Managing Disruptive and Sustaining Innovations in Green IT

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Green IT has gained significant attention, but specific guidance on how to implement and manage various green IT initiatives is largely underdeveloped. A new framework helps by classifying green IT used in organizations as sustaining or disrupting innovations.

What are the different types of green IT innovations, and what strategies help in effectively managing them? To address these questions—which are among the chief concerns of IT organizations—we present a framework that outlines strategies for managing green IT innovations.

Green IT initiatives can range from those that focus on reducing IT infrastructure's carbon footprint to those that transform a business. Green IT can be deployed to support a variety of sustainability initiatives, such as those to measure carbon footprints, monitor the environmental impact of business practices, reduce waste in business processes, lower resource consumption, or increase energy efficiency and reduce greenhouse gas emissions.[1] Although most organizations engage in sustainability initiatives to comply with regulations and mandates, green IT also presents opportunities to create and deliver innovative products and services that enable a broader sustainability strategy.

Organizations must remain innovative to maintain and achieve a competitive advantage.[2] To help managers and IT professionals better understand and effectively manage the different types of green IT initiatives, our framework classifies such initiatives according to their focus and the nature of organizational changes they aim to implement.

A Framework for Green IT

Figure 1 shows our framework for examining green IT initiatives.

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Focus of Change: Internal vs. External

To examine the focus of organizational changes at the center of green IT initiatives, we draw from prior literature that relates organizational competitiveness to sustainability and green IT.[3,4] Our framework thus categorizes initiatives into two areas of competitive focus: internal (IT infrastructure and operations) and external (IT-enabled delivery of products and services).

The internal focus of change refers to the environmental efficiency of an organization's IT activities, from sourcing through operations to end-of-life management. For example, some organizations implement initiatives to reduce power, cooling, and real estate costs and increase data center efficiency to make their IT infrastructure more sustainable.

The external focus of change refers to products developed or services provided by the IT organization through which the organization can achieve sustainability. Because much of a modern organization's operations are IT enabled, using sustainable IT services can significantly reduce the organization's environmental footprint. For example, IT can help improve efficiency and reduce waste in business processes or help radically redesign such processes to make the organization more sustainable.

Nature of Change: Sustaining vs. Disruptive

We consider two types of innovations from the literature on organizational innovation to examine the nature of organizational change: sustaining and disruptive innovations.[5] Some green IT initiatives are considered routine—that is, they sustain innovations by incrementally improving existing processes (both within IT and throughout the rest of the organization). Other green IT initiatives, however, cause dramatic changes either in the technology used or in the IT-enabled implementation of business processes. Such initiatives might initially seem to lag behind in fulfilling existing customer demands, but they have the potential to disrupt an entire industry if they can capture emerging markets.

Sustaining innovations tend to maintain a rate of improvement in the attributes the customers already value. Disruptive innovations introduce a very different package of attributes from those that mainstream customers historically value and thus often perform worse along one or two dimensions of particular importance to those customers.[5] Such innovations have the potential to disrupt industries, because the new features they offer help develop new markets as well as rapidly capture existing markets.[6]

