

2007

A Change in the Weather

European Museum Coverage of Global Climate Change



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“A Change in the Weather”

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by

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SECTION 1

INTRODUCTION

Sustainability is commonly defined as the concept of providing society with current needs in a way that doesn't harm the ability of future generations to meet their needsⁱ. Definitions often include the three components environment, economy, and society (sometimes referred to as the three "Ps": planet, prosperity, and people). Together, these considerations make up what is often called the "triple bottom line" and serve as a yardstick for how sustainable a given action is.

This study focuses primarily on the environmental aspect of sustainability, which is the component closest to the mission of science museums and science centers.

Much of the recent discussion on the environmental component of sustainability at museums has focused on global warming. To a large degree, museums reflect society through their mission, director, board, exhibits, programs, publications, and other forms of interpretation. Because global warming is perceived by many to be the greatest threat of our time, it serves as an excellent indicator of how museums are responding to the changing needs of society.

Two factors place a special burden on museums with respect to this topic.

- First, informal science education organizations, including museums, science-technology centers, botanical gardens, zoos, aquariums, and similar organizations share a unique position in society. Surveys indicate that public trust in museums is higher than in any other ready source of informationⁱⁱ. This public trust places a special responsibility on museums to ensure that the information they present is correct.
- Second, there is a time delay in the development of exhibitions and programs of any museum. While many programs can be developed relatively quickly, permanent or even temporary exhibitions generally require significant resources and often take years from concept to opening. The field of global warming, however, is changing rapidly, and new data appear almost daily.

Because of the dual demands of public trust and time pressure, museums are doubly challenged in their effort to stay current in representing the topic of global warming to their audiences.

While environmental concerns have been with us for centuries, global warming is a new type of long-term threat which, like the atmospheric atomic bomb tests of the early 1960s and the ozone hole of the 1990s, has the potential to make the earth uninhabitable.

Both of these global threats were recognized by eminent scientists, brought to the attention of the public and world governments, and minimized through global agreements that reduced or eliminated the causative activities. Atomic tests were moved underground and greatly reduced in number. CFCs, the chemicals largely responsible for the increased loss of ozone in the upper atmosphere, were replaced with alternative chemicals. Fortunately, atmospheric radiation had a short half-life and quickly decreased; similarly, the ozone layer began to re-establish itself quickly, once the loading of CFCs was reduced. In both cases, the scientific and subsequent political activity happened quickly, and museums were not a strong voice in the resolution of these issues.

Global warming is fundamentally different.

The primary cause of global warming is acknowledged by nearly all scientists to be the increased level of atmospheric carbon dioxide generated by our burning of fossil fuels and other greenhouse gases resulting from anthropogenic causes (IPCC 2007). In fact, the level of CO₂ in the atmosphere is one of the most predictable environmental variables. The threat posed by atmospheric CO₂ differs from both atmospheric atomic bomb testing and the ozone hole in three important ways: 1) our entire world society and economy are based on carbon as a principal source of energy and there is at this time no ready substitute; 2) the retention time of CO₂ in the atmosphere is three to four generations (much longer than either the radiation from atomic tests or CFCs in the upper atmosphere); and 3) there is an increasing probability that, well before global temperatures reach a level that would require all humans to take immediate action, the Earth's climate may reach a tipping point and enter a series of cascading changes in global environmental systems that defy human intervention and lead to catastrophic climate change.

I was curious to find out how museums – given their position in society as trusted sources of information – are responding to the challenges of representing global warming to the public in light of the many conflicting interests, data, and stakeholders associated with the topic. I

selected Europe for study because of its early response to other environmental issues, such as waste management, recycling, pollution, acid rain, and land use, which I had observed 20 years earlier while studying in Germany. The current study involved visits to 34 science museums or related facilities in 10 countries between July and October 2007.

In mid-2007, most Europeans I spoke with informally were relatively informed and stated that they believe that human activities are causing climate change, leading to hotter average global air temperatures, rising sea levels, changes in ocean currents, more extreme storms, and altered precipitation patterns that will turn some areas into deserts and cause frequent flooding in others. As a general indication of their concern, essentially all countries of the European Union (EU) have signed on to the Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC), which specifies reductions of CO₂ and other greenhouse gases by 2012 (each country has a different target).

Over the course of the study, I observed a significant amount of discussion about global warming among various segments of European society, including the press, governments, corporations, and other organizations. My goal was to focus on museums and see first-hand what they were doing to facilitate public understanding and/or action.

