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Eco-visualisation:

Combining art and technology to reduce energy consumption

by

Tiffany Holmes

A dissertation submitted to the University of Plymouth
in partial fulfillment for the degree of

DOCTOR OF PHILOSOPHY

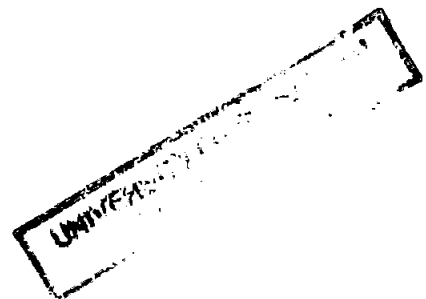
**Supplemented by: Proof of Practice of three case studies on 1 DVD and 1
additional DVD with Appendices and other supporting files,
fully inclusive of all software created**

Committee in Charge:

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and the University of Plymouth**

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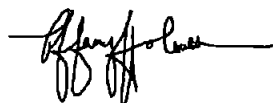
September 30, 2009



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A handwritten signature in black ink, appearing to be 'A. J. J. Jones', written over a horizontal line.

Date:

September 30, 2009

Abstract: Eco-visualisation: Combining art and technology to reduce energy consumption by Tiffany Holmes

Artworks that display the real time usage of key resources such as electricity offer new strategies to conserve energy. These *eco-visualisations*—or artworks that creatively visualise ecologically significant data in real time—represent a substantial contribution to new knowledge about dynamic feedback as a tool to promote energy conservation and environmental site-based learning in this interdisciplinary project that expands and builds on prior findings from the fields of art, design, environmental psychology, and human computer interaction (HCI).

The aims of this research endeavor were to locate answers to the following questions related to energy conservation in various public contexts. Might dynamic feedback from data-driven artwork create a better understanding of resource consumption patterns? Which environments are best for promoting eco-visualisation: home, workplace, or alternative spaces? What kinds of visualisation tactics are most effective in communicating energy consumption data? These initial questions generated a four-year research project that involved an extensive literature review in both environmental psychology and art history that culminated in three different case studies, which targeted the effectiveness of eco-visualisation as an innovative conservation strategy. The three primary claims to be proven with supporting evidence from the literature reviews and case studies are: (1) eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and encourages site-based learning; (2) eco-visualisation that provides real time visual feedback can increase environmental awareness and possibly increase the conservation behaviour in the viewing population; (3) eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.

Although the results of the three case studies are generally positive and prove the claims, there are larger social and environmental questions that will be addressed. How can eco-visualisation be productively integrated into the home or workplace without becoming a disposable gadget that represents a passing fad or fancy? Most importantly, how can energy conservation interventions be conceived to be as sustainable as possible, and non-threatening from a privacy perspective? These questions and more contribute to the discussion and analysis of the results of the three case studies that constitute the primary source of new knowledge asserted here in this dissertation.

The Background of this PhD Dissertation

Eco-visualisation is an important contribution to state of the art knowledge about novel approaches to promote greater understanding of site-based environmental data and to encourage conservation of energy. The term itself was generated via this dissertation research (Holmes 2007) and is now in usage in the fields of art, design and computer human interaction (Pierce et al 2008). Eco-visualisations are generally portable art and/or design works that creatively visualise ecologically relevant information using images or occasionally images and sound. Eco-visualisations can offer entertaining, “at a glance” learning experiences to varied populations. The research to be presented here will show that eco-visualisations that deliver energy consumption data represent a substantial contribution to new knowledge about dynamic feedback and public commitment as contemporary strategies to support energy conservation, and environmental education in general.

Dynamic feedback and public commitment are not particularly new tactics in the fight to encourage individuals to curtail energy usage. Real time feedback has been shown to increase levels of energy conservation both at home and in the workplace (Bittle et al 1979, McClelland and Cook 1979, Dobson and Griffin 1992, Chartwell Inc. 2007, Parker et al 2008). Likewise, research has revealed that a public commitment can enhance an individual’s ability to save electricity (Katzev and Johnson 1994, Pallak and Cummings 1976). What has been made clear by the prior studies is that more investigation is needed in the arena of dynamic feedback that pertains to the potential of the approach to be expanded further. As recently as 2003, scientists like Teddy McCalley and Cees Midden cite the need for further research into the capacity of dynamic feedback to improve behaviour in their own study of what they term “eco-feedback” or the ability of specific objects or products to provide some sort of reactive data mirroring based on incoming information.

There has been a surge of creative activity in the last six years since 2003 that warrants a more sceptical, or perhaps more updated analysis of McCalley and Midden’s argument about the dearth of feedback research. More specifically, several artists and designers have been experimenting with instantaneous energy feedback mechanisms embedded in small gadgets (DiyKyoto’s Wattson, Ambient Device’s Energy Orb, TED, PowerCost Monitor). Furthermore, artists and design teams have made great strides in

embracing work that situates environmental stewardship at the forefront of their creative activity (Backlund et al 2006). Several have investigated the possibilities of real time data feedback as a mode of attracting an audience to create opportunities for learning (HeHe 2009, Birchfield et al 2005). However, very little research has been conducted to date that actually evaluates the relative success of an artwork to not only facilitate data exchange but also encourage energy conservation and site-based dialogue about ecological issues. The three case studies planned with the existing literature from environmental psychology, human computer interaction, and art and design arenas represent an effort to not only augment the existing literature focused on exploring dynamic feedback as a mode of promoting electricity curtailment, but also expand and define the emerging field of eco-visualisation as one of crucial significance in light of the climate issues affecting our planet today.

As previously suggested, McCalley and Midden's appeal for further research on "eco-feedback" does confirm the validity and relevance of this particular inquiry that will study the usefulness of eco-visualisation as a strategy to enable the public to conserve energy in admittedly rather small quantities, and also raise awareness about conservation in general. The *eco-visualisation* field posits a fresh arena to implement, analyse, and refine research on real time environmental feedback as a novel conservation strategy. In addition, the eco-visualisation arena creates a new space for artists and designers to possibly collaborate in the future with environmental psychologists and human computer interaction researchers to develop new technologies that aid and nurture various forms of ecological pedagogy in the home, workplace, or leisure environments. Innovative, low-cost, and portable strategies that monitor consumption patterns could offer a viable small-scale solution to the enormous problem for our global dependence on non-renewable sources of energy.

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AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

Relevant exhibitions and conferences were regularly attended at which work was often presented; external institutions were visited for consultation purposes and several papers prepared for publication.

Publications:

Searching for stories in the sea of data: Promoting environmental stewardship through eco-visualization (2007) *Journal of Museum Education*, Volume 32, Number 3 / Fall 2007: 273-284.

Ecoviz.org, a self-published blog, initiated December 2006.

Eco-visualization: combining art and technology to reduce energy consumption (2007) *Proceedings of the 6th ACM SIGCHI conference on Creativity & Cognition*, Washington, DC, USA, SESSION: Tools, media and environments: 153 - 162. Won "Best Paper" Award at conference.

Environmental Awareness through Eco-visualization: Combining Art and Technology To Promote Sustainability. *Reconstruction 6.3: Studies in Contemporary Culture*: "Water: Resources & Discourses," summer 2006.

Floating Point: A Creative Visualization of Water Quality, residency report, in *Artists-In-Labs: Processes of Inquiry*, editor, Jill Scott, Springer Press, 2006.

Selected Exhibitions:

2009

darkSky, interactive energy visualization at Chicago's Museum of Contemporary Art and Microwave New Media Festival, Hong Kong City Hall, Hong Kong.

2008

World Offset, launched for premiere of *EcoAesthetics* exhibition in Den Haag, Holland. (See worldoffset.org)

2007

Speculative Data and the Creative Imaginary, National Academy of Sciences, Washington D.C.

2006

Ecopoetics, Finger Lakes Environmental Film Festival, Ithaca, NY.

Global Crossings in Leonardo Electronic Almanac.

7,000 oaks and counting, public art commission for the National Center for Supercomputing Applications (NCSA), Urbana, IL.

Presentations and Conferences Attended:

2010

Beyond Eco-Art: 21st century Eco-visualization, a hybrid art and design practice that promotes sustainability, paper for College Art Association 2010 panel, Intersections of Art + Design (USA).

2009

Greenmedia Futures: Using Art and Technology to Promote Sustainability, lectures given at Marywood University, Northern Illinois University, and Northwestern University (USA).

DIY Solar Sculptures, an interactive workshop delivered at Chicago's Museum of Contemporary Art as part of the Saturday Shorts series, and also given at Northern Illinois University in DeKalb, IL (USA).

2008

Greenmedia Futures: Using Art and Technology to Promote Sustainability, panel organization and introductory lecture, College Art Association annual conference, Dallas, TX. Subsequent lectures given at: University of Illinois at Chicago and DXArts in Seattle, WA(USA).

2007

Invited artist's lecture, Art Institute of Chicago.

Eco-visualization panel, sponsored by Eyebeam, Conflux Media Festival, NYC.

"Eco-visualization: Combining art and technology to reduce energy consumption," Creativity and Cognition conference, Washington D.C. Won "Best Paper" Award.

"C6: The Art World is Flat: Globalism—Crisis and Opportunity," presentation at symposium at Art Chicago 2007.

2006

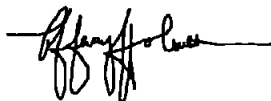
"Environmental Awareness through Eco-visualization," presentation at ISEA2006 and ZeroOne festival, San Jose, CA.

2005

"New Media Earthworks: History and Contemporary Directions," Bangkok University and Chiang Mai University, Thailand.

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September 30, 2009

Chapter 1: Introduction

1.1 Premise and overview of dissertation

Artworks that display the real time usage of key resources such as electricity offer first, *new visual strategies to conserve energy* and second, *new site-based environmental learning experiences*. These *eco-visualisations*—or artworks that creatively picture ecologically significant data in real time—represent a substantial contribution to new knowledge about dynamic feedback as a tool to promote energy conservation in the related fields of art, design, and human computer interaction (HCI). The aims of this research endeavour were to locate and debate answers to the following questions:

Can art trigger more environmentally responsible behaviour or merely raise awareness via site-based learning?

Can art possibly make energy conservation fun, and more importantly, vital to everyday life?

Might dynamic feedback from data-driven artwork create a better understanding of resource consumption patterns?

Can creative visualisations that translate energy consumption data of some kind inspire not only ecological awareness but also a reduction in a community's carbon footprint?

What kinds of visualisation strategies are most effective in communicating energy consumption data?

These questions generated a four-year research project that involved an extensive literature review that culminated in three different practice-based case studies that resulted in new findings about the specific nature and effectiveness of eco-visualisation as a novel conservation strategy. The three primary claims to be proven here are:

Goal 1: Eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and thus encourages new forms of site-based learning.

Goal 2: Eco-visualisation that provides real time visual feedback about energy usage can increase environmental awareness and possibly increase the conservation behaviour in the viewing population.

Goal 3: Eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.

Made with the philosophy of sustainability as a focus, artworks such as eco-visualisations offer novel tactics to improve attitudes toward nature, increase environmental awareness, and stimulate interest in conservation concerns. Chapter 1 will initially present an overview of the philosophy of sustainability that advocates for a new relationship between humankind and nature in the “Discussion of key concepts” section. This first half of Chapter 1 will also briefly assess why such a new rapport with the natural world is required given the looming threats presented by climate change. The second half of the introduction will be devoted to a literature review of case studies in the environmental psychology and interaction design fields that verify the potential of dynamic feedback to be an effective agent to increase conservation behaviour and thus energy savings. An analysis of these case studies will reveal that dynamic feedback is especially effective when combined with some other incentive such as a non-monetary reward, public recognition.

Chapter 2 will denote the historical context of environmental art and how creative practice has functioned from 1960 onward to promote environmental stewardship and site-based learning experiences. The first half of Chapter 2 will distinguish between the fields of land art, earthworks, and environmental art in order to show that this emerging field of eco-visualisation is rooted in the fine art arena, and has many historical precedents of interest such as Hans Haacke’s *Rhinewater Purification Plant*, Joseph Beuys’s *7000 Oaks*, Helen and Newton Harrison’s collaborative projects, as well as Jackie Brookner’s bio-sculptures. The last half of Chapter 2, titled “Beyond Eco-Art: 21st century Eco-visualisation”, will move on to explore some of the most contemporary eco-visualisation projects to serve as points of comparison to the three case studies to be described and detailed in Chapter 3. The four eco-visualisation projects investigated in great detail in Chapter 2 are the French collective, HeHe’s *Nuage Vert* public installation in Helsinki, the Swedish collective STATIC’s energy monitoring prototypes, the British duo, DIY Kyoto’s *Wattson*, and the American company, Ambient Device’s *Energy Orb*. All of these endeavors will show that creative eco-visualisation projects, that deliver key energy data at a glance, have had positive impacts on their host communities, and encouraged a moderate amount of energy conservation as well as novel learning situations.

In Chapter 3, the three case studies from this inquiry will be described and assessed: *7000 oaks and counting* (2006-09), *World Offset* (2008), and *darkSky* (2009). Prior to this assessment, the methodology and methods chosen to execute each piece will be discussed. While these case studies are similar in that all educate the viewer about energy conservation, they are distinct in that each of these proof-of-practice examples has a very different target audience. *7000 oaks and counting* is a public art project created for the National Center for Supercomputing Applications (USA) that measures electricity usage in real time for the purpose of education and possible curtailment of power usage. The artwork consists of an interactive computer kiosk and participatory website that allows building residents to proffer live carbon offset promises. Similar to *7000 oaks and counting*, *World Offset* shares the goal of making the general public aware and invested in their carbon footprint via the submission of carbon offset pledges. However, the audience is expanded. *World Offset* invites anyone with a web browser and active Internet connection to contribute while *7000 oaks and counting* is focused solely on the scientifically minded building community. In contrast, *darkSky* is perhaps the most “artistic” or open-ended of the projects to be assessed. *darkSky* is an interactive installation that invites the audience to choose a state for the installation—one that consumes large quantities of electricity and one that consumes minor amounts of energy. The choice is not only an aesthetic one as both states offer a different look but also an environmental one: should the eco-friendly state be favored or not? Because of its context, exhibited during the month of April 2009 at the Museum of Contemporary Art here in Chicago, *darkSky* attracts primarily an art-savvy audience not accustomed to examining work designed to produce energy-conscious behaviour. Other important questions to be considered in Chapter 3 would be:

- Did the artwork increase conservation behaviour in the viewing population? How and for how long?
- What kinds of site-based learning and dialogue happened with each of the three case studies?
- How did the different target audiences affect the assessment and relative success of each art project?

In summary, Chapter 3 will detail the methodology and methods that were utilized to produce and evaluate the success of each work, and will also attempt to contextualize

how each of these projects contribute to the emerging field of eco-visualisation through detailed discussion, comparative assessment, and analysis.

The investigation of the results of each of the three case studies will be expanded and broadened in Chapter 4. This chapter will offer a comparison of the successes and failures of the three case studies detailed in Chapter 3, and consider the various ways that each project could be improved. Some of the specific questions to be addressed in the results sections will be:

- What is art, and how does socially-conscious art provide even greater value to society?
- How did context affect each of three case studies— where would eco-visualisations of the future be best sited for maximum effect?
- How can success or failure of contemporary creative practice be assessed?
- What is the future of eco-visualisation, and why might privacy advocates and other concerned individuals challenge this practice of making energy consumption data public?

In summary, Chapter 4 will attempt to state the clear contribution to new knowledge that these three case studies deliver to the emerging field of eco-visualisation.

The overall results of this research bring further questions for analysis that the case studies have engendered. These additional questions involve the long-term viability of eco-visualisation projects and how they relate generally to electronic culture in the developed world. Although Chapter 3 will indicate that the results of the three case studies are generally positive, larger social and environmental questions remain. How can energy conservation interventions like eco-visualisation projects be conceived to be as sustainable as possible from a philosophic perspective? How can eco-visualisation be effectively integrated into the home or workplace without becoming a disposable gadget that represents a passing fad or fancy? Eco-visualisation is a practice that intends to steer clear of trends that may incorporate greenwashing tactics. Greenwashing is the targeted effort to have individuals buy their way to conservation by participating in pro-environmental consumer culture. Here, all conservation efforts will be accomplished due to the catalytic effect of information visualisation and thus not involve any purchase of consumer products. This fits Goal 2 of this eco-visualisation

inquiry, which is to increase conservation behaviour via small adjustments in individual daily habits to collectively reduce the planet's carbon footprint.

1.2. Discussion of key terms

1.2.1 Visualisation

A strong relationship between visualisation and learning has been reported in scientific literature (Wu et al 2001). Some of science's most powerful statements are not made in words. From Rosalind Franklin's x-rays of DNA to Lance Armstrong's televised lunar walk, the visualisation of science and engineering research has a long and illustrious history. Likewise, the participation of artists in publically promoting the findings of science has been ongoing—consider Leonardo DaVinci's anatomical drawings or Filippo Brunelleschi's illustration of one-point perspective by drawing the converging lines of various Florentine buildings onto a mirror. The goals of this inquiry are very much concerned with promoting learning through visualisation and thus, this work is just a small part of the overall history of artists translating scientific information to forms palatable to the general public.

Eco-visualization is a term that was generated via this dissertation research and the new expression is now in usage in the fields of art, design and computer human interaction.¹ Formally defined, eco-visualisations are works of art that creatively visualise ecologically significant data in real time. Because eco-visualisations are dynamic, eco-visualisations often utilize time-based media art forms such as video or animation. The case studies discussed in Chapter 3 will detail further specifics; however, see the image below in Figure 1.1 for an example of how a time-based animation might help depict electricity usage in a university building in real time. At midnight, very little power is used thus one views a series of spinning green tree rings. Conversely, at 3pm, there is a huge amount of power being drawn because the animation shows very few trees, and primarily objects that consume energy such as toasters and light bulbs. The visual rubric used is intentionally very simple: more trees—less power used—and hopes to engage viewers in scanning the animation

¹ The term eco-visualization was first formally published in 2006 in this article: Holmes, T. (2006) Environmental Awareness through Eco-visualization: Combining Art and Technology To Promote Sustainability. *Reconstruction 6.3: Studies in Contemporary Culture* on "Water: Resources & Discourses," summer 2006. The term has been adopted by Pierce and many others (2008).

frequently to spot trends in power usage in the building over time. Psychologists like Richard Lowe have extolled the virtues of animation to depict numeric or complex content for the purposes of education:

“Because animations can depict situational dynamics explicitly, they have the potential to help learners build coherent, high-quality mental models of complex change processes. Further, interactive animations provide opportunities for learners to deal with available information selectively and so avoid excessive processing demands” (Lowe 2004: 257).

In his research, Lowe recommends that designers of visualisations “address those information processing consequences of animations that appear to limit the extent to which learners can extract thematically relevant material from such depictions” (Lowe 2004: 271). In other words, Lowe warns about making the visuals too intricate for viewers to parse quickly. In the context of this inquiry, an eco-visualisation’s visual content has been generally designed to be clear, simple, and legible to enable rapid comprehension.

Eco-visualisation is an artistic practice. Thus, there are some poetic, aesthetically pleasing, and thus perhaps intentionally vague constituents that factor into the overall appearance of the eco-visualisations to be discussed in Chapters 3 and 4. This visual ambiguity is a key element of contemporary art practice. Visual ambiguity can enable multiple readings of the same artwork. Visual ambiguity can involve the viewer more personally in the artwork, as the viewer must work harder to interpret the graphics. Eco-visualisation is thus quite distinct from practice of information visualisation or scientific visualisation for educational purposes. This distinction is important to make, as eco-visualisation is an emerging practice that links the discourses of fine art with those of HCI, information visualisation, and sustainable design together in ways that are new, and generally very effective at stimulating popular interest in relatively routine topics like energy conservation at work.

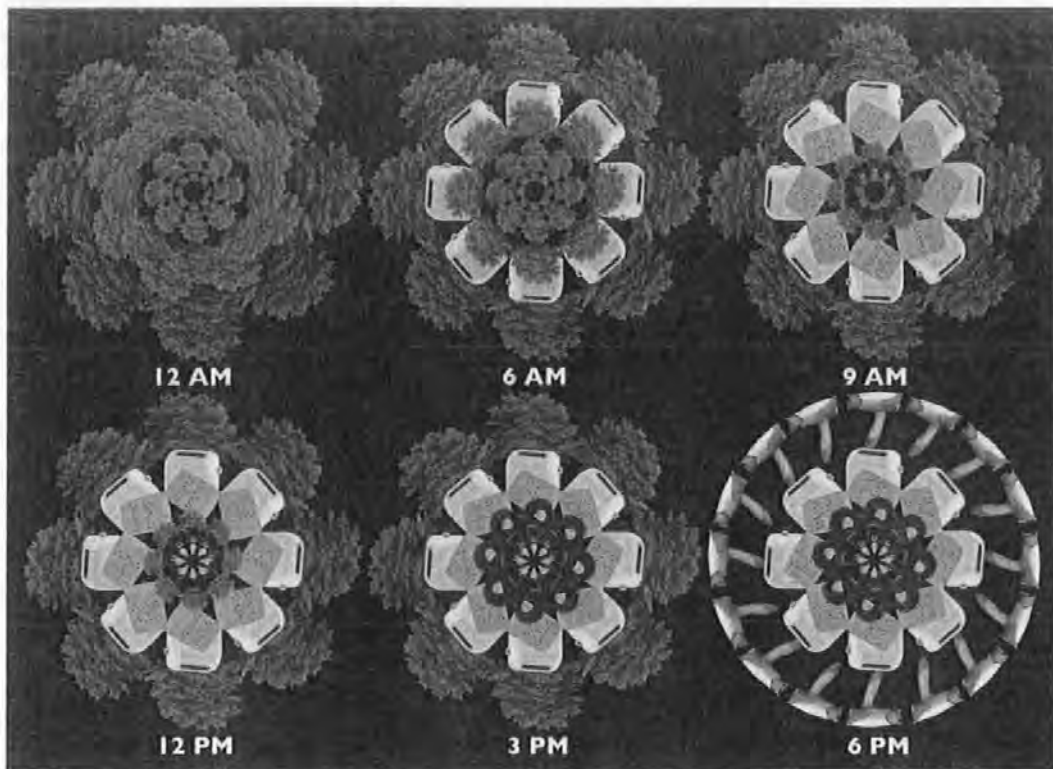


Figure 1.1: 7000 oaks and counting (2006-2009), animation stills

Eco-visualisation is more related to the field of information visualisation than scientific visualisation. The field of information visualisation can include media art that uses animation to represent numerical facts—often such numbers are dynamic, or delivered over the Internet in real time. Information visualisation, a term coined in the early 1990s, incorporates the use of computer-generated visual representations of abstract data, such as stock market volatility (Wattenburg 2005). Many accomplished media artists such as Casey Reas, Golan Levin, and Ben Fry have pioneered animations that visualise large datasets, however, the purpose of this research is to focus exclusively on media artists who use data visualisation to communicate environmental themes (Reas 2009, Levin 2009, Fry 2009). Mathematicians like Martin Wattenberg define new territory in the arena of information visualisation by exploring “social data exploration” or “new visualisations to let people understand their data” (2005). Eco-visualisations often encourage audience participation and thus represent a kind of social data exchange that encourages environmental stewardship in various ways, some of which will be detailed in Chapter 2.

In contrast to eco-visualisation, scientific visualisation is a rapidly growing field that is more illustrative, and less poetic, or ambiguous in its approach to depicting complex content. According to the US-based National Science Foundation (NSF),

because “science literacy is dismayingly rare” new visualisation strategies are key for the following reasons:

“Illustrations provide the most immediate and influential connection between scientists and other citizens, and the best hope for nurturing popular interest. Indeed, they are now a necessity for public understanding of research developments” (NSF 2009).

Scientific visualisation is quite different from eco-visualisation although both practices are intended to elevate learning about science. The subtle distinction here is that individuals who engage in scientific visualisation are scientists, engineers, or 3D software technical experts who often have very different concerns than more conceptually-trained fine artists who are accustomed to using a variety of media and communication strategies to accomplish their artistic goals. Artists are perhaps more skilled in at visual communication than scientists or engineers. Most of the participants in the field of scientific visualisation are only interested in still or time-based 3D imaging applications, thus the visualisations take on the look and feel of that particular software (see Figures 1.3, 1.4, and 1.5).

Looking at a few examples can help specify the aesthetic differences between scientific visualisation and information visualisation projects by artists. One of the biggest competitions in the area of scientific visualisation is the international *Science and Engineering Visualisation Challenge*, now in its sixth year, sponsored jointly by the journal *Science* and the NSF. The 2008 competition drew 181 entries from 20 U.S. states and the District of Columbia and 20 countries (NSF 2009). As mentioned previously, most entries are 3D renderings that illustrate some aspect of a very particular scientific research project, such as the flight dynamics of short-nosed fruit bats (Figure 1.3). As the scientists do not have training in fine arts, the kinds of creative decisions made in their depictions of scientific phenomena might be rather different from similar depictions finished by artists. See Figures 1.3, 1.4, and 1.5 below that feature 3D stills from the award-winning entrants in the category of Information Graphics. The level of visual complexity in these graphics is much higher than the artistic visualisations shown in Figure 1.1 or in Figure 1.2. Yet increased complexity is not necessarily an indicator of elevated communication as Lowe’s research affirms (2005: 271).

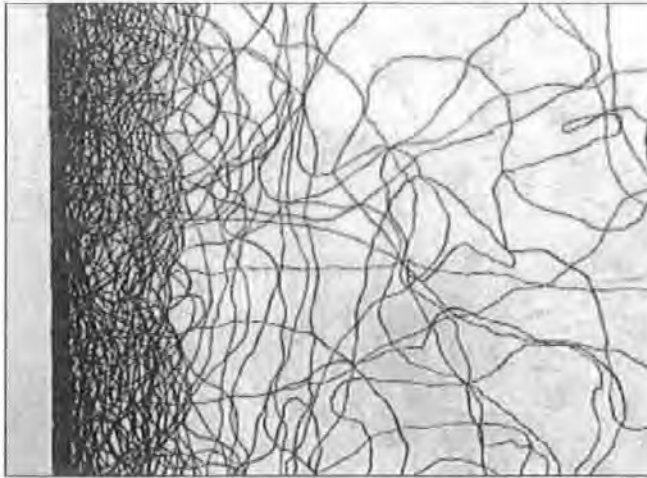


Figure 1.2: Yukinori Yanagi, *Wandering Position*, 1997 (detail)

Artist Yukinori Yanagi released an ant in the confined area and followed closely behind with a crayon, tracing the ant's movements. He did this for 15-20 minute intervals, after which he and the ant collected themselves for their next foray.

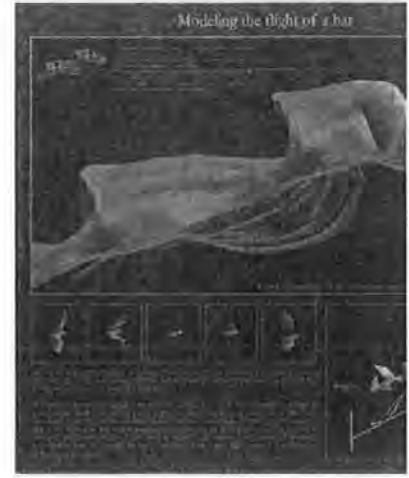


Figure 1.3: 2007 Winner, Informational Graphics, *International Science & Engineering Visualisation Challenge*, Modeling the Flight of a Bat
Credit: Kenneth S. Breuer, David J. Willis, Mykhaylo Kostandov, Daniel K. Riskin, Jaime Peraire, David H. Laidlaw, Sharon M. Swartz

Comparing the fruit bat flight diagram (Figure 1.3) to artist Yukinori Yanagi's ant motion trace drawings (Figure 1.2) reveals some major differences in look and feel, and in how key content is communicated. Yanagi and the scientists all embarked on their research because they were committed to making visible an ordinarily invisible phenomenon related to movement of a small body. In Yanagi's case, he chose to use a red crayon, not the most sophisticated drawing tool, to trace the meandering path of an ant within a 5-meter square enclosure on Alcatraz Island in the US, a famous prison facility. Yanagi's piece is about more than the ant's motion, it is compelling in its subtle questioning of socially prescribed boundaries. Note that the ant's motion in Figure 1.2 is primarily concentrated near the edges of the enclosure. The artist comments on his work:

"We feel that the incarcerated lack liberty, and that all of their activity is controlled and watched and we assume that this is completely opposite to the way we live our daily life, but I ask myself... Is what I watch, what I watch by my will? Is the direction I am walking determined by me? Is what I am thinking really thought by me? What drives our journeys through life?" (Yanagi 1998-99).

Yanagi's motive for making the work then is not only visual, but also conceptually tied up in exploring issues of spatial, social, and geographic boundary functions. The red crayon drawing has an aesthetic appeal but it is meant to mean more once the viewer discovers how it was made. In the case of the fruit bats, Brown University engineer Kenneth Breuer used lasers and a sophisticated multi-camera motion-tracking system to record how their wings flapped against the wind. Based on the experiments, aeronautical engineer David Willis, computer scientist Mykhaylo Kostandov, and their colleagues created a computer model of bat flight (Figure 1.3). "When viewed in slow motion", says Willis, "bat flight is beautiful and complex. The goal of this illustration is to capture that beauty while also adding scientific merit" (NSF 2009). The scientists use far more complicated imaging equipment but they are focused perhaps on a more illustrative objective, to create this mathematical model of the bat in flight.



Figure 1.4: 2008 Winner, Informational Graphics, International Science & Engineering Visualisation Challenge, "Mad Hatter's Tea" From Alice's Adventures in a Microscopic Wonderland. Credit: Colleen Champ and Dennis Kunkel, Concise Image Studios

While wandering through the forest of wonderland, Alice stumbles upon three beetles having tea. That's not exactly how Lewis Carroll's classic tale goes, but this recreation of the Mad Hatter's tea could certainly belong in the story.

Freelance illustrator Colleen Champ produced her own version of the scene using micrographs by photo-micrographer Dennis Kunkel. The goal was to demonstrate the fantastic nature of reality by arranging the actual images in fanciful ways, Champ says: "You cannot create anything yourself that hasn't already been created in nature". (NSF 2009)



Figure 1.5: 2006 Winner, Informational Graphics, International Science & Engineering Visualisation Challenge, Hawaii, the Highest Mountain on Earth.

Credit: Nils Sparwasser, Thorsten Andresen, Stephan Reiniger; Robert Meisner, German Aerospace Center (DLR)

"Mount Everest is the highest mountain on Earth above sea level, but it's not the world's tallest mountain. That honour goes to the Hawaiian volcano Mauna Kea.

When measured from its base on the Pacific Ocean floor, it is about 1,000 meters taller than Mount Everest. Mauna Kea is part of a 5,600-kilometer-long string of volcanoes stretching westward from the main Hawaiian island. Geographer Nils Sparwarr and his colleagues at the German Aerospace Center in Oberpfaffenhofen introduces us to the Hawaiian volcanoes with this panoramic

Eco-visualisation, while related to scientific visualisation in its goals to provide a unique learning experience, is at its core an artistic practice with interdisciplinary connections to the fields of sustainable design and human computer interaction (HCI). These three fields then—fine art, sustainable design, and HCI—form the foundation for the multidisciplinary methodology that guided this research. The concept of “sustainability” and sustainable design will be assessed in the next section. The point of comparing Yanagi’s crayon drawing to the award-winning scientific visualisation of bats in flight is to clearly distinguish the primary aspects of artistic visualisation from scientific visualisation. Though the goals may be similarly laudable, the practices are rather distinct for this primary reason. Contemporary artists who engage in eco-visualisation are not only visualizing hidden or abstract data, but they also are engaging in a much larger social critique or conversation, about how humans perceive nature, and how humans use resources. Scientists are generally invested in the minutiae of a very complex research problem such as mapping the flight dynamics of bats that weigh less than 50 grams. Professionally, scientists maintain a more neutral position in how their research pertains to broader societal issues, though certainly many scientists are quite vocal about the plight of the planet in a variety of ways.

To generalize for the purposes of this discussion, artists might offer broader social and political critique through their visualisation work than can scientists due perhaps to the rigorous and restrictive nature of how scientific research is funded and published. The work of artists doing eco-visualisation might engage 2D or 3D imaging techniques, or even traditional media, but most importantly it employs extremely simple, legible, techniques to communicate in the meaning of the information being tracked. The data translation might be didactic, or more poetic in an eco-visualisation, but overall, the eco-visualisation positions the data stream as one that is not culturally neutral; the information is inextricably linked to a host of global issues related to social concerns about the environment, or as in Yanagi’s case, about spaces of institutional confinement. Conversely, the work of scientists is generally expected to be politically and culturally more dispassionate, or unbiased than that of artists.

1.2.2 Sustainability

An interdisciplinary practice, eco-visualisation incorporates the philosophy of sustainability—especially as this philosophy has had an enormous influence on the work of sustainably minded artists and designers whose work will be detailed in Chapter 2. Presently, sustainability is an umbrella term used to describe the philosophy of maintaining the diversity of life and resources on the planet. The term is rather contested in that “sustainability” is a concept that has numerous subtleties and meanings, as well as a lengthy timeline of usage. The two related terms, sustainability and sustainable development originated with 18th century forest managers determined to safeguard timber supplies by employing innovative strategies of reforestation.² The terms resurfaced twenty-five years ago in a political context. According to the 1987 Brundtland Report, sustainable development involves: “Meeting the needs of the present generation without compromising the ability of future generations to meet their needs” (World Commission on Environment and Development 1987: 43). The historic context of the term sustainability thus links robust economic development with inventive resource management. Canadian environmentalist and scientist David Suzuki provides a more popular definition of sustainability for his television audiences that perhaps mistakenly encourages conservation without evident sacrifice:

“Quite simply, sustainability means living within the earth’s limits. It means living in a world where feeding people does not necessitate polluting groundwater and coastal shorelines. Where transporting people and goods does not mean polluting our air and changing our climate. Where heating our homes and powering our industries does not require vast amounts of polluting fossil fuels. Sustainability means doing things better—not doing without” (2005).

Historians like Victor Margolin discuss the need for the philosophy of sustainability to include a social and environmental justice component (2006: 11-12). Geographer Dan

² In 18th century Europe, forests were clear-cut for wood needed for fuel, furniture, and construction. But the forests that grew back after clear-cutting did not always provide the quality of wood fiber needed for the European economy. The foresters, particularly the German foresters thus invented *sustainable* forestry. The idea was straightforward. If enough trees were planted to replace the wood from the trees that were harvested every year, and the growth rate of the entire forest was scientifically monitored to ensure effective planting strategies, then the forest would be sustainable. Historically, *sustainable* meant that an over-utilized resource must be replaced by growing additional amounts of that resource. In the modern context of the word, resource replenishment is an impossible concept because there are many resources, such as oil or iron ore, that cannot be grown. Still, these resources, like the trees in Europe’s forests, are finite. If all the oil is extracted, there will not be any more oil. Still, if humanity is to survive with a civilization for another 1,000 years, we are still going to need to heat our homes and fulfill many of the same purposes that oil now fulfills. This information is detailed further in Thomas Davis, “What is Sustainable Development”, available at: <http://www.menominee.edu/sdi/whatis.htm> [December 1, 2005].

Harvey rejects sustainability because of its supposedly positive endorsement of capitalism that “lessens the force of more purely moral arguments” to engage in conservation behaviour (1997: 378). Cultural theorist Tony Fry believes that the term sustainability is oxymoronic and ill defined:

“Increasingly one sees and hears sustainability evoked as if its meaning were self-evident...What exactly is demonstrated to be unsustainable, and what needs to be sustained, generally is not specifically addressed” (2003).

In the context of this research, the concept of sustainability must address Fry’s concerns and expand the Brundtland report’s limited goal of meeting present and future human needs (1987:65). Here, the philosophy of sustainability is to be defined by how humans manage and maintain natural resources like coal and oil for future use by all cultures with focused attention given to social and environmental justice components.

Sustainability demands a localized resource management strategy that encourages harmony among organisms from all types of ecosystems—both urban and rural—and among individuals from different cultural and economic backgrounds, with the overall goal of slowing climate change through aggregated, or collective behavioural shifts in conservation actions. The three case studies detailed in Chapter 3 directly address the unsustainable energy consumption patterns evident today in the United States and beyond. Practitioners of eco-visualisation explore many varied themes, but the *overall goal is to promote sustainability, a sustainability that incorporates present and future human needs as well as the need to conserve for the health of ecosystems all over the globe*. What must be sustained is public consciousness of patterns of resource usage and the long-term effect of those patterns on local and global ecosystems, especially with respect to climate change.

In attempting to define the eco-visualisation field, linkages and crossovers in the sustainable design field must be identified and acknowledged especially within the field of human computer interaction (HCI). Sustainable design is an interdisciplinary approach to creating items that embrace practices of resource conservation as well as a commitment to the general philosophy of sustainability as previously defined. Sustainable design is the contemporary term for a rapidly growing area that extends across the fields of architecture, industrial design, interior design, and HCI (McDonough and Braungart 2002a). Sometimes referred to as “green design” or “eco-design”, the broad principles of sustainable design focus on resource conservation (McLennan 2004). Sustainable design chooses energy efficient methods wherever

possible. Sustainable design works to harmonize and not disrupt the natural assets surrounding the project site. Sustainable design uses materials made from renewable resources or recycled goods. Leading theorists in the sustainable design field believe that our dependence on nonrenewable resources is a design problem disguised by politics—subsidies that benefit the fossil fuel industry (McDonough and Braungart 2002b). Architectural theorist William McDonough and chemist Michael Braungart seek harmony between humans and their surrounding ecosystems through human invention:

“Sustainable design can be seen as one of the essential paths to peace and security. Consider resource dependency. From the viewpoint of both sustainability and international relations, reliance on a single, non-renewable resource to fuel economic growth is a signal of a design problem” (2002b).

Eco-visualisation is a practice that is highly influenced by the field of sustainable design. Is eco-visualisation a form of sustainable design or art, or is eco-visualisation really an extension of the HCI field? As previously stated, eco-visualisation will be presented here as an emerging field with interdisciplinary links to the aforementioned fields of study. However, eco-visualisation has clear undeniable roots in the arena of environmental art and the eco-activism of the 1970s (Spaid 2002); this is the topic of the next chapter. For the purposes of this inquiry, the fields of eco-visualisation and sustainable design will be contextualized as merged, as more and more scholars are noticing that creative persons of all sorts—artists and designers—are working with similar methods to come up with creative solutions to the problem of energy conservation. Many curators and theorists are just beginning to explore the question of how sustainable design of the 21st century merges art, technology, and environmental stewardship into mobile forms that have the potential to reach wider audiences (Smith 2006). Stephanie Smith, curator of the *Beyond Green* exhibition, discusses the huge potential for hybrid, transportable projects that focus on providing new environmental learning situations to help humankind redefine our relationship to the world:

“Such works might have a generative connection to a particular spot, but they can mutate and adapt over time and in new places. Additionally, many address the contested spaces of contemporary cities and towns and thus might be seen as extending that strand of environmental work that emphasizes populated places rather than remote ones. Such projects chip away at perceptions that ‘the environment’ is not something ‘out there’ and that cities are not as deeply connected to other ecosystems as they are to global trade networks” (2006: 12).

Defining the theoretical and practical field of *eco-visualisation* is complex given the varied interpretations of the concept of sustainability. Smith seems to support this inquiry's premise that projects that come from hybrid disciplines like eco-visualisation can "chip away at perceptions" and actually generate new creative thinking and learning in the viewing public. Certainly, the environmental problems now facing the world demand new modes of addressing the linked issues of global warming and resource conservation to be summarized briefly in the next session.

1.3 Global warming, global whining: Why don't we conserve?

On January 12, 2008, the UK's chief scientific advisor, Sir David King told the *Guardian*: "any approach that does not focus on technological solutions to climate change—including nuclear power—is one of utter hopelessness" (2008: 17). Many disagree with this statement including Richard Heinberg, Senior Fellow of the Post Carbon Institute. He calls it a "blindingly superficial framing of the situation" (2008). Embracing the philosophy of sustainability, Heinberg believes that climate change is linked to a whole host of planetary problems (2008). Heinberg goes on to argue that global warming and resource depletion are equally at issue, and that new policies to encourage conservation are vital to our survival on the planet:

"It's not just climate change that threatens us, but depletion of resources including oil, fresh water, and minerals; as well as destruction of habitat and accelerating biodiversity loss, which is exacerbated by climate change, but also happens for other anthropogenic reasons. In essence, there are too many of us using too much too fast" (2008).

The problem is that generally human beings do not intend to "curtail" or cut back their consumption of electricity, or alter their quality of life in any drastic way. This is precisely why advertisements promoting "energy diets" are so utterly ineffective (see Figure 1.6). What strategies might inspire a population to conserve energy? How can citizens of the world move away from what Heinberg calls the "using too much too fast" mentality?

It's time to go on a low-carbon diet.

Transition By shifting the balance of the energy that runs from coal to natural gas, the massive burning of BP's fuel, the U.S. could reduce carbon dioxide emissions in new power generation by up to 63%. Today, natural gas accounts for almost 40% of BP's global production.

Transition BP is the largest partner in the Department of Energy's hydrogen program, working with automakers to test hydrogen-powered cars. Though several decades away, we've already launched the program's first pilot refueling sites to better focus how we can supply hydrogen in the future.

Transition BP is working with The Natural Energy Lab of the future, a new center for clean energy research. The center will focus on clean energy research, making it easier for businesses to invest in clean energy technology. BP is also working to reduce its own carbon footprint by 10% by 2010, while producing 100% emissions-free electricity. Today, BP is one of the largest providers of clean energy in the world.



beyond petroleum

bp.com

Figure 1.6: BP advertisement promoting sustainability via a diet metaphor.

Many complex factors influence a resident population's ability and desire to conserve resources like electricity and water. Conservation behaviour is connected to perceptions of nature, economies of resource availability, and individual environmental ethics. Americans, in particular, are the biggest consumers of electricity and thus produce more harmful greenhouse gases that can accelerate global climate change (Revkin 2005). Many political strategies to conserve electricity have failed. For example, government mandated policies of aggressive emissions cutbacks did not affect conservation behaviour in the United States during the G.W. Bush administration. The 1997 Kyoto Protocol could not solve the problems of the world's energy needs and global warming because various nations rejected a collective international request to improve efforts to conserve resources. The world's largest energy consumers, the United States, India, and China, refused to curb emissions to conform to Kyoto's goals. Conservation behaviour is thus not necessarily enhanced by international politics. The main question to be addressed here is, what other incentives, other than political or monetary, can increase conservation behaviour for particular resident populations?