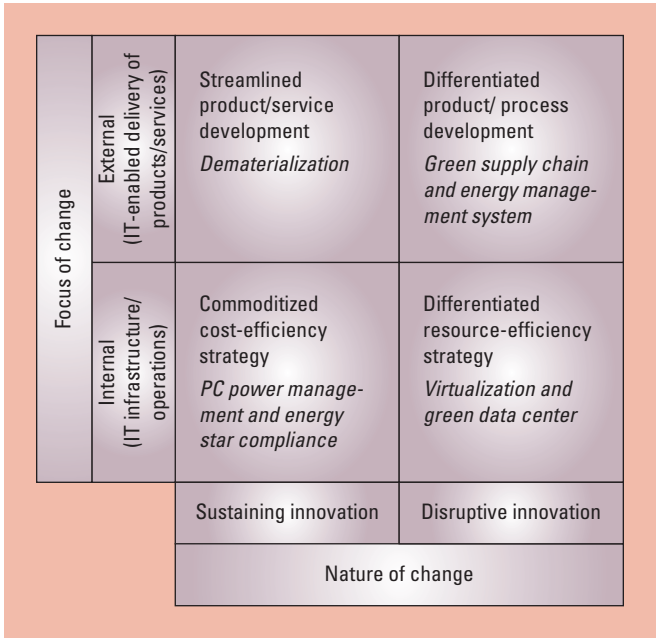

Figure 1. The green IT framework. Different types of green IT initiatives are classified according to their focus and the nature of organizational changes they aim to implement.

In the context of green IT, cloud computing is an example of a potentially disruptive technology with profound implications not only for Internet services but also for the IT sector as a whole. Its emergence promises to streamline the on-demand provisioning of software, hardware, and data as services, achieving economies of scale in the deployment and operation of IT solutions.[7] Cloud computing might still be in early stages of adoption, but the widespread interest of IT professionals suggests that it could reach the level of widespread adoption and indeed claim "disruptive technology" status.

Strategies for Green IT Innovation

As depicted in our framework in Figure 1, we identify four strategies for organizations to pursue green IT innovation.

A Commoditized Cost-Efficiency Strategy

A strategy that aims to achieve cost efficiency by streamlining the IT infrastructure's energy use supports initiatives that can be commoditized

because they're relatively easy to replicate, which isn't always the case with the other three strategies identified in our framework. These strategic initiatives usually pass muster with conventional performance metrics, such as cost and speed.

One example of this strategy is to focus on PC power management and Energy Star compliance. (Energy Star is a joint program of the US Environmental Protection Agency and US Department of Energy, and it specifies standards for energy-efficient consumer products.) Consider FedEx, which saved US$1 million and prevented 9,500 tons of carbon dioxide emissions annually by activating power management features that place computers and monitors in a low-power mode after a period of inactivity.[8]

Enabling power-management features usually requires a relatively low investment and can be routinely implemented in organizations. However, critical challenges in implementing such initiatives include encouraging user participation, gaining top management support, and performing the appropriate testing. Centralized PC power management can result in significant cost savings, which can be further amplified by using equipment that's compliant with energy-efficiency standards such as Energy Star, which specifies ranges of energy-efficiency requirements for different types of IT infrastructure.

The greening of data centers is driven not only by the cost and power requirements of IT equipment but also by resource constraints.

A Streamlined Product/Service Development Strategy

A strategy centered on using IT to reduce the material inputs of business processes aims to lower the environmental impact. Although initiatives in this strategy can be implemented relatively easily, significant customizations are necessary to handle the variations in affected business processes. Innovations used in this strategy are sustaining, because they concentrate on well-established markets and current customers and seek to satisfy traditional performance metrics.

For example, this strategy would support dematerialization through process automation. Converting manual business processes to digitally enabled processes can reduce costs and environmental impacts. To speed up shipping, FedEx started digitizing documents prior to shipping.[9] It then printed the files at a location near the final destination prior to the physical delivery. Reducing printed statements and bills, digitizing organizational workflows, and better managing printing can not only reduce costs but also demonstrate an environmental consciousness. In addition to the use of paper, printing involves costs pertaining to ink, the acquisition and maintenance of printing equipment, photocopying, filing, the retrieval of lost documents, and document destruction. Reengineering critical steps in the digital printing workflow from file creation to output will likely improve speed, efficiency, and turnaround times and reduce costs.

A Differentiated Resource-Efficiency Strategy

This strategy centers on the efficient use of resources in managing IT infrastructure. It's disruptive because it shifts from the traditional assessment of IT infrastructure based on conventional metrics such as the cost-performance ratio to include metrics such as a cost-sustainability ratio. This strategy considers factors such as organization-wide challenges, resource limitations, user needs, and the balance between short- and long-term orientation. This strategy helps organizations differentiate themselves from their competitors by leaping beyond the requirements of current regulations and standards such as ISO 14001. In fact, it might even help organizations shape future regulations.