A. OUTLINE

The monograph is divided into five sections. Section 1 provides an introduction, along with a map and list of sites visited. A table summarizes the general characteristics of the museums and their exhibit and program activities related to global warming. Section 2 considers the broader educational role of museums in Europe, including issues related to the covered subjects, core educational messages, and approaches to the use of historical objects and recently created exhibits as vehicles for the public understanding of science. Section 3 describes current exhibits and programs related to global warming and how these relate to sustainability and global warming, in particular. Section 4 describes internal (i.e., non-public) initiatives by museums related to global warming, such as capital projects to save energy or operational measures to

reduce an organization’s carbon footprint. Section 5 presents a summary and recommendations for the study.

B. THE STUDY

To assess how museums in Europe are portraying the topic of global warming to the public, I visited 34 science-related museums, organizations, or related facilities between July 9 and October 9, 2007, traveling 14,000 km in 10 countries. Referred to as the “study group,” these 34 organizations are shown as black dots in Figure 1 and included the following:



Figure 1: Index map showing 34 science museums of the study group visited in 2007.

Belgium (1)

- *Technopolis[®], the Flemish Science Center* – Mechelen*

England (4)

- *Explore-At-Bristol* – Bristol*
- *Eden Project* – Cornwall*
- *Natural History Museum* – London*
- *Science Museum* – London

Finland (1)

- *Heureka* – Helsinki/Vaanta*

France (2)

- *City of Science and Industry* – Paris*
- *Palace of Discovery* – Paris*

Germany (14)

- *Artefact* – Glücksburg
- *Deutsches Museum* – Main Museum – Munich*
- *Deutsches Museum* – Aviation Museum – Munich/Oberschleissheim
- *Deutsches Museum* – Transportation Museum – Munich
- *Klimahaus 8 Degrees East* – Bremerhaven (under construction)*
- *Museum of Man and Nature* – Munich
- *Museum of Natural History* – Berlin
- *Museum of Science and Technology* – Berlin
- *Phaeno* – Wolfsburg*
- *Phaenomena* – Bremerhaven*
- *Phaenomena* – Flensburg*
- *Siemens Forum* – Munich
- *Spectrum* – Berlin*
- *Universum* – Bremen*

Italy (1)

- *National Museum of Science and Technology 'Leonardo da Vinci'* – Milan*

Norway (2)

- *Museum of Science and Technology* – Oslo*
- *Natural History Museum* – Oslo*

Sweden (7)

- *Museum of Science and Technology* – Stockholm*
- *Nacka Nature School* – Stockholm*
- *Natural History Museum* – Stockholm*
- *Nobel Museum* – Stockholm
- *Teknikens Hus* – Lulea*
- *Tom Tits Experiment* – Stockholm/Södertälje*
- *Universeum* – Gothenberg

Switzerland (1)

- *Technorama* – Winterthur*

Wales (1)

- *Techniquet* – Cardiff*

* Note: Visit included meetings with one or more staff members.

At each location, I toured the facility, took pictures, and collected brochures, guides, and other readily available information. At two-thirds of the sites, I met with the director, educators, and/or exhibit staff members, as available. After each visit, I posted general observations and pictures to a blog (<http://cTrautmann.blogspot.com>).

Because of time and budget constraints, the original and longer list of potential sites was narrowed to 34. The process for selecting museums was guided by the following considerations:

- interest of the organization in global warming
- recommendations of colleagues
- available time and budget, and proximity to other sites being visited

The list of sites was intended to be representative rather than exhaustive and in no sense implies that other organizations are not doing excellent work in educating the public about global warming and sustainability. Had more time and funding been available, the list of museums in the study group would have been considerably longer.

Table 1 provides a summary of basic information for the museums. In this table, the following terms and conventions have been used:

- **NAME** – In general, the English version of the museum name has been used, except in cases such as “Phaeno” or “Universum,” where no reasonable translation exists.
- **TYPE** – Museums were classified according to their principal content area and mode of communication. Several institutions have overlapping categories. For example, the Deutsches Museum (Munich) and the Science Museum (London) have a growing number of new interactive exhibits characteristic of a science center; however, their current portfolio of exhibits is dominated by historical objects of science and technology, and so both are classified here as “science museums.” In contrast, “science centers” are characterized in this report as presenting exhibits that are built specifically for display, rather than objects that are collected and then displayed. Clearly there is much overlap.
- **SIZE** – Museum size is based on the Association of Science-Technology Centers (ASTC) classification system, which uses the indoor exhibit floor area as the metric.
 - Very Small (VS) – under 1,116 m²
 - Small (S) – 1,116 to 2,325 m²
 - Medium (M) – 2,325 to 4,650 m²
 - Large (L) – over 4,650 m²
- **PRIMARY INCOME** – The institution’s largest single source of income, according to the four categories:
 - C – Corporate sponsorship
 - E – Earned income such as admission, membership, store, food, exhibition rentals and sales, funded (fee for service) projects, etc.
 - G – Government operating support
 - P – Private
- **OUTDOOR EXHIBITS** – Indicates the institution has outdoor exhibits; exhibits may not be available at all times throughout the year.