Real time data display can be a potent tool for increasing energy conservation behaviour. This has been known since the late 1970s, yet few researchers seriously tested the theory until faced with the oil embargoes of the 1980s and the climate change concerns of the 2000s. According to psychologists Clive Seligman and John Darley,

daily feedback of electricity usage in buildings has a proven record of reducing electricity consumption in the home (1977). Two years later, scientists L. McClelland and Stephen Cook used a visualisation device called the Fitch Energy Monitor, a tool that displayed the amount of money spent per hour consuming electricity (1979-80). Energy use in homes with the monitor was lower in all 11 months of the study. The decrease in electricity usage in homes using the Fitch monitor averaged 12%, with even larger decreases in low-consumption months (1979-80). Overall, the Fitch monitor facilitated environmental learning and behavioural change with visual, site-specific, real time feedback on electricity costs.

There are no easy solutions and no clear paths toward collaboratively addressing the complicated issues of designing effective strategies to promote conservation behaviour and support good environmental stewardship. Scientists like Teddy McCalley and Cees Midden cited the need for further research into the capacity of dynamic feedback to improve behaviour in their own study on eco-feedback, that is the ability of objects to dynamically deliver ecologically significant data in real time to the user:

“By focusing on the interaction between the product and the user it is possible to generate responsible conservation behaviour using eco-feedback. Eco-feedback is information presented during the product-user interaction which prompts the user to adopt energy saving strategies, however, *little is known about how such feedback works and thus how it can best be applied for optimal effect*” (1998: 344).

McCalley and Midden’s appeal to continue exploring the effectiveness of eco-feedback directly correlates with the central aim of this inquiry: to assess whether immediate visual feedback can activate site-based learning to promote conservation of electricity. In the final sections of this introduction, a review of various strategies delivering real time eco-feedback will be compared. McCalley and Midden claimed again, as recently as 2003 that there was little conclusive research in this area but this study hopes to prove otherwise: “Although some interesting results have been reported, feedback as an instrument has rarely achieved the results that should be expected on theoretical grounds. This is caused to a large extent by technical and organizational problems to make the feedback specific and instantaneous” (2003). There has been a surge of creative activity in the last six years since 2003 that warrants a more updated analysis of McCalley and Midden’s argument about the dearth of feedback research.

McCalley and Midden's plea for further research on eco-feedback" does confirm the validity and relevance of this particular inquiry that will study the effectiveness of eco-visualisation as a strategy to enable the public to conserve energy in admittedly small quantities, and also raise awareness about conservation in general. The *eco-visualisation* field posits a fresh arena to implement, analyse, and refine research on real time environmental feedback as a novel conservation strategy. Innovative, low-cost, and portable strategies that monitor consumption patterns could offer a viable small-scale solution to the enormous problem of the global dependence on non-renewable sources of energy. Economists like Ernst Schumacher who responded to the energy crisis of 1973 by criticizing modern economic policies for creating rampant inefficiency, environmental degradation, and dehumanising labour conditions, advocated repeatedly for small-scale, localised, pedagogical initiatives to reframe concepts of nature for Western society. Schumacher perceived nature as a special form of wealth to be protected using any means necessary:

"Let us take a closer look at this 'natural capital.' First of all, and most obviously, there are the fossil fuels. No one, I am sure, will deny that we are treating them as income items although they are undeniably capital items. If we treated them as capital items, *we should be concerned with conservation; we should do everything in our power to try and minimize their current rate of use*" (1973: 15).

Schumacher supported small-scale efforts to reduce energy usage—thus, his views align directly with the aims of this inquiry.

Although Schumacher's philosophy correlates with that of this inquiry, Schumacher's arguments were not well received by mainstream economists, who see small-scale conservation solutions as impractical for future development. For example, the Oxford economist Wilfred Beckerman published a caustic rebuttal of the liberal principles of Schumacher's *Small is Beautiful* titled *Small is Stupid* (1996). Despite Beckerman's scholarly critique of the alarmist mentality of the environmental movement, Schumacher's words remain a compelling reminder that our contemporary relationship with nature and natural resources is far from sustainable and generally fraught with hypocrisy: "Modern man does not experience himself as a part of nature but as an outside force destined to dominate and conquer it. He even talks of a battle with nature, forgetting that, if he won the battle, he would find himself on the losing side" (1973: 14). It is the overall goal of this inquiry, to adopt Schumacher's notion of

small-scale change, which could have a ripple effect. This ripple effect is the primary motivation for the work in this dissertation in expanding and analyzing the practice of *eco-visualisation*. In other words, small-scale successes in inviting micro-communities to conserve energy could, if expanded have a notable impact on the world outlook for strategies to curtail energy usage effectively.

The linked issues of climate change and global warming are demanding and will remain challenging for decades to come. Eco-visualisation offers a new approach to implement long-term resource conservation by using dynamic feedback in the form of creative visuals that make site-based consumption patterns visible, intelligible, motivating, as well as relevant to a local resident population. Next, existing research will be reviewed that tested the capacity of dynamic feedback to promote conservation. Most of the studies to be investigated in the next section use only *numeric* feedback, either static or dynamic. Numeric feedback is different from eco-visualization, which uses more abstract imagery to portray data shifts. Many of the previous investigations come from either the environmental psychology field or from the HCI arena. Thus, while these sorts of explorations are not immediately part of the emerging field of eco-visualisation which uses abstract visuals, not numbers to communicate resource consumption, the studies are relevant to evaluate the potential of dynamic feedback to increase conservation behaviour.

1.4 Real time data, Real world change: How to increase conservation behaviour via curtailment methods

In this dissertation, the premise is that art, which visualises real-time energy loads, will elevate commitment to resource conservation, raise energy awareness through site-based learning, and possibly increase conservation behaviour. Why don't people think about conserving electricity or water on a daily basis? Several behavioural studies have concluded that most individuals have no idea how much electricity they use on a monthly basis (Winett et al 1978). What stimuli if any, actually inspire people to conserve? In his study "Relating attitudes to residential energy use", Peter Crabb, a behavioural psychologist, points out that people don't *use* energy, they use products, which use energy; the way that these products are designed determines how we use them, which in turn determines the rate of energy consumption (1998: 815). Crabb suggests that the restructuring of familiar objects could be a more effective tactic to

promoting conservation than strategies to modify consumer behaviour (1998: 815). This preliminary literature review suggests that *eco-visualisations*—moving graphics that recreate the familiar graphs on the monthly utility bill dynamically—have the potential to not only reveal a pattern of consistent usage for users but also provide them with visual reminders to conserve. In Chapter 3, several fine art and sustainable design projects that promote energy conservation through dynamic feedback will be analysed in great detail. This remainder of this chapter is devoted to a review of the scientific studies to date that attempt to assess the effectiveness of various curtailment strategies to conserve energy: public commitment, monetary or social reward, dynamic feedback, and comparative feedback.

1.4.1 Comparing curtailment strategies to conserve energy: reward, feedback, and commitment

This component of the inquiry will focus primarily on curtailment strategies that do not involve monetary rewards, despite the fact that some researchers have shown financial savings to be a big motivator to conserve. For example, professor of marketing Louise Heslop and collaborators have shown that *personal sensitivity to price* seemed to be the major factor in determining energy use behaviour (1981). This early study and others have established that energy consumption was not very affected by so-called consciousness variables, like environmental philosophy and social responsibility. Rather, people conserved power best when faced with higher prices for energy. In the study, individuals responded to increased price with decreased usage, thus increasing price consciousness is usually cited as an effective policy measure.

Yet other more recent studies to be discussed in this section have demonstrated that only *massive price adjustments* inspire conservation in the long term (Kaufmann 2009). Additionally, artists and citizens cannot directly alter the price of electricity or the price of oil. Because this inquiry is focused on small-scale, citizen-designed interventions to increase energy conservation for the purpose of combating climate change, the following literature review will present scientific case studies that focus less on using money as a motivator to conserve and concentrate on other behavioural techniques proven to modify habits of consumption such as public commitment, non-monetary reward, and various forms of feedback. In other words, this inquiry will

profile primarily case studies unlike Helsop's that show that non-monetary forms of reward can additionally work to stimulate conservation behaviour and raise environmental awareness.

The most relevant behavioural studies revealed that feedback of any sort—static or dynamic—is generally better than monetary incentives in inspiring conservation behaviour. These studies also showed that static feedback, when coupled with a personal commitment, raised conservation levels even higher. For example, psychologist Richard Katzev and his team monitored electricity usage of various experimental groups during an initial experimental phase, and then conducted a three month observation phase in which no conditions were applied (Katzev and Johnson 1984). The first group was the control; meters were read to determine usage—no written feedback was provided. The other five groups were given the following as motivators: commitment (1), questionnaire³ (2), commitment and questionnaire (3), incentive (4), and finally, commitment, questionnaire, and incentive (5). Absolute levels of consumption for each group were quite similar, but deviations existed when viewed as a percent change from the baseline. Data showed that *the commitment group was found to consume significantly less electricity* than the control, incentive or questionnaire groups. Also, the commitment group and the group with the questionnaire, commitment, and incentive contained a significantly higher percentage of conservers than did the incentive group alone. Katzev's study further supports the notion that a public commitment to conserve is far more effective than monetary incentives in inducing conservation behaviour (1984).

In addition to feedback, some kind of non-financial reward, or recognition for "doing a good deed" has been found to motivate more energy curtailment. Public recognition for outstanding conservation behaviour encouraged more energy savings than simply maintaining "good environmental values". Researcher Keith Neuman concluded that personal values are only weakly correlated with commitment to conserve, and thus don't present a significant obstacle or boon to conservation efforts (1986). Another study conducted by psychologists Michael Pallak and William Cummings confirmed that public recognition and display of good conservation behaviour resulted in decreased energy consumption (1976). In the above-mentioned

³ A short questionnaire about energy use was distributed to raise awareness and pique curiosity in the test population as one of the methods of Katzev and Johnson's study.

study, a lower rate of increase of electricity and natural gas usage was found for participants in the public commitment group compared to the private commitment or control group. The public commitment group expected their names to be in newspaper; in the private commitment group names were confidential (Pallak and Cummings 1976). Pallak and Cummings showed that *public recognition of good conservation behaviour* could be an effective motivator for conservation of energy resources (1976). Two of this inquiry's case studies (*7000 oaks and counting* and *darkSky*) were designed using the method of public recognition due to the success of Pallak and Cummings in this area.



Figure 1.7: Promotional image for PowerCost Monitor which retails for \$119 Canadian.

1.4.2 Dynamic and comparative feedback

The previously described studies provide evidence that energy curtailment in the general public is enhanced via static feedback, personal commitment and public recognition. However, the focus in this inquiry is on the capacity of creative imaging in the form of real-time feedback that could persuade individuals to conserve. Many of the energy studies that have examined dynamic feedback have utilized gadgetry that itself is non-sustainable and text-based, as well as aesthetically unappealing. While these studies detailed below prove the capacity of dynamic feedback to inspire small-scale conservation, the primary issue is that the devices used to measure energy consumption are unsightly and not recyclable. The case studies to be detailed in Chapter 3 that utilize techniques of eco-visualization—or creative imagery to imagine the energy usage statistics—will be shown to have a potentially more long-term effect than the feedback cards and electricity monitors discussed below.

Several energy studies from the 1970s and 1980s have revealed that daily or continuous feedback that displays load levels in various text-based formats has the capacity to increase conservation behaviour. For example, psychologist Ronald Bittle and his research team placed daily feedback cards in residential mailboxes that reported

the kilowatts used per day. The feedback group utilized an average of 1-9% less electricity than the group that did not receive feedback (Bittle et al 1979). A far more recent study demonstrated an even greater capacity to conserve energy via dynamic feedback. In 1992, Ontario Hydro in Canada distributed several hundred computer-based continuous display electricity use monitors; each was called a “Residential Electricity Cost Speedometer” (RECS). Homes that made use of the RECS display reduced electricity consumption by 12.9% (Dobson and Griffin 1992). Another current report on the effects of dynamic feedback by Hydro One, a Canadian power company, adopted the newer PowerCost Monitor (Figure 1.7) which was deployed in 500 Ontario homes from mid-2004 to early 2006—a substantial amount of time. The PowerCost Monitor research showed an average 6.5% drop in total electricity use when compared with a similarly sized control group (Chartwell Inc. 2007: 3). Hydro One subsequently offered free power monitors to 30,000 customers based on the success of the pilot (Chartwell Inc. 2007: 1). These sorts of large-scale incentives still have the potential to create enormous savings although some users were quite critical of manufacturing defects in the gadget that impeded continuous performance.⁴



Figure 1.8: TED - The Energy Detective Electricity Monitor

Several electricity-monitoring gadgets are now available to the consumer market. These clock-like appliances offer simple text-based dynamic feedback related to energy consumption (Figure 1.8). The aforementioned PowerCost Monitor is an

⁴ Consumers did not like the fact that the PowerCost Monitor constantly lost connection with the transmitter and that it ran on batteries that needed replacement once monthly. More critique available at: http://www.powercostmonitor.com/p3982/power_cost_monitor.php [February 11, 2009].

example of such a gadget. These smart tools, though favourably reviewed by their users are sometimes critiqued for their flimsy construction, poor technical support and challenging home installation. The Energy Detective (TED), having won a number of technology awards, has a cohort of regular users: “We have had TED for 9 months. When comparing with the same periods last year our electric use is down 28.5%! I am surprised it is so effective” (Energy Detective 2009). TED is extendible—the gadget can be hooked up to data-logging software, called *Footprints*, that allows users to log their energy consumption in a computer database. The Florida Solar Energy Centre (USA) elected to use TED in a study of twenty case study homes to determine how much conservation might be expected over the long term. In the second year of monitoring the twenty homes showed an average of 7% reduction in energy consumption (Parker et al 2008:3). Another electricity monitoring gadget called the Cent-A-Meter has enjoyed positive testimonials by newly converted conservationists:

“When you know at a glance how much power your home is drawing, it changes your behaviour. You learn what is normal and abnormal energy usage...A few weeks ago, I received a Home Energy Report from Puget Sound Energy. I'm using 66% less energy than my so-called "efficient neighbours" and saved \$1301 last year in electricity relative to the previous year. Most of this I attribute to the Cent-A-Meter. Once you know what you are using, it's easy to turn stuff off” (Cent-a-meter 2009).

In general, the home monitoring gadgets accessible to consumers have shown the potential to reduce energy consumption in the home by 5-15% on average (Parker et al 2008). Home energy tracking tools like the PowerCost Monitor, TED, and Cent-A-Meter have a proven record of inspiring people to use less energy, and in many cases, of enabling conservation behaviour. To clarify, these devices do not display “eco-visualisations” as they use only text and numbers to deliver the dynamic feedback. In fact, some of the displays are difficult to read in a quick glance (See the display on TED in Figure 1.8). In other words, plain text-based gadgetry may be less effective than eco-visualisation at stimulating interest and learning in energy conservation. The next logical question to ask is how does dynamic feedback work in situations where users do not pay their energy bills or have access to energy-broadcasting gadgets: how might one inspire conservation *outside the home*?

Curtailment is especially difficult in places where energy users do not pay their own utility bills such as workplace environments or college dormitories. What has been

proven to work in these contexts is dynamic feedback combined with comparative feedback. In other words, the process of asking individuals to evaluate how their energy usage stacked up against another group inspired conservation. A study by environmental behaviourists Frans Siero and team verified that employees who received comparative feedback about their energy consumption day to day saved more energy than employees who received information six months later (Siero et al 1996: 235). In this study, the group that obtained daily feedback conserved more electricity but minimal changes in attitudes were found. This finding was consistent with other findings, which reported that attitudes toward conservation are not linked directly to conservation behaviour. For example, direct feedback reduced energy consumption in college dormitories at the University of Colorado (McClelland and Belsten 1979-80).

College dormitories have provided an excellent venue for controlled study of the effects of dynamic, comparative feedback. Web delivery of primarily statistical feedback information proved to be fast and efficient. Comparative feedback in an energy competition between dormitory residents at Oberlin College (USA) resulted in a 32 percent reduction in electricity use, which amounted to savings of 68,300 kWh, \$5,107 (USD) and 148,000 pounds of carbon dioxide (Peterson et al 2007). Environmental studies professors John Peterson and Kathryn Janda and their students at Oberlin College (USA) conducted the 2007 study. An automated data monitoring system was developed that gave dormitory residents real-time web-based feedback on energy use in two “high resolution” dormitories. In contrast, utility meters were manually read for 20 “low-resolution” dormitories, and data were provided to residents once per week. Dormitories that received high-resolution feedback were more effective at conservation, reducing their electricity consumption by 55 percent compared to 31 percent for low-resolution dormitories (Peterson et al 2007). In a post-competition survey, students reported that they would continue conservation practices developed during the competition and that they would view web-based, real-time data even in the absence of the context of the “contest”. This important study affirmed also this inquiry’s premise that a real-time information display can provide important site-based learning experiences. The Oberlin experiment proved that web-based dynamic feedback is a powerful motivator to encourage individuals to *learn independently about their consumption patterns*. The question for this inquiry then is whether image-based feedback might work more or less effectively than the online statistics broadcast in the Peterson study at Oberlin College.

Web-based tools provided a unique pedagogic feedback mechanism for the residents of the college dormitories (Oberlin Dorm Energy Competition 2009). The Oberlin students on the Peterson/Janda research team created their own company, Lucid Design Group which now markets web-based software called Building Dashboard® to deliver dynamic, comparative energy consumption data to school and business contexts (Figure 1.4.3). Real-time feedback made available by Building Dashboard® has been shown to effectively reduce consumption on the order of 10-56% depending on the context (Lucid Design Group 2009). Elon College's Building Dashboard® Competition module enabled students to battle in real time to reduce electricity consumption. In a matter of weeks, competing residence halls averted 24,000 pounds of carbon dioxide from the atmosphere and saved \$1,260 (Lucid Design Group 2009). Like TED, Building Dashboard® has claimed a number of industry and design awards that profile the effectiveness of dynamic feedback to make users aware of their consumption patterns. Unlike TED and the PowerCost Monitor, Building Dashboard® has a colourful, easy-to-read virtual console that is interpreted through a browser window. While not an eco-visualization in the strict sense as it uses numbers instead of images to communicate information, Building Dashboard® has a much more appealing aesthetic than the other two gadgets. Lucid Design Group has contributed proof that web-based software that transmitted easy-to-read data on energy loads *increases energy conservation*, especially in comparative contexts like dorm energy competitions.

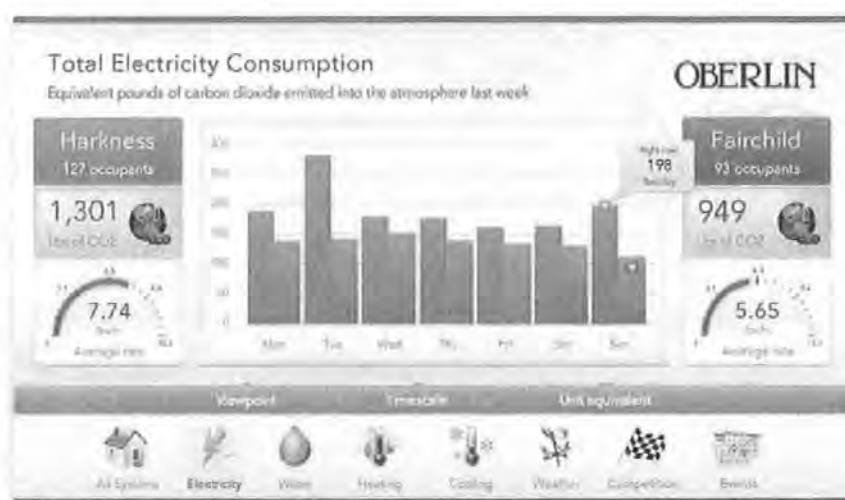


Figure 1.9: Oberlin dormitory energy competition screenshot: Harkness against Fairchild

A number of power generation companies have been taking advantage of the ability to deliver comparative feedback for energy conservation. The Sacramento

Municipal Energy District attempted to use traditional means to get citizens to cut back such as offering rebates for energy-efficient appliances. But the energy goals were not met (Kaufmann 2009). Thus, the district tried something fresh: a contest to see which neighbour conserved more energy that month. In April of 2008, utility bills were mailed to 35,000 customers that compared how their energy profiles compared to those of 100 neighbours residing in homes of similar size. The visuals were quite simple. More energy efficient customers received a smiley face; and the energy gluttons got frowning ones. Interestingly, the sad faces caused a lot of controversy among customers who believed that they were being improperly sanctioned via the negative icon. Thus, the utility company had to remove them and utilize the smiley faces for positive feedback only. Despite the demise of the frowning face, the Sacramento utility company noted that after only six months, the customers who received the personalized report comparing household energy use reduced energy use by 2% more compared to customers who were given standard statements (Figure 1.10). While the Sacramento Municipal Energy District project's graphical display of power usage did not constitute eco-visualization in the strict sense because it was not a dynamic display—the smiley and frowning faces summarized a month's consumption data—the project does reveal that users have strong emotional reactions to image-based feedback. Because the primary premise of this inquiry is that image-based dynamic feedback can increase site-based learning (Goal 1), foster environmental awareness and possibly conservation (Goal 2), and promote dialogue about ecological issues (Goal 3), the Sacramento study provides some useful evidence that viewers were motivated to change their behaviour based on the impact of an image in their monthly utility bill.

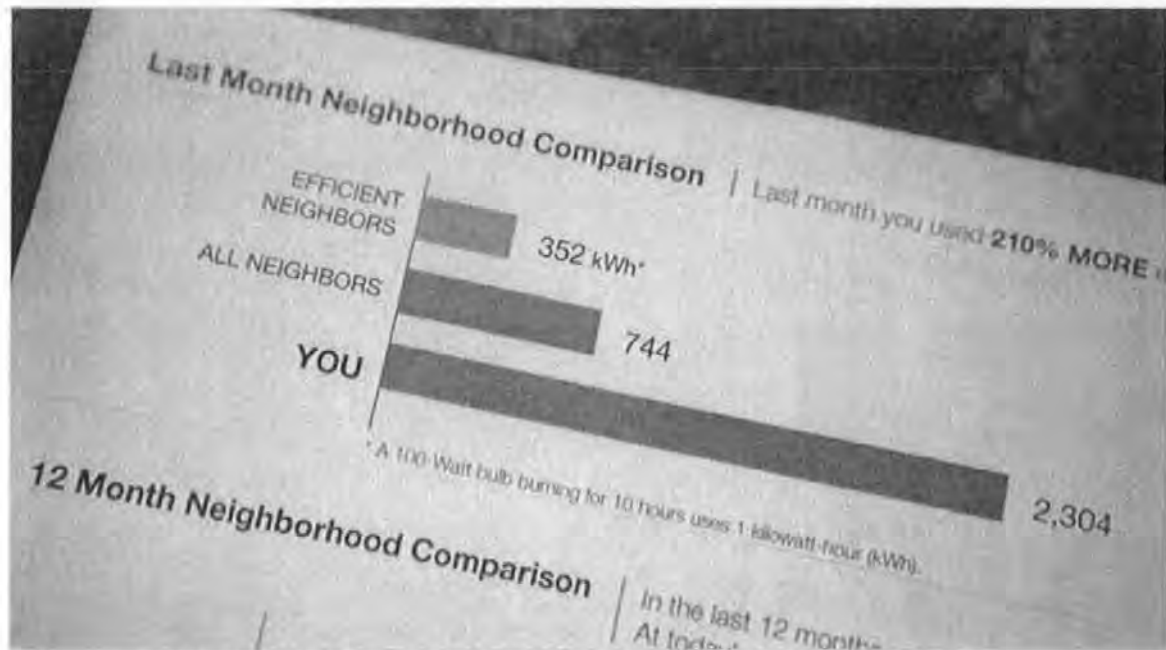


Figure 1.10: Sacramento Municipal Energy District statement that shows comparative feedback of energy use in 100 California households.

Dynamic feedback delivered from “smart” electric meters that also transmit conservation information in real time to power generation facilities has proved quite profitable (Levy 2008). According to Siemens Product Lifecycle manager Bernd Müller, the technology of the smart meter is only part of the solution to energy conservation; consumers also have to do their share (2008). The Fraunhofer Institute for Solar Energy (ISE) Systems in Freiburg, Germany, examined how consumer behaviour can help stabilize power grids. In a research project in Karlsruhe-Stutensee, approximately one hundred private households were equipped with communication-capable electric meters that were connected to a computer at a transformer substation. Using the catchphrase “Let the sun do your laundry!” the households obtained a text message asking them to wash their laundry whenever there was bright sunshine (Müller 2008). Households that complied received a discount of €0.50/kWh. According to Sebastian Götz of the ISE, customers tended to conserve in the long term only if the savings are large and feedback was frequent: “We want energy saving to be fun. If you only get an electric bill once a year, you can’t possibly figure out why you used more energy” (cited in Müller 2008). Some of the eco-visualisation projects that will be discussed in the second section of Chapter 2 are considerably more entertaining than simple text messaging and thus offer an exciting way to introduce new conservation strategies to the general public.

While comparative feedback and dynamic feedback have been identified as the most effective strategies to heighten energy savings, these curtailment methods have some negative effects. As the Sacramento Municipal Energy District recently discovered, many individuals do not wish to be put under surveillance and compared with their neighbours in a pessimistic light. An earlier study conducted by MIT professor George Hart found that all novel technologies such as electricity monitoring devices have the potential to affect society in a complex manner, with both beneficial and detrimental consequences (1989). Hart provided an illustrative case study via the use of a hidden appliance load-monitoring device that displayed vital information to aid conservation, but unfortunately, this device that could also be used for surveillance purposes. Hart argued that there was significant potential for the technology to be abused (1989). The danger that energy-monitoring technology might eventually lead to the deterioration of civil liberties and privacy rights could create an ethical quandary. This topic will be brought up for further debate in Chapter 4. For the purposes of this inquiry, curtailment strategies like dynamic and comparative feedback will be regarded for the moment as generally positive methods of promoting energy conservation, worthy of further testing and exploration.

1.5 Conclusion

The primary premise of this inquiry is to investigate whether eco-visualisations offer first, *new strategies to conserve energy* and second, *new site-based environmental learning experiences*. Eco-visualisations are generally portable art and/or design works that creatively visualise ecologically relevant data using images and occasionally images and sound. Eco-visualisations can offer enjoyable, “at a glance” learning experiences to varied populations. It is the aim of this inquiry to show that eco-visualisations that deliver energy consumption data represent a substantial contribution to new knowledge about dynamic feedback as a tool to promote energy conservation—McCalley and Midden actually cited the need for further research in this arena of eco-feedback (1998). While this inquiry will be limited to eco-visualisations that display *energy usage statistics*, it should be noted that the field could extend much further. Future research could explore how real time imaging of tap water usage might promote greater freshwater conservation or how the visualisation of air pollution might make people drive less.

The exploration of the potential of eco-visualisation to connect an audience with a local energy-learning experience is grounded in the philosophy of sustainability. As discussed in “*Definitions of key terms*”, this inquiry’s philosophy of sustainability is rooted in how humans manage natural resources like oil and coal for future use by all cultures while ideally incorporating an environmental and social justice component. The section “*Global warming, global whining: Why don’t we conserve?*” hopefully explained why new grassroots methods to encourage conservation are vital to the planet’s health. As previously stated, the primary goal of this research is to support environmental stewardship either through direct measureable conservation or through eco-education only—that is, through non-monetary means. Thus, the aim is to incorporate the discourse of sustainability and eco-visualisation into three small-scale case studies projects: *7000 Oaks and Counting* (2006-09), *World Offset* (2008), and *darkSky* (2009). As discussed by economists like Schumacher, the concept “small is beautiful” applies generally to this inquiry as the three projects have affected three relatively tiny, but growing communities. Thus, this research possesses clear limitations especially in terms of the question of how to inspire change on a large scale. Yet the previous section, “*Real time data, real world change*”, provides an argument that art works that deliver dynamic feedback in a fun, visual way could have the potential to

increase conservation behaviour although there are some negative aspects of monitoring on a large scale that relate to surveillance and the loss of privacy. This inquiry will focus primarily on the positive aspects of using dynamic feedback via images to promote resource conservation.

The next chapter, “*Earthworks, Environmental art, and Eco-visualisation: 1960-2004*”, will contextualize the interdisciplinary field of eco-visualisation initially in the landscape of art history. While eco-visualisation has been discussed as an interdisciplinary field integrating aspects of media art, architecture, industrial design, interior design, and HCI, this expanding field possesses the greatest number of historical precedents in the fields of art and design. Contemporary examples of eco-visualisation come equally from the fields of art and design, although these two fields are today discussed using many crossover terms. As Chapter 3 will demonstrate, many of the methods driving the creation of the proof-of-practice projects came from the field of art though many originated from design methodology or social science methodology thus displaying the hybridism and interdisciplinary nature of this emerging arena of eco-visualisation.

Chapter 2: Earthworks, Environmental art, and Eco-visualisation: 1960-2004

Eco-visualisation offers a new arena for artists to utilize their visual problem-solving skills to respond to the enormous challenge of reducing energy consumption. In the context of communicating local energy usage, real time animations have particular advantages over static objects for the following reasons. First, they favour the transmission of a direct message that changes over time, and thus requires the continuous attention of a viewer. Second, the dynamic works convey actual data quickly and accurately. Third, animations could be perceived as more amusing and accessible than text-based LED displays or more punitive pleas to cut back power usage. Fourth, real time interaction increases the potentials for viewers to learn at their own pace over time. As discussed in Chapter 1, eco-visualisation is an interdisciplinary practice whose methodology borrows from the fields of fine art, sustainable design, and HCI. But how exactly does the field of fine art contribute to this more contemporary practice of data visualisation to promote environmental stewardship?

Earthworks and environmental art created prior to the year 2005 constitute an impressive array of creative activity that laid the conceptual foundations for the contemporary eco-visualisations that are the primary subject of this inquiry. It is important to distinguish here between the varied arenas of earthworks, land art, and environmental art in the first section of this chapter. Next, a brief look at the history of environmental art will provide clear evidence that art can raise long-term public awareness about ecological issues and offer an opportunity for a shared learning experience. This overview of the eco-art field allows a glimpse of the historic precedents that gave rise to the more contemporary experiments in eco-visualisation that will be discussed in the last section of the chapter. The review of comparable eco-visualisation works will suggest that eco-visualisations offer new, exciting ways for artists and designers to inspire energy conservation using visual feedback exclusively, or in some cases, visual feedback combined with a reward of some kind. The environmental art projects analysed in the first half of the chapter connect the newer eco-visualisation projects with a distinct historical context and conceptual legacy.

2.1 Earthworks vs. Environmental Art

This first part of this chapter will quickly contextualize the genre of art known as earthworks, and its relation to the arena of environmental art and its beginnings in the activist art works of the 1960's. Environmental art is different from the seemingly related fields of land art and earthworks. Land art is a term used to describe the practice of artists who work with natural materials and impromptu performance in the landscape, such as the UK-based artists Andy Goldsworthy and Hamish Fulton. Land artists like Goldsworthy could be said to have a sustainable practice, however, unlike the environmental artists to be discussed shortly, most of the land artists were motivated to work in this way due to conceptual or aesthetic concerns rather than due to an activist sensibility.

Part of the land art genre, the earthworks movement involved American artists like Robert Smithson, Michael Heizer, Robert Oppenheim, and Walter de Maria who created privately-funded, massive sculptures in the expansive desert landscapes of the American Southwest. Most of these artists initially operated without much concern for the environment—Michael Heizer's *Double Negative* (1969-1970) for instance, involved the bulldozing of 240,000 tons of earth from a mesa north of Overton, Nevada in the USA. Today the piece is an open pit that contrasts the now-paltry human intervention with the giant geologic force of erosion (Taylor 2004). Generally speaking, the land art and earthworks practitioners were creating work in "nature" far from the gaze of the public, and did not prioritize an environmental message of any sort in the work.

Robert Smithson is an earthworks artist who could be considered something of an environmental artist today. His practice and writing form an interesting bridge to the environmental art movement. In 1973, Smithson wrote prolifically about his redefining of the well-known definition of entropy, or the tendency of humans to destroy their environment for the sake of profit and the pursuit of luxury: "You have a closed system which eventually deteriorates and starts to break apart and there's no way that you can really piece it back together again" (1973 cited in Flam 1996). The artist's words sound uncannily appropriate today given the ecological challenges posed by climate change. Smithson favoured working in outdoor sites that were abandoned by industry such as old quarries or scrapped oil-drilling locales because these were prime areas to highlight

the processes of entropy and human impacts on the landscape. His experiments with pouring industrial materials into old quarries (Figure 2.1) have seemingly little to do with raising environmental awareness—but they do highlight the residues of manmade materials from road building. Yet other works like *Spiral Jetty* (Figure 2.2) because of their proximity to oil resources have inspired ecological controversy and anti-drilling activism as recently as 2008, nearly thirty years after the work was completed.⁵

Different from land art or earthworks, environmental art, or eco-art as described by Sue Spaid, includes works made by artists that *actively attempt to raise awareness about and offer solutions to ecological problems* (2002). This distinction is important.

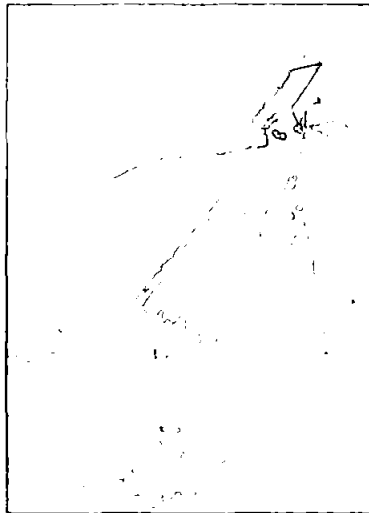
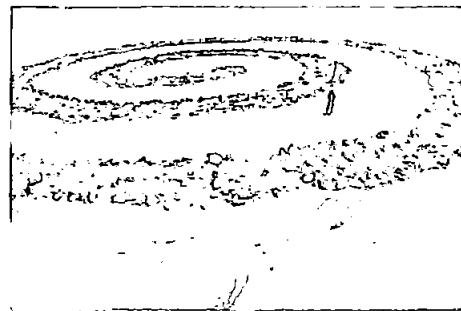


Figure 2.1 (left): Robert Smithson, *Asphalt Rundown*, 1969.⁶

Figure 2.2 (below): Robert Smithson, *Spiral Jetty*, 1970. Long-term installation in Rozel Point, Box Elder County, Utah. Photo: Gianfranco Gorgoni.



⁵ Smithson's most monumental piece, *Spiral Jetty* (1969-70), received critical accolades as an earthwork (Cooke and Kelly 2005). This project offers additional lessons in how Smithson, via his selection of a site, contributed to a long-term raising of ecological awareness. Built of basalt rocks, earth, and water on the Great Salt Lake near Rozel Point in Utah, the jetty is a 1500-foot long, 15-foot wide counter clockwise coil that starts at the shore of the lake (Figure 2.2). The outdoor sculpture is only visible when the level of the Great Salt Lake falls below an elevation of 4,1975 feet. It is visible only during periods of drought and has been visible since 2003, and possibly will remain visible for some time due to the effects of climate change. Smithson was reportedly attracted to the Rozel Point site because of the stark anti-pastoral beauty and industrial remnants from nearby Golden Spike National Historic Site, as well as an old pier and a few unused oil rigs. The dynamics of the abandoned drilling site, and the fact that the water levels would change the look of the sculpture over time fascinated Smithson who sadly died in plane crash a few years after *Spiral Jetty* was completed.

In early 2008, the Canadian oil and gas company Pearl Montana Exploration and Production filed permit requests for exploratory drilling in the Great Salt Lake about four miles from Robert Smithson's iconic sculpture. Oil extraction of any kind would interrupt the artwork's context, disturb the area's isolated character, and degrade the natural environment of the Lake. In response, the Dia Art Foundation, the sculpture's current owners, and the National Trust for Historic Preservation began an extensive email campaign explaining this situation. As a result, during the public comment period for Pearl Montana's application, which ended on February 13, 2008, the State of Utah received more than 3,100 emails and letters, as well as 300 phone calls, from concerned parties in the United States and abroad. Permits for drilling were denied. Subsequently, Dia met with Utah officials to discuss the long-term preservation of *Spiral Jetty*. Together, Dia and the State decided to pursue the creation of a buffer zone around the sculpture that would both help protect the artwork for future generations. This is a great example of how the artist's selection of a particular site can influence future environmental policy decisions.

⁶ Whole film available at: <http://www.robertsmithson.com/films/txt/runtdown.html> [February 4, 2009].

Earthworks and land art practitioners like Robert Smithson focused primarily on issues of site, materials, and process in creating their work. Promoting sustainability through art in the environment was not really a focus for earthworks artists. Environmental artists, in contrast, put the notion of “environmental activism through art” first and foremost. In other words, the capacity of the artwork to inspire ecological awareness took precedence over other formal concerns. The early experiments by environmental artists provide evidence that supports the main goals of this inquiry, listed below for review:

Goal 1: Eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and thus encourages new forms of site-based learning.

Goal 2: Eco-visualisation that provides real time visual feedback about energy usage can increase environmental awareness and possibly increase the conservation behaviour in the viewing population.

Goal 3: Eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.

For example, works made in the early 1980’s by the German artist Hans Haacke, certainly support the notion that art is capable of engaging the viewer in a new learning situation (Goal 1), increase environmental awareness (Goal 2) and inspire new site-based dialogue (Goal 3). The next section of this chapter will detail some of the early contributions made by practitioners of environmental art in the context of this study’s three primary goals.

2.2 Standing up: Environmental Art and Activism

Perceptions of nature changed radically in the 1960s primarily due to shared community concerns about public health. Rachel Carson’s controversial book, *Silent Spring* (1962), proved the destructive effects of the pesticide DDT on the reproductive capacity of waterfowl. By 1972, DDT was banned in the US, though other more toxic chemicals were not (Lear 1997). Artists and activists developed new methods to create art in unusual spaces to educate the public about the negative environmental impacts of industry: water pollution, chemical dumping and pesticide use. Art historian Grant Kester has suggested that the early practitioners of art and cultural activism produced an entirely new type of social awareness, or “knowledge that

aesthetic experience is capable of producing” (2004: 9). Early experiments in generating environmental awareness through art were conducted in projects from the 1960’s through the 1980’s using a variety of strategies to be introduced here: real-time remediation, outdoor performances, community engagement, scientific collaboration, and public education. Brief description and analysis of these precedent-setting strategies to promote learning via visual feedback and learning will help link the work of environmental artists to contemporary practitioners of eco-visualisation.

The German artist, Hans Haacke provided an early example of how site-specific art with dynamic visual feedback could produce unique learning situations including: uninvited collaboration with a polluting industry, new resource conservation technology, and most importantly, local education about resource contamination. In 1972, Haacke created a durational installation for the Museum Haus Lange that purified polluted water titled *Rhinewater Purification Plant* (Figure 2.3 below).

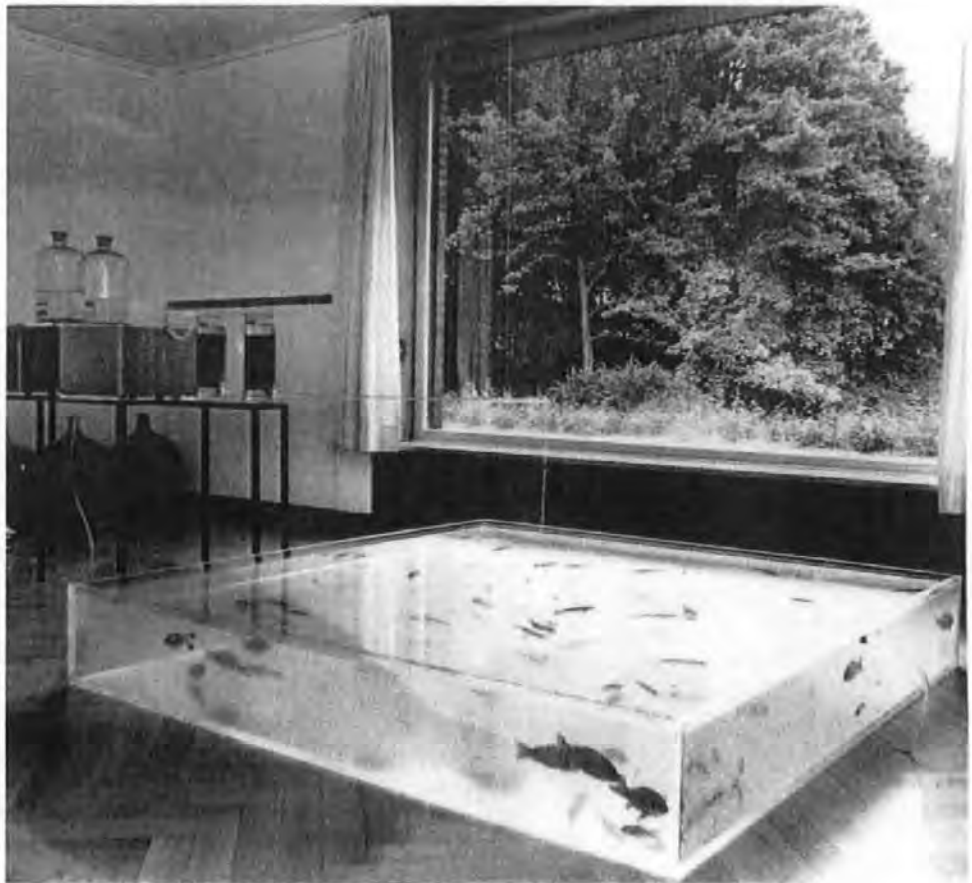


Figure 2.3: Hans Haacke, *Rhinewater Purification Plant*, 1972

In a room with a large window, the artist placed glass bottles filled with fouled water from the Krefeld sewage plant collected from the nearby Rhine River. Resembling a laboratory, the installation featured a custom pump paired with a filter that sanitized the tainted liquid for release into a large tank filled with live goldfish. The minimalist glass

tank was not only a sculptural object but a real time visualisation that provided evidence that the filtered water was healthy enough for the fish. Surplus water was discharged from the window to irrigate the museum's gardens (Matilsky 1992: 41). In transforming the Krefeld Sewage Plant's murky effluent to life-supporting water, Haacke brought public attention to the sewage plant's role in degrading the river. Most importantly, by pumping the polluted water through an additional filtration system and using the excess water to water the museum's garden, he introduced the concept grey-water reclamation. Grey water reclamation is a technique still used today by urban planners to reduce strain on drinking water supplies by recycling water from domestic showers and sinks to water plants outdoors (Ludwig 2006). It is significant that an artist conceptualized this technique first for a European audience, before a scientist or engineer, for the purposes of *educating the public collectively about the wonders of filtration via a dynamic process*. Contemporary artist collaborative groups like the Future Farmers recently created a whole installation to introducing the public to grey water reclamation called *Rainwater Harvester* (2009). Haacke's seminal work lives on in their practice (See Figure 2.4 below).