Green data centers and virtualization are examples of this strategy. The greening of data centers is driven not only by the cost and power requirements of IT equipment but also by resource constraints such as a lack of real estate for the data centers, the strain on electrical grids, and the density of power usage in data centers. Energy consumption of data centers is 15 to 25 times more than that of a typical office building. Data center design involves considering not only the type of IT equipment but also its cooling needs. Typically, 50 percent of the electricity consumed in data centers is used for cooling.

Organizations that need sophisticated data centers have been touting significant improvements in their data center design. Metrics such as *power usage effectiveness*, which refers to the ratio of total power to IT equipment power, are gaining significance. Physical design considerations—such as hot and cold aisles, cabling, the use of appropriate economizers, and the location of data centers based on power congestion status—can significantly reduce costs, as can the selection of appropriate types of servers and virtualization. The latter involves sharing a single piece of hardware to run multiple guest operating systems, which, in turn, run several software services. Virtualization addresses the problem of server underutilization, because servers in data centers typically use only 10 to 15 percent of their total processing capacity. Virtualization reduces not only the number of servers needed to support software services; it also reduces the need for additional space.

A Differentiated Product/Process Development Strategy

Applying IT solutions to radically redesign business processes to differentiate an organization's products and processes is a disruptive strategy that can help an organization develop new products or deliver services more effectively. Here, IT alters the status quo by advancing sustainability-related metrics in addition to traditional ones.

Although the strategic use of IT to implement novel business models has long been advocated, this strategy emphasizes how IT enables sustainable business processes. The differentiation might require collaboration among multiple stakeholders within or across organizations, making its replication by other organizations challenging.

Green supply-chain and energy-management systems are two examples that this strategy supports. Strengthening alliances across different parties involved in supply chains can enhance information sharing to help organizations better manage their inventory. Using IT to manage supply chains can help significantly reduce waste and obsolescence of inventory.[10] IT-enabled supply-chain management can increase visibility across the supply chain, reducing the adverse impact of the *bullwhip effect*[11]—that is, the amplification of the demand-order variabilities in a supply chain resulting from the distortion of information from one end of the supply chain to the other. Effective use of IT can reduce the information asymmetry that causes the bullwhip effect and reduce inefficiencies in the supply chain.

IT-enabled supply chains can also benefit from traceability—the ability to trace the life of any product that traverses the supply chain—and can help identify product sources. For example, it can help prevent hazardous or contaminated substances from entering a food chain.[10]

Carbon-footprint accounting has become significantly more challenging due to the globalization of sourcing, prompting both hardware and software-based initiatives to enable a sustainable supply chain. Solutions range from RFID-based tracking of inventory (to account for carbon footprints to collaborative planning, forecasting, and replenishment, and the implementation of the supply-chain operations reference model. Organizations that manufacture computing equipment claim to promote sustainability by maximizing product energy efficiency, reducing and eliminating sensitive materials from their products, and providing responsible and convenient computer recycling options for customers.

IT-enabled supply-chain management can increase visibility across the supply chain, reducing the adverse impact of the *bullwhip effect*.

Most modern nonresidential buildings have Energy Management Systems (EMS) that use automatic controllers and a central processor. Advanced EMS facilitate trending and monitoring that can be used to improve energy use. Organizations (such as the International Organization for Standardization) that develop standards have begun launching initiatives to develop international energy management standards. Technologies such as Cisco's Energy Wise and Silver Stream Networks' smart energy platform cater to comprehensive energy management needs of large organizations and utilities.