Table 1. Summary of Global Warming Activities at Museums in the European Study Group

NAME	LOCATION	TYPE	SIZE	PRIMARY INCOME	EXHIBITS						PROGRAMS				INTERNAL OPERATIONS	
					TEMP		PERM				SCHOOL	SHOW	EVENT	OTHER		
					PANEL	INTERACTIVE	PANEL	INTERACTIVE	OUTDOOR	IN DEVELOPMENT						
Technopolis, the Flemish Science Center	Mechelen, Belgium	SC	L	E				X					X	X	X	
Explore-At-Bristol	Bristol, England	SC	M	E				X		X	X				X	
Eden	Cornwall, England	BG	n/a	E			X	X	X							X
Natural History Museum	London, England	NH	L	G	X	X	X									
Science Museum	London, England	SM	L	G			X	X		X	X	X	X	X	X	X
Heureka	Vaanta, Finland	SC	M	G				X								
La Cité des Sciences & de l'industrie	Paris, France	SC	L	G		X					X				X	X
Palais de la Découverte	Paris, France	SC	L	G		X					X					
Artefact	Glücksburg, Germany	NH	n/a	P				X	X		X					X
Deutsches Museum	Munich, Germany	SM	L	G			X				X					
Deutsches Museum - Aviation	Munich, Germany	SM	L	G												
Deutsches Museum - Transportation Center	Munich, Germany	SM	L	G							X					
Klimahaus	Bremerhaven, Germany	SC	L	E						X	X	X				
Museum of Man and Nature	Munich, Germany	NH	S	G	X										X	
German Museum of Technology	Berlin, Germany	SM	L	G	X											
Natural History Museum	Berlin, Germany	NH	L	G	X											
Phaeno	Wolfsburg, Germany	SC	M	G				X								
Phaenomena	Flensburg, Germany	SC	S	P												
Phaenomena	Bremerhaven, Germany	SC	VS	P												
SiemensForum	Munich, Germany	SM	S	C			X									
Spectrum	Berlin, Germany	SC	S	G												
Universum	Bremen, Germany	SC	M	P			X									
National Museum of Science & Technology	Milan, Italy	SM	L	P							X					

Table 1 (cont.). Summary of Global Warming Activities at Museums in the European Study Group

NAME	LOCATION	TYPE	SIZE	PRIMARY INCOME	EXHIBITS						PROGRAMS				INTERNAL OPERATIONS	
					TEMP		PERM				SCHOOL	SHOW	EVENT	OTHER		
					PANEL	INTERACTIVE	PANEL	INTERACTIVE	OUTDOOR	IN DEVELOPMENT						
National Museum of Science & Technology	Milan, Italy	SM	L	P								X				
Museum of Science & Technology	Oslo, Norway	SM	L	G							X					
Natural History Museum	Oslo, Norway	NH	L	G											X	
Museum of Science & Technology	Stockholm, Sweden	SM	L	G												
Nacka Nature School	Stockholm, Sweden	NC	VS	G		X										X
Natural History Museum	Stockholm, Sweden	NH	L	G				X				X				
Nobel Museum	Stockholm, Sweden	HS	S	P												
Teknikens Hus	Lulea, Sweden	SC	M	E		X							X			
Tom Tits Experiment	Stockholm, Sweden	SC	L	E				X	X	X	X	X	X	X	X	X
Universeum	Gothenberg, Sweden	SC	L	G						X						X
Technorama	Winterthur, Switzerland	SC	L	G									X			
Techniquet	Cardiff, Wales	SC	S	G		X		X		X	X	X	X	X	X	X

NOTES:
MUSEUM TYPE: **SC** = science center, **SM** = science museum, **BG** = botanical garden, **NH** = natural history museum, **NC** = nature center, **HS** = history of science
SIZE (indoor exhibit area in m²): **VS** = 0-1100, **S** = 1100-2300, **M** = 2300-4600, **L** = > 4600, **n/a** = not applicable/outdoor facility
PRIMARY INCOME: **C** = Corporate, **E** = Earned, **G** = Government, **P** = Private

