Can More Efficient IT Be Worse for the Environment?

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In efforts to reduce energy usage, IT professionals must ensure that efficiency aligns with sustainability.

In his 5 October 2009 executive order, "Federal Leadership in Environmental, Energy, and Economic Performance," US President Barack Obama called for increased energy efficiency as part of the federal government's "integrated strategy towards sustainability" (www.whitehouse.gov/assets/documents/2009fedleader_eo_rel.pdf). While researchers generally agree that energy efficiency leads to short-term economic prosperity, there is a lack of consensus that it actually makes civilization more sustainable. Broad awareness of such ambiguity could help computing professionals and society at large reassess current priorities in this effort.

Understanding the role that energy efficiency can play in enabling IT to serve sustainability is critical, both to the computing industry and to the global ecosystem. The information and communication technology sector accounts for 2-2.5 percent of global CO_2 emissions and is growing rapidly.

IT supports a gamut of human endeavors, and as such has very broad effects. The Climate Group's 2008 report *Smart 2020: Enabling the Low Carbon Economy in the Information Age* suggests that this sector can offset five times its own carbon footprint by enabling efficiencies in other facets of society (www.smart2020.org/_assets/files/02_Smart2020Report.pdf). On the other hand, making IT more efficient can also contribute to unsustainable economic growth and related environmentally harmful activities.

ENERGY EFFICIENCY AND SUSTAINABILITY

Energy efficiency can be defined in many ways, ranging from narrow and technical to broad and inclusive. According to the US Department of Energy's Energy Information Administration, "increases in energy efficiency take place when either energy inputs are reduced for a given level of service or there are increased or enhanced services for a given amount of energy inputs" (www.eia.doe.gov/emeu/efficiency/ee_ch2.htm).

Sustainability is still more difficult to define. A sustainable system is, in the simplest terms, one that continues to exist over time. In the context of green IT, sustainability is shorthand for "global environmental sustainability," a characteristic of Earth's future in which certain essential processes persist for a period of time comparable with human lives. Exactly which processes these are, and how long they must persist, are subjects of considerable debate. However, potentially useful criteria include the continuation of the human species at a relatively high quality of life for thousands of years, the restriction of humanity's exploitation of the global ecosystem to a rate that does not exceed the rate of renewal by other factors, and a species extinction rate no greater than average across a geologic timescale.

As a practical matter, absolute sustainability is too high a bar; it is more useful to discuss whether IT systems are "aligned with sustainability" or "sustainability-directed"—that is, more sustainable than the systems they supplant. Reducing CO_2 emissions is often a proxy for moving toward sustainability because the reduction of greenhouse gasses is a key factor in mitigating global climatic disruption, an environmental problem central to all three sustainability criteria.

DIRECT AND INDIRECT EFFECTS

Many factors influence whether a given effort to increase energy efficiency aligns with sustainability. Considered narrowly, energy efficiency appears to help us live more sustainably because it enables a system to expend less energy to achieve the same end result, leading to reduced carbon emissions.

However, several indirect effects also play a role. For example, decreasing the cost of energy usage embodied in a particular product could cause consumers to buy more of that product. The savings could also end up in the pockets of shareholders or consumers, who will then use them for other purposes—to buy different goods, invest elsewhere, and so on. A decrease in energy price could also lead to entirely new industries; the Internet, for example, might not have evolved into its present form if energy had been significantly more expensive during the past several decades. Taken together, these indirect efficiency effects can sometimes account for more environmental harm than was averted by the original savings.

English economist William Stanley Jevons first recognized the potential for this energy efficiency "backfire" in 1865, when he noted in *The Coal Question* that improvements in steam engine technology paradoxically led to increases, rather than decreases, in coal usage as new industries started using such engines. In recent decades, there has been vigorous discussion of the direct and indirect impacts of increased energy efficiency. Researchers have developed an array of quantitative techniques for tracing indirect effects across different economic sectors, but there are still relatively few contexts in which the sum total of these effects has been examined, let alone established definitively.

