Sustainability in (Inter)Action provides a forum for innovative thought, design, and research in the area of interaction design and environmental sustainability. The forum explores how HCI can contribute to the complex and interdisciplinary efforts to address sustainability challenges.

Elaine M. Huang, Editor

HCI and Sustainability: A Tale of Two Motivations

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In 2006, when I began working in the area of sustainability, it was still a blip on the radar at conferences like CHI. Since then it has been the topic of numerous well-received papers, workshops, and special-interest groups. And following this success have come the first questions about what we are doing, most notably articulated by Paul Dourish in his 2010 article on HCI and environmental sustainability [1]. Thanks to that article and many other readings, I've been feeling an inkling of discomfort with the standard motivation for some of our work on the StepGreen project (research.stepgreen.org). I've seen the same concern crop up in various forms in reviews and on thesis committees I've been privy to: How much of an impact do sustainability projects really have, and does it justify the cost, time, and effort put into them? Like privacy in ubiquitous computing work, the issue is often avoided or handled in a cursory fashion. I wanted to investigate in more depth.

The Cart Leads the Horse

The standard motivation for much of the work in sustainability in the HCI community (and I've used this line myself) goes something like this: "Using too much energy is bad (list of reasons). But, look, energy is used by people for everyday activities (percentage given), and daily activities are a big percentage of this (more percentages). These things are within our control, and because they involve human choice, they are an area that HCI has something to say about. Not only that, but technology has advanced and… " (I choose energy here as an example, but similar motivations can be constructed for other sustainability issues as well.) I'll stop here, because there is some divergence at this point. Are we looking at individuals? At businesses? At campuses? What technology have we advanced and in what way? What study did we do? These things vary from project to project.

On the positive side, this motivation is exciting, encouraging, and easy to connect to HCI work such as technologies for behavior change. "Feel good" motivation has played a role in many influential areas in our field, including health and education research. This seems especially valuable when an area is just starting out and needs to be nurtured, but it must eventually be supplanted by work that has as much scientific as social value. On the negative side, and as others before me have argued (e.g., [1]), this motivation for sustainability projects is utopian, ungrounded, and difficult to measure.

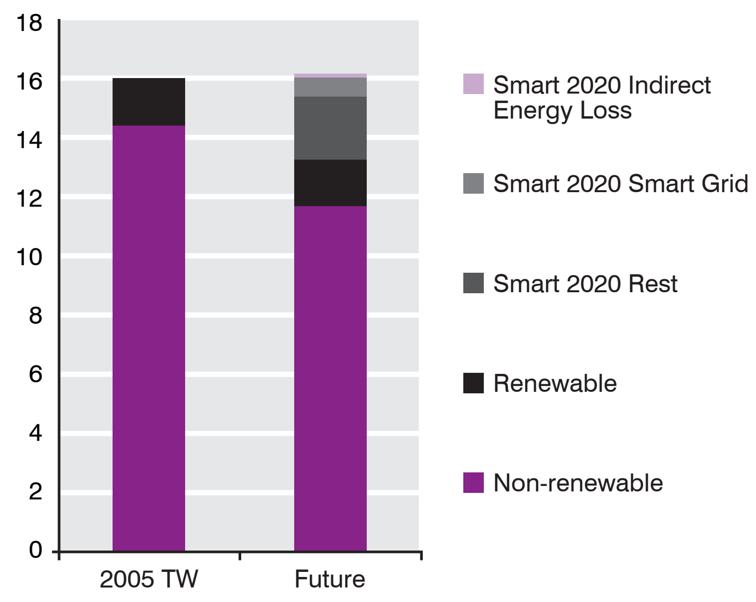
As a thought exercise, I would like to explore a different way of motivating sustainability work. I choose this motivation for its focus on impact, regardless of how well it might sell our work. We will work from raw facts down to a specific potential impact number. Such a motivation might start from the same place (using too much energy is bad), but the ending is quite different.

Globally, we used 16 terawatts (TW) of energy in 2005, 90 percent of which came from nonrenewable sources (gas, coal, oil, nuclear) [2]. According to the Climate Group, authors of the Smart 2020 report, about 7.8 gigatons of CO_2 ($GtCO_2$) emissions can be removed by information technology advances [3]. This is about 2.7 TW by my calculations [4], assuming the source is coal (about 17 percent of 2005 emissions). Of the categories of IT work proposed in Smart 2020, the category with the largest impact on energy is the smart grid (2.03 $GtCO_2$). More than half of the energy generated each year is wasted in the grid (directly) or is wasted because it is unnecessary to use it (indirectly). The indirect component adds up to about