- TEMPORARY EXHIBITIONS (related to global warming)
 - *Temporary Exhibitions* – Those on display for less than two years, or traveling exhibitions that tour among other museums.
 - *Panel* – Primarily non-interactive exhibits characterized by a large percentage of text and graphics; generally aimed at older audiences. May include one or more hands-on interactive activities, but these are a relatively small percentage of the overall exhibition.
 - *Interactive* – Hands-on exhibit activities constitute a significant percentage of the overall exhibition.
- PERMANENT EXHIBITIONS (related to global warming)
 - *Permanent Exhibitions* – Those on display for more than two years.
 - *Panel* – Primarily non-interactive exhibits characterized by a large percentage of text and graphics; generally aimed at older audiences. May include one or more hands-on interactive activities, but these are a relatively small percentage of the overall exhibition.
 - *Interactive* – Hands-on exhibit activities constitute a significant percentage of the overall exhibition.
 - *In Development* – Exhibitions with a budget and scheduled to open in 2008 or 2009.
 - *Summary* – Museums with any exhibits related to global warming (does not include museums in which global warming is mentioned in passing in a temporary traveling exhibition).
- PROGRAMS
 - *School* – Regularly offered programs for visiting school classes.
 - *Show* – In-museum programs offered to the public on a regular, relatively permanent basis

- *Event* – One-time programs (in-museum or off-site); may include educational activities, exhibits, and/or media.
- *Other* – Non-exhibit activities related to global warming that do not fit into the above three categories.
- INTERNAL – Non-public, organizational activities related to improving sustainability. It is assumed all organizations now have a recycling process, so recycling alone is not counted here. The category highlights additional activities such as the purchase or generation of alternative energy, composting, on-site waste water treatment, carbon offset purchases, etc.

There are surprisingly few norms or benchmarks against which the 34 museums of the study group can be compared. Each museum has a distinct history, culture, staff, financial situation, exhibits, approach to education, and organizational priorities. While looking for points of commonality, I often found contrasting approaches that worked well for the particular institution at that point in time. It was clear that rarely are there right or wrong approaches – just different approaches. In some cases, institutions were in transition, with staff working hard to update practices that had been institutionalized for years or decades. In these cases, a casual visit to the museum floor might have yielded a very different impression as to the future direction of the museum from what I received in meetings with staff. In other cases, I found education staff working to infuse current educational theory into exhibits and labels that reflected many years of institutional or historical inertia. Without exception, however, I found staff who were genuinely passionate about their work and eager to make an impact on their visitors through their efforts.

C. ACKNOWLEDGMENTS

This study was made possible by the contributions of many people and organizations.

First, I am indebted to the trustees and staff of my home institution, the Sciencenter of Ithaca, NY, for granting me a 3-month sabbatical leave with full salary. In particular, this project would not have been possible without the leadership and extra efforts of Lara Kimber, Associate Director, who took over my responsibilities, in addition to her own, during my absence. I would also like to acknowledge the insights and counsel of John Neuman, who steered us through a number of planning and organizational issues before, during, and after my leave.

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SECTION 2

ROLE OF EUROPEAN MUSEUMS RELATIVE TO GLOBAL WARMING

Many factors influence the capacity of a museum to make an educational impact on its audience. Some factors are external, such as the community from which the museum draws the majority of its visitors, the funding landscape in which it is embedded, its media support, and the issues that form the subjects of its exhibitions. Other factors are internal, such as the staff it hires to carry out its mission, the core messages it chooses to convey, and the educational approach it uses to convey its messages.

This section focuses on the internal aspects of museums in the study group and describes some observations relative to the role they see themselves playing with respect to global warming. Because the issue is changing so rapidly, these observations should be regarded as a snapshot in time.

A. PUBLIC TRUST

Throughout the world, people tend to regard museums as a trusted and reliable source of information. Most senior staff members of European museums are aware of this special regard the public holds for museums and understand that people commonly place a higher level of trust in museums than in the media, politicians, and many other information conduits, including scientists themselves. This trust imposes a significant duty of care on museums – one which many museums take seriously and which influences museums in three ways:

1. taking risks;
2. providing a balanced representation of opposing points of view; and
3. aligning the organization's actions with its educational message.

