders to co-create long-term customer and societal value. A framework for sustainable IT, adapted from Porter and Kramer, is proposed for integrating societal sustainability requirements with business economic goals.

Much work remains to be done in defining the emerging discipline of sustainable IT. Clearly tools for

better collaboration will be involved. It is also likely that the real impact from sustainable IT will not be from discovering new ways to more efficiently deploy the physical infrastructure, computers, and software that are commonly associated with IT. It will be from the development of innovative uses of computing power and IT knowledge to actually solve heretofore intractable environmental and social problems.

Future research should address the relationship between customer value, business value, and societal value and how they can be redefined to reflect value-in-use instead of the value-in-exchange static approaches to value measurement that are featured in most marketing and economics research studies. Research is needed to define the dimensions of sustainable IT as a service and to fully explore its implications in a S-D logic orientation. Finally, research is needed on the changing role of the IT organization itself. It has been moving from a product-orientation to that of a services provider. However, the IT organization still thinks in terms of products and services as products, a G-D logic paradigm. What steps are needed to truly morph IT into a service organization?

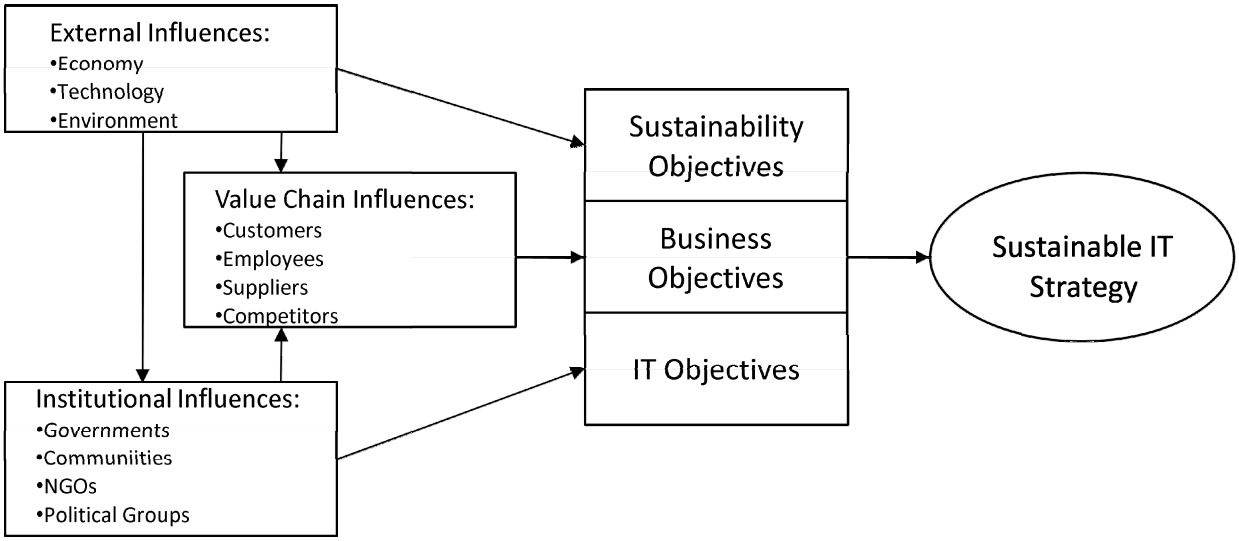

Figure 1. The Influencers of Sustainable IT Strategy

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