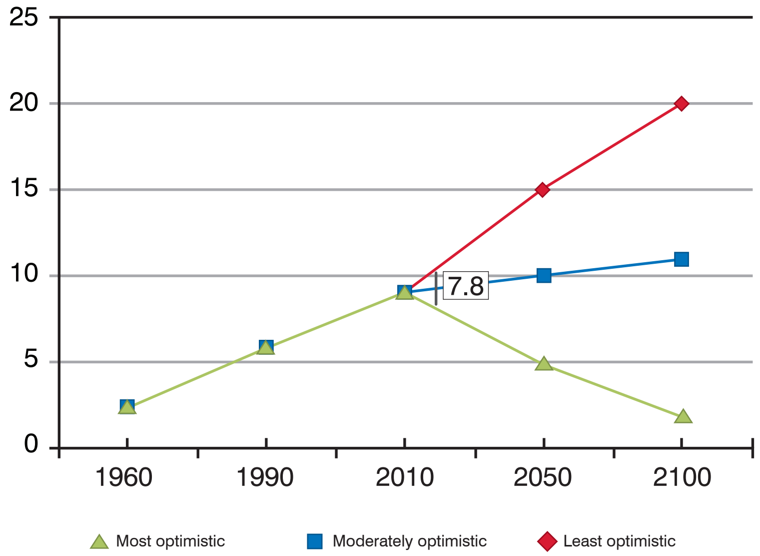
.28 $GtCO_2$ [3]. This is a very small portion of global energy emissions (.6 percent), as shown in Figure 1 under the label "Smart 2020 Indirect Energy Loss." Human-behavior change to reduce energy use (such as home heating and cooling) falls into this category. It follows that the maximum impact we can have is .6 percent of global energy emissions, assuming that we had a systemic impact on all energy wasted post-grid (not just home heating and cooling in a few households in one or two developed countries).

The calculations behind this motivation are measurable, can be used to set real goals, and are based on real data. Unfortunately, they are discouraging and highlight how much we don't know. For example, over what time period is Smart 2020 technology expected to have its effect? What are the current global emissions, and how much are they likely to rise? The 7.8 $GtCO_2$ saved by the Smart 2020 projects pales in comparison to projections of possible global increases, as shown in Figure 2. Would such work actually replace or reduce coal plant emissions, or just enable increased energy use globally? What percentage, really, would even global adoption of any of our projects create? Is any of the work we do appropriately designed for a global context? To make matters worse, projecting impact requires projecting future trends, something I would argue requires more formal methods, as humans are notoriously bad at doing this intuitively in the face of exponentially increasing change [5].

It seems that neither of the two most obvious motivations for doing sustainable HCI work seems to justify the time we are putting in. Is there an alternative?



▸ Figure 1: Projected global emissions vs. Smart 2020 decreases.



▸ Figure 2: Global carbon emissions from fossil fuel use, 1960–2010 and for the IIASA-WEC scenarios to 2100 (In $GtCO_2$, data from http://www.iiasa.ac.at/cgi-bin/ecs/book_dyn/bookcnt.py). The potential savings in 2020 from all IT work (7.8 $GtCO_2$) as estimated by the Smart 2020 group is shown by the vertical line.

I would like to argue for a new checklist for impact. Projects must be explicit about the potential for both direct and indirect impact, measurable, and (ideally) scalable. They should consider major growth trends, multiple cultural contexts, and address energy production as well as use.

A New Path Forward

Moving forward requires putting our work in a new context and viewing it in a new way. Before describing that motivation, we need to explore a broader theory of how we might globally address sustainability. Many opinions exist about how to go about this. Most of them come from fields other than HCI. While we lack the space to discuss all of them here, I have chosen two examples, again focused on energy use. The first is an article by Pacala and Socolow [6] discussing "wedges" (made famous in the 2006 film *An Inconvenient Truth*) that can together create a global reduction in emissions sufficient to bring CO_2 emissions back to a zero net level (i.e., no more CO_2 emitted than is naturally absorbed). The second is a book written by a young Al Gore in 1992 describing a policymaker's perspective on how to achieve worldwide changes in energy consumption [7]. Though the book is two decades old, its recommendations represent a much broader perspective than is typical of many treatises on the topic. If we combine the recommendations of Pacala and Socolow and Gore, we can see that the list of ways to reduce carbon emissions is both broader than either of the motivations provided above can encompass and amenable to research at the intersection of technology and people.

Table 1 shows a partial list. The left column lists direct ways of reducing carbon emissions; the right column lists indirect ways of reducing carbon emissions.

Though many of these things are far removed from HCI research (such as the basic science necessary to explore carbon capture and storage), there may be ways we can contribute to the science, politics, education, and mobilization necessary to achieve them. Indeed, interactive systems may have already contributed in subtle ways to some of these topics. For example, eBay might be credited with increasing the market for reuse of durable goods, a form of improved efficiency, while Twitter and SMS may have had an impact on group mobilization and communication.