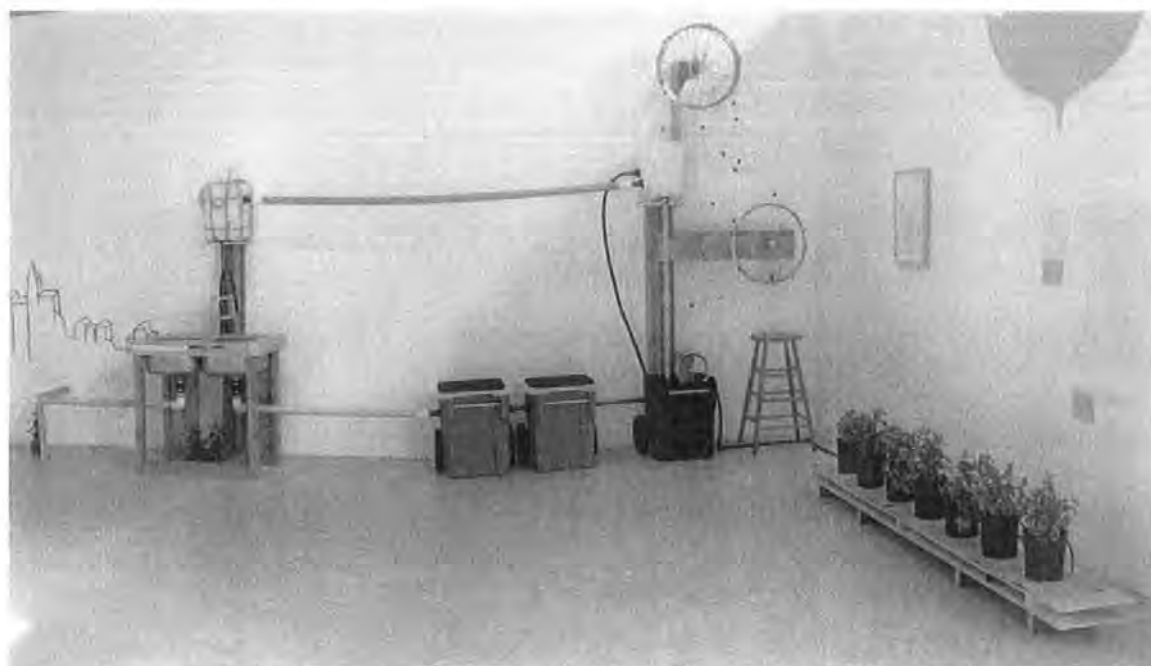


Figure 2.4: Future Farmers artists Amy Franceschini and Michael Swaine, *Rainwater Harvester / Greywater System Feedback loop*, 2007

Rhinewater Purification Plant was immensely significant to environmental artists though limited in its scope of impact. Art historian Miwon Kwon admired Haacke's ability to expand the content presented in the standard white-box space of the museum—this “cultural framework defined by the institutions of art”—to incorporate

an ideological critique of the sewage plant's damaging activities (2002: 13). Despite such praise, only a small audience of museum visitors actually visited *Rhinewater Purification Plant*. Within the art world, Haacke's unconventional work inspired others to break with the confining economics of the museum. For example, Allan Kaprow encouraged young artists to reinvigorate the practice of art making by devising new strategies of engaging new content related to local environments and everyday activities: "Lifelike art holds that art is connected to life and everything else" (1983: 201). Theorists like Noah Wardrip-Fruin have argued that Kaprow's writings are a touchstone for contemporary artists as they not only promote a non-hierarchical formulation of art but also provoked a "desire to break down distinctions between creator and audience" (2003: 83). Artists like Haacke and Kaprow were surely influential in promoting artwork with site-specific content that presented audiences with either a participatory or learning opportunity. Art historian Kester noted that the art world provides a "relatively narrow" space for work like Haacke's that critiques powerful, for-profit entities like the sewage plant (2004: 68). Kester claimed that the moment the artist attempts to bring the work out into the real world the "level of toleration diminishes rather rapidly" (2004: 68). So although these artists were trying to escape the paralyzing politics of the museum, the art world provided a necessary space for some of this activist work to be exhibited without resistance from corporate interests—such as the Krefeld sewage plant.

Like Haacke and Kaprow, the German artist, Joseph Beuys provided a historical precedent for today's eco-visualisation artists by breaking down barriers between high art and everyday activity to promote site-based learning (Goal 1) and community dialogue (Goal 3). Beuys was even able to engage a population outside the limited confines of the art world and provide an opportunity for public education in later works like *7000 Oaks* (1982), a project that inspired one of the case studies to be described in Chapter 3, *7000 oaks and counting*. In a project that continued after his death, Beuys motivated an entire community in Kassel to plant oak trees for four years to not only protest deforestation via acid rain but also promote urban renewal (Mesch 2007). Beuys recognized that performance artworks outside the museum's confines could function as a gesture of environmental activism and that trees were themselves a dynamic work of art. In his early performance *Eine Aktion im Moor* (Bog Action) (1971), Beuys celebrated the natural diversity of wetlands that were to be drained to form low-lying land masses known as polders:

“Bogs are the liveliest elements in the European landscape, not just from the point of view of flora, fauna, birds and animals, but as storing places of life, mystery and chemical change, preservers of ancient history. They are essential to the whole eco-system for water regulation, humidity, ground water and climate in general” (cited in Tisdale 1979: 39).

Beuys called attention to the destruction of European wetlands by personally enveloping himself in the endangered waters. In the performance, Beuys ran through a bog, bathed in the mud, and then swam through a swampy trench. Beuys’ immersion in the pungent mud and murky waters of the polders was meant to literally portray the connection our own bodies have with these non-romanticized ecosystems. Unlike mountains and rivers, tourists did not visit wetlands, the great natural filters of our water resources. Live outdoor performance in the form of the artist bathing in a bog or Kassel residents planting oak trees helped raise awareness about an important environmental issue (Goal 2), the wetland, an underappreciated natural space. Art historian John Grande praised Beuys’ conceptual experiments as proof that artists can help their audiences develop a more evolved relationship with nature: “Art could play a leading role in the future of our society if our artists accepted the importance of studying nature, and recognized their own place within an ecosystem” (2004: 38). In the USA in the late 1960s, artists like Newton Harrison were eating dirt as part of a public performance to educate the public about the connection between healthy compost and high quality food (Goal 1). Along with his wife Helen, this collaborative team went on to create several installations that facilitated learning about ecological issues through art. Environmental artists like Beuys and the Harrisons were very focused on using art to inform, educate, and converse with the public about key ecological issues like the demise of wetlands and the need to understand our food sources.

Artists like Beuys, Haacke, and the Harrisons contributed to a wave of environmental interventions performed by citizen activists that characterized the whole decade of the 1960’s and 1970’s. The same year that Beuys performed his *Eine Aktion im Moor*, a group of Canadian citizens set sail from Vancouver to protest the USA’s underground nuclear testing on Amchitka — a tiny island off the coast of Alaska that was a refuge for endangered sea otters, bald eagles, and peregrine falcons. The venture sparked a public outcry with positive results: nuclear testing on Amchitka was discontinued, and the island became a bird sanctuary. The activist team that initiated the preservation of the avian refuge is known today as Greenpeace. Based in

Amsterdam, Greenpeace has expanded to support 2.8 million members worldwide, and offices in 41 countries (Weyler 2004). While Greenpeace has become a global symbol for promoting sustainability through nonviolent actions, the group has been heavily criticized for its one-sided protests that focus on only one side of an issue that involves a precious resource such as the seal population. Cultural historian Alexander Wilson points out that although Greenpeace efficiently facilitated the collapse of the commercial market for seal fur in the early 1980s, the group's campaign enraged aboriginal groups for whom hunting seals is part of a local subsistence economy (1992: 139-140). Although activist groups can effectively elicit policy changes that promote sustainability in the short term, it may be the case that artists can also utilize their talents to bring about similar changes while allowing multiple viewpoints from each side of the issue to be profiled—the Harrisons' practice is detailed below as an example.

As compared to activist groups like Greenpeace, artists might display better records when it comes to fully understanding the multiple effects of ecological stresses to instigate change without negative feedback. Newton and Helen Harrison's 1989 multi-faceted proposal to restore the polluted Sava River valley in Yugoslavia met with widespread acceptance and the potential to alter land use policy (Heartney 1995: 155). Art historian Eleanor Heartney cites the unique ability of the artist to *transcend socio-political boundaries*: "They refuse to be bound by the rules of any specialized field or the political needs of any special-interest group" (1995: 162-165). The Harrisons also can boast some of the most "results" in actually promoting long-term environmental changes via art. Their proposal was actually a hybrid art and design project to retain green space in an industrial, rapidly gentrifying area of Holland. The Harrisons' proposal was immediately accepted, debated, and ultimately put into place with a few modifications by the Dutch government. Heartney highlights the massive contributions and influence of the Harrisons as artists working on "real-world" problems:

"Certainly in the context of present-day America, such ideas seem hopelessly visionary, which may explain why most of the Harrisons' projects have originated in Europe. But where there is a receptive government or populace, the pair can point to some real-world accomplishments. The "Green Heart" project, for instance, was immediately embraced by Holland's Green Party, and has gone through various ups and downs with a succession of governments. Today, elements of this proposal, among them the preservation of the country's center, the physical separation of cities and the redirection of new development, have become part of the government's plan for this area" (1995: 119).

Art historian Grant Kester has noted that although artists lack the knowledge of the specialist, artists are better able to “grasp and represent the interactions of vast ecosystems as well as a form of temporal imagination that allows them to envision the long-term impact of current human and environmental processes on an ecosystem” (2004: 66). Kester like Heartney was suggesting that artists—not necessarily activists or scientists—possess unique abilities to visualise and halt the effects of environmental stressors. For the purposes of this inquiry, it is important to note that the eco-visualization artworks simply form a field that augments the work of activists and scientists working concurrently to promote small scale shifts in site-based learning (Goal 1), conservation behaviour (Goal 2) and eco-dialogue (Goal 3).

Hans Haacke, Joseph Beuys, and the Harrisons inspired many artists to pursue projects that integrated dynamic change, site-based education, and an ecological message. Influenced by Haacke’s experiments in river clean-up, contemporary eco-artist Jackie Brookner creates public sculptures such as *Prima Lingua* (1996-2002) that sanitize tainted ponds via a dynamic biological process (See Figure 2.5 below). This giant sculptural tongue employs plants—a truly sustainable technology—to filter and clean polluted water. Brookner’s trademarked *Biosculptures* form natural water treatment systems, and teach a vital ecological concept: no waste exists in healthy ecosystems. The excrement of one organism becomes food for another. As water flows over the sculptures, the plants and associated bacteria transform pollutants and toxins into life sustaining nutrients. Fish, snails, and other aquatic organisms live in the water and enrich the *Biosculptures* over time.



Figure 2.5: Jackie Brookner, *Prima Lingua* (1996-2002). Materials include: concrete, volcanic rock, mosses, ferns, wetland plants, fish, and steel.

Brookner's biosculptures are a good example of public art that provides an opportunity to educate the public about environmental issues on site. Brookner claims that her artistic practice raises "community awareness of the urgency of restoring health to aquatic ecosystems" (2009). In Brookner's case, the collective viewing of a time-based phenomenon—the live filtering of filthy water—focuses viewers on dynamic solutions to a common environmental problem of water pollution. The environmental artists of the 1960s, 1970s, and 1980s shared a focus on *site-based education through a shared dialogical experience* that directly relates to the three primary goals of this inquiry.

2.3 Introduction to eco-visualisation: Site-based education through observation of dynamic processes

Eco-visualisations—artworks that translate ecological data into easy-to-understand images and sound—further expand the trajectory of the environmental art arena. Like Jackie Brookner’s biosculptures, *eco-visualisation* artwork promotes *sustainability* through a shared experience of a real time *happening* that is controlled by a computer or associated electronic technology—as opposed to organic materials like liverworts that filter water in Brookner’s *Prima Lingua*. Much of this work is quite new—and so far there are very few examples. Due to technical complexities, some installations remain permanently in the prototyping stage. Conceptually, the work is quite strong due to the innovative exploration of new educational strategies made possible by new media forms such as computer algorithms. Overall, the *eco-visualisation* projects incorporate a message of positive environmental stewardship as a primary focus—often through display in a public place to facilitate community dialogue (Goal 3). But do the viewers receive and process the message? This is a point to debate in the next several sections of this chapter.

Prior to 2000, there were very few artworks that *electronically visualised a resource in short supply*—but some exemplary pieces have been produced in the last few years. *Sustainable* (2004), a dynamic robotic sound installation creatively displays a water resource-sharing algorithm (Birchfield et al 2005). The installation’s pulsing lights and jarring clangs characterize the constant water shortages in the American West. Built by a collaborative team of David Birchfield, David Lorig, and Kelly Phillips from Arizona State University, *Sustainable* consists of a network of seven robotic gongs suspended over large tanks with varied amounts of water (Figure 2.6). Each tank is linked via water tubes to an upstream and downstream neighbour. The network is closed. There is a finite, or limited amount of water to share. A computer runs a custom water resource-sharing algorithm that simulates a fluctuating water demand for each tank. The tanks are greedy but assign temporary water allotments via the *eco-visualisation* software. The artists want viewers to compare the artwork to a “group of farmers or golf courses that have high demands for water usage, but must share and negotiate for the rights to use water” (Birchfield et al 2005). In *Sustainable*, water demand is visualised organically in both image and sound. The lamp below the gong is illuminated when the current water level does not meet the desired level. Also,

tanks that have less water have gongs that clang louder. The water held in full tanks muffles the sound of the gong. Bright illumination and cacophonous sounds thus envision resource scarcity.

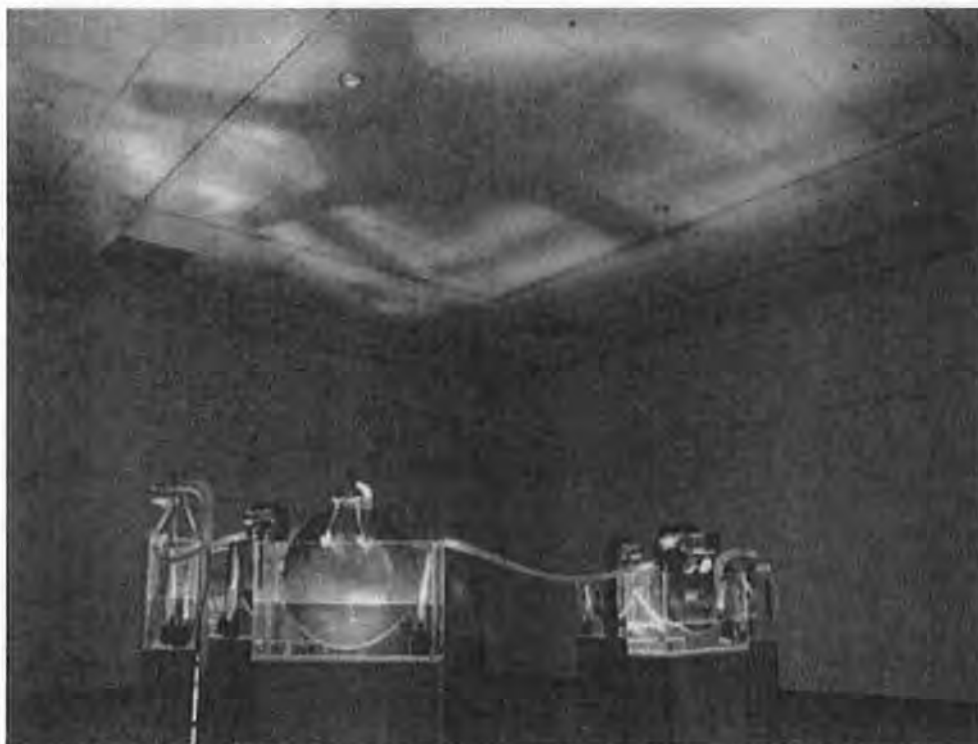


Figure 2.6: David Birchfield, David Lorig, and Kelly Phillips, *Sustainable*, 2004⁷

Overall, the *Sustainable* installation is quite complex. The collaborative team discovered that the system displays non-linear, or unpredictable sharing behaviour despite the simple rule-structure of the algorithm (Birchfield et al 2005). In other words, each tank selfishly tries to keep its tank full. The interaction of the tanks creates new sequences of sharing. The installation provides a way for viewers to imagine the water shortage in the west without having to read a detailed scientific paper or journal article directed at an audience of specialists. Yet *Sustainable* is not intended as a substitute for academic publications. Rather, the piece provides an exciting audiovisual space that illustrates the potential for volatile conflict in communities without adequate freshwater resources. While the installation is accomplished technically and offers great visual interest, it does not directly suggest solutions for the water crisis nor does it purport to inspire site-based dialogue or interaction as computers, not viewers, exclusively control the water levels in the tanks. A viewer-controlled water sharing installation would be a much stronger improvement on the potential to learn about resource conservation via the installation. Overall, *Sustainable* offers viewers a

⁷ See videos of the *Sustainable* installation. Available at: <http://ame2.asu.edu/faculty/dab/sustainable.php> [December 29, 2005].

sophisticated audiovisual experience that illustrates sample data behind a typical water shortage problem with a poetics of light and sound that occurs in real time. The piece is poetic but would certainly benefit from expanded viewer involvement.

Many of the artworks discussed up to this point in this chapter all share some important commonalities: promoting stewardship, providing environmental education of some variety, and displaying some form of dynamic process. Works like Smithson's *Spiral Jetty* and inspired public action to save an unprotected site from oil drilling while Beuys's *7000 Oaks* inspired a community to replant a diminishing natural resource like trees. Haacke's *Rhinewater Purification Plant* and Brookner's *Prima Lingua* clearly illustrate relatively simple ways for the public to promote clean and healthy freshwater resources. The "early" eco-visualisation, *Sustainable* (2004), builds on these precedents from environmental artists and shows viewers how challenging water resources sharing can be through a simulation of the very real problems facing the states in the arid American southwest. This prior section thus provides a rather brief overview of how environmental art grew out of the eco-activism and creative land-based experiments of the 60s. Environmental art is the foundation for the arena of eco-visualisation. The last portion of this chapter is exclusively focused on comparing examples of contemporary eco-visualisations that use dynamic feedback of energy consumption to inspire conservation and promote stewardship.

2.4 Beyond Eco-Art: 21st century Eco-visualisation

“We can't solve problems by using the same kind of thinking we used when we created them”. Albert Einstein

2.4.1 Overview: from eco-art to eco-visualisation

Land art, earthworks, and environmental art made prior to 2005 constitute an impressive lineage of creative activity that provided evidence that artistic interventions, particularly when made in public space, can have a *beneficial societal effect* and also *raise public awareness about ecological issues*. The previous section also considered the history of environmental activism as it manifested itself in the panoply of earth friendly artworks created from 1960s to the 1990s, and art historians like Kester offered the assertion that artists—as opposed to engineers or scientists—might possess unique abilities to visualise and halt the effects of environmental degradation (2004: 66).

This chapter concerns itself with the primary question of inquiry in terms of how it relates to contemporary art and design: *Can visualisation projects that use dynamic feedback trigger ecologically responsible behaviour such as energy conservation?* To consider this question, new works from several artists and designers who visually translate energy data via dynamic feedback for the purpose of promoting stewardship will be assessed using the following criteria:

- Did the artwork increase conservation behaviour in the viewing population?
How was this accomplished, and for how long?
- What forms of visualisation are most effective to aiding conservation of resources?
- What are the aesthetics of 21st century eco-visualisation? Do particular kinds of aesthetics inspire greater amounts of conservation action or knowledge?

Contemporary art and design that integrate dynamic feedback related to electricity usage will be the focus in the sections to follow. The selected creative endeavors are quite new. These projects have not been critiqued in academic journals, nor in art magazines, much less published in books. It is the combination of innovative concepts, state-of-the-art technology, and contemporary visualisation aesthetics that make all of these projects target environmental problems in a completely novel way. These projects

extend the history of eco-art into the 21st century, so there is a strong connection to the past. However, the contemporary works like HeHe's *Nuage Vert* (2008) offer new knowledge about how public art can impact a community's ability to engage in site-based learning (Goal 1), conserve resources (Goal 2), or establish new dialogues about resource conservation (Goal 3). In addition, hybrid art-design project like STATIC's "smart" household decor, DIY Kyoto's *Wattson*, and Ambient Devices' *Energy Orb* offer local citizens and organizations the opportunity to personally regulate and control their own resource consumption. STATIC, DIY Kyoto, and Ambient Devices focus on introducing custom objects into the home or work space that offer dynamic information feedback at a glance. All of the projects described below do not presume to offer a universal solution to the problem of over-consumption, but rather, to explore art and design as a means of promoting site-based learning (Goal 1), increased awareness of energy consumption (Goal 2), and to provoke response and dialogue (Goal 3).

2.4.2 *Nuage Vert*: The cloud that counted kilowatts



Figure 2.7: *Nuage Vert*, HeHe, 2008 (Photo by Niklas Sjöblom)

Nuage Vert was a city-scale light installation produced by the collaborative HeHe composed of artists Helen Evans and Heiko Hansen and located in the sky above Ruoholahti, Helsinki (Figure 2.7 above). Every night from the 22nd to the 29th of February 2008, the vapor emissions from the Salmisaari coal burning power plant were illuminated with a high power green laser animation. The animation drawn with the

laser corresponded in real time to how much electricity was being used by the city residents. If the green cloud shape was very large, the energy consumption citywide was reduced. If the green cloud was small in area the electricity loads in Ruoholahti were presumably quite high (Figure 2.8). Viewers were expected to work collectively to unplug devices in their homes to increase the size and scope of the green cloud hovering above the smokestack.

How effective was the *Nuage Vert* project, and how many people got to see it or be influenced by it? The project got an enormous amount of media coverage: all the local newspapers, the citywide press, national radio and regional TV news featured the project prominently (Evans 2008). For roughly 574,000 residents of Helsinki, this media coverage must have been significant. The Ruoholahti district is located in the southwestern part of the central city area of Helsinki, close to the Lauttasaari Island, and it functions as the principal connection between the Helsinki city centre and the city of Espoo to the west. In an effort to target publicity for *Nuage Vert*, the artists developed a communications platform that employed an iconic language designed by Devalence, a Parisian design group. Working with local cultural management students, slogans were created for flyers and posters, such as: “Aurora borealis in Helsinki?” With Dodo, an Finnish environmental activist group, *Nuage Vert* was presented and discussed with 240 local school children, between the ages of seven and sixteen. Local community groups distributed posters. A custom-designed sticker for electrical outlets asking people to “*Unplug!*” was distributed to 4,000 households. Although the above-described communication strategy focused on activating Ruoholahti residents, the greening of the cloud was visible beyond the boundary of the neighbourhood, over 10 km away (Evans 2008).

In addition to the masses of Helsinki residents who saw the public work, there was a body of people who normally were not connected with the art world who were perhaps overwhelmingly affected by the piece. The glowing cloud was the product of a four-year intensive collaboration that began in France. Initially HeHe tried to orchestrate the piece in Paris but met resistance. The artist duo patiently initiated and ultimately negotiated the right to exhibit the public artwork in Ruoholahti with support from the following organizations: the laser physics department at Helsinki Technical University, the computer science department at the University of Illinois, as well as a medical laser manufacturer, and the power plant itself, Helsinki Energy. The sheer

number of co-sponsoring organizations outside of the traditional art world was impressive and given the technical challenge, the support of each was vital to the project's success. Also, these diverse groups from culture, science, industry, communication and ecology would not ordinarily work together—the artists were the linking factor. Given the number of persons involved, the project most likely deeply impacted each of the collaborators and facilitators and their families. Although not quantifiable, this opportunity to work on a community project with high visibility must have influenced each team member's opinions about electricity conservation and the ability of public art to bring these conservation issues to “light”, literally.

Overall, the *Nuage Vert* project is the most exciting public art project to date that utilized dynamic feedback to inspire a local population to conserve electricity—though there were potential issues with its transmission of live data in that viewers may have been confused as to what the size of the green cloud actually meant—this issue will be investigated in more detail shortly. As mentioned previously, *Nuage Vert* most likely influenced a great number of persons who live in the Helsinki area because of the media blitz and the spectacle of the green cloud viewable from ten kilometers away. The project thus can boast positive influence more in the category of awareness raising via a visual spectacle than in measureable effectiveness in lowering power consumption. In addition, *Nuage Vert* has won a number of prestigious art prizes: the Ars Electronica Golden Nica (Austria) and the OISJ Green Prix for Environmental Art (USA). In a sense, these awards are a direct indication of the project's immense influence and esteemed quality but the awards do not convey any information about the cloud's effectiveness, or the ability to encourage and foster greater energy conservation. Yet because the green cloud was directly linked to the output of the power plant, there is some real quantitative proof that this public art has a proven record of encouraging energy conservation. As described previously in conjunction with the marketing platform, HeHe facilitated an “unplug” event in Helsinki, on the evening of Friday the 29th of February. Between 7 and 8pm Finnish time, 4,000 local residents reduced their energy consumption by 800 kilovolt-amperes (kVA) (Evans 2008). This is roughly the equivalent of the power generated by one windmill running for one hour. This collective attempt to conserve—admittedly for a very short period of time—represents the great potential of eco-visualisation to help the general public conserve and witness the collective power usage dynamically by watching the green cloud grow as power demand decreased.

The *Nuage Vert* project marks the very first time that an invisible digital infrastructure measuring local electricity consumption had been made public and visible via an eco-visualisation for a radius of ten kilometers. Incredibly, despite the current energy crisis and the ever-increasing demand, energy flows freely. Electricity is monitored in most countries on an individual basis via a meter locked up in a boiler room or basement. The encouraging outcome of HeHe's "unplug" event speaks to the myriad future possibilities for urban planners and private business interests to make ecologically relevant data and networked information available in a public forum—perhaps through eco-visualisation. Giving a literal green outline to the relationships between power companies and those that consume their services could lead to the creation of a new form of pro-active citizenry and the aesthetic and potentially moral transformation of an urban community.

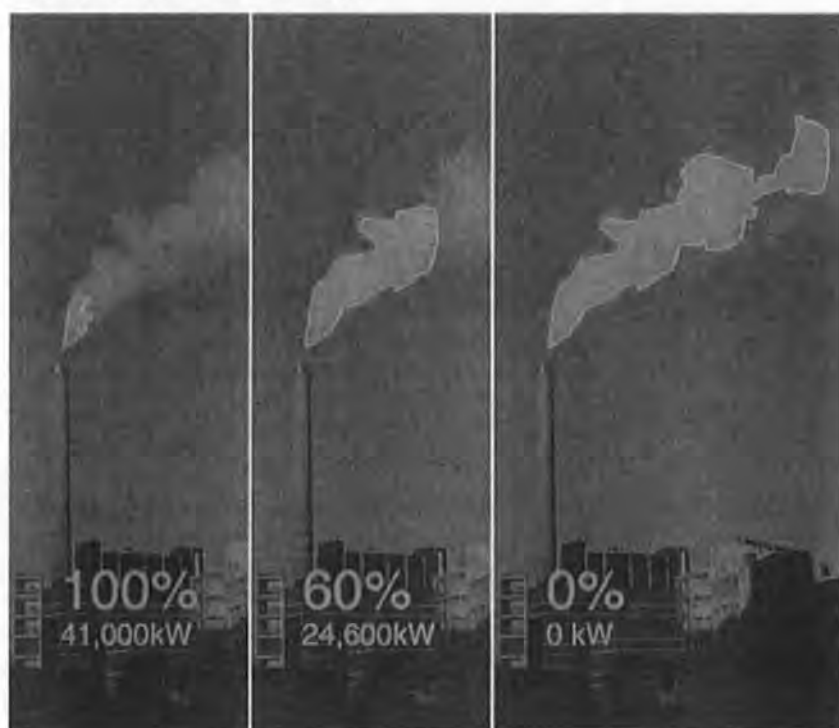


Figure 2.8: *Nuage Vert*, HeHe, 2008

The green laser performance must have been dramatic for the residents of Ruoholahti all of whom were accustomed to viewing the white steam pouring from the power plant's smokestack. The aesthetic choices here could not be more specific and targeted, though the visual paradigms could confuse those who were not immediately on the scene. *Nuage Vert*, translated from the Finnish means "Green Cloud". The laser drew an outline of the moving cloud onto the cloud itself, enshrouding the usual white vapor in a vivid green hue (Figure 2.8). Promotional material distributed by HeHe encouraged residents to "feed" the green cloud and make it larger by turning off lights

and generally not using electricity. In this sense, the larger green cloud was imagined as a potent and benevolent symbol of collective conservation. On the other hand, the acidic green of the larger cloud could make one consider imagery of poisonous, possibly radioactive sorts of noxious vapours, and thus this presumed symbol of sustainability could also be interpreted as a malevolent orb hovering over an guilty populace. In other words, HeHe set up a potentially counter-intuitive visualisation strategy. Some viewers might think the larger green cloud was “good” others might perceive it as “bad”. The artists stated that they fully intended for both aesthetic readings of the cloud to take place—but perhaps the project would have been stronger without such an ambiguous visual schema:

“As a transmitting architecture, *Nuage Vert* conveys multiple ideas: could this green cloud be a toxic cloud or an emblem for the collective effort of the local community? The meaning is left open for each and all to decide, and will depend upon the level of engagement...*Nuage Vert* is ambiguous, as it doesn’t offer a simple moralistic message, but rather tries to confront the city dweller with an evocative and aesthetic spectacle, which is open to interpretation and challenges ordinary perception (Evans 2008)”.

Perhaps the larger question here is whether it is indeed appropriate for an artist’s group to fully aestheticize a power plant without being direct about the message. According to the goals of this inquiry, HeHe should have worked harder to document the effectiveness of the piece and clarify the meaning conveyed by the visual spectacle. HeHe desired an open-ended, non-didactic piece but made a striking spectacle of the power plant, drawing all eyes to its daily production of energy. It was gorgeous, but was it not also horrifying too? Where was the horror in the piece? The acidic quality of the light might have subtly communicated an ill feeling, but the majority of the effect was perhaps overly celebratory of the lavish display. On the other hand, perhaps the real hidden horror of the piece is in the futility of the general practice conserving energy on specific days with no real duration or sustained conservation effort.

Why is energy conservation for an event like HeHe’s “Unplug” potentially meaningful in the short term as a site-based learning event and relatively futile in the long term? Since vast amounts of energy cannot be stored, producers across large geographical regions have to produce precisely the amount of energy that is being consumed, within microseconds. In Finland, the energy grid is linked to Norway, Sweden and Denmark, which means that if people in Ruoholahti consume less for a

day, there will be *no less coal burned at the Salmisaari power plant*. However, if the residents of Ruoholahti were to consume less for a month or longer, there would ultimately be less coal burned somewhere within the Nordic Pool at some point. This is the hopeful point, yet the reality is that the *Nuage Vert* installation lasted only a week and it is quite likely that consumption levels went back to normal after the green cloud left the sky. One final point about the weaknesses inherent in the *Nuage Vert* installation is that the energy required to run the lasers that beam the green light on the cloud is quite vast. It would be more sustainable over the long term if future versions of this piece might involve setting up a solar panel unit that could power the lasers. Sustainable thinking must also ultimately be applied to the processes chosen to make the eco-visualisation.

2.4.3 “Power” of the gaze: Smart objects promote energy conservation

STATIC’s “smart” household decor, DIY Kyoto’s *Wattson*, and Ambient Device’s Energy Orb are smart objects with embedded data-harvesting technologies that explore design as a means of promoting increased awareness and to provoke responses and dialogue about environmental issues. Most importantly, all of these objects attempt to communicate data about real time energy consumption to their users in one instant via a simple glance. In most cases, the information is reduced to a memorable colour key. According to David Lewis, psychologist and advisor in aircraft cockpit design, such smart objects can allow humans, already suffering from information overload, to comprehend data quickly and accurately: “Filtering information in this way makes sense, since trying to process too much information is a source of stress and can lead to mistakes” (Background Illumination 2004). Next, some of the smart objects that visualize energy usage via image and/or colour will be investigated and their effectiveness compared.

***STATIC* (Sweden)**

STATIC is a design research program funded by the Swedish Energy Agency. STATIC is structured to create a palette of sample prototypes to illustrate the possibilities offered by household objects that deliver dynamic energy feedback. The research approach in the STATIC group has two primary focuses: (1) the idea that the collaborative might work with energy monitoring not only from a technical but also

from an aesthetic point of view, and (2) the notion that the prototypes need not only be about utility and ease of use, but also about inspiring critical conversation in the context of use (Backlund et al 2006). The collaborative makes clear its aim to completely rethink the look and feel of every energy-consuming device in the home:

“Consider, for instance, how the ‘design problem’ of providing artificial light using lamps is split between the shaping of things like lampshades and fixtures on one hand and the systems for producing and distributing power on the other. If we do not want to hide energy consumption under ‘discreet and pleasant surfaces’, but instead expose issues such as sustainability as an integral part of an object, we somehow need to make energy itself more present in the design of the thing itself and the design of interacting and living with such things” (Backlund et al 2006:3).

While Chapter 1 provided a look at several scientific studies that describe how daily feedback altered habits of electricity usage, there are very few precedents for electronic art or design works that give dynamic feedback for energy usage. The capacity of such art works to alter habits of consumption have not been adequately measured and documented. The closest examples of objects that have been designed, but not tested, are STATIC’s *Flower Lamp*, *Disappearing Pattern Tiles*, and the *Power Aware Cord*.



Figure 2.9: *Flower Lamp* displaying low energy loads, lamp “blooms”. Project Team: Sofia Lagerkvist, Charlotte von der Lancken, Anna Lindgren, Katja Sävström, and Göran Nordahl

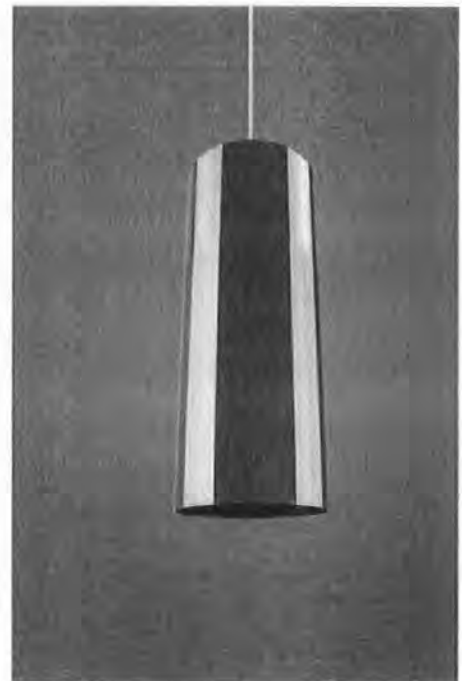


Figure 2.10: *Flower Lamp* displaying high-energy loads, lamp closed.

Household light fixtures typically have very basic functionality with respect to energy usage; a lamp is either switched on or off. In the *Flower Lamp* example (Figure 2.9 and 2.10), it is not just the light of the lamp but its very form that reflects the amount energy used in the household. The experimental lamp does not show how the precise number of watts being consumed in real time. Rather, the light fixture displays the overall trends in home energy consumption. If the household decreases its energy usage, the *Flower Lamp* rewards you by slowly opening up to “bloom”. If, on the other hand, energy loads increase over time, the lamp closes shut. Thus the lamp, in both light and form, is reflecting the cycles of local energy use in a subtle and poetic way that makes smaller sacrifices of heat and warm water potentially worthwhile. Thus, a change of behaviour is required if residents are going to see the lamp bloom while present in the home. One might perceive the chosen aesthetics here to be a bit counter-intuitive. The greatest reward, the plant “blooming” occurs when no one is at home consuming power.



Figure 2.11: STATIC, *Disappearing Pattern Tiles*, prototype, Project Team: Sofia Lagerkvist, Charlotte von der Lancken, Anna Lindgren, Katja Sävström

In terms of basic functionality and unique aesthetics, STATIC’s prototype for *Disappearing Pattern Tiles* is by far the most sophisticated and accomplished, and thus perhaps most usable piece. The project team decorated basic white bathroom tiles with patterns drawn with thermo-chromic ink. This ink reacts to heat, fading away to reflect splashes and various intensities of hot water use (Figure 2.11). So, the longer a resident lingers in a warm shower the less decoration there is on the wall. The dynamic architectural surface acts as a subtle reminder of personal energy use over time, reflecting the duration and waste of heat energy during a lengthy shower. Unlike the *Flower Lamp*, where positive feedback is an “estimation” of the reduction of household energy use, the tiles offer direct and consistent feedback with a unique aesthetic: Salvador Dali-esque melting surface design.



Figure 2.12: STATIC, *Power Aware Cord: Seeing Personal Energy Consumption*, prototype.
Project Team: Anton Gustafsson and Magnus Gyllenswärd

STATIC's newly patented *Power Aware Cord* (2005) is an award-winning prototype of a smart power strip. Power strips are used in nearly every home as a means of safely transporting energy to multiple electronic appliances with basic surge protection. STATIC has retooled the humble power strip and given it a transparent cord made from electroluminescent wire. This wire contains a phosphor layer that glows with an intense blue-green light when an alternating current is introduced. The *Power Aware Cord* also has a cable that glows red if loads increase on the line. Due to the colour of the phosphor, the wire appears to be white when unpowered, a feature that greatly reduces the appearance of the device when no energy is used. It should be noted that one critique of the *Power Aware Cord* is that the device itself consumes electricity in order to create the varied colours. Like HeHe, the STATIC team focuses their efforts on using colour, or *non-numerical forms of communication to depict real time energy flows*. The creators of the *Power Aware Cord* are presently experimenting with other types of data mapping in addition to colour, specifically pulsing light signals to indicate periods of high power use. Because electrical current is such an abstract concept in and of itself, the team believes that hue and pulsation rates would be good aesthetic metaphors to imagine power usage. The project team states:

"Our aim is also that users might perceive the light patterns as the actual electricity in the cord, if not on a direct level then at least on an intuitive and metaphoric level. By this, we mean that people might talk about and refer to the light just as if it would be the electricity itself, even if they on a logical level

would realize that it is just a representation” (Gyllensward and Gustafsson 2005: 1424).

Unfortunately, this product has not been widely tested, although the STATIC group conducted some targeted user testing with fifteen persons that yielded preliminary results. The prototype was not working fully when the user testing was conducted so the users merely observed different “states” of the *Power Aware Cord* and the users’ ability to interpret the different power levels via hue and pulsation was recorded. No other prototypes have been evaluated at this point. People felt that the static hue with subtle colour shifts was very pleasing to the senses, however most thought the pulsing lights were more informative. The pulsing light at high energy levels were often seen as irritating to the eyes although some felt transfixed by the blinking: “One person remarked that he felt something being transported when the cord was pulsating compared to when it was shining in a constant level of intensity” (Gyllensward and Gustafsson 2005: 1424). Despite the negative aspect of the pulsing lights, overall, the *Power Aware Cords* with static colours only were considered less informative than those with hue shifts and pulsing flashes—more frequent pulses meant more energy was being used by the cable.

The STATIC group has made real strides in terms of designing prototypes that deliver poetic, yet dynamic aesthetic feedback in the home with regard to how much energy is being used at any given moment—yet there is a real need for further evaluation. Of all of the STATIC projects, *Flower Lamp*, *Disappearing Pattern Tiles*, and the *Power Aware Cord* do this the best. However, the group has not performed comprehensive user testing so it is not possible to quantify precisely how much electricity has been conserved or how many persons have been impacted by the project. Rather, the STATIC group’s best contribution to this discussion about the potentials of introducing “smart” objects into the home is their tremendous creativity in considering how familiar objects such as lamps, tiles, and cords can actually ‘talk’ about sometimes bothersome numbers, like kilowatts, in a aesthetically appealing and abstract manner.

Wattson/Holmes by DIY Kyoto (UK)

Conceived by Royal College of Art design students, *Wattson* is a portable wireless unit that allows real time reading of electricity use anywhere in the home. The device is sold in the UK via a company aptly titled DIY Kyoto. The interactive device

is primarily used in the UK although there is a small user population in Scandinavia. The book-sized console unit is molded to sit on a table in an upside down “U” form. The *Wattson* has an accompanying sensor clip which attaches to either of the main electricity cables leading from the meter box to the fuse box. This cable is also plugged into a transmitter that sends information to the wireless unit. *Wattson* uses light as the primary mode of information transfer. However, there is an LED digital display that additionally shows exactly how much electricity is being consumed in watts or pounds. The aesthetic presentation is as follows. *Wattson* features an ambient light display (also LED) on the underside of the console. When the lights glow blue, energy use is below average. When *Wattson* emits a purple glow, usage levels are approximately average for the household. When the lights are red, more electricity than usual is being used.



Figure 2.13: DIY Kyoto's Wattson

Of all of the various objects that have been examined in this chapter, only the Wattson has been manufactured with general sustainable design principles in place. The product is constructed without adhesives for easy disassembly and recycling. The white outer and inner casing is constructed from polycarbonate, although polycarbonate may leach bisphenol A (Carwile et al 2009). The LED display is mounted on the printed circuit board that controls *Wattson's* operation. The product is manufactured locally in Margate, Kent although some components are produced in China. The Wattson's packaging is made from lightweight recycled card, and uses inks with minimal environmental impact. The latest version of *Wattson*, *Wattson 01*, uses up to 4W of energy—costing only £4 per year to run. Together with companion software *Holmes*, which offers more detailed analysis of energy use and opportunities for

savings, Wattson 01 can help reduce a typical household electricity bill. In this dissertation, only the smart object, *Wattson*, will be discussed (not the data harvesting software Holmes). Holmes offers more densely detailed energy usage maps, while Wattson offers the information at a glance that is the topic of this particular section.