The time lag before many indirect effects manifest themselves further complicates analysis. While the direct benefits of efficiency help reduce current energy use, the indirect effects accrue over an indefinite period of time into the future. Efficiency can thus arguably "buy us time" to develop lower-carbon energy sources and enact broad-scale change. However, if society uses such bought time to conduct business as usual, efficiency could ultimately make the problem worse.

Whether the time-discounted value of all the various direct and indirect effects for a particular efficiency adds up to an environmentally positive or negative result, efforts to calculate sustainability implications must consider temporal factors. Combined with the difficulty in even roughly estimating various indirect effects, the fact that many effects might not fully emerge for years or even decades suggests that, in most cases, the relationship between energy efficiency and sustainability is ambiguous.

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Assessing sustainability impacts for IT energy efficiency is particularly difficult. As a general-purpose technology (GPT), IT influences many sectors of industry and aspects of society. For example, making server technology more energy efficient is likely to produce efficiencies across a vast array of contexts. To assess total IT efficiency accurately would entail understanding each of those contexts to a greater extent than is currently feasible. Even if such knowledge was attainable, it would likely be both publicly unpalatable due to privacy issues and directly opposed to various facets of corporate law.

However, a 2007 report by the UK Energy Research Centre, *The Rebound Effect: An Assessment of the Evidence for Economy-Wide Energy Savings from Improved Energy Efficiency*, suggests that efficiency-improvement efforts aimed at GPTs are more likely to rebound than those aimed at specialized technologies because "the opportunities offered by these technologies have such long term and significant effects on innovation, productivity and economic growth that economy-wide energy consumption is increased" (www.ukerc.ac.uk/Downloads/PDF/07/0710ReboundEffect/0710ReboundEffectReport.pdf). For example, creating a new sociotechnical system such as the Internet brings about a set of entirely new and unforeseen energy demands.

In short, whether IT energy efficiency will ultimately reduce society's total energy use is unclear. Even if does, the reductions will likely be smaller than many expect.

WHAT IS TO BE DONE?

Our objective here is not to undermine efficiency efforts. Efficiency tends to foster economic growth, which is a policy goal for all industrialized nations and often increases people's standard of living. However, many computing professionals seek to improve efficiency because they believe it is a reliable way to reduce humanity's environmental impact. Unfortunately there is no clear consensus on this relationship in the environmental science and economics literature.

If developing an energy-efficient system is no guarantee that it will align directly with sustainability, then what should we do? Not surprisingly, there is no simple answer. However, several opportunities are promising.

IT professionals interested in energy efficiency can partner with experts in economics, environmental science, and other domains to help determine which efficiencies are most likely to be sustainability-directed. In particular, those already engaged in an efficiency effort could seek to analyze their own project in this regard. Locating sustainability-aligned efficiency opportunities would enable IT professionals to continue researching efficiency in general, even if a particular efficiency effort turns out to be counterproductive in terms of sustainability.

Moving beyond efficiency, contributing to projects that reduce the demand for energy—for example, by shifting social norms away from consumption-based lifestyles—could help our civilization become more sustainable. Alternatively, if there is freedom to change direction dramatically, IT professionals could redirect their efforts to sustainability-related projects such as preserving and restoring endangered habitats or lowering global birth rates. Through such initiatives, the IT industry can continue to thrive while shrinking humanity's global footprint.

More broadly, as members of society, IT professionals can support government efforts that are likely to have positive sustainability outcomes. According to *Limiting the Magnitude of Future Climate Change* (www.nap.edu/catalog.php?record_id=12785#toc), a 2010 report by the National Research Council, "A carbon-pricing system is the most cost-effective way to reduce emissions. Either cap-and-trade, a system of taxing emissions, or a combination of the two could provide the needed incentives."

Intelligently applied efficiency is vital to achieving sustainability, but it must be coupled with a carbon tax or similar potent measure to effect meaningful environmental change; without it, we will simply get more of what we already have: increasing environmental destruction.

Identifying which particular energy efficiencies can be sustainability-directed is currently very difficult. In pursuing sustainability through efficiency, we must first determine the conditions under which efficiency aligns with sustainability and undertake only the efforts that satisfy those conditions. To borrow a phrase from University of British Columbia ecologist Bill Rees, pursuing other efficiencies will only make human civilizations "more efficiently unsustainable."

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