In 2009, John Lamb described green IT as “the study and practice of using computing resources efficiently.”¹ Last year, San Murugesan provided a more comprehensive definition:

Green IT [is] the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems (such as monitors, printers, storage devices, and networking and communications systems) efficiently and effectively with minimal or no impact on the environment.²

These definitions underscore green IT’s initial focus on reducing the carbon emissions emanating from IT equipment and infrastructure. However, there are greater opportunities in the green IT domain arising from IT’s potential to reduce carbon emissions emanating from the entire organization.

According to the Smart 2020 report, green IT could save 7.8 gigatonnes of carbon dioxide equivalent in 2012 (that’s 15 percent of all green house gas emissions).³ In exploring green IT practices and their impact, three different time-frames emerge (see Figure 1), revealing current and future trends for this growing field.⁴

**Immediate Trends**

Current green IT trends are characterized by attempts—primarily by IT management—to more efficiently and effectively use IT resources to reduce the environmental impact. However, individual users can also influence green IT by making simple changes in their daily activities (such as switching off monitors, minimizing printing, or using recycled paper and toner).

Immediate green IT trends including the following:

- implementing smart operating systems and associated software (such as Greentrac.com) that automatically turn off desktops, laptops, and other individual user devices when not in use;
- using smart meters (such as EnviR; www.currentcost.com/product-envir.html) not only to measure and relay emissions in real time but also to reduce emissions by encouraging more efficient use of equipment;
- implementing centralized solutions to manage numerous computers in organizations to enable efficient uploads and downloads, and selective startup and automatic shutdowns based on various organizational policies;
- efficiently using printers by defaulting to the draft printing setting, printing double sided, and recycling ink cartridges;
- optimizing data servers and desktops through virtualization;
- replacing old computers, monitors, and network devices with low-power-consuming and low-carbon-emitting devices;
- using spreadsheets to collect and disseminate standardized carbon data;
- using mobile technologies to collect and disseminate in real time carbon emissions data pertaining to the organization, thereby eliminating the duplication of and errors in carbon data; and
- raising awareness among user groups of environmental sustainability and green IT through basic training.

These trends are currently occurring in organizations worldwide.
Medium-Term Goals
Over the next few years, green IT will try to capitalize on the promise of IT to reduce carbon emissions across all organizational processes and methods. Close alignment of green IT with business processes, goals, and standards opens up opportunities for businesses in the economics of energy efficiency. Green IT improves processes (such as supply chains) and applies standards (such as ISO 14001) in all areas of business.

Figure 2 compiles results from a survey that Bharti Trivedi and I conducted last year.5,6 For many CIOs, environmental considerations are a top strategic priority, which the following medium-term trends reflect.

Optimize Business Processes
Many organizations plan to apply new (or extend current) business optimization processes (such as the Lean Six Sigma business management strategy). As Figure 2 shows, 66 percent of survey respondents agreed (12 percent of which “strongly” agreed) that organizations need a formal method for controlling carbon emissions. A “Lean-Green” approach can combine business optimization processes with green computing practices.

Implement Standards
Standards serve as the basis for most environmental management systems. ISO 14001 defines an EMS as

...part of the overall management system, which includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving and maintaining the environmental policy.8

In the medium term, this standard will provide not only a basis for internal and external EMS implementation but also a starting point for comparing organizational green maturity. I anticipate further modification to this standard to enable its application to a full industrial sector rather than to just an organization.

Apply Metrics
Green metrics (to determine the return on investment) and total-carbon-cost-of-ownership (TCCO) metrics will provide sophistication in both procurement and operational decisions relating to equipments, buildings, and other infrastructure.

Starting with desktop machines, laptops, mobile phones, and printers, TCCO calculations will permeate the data servers, building, infrastructure, and costs associated with disposals. Electronic waste disposal will be closely tied with carbon measurements, starting with the design and production of the equipment and its procurement, operation, and disposal costs.

Exploit Social Networking
Many organizations will try to capitalize on social media networks. Applications that generate public opinion, provide information
on standards, or facilitate crowdsourcing (in which a member of the “crowd” reports on wastes such as street lights on during the day, an oil spill in the neighborhood, or the improper disposal of batteries or mobile phones) will be popular in reducing carbon emissions.