Regarding the first issue, the duty of care can limit the degree of risk a museum is willing to take, such as displaying exhibitions on controversial topics or deciding how much weight to give to opposing views. For example, one museum decided not to show an exhibition in which human bodies are preserved for display, education, and profit, because the risk of alienating one or more key sponsors was not thought to be worth the potential gain for the museum and its audience. In another case, a museum was hesitant to address the topic of global warming because several of its key scientists did not themselves believe human activities are related to the trend of increasing global temperatures.

A second issue – how much weight to give to opposing views – varies from museum to museum and is in a state of flux with respect to global warming, as new information comes to light. In one case, a museum organized public programs on global warming and initially invited scientists with opposing views for balance. However, as the preponderance of evidence began to tip towards a human influence for global warming, the opposing speakers increasingly used “merchant of doubt” tactics in public debates, quoting obscure journal articles and raising hypothetical questions with no real answers, in their attempt to prevail in an open forum. Because this non-scientific approach became a regular occurrence, the museum stopped including presenters with opposing views.

A third and potentially difficult issue for many museums is the gap between their educational message and their own actions as an organization. Many museums had exhibits stressing sustainable practices, energy conservation, and specific actions such as improving building insulation and purchasing green power. Yet the majority of the organizations presenting these messages had not adopted any of these practices in their own buildings.

On the other hand, the organizations with an ongoing process of evaluating and adopting green practices *and letting their visitors know about it* report positive feedback from their audience about the impact of their efforts. In some cases, this positive feedback includes increasing levels of funding from sponsors and donors.

B. EDUCATIONAL GOALS

There was consensus among museums in Europe regarding their educational goals. Almost without exception, when asked the question, “What impact do you want to have on your visitors?”, staff at all levels responded with answers such as:

- “inspire visitors to become more interested in science and understand its role in the world around them”
- “make connections between science and their everyday lives”
- “help visitors to become better critical thinkers”
- “help visitors to use science to make better decisions”
- “appreciate the role of science in their heritage”
- “personal contact with science”
- “provide a forum using science to discuss current topics”
- “raise awareness about a topic “
- “provide specific information on a topic”

Some museums have additional goals. For example, several European museums have been founded in the last two decades to lead more children into careers in science and technology. However, this goal has been elusive for several reasons. First, museums have had a difficult time demonstrating they have in fact caused a measurable increase in either the quantity or quality of students opting for careers in science and technology. Second, in some European countries, the current demand for scientists is flat or down, with the result that career options for recent graduates may be limited and salaries may lag behind those in other fields. Where this is the case, recent university graduates are finding the job market challenging, and the argument for attracting more students into science has been weakened.

Some museums seek to help the public understand the role of the scientific enterprise in our society, with an eye toward helping people make better-informed decisions on projects, research, and contemporary issues in science. A number of museums have experimented with public understanding of science and research, using activities such as:

Changing Exhibits: Some museums have dedicated staff responsible for producing new informational kiosk-type mini-exhibits every few months. These exhibits present visitors with an in-depth look at a project or issue through investigating goals, methods, and/or interim results. In some cases, interactive computers provide additional layers of information, multimedia clips, or opportunities for visitors to express their own views. Museums commonly archive these mini-exhibits on their website with the result that there is a growing online collection addressing current science. One recent temporary exhibit provided information on a controversial experiment to remove CO₂ from the atmosphere through biological means. In this exhibit, visitors were invited to weigh the evidence and then post their opinion about the proposed experiment on a computer listing for other visitors to read.

Resident Scientists: One museum has provided space for a graduate student from a nearby university to set up a working lab. The student does essentially all of his research in the museum, from sample preparation to making measurements, analyzing data, and writing up results. A significant portion of his work is to talk with visitors and share the excitement of his research with them. In this case, the project had no direct connection with environmental science.

Scientist Programs: A number of museums have worked with scientists to help them share their research with visitors through lectures, debates, seminars, workshops, conversations, mini-exhibitions, and other forms of interaction. An increasing number of these are on environmental topics. Ongoing programs are characterized by large staff teams, with one museum hiring 8 full-time staff and another museum 20 full-time staff to keep their current science program fresh, accurate, and online.

Taken as a group, museums in Europe were actively debating the extent to which they should allow the perceived urgency of the global warming problem to influence their traditional educational goals. A growing number are deciding that this topic merits new approaches.