The "alternate sources of energy" category requires special attention, as most people underestimate exactly what is involved in making a significant change in how we produce energy. According to Griffith, to replace 14 (of 16) TW of global energy use with alternative sources (which would be sufficient to reduce CO_2 emissions to a manageable level), we would need to build, in total, for the next 25 years: One 1250m^2 pool of algae per second; one 100m^2 solar cell per second; one 50m^2 thermal mirror per second; 12 wind turbines per hour; three geothermal turbines per day; and one nuclear plant per week. This paints a daunting picture of how big the effort required is to truly solve the problems we face (and suggests, once more, that the role of HCI may be something other than reducing home energy use).

Projects about individual behavior also fit within the list in Table 1 (under Efficiency), but I would argue that the list of indirect ways of reducing emissions are potentially much more impactful. In fact, we must engage with this broader list, or we risk, as Dourish states, that "framing sustainability solely in terms of personal moral choice in a marketplace of consumption options may obscure the broader political and regulatory questions that attend significant change" [1].

Making Work Accountable

Where do we go from here? What is the "right" motivation for sustainable HCI work? I would like to argue for a new checklist for impact. Projects must be explicit about the potential for both direct and indirect impact, measurable, and (ideally) scalable. They should consider major growth trends, multiple cultural contexts, and address energy production as well as use. Here is a partial checklist of issues to consider:

What is the core goal?

• How does the research directly

OPPORTUNITIES FOR DIRECT REDUCTIONS	OPPORTUNITIES FOR INDIRECT REDUCTIONS
Efficiency (new technologies, new patterns of use, better buildings, etc.)	Population control
Carbon capture and storage	Economic controls (e.g., taxes)
Alternate sources of energy	Cross-cultural solutions (expanding solutions in either category to work in multiple global contexts)
Carbon sinks (e.g., reforestation)	Improved energy grid
	Education
	Governmental buy in (local laws, world treaties, etc.)
	Advances in science

▸ Table 1: Opportunities for direct and indirect carbon-emission reductions.

contribute to *and* take away from that goal? For example, with respect to energy, how much energy is produced, and how much is needed for the project?

• How does the research indirectly contribute to *and* take away from the goal?

• Externalities: What are the other potential negative and positive impacts? For example, what waste is generated? What are the economic and societal benefits and costs?

Metrics and measures:

• At what level of detail can the impacts of the project be described? What are the right units and measures?

• What are the uncertainties?

Scale (and scalability) of impact:

• At what scale must the project be deployed to have impact? One person at a time (landlords, tenants, homeowners, managers)? Institutional (corporations, cities, campuses)? Cultural/national (social movements, governments, science)? International (countries, corporations, advocacy groups)?

• How could that impact be achieved? Is there a feasible plan for scaling up to the point where impact is possible, or is it improbable that the technology will scale?

• What are the limitations (certain cultural contexts or economic groups)?

• How much impact/cost does the project have at scale?

This is just a partial list of things we might consider when choosing a project. Many of these may be difficult to make progress on. For example, how do we address population control in ways that are sensitive to individual rights and cultural differences? Is this even a domain for computer science? However, I would argue that when we accept the importance of things like scale, internationalization, and indirect options for reducing energy use, a new focus for sustainable HCI emerges. This focus requires locally grounded, socially focused solutions. It attempts to decentralize, increase sharing, and encourage environmentality [8]. We must measure waste (of all sorts) so it can be regulated and taxed, monitor and model resource use, and inform governments as well as individuals about what we discover. And all of this must be made relevant across sectors and scale up to cities, nations, or higher.

Feel-good motivations are no longer enough—the crisis we face is too big for them. Luckily, it turns out that indirect influences on energy use are as important as direct influences. If we think about IT for sustainability more broadly, perhaps we can begin to have the impact that is needed. IT has changed so much in the world. It's worth believing (and trying) to do this as well.

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ENDNOTES:

1. Dourish, P. HCI and environmental sustainability: The politics of design and the design of politics. *Proc. DIS 2010.* ACM, New York, 1-10.

2. Griffith, S. GamePlan 1.0. 2008; http://www.slideshare.net/skeen/game-plan-v10-1

3. The Climate Group. Smart 2020: Enabling the low carbon economy in the information age. 2008; http://www.smart2020.org/_assets/files/02_Smart2020Report.pdf

4. I will not repeat the entire calculation here, but I calculated a conversion factor of .036 using the following data sources to help: http://www.nezhadpmd.com/worldenergyscenarios.pdf; http://en.wikipedia.org/wiki/World_energy_consumption; http://205.254.135.24/forecasts/ieo/more_highlights.cfm#world

5. Mankoff, J., Rode, J., and Haakon, F. Looking past yesterday's tomorrow: Using Future Studies methods to extend the research horizon (In submission).

6. Pacala, S. and Socolow, R. Stabilization wedges: Solving the climate problem for the next 50 years with current technologies. *Science 305,* 5686 (2004), 968-972.

7. Gore, A. *Earth in the Balance: Ecology and the Human Spirit.* Houghton Mifflin, New York, 1992.

8. Agarwal, A. Environmentality: Community, intimate government, and the making of environmental subjects. *Current Anthropology 46*, 2 (2004).

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