DIY Kyoto founders Richard Woods, Greta Corke, and Jon Sawdon Smith claim their customers can save up to 25% on their energy costs. At the moment, there is not any evidence supporting this claim, although the user community is expanding. By making energy-usage information engaging and enjoyable, consumers who paid approximately £149 are generally pleased with the results. User Wendy reports her family's experience with the Wattson:

“Shortly after getting it we uncovered a fault with a pump which serves a well in the garden – it had become faulty and was constantly on making for extremely high electricity bills. We also stay in quite a large house so it is useful to look at Wattson before going out to make sure the children haven't left anything on – I think after a while you get to know what a ‘normal’ reading is for a particular time of the day” (DIY Kyoto 2009).

The *Wattson* has inspired an entire community of people to compare their energy usage. This is hugely significant. Because the Wattson is a household object, the comparisons could go on indefinitely, while projects like HeHe's *Nuage Vert* only allowed the community access to energy data for one week. As of January 29, 2009, 301 Wattsons were connected and broadcasting live data to the website “Wattson Village”. An average daily usage of 12,817 kilowatt hours (kWh) was reported (DIY Kyoto 2009). Having access to this data additionally enables the “green-conscious” consumer to see how one's household data stacks up against the reported average. One potential issue with these comparisons is that the household size is not a variable taken into consideration—at some point in the future it would be useful to include this baseline data. As demonstrated by the literature in Chapter 2, social commitment was proved to be very effective in increasing a population's ability to conserve energy. Although Wattson Village, is comparatively new as it launched in December of 2008, the potential to inspire a whole group of users to conserve over a longer period of time is enormous, especially if the capacity to compare energy usage among homes of similar size is incorporated.

What might inspire an individual to actually want to compare energy data in a virtual community? Wattson Village is part of an enormous wave of social networking software that enables individual to keep in touch about a whole host of issues. Residents of the Wattson Village join perhaps wanting to be a part of a fashionable do-gooder community, and also wanting to compare their household's energy consumption with others. The new online community has much room for improvement based on what exists already in the numerous Web 2.0 communities online:

“At this point the Wattson ... would benefit from more customization features. The main way users can clearly customize their pages is through the notes section, which is basically a list of comments below the user's energy data. (For example, one user tries to justify his high energy bill by explaining that his house in Finland is freezing and needs to be heated a lot.) The company says it has implemented a tagging feature so that users can point out where they're saving money, but I didn't see a lot of people using those features. ... At this point all of the users have the same white (but cute) anime-style *Wattson* logo; light customization could enable hardcore users to stand out and make the community more sticky” (Fehrenbacher 2008).

The *Wattson* community is emerging and certainly many more features could make the Wattson Village site more enticing: Facebook compatibility, a greater number of users, and some way of not only tracking conservation of energy over time, but also comparing select households' consumption data. DIY Kyoto's *Wattson* has been shown to have great potential to attract a community of long-term conservers, but there is simply not enough evidence at this time to evaluate its effectiveness. The next two smart objects discussed, the Ambient Energy Orb and also Lucid Design Group's Dashboard have garnered substantially larger user communities, and also proven to increase levels of energy conservation.

Ambient Energy Orb by Pacific Gas and Electric Company (USA)

Ambient Devices, a Cambridge, Massachusetts start-up firm staffed mainly with MIT graduates, introduced the Energy Orb as a saleable object in 2004. The Orb proved popular out of the box; Ambient sold 20,000 in 2004 (Felberbaum 2004). The web-connected glass balls were programmed to glow different colors based on the performance of the US stock market. If the Dow average was up for the day, the Orb glowed green. On a down day, the Orb reddened. The colors' intensity reflected the extent of the swing; yellow meant that the stock market was stable.

Not surprisingly, a number of Orb users wanted to track data other than the stock market via classy glass balls on their desks. Ambient users have programmed Orbs for a remarkable array of tasks: tracking job openings in Atlanta, measuring the flow of visitors to a Boston-based interactive design agency's Web site, gauging energy use in a New York City apartment, tracking eBay auctions, notifying someone when a certain number of e-mails have arrived, and monitoring the amount of electricity used in high demand cycles in California. The idea behind the Orb itself came out of the Massachusetts Institute of Technology's Media Lab, where "Tangible Media" research led by Professor Hiroshi Ishii who promised to replace computers' graphical user interface with tangible representations of the data they produce — giving physical form to information. Ishii and other members of the Tangible Media Group at MIT believed that information gathered in one glance from a visual image can be more memorable than numeric data garnered from a computer screen (Ishii and Ullmer 1997).

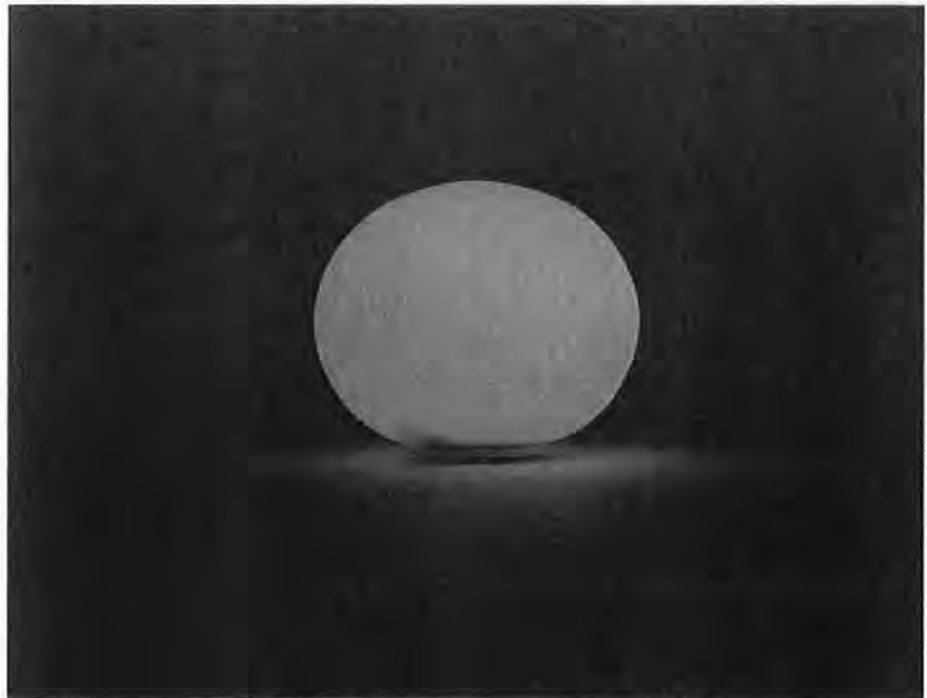


Figure 2.14: Energy Orb, or the PG&E Demand-Response Orb, Pacific Gas and Electric Co., 2006

In 2006, the Energy Orb was released for free to a limited audience: companies that used tremendous amounts of electricity. The goal was to get previously identified “energy hog” customers to conserve power during high demand cycles. Southern California Edison power station manager Mark Martinez was looking for an innovative way to get these customers to use less energy, and prior attempts using automated text

messages, emails and phone calls had no effect whatsoever. So Martinez bought an Ambient Orb and the hacking began. Martinez realized he could use the Orbs to signal changes in electrical rates, programming them to glow green when the grid was underused — and, thus, electricity cheaper — and red during peak hours when customers were paying more for power. He bought 120 Orbs, retrofitted them to glow based on the dynamic California electrical grid, then handed them out for free to his biggest energy consumers, and awaited the results (Thompson 2007).

In about a month, the Orb users reduced their peak-period energy use by 40 percent (Thompson 2007). Why? Because, Martinez explains, the glowing sphere was less annoying and more persistent than a text alert. "It's nonintrusive", he says, "It has a relatively benign effect. But when you suddenly see your ball flashing red, you notice" (cited in Thompson 2007). Martinez discovered, via the Orb, an excellent way to broadcast key environmental information: eco-visualisation, or dynamic feedback coupled in this case with a monetary reward, cash rebates. The Energy Orb had an easy to read interface that was abstract enough not to require more than a millisecond to comprehend. The PG&E consumers responded well because, as Chapter 2, demonstrated, dynamic feedback aids conservation efforts generally because of the ease of receiving the data. "Cognitive psychologists call this pre-attentive processing", said Ambient Devices President David Rose, "because it uses a part of your brain that happens before your conscious mind attends. Think of it as pure peripheral vision; you receive the information without perceiving it as being taxing" (cited in Walker 2004). The reward component was fairly substantial, and will next be illustrated through one company's particular experience with the Orb.

The Buck Institute is an example of an energy-consuming customer who received a free Orb from PG&E. The Orb sits on the desk belonging to Ralph O'Rear, vice president of facilities and planning for the Novato Age Research Institute. On days when the region's demand for electricity threatens to outstrip supply, O'Rear's Orb will change color, from blue to yellow (Figure 2.14). When the yellow orb event occurs, Buck Institute managers will contact PG&E and let the company know how much the Institute can reduce its use of electricity. The Buck Institute will receive a payment based on that amount. Because it has its own generator, the institute can even sell a portion of its power to PG&E in some situations. O'Rear is thrilled with the reward arrangement for conservation of energy:

"Every dollar we can save on electricity is a dollar we can spend on science... The Institute spends between \$550,000 and \$600,000 a year on energy... If we could save 30 percent of the money we spend on energy each year, that could allow us to hire one more investigator, or add one more person to a research team" (cited in Rogers 2006).

As the orb continues to change from yellow to red, Buck Institute managers will transfer some of the building's most important functions to its own generator, and reduce power consumption in the rest of the building. How does the Institute actually conserve power? O'Rear continues to explain:

"Parts of the building will shut down, and our heating, ventilation and air conditioning will be reduced to the lowest comfortable standard... We'll be turning as many of our lights off as we can, and switching to emergency power" (cited in Rogers 2006).

That kind of voluntary conservation could help the region avoid the kind of blackouts and brownouts that plagued California during the electricity crisis of 2000-2001, according to PG&E representatives. PG&E believes that the Orbs can help reduce power consumption by 600 megawatts—enough power to supply 450,000 homes - in critical situations. "Up until the early 1980s, California was one of the paramount states for energy conservation", said Lloyd Coker, a PG&E spokesman. "We seem to have gotten away from that. But with the recent concern over energy, we're hoping to be able to rectify that" (cited in Rogers 2006).



Figure 2.15: Colour key, *Ambient Energy Orb*, Pacific Gas and Electric Company, sold through Ambient Devices (USA)

Other California utility companies have experimented in similar ways with the Energy Orb and generated record energy savings. In 2004, Southern California Edison, one of the state's three utilities, launched a pilot program to test dynamic pricing. Half of the customers in the project were given an orb, programmed to track electricity costs. It glowed blue during off-peak hours and green when the price of electricity was at its peak". The customers with the orbs conserved twice as much electricity as the customers in the control group", says Mark Martinez, the project manager who conceived and implemented the program (cited in Scanlon 2005). The Energy Orb project has since been expanded to all three California utilities, and 15,000 to 18,000 Orbs were distributed in 2005 alone.

The Energy Orbs are an incredibly significant development in the landscape of eco-visualisation. As discussed previously, the Orbs deliver "at a glance" visual feedback about electricity loads on the California grid in real time. Enormous amounts of electricity were conserved as reported by Southern California Edison, and in the case of the Buck Institute, large quantities of money were received as a reward for conservation. The Orb and the Wattson both represent two of the only examples of eco-visualisation that have been tested on a large scale on a long-term basis (i.e. longer than a few months). Unlike DIY Kyoto, the Ambient Devices firm is not particularly

concerned with marketing the Orbs with sustainable design principles in mind; the Orbs are made in China via standard manufacturing. So the Orb is perhaps not as green as it could be although the glass could be recycled. On the positive side possibly due to the volume in sales and versatility, the Orbs are more cost-effective to use. In 2004, they were priced at \$300; today they retail for around \$100. The Orb is infinitely more configurable than a device like STATIC's *Flower Lamp* or DIY Kyoto's *Wattson*. Ambient operates a server that pushes all sorts of data to Orbs configured in various ways. Any Orb consumer can bring an idea forward, like the innovative project manager Mark Martinez did who helped distribute the *Energy Orb* to 18,000 utilities customers. Of all the smart objects discussed in this section that offer easy to read data at a glance, the Orb is by far the most effective in assisting individuals to conserve electricity on a large scale despite the lack of attention to green design principles in its construction.

2.5 Conclusions about eco-visualisation for resource conservation

Dynamic feedback—when delivered in a visual “energy consumption levels at a glance” form—works to reduce energy consumption. *Nuage Vert*, *Flower Lamp*, *Disappearing Pattern Tiles*, *Power-Aware Cord*, *Wattson*, and the *Energy Orb* all share the same aim: to use creative imaging—eco-visualisation—to encourage a local population to cut back their energy usage. As discussed in Chapter 1, traditional curtailment strategies using numeric feedback on standard LCD screens are in some ways, doomed to fail. The information provided by the literature review of the scientific studies seemed to indicate that because human behaviour is so intractable, the only sort of measurable change in resource consumption was likely to be only short-term. However, none of the scientific studies considered creative implementation of dynamic feedback except John E. Petersen, Vladislav Shunturov, Kathryn Janda, Gavin Platt and Kate Weinberger's 2007 report on the effectiveness of dormitory energy competitions among college students. That particular report showed that tremendous amounts of savings could be generated in a youth population motivated with dynamic feedback, comparative feedback, public commitment and the reward of winning a competition. Admittedly, the Peterson study was also conducted in the short term. However, what is significant about the findings in the Peterson report is that dynamic feedback, when visual and combined with novel rewards created optimal circumstances

for energy conservation. The Peterson study is in line also with psychologist Richard Katzev's aforementioned report that showed that an increased commitment to energy conservation based on feedback is far more functional than monetary incentives in inducing conservation behaviour.

While devices like the *Flower Lamp* and the *Wattson* offered interesting ways for home users to monitor their levels of energy consumption, the truly innovative projects were the ones that integrated creative visualisation directly with the data from the local utility company. The *Nuage Vert* public installation and the *Energy Orb* project both enabled local energy consumers to actually see and be connected with the load usage statistics of the nearby power plants *in real time*. *Nuage Vert* required extensive cooperation from the power company, and in the case of the *Energy Orb*, the project was initiated by the utility and required widespread cooperation from the resident users. Both creative endeavors should be held up as exemplary efforts from both the public and private sector as modes of initiating periods of curtailment of consumption as both worked quite magically though in very different ways. *Nuage Vert* due to the cost and energy usage of the lasers themselves was restricted to a very short exhibition period. Conversely, the *Energy Orb* allowed a whole population of consumers to save vast amounts of money on energy by equipping willing companies with a glass ball that changed from blue to yellow occasionally. Artists and designers hoping to expand on the legacy of HeHe and Ambient Devices should emulate both projects in the future, and tweak them to be even more effective and provocative.

Some of STATIC's untested prototypes such as the *Disappearing Pattern Tiles*, also hold great promise for widespread behaviour adaptation; seeing the pattern literally melt away from the tile could induce one to cut short the shower. However, despite the vast potential, the key here is to continue this line of research in multiple disciplines—art, design, human-computer interaction (HCI), psychology, and architecture—to determine which projects to date have been most successful in encouraging electricity cut backs. Despite the gloomy outlook on the advanced state of global warming, creative thinkers, artists, and designers are clearly making great strides in introducing new ideas to the planet to promote energy conservation.

Chapter 3: Three eco-visualisation case studies: *7000 oaks and counting* (2006-2009), *World Offset* (2008), and *darkSky* (2009)

3.1 Introduction to methodologies

In order to test the potential value and limitations of eco-visualisation, three case studies were conducted during the research period from 2005 to 2009: *7000 oaks and counting*, *World Offset*, and *darkSky*. These projects adopted very different contexts to observe various aspects of eco-visualisation as both an educational tool and a unique experience that generated dialogical interaction around the topic of energy conservation. Specifically, *7000 oaks and counting* was an eco-visualisation embedded in the architecture of a public building; the objective was to explore electricity conservation in the workplace. *World Offset* was a related, though Internet-based eco-visualisation focused on examining the possibilities of energy conservation via a more global audience by inviting visitors to pledge a carbon offset online. Finally, *darkSky* was an immersive, interactive installation exhibited in a fine art context, a contemporary art museum; this piece was designed to test the potential for dialogical interaction in eco-visualisation.

Below these three projects will be discussed in conjunction with a look at the interdisciplinary combination of methodologies drawn from the fields of fine arts, design, and human computer interaction (HCI) which were used to generate the projects. A general introduction to the methodologies employed to produce and evaluate the three eco-visualisation case studies will be provided first. This methodologies overview will clarify the question of how the creative process of making the eco-visualisation projects might be evaluated and discussed most appropriately here and in also in Chapter 4. In the final section of Chapter 3, the relative successes and limitations of the case studies will be compared.

Fine arts will be one of two primary methodologies utilized to discuss and analyse the results of this inquiry. HCI methodology will play an equal important role. HCI is really a very particular form of design research that examines how humans interact with and interpret technology as well as technological interfaces. Eco-visualisation, an emerging genre of art that purports to transform ecological data into readable imagery as an educational tool has an obvious crossover with HCI research.

An important question from the design perspective is how to determine whether the “users” of the artworks “read” the visual information correctly. The question of user interpretation is measurable via common HCI research methods such as surveys that take the form of online questionnaires.

An online questionnaire was designed in January 2009 to survey viewers of all three case studies (see 196-199 to view a blank copy). A copy of the survey was informally sent to two professionals for evaluation, one an HCI researcher and the other a media theorist. Both professionals agreed that the ten proposed questions seemed generally non-biased although each asserted that creating a non-biased survey was virtually impossible. Because an artist, not a social scientist, created this survey there is no question that a lack of experience and expertise affected the variety and number of responses. A total of 91 surveys were collected: 16 for *7000 oaks and counting*, 29 for *World Offset*, and 46 for *darkSky*. As will be discussed in the forthcoming chapter, the survey questions that required users to type in a sentence, or a qualitative answer proved to be far more informative in assessing the three goals of this inquiry than the survey questions that asked users to choose a multiple choice answer.

The electronic surveys attempted to capture information that would be relevant to a fine arts assessment of the case studies. For example, were viewers ‘moved’ by the artwork? And another, were any viewers moved enough to actually change their energy consuming habits? In other words, did the viewers realize or learn something significant from all of the information presented? Was a pro-environmental message effectively transmitted by the case study and did any of the viewers behave differently as a result of the piece? These last few queries are all very broad qualitative sorts of questions that will be addressed via the results of the online surveys—though the results are limited to overall a pool of 91 responses. A fine arts methodology that utilizes quotations from critical reviews will be brought into the discussions to bring a more expansive and perhaps less survey-driven exploration of how the various artworks might have affected or not affected their audiences. All of these questions will begin to be addressed here as each individual project is described below, but will be mostly answered when the results of the questionnaires and interviews from each project are discussed and analysed. Before the overview of case study’s development in depth, an overall look at fine arts methodology is necessary.

Interestingly, many HCI scientists are now looking outside their respective fields of study to examine what methods in the fine arts might offer the researcher interested in promoting environmental stewardship (DiSalvo et al 2009, Jennings et al 2006). ‘Critical discourse’ is a common phrase used in the fine arts to describe the ongoing construction of arguments concerning ideas that are set forth via images. To understand what discourse might mean in the context of this inquiry, two frameworks of discourse relevant to proving why eco-visualisation might fit into existing theoretical ideas about fine art will be identified; the first is one from art historian and cultural theorist Malcolm Miles (2006) and the other is from art historian Grant Kester (2004). Discourse generally originates from well-regarded art historians, curators, and critics. The most legitimate form of fine art discourse comes from scholars with PhDs and lengthy publication records. Miles proposes a system of categorizing environmental art. Kester identifies essential components of dialogic art and activism that relate specifically to artists pursuing environmental themes in their work. The two schema put forth by Miles and Kester form critical frameworks to be taken as generative themes that helped to create the series of methods that created the three artworks. These critical frameworks provided by Miles and Kester will be discussed as open platforms for inquiry as opposed to prescriptive instructions or definitive classifications. The primary role of the two frameworks in this sense is not to uncover a groundbreaking truth about a particular phenomenon, but rather to spark conversation about the organic development of a body of practice-based work, in this case around the development of three eco-visualisations that promote energy conservation and site-based learning. According to HCI researchers, the value of utilizing a fine art framework is in articulating a point of view that can be debated or engaged with, that opens up conversation and prompts new ways of thinking (DiSalvo et al 2009).

Malcolm Miles proposes a four-part categorization scheme to constitute an effective discourse around the central issues in environmental art, of which eco-visualisation is a component. One issue that intrigues Miles is how aesthetics can possibly substitute or be a stand in for government policy retooling (2006). He sums up the conundrum with this question, how can “art work be seen as bringing aesthetic value to what is at root a political problem” (2006). Miles is far more concerned with content in artwork than with aesthetics. The four categories in Miles’ framework for critically discussing environmental art are:

1. Art that represents the natural world visually.
2. Art that enters into a narrative or discourse about the natural world and the apprehension of various phenomena.
3. Cultural production that tests methods of environmental salvage or contributes to sustainable forms of living.
4. Dialogic inter-action at the cusp of art and activism.

This framework is quite comprehensive: it covers a broad range of work using direct, simple categories. This is not to imply that it is unsophisticated. It offers a refined set of parameters from which to compare various sorts of ecologically engaged artworks and provides a foundation for identifying important courses of inquiry for new perspectives on how fine art, design and HCI might be blended to produce a work with measurable impact on environmental stewardship.

The second framework of discourse to be utilized in this inquiry is one cultivated by art historian Grant Kester that is based on “dialogical art practice” (2004:9). Dialogic practice is art that is based on communication, or dialogue that the artwork activates in the process of its production and/or deployment. French theorist Nicolas Bourriaud calls his interpretation of site-based work that engages the audience directly “relational aesthetics” or art that by using everyday content is able to inspire more direct conversation amongst the viewers (1998). A number of theorists like Kester and Bourriaud have forged new ground in the last ten years in offering novel modes of discourse on artworks that exist outside the gallery or museum that offer site-based learning and interaction opportunities. Kester’s writings will be primarily engaged in the discussion of the results, as the question of whether the case studies encouraged site-based dialogue is one of the key goals (Goal 3).

To sum up the major points of Kester’s methodology or his mode of creating fine art discourse, is to focus first on what is *not dialogical* in the art world. Kester gives convincing examples of the traditional artist/audience relationship, where the artist generally creates work in isolation without any consideration of the future viewer. There is no interaction between the artist and the audience in the painting of the *Mona Lisa*. The artist holds power and information about the subject—interpretation is open. The art object operates as an extension of the artist's personal language and thus, the viewer must translate, or guess the meaning—it is a linear model of communicating in which the object acts as intermediary between artist and audience. In contrast, “dialogical practices” offer a cyclical model to make art and engage conversation

through various means of engaging the viewers in participation in the formation of the artwork. Kester includes the examples of several artists: Stephen Willats, Wochenklausur, as well as Helen and Newton Harrison whose work was discussed in Chapter 2. The dialogic artwork is produced as result of the interacting, listening, reacting, responding, acting in the very space in which the artwork resides. Thus, the context and location of the artwork becomes rather critical to the way that the audience responds to it—this topic will be greatly expanded in Chapter 4 and in the concluding discussion here.

After the initial descriptions of each case study, results will be discussed using the analytical frameworks provided by Miles and Kester as well as writings by journalists and art critics. The relative success of the three case studies will be analysed also via familiar HCI methods such as contextual inquiry and electronic surveys. Eco-visualisation provides a much-needed link between scientific data modelling and public education. As demonstrated in Chapter 2, artists and designers have a vital role to play in the representation and contextualization of ecological information. In the forthcoming discussion of three software-driven art works that deal with issues of information representation and comprehension, the following aims of this inquiry will be assessed in the Results section for each project:

Goal 1: Eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and thus encourages new forms of site-based learning.

Goal 2: Eco-visualisation that provides real time visual feedback can increase environmental awareness and possibly increase the conservation behaviour in the viewing population.

Goal 3: Eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.

3.2 7000 oaks and counting (2005-2009)

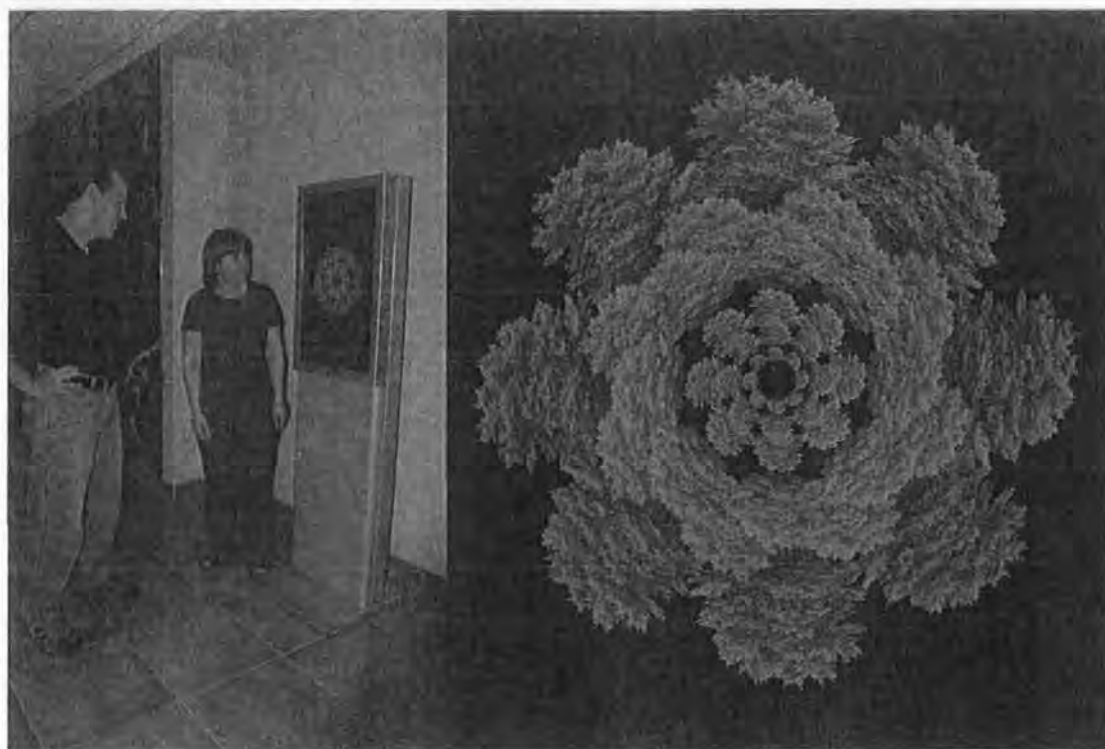


Figure 3.1: Left, *7000 oaks and counting*, interactive touch screen kiosk. Right, animation still, midnight CST. The animation is entirely green as less power is typically consumed at the midnight hour.

3.2.1 Description, *7000 oaks and counting* (2005-2009)

Launched in summer of 2009, the *7000 oaks and counting* project consists of an interactive touch screen kiosk standing two meters tall in the hallway outside the National Centre for Supercomputing Applications (NCSA) director's office on the 4th floor and an internal website that is accessible only to faculty and staff in the NCSA building itself (Figure 3.1). The animation that represents the eco-visualisation is quite simple. The animation resets, or begins at midnight every day. There are six rings of spinning green tree rings when power loads are at the lower end. At midnight, each ring is mostly composed of green leafy trees as loads are reduced when few people are working in the building, and the heating and cooling systems are not running as much. Each tree ring spins in a direction opposite to its neighbours: three rings spin clockwise, and three spin counter clockwise. Because spin speed is tied directly to energy loads, at midnight the trees spin more slowly than later in the day when more power has been consumed (See accompanying DVD for video examples in the slideshow detailing *7000 oaks and counting* in Appendix N).

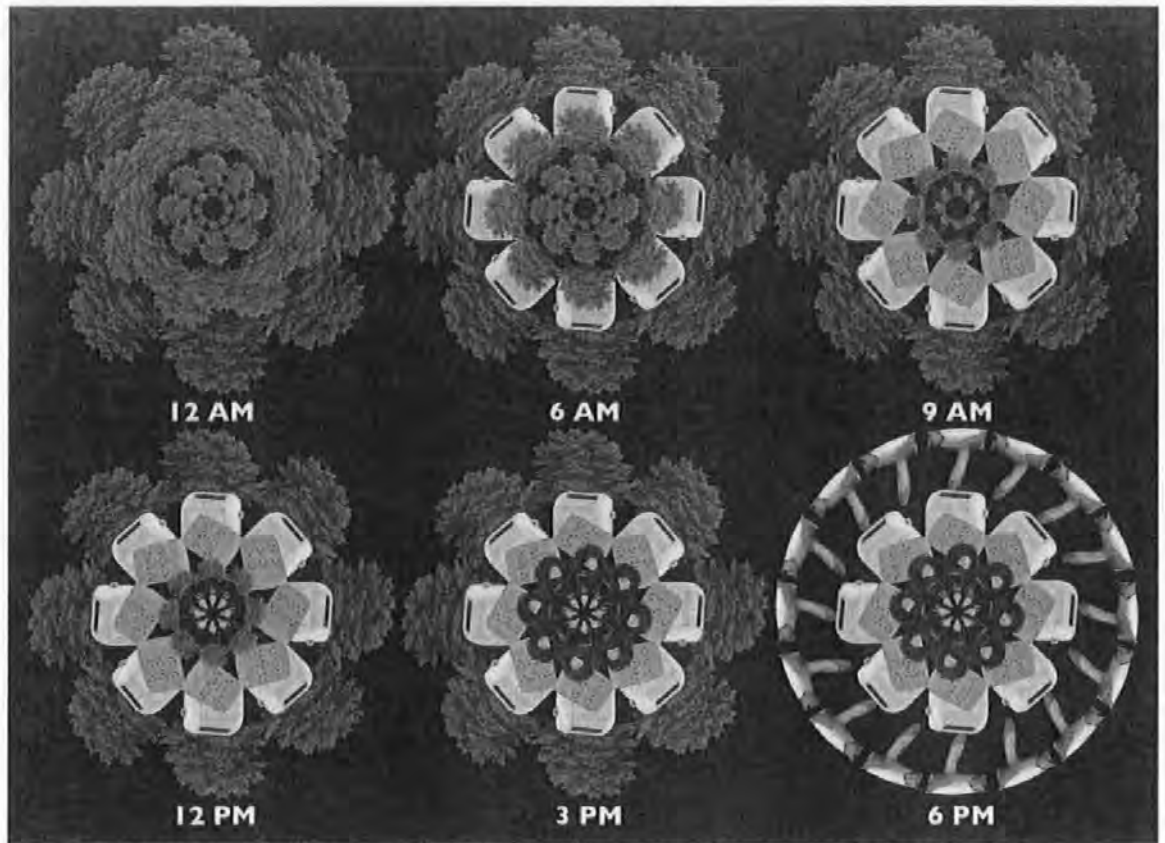


Figure 3.2 *7000 oaks and counting*, animation stills pictured throughout the day. Animation resets every day at midnight. Trending information available on linked website.

The primary animation changes as energy loads increase during the day. Figure 3.2 presents a time-based series of sample animation stills. At 6am, spinning toasters replace one of the six tree rings. At 9am, toasters and electrical outlets stand in for two of the six tree rings. At 12pm, toasters, electrical outlets, and lamps substitute for three of the six tree rings. At 3pm, toasters, electrical outlets, lamps, extension cords, and light bulbs are alternates for five of the six tree rings. Finally, at 6pm, all of the green is gone, and a series of energy consuming appliances are visible in the animation. The visual goal here was to provide a simple informative animation that might enable building residents to detect subtle changes in energy loads throughout the day in the NCSA building. For example, if the animation were installed in the lobby, most building residents would see the animation two or three times a day as they strolled into their offices, and when they walked out to leave for the day or for an errand. If the weather outside was rather mild on a spring day, it might be that the building resident would see mostly green trees at quitting time, while on a blustery winter day when the heating systems in the buildings were fully engaged, the building resident might view only toasters, extension cords, and light bulbs with no green whatsoever in the animation. The animation has the ability to randomly select from a database of approximately thirty appliances—so the viewer sees some variety in terms of the

aesthetics. The principle is the same however, more appliances means a higher energy load in the building while more green trees corresponds to a lowered energy load in the building.

The accompanying internal website to the project invites building residents to submit a carbon offset (*7000 oaks and counting* 2009). Carbon offsets could also be submitted live at the kiosk by touching the interactive screen of spinning disks. There, individuals choose to make one or more pledges to conserve energy in one of seven categories, each marked by a square button labelled: “EAT”, “DRINK”, “GO”, “LIVE”, “MAIL”, “TRASH”, and “WORK”. Clicking on the button reveals a sliding accordion-style menu that reveals several possible actions to enact. For example, clicking on the “DRINK” button reveals the following choice; a pop-up menu shows numbers between one and seven in the “___”: *I promise to use reusable coffee cups “___” day(s) this week.*

A NCSA building resident who promises to use a ceramic coffee cup instead of disposable paper cups for five days can save 1.25 pounds of carbon per week, if the promise is kept. The calculations made by professionals to estimate carbon offsets are often approximations at best. In order to confirm the manner in which the cup calculation was determined, the visitor would click “More Information” next to “I promise to use reusable coffee cups”, which would reveal the following text and web link:

“If every Starbucks customer used a re-usable coffee cup or thermos, we could save 1,181,600 tons of wood, 2,040,061,237 pounds of carbon dioxide, and 4,441,093,624 gallons of water every year. That’s more carbon dioxide than would be emitted if the entire population of San Francisco got in their cars and drove from San Francisco to New York.

Savings: 1.25 lbs for five days, .25 lbs per day
Source: stanford.edu”

Although the difficulty of calculating carbon offsets is acknowledged, there are many scientists such as Gidon Eshel and Pamela Martin who are working to clarify these questions of how to provide average offset estimates for everyday activities such as eating a hamburger or utilizing a paper cup (2008). Still, the calculations given for offsets on the internal website are average amounts, or mostly educated guesswork constructed by qualified scientists.

The final step on the “PROMISE” page of the internal website would be to click the “SUBMIT” button, thereby allowing the form data to enter the *7000 oaks and counting* dynamic database. After submission, the contribution is instantly updated on the “GOODPEOPLE” link for all to see. The database shows the name of the contributor, the precise amount of carbon promised, the date and time promised, the methods used to obtain the offsets. As soon as a user submits a contribution, the user’s name immediately is not only registered on the website but also updated in the animation on the touch screen kiosk. Every time a user submits a carbon offset pledge, a virtual tree is planted in their name onscreen on the kiosk. The contributor’s name and contribution is noted on screen beneath a rapidly growing tree that reflects the season of the contribution: autumn, winter, spring, or summer (See Figure 3.3 below). The tree pledge data plays every five minutes on the touch screen kiosk via the animations of the virtual trees.

The overall intention behind *7000 oaks and counting* was to make individuals in the workplace more conscious of their energy decisions and to possibly encourage electricity conservation. The original proposal included a hidden surprise. If multiple users collectively worked to infuse the database with higher carbon offsets the building might strive to render itself temporarily carbon neutral.⁸ Due to large energy loads and intermittent participation, the building would probably never be able to claim carbon neutral status; consequently this option was removed from the code of the final visualisation. One addition to the project that was welcomed by NCSA staff was the inclusion of a downloadable version of the eco-visualisation application that could be run on Macs or PCs in the building. Individuals expressed excitement about being able to run the eco-visualisation as a screensaver on their own computers.

⁸ Because of the debate initiated by NCSA leadership around the reality of NCSA’s justifiably heavy energy use, Holmes initially agreed to remove this somewhat hidden aspect of the computer software. Admittedly, due to the inflated energy use it would have been very difficult to render the building carbon neutral, even for a few minutes in the morning. This may be something that could be added to the animation after NCSA residents become more comfortable with the piece.

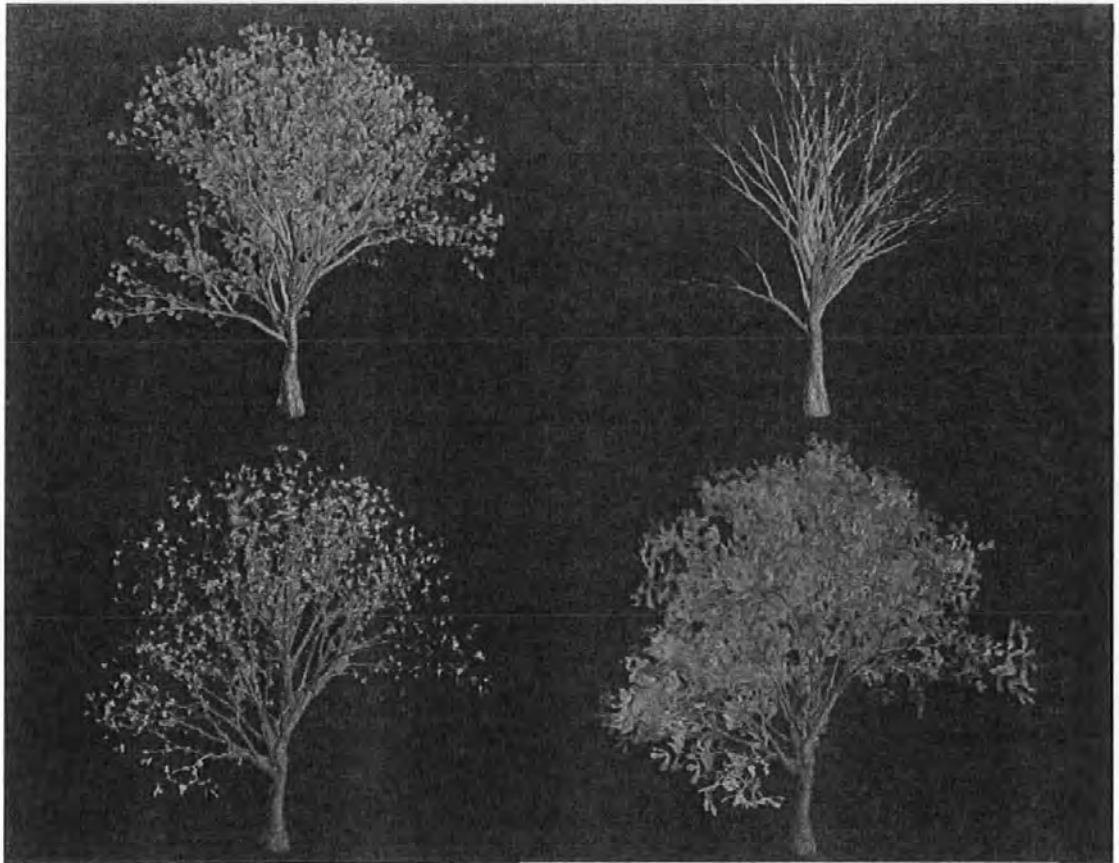


Figure 3.3 *7000 oaks and counting*, animation stills throughout the day of virtual “trees” that are planted in honour of individuals who submit carbon offsets via the internal website. The tree in the upper left is the fall tree, upper right is winter tree, lower left is spring tree, and lower right is summer tree.

See DVD, Appendix N, for actual animations.

3.2.2 Production and Methods, *7000 oaks and counting*

Electronic surveys and personal interviews were the HCI methods employed to evaluate *7000 oaks and counting*. Members of the NCSA community were sent a survey link to an electronic questionnaire that contained the same questions that were posited to viewers of *World Offset* and *darkSky*. A print copy of a blank electronic survey is available on page 196 for reference. The *7000 oaks and counting* survey was opened on September 11, 2009 and was open for approximately 10 days closing on the 23rd. Sixteen persons responded in total. Every online survey participant has the option to be anonymous.

Surveys are very important in HCI research because they help to amass information from the users about the design and development of a technological interface (Kuter and Yilmaz 2001), or in this case, the interface of a web site that encourages visitors to make carbon offsets. Of the three practical projects, *7000 oaks and counting* is one that fits well within HCI methodology as there is a very particular workflow the user needs to follow to submit an offset.

Project roadblocks

The project *7000 oaks and counting* was awarded public art funding from the Capital Development Board of the State of Illinois in the USA in early 2006. In the USA, most new construction that is funded by government entities has to by law, incorporate public art into the architecture of the building. Since it was created in 1977 under Public Act 80-241, the Illinois Art-in-Architecture program has worked to promote and preserve the arts of Illinois by securing artwork of all media for buildings constructed with funds from the state in the amount of one-half of one percent of the construction appropriation for the new edifice (2009). The Illinois Art-in-Architecture program typically commissions work that artists design expressly for particular locations within or outside the new buildings. The term public art traditionally refers to art, usually outdoor sculptures that have been planned with the express purpose of being sited in the public domain, and thus accessible to all. Fortunately, typologies of public art are shifting (Phillips 2007). The art world is no longer commissioning the “turd in the plaza”, a colourful phrase used to describe large-scale outdoor sculpture that was

literally “plopped” into a space. Today, public art actively explores social issues, often with implications of site specificity, community involvement and collaboration.