Apply New Software and Services
Increasingly, data gathered for statutory reporting purposes will be collated, paving the way for comprehensive carbon emissions management software (CEMS). Embedding environmentally conscious green policies and procedures within enterprise resource planning (ERP) applications using service-oriented-architecture Web services will result in green customer-relation management, green supply-chain management (SCM), and their integration with CEMS. Sixty percent of respondents agreed to apply such policies and support the corresponding funding arrangements (see Figure 2). CEMS should also help with real-time calculations, reporting, compliance, and the amelioration of energy consumption.

In addition, organizations will place greater emphasis on carbon-based Web services and their interfaces and integration. These interfaces will facilitate correlations across various other information silos of the organization to produce actionable knowledge and environmental intelligence. EI will comprise data warehouses, analytical tools, and reporting tools and will combine existing business intelligence systems and organizational processes with tacit green knowledge.

Use Renewable Energy Sources
Organizations will search for renewable sources of energy, such as solar, wind, and nuclear power. Increased sophistication in carbon reporting systems will make it easier to select an energy source and identify the effects of that choice.

The Long-Term Outlook
Identifying future trends in a domain that’s constantly changing is challenging. However, by reviewing the green IT principles, strategies, and practices that organizations are currently and rapidly adopting, we can start to identify some of the longer-term trends in green IT.

A New Attitude
Green IT’s long-term impact will be realized through portals that support decision-making for employees, customers, and partners with respect to environmental issues. As green IT tries to capitalize on changes in people’s attitude, we’ll likely see an increased focus

Figure 2. Strategic plans for green IT in the next two to five years.5,6

<table>
<thead>
<tr>
<th>Approach</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of power-management software</td>
<td>37%</td>
</tr>
<tr>
<td>Adopt a methodology to undertake suitable and defensive power consumption</td>
<td>50%</td>
</tr>
<tr>
<td>Create power-management policies to reduce energy consumption</td>
<td>50%</td>
</tr>
<tr>
<td>Modify current business processes to incorporate environmental needs</td>
<td>34%</td>
</tr>
<tr>
<td>Seek external help for upgrades to a greener business system</td>
<td>35%</td>
</tr>
<tr>
<td>Develop training plans and budgets to help employees understand green issues</td>
<td>44%</td>
</tr>
<tr>
<td>Dedicate investment funds to incorporate green policies</td>
<td>37%</td>
</tr>
<tr>
<td>Document targets for carbon footprint reduction</td>
<td>39%</td>
</tr>
</tbody>
</table>

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree
on equipment and infrastructure designs that mimic the natural world and thus reduce carbon emissions by virtue of those designs rather than only through operational efficiencies. Nature is inherently carbon neutral—and the biomimicry domain aspires to reflect that carbon neutrality in the architecture and design of computing and other equipment.

Carbon Trading
The next three to five years will see substantial creation and application of power management policies that are based on the integration of the new CEMS with existing organizational systems (typically ERP packages, such as customer-relation management). CEMS will also support carbon trading on carbon stock exchanges, maturing into systems-based automated trades monitored and enforced by law. Organizational equipment (including monitors, desktops, mobiles, and vehicles) will be indexed by corresponding carbon contents related to its design, production, procurement, usage, and disposal. James Bradfield Moody and Bianca Nogrady refer to this anticipated “Carbon Age” as the “Sixth Wave.”

A Collaborative Green Space
The integration of CEMS with existing ERP systems and with collaborating partners and regulators will result in dynamic collaborations amongst organizations, governments, industry and research organizations, and standards bodies. Government bodies (local, state, or national) will collaborate as they fine-tune the permissible levels of emission, and generic international bodies such as the Intergovernmental Panel on Climate Change will continue to research ways to reduce emissions. Furthermore, standards bodies such as the ISO will extend and advance the 14000 family of standards to go beyond the organization and into globally comparable industry sectors.

Trust and security will remain a concern, but cloud computing will enable businesses to successfully shift their non-core (typically non-IT) resources outside the organizational boundary.

Finally, EI systems will pull in organization-specific information from systems outside organizational boundaries (such as from a partner organization’s systems or an SCM system) and from government and related regulatory databases and standards.

A recurring theme in these green IT trends is synergizing business and carbon objectives. Successful green IT initiatives will have to provide value to the business by enabling carbon-efficient processes, systems, technologies, and work practices. Carbon reduction is no longer just a business overhead; it’s an all-encompassing and holistic business strategy that closely aligns with an organization’s business goals.

Nature is inherently carbon neutral; biomimicry aspires to reflect that neutrality in the architecture and design of computing.

References
3. “Smart 2020: Enabling the Low Carbon Economy in the Information Age,” The Climate Group, 2008;

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