The Value of Green IT Initiatives

Internally focused strategies (commoditized cost efficiency and differentiated resource efficiency)

provide value in terms of improved operational performance through cost savings in energy and raw material costs. They might also provide additional benefits such as reduced business risks through compliance with regulations.

On the other hand, externally focused strategies (streamlined product/service development and differentiated product/process development) focus on generating growth by creating products and services that command a premium in the marketplace. They might also save costs by optimizing product and service development activities.

Recommendations for Managing Green IT Initiatives

In practicing green IT, organizations can benefit from recommendations drawn from the literature on disruptive innovations.[12] We identify several recommendations that top management and IT professionals can apply to effectively implement and manage green IT initiatives.

Implementing disruptive innovations requires a radical redesign of IT operations and business processes.

Offer Early-Stage Support

It's important to identify and support early-stage disruptive green IT initiatives. The nature of innovation (sustaining or disruptive) should guide organizations in their strategic responses to these innovations.

The first step is to identify disruptive green IT initiatives.[5] Companies should assess such initiatives according to new metrics that consider the innovation's potential for disruption. Companies must understand that adopting disruptive green IT is a dynamic process that involves a staged evolution of IT innovation—from infancy, when deployment might compromise performance, to a stage that's mature enough to displace incumbent technologies based on conventional performance metrics.[13] During early development, disruptive technologies only serve niche segments of eco-efficiency, yet they can have a higher cost or inferior performance. The green IT initiatives at this stage need strong support from top management to survive.

Over time, further development raises the green IT initiatives' performance until they can finally displace the mainstream technology. For example, Google Docs is attempting to displace traditional desktop word processing by moving it to the cloud. Although it might currently suffer from its lack of feature richness, this could rapidly change as the technology evolves. When this happens, Google Docs might become disruptive enough to displace incumbent technologies, as evidenced by initiatives from dominant players—such as Microsoft, which aims to move MS-Office products from the desktop to a cloud-based environment. Companies must recognize this evolution and put in place mechanisms that will foster rather than discard the innovation, regardless of its initial performance.

Develop an Organization-Wide Strategy

Sustaining innovations often focus on improving operational efficiency—typically by lowering the IT infrastructure operating costs or by digitizing business processes—so it's usually easier for organizations to implement them. Disruptive innovations, on the other hand, require radical rethinking. For example, the implementation of a differentiated resource-efficiency strategy requires investments in new infrastructure, which might replace existing infrastructure. Similarly, the IT-enabled development of differentiated products and services requires a radical redesign of core business processes.

Implementing disruptive innovations requires significant resource commitments and radical redesign of IT operations and business processes, so it's likely to face organizational resistance and inertia. However, in contrast to incremental improvements provided by sustaining innovations, disruptive innovations offer the potential for significant resource efficiencies and competitive advantages. Therefore, it's important for organizations to develop an organization-wide strategy to nurture an environment that fosters disruptive innovations in green IT as opposed to pursuing fragmented case-by-case solutions.

Develop Broad Organizational Commitment

A broader organizational commitment by top management is critical for managing green IT initiatives.[14] Organizations can demonstrate

their commitment by assigning sustainability-related roles to senior management or putting in place carbon reporting mechanisms.

For example, Georgia Pacific appointed a chief sustainability officer (CSO) with "green responsibilities" who reports to the CEO.[15] The CSO is responsible for developing and implementing sustainable strategies, goals, measurements, and reports, and he or she represents the company in external sustainability discussions with customers and other groups. Several other major corporations, such as Dow Chemical, Du Point, Owens Corning, and Home Depot, have taken on similar initiatives.

Also, as part of sustainability efforts, more companies are reporting the business implications of climate change to their stakeholders. Such reporting involves significant commitment from top management to corporate social responsibility initiatives that include measurement, control, and reporting of sustainability data and the development of a culture and system that will enable stakeholders to align their goals with corporate social responsibility.