Though it was fully funded in 2006, the project *7000 oaks and counting* did not launch until the summer of 2009 due to a localized conflict that illustrates the issues with making energy consumption information freely available and transparent. The proposed artwork intended to visualise energy usage in the new National Centre for Supercomputing Applications (NCSA) building at the University of Illinois in Urbana in the USA. The eco-visualisation itself was to appear on a touch screen kiosk that would enable curious viewers to touch the visual imagery, and subsequently view real time statistical data about energy usage in the building that day, that month and even over the course of the entire year. There was to be an accompanying website that would allow building residents to submit carbon offsets to reduce the overall carbon footprint of the NCSA building and thus render it more carbon-neutral. The primary issue that came up that delayed the installation of the proposed artwork was one that dealt with public disclosure of energy usage data on kiosk and on the website. In August 2007, the NCSA Public Information Specialist Trish Barker attempted to diplomatically sum up the tension: “I forgot to let you know that we were going to close external access to that site for the time being...because the NCSA leadership is still very sensitive about the messages it conveys, we aren't comfortable with a live public website at this stage. Currently, the site can only be accessed by NCSA staff”.⁹

Barker’s conciliatory note reveals the various tensions at work at NCSA. In sum, NCSA uses far more energy than many other university organizations simply because of the nature of its work. For more than 20 years, NCSA has been a world leader in deploying robust high-performance computing resources and in working with research communities to develop new computing and software technologies for science and engineering (NCSA 2009). The facility houses hundreds of servers and computing devices for engagement with very high-level number crunching problems. The NCSA facility thus employs a tremendous amount of energy to facilitate its mission to expend its massive computing power in the service of scientists. Because of localized tensions on the University of Illinois campus, the leadership of NCSA did not want an artwork in its lobby to broadcast its usage of what might be considered to be the lion’s share of

⁹ Personal email to the author from Trish Barker on August 8, 2007.

electricity produced by the campus coal-generation plant. Nor did the leadership of NCSA want an external individual, that is, an artist, to suggest that their organization needed to become carbon neutral. For these reasons then, the *7000 oaks and counting* website was removed from public view and the project was delayed over two years.

The public art selection committee that chose to fund *7000 oaks and counting* did not have members from the highest leadership level of NCSA—this fact both enabled the project's funding and also limited its scope in the years that followed the award. This situation is rather typical on jury groups as busy scientists and administrators often perceive art as more of a leisure time activity, and thus send intermediaries as stand-ins when they are required to spend a day assessing art for a major commission. For these individuals, art becomes a surface detail in the workplace and thus cannot demand much of their working time. For these reasons, the lead NCSA administrators chose not to attend a day of meetings with artists who were competing for the Percent for Art awards. Consequently, the *7000 oaks and counting* project was fully funded with enthusiastic committee members that saw something interesting in using public art funds to commission a piece with social and environmental learning opportunities, real time data visualisation, and interactive components. The problems began when the time came to actually tap into the electricity meters in the basement of the NCSA facility and the leadership became increasingly more aware that an artwork could function as more than surface decoration in the building.

Specialized hardware to be purchased from Lucid Design Group was slated in early 2007 to be installed in the NCSA facility to enable easy transfer of data from the two electricity meters in the basement. Several delays occurred around installation of this equipment. Many months passed without project progress, then, a bit of good fortune appeared. Keith Erickson, an administrator of the University of Illinois' Campus Facilities, sent an email announcing that all campus buildings recently had IP numbers assigned to their meters to enable real time monitoring on campus.¹⁰ In other words, real time energy data was theoretically now available online. Thus, there was no longer any need to install custom hardware to monitor electricity usage. Erickson was ultimately helped by the *7000 oaks and counting* project as NCSA proved to be the last building on campus to bring its meters online—another indicator that the organization preferred privatized as opposed to public data transmission. The project moved forward

¹⁰ Personal email from Keith Erickson to the author sent June 21, 2007.

after Erickson assisted with providing IP numbers to each NCSA meter, allowing easy access to energy usage data. The NCSA organization asked for the language about the building becoming carbon neutral to be tempered, and delayed installation of an Ethernet jack for the kiosk for several months, but really there were few roadblocks to installation after September 2007.¹¹

¹¹ The *7000 oaks and counting* project moved along swiftly after the electricity meters came online. The author however, had to take a year off from the project from October 2007 to October 2008 roughly due to the birth of her first child.

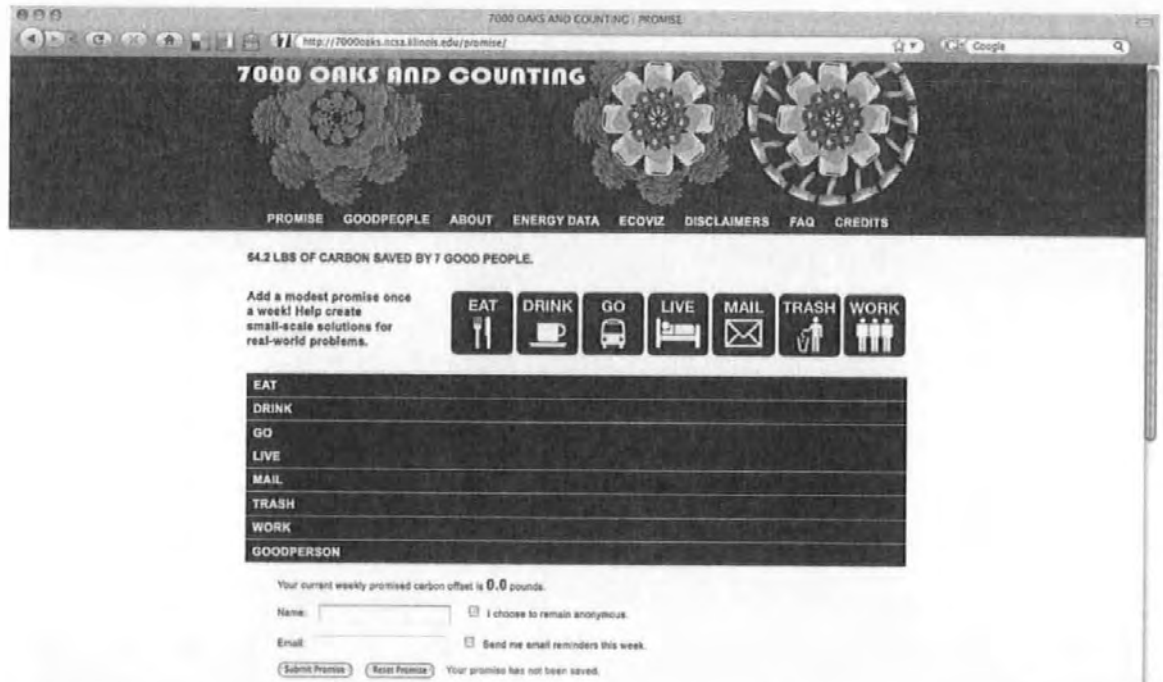


Figure 3.4 7000 oaks and counting, screenshot of website (top) and touch screen kiosk (below)

3.2.3 Results, 7000 oaks and counting

7000 oaks and counting is a project that might indicate a future direction in integrated art-in-architecture experiments. Truly intelligent buildings of the 21st century could harness the existing data structures hidden within digital control systems and use this information to encourage conservation of energy, heat, or water. The management of electricity usage in the American workplace has significance, as the heating, ventilation, air-conditioning (HVAC), and lighting of buildings accounts for 40 percent of the United States' total energy consumption (Interlaboratory Working Group (1997) cited in Loftness 2004). Worldwide figures are similar. The lofty aim of this public art project is to reduce average daily electricity loads in the NCSA building using visual feedback in art. The more modest aim of *7000 oaks and counting* is to raise awareness of a building's carbon footprint by making hidden information like load profiles continuously available to the building residents. Below, the results will indicate that while the more high-minded goal was not met, *7000 oaks and counting* did inspire a good amount of site-based learning.

Visualisation abstract, but meaningful to viewers

The dominant graphical interface for the energy visualisation for *7000 oaks and counting* is a series of spinning disks filled with trees, or filled with objects that consume electricity such as hairdryers, airplanes, coffeepots, laptops, printers, and several others. If the animation showed primarily green trees then the viewer would assume energy loads to be low. Seeing more electrical appliances in lieu of trees would mean that energy loads were increasing in the building.

According to Survey Question #4, only 26% of the respondents fully understood the visualisation instinctively without reading an explanation similar to the one in the previous paragraph. 33% of the respondents said that the “images chosen to represent the energy used or conserved sort of made sense to me” and another 33% said that they only understood the animation after reading about how to interpret the trees vs. appliances. In Survey Question #5, nearly 94% of the viewers felt that the “artwork was visually or graphically interesting” and another 75% believed that the “artwork had conceptual depth in that it made me think”. In Survey Question #6, one respondent expressed approval for the tree metaphor that was selected for this particular eco-

visualisation: “I do think that representing energy conservation through trees saved is a good idea. It gives us a concrete consequence to symbolize how our choices affect the planet” (More responses in Appendix A).

Interaction promoted learning but not necessarily conservation

7000 oaks and counting certainly inspired a degree of environmental education locally in the building (Goal 1). Survey Question #2, “Did you learn anything new from seeing the artwork?” was answered by 10 of 16 respondents. Most of the respondents were excited to see a dataset like energy usage made available to NCSA staff. See the varied answers below:

1. The installation provided a way for everyone in the building to track shared energy use.
2. How much energy we use each day
3. That energy output from campus buildings was available.
4. On-site energy consumption can be visually displayed, really made me think about how much our building uses
5. Through the interactive promise menu, I learned new ways to lower my energy consumption.
6. I was able to visualise how much energy we use here at NCSA. I had no idea what our daily consumption was.
7. Interesting visual presentation of real time power consumption
8. Some hard numbers about the power consumption of the building - very interesting.
9. Quite a few things that could save energy that I would not have previously considered...reusable coffee cups, computer energy settings, etc.
10. The piece highlighted a lot of different energy consumption patterns that we don't normally call attention to throughout the day. It is a good visual representation of how even a slight change can make an impact on the environment.

Additionally in Survey Question #3 nearly 70% of the respondents believed that the “Artwork got me thinking about energy usage and resource conservation” (Goal 2). Part of Goal 2 was met in the sense that the piece raised awareness about electricity loads in the building but the real failing of the piece was in terms of measurement of actual conservation. In Question #5, 68% of the respondents generally or strongly agreed with the statement “Artwork made me want to conserve energy somehow”, however only 31% felt that the “Artwork catalyzed some small act of energy conservation I performed recently”. There were a few reasons that came up in other

sections of the survey that suggested why individuals might not want to conserve energy at work. For example, one respondent objected to a kind of pressure to perform that would be witnessed by supervisors: "The fact that the application has the potential to track individual contributions and does so on a kiosk right in front of the Director's office may seem a bit Big Brother to users. I can't personally imagine ever entering my name into such a system within a work context" (Response to Question #6).

Individuals at NCSA were generally not motivated to conserve energy at work (Goal 2). Conversations with viewers near the kiosk revealed that most people did not have the ability to unplug many items in their offices nor could they turn off their machines during the workday though all were excited to make other kinds of offset promises mainly having to do with altering their diet or transportation mode (Appendix N). In the interviews near the piece, many persons stated that they rarely made it up to the 4th floor in the building (Appendix N). Quantitatively speaking, 64.2 pounds of carbon were promised during the first week the artwork was up, presumably a time when motivation would be high to contribute and to interact with the work. The overall building energy usage has changed slightly since the installation of *7000 oaks and counting*, however further long-term research is necessary to determine whether this information is accurate.

For instance, on September 22, 2009, a trip was made to NCSA to promote the artwork and uphold its message of energy conservation. The piece was discussed with at least 50 of the staff. Each person was encouraged to make a few changes that day in their energy footprint. On this particular day, the average energy usage was 268 kilowatts per hour, equivalent to approximately 483 pounds of carbon emitted per hour. One year ago, on September 22, 2008, the average energy usage was 300 kilowatts per hour, equivalent to approximately 541 pounds of carbon (Appendix F). Although this seems like a significant reduction of 11%, the figures could be reflecting other factors.

In pure fact, the average power usage was down by 32 kilowatts per hour on September 22, 2009 vs. September 22, 2008. However, given the various issues with motivating NCSA employees to be interested in making regular promises via the kiosk, the energy reductions that day might have been a reflection of other energy conservation measures taken in the building over the past year. Additionally, for such comparative numbers to be more accurate, it would be useful to track energy usage over

the course of the first two years that the kiosk runs. Then a comparison of the 2009-2010 usage statistics to those taken in 2008-2009 would be more useful. Over the next year from September 1, 2009 to September 1, 2010, data will be gathered about average energy usage in the NCSA building to hopefully build a case that the eco-visualisation was in some part, responsible for any energy reductions similar to those noted on September 22, 2009.

3.2.4 Discussion, 7000 oaks and counting

Enormous potential to succeed, initial results disappoint

7000 oaks and counting was a project that proposed to visualise the internal energy flows of a university building dynamically, and make that information available instantly to everyone in the building. A preliminary version of the animation was presented at the National Academy of Sciences in Washington D.C. in the exhibition “Speculative Data and the Imaginary”, that was open during the *Creativity and Cognition* conference in June of 2007. A published paper was delivered at this same conference titled “Eco-visualisation: Art and Technology to Promote Sustainability” that focused primarily on the *7000 oaks and counting* project. This publication won one of two “Best Paper” awards. Enthusiasm for the potential for eco-visualisation was enormous among the research scientists, designers, and HCI researchers who attended *Creativity and Cognition* that year. Likewise, the *7000 oaks and counting* project was profiled in a journal targeted toward the fine arts, *Public Art Review* (Compton 2009), and in *Time Out Chicago*, a publication geared more toward the general public (Lopez 2005). In terms of critical feedback, the piece garnered positive reviews from three primary sectors of publication: HCI research, fine arts, and the local entertainment feature.

Unfortunately, *7000 oaks and counting* did not perform as well as had been anticipated in that not many NCSA staff interacted with the piece. Perhaps, given the various challenges of relocating the kiosk from the ground-floor lobby to the fourth floor of NCSA, the installation failed to generate the appropriate amount of daily traffic to feed community excitement about the piece. Possibly the notion of conserving energy at work was impractical, as many staff members mentioned in interviews on site that there were few appliances in their offices that could be turned off. Additionally, the respondent who argued that “I can't personally imagine ever entering my name into such a system within a work context” due to surveillance fears may not have been alone. Other employees might have been uncomfortable with the localized monitoring and thus chose not to participate in the public commitment reward system that originated with Katzev and Johnson's 1984 study on the potentials of civic recognition for conservation behaviour. The design of *7000 oaks and counting* is strong and must

thus be tested in other contexts before the conclusion can be drawn that the eco-visualisation failed from a conservation of energy perspective (Goal 2).

Visual vs. numeric content: Trees a strong and realistic metaphor with limitations

The information disseminated by the kiosk is primarily visual. Every five minutes, the spinning rings disappear and the virtual 3D trees are planted on behalf of every offset contributor for the week. Tapping the screen enables a viewer to leave the visualisation and see a text-based rendition of the dynamic energy usage, plus a carbon footprint estimate (Appendix N for video of the touch screen in operation). The numbers corresponding to kilowatts used only appear if a user strikes the LCD panel. A small plaque next to the kiosk does provide the information that the piece is interactive.

Several survey respondents, when prompted to describe improvements to the piece, mentioned the uneasy relationship between the kiosk and the viewer. More specifically, many were concerned that the piece would be perceived as static, and not interactive. Another cohort of respondents believed that the numeric information could be more varied, and permeate the piece a bit more. Although trees were viewed as a strong metaphor (“representing energy conservation through trees saved is a good idea”), the lack of graphical or numeric detail in the main screen was perceived as a weakness. Only about a third of the survey respondents understood the graphic visualisation prior to reading about its translation. For example, this respondent advocates for a mixture of pictures and numbers: “I enjoy statistical representation that correlates directly with the visuals. Seeing the numbers makes a big difference in what the visual is trying to portray. It was a little hard to get a sense of what the visuals were before the contribution” (Appendix A). Other respondents expressed a desire for a comparative feedback where several buildings at the university would be simultaneously monitored and compared to add richness and complexity to the information visualisation: “More facilities being monitored/metered, even more variety of info-graphics” (Appendix A). This kind of functionality would be very easy given that the all University of Illinois energy meters are assigned IP addresses. This last recommendation would be a good extension of this inquiry’s findings. A comparative assessment of energy usage in buildings in proximity to each other, and of equal size would be very engaging and encourage a sort of energy conservation competition using

comparative feedback similar to that cited in Peterson's Oberlin study that could result in measureable electricity conservation (2007).

Regarding the selection of tree as conservation metaphor, the inspiration was the previously mentioned *7000 oaks* project by Joseph Beuys, which inspired the title for the NCSA case study. As described in Chapter 2, Beuys planted 7000 oak trees for the Documenta Festival of 1987 for the sake of protesting deforestation via acid rain and to promote healthy community living and interconnections between humans and nature (Scholz 1986: 32). Most scientists in the NCSA building were unfamiliar with the Beuys project, which was mentioned during the introductions to the informal interviews. The viewers were interested to learn about this connection between their hall kiosk to the history of contemporary art.

Regarding the specific visual icons chosen for the animation, some observers had difficulty translating the eco-visualisation immediately. The survey results reinforce this potential weakness in immediacy of information transfer. However, *7000 oaks and counting* is a piece that will be displayed for 10 or more years to essentially the same population of viewers, the inhabitants of the NCSA building. Because the piece needed to remain visually compelling for several years, the imagery choices were intentionally made to be slightly complex. Individuals would be required to learn about the piece via the information presented on the touch screen interface. This design thinking was congruent with design theorist Malcolm McCullough's argument about content in interaction design:

"Content is participatory; it is something you do, or perceive, not simply information you receive...By expanding the design of context-based information technology to reflect appreciation, experience, usability, and desire, more of us can contribute to the cultural assimilation of so much technical production" (McCullough 2004:168).

Overall, this piece was intended to inspire pride in NCSA employees who temporarily took control of a portion of the building's carbon footprint. Residents of the building could guide visitors to the kiosk and display the information flows in the copper wiring behind the walls of the conference rooms. As McCullough contends that "content is something you do", perhaps this concept might be extended: content is something that you learn as you are immersed in it. As more and more new buildings are wired to accommodate large data flows that reflect human usage patterns within, the

opportunities for artists and designers expand exponentially to capture this information, and give it shape, form, meaning, and purpose. Given the climate problems facing populations of developed countries today, eco-visualisation as manifested in projects like *7000 oaks and counting*, will hold an important role to inform an increasingly distracted public about the consequences of their day to day energy choices.

3.3 World Offset (2008)

3.3.1 Description, World Offset

Launched March 22, 2008 in conjunction with the *EcoAesthetics* exhibition in Holland, *World Offset* is an interactive website (worldoffset.org) that invites visitors to pledge a small carbon offset and work together to alter an online visualization by turning it fully green.¹² The primary artistic concept is that collectively, these small gestures of conservation can produce some awareness about the immense challenge of reducing our collective carbon footprint on the planet. Another important idea embedded in *World Offset* is to use the Internet to publicly celebrate examples of everyday people making small daily gestures to reduce their resource consumption and combat the problem of global warming. As evidenced by psychologist Richard Katzev's 1984 study discussed in Chapter 1, communal commitment has a pronounced effect on a group's ability to conserve. Like *7000 oaks and counting*, the main goal is to use an online visualisation tool, public recognition, and dynamic feedback to get people to become more aware of their weekly consumption habits, and to think about reducing their individual footprint on a longer-term basis. Unlike *7000 oaks and counting*, *World Offset* did not target a site-specific population; rather, it engaged a global population of online viewers.

When arriving at the *World Offset* website, visitors see a splash page that announces "NO GREENWASHING HERE" and a statistic that declares how much carbon has been offset to date such as "590,448 POUNDS PROMISED" (2009). Greenwashing became a catchphrase in the 1980s after American environmentalist Jay Westerveld used it to censure hypocritical hotels that asked their customers to reuse towels, but lacked actual recycling strategies in the workplace (cited in Othmer :284). Today, greenwashing is a derogatory term used to identify business practices that involve spending significantly more time and money on advertising corporate sensitivity to environmental issues, rather than actually spending time and money on facilitating ecologically sound practices. *World Offset* promotes the idea of reducing

¹² World Offset is available at <http://worldoffset.org> (May 15, 2009) and the *EcoAesthetics* exhibition documentation can be viewed here: <http://www.tag004.nl/new/system/main.php?pageid=451> (May 15, 2009). The author was a co-curator of the *EcoAesthetics* exhibition, a wonderful opportunity that enabled her to meet a number of the artists active in the arena of eco-visualization.

an individual carbon footprint through small actions such as bicycling to work rather than driving. The choices available on *World Offset* are primarily about doing something to reduce climate change, as opposed to buying something to promote environmental stewardship.



Figure 3.5: *World Offset*, participatory website. Viewer making a carbon offset promise at the “PROMISE” page. Viewer promises to eat a vegetarian diet two days a week saving 4 pounds of carbon as a result, if the promise is kept.

The workflow to create an offset promise is very similar to *7000 oaks and counting*. After clicking on the large image on the splash page next to the phrase “NO GREENWASHING HERE”, visitors arrive at the interactive “PROMISE” link (Figure 3.5 above). There, individuals choose to make one or more pledges to conserve energy in one of seven categories, each marked by a square button labelled: “EAT”, “DRINK”, “GO”, “LIVE”, “MAIL”, “TRASH”, and “WORK”. Clicking on the button reveals a sliding accordion-style menu that reveals several possible actions to enact. For example, selecting the “EAT” button discloses the following three choices:

- I promise to eat a vegetarian diet 1 day this week.
- I promise to eat one meal with only locally produced food 1 day this week.
- I promise to eat organic food 1 day this week.

In Figure 3.5 above, a *World Offset* visitor promises to eat a vegetarian diet two days a week saving four pounds of carbon as a result, if the promise is kept. The calculations made by professionals to estimate carbon offsets are often approximations at best. In order to confirm the manner in which the vegetarian diet calculation was determined, the visitor would click “More Information” next to “I promise to eat a vegetarian diet..”, which would reveal the following text accompanied also by a web link:

According to Gidon Eschel and Pamela A. Martin of the University of Chicago, a person with a red meat diet emits the global warming equivalent of 2.52 tons of CO₂ a year more than a person with a vegetarian diet. For each day a week you eat on a vegetarian diet, you save 718 lbs of CO₂ a year. It is assumed that the portion of animal-based calories in the diet is 26%.

Savings: 2 pounds per day
Source: geosci.uchicago.edu

Although the difficulty of calculating carbon offsets is acknowledged, scientists such as Eshel and Martin work to clarify these questions of how to provide “average” offset estimates for everyday activities such as eating a hamburger or utilizing a paper cup (2006).

The final step on the “PROMISE” page would be to click the “SUBMIT” button, thereby allowing the form data to immediately enter the *World Offset* database. After submission, the contribution is dynamically updated on the “GOODPEOPLE” link for all to see. The database shows the name of the contributor, the precise amount of carbon promised, the date and time (CST) promised, the methods used to obtain the offsets, as well as the country in which the contributor resides. As of September 21, 2009, exactly 318 contributors have promised to offset a total of 590,448 pounds of carbon mostly via curtailment methods such as cutting back on meat consumption or power needs (*World Offset* 2009).

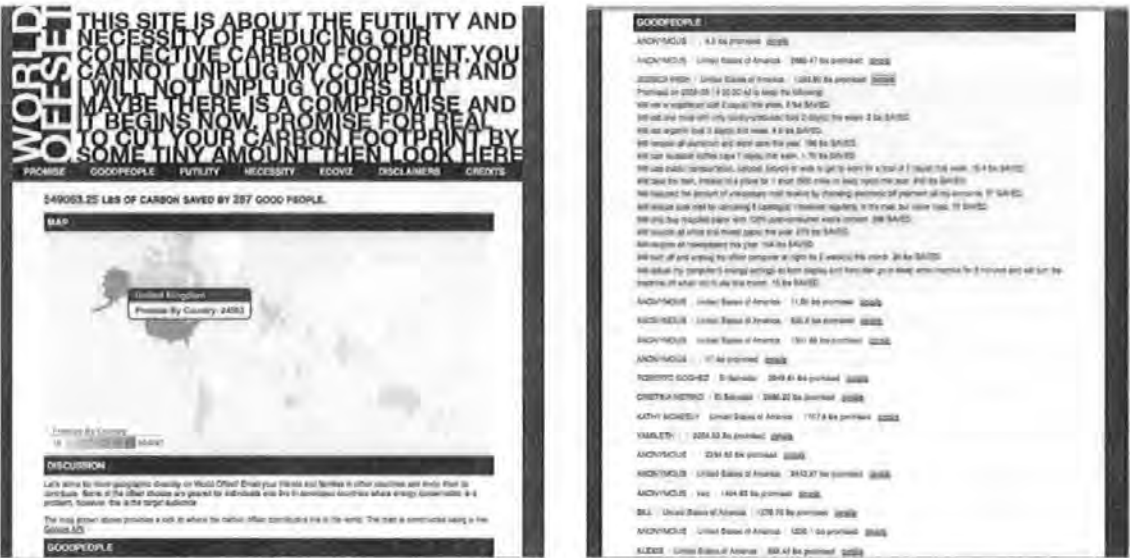


Figure 3.6: World Offset, participatory website, “GOODPEOPLE” link. At left is a map displaying how many pounds of carbon have been promised via country. At right is a clickable list of participants. Note that Jessica Irish contributed a promise of 1293 pounds on May 14, 2009.

When an individual makes a promise online, the amount of carbon offset can alter the visuals in the eco-visualisation (“ECOVIZ” link). Restating this definition of

eco-visualisation is important in the context of this inquiry. An eco-visualisation is a mode of interpreting environmental data via creative imaging to make it more accessible, more understandable, and potentially more interesting to the general public. In this case, the eco-visualisation had a clear linear goal to work towards: contribute an offset and green the animation. The web-based animation launched on March 22, 2008 with no carbon offsets registered. All of the spinning disks were filled with devices that consume energy: coffee pots, extension cords, electric outlets, pickup trucks, airplanes, and hair dryers. There were six spinning “rings” of objects for the web users to work collectively toward transforming to green trees. See Figures 3.7 and 3.8 below.

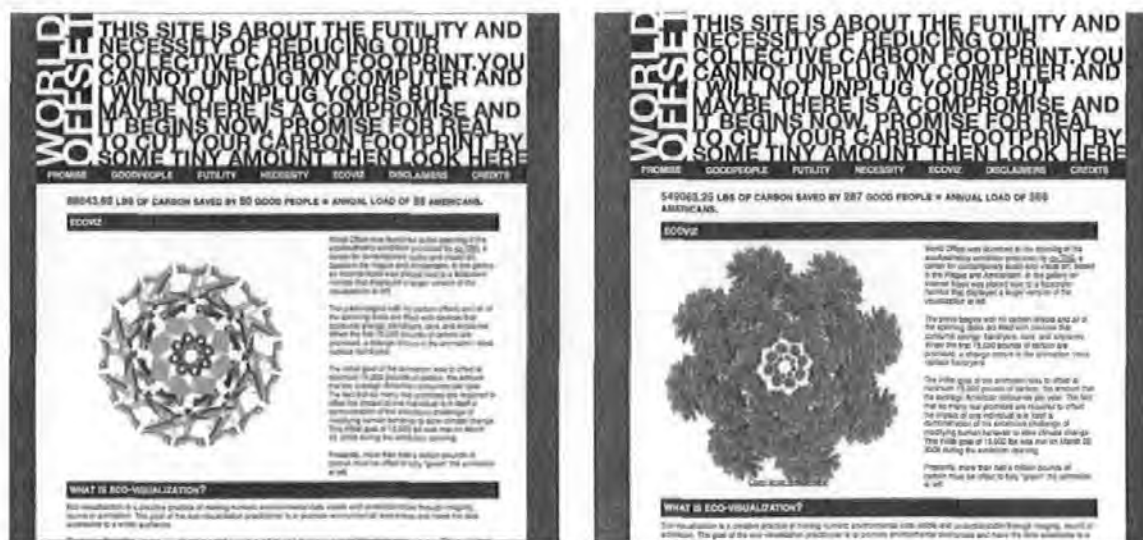


Figure 3.7: *World Offset*, “ECOVIZ” link. Eco-visualisation on left shows only 88,843 pounds of carbon promised while the one on the right shows 549,063. Image on left taken shortly after animation launch in spring 2008 while image on right was taken on May 15, 2009. Note that there is only one ring of green in the animation on the left. The overall goal was to fully green the animation by collecting promises to offset half a million pounds of carbon. The goal for 2010 is to offset a million pounds of carbon; the visualisation will be “reset” to show no green in summer 2009.

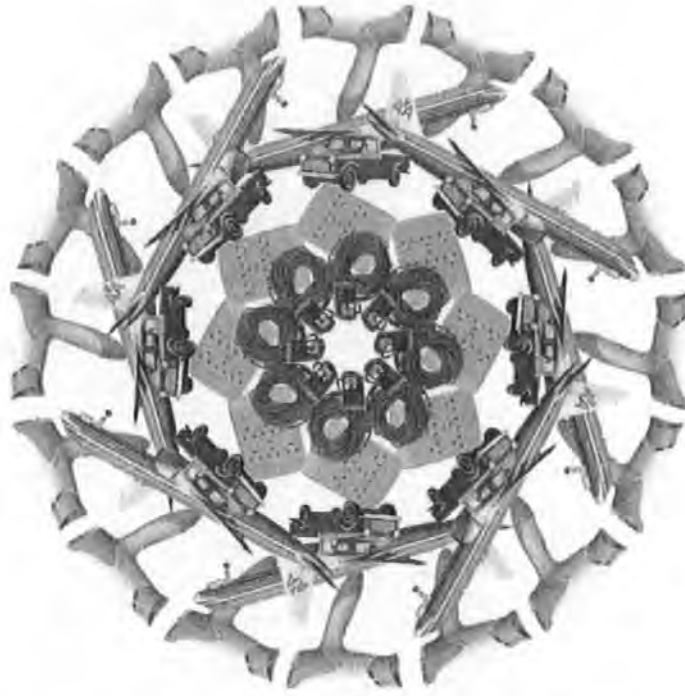


Figure 3.8: *World Offset*, “ECOVIZ” link at launch on March 22, 2008 prior to any carbon offset contributions. Spinning disks are filled with (from centre outward) coffee makers, extension cords, electrical outlets, pickup trucks, airplanes, and hair dryers.

When the first 75,000 pounds of carbon were promised, a change occurred in the animation: trees replaced coffeepots (Figure 3.7). On opening night, the initial goal for the launch of the animation was to offset at minimum 15,000 pounds of carbon, the amount that the average American consumes per year. The fact that so many real promises are required to offset the impact of one individual is in itself a demonstration of the enormous challenge of modifying human behaviour to slow climate change. On the website, clicking the “FUTILITY” link conveys a discussion of the challenge of conservation via curtailment methods in a decade where advertisers are using the environment as a way to sell products. Clicking the “NECESSITY” link brings a summary of how top scientists perceive climate change as manifesting on the planet. In the visualisation, more than a million pounds of carbon must be offset to fully “green” the animation at the “ECOVIZ” link on the site. Each year the goal will be updated to set further challenges before the participating online audience.

3.3.2 Production and Methods: *World Offset* (2008)

Hardware and Software Development: Successes and Dilemmas

World Offset was created during February and March of 2008. The invitation and funding to produce the piece for the *EcoAesthetics* exhibition came on February 6, 2008. Because the artist had less than two months to produce the piece, there was little time for usability testing in the form of contextual inquiry prior to site launch. Despite these time constraints, the functionality of the *World Offset* web site has been consistently reliable.

Electronic surveys

Every *World Offset* participant was sent a survey link to an electronic questionnaire that contained the same questions that were posited to viewers of *7000 oaks and counting* and *darkSky*. The survey was opened on April 9, 2009 for approximately two months. Twenty-nine persons responded in total. Every *World Offset* contributor has the option to be anonymous, however, most were not which enabled easy distribution of the electronic survey via emails supplied by the users.

Surveys are very important in HCI research because they help to amass information from the users about the design and development of a technological interface (Kuter and Yimez 2001), or in this case, the interface of a web site that encourages visitors to make carbon offsets. Of the three practical projects, *World Offset* and *7000 oaks and counting* perhaps best fit within HCI methodology as there is a very particular “workflow” the user needs to follow to submit an offset.

3.3.3 Results, *World Offset*

Overall, the results from the *World Offset* online exhibition, were sufficient to support the three major claims of this inquiry, that is to prove that:

Goal 1: Eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and thus encourages new forms of site-based learning.

Goal 2: Eco-visualisation that provides real time visual feedback can increase environmental awareness and possibly increase the conservation behaviour in the viewing population.

Goal 3: Eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.

World Offset's results come from two primary sources: online questionnaires and data from the website itself, though some of this data is unreliable. The quantitative goal set for the *World Offset* project was to offset 500,000 pounds of carbon in one year; this objective was easily met in just over one year with minimal marketing and promotion. According to Webalizer statistics, the *World Offset* web site has received 210,000 hits in the last year.¹³ Although this number is quite large, only 300 persons took the time to actually compose an offset contribution.¹⁴ Thus, although the *World Offset* hit count of 210,000 is generally encouraging, the data cannot be regarded as evidence of participation. The real number of distinction is the 300-plus visitors who took the time to promise to do something that would offset the amount of carbon in our collective atmosphere.

Surveys say *World Offset* catalyzed conservation behaviour

The results from the electronic surveys fulfil all three goals of the inquiry though especially Goals 1 and Goal 2. The survey respondents all contributed an offset to *World Offset*, and thus were familiar with the interactive interface online. In Question #3 of the survey, the vast majority of the participants reported that *World Offset* “got me thinking about energy usage and resource conservation”, “made me think about energy usage and resource conservation in a new way”, and “made me want to try harder to conserve energy and other resources” (Figure 3.9 below). By far the

¹³ Webalizer statistics are available at the web host's control panel for worldoffset.org; Webalizer statistics are typically not publically accessible.

¹⁴ This discrepancy between 210,000 hits and 300 carbon promises can be easily explained. Website hit count can be a bit misleading as a statistic to learn how many persons actually viewed the *World Offset* artwork (Douglass et al: 498). HTTP protocol allows the *World Offset* web server only to see requests from a remote IP address. The remote address connects, sends a request, receives a response and then disconnects. The web server thus has no idea what the remote side is doing between these requests, or even what it did with the response sent to it. This makes it impossible to determine things like how long a user spends on the site. For example, if an IP address makes a request to the server for the *World Offset* PROMISE page, then 15 minutes later creates a demand for some other page on the site, can one determine how long the user had been at the PROMISE page? Unfortunately, the answer is no. Just because several minutes expired between requests, the remote visitor could have gone somewhere else on the web, only to come back 15 minutes later to request another page. Some software analysis packages will claim that the user stayed on the site but this is actually just a guess, and nothing more.

most compelling result is that in Question #3, 62% of the respondents claimed that *World Offset* “inspired me to ACTUALLY change my behaviour related to energy conservation”.

Artwork got me thinking about energy usage and resource conservation.	62.1%
Artwork made me think about energy usage and resource conservation in a new way.	51.7%
Artwork made me want to try harder to conserve energy and other resources.	62.1%
Artwork inspired me to ACTUALLY change my behaviour related to energy conservation.	62.1%
None of the above applied to me.	3.4%

Select the statements that fit with your experience of the artwork from Question #1. Multiple statements may be selected.

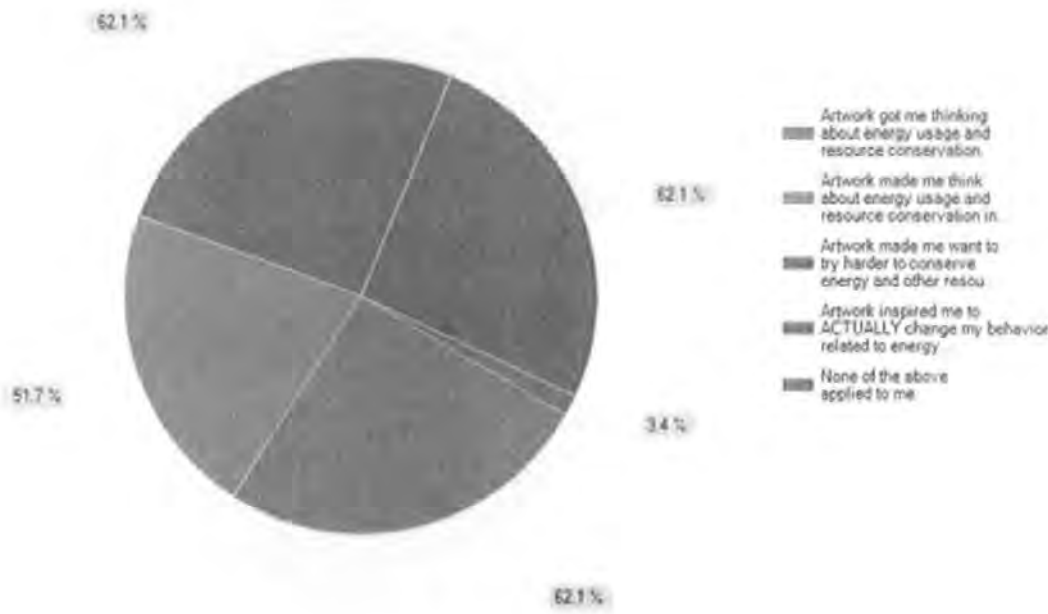


Figure 3.9: Survey Question #3 filtered to include only World Offset respondents. (Raw data above and pie chart below)

The quantitative evidence from the GOODPEOPLE link supports the claim that *World Offset* met Goal 2 of this inquiry in particular. As of September 21, 2009, 318 participants promised to change their daily habits to offset over 590,448 pounds of carbon. This fact alone proves that Goal 2, or the capacity of eco-visualisation to increase conservation was met by *World Offset*. Other evidence supporting Goal 2 can be seen in Question #5, where respondents were invited to choose “Disagree”, “Slightly disagree”, “Undecided, or neutral”, “Generally agree”, and “Strongly agree” when faced with the statement “Artwork made me want to conserve energy somehow” (See

Figure 3.10 below). 94% of the survey population agreed strongly or generally with this previous statement.¹⁵ Also, 66% of the survey population agreed strongly or generally with this claim: “Artwork catalyzed some small act of energy conservation I performed recently”. Interestingly, 42% of the respondents found the artwork overly didactic. As will be discussed in the concluding comparative discussion of the three case studies, *World Offset* was likely the best of the three eco-visualisation proof-of-practice projects that demonstrated clear, quantifiable results proving that the artwork did increase conservation behaviour in the viewing population.

	Disagree	Slightly disagree	Undecided, Neutral	Generally agree	Strongly agree
Artwork was visually or graphically interesting.	0.0%	4.8%	4.8%	<u>52.4%</u>	38.1%
Artwork had conceptual depth in that it made me think.	0.0%	8.7%	4.3%	<u>47.8%</u>	39.1%
Artwork made me think about environmental issues.	0.0%	0.0%	4.5%	40.9%	<u>54.5%</u>
Artwork taught something new about eco-issues or eco-data.	4.5%	0.0%	27.3%	22.7%	<u>45.5%</u>
Artwork was so fascinating I wanted to stay with it, or go back and revisit the piece.	4.2%	12.5%	16.7%	<u>50.0%</u>	16.7%
Artwork was overly didactic and preachy about energy conservation.	<u>41.7%</u>	25.0%	16.7%	12.5%	4.2%
Artwork made me want to conserve energy somehow.	0.0%	5.3%	0.0%	<u>63.2%</u>	31.6%
Artwork catalyzed some small act of energy conservation I performed recently.	4.2%	4.2%	25.0%	<u>33.3%</u>	<u>33.3%</u>

¹⁵ Technically, 69% generally agreed with the statement and 25% strongly agreed with the statement, for a total of 94% of the population agreeing.

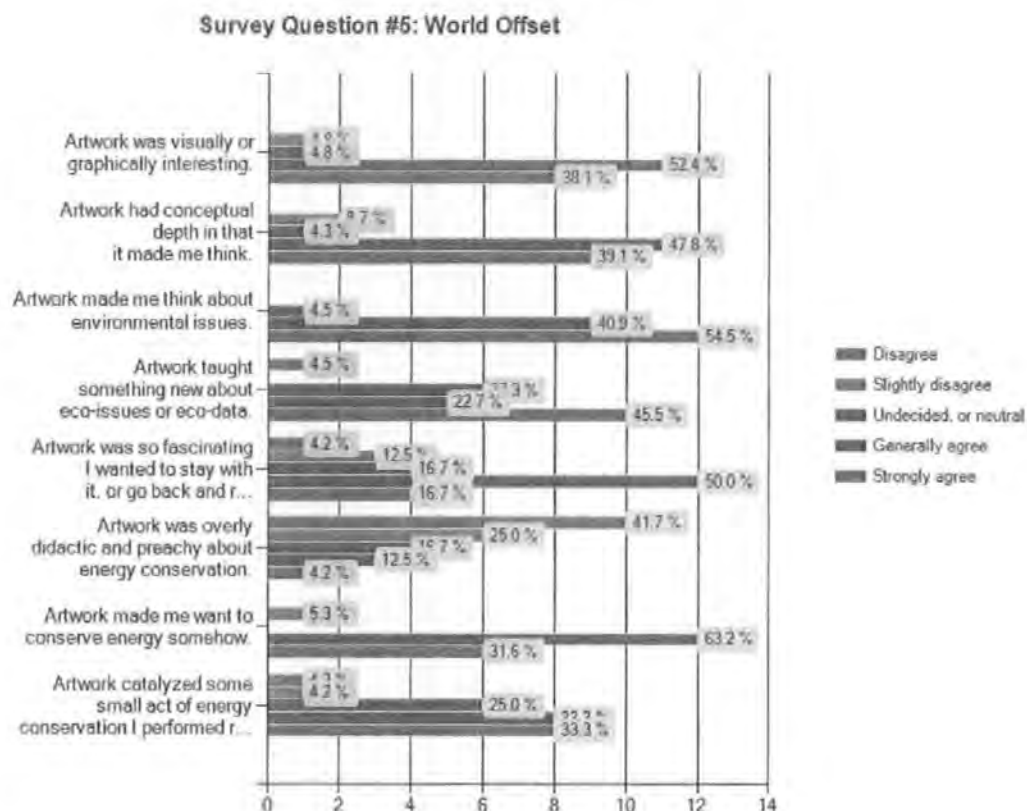


Figure 3.10: Survey Question #5 filtered to include only World Offset respondents

Users developed unique ways to personalize the World Offset website

Most users of World Offset utilized the site in a linear way: they read through the promise form, and contributed a carbon offset that was then published online under the “GOODPEOPLE” link. However, some users of *World Offset* devised some unusual and interesting ways to use the website to increase connections and goals within their home communities (Goal 3). Emily Longway, an assistant brand manager for US-based Corazonas Foods, wrote:

“I just came across your creation and it is fantastic! I am incorporating it into a corporate pledge program where our team is promising to offset our commutes for a month. ...Thanks so much for your contribution to the climate crisis; we’ll be spreading the word about your site to our database of 55,000 people to do our part as well!