C. CHANGING VISITOR BEHAVIOR AND ADVOCACY RELATIVE TO GLOBAL WARMING

The museums in the study group all hope to change the behavior of their visitors in some way, such as inspiring them to become more interested in science. In general, the museums fell into three groups with respect to their public response to global warming:

- *No Activity*: Some museums stated that they work only with “pure” science and avoid addressing technology or current issues. Other museums restrict their focus to issues related to the history of science and society or have a niche focus. For these museums, a topic such as global warming is simply not within their mission. Still other museums have chosen not to address the topic, in favor of other priorities.
- *Informational Exhibits and Programs*: Some museums seek to inform the public on issues, provide examples and options, and ask questions of visitors in an attempt to help them think more critically and make better decisions after considering information on probable impacts.
- *Advocacy*: Some museums advocate specific actions, such as changing your light bulbs, buying local food, riding your bike to work, insulating your home, etc. They may also encourage their visitors and members to take specific political positions, such as supporting a proposed law to prohibit the sale of incandescent light bulbs.

Many museums find themselves in a difficult position with respect to advocacy aimed at attempting to change the behavior of their visitors in specific ways. Most staff interviewed felt that it is not the role of a museum to advocate for specific actions on the part of their visitors, although they did hope the museum experience would lead visitors to make more informed decisions, become more curious about science, and increase their self-initiated learning about topics of scientific interest.

Often, museum staff stated that they seek to provide their visitors with the tools to analyze choices and become better-informed consumers and decision makers. With respect to global warming, one staff member said, “Visitors want us to give them a list of 10 things that they can do to personally reduce global warming. We would rather raise their awareness of the issues and

give them knowledge, so that the next time they need light bulbs, they can read the labels on the boxes, do the comparison themselves, and make the best choice.”

Although this desired outcome was expressed by many museums, surprisingly few exhibits helped the public actually learn how to recognize and make those comparisons, trade-offs, and decisions. This gap needs to be addressed if museums are to make an impact in reducing global warming.

D. OBJECTS, INFORMATION, AND PHENOMENON-BASED EXHIBITS

The relative educational merits of historical objects, information panels, multimedia presentations, and hands-on interactive exhibits was a topic that came up frequently among museum staff at European science museums. While in the U.S., the terms “science museums” and “science centers” are used interchangeably, European institutions typically make a distinction between the two.

In some cases, it is a legal or statutory distinction (science centers in France, for example, are not allowed to refer to themselves as “museums” because they do not have the primary mission to collect and curate objects of historical value). In other cases, it is a philosophical issue, with some centers focused entirely on scientific phenomena and wanting to make the clear statement to their visitors that they will find no historical objects or “book-on-the-wall” exhibits within their walls. In contrast, The Eden Project, actively seeks to blur all distinctions and does not want to be labeled as any particular type of institution at all.

If there is a trend in European informal science overall, it is that object-based museums are increasing their percentage of hands-on exhibits and starting to reduce the distinction between object-based “museums” and interactive “science centers.” For example, the director of one major institution with significant collections communicated his hope that in the future, his institution would be considered “both a science museum and a science center.”

Regarding exhibits on global warming, there were many examples of institutions using each of the above modes of display, often in the same exhibition. These examples are described in more detail in the next section. With a few notable exceptions, most exhibitions on global warming

consisted primarily of text and graphics panels that were geared toward an adult audience. Interactive exhibits in several cases appeared to attract visitors, but did not always add to the educational message of the exhibition. In a few exhibitions, objects such as animal mounts, scientific instruments, cultural artifacts, and objects from the daily life of polar researchers added significantly to the impact of the exhibitions by adding human interest and helping the science to “come alive” for visitors.

E. MUSEUM PROGRAMS

Most successful exhibitions, on any topic, are accompanied by educational programs that target specific audience segments, such as families, adults, or school groups. This was also the case for the global warming exhibitions in the study group, and most museums relied heavily on programs to deliver their educational message, to school audiences in particular.

In almost all cases, school programs on global warming targeted a middle or high school audience. Worksheets guided students working individually or in small teams to look for information from the exhibits and answer questions with a few words or phrases. Worksheet activities typically were preceded by a lecture or tour of the exhibition by a staff educator. Only rarely were students given the opportunity to use hands-on exhibit components or experiments to help them answer the questions on their worksheets; in most cases they had to read text panels to find the answers.

One museum developed a 20-minute science theater show (in Swedish) to accompany an exhibition on polar science. In the 2-person show aimed at elementary aged children, a polar scientist meets a penguin and learns from it (along with the audience) about the science behind some of the ways in which penguins have adapted to the extreme conditions in the Antarctic.