This suggests a shift in focus from the more traditional financial organizational performance metrics to considering a balanced triple bottom line. Such an approach, and proper alignment between corporate and IT strategies, will prompt an IT-savvy organization to consider green IT initiatives seriously.[16]

Overcome Incumbent, Institutional Forces

Organizational inertia and unwillingness to cannibalize existing technology can stifle disruptive innovations. Other factors that might discourage disruptive innovations include the

- legacy technology's inherent limits, which might prevent adaptation from matching the capabilities of disruptive technologies;
- new technology's inability to meet traditional performance metrics;
- existing staff's lack of enthusiasm in mastering new skills;
- influence of consumer needs on technology development;
- organization's business strategy, and
- broader evolution of technological trajectories.[13]

To address these challenges, top management can structure different types of innovations into independent organizational units to mitigate the resistance to adopting disruptive innovations that might come from within the organization.

Trajectories followed by the industry's dominant players might also explain resistance to embracing disruptive innovations. Dominant players focus on innovations that are sustaining rather than disruptive as they continue to develop high-performing solutions to support sophisticated users. In comparison, start-up companies focus on disruptive technologies that target entry-level users. Because such technologies eventually disrupt the status quo by displacing the sustaining innovations, organizations need to put in place mechanisms to not only encourage bottom-up development of disruptive innovations but also scan their environment to better understand the focus of dominant players and opportunities for disruptive innovations.

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Balance Disruptive and Sustaining Initiatives

Sustaining innovations focus on efficiency, whereas disruptive innovations focus on organizational effectiveness. Very few organizations can achieve organizational ambidexterity,[17] which is the ability to simultaneously pursue both efficiency- and effectiveness-focused strategies. However, the dynamic nature of the landscape characterizing green IT offers significant benefits to organizations that achieve ambidexterity. Therefore, it's important for IT organizations and senior executives to create organizational incentives and a culture that supports and nurtures the pursuit of both objectives.

Specifically, some organizations may find it more appropriate to structurally separate organizational units that pursue disruptive innovations. For example, organization-wide sustainability initiatives might often necessitate creation of independent sustainability offices with a designated CSO. Others might be able to create incentives that encourage all organizational entities to

pursue both goals simultaneously. For example, IT departments typically don't designate personnel with only sustainability-specific roles. Every role will likely involve some sustainability-related responsibilities.

Differentiate Internalized and Externalized change

Internalized change refers to sustainability-focused changes within the IT department that focus on the IT infrastructure. Externalized change refers to changes in the business services provided by IT to address sustainability issues. This is consistent with the competitive environmental strategies framework that identifies organizational processes (internalized) and products and services (externalized) as two elements of competitive focus.[4]

Organizations must understand the key differences in strategies and mechanisms that enable the two types of changes—internalized and externalized. Internalized changes might have relatively lesser impact on the users that IT caters to, and the decisions primarily revolve around capabilities and resources available for the IT department to move in the direction of sustainable operations. Externalized changes involve a wider range of stakeholders, because these changes might directly affect the execution of key business processes in which several layers of users are involved.

Such changes must be orchestrated with a broader view of strategic deployment of IT resources to green business processes. Knowledge sharing and collaboration across different organizational units and strong top management commitment become critical success factors.

Consider the Risks

Organizations that implement sustaining and disruptive innovations in green IT should also consider some of the risks involved. Disruptive innovations might result in the organization changing direction from a planned and established roadmap, thereby increasing the risk of adopting solutions that might not gain traction in the marketplace. Also, adhering only to sustaining innovations at the expense of promising disruptive innovations might render an IT organization obsolete and unable to catch up with evolving regulations.

Our framework suggests that, depending on the nature and focus of various initiatives, organizations should tailor their structure and processes to foster—not stifle—innovation. While the focus of this article is to provide a conceptual foundation to understand the nature of green IT initiatives, detailed studies of organizations pursuing initiatives in the four quadrants in our framework is the subject of ongoing research.

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