...For our 13-person team, our collective commute footprint is 17,211.6 lbs in February. We have made commitments using your site to offset this completely”.¹⁶

¹⁶ Email sent by Emily Longway to the author on January 30, 2009. Longway initially contacted Holmes to report an error in the formula computation of how many pounds of carbon were offset by eating “locally grown” food. Thanks to Longway’s input, this error was immediately corrected.

Longway used the World Offset site to allow her 13-person team to work together to offset the pounds of carbon they spent in commuting to and from work in the course of one month. The additional marketing no doubt helped to increase traffic and interest in *World Offset*—see Figure 3.11 below for a look at how Corazonas Food publicized *World Offset* on their corporate website.

This specific example of community-based usage by Corazonas Food shows the ability of *World Offset* to meet all three goals set in this inquiry: the ability to create new modes of visual, website-based learning (Goal 1), the capacity to increase conservation behaviour via art (Goal 2), and finally, the ability to make new community connections via conversation (Goal 3). This example will serve as a springboard to the more detailed discussion of the results in the next section.

Our Team Pledge for Heart Month



With both heart health and sustainability at the core of our mission here at Corazonas, our team is pledging to offset our collective commutes and air travel in the month of February through heart-healthy and earth friendly ways!

Research on climate change is showing that one of the most significant ways we can reduce our carbon footprint is by eating less red meat and/or dairy products, as livestock are responsible for 18% of greenhouse-gas emissions. Since these foods contribute saturated fat and cholesterol to our diets, reducing their consumption helps both our hearts and the planet!

Join us as we offset our carbon footprint for a healthier heart in just 3 simple steps!

1. Go to <http://www.carbonfootprint.com/calculator.aspx> to calculate your commute footprint
2. Once you have the amount of CO₂ in tonnes, multiply it by 2,200 to convert your footprint to pounds that need to be offset.
3. Then go to <http://worldoffset.org/promise> to choose the various ways you will pledge to offset your commute

It's amazing how small changes add up to big offsets that will warm our hearts instead of the globe!

shop online 

visit our blog 

send to a friend 

If you no longer wish to receive these e-mails, please click on the following link: [Unsubscribe](#)
Corazonas Foods • 11100 W. Olympic Blvd. Suite 630 • Los Angeles, CA 90064 • <http://corazonas.com>

Figure 3.11: US-based Corazonas Foods utilizes *World Offset* to offset their whole team's commuter footprint for the month of February 2009.

3.3.4 Discussion, *World Offset*

Viewers more positive about *World Offset* than *7000 oaks and counting* despite similar interactive interfaces

In terms of Goal 1, *World Offset* offered a novel visual way of making invisible energy data comprehensible, and thus encouraged new forms of site-based learning in

the sense that a global population worked collectively to change, or “green” the eco-visualisation. In *World Offset*, the learning occurred on the website, not in a particular physical space. In Survey Question #3, 58% of viewers said that *World Offset* facilitated *new ways of thinking about energy usage*, while 65% acknowledged that the piece definitely got them thinking about energy usage but perhaps in more traditional ways. In *7000 oaks and counting*, only 37% of the respondents stated that they learned something new from the project. Perhaps the academic audience at NCSA was more educated about energy choices? Or rather, the *World Offset* audience who utilized the piece during their leisure time found more minutes to browse and learn more about what the piece offered? Both of these hypotheses could be proved, however, those actions would require additional surveys and interviews.

Carbon offset counters are not a particularly new form of website.¹⁷ However, what is new about *World Offset* is that it invited people to make a small contribution to create a large collective offset that alters the eco-visualisation online, and that it celebrates individual contributions *publicly* around the world—this is quite unique. As Pallak and Cummings’s 1976 study proved, public recognition and display of good conservation behaviour resulted in decreased energy consumption. Likewise, communal commitment has a pronounced effect on a group’s ability to conserve (Katzew and Johnson 1984). Most contributors preferred to use their actual names online, and not remain anonymous. Perhaps, the public front of the GOODPEOPLE page encouraged individuals to get competitive over offset promises and reveal their actual identity. Compared to *7000 oaks and counting*’s users, the *World Offset* contributors exhibited no reservations about making their commitments to a more sustainable environment very public, and accessible. This significant difference in attitude could be correlated to potential stressors in the workplace (*7000 oaks and counting* viewers did not want their supervisors to see them wasting time browsing the kiosk) versus the pleasure of using one’s leisure time to engage in environmentally beneficial direct action (*World Offset* viewers tended to enjoy making sustainable energy choices).

¹⁷ The most similar example of a carbon counting website is the very beautiful “Count Down Your Carbon” available at: <http://www.countdownyourcarbon.org/> (May 28, 2009).

***World Offset* encouraged site-based learning and new connections between people around the globe**

Qualitative data from the online questionnaire indicated that the majority of viewers did learn something distinctive from *World Offset* (Goals 1 and 2) and also formed new knowledge about their own relationship to this broader human population (Goal 3). Survey Question #2 asked viewers whether they learned anything new via an open-ended more qualitative question. Those persons who took the time to type in an answer had a whole variety of responses; most were positive though one was rather critical. The answers that relate to most to Goal 3, linking the viewer to the broader global community via the artwork, have been italicized for discussion. All of the statements below are from survey respondents who claimed to learn something unique from *World Offset*:

“[I learned..] How exponentially effective small changes in behaviour are for carbon offsetting”.

“Yes, facts about carbon offsets”.

“I was frankly disappointed to see that "introducing a new consumer", e.g. having a child is NOT discussed in this work. This isn't an anti-family stance, but really, choosing to reproduce while a beautiful thing has far more of an impact than using an alternative light bulb”.

“Awareness of my current habits”.

“Yes - it gave me a sense (accurate or not) that I'm slightly greener than I thought I was. I only entered the things that I already do. It helped that I work at home and that I eat mostly (though not exclusively) vegetarian”.

“I learned how I, as an individual, could have a positive impact on the environment”.

“I learnt about contributing to offsetting my own footprint & exactly what sorts of things I could change and commit to help create change”.

“The relationship in-between energy conservation and eco-aesthetics”.

“Not necessarily learnt something new, rather being made aware how one can make a difference through a small effort, making world concerns more in reach of your own actions. Enlightening experience”.

“Yes, innovative and simple ways to reduce energy consumption”.

“I learned about the different, easy ways to help offset our individual carbon footprints”.

“There were some items that I had never thought about being part of the problem when dealing with conservation”.

“A beautiful quantitative display of my consumption”.

“Eating vegetables saves energy. Raised concerns about the uses of energy”.

“That 30% of carbon pollution in the US comes from buildings”.

“This is an excellent tool to help people realize that they have the power to affect change”.

“Learned how much (or in some cases - how little) carbon minor lifestyle changes can reduce”.

“How I could make a lot of changes with very little effort”.

“Interesting facts as to what one could do in order to lead a little greener of a life”.

The most critical response to the piece (See #3 above) was “I was frankly disappointed to see that ‘introducing a new consumer,’ e.g. having a child is NOT discussed in this work”. It should be noted that this individual also disagreed with the statement, “Artwork taught something new about eco-issues or eco-data”.¹⁸ This particular respondent sounds like a highly educated person with above average knowledge of the various issues confronting the planet. Certainly, the world population is growing enormously and the more babies born, the more resources used. To briefly defend, *World Offset* is a website that invites visitors to make a quick decision to eat one more vegetarian meal or to unplug their computer in the evening. The website is not designed to offer a fully comprehensive list of actions that result in massive amounts of carbon being offset. If this were the case, the site would need to ask individuals to give up their cars, airline travel, desire for children, etc. The *World Offset* project is focused on helping individuals to realize how one person might make “a lot of changes with very little effort” in a single week (Respondent in #18 stated above). The *World Offset* project also intends to pull people together to observe how a series of minute changes in lifestyle could add up to bigger changes for the planet. It seems that the respondents quoted in #1, #9, #16, and #20 were struck by the many possibilities that small human gestures could translate to more significant ones over time. These particular respondents’ reactions reinforce that *World Offset* did provide a

¹⁸ This respondent was anonymous, but took the survey on May 27, 2009 from IP 76.205.27.165.

site-based learning experience (Goal 1), encourage conservation (Goal 2), and illuminate connections among individuals (Goal 3).

World Offset and critical commentary

How did the case study *World Offset* fare in terms of theoretical discourse on the concept of the artwork? Generally, critical response to *World Offset* was good—Peter Hall, a NYC-based design critic commended the website’s focus on using visuals to inspire conservation (2007). Allison Compton praised the work’s participatory aspects in her article in the summer 2009 issue of *Public Art Review*. Blogger Pia Gahagan praised the visualisation and website, though she brings one of the project’s great weaknesses into focus—see the italicized sentence below:

“This project asks people to come together and make real life promises in order to enact any kind of significant change. *This project will only work if one abides by the promises they make.* If they cheat, they are not only cheating themselves but also the community they have become involved in, and the world affected by climate change. If the participant starts wavering from their commitment they can go to the website to see how many more people have pledged which may re-invigorate their interest and make them potentially pledge more promises. The visualisation acts as a visual metaphor to convey exactly how much their commitment to the cause makes a real-life impact. Being able to see results in this way and knowing that other people are also joining in may just make an individuals choice to do what they can seem a little less futile” (2008).

Gahagan, in attempting to extol the project for encouraging viewers to connect realistically with the climate change problem by putting their own commitments on display in public, actually raises an enormous issue: what if the 300-plus contributors did not keep their promises? While there is no hard evidence that viewers kept or did not keep their carbon offset promises, the survey data shows that 66% of the respondents believe that *World Offset* catalyzed some act of conservation for them (Figure 3.10). Gahagan’s comments reinforce how effective *World Offset* was in meeting the goal of getting visitors to connect to global problems in a realistic way. Goal 3 states that “eco-visualisation encourages new perceptions of linkages between the single individual and a larger community” and the record shows that *World Offset* set a sensible goal to allow online users to work together to collectively reduce their carbon output by 500,000 pounds in the first year. Other critics such as Antonio Pasolini, a Brazilian writer and video art curator based in London praise *World Offset* for its clear mission to increase conservation via art (Goals 1 and 2): “The website looks

great and it offers a very user-friendly interface. I made my promises and saved 5,693.2 pounds of carbon. I wish more artists came up with ideas like this and explored their talents to help promote behavioural change in the fight against climate change” (2008). In conclusion, critical responses to World Offset from the journalism sector were positive, and supported Goals 1, 2 and 3.

Recommendations for the future of World Offset

The survey responses revealed several new directions for *World Offset* should the project be redesigned, and redeployed in different formats. Perhaps the greatest weakness of the piece in the context of the stated goals of the dissertation was the website’s failure to initiate direct site-based dialogue. Participation occurred in a predictable linear mode: viewer encountered PROMISE page, viewer contributed an offset promise, and viewer then added to the database of “GOODPEOPLE”. *World Offset* was strong as an artwork that inspired quantifiable conservation yet must be regarded as weak in generating site-based dialogue. In the next instantiation of the artwork, a Twitter feed and/or blog component might be included that would allow participants to compare thoughts and beliefs about energy curtailment via online dialogue (Goal 3).

Ever-evolving social media technologies continue to create increasingly complex modes for people to interact and converse online. Interestingly, the more open-ended Survey Question #6 confirmed that introducing more complex modes of participatory behaviours would enhance the artwork. Survey Question #6 asked, “If the artwork from Question #1 were to be exhibited in a new context, what might be altered or added to improve it?” Some of the more compelling ideas contributed by the survey respondents were:

“I’d be interested in seeing how project could be re-worked in a mobile media context. There might be social and informational benefits to space-based and time-oriented media” (Respondent #28 of 29, Appendix B).

“Make a FaceBook and/or MySpace application, possibly one for the iPhone? People could make a promise for the World Offset and then confirm they did it during the day. Then on the phone or their social page they could each have their own little tree that starts to grow the more they confirm they kept their promise, and for x amount of promises they have x amount of trees” (Respondent #11 of 29, Appendix B).

The full list of suggested modifications to *World Offset* can be found in Appendix B. Overall, the *World Offset* website was very efficient in motivating individuals to adopt more environmentally friendly conservation behaviour though, according to over a third of the users, the website achieved energy curtailment by adopting a rather didactic manner. But should “didactic” be interpreted as a pejorative statement toward the case study? After all, one of the primary goals was to inspire site-based learning. Although there was a pedagogic flavour to the text on the website, the true purpose was to generate the transmission of new knowledge, and if this was considered didactic by the viewing population, then this potential critique should be regarded as positive.

3.4 *darkSky* (2009)

3.4.1 Project description, *darkSky*

On October 2, 2008, Tricia van Eck, Curatorial Coordinator and Curator of Artists' Books at the Museum of Contemporary Art in Chicago (MCA) organized a meeting with the MCA engineers to discuss the feasibility of doing a month-long energy monitoring artwork using dynamic data from the building. The initial proposal was an artwork that could graphically visualise the entire museum's usage of energy. That proposal was rejected, as the building engineers did not want to introduce external hardware into a primary electric panel for the relatively short period of the proposed exhibition, one month. It is entirely possible that the institution did not wish to have its energy profile fully disclosed to the public, as was the case with NCSA. As an alternate, the second proposal was to create *darkSky*, an interactive installation that visualised energy usage in real time from a single 20-amp circuit in the UBS 12 x 12: New Artists/New Work gallery. The *darkSky* proposition was immediately accepted with excitement, as the curators believed the piece would pair well with the main exhibition running concurrently on Buckminster Fuller, which had a sustainability theme.



Figure 3.12: *darkSky* (2009). Installation view from outside gallery. All bulbs turned on at beginning of exhibition.

From April 4-April 26, 2009, the MCA exhibited *darkSky*—*darkSky* is the first piece that monitored energy usage that had ever been displayed in the museum.

darkSky is an interactive installation that filled a gallery measuring roughly eight meters square. A long, low table measuring two meters in length sits in the centre of the space. Twenty-seven salvaged table lamps displaying clear bulbs without shades adorn the table—all lamps were sprayed white to create a sense of uniformity. Signage on the wall invites viewers to turn the light bulbs on or off to create the look and feel of the work. A data logger dynamically monitors the flow of electricity through the circuit in the gallery. Two 42-inch plasma monitors hang on the walls opposite the shorter ends of the table. These monitors display an abstract animation of what appear to be small yellow dots—the dots change behaviour based on how much electricity is being used by the lamps. When all of the lamps are on, the light from the illuminated bulbs overwhelms the space and the dots stop moving and go dark, resembling stars in an urban sky (Figure 3.13). Turning all of the lights off produces an increase in the velocity and number of dots, now resembling swarming fireflies (Figure 3.14). Through visitor choice, the artwork itself consumes large or small quantities of electricity and immediately visualises its own consumption. *darkSky* aims to make tangible the often difficult-to-grasp issues of the aesthetic, economic, and environmental impact of an individual's energy choices.

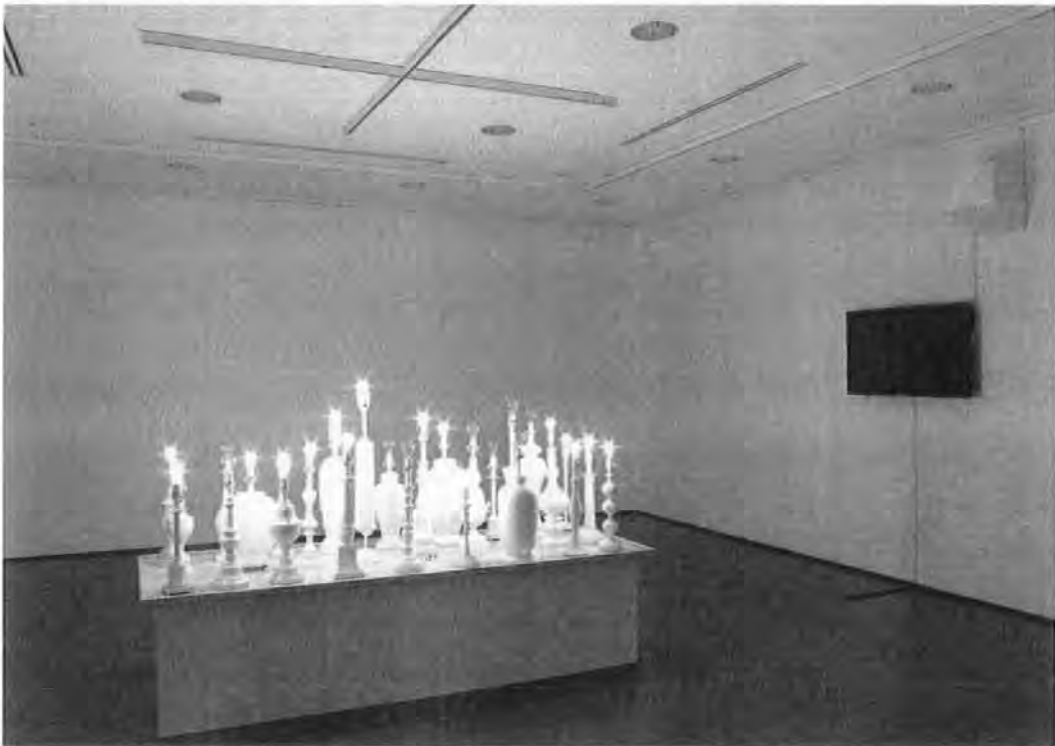


Figure 3.13: *darkSky* (2009). Installation view. More than half of the bulbs are lit; animation is slightly more subdued showing only dim stars that do not move on the plasma monitors.

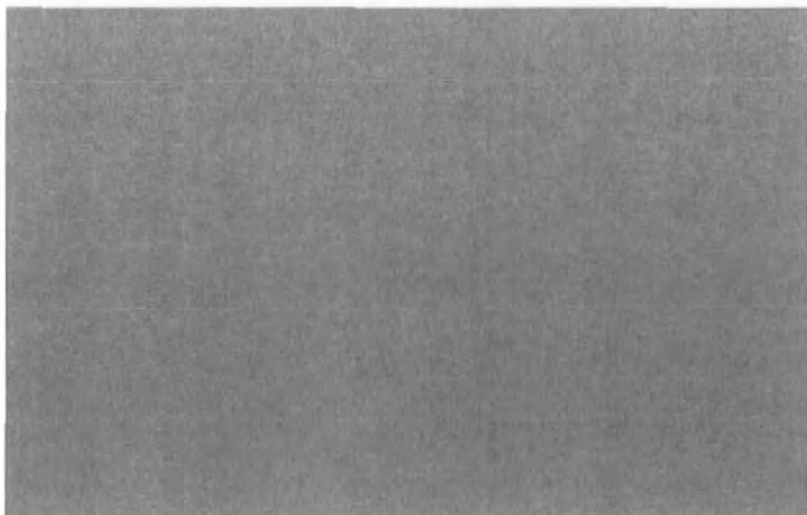


Figure 3.14: *darkSky* (2009). Animation still. Plasma screen shows very tiny pinpoints of light that resemble a night sky in urban areas when light dulls the brightness of the stars.

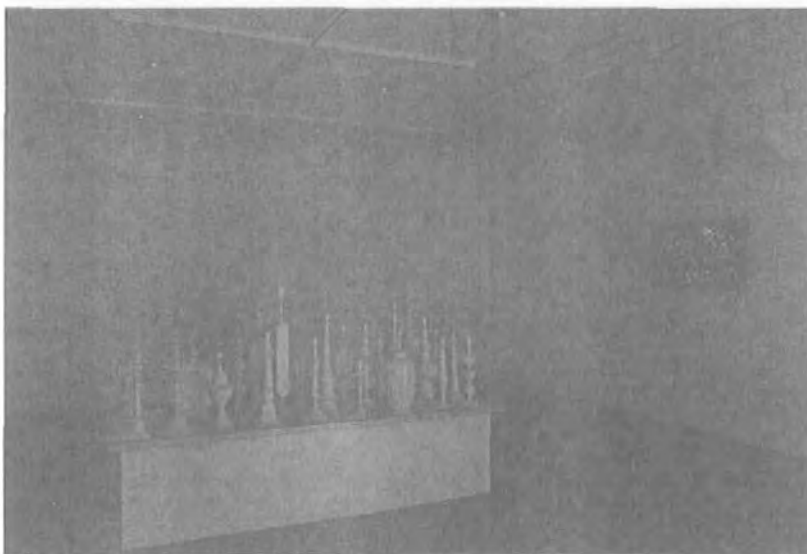


Figure 3.15: *darkSky* (2009). Installation view.
All bulbs are off with animation showing swarms of fireflies moving on the plasma monitors.



Figure 3.16: *darkSky* (2009). Animation still. Plasma screen shows flocks of swarming fireflies when fewer bulbs are turned on, and less energy is used.

3.4.2 Production and Methods, *darkSky*

Hardware and Software Development: Successes and Dilemmas

In order to achieve real-time electricity monitoring on a single 20-amp electrical circuit, a new configuration of off-the-shelf hardware was necessary along with the writing of custom software to acquire the live energy load data. Michael Murray of Lucid Design Group supplied the hardware to run *darkSky*. Hardware consisted of a WattNode for ModBus¹⁹ and a proprietary Lucid-designed AcquisSuite Data Acquisition Server. The WattNode ModBus was a networkable kilowatt-hour (kWh) energy and power meter that measures 1, 2, or 3 phases with voltages from 120 to 600 volts, alternating current. The WattNode's readings were communicated directly to Lucid's Data Acquisition Server, a small device that stored information and transferred it to a web page. A hardwired Ethernet connection to the Data Acquisition Server allowed information about the energy load to be transmitted in real time to anyone on the network with access to the Data Acquisition Server's static IP address. A simple web page communicated the dynamic power usage on the circuit via XML files that Lucid's Data Acquisition Server had been previously programmed to deliver via proprietary software. Because the *darkSky* energy data was being utilized for non-standard (i.e. visual/artistic) output, the web page itself was insufficient as a data viewer. New software had to be developed in creating the animation of the fireflies that runs in the *darkSky* installation (Appendices K and N). In addition, the relatively "small scale" electricity load readings that *darkSky* returned presented a unique set of technical issues with regard to energy monitoring.

In order to monitor the amount of energy that the 27 lamps were using in *darkSky*, the WattNode was equipped with a 5-amp split core current transformer that enabled accurate readings when only one 60-watt bulb was drawing half an amp of power. This feat is *remarkable* in that most power meters are configured to read *much larger* energy loads, that of a standard residential electrical panel (250 amps) or higher. Readings were very accurate between 0 and 10 amps, however, as more lamps were turned on, load readings were slightly inflated after approximately 22 light bulbs had been activated and 11 amps of power was consumed. Because current transformers were manufactured with an amperage rating, most are only precise within from 10% to

¹⁹ Wattnode available for purchase at: <http://www.ccontrols.com/> [May 12, 2009].

130% of the rated current.²⁰ For the purposes of the *darkSky* project, the more accurate readings were required at lower amperages; in other words, the animation really transformed as the eighth, seventh, and sixth lamp were being switched off and the swarms of fireflies became more visible. However, if a different project required the most accurate readings in the 10-amp to 20-amp range, a 10-amp split core current transformer must be used. It should be noted that the use of more sustainable compact florescent bulbs (CFLs) *would not have worked* in this particular installation context. CFLs that are comparable to 60-watt light bulbs consume only 13 watts of power. The smallest current transformer available off the shelf is the 5-amp variety, and these would not read accurately a load of only 13 watts, or 0.1 amps of power. Ironically, *darkSky* could not have been produced using energy efficient bulbs unless the project had been retooled or a much smaller custom current transformer could have been manufactured.

Although the custom hardware and software generally functioned reliably and accurately, there was a delay, or latency issue in the data transmission protocol. The Flash application that ran the firefly animations that communicated the overall electricity amount being consumed by *darkSky* at any given moment queried the server twice a second to obtain accurate energy load data from the XML files generated by the Data Acquisition Server. A slight latency problem was observed during setup. If a new bulb was turned on adding another half an amp of load—the animation only recognized the change after about a second or two. The latency issue was not in the Flash protocol developed in the course of this inquiry because it was observable from the web page that displayed all the data associated with what the WattNode, the energy meter, was generating. In other words, the latency issue was present in the proprietary hardware and software from Lucid Design Group.²¹ Fortunately, the Flash animations in *darkSky* were abstract enough that the viewing population did not complain about any latency issues in the gallery.²² The *darkSky* installation was making use of off-the-shelf hardware and software that was generally used for energy monitoring in buildings over

²⁰ Split core current transformer specifications available at: http://www.ccontrols.com/products/current_transformers.html [May 12, 2009].

²¹ Lucid's engineers were aware of the latency problem, however, in their line of work, they did not deal with "interactive installation" scenarios. They consider the software and hardware to be dynamic, a one or two-second delay was negligible in their line of work.

²² During an artist talk on April 21, 2009, many viewers commented on the accuracy and wonder of seeing their energy choices reflected in the animations on the plasma screens. A brief conversation ensued with the group of 40 or so viewers who claimed that latency was not an issue at all in understanding the animations.

days, months, and years—yet this installation needed updating every second. Because viewers have very short attention spans when they know a piece is interactive, it was crucial that the overall interface design reflect no stoppage. As most viewers could turn on or off three or four lamps in two seconds the gesture was dramatic enough for the Flash animation to recognize via the data, and thus, the viewers generally believed that their actions were affecting the animations in real time, despite this slight latency.

Another dilemma that arose in the planning of the *darkSky* installation related to the overall amount of electricity required by the installation itself. The conceptual aim was to have the entire installation space under energy surveillance. However, given the amount of electricity consuming objects involved, and the previously described issue of the difficulty of mapping smaller amounts of energy used, this goal was not possible. A standard electrical receptacle in the USA provided a maximum 20-amps of power. If more power was requested the circuit would be disrupted. If all twenty-seven bulbs were turned on, and if the entire installation was connected to one circuit, *darkSky* would draw a total of 21.85 amps (*darkSky*'s power requirements are detailed below in Figure 3.17). Because this amount was over the 20-amp limit of the circuit, the *darkSky*'s plasma monitors and computers had to be run on a different circuit. From an aesthetic perspective, this configuration actually worked best because the cords for the plasma monitor and the computer could be hidden on the wall rather than having to trail onto the floor beneath the central table. Electric cables on the floor would be both a safety hazard and a visually unappealing detail in an otherwise clean art installation. In the next iteration of *darkSky*, extra care should be taken to ensure that *darkSky*'s power requirements are below the 20-amp mark. This aim could be accomplished in a few different ways. The easiest would be to re-code the animation to work with five less lamps although the table surface would have to be patched to remove the extra holes for the cords. Alternatively, as the energy efficiency of plasma monitors and computers improves in the next decade, it may be possible to run LCD monitors that draw less power, or computers that require less energy.

NUMBER OF LAMPS "ON"	POWER (WATTS)	CURRENT	ANIMATION SHOWS
0 lamp	0	0	550 fireflies; flying; bright
1 lamp	60	0.5 amps	550 fireflies; flying; bright
3 lamps	180	1.5 amps	450 fireflies; flying; bright
6 lamps	360	3 amps	450 fireflies; flying; bright
9 lamps	540	4.5 amps	350 fireflies; flying; dimming
12 lamps	720	6 amps	250 fireflies; flying; dimming
15 lamps	900	7.5 amps	150 fireflies; flying; dimming
18 lamps	1080	9 amps	75 stars; minimal movement; dim
21 lamps	1260	10.5 amps	75 stars; still; dim
24 lamps	1440	12 amps	75 stars; still; dim
27 lamps	1620	13.5 amps	75 stars; still; dim
<i>Additional energy consuming hardware</i>		8.35 amps	
Linksys router	60	0.5 amps	
Data acquisition server	60	0.5 amps	
WattNode	~30	.25 amps	
2 plasma monitors	674	5.6 amps	
2 MacMini computers	220	1.5 amps	
ENERGY TOTALS: ALL DEVICES ON		21.85 amps	

Figure 3.17: Energy requirements of the *darkSky* installation with animation features listed. The top of the table shows how much power is required for different scenarios of light bulbs in *darkSky*. The formula used to compute load readings was " $P=IV$ ". (Power in watts equals current in amps times voltage).

The overall ambition, in *darkSky*, was to provide viewers with an interactive art experience that poetically conveys the consequences of everyday individual energy decisions. The "on-off" switch formed a relatively seamless interface, as lamps were familiar objects to all viewers young and old—more will be said about the interactive interface in the upcoming *Results* discussion. The issue of how to best visually portray the consequences of individual energy decisions was an individual creative decision made with the critical frameworks of Kester and Miles in mind. *darkSky* was formed with Kester's "dialogical practices" model as a focus, that is, *darkSky* intended to engage conversation at the lamp table by encouraging various viewers to talk about what they saw happening on the plasma screens as they switched bulbs off. Likewise, *darkSky* engaged three of the four categories that Miles described for environmental art. *darkSky* invoked Miles' category two, or the apprehension of various phenomena, the presence of light from the bulbs, and the absence of fireflies, or rather, the lack of light from the bulbs, and the vast expansion of the virtual firefly population onscreen.

darkSky also intersected with Miles' category three; *darkSky* is indeed a form of cultural production that contributes to sustainable forms of living. Every effort was made to utilize green materials where possible: all the lamps were salvaged from junk stores, and the table was made from bamboo and sustainably forested white birch. Finally, *darkSky* intended to produce what Miles described as the fourth category, "dialogic inter-action at the cusp of art and activism". Miles' category four and Kester's philosophy of "dialogical practice" are similar in that both want the art to create critical conversation on-site—conversation inspired by the art that according to the aims of eco-visualisation, would encourage site-based learning. The overall design of the *darkSky* experience showed a great deal of synergy between the critical platforms engaged by Miles and Kester, however, the *Results* section will detail whether these individual creative goals were met or not.

Surveys and Reviews

Paper and pencil surveys were distributed at the MCA on April 21, 2009. In addition, the same survey was delivered electronically to a number of viewers who signed up for the artist's email list and the survey was posted on the artist's FaceBook profile. The survey was opened on April 9, 2009 for approximately two months. Only about 33% of those individuals who were emailed about the online survey link actually filled out the survey. Because of the context in which the survey was delivered or posted there would have been some potential bias present in that several of the participants know the artist in either a professional or personal context. Every online survey participant has the option to be anonymous. About 29% of the 46 respondents provided their names and email addresses in the context of the electronic survey.²³

Survey research is very important in HCI research because it helps in gathering information from the users about the design and development of a technological interface, or in this case, the interface of a rather abstract art installation. Yet in fine arts discourse, survey research is not a particularly common method. Rather, published dialogue focused on the conceptual arguments presented by the artwork is valued. Generally in the case of contemporary art, this critical dialogue comes from critics who write reviews of artworks in print publications like newspapers or online in blogs. In

²³ Of this group of 13 persons who chose to give their names and contact info in the *darkSky* online survey, 5 persons were known previously in a professional context by the author.

the case of *darkSky*, Alan Artner, a prominent art critic from the *Chicago Tribune* wrote a review that will contribute a critical analysis in addition to the survey results.

Task analysis: Contextual Inquiry

Task analysis, or examining each component of human interaction with an object or interface was another important component of the HCI research methods that were utilized in the assessment of *darkSky*. Task analysis was conducted via contextual inquiry at the MCA in conjunction with the *darkSky* exhibition on April 3, 2009 and on April 11, 2009. Contextual inquiry is an observational technique that collects data by observing the activities of users attempting to interact with a particular object or interface. In the case of *darkSky*, users were viewed in their typical environment, or the space of the museum gallery at work at the task: making sense of the interactive lamp interface and accompanying eco-visualisation. Contextual inquiries produced information not only about user behaviour, and also elucidated the impact of the installation's spatial context on group behaviour in *darkSky*.

There were some clear advantages and disadvantages to using contextual inquiry to observe viewers interacting with an interactive installation sited in a museum of contemporary art. The main advantage was that contextual inquiry generated information that could not be collected by any other means (Kuter and Yilmaz 2001). In the case of *darkSky*, it provided a clear portrait of user behaviour, but more importantly, it delivered a picture of users in their natural environment, or in this case, the space of an interactive artwork in a museum, a place where most people are generally unaccustomed to touching objects on display. On the other hand, there were several disadvantages to using contextual inquiry as a research method. Observation was a time-consuming, rather intensive activity; also, the observational data contained an extremely widespread amount of information, or even noise. Direct observation could also be an intrusive practice. The presence of an observer may also have influenced user behaviour as it most certainly did in the case of *darkSky*, where viewers innocently asked the observer questions about the piece.

3.4.3 Results, *darkSky*

Opening night, April 3, 2009

500 persons entered the *darkSky* exhibition gallery at the MCA on opening night. Contextual inquiry, or site-based observation during this four-hour opening revealed a number of interesting issues related to all three goals set for *darkSky*. First, if there were individuals at the table turning lamps on and off, other participants would immediately join them, and often initiate a conversation about the piece. The conversation generally related to a kind of site-based group learning process to determine what exactly happened when the lamps were all switched on or off. Statements were overheard such as: “Turn them all off it looks cool”, “Are some of them supposed to be on and some off?” and “Help me turn them off it saves energy”.²⁴ This kind of behaviour was in sync with the aims that were based on Kester’s conceptual description of dialogical art and Miles’s fourth category of environmental art related to interaction. There was no right answer to the question of whether all the lamps should be on or off—and the ensuing confusion over the lamps was a frequent subject of dialogue at the table. Some viewers immediately got on the ‘green bandwagon’ and told other viewers to turn the lamps off, however, there were nearly as many viewers who simply played with various arrangements of bulbs being on and off. The third goal of this inquiry, that the artwork might encourage viewers to imagine “new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation” seems to be met through the contextual inquiry methods employed on opening night with one or two exceptions.

On opening night there were few viewers who stood in the gallery space alone, but those who did enter an empty space were a bit perplexed by the installation. Viewers were invited in the exhibition information card in the very first sentence to interact with the lamps and then leave the bulbs in any lit or unlit arrangement. Probably the biggest issue observed that evening was the case when a viewer encountered *darkSky* without the presence of other viewers and did not read the exhibition information card. Those individuals treated *darkSky* like a piece of precious museum sculpture and never touched a lamp. Because the viewing context was the white-walled MCA, this behaviour was not terribly surprising. However, all viewers

²⁴ Statements recorded on notepad via observation opening night, April 3, 2009, via contextual inquiry.

who read some, if not the entire exhibition information card immediately came toward the lamps to experiment with turning the bulbs on or off. The matter of how easy or difficult the interface was to navigate will be discussed further in the review of the results of the online questionnaires. Overall, the contextual observations on April 3, 2009 showed that most viewers through a combination of reading the exhibition information card and conversation with other viewers were able to easily interact with the interface of the *darkSky* installation, and quickly comprehend the meaning of the eco-visualisation.

Survey results, darkSky

The questions posed to viewers of *darkSky* were the same as the questions utilized to query *7000 oaks and counting* and *World Offset* participants. Survey Question #2, a qualitative, open-ended query, asked viewers if they learned anything new via their *darkSky* experience. 21 of 46 persons answered the question and indicating evidence that they had acquired new knowledge via the viewing experience. One respondent, media artist Lincoln Schatz, claimed that the installation made him think about his relationship with nature (Goal 3): “the multiple layers of meaning caused me to think about my regular distance from nature and impact that I exert through my daily life”. (See more responses in Appendix C). More specifics on these qualitative responses that support the three goals of this inquiry will be provided in the forthcoming discussion section.

Survey Question #3 in the electronic survey illuminated the effectiveness of *darkSky* as a site-specific learning experience. Question #3 asked viewers to check statements that fit with their experience of the MCA installation. See the table below that shows that the majority of the respondents were overwhelmingly positive that this learning experience incorporated an environmental message related to energy conservation. Over 55% said that the installation inspired thinking about resource conservation. Another 28% claimed *darkSky* generated new thinking about energy usage, 32% indicated the artwork sent a strong conservation message that affected them personally, and 21% believed that the installation catalyzed some sort of behavioural change related to energy curtailment.

Survey Question #3: Select the statements that fit with your experience of *darkSky*.

Artwork got me thinking about energy usage and resource conservation.	55.8%
Artwork made me think about energy usage and resource conservation in a new way.	27.9%
Artwork made me want to try harder to conserve energy and other resources.	32.6%
Artwork inspired me to ACTUALLY change my behaviour related to energy conservation.	20.9%
None of the above applied to me.	11.6%

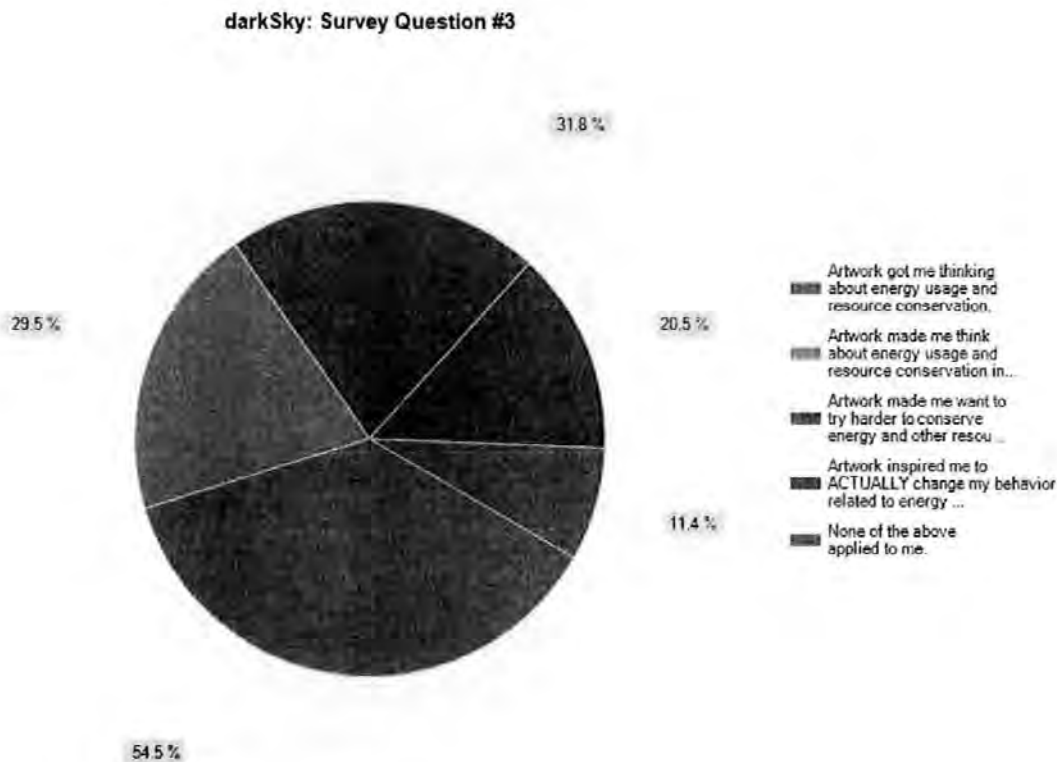


Figure 3.18: Survey Question #3 filtered to include only *darkSky* respondents. (Raw data above and pie chart below)

Only 11% stated that none of the supplied choices applied to them, however, these respondents wrote specific comments to clarify such as: “I found myself thinking less concretely than the above options, more whimsical and mysterious...human impact on environment, yes, conservation, no”, and “Reinforced the beauty of conserving and living more simply”. The two other respondents who answered “None of the above applied to me” wrote that the installation really encouraged thinking about information aesthetics in addition to the environmental issues, and another said that the piece did not make one think about sustainability the way some of the other case studies like *World*

Offset did (Appendix C). This small group of respondents was still positively impacted by *darkSky*, yet they felt limited by the admittedly prescribed manner in which the survey attempted to capture their experience of the artwork.



Figure 3.19: *darkSky* (2009) installation view: close up of interactive lamp interface

Question #4 in the online survey asked whether the eco-visualisation with the dots made sense to the viewing population (Appendix C). 67% of the respondents answered “The images chosen to represent the energy used or conserved IMMEDIATELY made sense to me”, while only 7% said “The images chosen to represent the energy used or conserved made sense ONLY AFTER I READ ABOUT HOW TO INTERPRET THEM”. About 16% agreed: “I did not really need to understand the data visualisation to appreciate the artwork”. Because 67%, or the majority of the viewing population instantly grasped the visual concept, the conclusion is that the visualisation of the dots becoming fireflies to represent “good” or sustainable energy choices was highly effective.

In the electronic survey, viewers were additionally queried about a variety of issues related to the conceptual integrity and aesthetic perspective on conveying environmental issues through art. In Question #5, respondents were given a series of statements about the artwork, and could tick off one of five choices: “Disagree”, “Slightly disagree”, “Undecided, or neutral”, “Generally agree”, and “Strongly agree”

(See Figure 3.21 below). Perhaps the most interesting result of the survey was that nearly 60% of the respondents generally agreed with this statement: “Artwork made me think about environmental issues (Goal 1)”. Over half of the respondents strongly agreed with this statement: “Artwork was visually or graphically interesting”. These two statistics alone will create a strong case that eco-visualisation can be a highly effective way to get an audience initially interested in ecological data of any sort. What the audience does with that content is entirely another matter to be addressed in the next chapter, which in part, will present discussion of what can be regarded as success or failure in an artwork.



Figure 3.20: *darkSky* (2009); Viewers interacting with lamps by turning bulbs on or off.

In Survey Question #5 there was a blank text box for participants to write additional comments and critiques, though only 4 of 46 respondents used this option. One respondent wrote:

“The work was lovely and had a message. But though I understood the intent, my ultimate interest was in what it looked like to visually turn all the lights on and then off and then on again. I felt less in touch with the real-life conservation of energy, and more geeked out by the novelty of energy-activated ‘fireflies’ in a gallery setting” (Anonymous respondent #33, see Appendix C).

This honest critique was well deserved as the magical appeal of technology, or technophilia, can sometimes distract viewers from accessing a more conceptual

message. Despite this useful individual critique, over half of the respondents agreed that the artwork “had conceptual depth”, was “graphically interesting”, “made me think about environmental issues”, and was “so fascinating I wanted to stay with it, or go back and revisit the piece (See Table 3.21)”. Over 72% of the viewers believed that *darkSky* was a far more poetic phenomenon as opposed to a didactic learning episode. The majority of the viewers who responded to the electronic survey judged *darkSky* to be an important exhibition that did indeed catalyze site-based learning and general curiosity about energy monitoring issues.