Figure 2: Amphitheater program on polar science at Teknikens Hus.

Technique developed a simple public program in which visitors used a large floor map of the world to investigate the energy requirements and atmospheric CO₂ loading associated with various sources of common foods.

Some museums have hosted events, such as inviting the adult public to play the two-hour DECIDE game (**DE**liberative **CI**tizens **DE**bates) on global warming to learn about the issues and possible responses.

Many museums have made use of the extensive resources of the Association of Science-Technology Centers IGLO program (**I**nternational Action on **G**LObal Warming) to provide educational programming for public and school audiences: www.astc.org/iglo.

SECTION 3

EXHIBITS AND PROGRAMS ON GLOBAL WARMING

With few exceptions, the staff at all levels from museums in the study group stated that they accept global warming as a something that is now taking place and that it is due in large part to the increase of CO₂ and other greenhouse gases that humans have introduced into the atmosphere since the start of the Industrial Revolution.

The issue for the museums choosing to address the issue in their exhibitions and programs now revolves around “What is the scientific basis for what is happening?” and “What can we do about it?”, rather than “Is it happening?” Because most European corporations agree with this outlook, there appeared to be few issues associated with being in conflict with potential sponsors.

The primary educational activities observed at the museums in the study group included the following:

- permanent exhibitions
- temporary exhibitions
- traveling exhibitions
- individual exhibits
- public programs
- exhibit signage mentioning global warming

The sections that follow describe the offerings of the museums in the study group relative to these categories. None of the exhibitions or programs described below had been formally evaluated, and there are no data regarding numbers of visitors, average dwell time, or impact on visitor changes in knowledge, attitude, or behavior as a result of their experience with the exhibitions.

A. PERMANENT EXHIBITIONS

Deutsches Museum (Munich, Germany) – Environment Gallery.

Using portions of a previous temporary exhibition entitled, *Climate: The Experiment with the Planet Earth*, the Deutsches Museum has mounted a permanent panel exhibition in its environment gallery. The overall exhibition consists of several dozen tall panels with text and graphics, covering a variety of environmental issues such as global warming, energy, waste management, and population. Text is in both German and English.

School groups can sign up for a two-hour program in which an educator provides a guided tour of the exhibition and then supplies various worksheets to be filled out in small groups. At the end of the program, students can share their answers with the rest of the class.



Figure 3: School group program on climate change at the Deutsches Museum.

The exhibition contains a large amount of information, including a useful summary of the older 2001 report of the Intergovernmental Panel on Climate Change (IPCC). In addition to the informational panels, there is a push-button exhibit that depicts the greenhouse effect as a model behind glass, and there are several wall-mounted touch screens with questions and informational

responses related to global warming. The exhibition seems to work best for single or paired adults who are interested in the topic and are eager to read about the details. Children and families tend to spend relatively little time in the gallery, most likely because there are few objects to view or interact with.

Artefact Energy Park (Glücksburg, Germany) – Outdoor Energy Area

Artefact is an outdoor nature center with a strong focus on renewable energy. Many of the exhibits are interactive and address topics such as kinetic and potential energy, conversion of energy from one form to another, and harnessing renewable energy such as wind and solar.



Figure 4: Outdoor interactive energy exhibit at Artefact.

Visitors can see a working solar array and watch the instantaneous change in energy output as clouds pass by. There is a wind mill on a tall tower, although there is no readout of power output to allow a real-time comparison of energy production, as for the solar array. Other exhibits address water power, coal-based power, and other types of power generation. A cutaway full-sized blade from a commercial wind mill is an impressive exhibit for visitors who normally see

these devices only from great distances. Additional areas of Artefact include demonstration gardens, a small demonstration swine farm, and residential and instructional buildings.

Phaeno (Wolfsburg, Germany) – Renewable Energy Exhibition

Phaeno is a new science center located in an impressive, award-winning concrete structure in Wolfsburg, the home of Volkswagen.



Figure 5: View of Phaeno, which opened a series of exhibits on energy in October 2007.

At the time of my visit, a group of permanent exhibits related to renewable energy was in development, and these have since been opened to the public as of fall 2007. The exhibits are hands-on interactives and cover a variety of basic electrical, magnetic, and meteorological phenomena. Also included are several exhibits that address aspects of renewable energy, such as solar and wind.

Science Museum (London, England) – Energy Area

The Science Museum is a large museum with a long history of displaying interesting historical objects, as well as experimenting with the communication of science. In recent years, the Science Museum has been one of the pioneers in promoting the public understanding of science and technology through exhibits and programs that encourage visitors to reflect on the implications of science and technology on society.