	Disagree	Slightly disagree	Undecided, neutral	Generally agree	Strongly agree
Artwork was visually or graphically interesting.	2.7%	2.7%	5.4%	37.8%	<u>51.4%</u>
Artwork had conceptual depth in that it made me think.	3.4%	0.0%	17.2%	<u>51.7%</u>	27.6%
Artwork made me think about environmental issues.	0.0%	5.9%	11.8%	<u>58.8%</u>	23.5%
Artwork taught something new about eco-issues or eco-data.	0.0%	21.9%	<u>37.5%</u>	34.4%	6.3%
Artwork was so fascinating I wanted to stay with it, or go back and revisit the piece.	6.1%	3.0%	27.3%	<u>51.5%</u>	12.1%
Artwork was overly didactic and preachy about energy conservation.	<u>51.5%</u>	21.2%	21.2%	6.1%	0.0%
Artwork made me want to conserve energy somehow.	0.0%	3.1%	34.4%	<u>43.8%</u>	18.8%
Artwork catalyzed some small act of energy conservation I performed recently.	2.9%	11.4%	<u>51.4%</u>	22.9%	11.4%

Figure 3.21 Survey Question #5 filtered to include only darkSky respondents.
(Raw data above and pie chart next page)

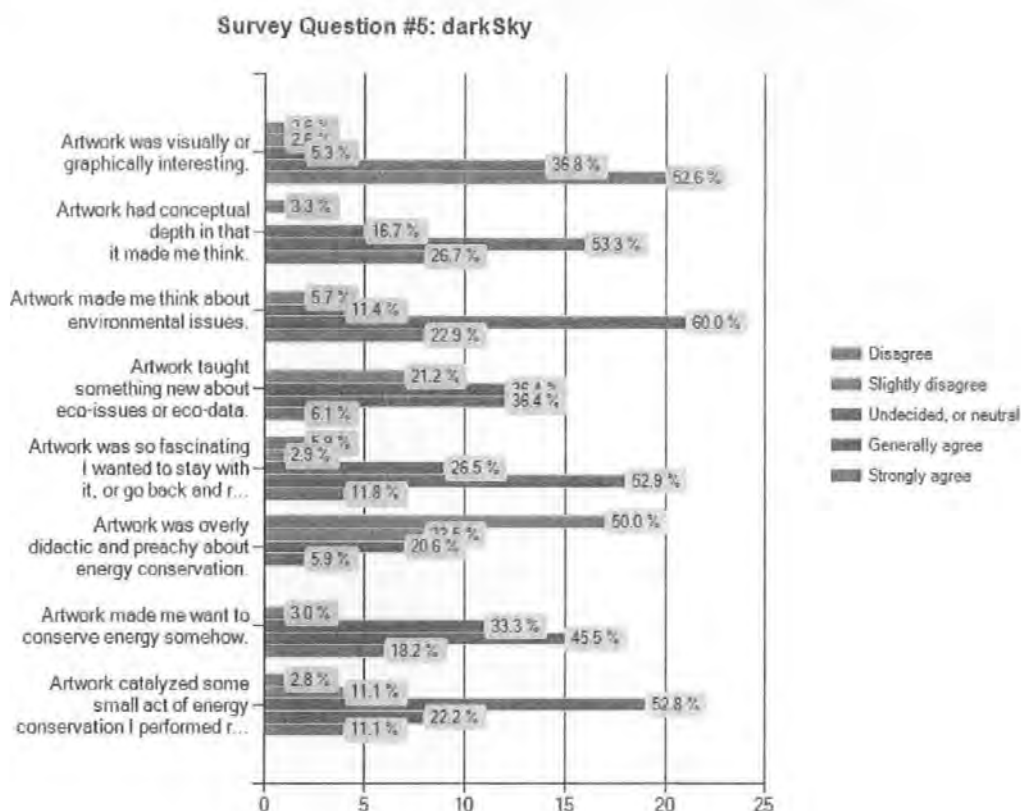


Figure 3.21 Survey Question #5 filtered to include only darkSky respondents.
(Raw data above, previous page)

Question #6 asked if *darkSky* “were to be exhibited in a new context, what might be altered or added to improve it?” 19 individuals out of 46 provided qualitative typewritten responses (see Appendix C) that will be discussed in the forthcoming results debate that relates to evaluating further steps to be taken with this eco-visualisation research.

3.4.4 Discussion, *darkSky*

Learning inspired via fireflies, a metaphor from the natural world

Overall, the results from the *darkSky* MCA exhibition generally supported the three major claims of this inquiry:

Goal 1: Eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and thus encourages new forms of site-based learning.

Goal 2: Eco-visualisation that provides real time visual feedback can increase environmental awareness and possibly increase the conservation behaviour in the viewing population.

Goal 3: Eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.



Figure 3.22: *darkSky* (2009); Viewers interacting with lamps by turning bulbs on or off.

The first goal, “Eco-visualisation offers novel visual ways of making invisible energy data comprehensible and easily accessible, and thus encourages new forms of site-based learning” was most definitely met. In Survey Question #4, over 82% of the respondents indicated that they generally understood the simple energy graphics of the moving fireflies and static stars. Compare this figure to 59% of the viewers who claimed to comprehend the visual logic in the *7000 oaks and counting visualisation*, and the 75% who purported to grasp the concept of greening the animation in *World*

Offset. Despite the fact that *darkSky* set forth an incredibly abstract animation to represent energy flows in the installation space, the viewers, in the context of a contemporary art museum, worked together to decode the firefly pictures and draw logical conclusions about how the lamp interface affected the moving images onscreen. *darkSky* emerged as the clear success of all three case studies in the pictorial representation of electricity streams.

Contemporary art museum an ideal context for environmental pedagogy

In terms of accessibility to encourage site-based learning the museum proved to be a fruitful venue for the eco-visualisation piece, even though the case study was interactive and encouraged touch, an atypical experience in the contemporary art world. On April 2, 2009, 534 individuals viewed the interactive installation *darkSky* at the MCA in the space of four hours though over 2000 persons entered the museum that evening.²⁵ More than 25% of this opening night crowd was thus able to directly observe or interact with the piece—this is a considerably large number of viewers especially when compared to the initial viewings of *7000 oaks and counting* and *World Offset*. Major museums continue to attract larger groups of viewers for artworks than university buildings or even websites.

According to the results from contextual inquiry, online questionnaires, and published art reviews, *darkSky* was perhaps most successful in addressing Goal 1, making energy data visible to encourage site-based learning. The installation was reasonably effective in meeting Goal 2, that is, *darkSky* increased environmental awareness in the majority of the viewing population and inspired a few visitors to conserve energy. Nearly 60% of the online survey respondents claimed that *darkSky* “made me think about environmental issues” in Survey Question #3. Over 89% of the respondents verified that *darkSky* was a learning experience that incorporated an environmental message related to energy conservation, thus indicating that the vast majority of the viewing population fully understood the installation’s visualisation and lamp interface. Only 20% indicated that seeing *darkSky* motivated them to conserve more energy but these claims were not verifiable within the bounds of this inquiry. *darkSky* was thus far more efficient at raising awareness about electricity monitoring

²⁵ Data provided to the author via email by MCA curator Tricia van Eyk via Chaz Olajide who counted with a clicker the number of people in the 12 x 12 gallery space on April 2, 2009.

and conservation than in producing tangible evidence of energy curtailment—something that *World Offset*, a more didactic, and less poetic piece did do well. The results from contextual inquiry suggested that the *darkSky* eco-visualisation encouraged museum visitors to talk amongst themselves in the installation space about the relationship of electricity to the artwork and to themselves —this relates to Miles’ and Kester’s frameworks for dialogical artworks (Goal 3). Due to the short term viewing experiences prevalent in museums, these live dialogue sessions were rather short-lived but the content of the conversation did incorporate a discussion about how much energy was being used by the artwork as noted by the contextual inquiry observations which were conducted on opening night and on April 11, 2009.

***darkSky* catalyzed cooperative activity but minimal conservation**

While *darkSky* did raise awareness about energy consumption, it did not effectively persuade a hands-on conservation effort, as did *7000 oaks and counting* and *World Offset* via the offset promises. Nearly 53% of the *darkSky* respondents were undecided about whether the artwork might catalyze some new act of conservation for them (Survey Question #5). In Survey Question #3, only 20% of the viewers claimed “Artwork inspired me to ACTUALLY change my behaviour related to energy conservation”, compared to 62% for *World Offset* (only 12% for *7000 oaks and counting*). Nor did *darkSky* necessarily promote a specific message about community involvement or human linkages with nature (Goal 3). Contextual inquiry revealed that a great deal of dialogue took place at the lamp table related to how to manipulate the interaction, and use more or less energy. Furthermore, some individual survey respondents wrote that the installation did influence them to internally raise questions about human interconnectedness (Goal 3). Consider media artist Lincoln Schatz’s previously mentioned remark “the multiple layers of meaning caused me to think about my regular distance from nature” and performance artist Mark Jeffrey’s comment: “how do I then begin to think about the idea of less energy usage, how does a single bulb / body respond when other lamps / bodies are turned on and the response and responsibility this means to me?” Taking into account all three goals for this inquiry, the results showed that *darkSky* was best suited to meet Goals 1 and 2 in translating energy data to encourage a non-didactic site-based learning experience, despite the fact that *darkSky* was less adept at promoting measureable conservation. In addition, the

evidence is good that *darkSky* inspired new site-based dialogue about the effects of energy consumption and the relationship of humans to the natural world (Goal 3).

***darkSky* and critical commentary regarding non-didactic pedagogic process**

Professional critics and curators genuinely seemed excited by the interactive possibilities and alternative modes of inciting new thinking about energy usage and conservation in the *darkSky* project. The critical feedback supported all three goals of this inquiry. For example, on April 10, 2009, the art critic Alan Artner reviewed *darkSky* in the *Chicago Tribune*. He was impressed with both the viewer participation component and with the capacity of *darkSky* to visualise the social aspects of environmental issues in a non-didactic, highly visual manner:

“Everything that happens in *darkSky*, the Chicago media artist's installation at the Museum of Contemporary Art, is a direct result of viewer participation. Ideas are not grafted on, attributed or hidden. What the piece has to say is achieved through visual means alone...*darkSky* is a poetic visualisation of consequences of electric consumption. There is no lesson or finger-wagging in it. There does not have to be. Each viewer is shown aesthetically the impact of his or her environmental behaviour. An action taken with one kind of light is measured for us through another” (2009).

Other critics like William Shaw of the UK's Arts & Ecology blog further emphasized the elegant simplicity of the eco-visualisation in *darkSky* (2009). Yet Shaw makes the point that the piece is not designed for green energy perfectionists because even in its low power state the installation still uses energy:

“This simple idea from Tiffany Holmes at ecoviz.org was displayed at the Museum of Contemporary Art in Chicago last month under the title *darkSky*. Viewers are encouraged to turn these salvaged lamps on or off as they please. The resulting electricity consumption is displayed on a screen nearby. I'm guessing the purists can't resist turning all the lamps off, while the aesthetes can't resist turning them back on again. Of course the really smart purist would turn the TV monitor off as well” (2009).

Shaw's statements above highlighted the natural diversity present in any viewing population, and certainly the electronic survey responses supported the claim that site-based learning occurred, albeit a very broad range of learning. Question #2 on the electronic survey asked for qualitative responses to *darkSky* such as “Did you learn anything new from seeing the artwork?” Just under half of the respondents typed an

answer while the others bypassed it. The most interesting qualitative response was from Mark Jeffrey a well-known performance artist associated with the Goat Island troupe:

“If the lamps in *darkSky* are our individual bodies — how do I then begin to think about the idea of less energy usage, how does a single bulb / body respond when other lamps / bodies are turned on and the response and responsibility this means to me and the collective gallery audience [could be] as simple as turning the lights off when you are not using them in the home, to processing how much energy consumption one uses in a 24 hour day as I take out the rubbish on a night time - each Sunday to see the bins full in the alleyway outside our house. The increasing awareness of consumption - the need to change one's consumption, the pattern of how one consumes from an individual standpoint, how one's actions can also ripple onto other bodies and effect other people's actions” (Appendix C).

Jeffrey's comments indicated that he was considering the installation from a dialogical perspective in that he wondered aloud about how his energy usage might affect others (Goal 3). Other pertinent responses to the question of what was actually learned from the art viewing experience included (full unfiltered list in Appendix C):

“The multiple layers of meaning caused me to think about my regular distance from nature and impact that I exert through my daily life”.

“[darkSky made me think about] how abstract energy concepts can be visualised”.

“Yes [I learned something new]. I felt personally responsible for the lights (energy) I turned on because I could immediately see the effects of light pollution”.

“Amazed that the artist was able to visually represent energy consumption”.

“Incandescent lights use a lot of energy and are very hard to look at without a shade”.

“Education can be an object”.

“Better grasp of how elegant/simple the choices can be and the value/benefit of those (I think we complexify these choices)”.

“Amazed that the artist was able to visually represent energy consumption”.

“People are more into conservation in Chicago than I thought”.

“There is something to learn in everything”.

The above responses, while rather diverse, showed that participants in the *darkSky* installation were learning about any one or combination of the following via a

brief interaction with the artwork: light pollution, energy consumption, Chicago-based sustainability, and personal responsibility. Chicago Tribune critic Artner accurately portrayed *darkSky* as “a poetic visualisation of the consequences of energy consumption”. The inherent poetics of the piece and the immediacy of the interaction made specific measurable conservation efforts difficult as mentioned previously. However, despite the lack of hard evidence measuring gains in energy curtailment, the *darkSky* piece was highly effective in generating interest and awareness about electricity consumption as shown by the positive critical reviews and the previously cited survey data. Evidence like the results from Survey Question #5, that showed that over 79% of the respondents believed the artwork “made them think” prove that eco-visualisations like *darkSky* have serious potential to begin new conversations about personal energy conservation. Because *darkSky*’s results were positive, no major modifications are recommended. *darkSky* will be exhibited next in November of 2009 in Hong Kong at the Microwave Festival where the theme is: “Nature Transformer”. While all of the case studies were successful on some level, the following comparative discussion will attempt to conclude which case study shows the most potential for future research.

3.5 Comparative discussion of case studies: *7000 oaks and counting*, *World Offset*, and *darkSky*

Before comparing the three case studies undertaken here, the relative uniqueness of this practice-based research that combines fine art, HCI, and energy monitoring must be emphasized in light of this inquiry’s contribution to new knowledge. This in-depth user testing of eco-visualization works that expand the field of dynamic feedback to promote energy conservation has not been conducted in past projects like *Nuage Vert*, the Wattson, etc. While Chapter 1 provided a look at several scientific studies that describe how daily feedback altered habits of electricity usage, there are very few precedents for electronic art or design works that give dynamic feedback for energy usage via *images only* as opposed to numeric feedback such as that available from the gadget called TED, the Energy Detective. In Chapter 2, the closest examples of energy-monitoring visual objects are STATIC’s *Flower Lamp*, *Power Aware Cord*, and *Disappearing Pattern Tiles*, however, these design prototypes have not been formally assessed. Described also in Chapter 2, the *Energy Orb* is probably the best-known case

study that has been tested to demonstrate the capacity of eco-visualisation to promote site-based learning and energy conservation (Goals 1 and 2) though HeHe's *Nuage Vert* attracted a lot of critical attention from journalists during the short time the piece was performed in Helsinki and has won many prestigious awards. Yet awards and exposure are not a substitute for user testing. The capacity of most eco-visualizations to alter habits of consumption have not been adequately measured and documented—this entire *Results* section is an effort to extend the emerging field of eco-visualisation in the context of user-related feedback.

One of the most exciting outcomes here is that an electricity visualizing animation would be selected for a public art commission and that a contemporary art museum like the MCA would actually invite an energy-monitoring installation into its building with enthusiasm and full support of all the curators.²⁶ Digital technologies and techniques like the visualisation of energy data are perhaps at a point where they might become mainstream, or available in locations as diverse as academic buildings, art museums, individual homes, governmental organizations and others. A diverse array of venues for future eco-visualisation testing and research should be engaged.

In the coming decades, as computing technology becomes more all encompassing and as databases grow, visualisations will likely become a primary method utilized to sketch large swaths of data to be made palatable to the general public. Indeed design theorist McCullough has convincingly argued for more interdisciplinary research that combines info-graphics, architecture and social content for this reason: "As a consequence of pervasive computing, interaction design is poised to become one of the main liberal arts of the twenty-first century" (2004). Computer scientists Paul Dourish and Genevieve Bell have summed up the potential for everyday data-driven learning experiences:

Although the current developments in ubiquitous and pervasive computing are driven largely by technological opportunities, they have radical implications not just for technology design but also for the ways in which we experience and interact with computation. In particular, the move of computation 'off the desktop' and into the world, whether embedded in the environment around us or

²⁶ Even better, the curators selected a month for the *darkSky* exhibition where it could be effectively paired with the Buckminster Fuller exhibition on the upper floors of the museum. The MCA curators believed that there was a good synergy between the energy-conserving message of *darkSky* and the history of Fuller's conceptual architectural practice.

carried or worn on our bodies, suggests that computation is beginning to manifest itself in new ways as an aspect of the everyday environment” (2007).

In Dourish’s previous writings on the potentials of interactive media, eco-visualisation could fit into an arena he describes as context-specific embodied interaction, or a mode of using computational tools to further human understanding of phenomena relevant to our everyday lives: “embodied interaction is based on the understanding that users create and communicate meaning through their interaction with the system” (Dourish 2001). Because energy data is literally embedded into our daily lives the key here is to make that information relevant and distinctive to the everyday user. Dourish’s thinking on this notion of embodied interaction relates also to Miles’ and Kester’s interest in art that creates and sustains localized dialogue amongst the viewing population.

Each of the three case studies required a viewer to directly participate, or interact with the artwork and potentially enter into dialogue with others in the process. The contexts for dialogue were quite different: a professional building, a website, and a museum exhibition. In *7000 oaks and counting*, an academic audience used either a touch screen kiosk or internal website to submit carbon offsets. In *World Offset*, viewers navigated a website to make a conservation pledge that over time, led to cumulative change in the accompanying eco-visualisation. In *darkSky*, museum visitors had to work cooperatively to turn lamps on or off to see the related changes in the animation. All three case studies demanded what Kester termed a “concrete intervention”, an actual action taken, in addition to the cultivation of a particular environmental consciousness (2004: 174).

This sort of artwork, an eco-visualisation that calls for participation, dialogue, and a sort of political commitment on the part of the viewer to be sensitive to the issues of climate change is still rather unusual as discussed in Chapter 2. Kester himself acknowledges that art historians and critics have not performed well in arguing the relevance of this sort of work to the fields of aesthetics and art history: “Some of the most cogent writing on community-based and dialogical projects comes from the artists themselves” (2004: 189). Kester’s comment points again to the value of this inquiry in terms of contributing to new knowledge in the field of eco-visualization and also dialogical projects. Critical writing and user testing is additionally very sporadic in the landscape of art and technology related projects. In his summary of what is lacking in his own research on dialogical practice, Kester notes that new artistic expression in

electronic visualisation was notably absent from his discussions: “A second area I have neglected concerns the possible connections between the idea of a dialogical aesthetic and artistic paradigms based on concepts of networking and communication in recent digital media theory and practice” (2004: 189). In conclusion, there is still much research to be conducted to determine how a dialogical aesthetic might positively impact an eco-visualisation intent on distributing a didactic message or imparting more abstract content for debate. The analysis of these case studies extends the field, but there is still more work to be done.

The three case studies presented in this chapter are situated first and foremost as art. There is an uncontested relationship here to design, specifically to sustainable design promoted by HCI researchers. Using a time-tested definition of design from designer and educator Victor Papanek, “Design is the conscious and intuitive effort to impose meaningful order” (1985: 4). It would seem that the very practice of visualisation is embedded in the language of design. These three case studies are all about attempting to locate some kind of “meaningful order” in an expanding data landscape in a world beset by environmental challenges of the largest order. A designer might interpret the significance of the projects differently, however, a question to be debated here is can these case studies be regarded as examples of an emerging digital dialogical art? If so, what has been learned from these three case studies and what might further research in this arena bring forward for deliberation and conversation?

Eco-visualisation can utilize images to literally teach individuals to develop empathy for the environment. Earlier in this chapter, art historian Malcolm Miles was noted for having riskily stated his preference for content over aesthetics, in that art might be best seen as “bringing aesthetic value to what is at root a political problem”, here meaning specifically that images could be used to make viewers more interested in contemporary environmental issues. This is the true potential of eco-visualisation: the capacity to motivate the general public to pay more attention to energy conservation. The evidence presented in Chapter 1 shows that energy monitoring devices like the PowerCost Monitor, the Energy Detective (TED), and Ontario Hydro’s “Residential Electricity Cost Speedometer” all worked effectively to lower total electricity usage in the home sometimes by as much as 6%. Likewise, Pallak and Cummings’ research from 1976 showed that public recognition and display of good conservation behaviour resulted in decreased energy consumption. Given all of these facts, one might

hypothesize that the dynamic energy visualisation in the NCSA building with individual carbon offset promises made public would result in increased energy conservation. Unfortunately, this was not necessarily the case. While this particular case study has been proven to be relatively unproductive, the animation and its accompanying pedagogy could hold great potential in alternative contexts.

The *7000 oaks and counting* study faced numerous challenges in reception and deployment at NCSA as previously mentioned. Another trial that the project confronted is that it was launched during a particularly warm month so energy usage to cool the building was potentially increased during that particular time period. The conservation savings gained were perhaps imperceptible due to the increased energy loads required to run the air conditioning systems. Despite the lack of favourable results at NCSA related to quantifiable electricity conservation, this sort of image-based energy visualisation should be tested in another environment. Further testing is recommended in another workplace where perhaps the HVAC system operation would be separate from office energy usage. Additionally this software must be tested in an individual home, a space where it is perhaps easier to control energy usage, as thermostats in large university buildings are not adjustable. Heating and cooling systems are the largest single consumers of energy in buildings (EnergyStar 2009). Chapter 4 will provide a series of reasons why it was not feasible in the course of this 5-year research project to test the *7000 oaks and counting* eco-visualisation in more of a variety of venues.

Which project used dynamic visualisation most effectively to encourage energy conservation? This question may be unanswerable due to the sheer variation of the contexts of the case study. Both *World Offset* and *7000 oaks and counting* catalyzed an increase in conservation behaviour. From a quantitative perspective, *World Offset* was the obvious success story with a documented total of over 590,448 pounds of carbon promised by a total of 318 individuals over the course of approximately 18 months. Although the *7000 oaks and counting* kiosk has not yet been displayed for more than a month and thus comparable data cannot be supplied, consider this. In the first week that *7000 oaks and counting* was launched, a total of about 62 pounds of carbon were offset compared to 15,000 pounds of carbon offset in one day on *World Offset*. In addition, when comparing the responses to Survey Question #5, over 66% of the *World Offset* respondents agreed strongly or generally with this statement: “Artwork catalyzed some small act of energy conservation I performed recently”. This percentage was higher

than for either the *darkSky* (33%) or the *7000 oaks and counting* (30%) viewers. In both *World Offset* and *7000 oaks and counting*, the interface demanded what Kester termed a “concrete intervention” or what Dourish called “embodied interaction” from a distance. In this way, the viewers, by committing a promise online, agreed to the transaction in a highly public and transparent manner, thereby increasing the chance that they would actually follow through and enact the conservation action. Additionally, the *World Offset* users committed the declaration during leisure time, vs. the *7000 oaks and counting* users who would have to make a pledge while at work. Although *World Offset* inspired more direct conservation, the strength of the visualisation itself may not be directly related to the project’s success. In *World Offset*, the more motivating circumstance was perhaps the desire to make a public commitment during one’s free time and less the quest to alter the visualisation. The aim of the visualisation was to have site users deliver offset promises and collectively work to replace the hairdryers and coffee pots with green trees. Through many contributions, the dynamic imagery changed substantially over time. In sum, *World Offset* was the case study that proved that eco-visualisations can alter conservation behaviour substantially, however, it’s not clear whether this success is due to the eco-visualisation itself or the web-based project as a whole.

Which case study overall met the three goals of this inquiry best? Perhaps a final review of the three targets of this study would be useful:

Goal 1: Eco-visualisation offers novel visual ways of making invisible energy data comprehensible, and thus encourages new forms of site-based learning.

Goal 2: Eco-visualisation that provides real time visual feedback can increase environmental awareness and possibly increase the conservation behaviour in the viewing population.

Goal 3: Eco-visualisation encourages new perceptions of linkages between the single individual and a larger community via site-based dialogue and conversation.

At the start of the study, this question seemed quite difficult to answer. *7000 oaks and counting* likely possessed the most promise to satisfy all three goals, however, due to the timing and setbacks at NCSA, the project failed to live up to its potential. Analyzing the survey evidence and the critical commentary from journalists, it seems that both *World Offset* and *darkSky* overall met the three goals of the dissertation in full

with *World Offset* edging ahead significantly. Survey responses showed that viewers believe that eco-visualisation does offer a new mode of communicating energy data as defined in Goal 1. 51.7% of the 29 survey respondents for *World Offset* stated positively: “Artwork made me think about energy usage and resource conservation in a new way”, compared to 29.5% for *darkSky* and 37% for *7000 oaks and counting* (Goal 1). Asked to react to the statement, “Artwork taught something new about eco-issues or eco-data”, over 45% of the *World Offset* survey participants strongly agreed, compared to 6% of the *darkSky* viewers and 12% of the *7000 oaks and counting* survey respondents (Goal 1). As mentioned in the Results sections for all three case studies, there was clear qualitative evidence of learning via the eco-visualisations through the diverse one-sentence answers to Question #2, “Did you learn anything new from seeing the artwork?” See Appendices A, B, and C to review these responses. These qualitative responses in particular confirm the great potential for eco-visualisation to be employed in various types of environments for pedagogic effect.

As previously discussed, *World Offset* probably met Goal 2 best in that this case study provided nearly irrefutable quantitative evidence that conservation behaviour was increased in the viewing population. Looking at the details from the surveys confirms that *World Offset* not only increased environmental awareness but also elevated the conservation behaviour in the viewing population (Goal 2). For example, 62% of the *World Offset* participants claimed that “Artwork inspired me to ACTUALLY change my behaviour related to energy conservation” compared to 20.5% for *darkSky* and 12% for *7000 oaks and counting* (Goal 2). Reacting to the statement “Artwork catalyzed some small act of energy conservation I performed recently”, 33% *World Offset* users strongly agreed while only 11% of *darkSky* viewers strongly concurred, and 12% for *7000 oaks and counting*. In a very similarly worded statement, “Artwork made me want to conserve energy somehow”, 95% of *World Offset* users agreed strongly and generally, while 63.7% of *darkSky* viewers agreed strongly and generally, along with 68% of the *7000 oaks and counting* respondents. Despite the fact that only one of the eco-visualisation case studies inspired measureable conservation, the majority of respondents believed that the art viewing experience planted the desire to conserve electricity; thus, the potential for such projects to impact conservation behaviour is confirmed (Goal 2). Further research must look specifically at how to encourage ecologically sensitive gestures and reward energy curtailment.

Goal 3, the aim to produce an eco-visualisation that generated site-based dialogue and conversation, as well as to promote knowledge of linkages between the individual and larger community is one of the most difficult to assess. Based on contextual inquiry, *darkSky* generated the most site-based dialogue possibly because the space was so crowded with viewers all the time. *darkSky* was also the only case study that facilitated and insisted on cooperative interaction to conserve energy, or switch all the lamps off quickly. However, in terms of survey results related to Goal 3, the lack of specific information is perhaps an error of survey design. Should these questionnaires be retooled, the inclusion of a statement such as "Artwork involved me in conversation with other individuals" or "Artwork made me feel connected to other individuals" that would require matrix of choices for response should be included to test Goal 3. However, a number of the survey responses that requested hand typed qualitative responses provide some insight into this issue of site-based dialogue and formulation of new connections. Appendices A, B, and C contain full responses to Survey Question #2, "Did you learn anything new from seeing the artwork?" Several responses indicate that participants did indeed forge a new sense of connection with the world. Consider these two responses as evidence that Goal 3 was achieved on some level via each case study: "The multiple layers of meaning caused me to think about my regular distance from nature and impact that I exert through my daily life (*darkSky* respondent)" and "Being made aware how one can make a difference through a small effort, making world concerns more in reach of your own actions. Enlightening experience" (*World Offset* user).

The combined survey results revealed one considerable weakness in the research undertaken and case studies tested. One of the most significant criticisms that could be levied at the practice of eco-visualisation is that image-based data transmission could be construed as a fad or gimmick that provokes interest initially but not for the long term. In Survey Question #5, the statement, "Artwork was so fascinating I wanted to stay with it, or go back and revisit the piece" garnered mixed responses. Only 12% of the *darksky* users strongly agreed that they would go back and see the piece repeatedly. Likewise, only 17% of *World Offset* participants felt strongly that they would contribute again to the piece. About 19% of the *7000 oaks and counting* viewers thought they would return frequently to examine the visualisation; although more individuals expressed casual interest in interviews in regular viewings if they could possess the application on their own computers as screensavers.

The problem with sustaining long-term interest in energy conservation is not new. Most of the energy conservation studies cited in Chapter 1 that prove the effectiveness of dynamic feedback lasted less than a month. However, there were exceptions. Lucid Design Group's web-based and kiosk software, Building Dashboard® enabled long-term conservation gains on the order of 10-56% depending on the context. Likewise, the Canadian company, Hydro One, conducted a yearlong survey with 500 Ontario homeowners that showed that real time electricity monitors could help homeowners reduce their consumption of electricity by up to 6.5% (Chartwell Inc. 2007: 3). The argument presented here is that eco-visualisation offers precisely the same information as do many of these studies using software visualisation tools cited, but eco-visualisation also provides a fun, potentially more visually exciting mode of representing the energy data as well as the numeric option.

Overall, the results from the three case studies furnish proof that eco-visualisation must be taken seriously as a method of promoting electricity conservation in the future. Further research is required to determine how eco-visualisation would promote energy curtailment at home as well as in the workplace. This chapter began with a disclosure that several case studies were designed to test the potential of eco-visualisation in three very different contexts: an academic workplace, the Internet, and a museum gallery. Yet one key arena left out of these case studies was the single-family home or apartment. The domestic environment may be a better place to pilot further eco-visualisation case studies. Due to the very high HVAC energy loads in the NCSA building, the carbon footprint of the building sometimes exceeded 500 pounds of carbon emitted per hour (Appendix F). NCSA staff and faculty had no recourse to change the thermostat thus, the it was rather difficult to convince the workplace population there to work collectively to strive to shrink the immense footprint. It proved to be too difficult a proposition, and thus, that animation that shows trees replacing coffeepots during low load cycles may be most appropriate for the home. New goals will continue to be set for *World Offset*, hopefully by March of 2010 over 1,000,000 pounds of carbon will be offset via the collective actions of Internet users around the world. The primary modification is a chat component that would enable friendly dialogue and competition about how to make simple lifestyle changes to lessen one's individual carbon footprint.

With regard to adjustments to *darkSky*, another version of the piece might include a monitor that discloses the minute-by-minute carbon loads that the lamps, computers, and associated hardware emit—though this addition would make the piece more didactic. Further research would test whether this additional teaching layer might push people to explore the piece for a longer period of time and to determine whether more learning could take place in this enhanced data context. Didacticism in the context of fine art, as opposed to documentary film is relatively uncelebrated; the critic Alan Artner for example, praises *darkSky's* poetics in lieu of pedagogy (2009). However, within the field of eco-visualisation, the instructional outcomes of artwork should be notable as was detailed in Goal 1. Furthermore, *darkSky* could be reconfigured to screen in a home on a plasma monitor or computer and the visual logic of the firefly animations could be edited to display the whole home's usage of power as opposed to the lamp display utilized for the museum exhibition. The audience at the MCA agreed quite unanimously that the aesthetics of the visualisation made sense to them. Thus, testing the animation itself in a variety of contexts in the future would augment the knowledge presented here.

Chapter 4: Learning from eco-visualisation: evaluating success and looking to the future

Eco-visualisation offers a robust process to transfer scientific data to the public through active engagement with images. Eco-visualization as a practice and a technique to engage the general public in energy conservation via art viewing substantially extends the existing field of research on dynamic feedback. The results from the three case studies indicate that active engagement via clicking to make a carbon offset promise or switching off a lamp can produce a rich learning experience for the majority of the viewers. Although further research is needed in this field, the three case studies provide sufficient evidence that environmental data displays can increase site-based learning, enhance an individual's willingness to adapt his or her behaviour to conserve energy, and also stimulate localized dialogue about carbon footprint issues or climate change in general.

4.1 Overview of chapter

In this final chapter, the results and discussion from the three case studies will be analysed in a much broader manner to launch a conversation about first, the value of socially-conscious art in the larger milieu of the purpose and meaning of fine art. Second comes a dialogue focused on how the three case studies were impacted by the context of the particular artworks, and what was lacking or needed in these physical and social spaces to make them more effective as pedagogic and conservation catalysts. Perhaps most importantly here important recommendations will be set forth for what future eco-visualisation research might take into consideration.

Third in the chapter, the various problems that artists face in locating funding to complete socially-motivated projects will be debated. In fact, there may be exciting new environmentally conscious art works that exist only as concepts due to the grim economic climate and lack of financial support for artworks that invite a dialogue about difficult socio-environmental problems such as climate change. Here a narrative will be presented that evaluates a failed public art proposal to display the challenges artists face in finding economic backing for socially conscious art. The fourth section of the chapter includes a debate regarding the criteria that can be used to measure success or failure in an art work. The fifth and final item to be presented is a concluding argument regarding the strengths and weaknesses of using art to promote social agendas—

specifically energy conservation, which includes an overview of the privacy issues involved in making energy data transparent to the general public.

4.2 What is the value of socially-conscious art?

The primary issue with doing research on the capacity of art to instigate energy conservation has to do first with the perceived role and function of fine art in culture, and second with the varied modes in which define success. A more poetic piece like *darkSky* seems best contextualized as an art work as opposed to a design project. To deal with the first issue here, how might contemporary art be defined in the context of this inquiry and what are the primary distinguishing features of the case studies presented in Chapter 3 that harmonize with the fine art field?

In this contemporary moment, art can be anything a creator contextualizes as art. In other words, if an artist claims that an object is art, then it is. This inquiry claims fine art status for all three case studies presented in Chapter 3. This legacy goes back to Marcel Duchamp's championing his 1917 work, *Fountain*, which was a urinal shifted from a bathroom to a museum (Tomkins 1996: 186). *Fountain* is justifiably considered a groundbreaking work primarily because it was such a new idea, to appropriate an entity from everyday life, a urinal, and upgrade it to fine art status. Art is a term that in some ways defies definition, however, for the purposes of this inquiry, it makes some sense to separate art from aesthetics to focus on art's ability to celebrate new human achievements in the way that Tolstoy defined it over a hundred years ago:

"Art is not, as the metaphysicians say, the manifestation of some mysterious idea of beauty or God; it is not, as the aesthetical physiologists say, a game in which man lets off his excess of stored-up energy; it is not the expression of man's emotions by external signs; it is not the production of pleasing objects; and, above all, it is not pleasure; but *it is a means of union among men, joining them together in the same feelings, and indispensable for the life and progress toward well-being of individuals and of humanity*" (Tolstoy 1899).

Tolstoy demotes art's ability to please the senses and rather favors art that brings about some form of shared emotional response—often one of pride in the capabilities of humanity. Tolstoy's view of art aligns well with Goal 3 of this inquiry in that the case studies pursue a shared dialogue that hopefully promotes a greater connection to other individuals. Interestingly, Tolstoy defines art by initially claiming what art is not. If

the term “men” in the last sentence is replaced with “humans”, then the quotation reads with more culturally-appropriate diction: “art is a means of union among humans”. Tolstoy’s chosen strategy to get at the heart of a conversation about what art is and how it operates on a viewer psychologically by repudiating what art cannot be seems very much in keeping with other well-known writers who attempt to define contemporary art. Take, for example, this definition by artist Claes Oldenburg in his widely-read 1961 manifesto:

“I am for an art that is political-eretical-mystical, that does something other than sit on its ass in a museum...

I am for an art that embroils itself with the everyday crap & still comes out on top.

I am for an art that imitates the human, that is comic, if necessary, or violent, or whatever is necessary.

I am for an art that takes its form from the lines of life itself, that twists and extends and accumulates and spits and drips, and is heavy and coarse and blunt and sweet and stupid as life itself” (Oldenburg 1961).

Admittedly a bit bombastic, Oldenburg seems relatively unconcerned with aesthetics or permanence, and defines the terms of his art in the context of what it does not do, that is, “sit on its ass in a museum”. Like Duchamp, and to some extent Tolstoy, Oldenburg was intrigued by artists who were able to utilize the content of daily life in their artmaking practice and embed their creative output in art-worthy contexts outside the museum. The truly admirable artists in Oldenburg’s view were able to elevate the travails of popular discourse, colourfully described as “everyday crap”, and make contemporary art from that content. All three case studies detailed in Chapter 3 were inspired in some manner by the writings of Tolstoy and Oldenburg. Oldenburg in particular argued for art placed outside a museum context that would work with data acquired from the “lines of life itself.” Contemporary eco-visualization could well fit within Oldenburg’s manifesto that argued for more diverse expressions of art.

The sentiments of both Tolstoy and Oldenburg fit quite well into the sort of public art that was produced in the form of three case studies in the context of this inquiry. Energy usage is generally considered a rather boring everyday statistic. Yet individuals in developed countries would be well-served by thinking more about their ecological footprint. Tolstoy is overwhelmingly positive in his assessment that art can

and should contribute to the “life and progress toward well-being of individuals and of humanity”. More contemporary art historians like Claire Bishop, editor of an anthology titled *Participation* view public art especially as a constructed situation that involves some form of participatory communication from the viewer to be considered effective (2006: 13). Yet as will be demonstrated shortly, there are numerous biases and problems that artists face when proposing socially conscious art to public art committees. In the context of this inquiry, Tolstoy’s overview of art rings true, in that art’s first purpose is to commune with an audience, or establish a dialogue or “concrete intervention” to use Kester’s terminology. Thus, the primary value of socially conscious art expressed in new media forms like *7000 oaks and counting*, *World Offset*, and *darkSky* is in their capacity to communicate—not in their overall aesthetic impact or lack thereof. There is no denying the influence of aesthetics, however, the foremost goals as stated in the introduction have to do primarily with site-based learning and dialogue, thus it makes sense to value art’s ability to generate conversation over simple aesthetics, or the ability of art to please the eyes.

4.3 Art in context: where do eco-visualisations of the future need to live?

There is a good amount to learn regarding how each of the three case studies were impacted by the context of exhibition space, and what was lacking or needed to make them more effective as learning and conservation catalysts. A final review will be conducted to determine what was discovered from the three case studies based on the extremely varied spaces they were exhibited in for long or short periods of time. Perhaps most importantly, in the conclusion, key recommendations will be made for what future eco-visualisation projects might take into consideration.

7000 oaks and counting was overall the least effective project based on the stated goals for this inquiry. In addition to all of the previously described problems which included resistance from the public art committee regarding a socially conscious artwork that measured energy consumption in the NCSA building, another problem emerged in 2008 with regard to the placement of the informational kiosk.

7000 oaks and counting was originally slated for placement in the large spacious lobby of the NCSA facility, new in 2006. However, the committee realized that because the kiosk was not on wheels, it could not be moved easily. The committee

chose to place the large kiosk that displayed the energy animation several floors up outside the director's office to leave the downstairs lobby space free and clear for parties, conferences and other events. This move had several implications. One, it removed the kiosk from view from all of the students who regularly walk through the NCSA lobby on their way to the Beckman Institute or the Siebel Science Center. Two, the kiosk was now hidden from faculty and staff coming and going from work. This new fourth floor location essentially allowed only the individuals who worked on that floor regular visual information about the building's energy consumption. Third and finally, the kiosk was relegated to this less visible location as a subtle reminder that the committee and leadership of the NCSA was perhaps more committed to concealing its energy consumption from the public than in showcasing its ability to participate in a conservation effort.

The location of *7000 oaks and counting* diminished its ability to produce localized discussion and dialogue about energy conservation at the University of Illinois (UI). Certainly, if funds and support were available, it would be motivating to remount the piece in the NCSA lobby to determine whether expanded public exposure would result in more measurable contributions to the linked carbon offset website, or more user activity on the touchscreen. Additionally, it would be exceedingly useful to mount precisely the same project, kiosk and linked website, in two different buildings at UI, such as the Environmental Science building and the Education Department's building and contrast the response rate and participation levels with what happened at NCSA. One future recommendation is to conduct an HCI-based study to compare at least three different spatial contexts at the same university and only vary the context based on the disciplinary arena targeted by the building. Unfortunately, *7000 oaks and counting* was an expensive piece to produce due to the cost of the touch-screen kiosk, so deploying three similar installations would pose budgetary challenges—the next two sections will detail how financial backing affects the creative output of artists in the next two sections. However, there could be sensible workarounds such as using a lower-cost computer such as an iMac to run the animation.



Figure 4.1: *darkSky*, MCA Family Day, April 18, 2009. Installation space was crowded all day. MCA employee in red shirt helped to explain the significance of the piece in terms of energy conservation.

Unlike *7000 oaks and counting*, the location of *darkSky* fostered increased audience involvement especially in terms of numbers of persons who interacted with the piece. Sited on the busy first floor of the Museum for Contemporary Art between the coat check and the spiral staircase leading to exhibitions upstairs and down, *darkSky* enjoyed engagement from passerby who had no intention of visiting the installation but who ultimately ended up interacting with the piece. Indeed, the interactive installation was getting so much usage that the museum had to assign additional guards to work in the room during times where the museum saw increased attendance such as on free admission days or Family Days.²⁷

Audience participation in the three case studies was enormously affected by the artwork's location and proximity to a steady flow of new potential viewers. *World Offset* benefited from having a physical occurrence at the *EcoAesthetics* exhibition at <TAG> in the Hague, in Holland as well as a permanent online presence. Interestingly, the physical attendance of *World Offset* in this exhibition as an Internet kiosk did very little to encourage people to contribute carbon offset promises the first day. Of the first twenty contributions on April 22, 2008, only two of the promises originated in the

²⁷ MCA curator Tricia van Eyck mentioned this fact about increased guard coverage to *darkSky* in a conversation with Holmes on April 27, 2009.

Netherlands. This is undoubtedly because the art opening was not conducive to meditative, studied viewing of art; they tend to emphasize socializing and networking. Eighteen of the first twenty *World Offset* participants were interacting with the piece from their laptops at home, perhaps a better space for the kind of detail-oriented attention that a project like *World Offset* required. An early study by psychologist E.S. Robinson showed conclusively that museum viewers who were given the opportunity to sit down to view a work of art would spend the longest amount of time viewing pictures versus other visitors who experienced “museum fatigue” on their feet (1928). Yet mostly due to its physical presence as a live kiosk at the *EcoAesthetics* exhibition at <TAG>, over the course of the first year of the artwork, 31,421 pounds of carbon were submitted by the Dutch, while the German audience submitted only 4824, the French 447, the Spanish 7064, the Swiss 9893, and the British closer at 24,563. Holland is a relatively small country, and having a physical presence in a busy nonprofit organization, <TAG> enabled more persons to see and interact with the piece despite the potential language barrier with the website being in English only. The language limitation could also have affected participation from other European countries as the largest contributors come from English-speaking countries like the UK with 24,563 pounds of carbon offset and the USA with 379,769 pounds promised (See Figure 4.2).



Figure 4.2: Screenshot (August 5, 2009, 9:10 AM CST) of the *World Offset* “GOODPEOPLE” link showing a map that breaks down the carbon offset promises by country with the US, the biggest energy consumer, also ranking as the biggest conserver with 379,769 pounds promised.

From this evidence, the conclusion is that the Internet actually provides a relatively cost-free way for artists to engage audiences for longer periods of time without the kinds of huge budgets required for installation-related projects. However, there are problems with establishing robust audiences for Internet art projects run by single artists not connected with major organizations. To date over 300 individuals have participated in *World Offset*, and the site remains open and available to anyone in the world with an Internet connection. Yet this number, accumulated over an entire year, is approximately half of the number of people who interacted with *darkSky* on opening night. One possible deduction is that an Internet artwork might command significantly *longer* viewing times than an gallery-based piece however, as museums can receive far more traffic than many online artworks. The audiences are likely to be larger for museum exhibitions as opposed to small-scale Internet exhibitions not affiliated with major institutions. Of course, many art websites do receive more traffic than traditional museum galleries, though the art websites that obtain more hits tend to be products of multiple, as opposed to single authors.

The above discussion about viewing time and spatial context hopefully generated a reminder of how incredibly different each of the three case studies is with respect to audience, spatial context, and concept. To reiterate, *7000 oaks and counting* was an interactive electricity visualisation for an elite university audience, *World Offset* was an interactive, somewhat didactic website that encouraged viewers to change their behaviour to collectively combat climate change, and *darkSky* was a more abstract electricity visualisation designed for a museum audience—hence, it could perhaps be a bit more fun, playful, and challenging. This summary of the differences between the case studies brings up a very important question: what criteria can be used to judge an artwork's success or failure? The case studies' successes and limitations from an HCI perspective have been assessed via the survey results in Chapter 3. However, the question at hand is how might the creative aspect of the eco-visualization practice be appraised generally from a fine art standpoint? The next section will detail a narrative of a project's failure, the success issue will be discussed in the section following.

4.4 Learning from failed proposals

The results of the three case studies that form the majority of the new knowledge generated by this dissertation are somewhat biased in that all three of the

projects received funding from external organizations to enable their creation. Certainly arts grants can be perceived as a measure of success in that funded projects have attracted positive attention from curators, artists, scientists, architects and other arts professionals on the jury. However, an argument can be provided that the committees that decide Percent for Art commissions might have other agendas at work that influence their selection of a piece of artwork. A brief example will illustrate this point.

In August of 2005, *Waterlogged*, a design proposal for Grainger Hall, the new building that houses the University of Wisconsin's (UW) Business School was presented to the members of a Percent for Art Committee. *Waterlogged* was one of three finalists for a commission with nearly \$100,000 USD in funding. The proposal was to essentially track the real time water usage in the building and showcase that in real time visually through a live video of human feet in the building passing by. A large wall with a plasma monitor would display the animation by day and by night the animation would be projected into a window near the entrance to the business school. *Waterlogged* transformed the metaphor of the ecological footprint into a human footprint that was literal and dynamic within the building itself. See Figure 4.3 below for some images from the design proposal.

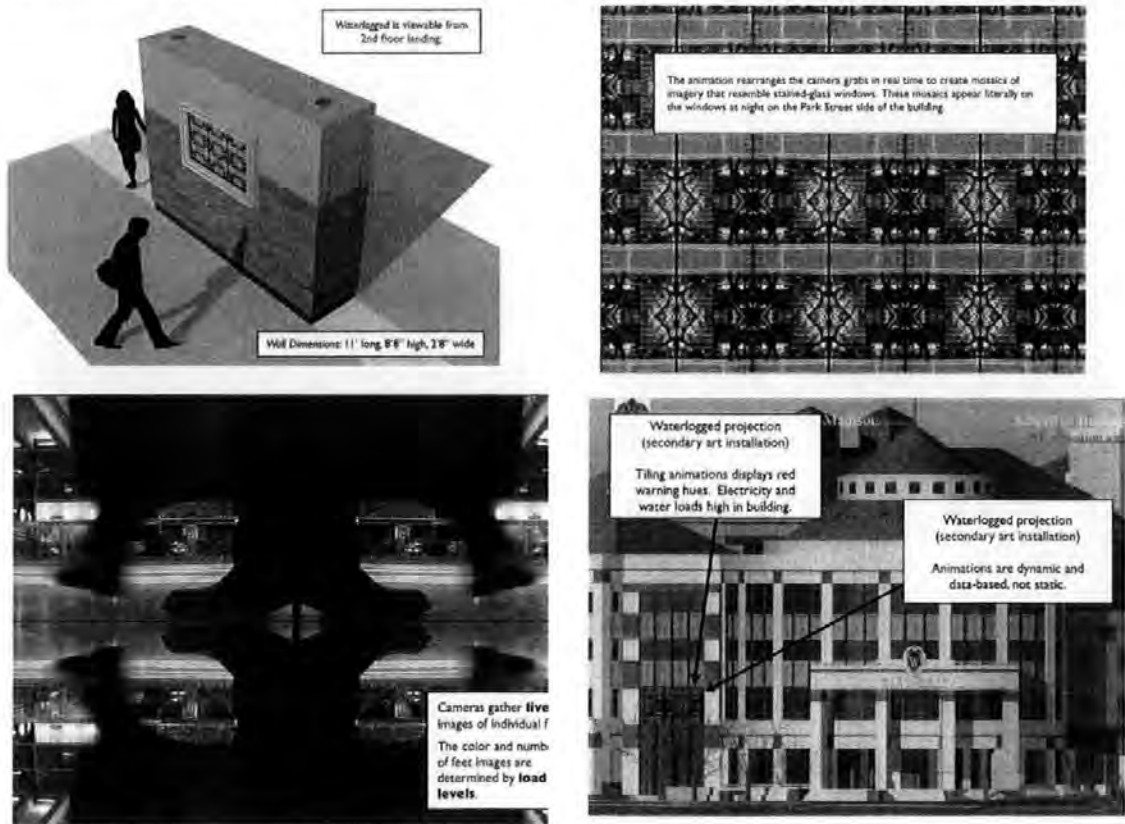


Figure 4.3: *Waterlogged*, Percent for Art Design Proposal, 2006 for Grainger Hall, UW-Madison Business School.

Waterlogged did not receive the public art commission. One of the committee members, Chris Manke, Percent for Art Coordinator of the Wisconsin Arts board, was able to provide some informal critical feedback in an informal email:

“The selection committee felt that your presentation was very professional and they were impressed with your knowledge of technology/media. They liked that the artwork had meaning and felt it was the most visually driven. They felt that this would be a fascinating artwork for a gallery but were expressed concern that the piece would need additional didactic information in this public context” (personal communication, September 1, 2006).

Essentially, the committee did not want the artwork to have an overly instructional component. *Waterlogged* had as its core agenda the notion to raise awareness about water consumption on the university campus. This was not palatable to the committee as they felt the Business School community was the wrong audience for an artwork about the environment. Manke wrote further:

The committee members were not sure how the content of your proposal with its emphasis on water and energy consumption connected to the mission of the Business School and thought that this project would be of greater relevance to students in the fields of earth sciences or environmental studies” (personal communication, September 1, 2006).

Curiously, this issue of a highly selective and elite group of university faculty rejecting work that pointedly deals with environmental issues was repeated in the previously discussed case study, *7000 oaks and counting*. There, the faculty and staff of the University of Illinois’ National Center for Supercomputing Applications were not thrilled to have a public project in their building that encouraged people to conserve energy. The NCSA group, like the UW-Business School did not see the relevance of tracking the carbon or water footprint of their own workplace. In the harshest analysis, it could be argued that elite university faculty believe their work to be so significant that it does not qualify for environmental impact analysis and discussion and thus forbids projects like *Waterlogged* and *7000 oaks and counting* from being endorsed by their institutions. In a milder examination, it could be said that elite university faculty follow strict disciplinary boundaries and desire the art in their buildings to celebrate the content within the confines of their discipline. Either way, the public art committees choosing the work to be displayed possessed definite bias and personal criteria that guided their selection of artwork. Moreover, these committees perceived their relationship with the artist to be that of the client where the client advises the artist about the worth of their

aesthetic and conceptual ideas. This was an unusual situation unique to public arts funding. Most artists would never take advice from a client, this is the purview of the designer. Of course, this sort of content-specific bias could be said to be true of museum curators and other arts professionals too, however, in the case of the three case studies, the Museum of Contemporary Art's curator proved much more flexible about deliverable product than did the public art committees charged with dispensing large quantities of state monies.

Sometimes the struggle between public art commissions and the artist can end positively with a stronger artwork being produced through the sharp dialogue generated by client-designer disputes. While *Waterlogged* was not awarded the public art commission, the proposal that did win was never built to the artist's specifications due to problems the artist encountered with the committee. Stuart Keeler was awarded the monies to complete *Virtual Exchange* in August 2006, a project that as proposed, included a sculptured concrete bench in the shape of a pie graph with a LCD screen that displayed real time stock quotes which was powered by a solar panel that hung from the side of the building. The committee initially chose *Virtual Exchange* due to its incorporation of stock exchange data, content that the business school felt more comfortable with being on display as opposed to the water consumption data proposed in *Waterlogged*—the NASDAQ ticker trumped localized dynamic water usage. Keeler said that difficulties with the committee occurred after the commission was awarded in that the committee wished the artist to put wheels on the bench to enable business school staff to remove the bench sculpture from the lobby space for parties, events, conferences, etc (personal communication, August 3, 2009). Keeler argued that the structural alteration to the bench shifted the look and feel of the overall installation and that it should be completely redesigned to be a wall-only piece.

The final version of *Virtual Exchange* was a collaboration between the artist and the public art committee. The wall-installation was an aesthetically appealing data visualisation of real time stock market updates with a focus on local Wisconsin stocks such as Harley Davidson. All of the pie chart and bar graph imagery was retooled into an elegantly fabricated "X" and "O" symbol that contained the flowing data from the Internet which was updated every twelve minutes.²⁸ Keeler speaks highly of how

²⁸ See video of Keeler's piece here: <http://www.flickr.com/photos/32135842@N04/?saved=1> (August 3, 2009).

tension between an artist-designer and a client can ultimately resolve itself in the production of art that is of higher quality than what was initially proposed. Despite Keeler's enthusiasm for the shared debate and his production of an stylish solution for the client, it is key to this inquiry that the jurying committee felt that environmental content had no relevance to the business school community. *Virtual Exchange* was an elegant data visualisation artwork that had no social agenda, thereby making it most attractive to a committee judging what artwork would fit best into a privileged academic environment. In sum, the public art committees wielded tremendous power to shape the sort of art that becomes incorporated for decades into public buildings, often university, school, and hospital facilities.



Figure 4.4: Stuart Keeler, *Virtual Exchange* (2008). University of Wisconsin-Madison Business School (USA)

The public art funding model in the United States is somewhat biased as described above. As previously mentioned, many states have rather small Percent for Art Commissions numbering between 5 and 10 members that preside over comparatively large sums of public money compared to the budgets of smaller arts organizations. In some situations as in the UW-Madison case and in the NCSA case, these committees exercise a considerable amount of authority to reject content of art they view as non-conforming. As a result, the public who views these works might also begin to develop an appreciation for more illustrative data visualisation work, having not been challenged by more socially conscious eco-visualisation. For this reason, public artworks tend to be more universally palatable than more mentally demanding work typically shown at art museums or at festivals—not at art galleries as they often

have a more commercial aim that trumps the altruistic desire to showcase work that demands social change and/or awareness. This fact is not necessarily a problem, instead, it is a reality that contemporary artists must negotiate. However the public could benefit from socially conscious, participatory artworks as the three case studies in this inquiry show that site-based learning (Goal 1) and greater environmental consciousness (Goal 2) occurred as a result of audience interaction and conversation (Goal 3).

As another point of comparison to the public art funding model, Rhizome, a well-known media art exhibition and archive platform associated with the New Museum in New York worked to remove some amount of curatorial bias in its award cycle by endorsing and promoting a “Member’s Commission” which was really an award selected by the greater Rhizome community via an online voting programme. Interestingly, a recent project, *solarCircus* (Holmes 2009) received an audience-choice Rhizome commission in June of 2009 for an educationally driven art project that encouraged learning about renewable energy by building DIY solar panels and sculptures. Given this radical comparison between public art juries and Rhizome’s methods of granting awards, it is possible that Percent for Art funding might benefit from increased input from the resident community, on the university campus and beyond. It is thus a strong recommendation of this inquiry that public art committees be expanded significantly to incorporate members outside of the architects and leadership of the buildings to increase the dialogue and breadth of content of the Per Cent for Art programmes.

4.5 Evaluating success in contemporary creative practice

The history of art is filled with examples of activist artists using creative projects to inspire viewers to alter their behaviours, beliefs, and lifestyle. Most of these artistic endeavors in the past were rather unique and never repeated, thus making them rather difficult to evaluate for success using comparative analysis, or methods from HCI like on-site interviews or surveys. Several of these projects that relate to using art to promote environmental stewardship were discussed in Chapter 2. Early practitioners like the Harrisons began by showcasing somewhat shocking performances of eating soil to promote the value of compost to produce high quality food and moved on to increasingly sophisticated projects like the previously mentioned Sava River valley

clean up. Many art historians like John Grande, Miwon Kwon, Eleanor Heartney, Malcolm Miles, and Grant Kester would view these projects as relatively successful despite the lack of measurable data regarding viewer reception and associated reactions. Although the Harrisons' earth eating event is rarely chronicled in survey texts or journal articles, the performance is still perceived to be an achievement due to the artists' embrace of a new mode of raising awareness in a shocking manner about something as banal as compost. New ideas are regarded very highly in the art world, by critics, curators, artists, and collectors as well.

What defines success for an artistic endeavor besides presenting a new idea? How to determine which new creative proposition holds more merit than another? Fine art is not a discipline that typically lends itself to the survey and interview methods endorsed by social scientists like HCI researchers as a means of evaluation—rather experts in the field prefer critical discourse as a means of evaluation, a way of talking about a project's goals and cultural import. Thus, the survey reporting completed in the context of the three case studies would be considered unusual by peers in the fine arts. Some artists regard discourse, or someone writing about their work in a monograph or journal, whether positive or negative, as a sure sign of success. Other artists perceive a record-breaking attendance of an opening to be a triumph while still others only wish to carry out a self-evaluation. In other words, these artists disparage any critique and or accolade and work only for their own edification. Still other artists believe that being continuously busy with new projects with financial backing is a sign of success. It is in this way that the cult of the new is nourished, and perhaps the reason why so many artists do not wish to test and repeat exhibitions in varying contexts.

Artists who are granted monies from different cultural organizations to complete work are generally regarded as successful. Like many researchers, artists are driven by their funding opportunities as well as the demands that organizations that provide financial backing feel compelled to make. For example, artists produce large-scale pieces generally when external economic support is available. *7000 oaks and counting* never could have been produced and tested without fiscal assistance from the Capital Development Board of the State of Illinois, and *darkSky* wouldn't exist without the commission from the MCA. Though *World Offset*, the Internet artwork could have been produced with or without sponsorship from the Dutch organization, <TAG>,

having the funds offered was a large incentive to launch the piece quickly in time for the *EcoAesthetics* opening in March of 2008.

There are several reasons why artists do not tend to repetitively exhibit the same, or related works for testing on various audiences for research and comparison. The best explanation is that artists genuinely like to work on new ideas only—usually in a dramatic way. This cult of the new also shows up from funders in Requests for Qualifications (RFQs) for public art works as well, meaning that financial sponsors want to subsidize a original idea, not something that has been exhibited before. See this recent call for a public sculpture in a library's outdoor garden as an example of the adoration of the novel project: "The program commissions only newly created, site specific artwork. Proposals for the display of existing works of art will not be considered " (See Also 2009). Because most organizations actively request new work, the desire and capacity to compare identical artworks as site-based learning experiences remains somewhat limited.

In this inquiry, the three case studies presented had as a commonality the goal to instigate ecological awareness through graphical visualisation of environmental data. Yet beyond these shared aims each project was quite different. Thus, each case study might be perceived as a reflection of the ways in which financial backing affects and defines the sorts of artwork a creative professional is able to produce. For example, Holmes received funding in 2006 to complete Project A (*7000 oaks and counting*) and then accepted alternate funding in spring of 2008 to complete Project B (*World Offset*), though Project A was not finished. Then in fall of 2008, an opportunity arose to receive monies to produce Project C (*darkSky*), and once more, Project A was pushed to the rear and finally completed in summer of 2009. In June of 2009, Holmes was awarded a grant to produce Project D, and the cycle continues (*solarCircus*). Due to this sequence of events, there remains little time or financial incentive to go back to Project A. Was then the low motivation a factor in the lessened success of *7000 oaks and counting*? Quite possibly, Holmes' perpetually diverted attentions coupled with the somewhat hostile reception to the artwork and its location change did work together to diminish the potential effectiveness of the installation—though there is no hard evidence to prove it. The main idea here is that three cultural organizations—the Capital Development Board of the State of Illinois, <TAG> in Holland, and the MCA in Chicago agreed to fund risky, new, socially conscious artworks focused on raising

awareness about energy consumption, rather atypical content. Thus, these grants are evidence of the strength of the arguments to utilize creative visualisation to create learning and dialogue about environmental issues. The multiple funding opportunities do qualify as a measure of success for these case studies, especially when coupled with the results presented in Chapter 3 that indicated that these new artworks did inspire people to not only learn more about energy conservation but also practice conservation in a more pronounced and public manner.

Would it then not be considered a measure of success to propagate multiple versions of *7000 oaks and counting* to gauge how different audiences—elite university faculty vs. City Hall workers—might react to the challenge to conserve energy at work? Should funding be sought for a repeat project? Possibly. Yet this sort of “art in series” project begins to sound more like an HCI user testing scenario. No doubt, it would have been quite interesting from a research perspective to deploy *7000 oaks and counting* in several buildings at different universities to determine how different academic audiences responded to the energy visualisation piece. It would be interesting to deploy the project in a university in Europe or one in Asia to determine what the reception of the piece in a different cultural milieu might be. It would be extremely useful to arrange several versions of the piece to be installed on a college campus in buildings with close proximity so that a new comparative feedback feature could be built in to the animation. However, due to the funding models previously mentioned, most cultural organizations prefer to sponsor a new work, and most creative persons prefer to propose something original. Thus, testing and re-testing an artwork out in various contexts is not generally considered useful by fine artists and their institutionalized patrons while designers and HCI researchers would likely endorse user testing in different arenas. Thus, in the context of this inquiry, there is a real dearth of comparable evidence from contemporary art projects directly related to the questions posed here. It would be extremely informative to have some analogous survey data from Hehe’s *Nuage Vert* project (Chapter 2). This lack of supporting evidence from related public artworks like *Nuage Vert* is a tremendous problem which likely will not improve over time as artists and art historians are not likely to change their working processes to incorporate HCI methods such as surveys and interviews.

It seems that the primary recommendation that can be offered here is that artists collaborate with HCI researchers to do what each professional does best. For example,

artists could raise funds to provide the new eco-visualisation apparatus to test and the HCI researchers might seek grants from science-focused organizations to enable the artwork to be stationed in varied locales for user testing. Much more extensive user testing is needed to determine answers to the more specific questions raised here, especially now that it is clear from the evidence presented in Chapter 3 that dynamic visualisation works very well to create dialogue and raise environmental awareness in an audience, and also inspire conservation. Here are a few examples of additional research questions that stemmed from this study: is a particular visual aesthetic (e.g. spinning trees vs. luminous fireflies) more effective in inciting greater energy conservation, how might regularly scheduled casual dialogue about energy conservation inspire further action, and how might dynamic eco-visualisations become even more specific and responsive to the users' actions? In the current capacity of this inquiry, the primary goal was to determine if audiences responded positively via site-based dialogue to images that expressed a conservation message and if viewers learned something new from the artwork. It seems apparent from the results and discussions in Chapter 3 that these goals were met yet there is still far more research to be conducted to establish whether it would be practical to deploy these sorts of artworks widely, and whether it makes more sense to install them in workplaces or cultural institutions. The results from this study shows that cultural institutions like the MCA Chicago were a better choice than elite academic environments like NCSA, however, there is really not enough evidence to really make this argument conclusive.

4.6 The future of eco-visualisation with a caveat about privacy issues

Michael Kimmelman, art critic for the *New York Times* writes "Artists fortunately remind us that there's in fact no single, correct way to look at any work of art, save for with an open mind and patience" (2009). Certainly this particularly undefined aspect of art consumption make owning and displaying art very exciting for a wide range of viewers from different socio-cultural and economic backgrounds. It is precisely this indeterminate quality of an artwork that gives it long term visual and conceptual interest, and thus, another reason why more artists should be using art as a platform to talk about critical social issues such as energy consumption and the environment. The wonderful thing about art that visualises data is that it transmits more ocular interest and feeling than a more typical bar graph or scatter plot drawing that displays household energy consumption. An artistic eco-visualisation like *7000 oaks*

and counting (spinning trees) or *darkSky* (blinking fireflies) is a far more attractive picture to display in one's living room or office than a numeric register—and thus, the eco-visualisation has the potential to reside in the home or the workplace longer than the typical energy monitoring gadget. In Chapter 1, a number of studies were presented that showed that households that used small electronic devices that tracked energy usage—McClelland and Cook's Fitch Monitor, PowerCost Monitor, and The Energy Detective (TED)—conserved significant amounts of energy thus proving the potential of dynamic feedback to alter behaviour, at least in the short term context of these studies. But here an interesting question should be raised, what about the very long-term aspects of having an audience conserve energy? The PowerCost Monitor and TED are both unsightly gray boxes that take up valuable space on the kitchen counter in the home. What if homes and offices of the future could have visually striking energy visualisations on electronic devices that already exist in the home such as computer monitors or flat screen televisions? Then there would be less waste in the manufacturing cycle—that is, less energy consuming gadgetry produced, and perhaps there would be longer term interest in the animations if portrayed as art, that is, something to collect and cherish. A recent survey of the usage of yet another portable gray boxlike household energy monitor resulted in users admitting indifference toward the display:

“We found that the monitor was most commonly placed in the kitchen, although the degree with which the household paid attention to the device varied considerably. Several respondents indicated looking at the display several times a day, but others reported disinterest and one considered the device an eyesore” (Parker et al 2008: 9).

The eco-visualisation offers a unique solution to the problem of creating visual interest in an everyday, often banal topic such as energy monitoring for conservation.

This research shows that eco-visualisation works as a tool to inspire site-based learning and conversation about key environmental issues. Given the ubiquitous proliferation of networked devices like cell phones, MP3 players, and computers it is imperative for new applications like eco-visualisations to be developed to be made cross platform and usable on a variety of screens—both permanent as on a dedicated kiosk and mobile as on a handheld phone. Though this portability could diminish the one-of-a-kind appeal of a singular art object, the increased flexibility will allow for the eco-visualisation to be viewed in multiple arenas, and thus ideally, become more

present in the viewer's day-to-day activities. Given today's climate challenges, it is rather imperative that individuals living in developed countries with ready access to cheap electricity and thousands of energy-consuming home and office devices and appliances be prepared to reduce electricity consuming activities as much as possible in the years ahead. This scaling-back will be more palatable if it is fun. Eco-visualisation offers a variety of interesting ways to get viewers involved in their own consumption patterns. In the future, there undoubtedly will be more creative professionals—artists, designers, musicians—who might experiment with alternate but equally innovative way to inspire conservation at work or in the domestic environment.

Though the research here effectively proves that eco-visualisation can inspire increased dialogue about ecological issues, privacy-advocates would severely criticize the art form given the history of data sharing applications made public at no cost. Given the prevalence of online applications like Google Mail that purport to offer presumably free platforms from which to distribute key personal information such as family photographs and private messages, it has become increasingly obvious that an individual's personal information is actually owned by a corporate entity poised to use that data for advertisement or other commercial purposes. In terms of eco-visualisation, privacy-advocates might regard the disclosure of energy consumption data in the home to be a matter of personal choice and confidentiality. In other words, if a citizen pays for his or her electricity then why reveal to the public whether one is a better conserver than his or her neighbour? In the case of the *7000 oaks and counting* project, NCSA was definitely not comfortable with the transparency of the electricity consumption data and delays ensued because of this privacy issue. Additionally, in the first *darkSky* meeting with the MCA engineers and curators, the artist proposed monitoring energy usage for the entire museum; this idea was supported by the curatorial staff but rejected by the engineers due to the problems of introducing non-standard equipment into the building control room. This sort of institutional resistance based on confidentiality concerns is likely to continue.

Based on the results of this inquiry, eco-visualisation might best be deployed for the long term in the home environment. New research needs to test this claim. Visual design projects like DIY Kyoto's Wattson, discussed in Chapter 1, really point the way to the future with the expansion of their "Communities" project. On August 4, 2009 the community showed 642 households uploading data from their networked portable

energy monitoring devices and willingly giving permission for their private energy data to be shared (Figure 4.5 below). Clicking on individual users allows one browsing the website to see who uses more energy than another. This “Communities” project while in its infancy shows great potential to create a long term dialogue and conversation about individual energy conservation and usage issues. The final recommendation of this inquiry is to suggest a joint project shared between an artist, a designer, and an HCI research team that would install a critically acclaimed networked eco-visualisation into several hundred homes with that volunteered for the experiment.

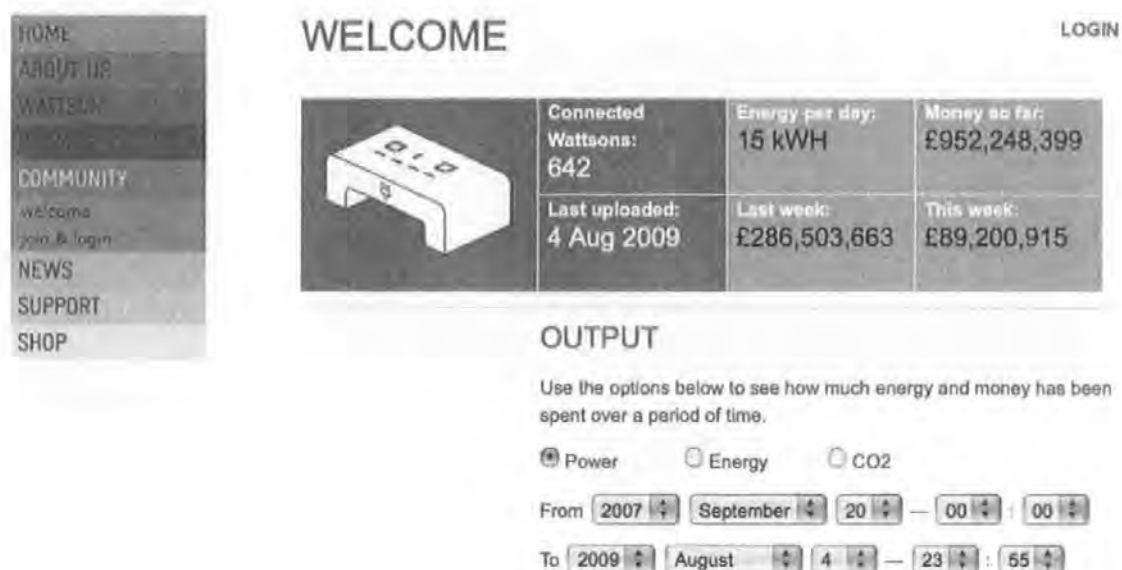


Figure 4.5: DIY Kyoto’s “Communities” web portal on August 4, 2009.

Eco-visualisation as an art form is ready to be tested at a much grander scale—should funding be available—as the results from this inquiry show the potential for eco-visualisation to initiate site-based learning and increase local conservation efforts. As stated in Chapter 1, climate change is a slow, incredibly complex process that has and will continue to affect communities around the world. In fact, it is so unhurried that of the hundred or so people that took this study’s primary survey, only 58% rate climate change as a worrisome problem (Survey Question #8, Appendix D). Surprisingly, over 70% of the respondents rate air quality, industrial pollution, and water quality as more critical. Yet all of these previously mentioned problems can be related to climate change. The general public must be encouraged in a whole variety of ways to make these linkages between one type of ecological issue and other connected environmental problems.

Artists who make work that establishes social and dialogical connections between individuals to encourage conversation about climate change must be encouraged to continue to work and be supported financially by a variety of institutions. Psychologist Daniel Goleman argues that environmental disaster can only be averted by collective human action enacted by a variety of professionals: artists, doctors, scientists, farmers, and others:

“Psychologists conventionally view intelligence as residing within an individual. But the ecological abilities we need in order to survive today must be a collective intelligence, one that we learn and master as a species, and that resides in a distributed fashion among far-flung networks of people. The challenges we face are too varied, too subtle, and too complicated to be understood and overcome by a single person: their recognition and solution require intense efforts by a vastly diverse range of experts, businesspeople, activists — by all of us” (Goleman 2009).

The survey respondents generally agree with Goleman that a whole variety of professionals are “capable of directly inspiring social and environmental change through their work”—Survey Question #7 allowed multiple occupations to be ticked off for the respondents, they did not need to pick only one. In particular these professionals garnered support from over half of the respondent group: artists (61.4%), scientists (77.3%), activists (57.5%), journalists (72.7%), politicians (59.1%) non-governmental organization members (51.7%), and corporate executives (52.0%). It is entirely possible that artists rank lower than scientists and journalists simply because the potentials of art as a communication and dialogue-producing tool are not yet well understood. It would be useful to return once more to the primary recommendation expressed here and imagine a future collaboration between an artist, an HCI scientist, and a journalist.

In sum, the results from this dissertation will continue to shape our understanding of eco-visualisation as a tool to institute environmental learning and dialogical conversation—and as a compelling strategy to promote energy conservation. McCalley and Midden cited the need for further research in this arena that they termed “eco- feedback” (1998). While this inquiry is limited to eco-visualisations that display energy usage statistics, it should be noted that the arena is far broader. Future research could explore how real time imaging of tap water usage might promote greater freshwater conservation or how the visualisation of air pollution might make people drive less.

Conclusion

In this inquiry, a series of arguments has been presented for the expansion of eco-visualisation as an arena to amplify citizen awareness of energy consumption, increase conservation behaviour, as well as augment localized dialogue about environmental issues (Goals 1, 2, and 3). The primary recommendation from this research is that further testing of eco-visualisation in a home environment must occur, as well as increased cooperation and collaboration among artists and HCI researchers to fully consider all aspects of an eco-visualisation's deployment into such new spaces. A literature review was conducted of the research conducted by psychologists, artists, designers, and HCI researchers in dynamic environmental feedback. Three case studies were designed based on what was learned from the preliminary findings:

- *Dynamic feedback increases energy conservation* (Bittle et al 1979, Dobson and Griffin 1992, Chartwell Inc. 2007, Parker et al 2008).
- *Public commitment can enhance an individual's ability to save energy* (Katzev and Johnson 1994, Pallak and Cummings 1976).
- *Medium and context can affect the public's acceptance and enthusiasm about a piece* (Works by Joseph Beuys, Hans Haacke, Jackie Brookner, Helen and Newton Harrison, etc.).
- *Poetic, easy to interpret visuals help the general public assimilate numeric information* (Hehe's *Nuage Vert*, Ambient Device's *Orb*).

The three case studies that were conceived, produced and exhibited during the course of the previous five years demonstrated the multiple potentials for eco-visualisation. All three case studies raised awareness about energy conservation and consumption issues in a site-based learning situation (Goal 1). *World Offset*, an interactive website that encouraged people around the world to submit carbon offset promises, seemed to be the most effective of the three case studies in conserving electricity (Goal 2). Over 500,000 pounds of carbon were offset in one year due to the deployment of this project, and the visualisation challenge to the audience to work collectively to green the animation. *darkSky*, an interactive eco-visualisation that employed a firefly animation to display how much energy was being used by the installation emerged as the case study that was most efficient at establishing dialogue and connections between audience members in a single space (Goal 3). *7000 oaks and counting*, perhaps the eco-visualisation with the most potential to create site-based

learning over time, has had a slow start in engaging its more academic audience. Thus, the hope is to deploy this piece in another locale, possibly the home environment, to adequately test the facility of the eco-visualisation to promote conservation and energy awareness in an alternative context.

The varied successes of the three case studies also point to the future limitations of eco-visualisation, as well as arenas where the research could be expanded. The primary issue with utilizing eco-visualisation as a mode of energy conservation is the associated issues with public surveillance of electricity flows as previously mentioned. There is also the problem of eco-visualisation being interpreted as a novelty item with a short-term use facility and thus, further research and long term reporting need to be conducted to test this hypothesis. One of the tactics that was not a component of the three case studies was the effect of comparative feedback. Research has shown that humans respond to feedback that compares individual performance of multiple parties (Siero et al 1996, (Peterson et al 2007, Kaufmann 2009). Future eco-visualisation projects might attempt to test the potential of comparative visual feedback to improve conservation efforts in a local population.

Eco-visualizations similar to the three case studies presented here can provide a series of small-scale solutions to the enormous challenge of increasing energy conservation to slow climate change. Climate change is a problem that humans will be facing for years to come, and thus will require many collective and individual efforts to raise awareness and create opportunities for energy curtailment. Resource conservation will continue to be an enormous challenge for both developed and developing countries. Richard Heinberg calls this issue the “using too much too fast” problem (2008).

Eco-visualisations of the 21st century represent a significant contribution to new knowledge in the form of extending the existing field of dynamic feedback for energy conservation. The term “eco-visualization” itself represents a significant contribution of this dissertation research to the enlargement of the field as many scholars have cited the term since 2007 to identify visual works that perform some kind of real time environmental feedback (Pierce et al 2008). The expansion of the field is interdisciplinary; most prior studies that assess data mirroring in the form of text and/or image to provide users the ability to dynamically read environmentally relevant data comes from the HCI or environmental psychology field—not from the art and design

arenas. No study prior to this one has attempted to test the ability of a range of art and design objects to inspire site-based learning (Goal 1), environmental awareness raising and conservation (Goal 2) and localized eco-dialogue (Goal 3). The overall conclusion is to further expand this vein of eco-visualization research to continue to augment and refine the scope and purpose of the field of dynamic feedback for energy conservation in the future.

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APPENDICES

AVAILABLE IN PAPER (197-200)

COPY OF BLANK ELECTRONIC SURVEY

AVAILABLE ON DVD:

*SURVEY DATA, CODE FILES, RAW ENERGY DATA,
DVD DOCUMENTATION OF THREE CASE STUDIES*

ART AND ENERGY CONSERVATION SURVEY (launched May 2009)

1.

1. Which of Tiffany Holmes' artworks did you see?

(If you have seen more than one, pick the one that had the most impact)

- ☐ World Offset (worldoffset.org, interactive website launched March 2008)
- ☐ darkSky (MCA Chicago, interactive installation, April 2009)
- ☐ 7000 oaks and counting (public art commission, NCSA Urbana, IL, site-specific energy visualization, 2008)

2. Did you learn anything new from seeing the artwork from Question #1?

If yes, could you describe what that was? (If no, leave blank.)

3. Select the statements that fit with your experience of the artwork from Question #1.

Multiple statements may be selected.

- ☐ Artwork got me thinking about energy usage and resource conservation.
- ☐ Artwork made me think about energy usage and resource conservation in a new way.
- ☐ Artwork made me want to try harder to conserve energy and other resources.
- ☐ Artwork inspired me to ACTUALLY change my behavior related to energy conservation.
- ☐ None of the above applied to me.

Other (please specify)

4. Select the statement that fits best with your experience of the animation/visual imagery used in the artwork from Question #1.

- ☐ The images chosen to represent the energy used or conserved IMMEDIATELY made sense to me.
- ☐ The images chosen to represent the energy used or conserved SORT OF made sense to me.
- ☐ The images chosen to represent the energy used or conserved made sense ONLY AFTER I READ ABOUT HOW TO INTERPRET THEM.
- ☐ I did not really need to understand the data visualization to appreciate the artwork.

Other (please specify)

ART AND ENERGY CONSERVATION SURVEY (launched May 2009)

5. Please choose an answer from the row choices based on your experience of the artwork you saw (from Question #1).

	Disagree	Slightly disagree	Undecided, or neutral	Generally agree	Strongly agree
Artwork was visually or graphically interesting.	☐	☐	☐	☐	☐
Artwork had conceptual depth in that it made me think.	☐	☐	☐	☐	☐
Artwork made me think about environmental issues.	☐	☐	☐	☐	☐
Artwork taught something new about eco-issues or eco-data.	☐	☐	☐	☐	☐
Artwork was so fascinating I wanted to stay with it, or go back and revisit the piece.	☐	☐	☐	☐	☐
Artwork was overly didactic and preachy about energy conservation.	☐	☐	☐	☐	☐
Artwork made me want to conserve energy somehow.	☐	☐	☐	☐	☐
Artwork catalyzed some small act of energy conservation I performed recently.	☐	☐	☐	☐	☐
Other (please specify)					

6. If the artwork from Question #1 were to be exhibited in a new context, what might be altered or added to improve it?

ART AND ENERGY CONSERVATION SURVEY (launched May 2009)

7. Drawing from your own personal experience, which of the following professionals are most capable of directly inspiring social and environmental change through their work?

Use the rating scale

	Very capable	Somewhat capable	Not capable
Artists	☐	☐	☐
Musicians	☐	☐	☐
Scientists	☐	☐	☐
Activists	☐	☐	☐
Journalists/writers	☐	☐	☐
Politicians/lobbyists	☐	☐	☐
NGOs (non-governmental organizations)	☐	☐	☐
Farmers	☐	☐	☐
Lawyers	☐	☐	☐
Doctors	☐	☐	☐
Corporate executives	☐	☐	☐
Other (please specify)			

8. Please rate your level of concern on each of the following environmental issues:

	Not Concerned	Somewhat Unconcerned	Somewhat Concerned	Totally Concerned
Climate change	☐	☐	☐	☐
Reliance on non-renewable energy sources	☐	☐	☐	☐
Personal energy conservation	☐	☐	☐	☐
Biodiversity/endangered species	☐	☐	☐	☐
Air quality	☐	☐	☐	☐
Water quality (drinking water)	☐	☐	☐	☐
Industrial pollution	☐	☐	☐	☐
Food contamination by chemicals	☐	☐	☐	☐
Food contamination by growth hormones and antibiotics	☐	☐	☐	☐
Bio-engineered food supply	☐	☐	☐	☐
Other (please specify)				

ART AND ENERGY CONSERVATION SURVEY (launched May 2009)

9. Where are you writing from?

Country:

10. Please contribute your name email to stay informed about this research--this is entirely optional and up to you.

Name:

Email Address:

List of accompanying DVDs



DISK #1: Three case studies: Video DVD

Insert and play as any other DVD.

This DVD contains small video clips that document the artworks produced to prove the three claims of this inquiry.



DISK #2: Appendices and other files (titled "Holmes_Appendices_Files")

- 1) Open directory named "HOLMES_APPENDICES" to view the PDF files. A Table of Contents for the Appendices DVD appears on page 202.
- 2) PowerPoint slideshow (same info and video as on DVD, DISK #1)
- 3) Supplemental flash animation files

More information on DISK#2

How to use the PowerPoint DVD:

- 1) The DVD contains a PowerPoint slideshow (PPS) that will play on a Mac and a PC, though, since it was made on a Mac the text formatting is more reliable. Just double click the file called "holmes_phd_documentation.pps." Slower and older computers may not play the PPS from the disk drive, and the reader may need to copy the files direct to the hard drive. This copying can be time consuming, and can occasionally cause issues with linked movies so please view the regular video DVD (#1) if difficulties ensue with the PPS. The content is the same.
- 2) Advance to the next slide by clicking with the mouse, or hitting the space bar.
- 3) To quit the slideshow in the middle press the Escape key twice.

SUPPLEMENTAL MATERIALS: see directory "Supplemental_files" on DVD DISK #2

- 1) Inside the folder marked “7000oaks_and_counting” there is a Mac (“768_7000oak-Mac”) and a PC version (“768_7000oak-PC.exe”) of the interactive kiosk software for 7000 oaks and counting. If you open the xml file called “realtimeEnergy.xml” in a text editor like BBEdit you can even play around with energy load numbers which will change the look and feel of the spinning disks. For accuracy, keep both numbers below 275.
- 2) There are stand-alone demo Flash (SWF) files for the darkSky and World Offset eco-visualisation animations. These SWF files only work on Apple computers. These are detailed in the PowerPoint slideshow via video, however if you have a MAC computer feel free to open these directly.
- 3) The “World_offset_app” file is not interactive, and again, only will work on the MAC computer platform.
- 4) In the file “darkSky_demo_app” the viewer can mouse into the upper left hand corner to change the number of “lamps” that the animation thinks is on. Keep numbers between 0 and 27 for accuracy.

Appendices DVD, Table of Contents

Note to reader: The accompanying DVD marked "Appendices" contains PDF versions of all appendices listed below from A to N. To view the Appendices simply place the DVD into your computers disk drive and double click to open and view the PDF files.

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