One recent exhibition that exemplifies this goal is an area devoted to energy. The exhibition takes an approach to the topic that stresses policy and personal responsibility. While the individual exhibits are interactive, they do not address the science of energy, but rather the implications of decisions we make about energy.



Figure 6: Comparing personal energy usage at the Science Museum.

Visitors are challenged to use what they know about energy to make decisions at many levels. At the personal level, for example, one exhibit asks visitors about the impacts of choices on transportation, food sources, etc., by spinning large wheels that serve as an interface with a graphics screen. While this same matching game could have easily been implemented on a

tabletop computer, the whole-body format leads to a depth of visitor engagement that was clearly evident.

At another scale, a computer-based game turns visitors into the energy czar for England and makes them responsible for ensuring an adequate supply of electricity for the country in the face of growing demand and increased concern about global warming. Visitors must make rapid choices on where to build new power plants (by clicking on a map) and what type (wind, coal, nuclear, solar, hydro, etc.) Visitors then get instant feedback (e.g., “The farmers are demonstrating in public about losing a lot of prime agricultural land, if you go through with that new solar power facility.”).

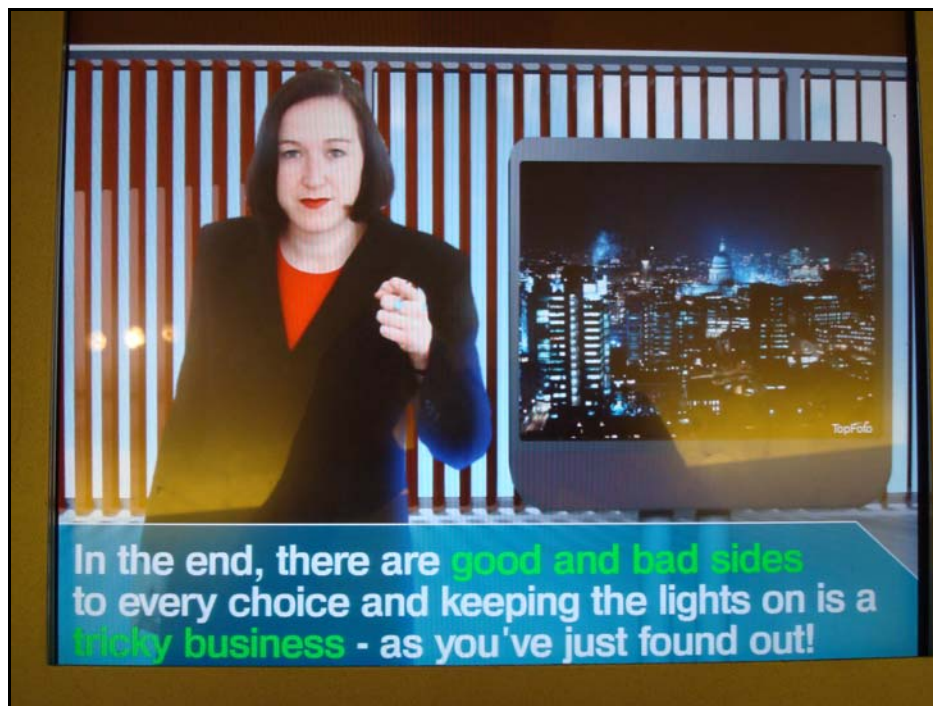


Figure 7: Ending screen from an energy allocation game at the Science Museum.

Other exhibits, some interactive and others more text-based, often with graphics or objects, pose similar types of questions or challenges to give visitors a chance to confront the issues and reflect on their assumptions and beliefs. While a few younger children use the more interactive components, the majority of visitors in this area are adults and families with older teens.

At-Bristol (Bristol, England)

At-Bristol hosts *News and Views* computer stations, which are updated regularly with contemporary science news, including climate change stories, allowing visitors to research a given topic, cast their vote, and leave a record of their opinion. At-Bristol has several other interactive web-based programs relating to natural resource use, climate change, and other sustainability issues.

The Eden Project (Cornwall, England)

The Eden Project is a large and spectacular botanical park with a strong focus on sustainability. Built in an abandoned clay pit mine with funds from the UK Government's Millennium Commission and the European Union's economic regeneration program and opened in 2000, Eden operates largely on earned income.

There is much to notice at Eden. The first thing one notices is the sheer scale. Multiple parking lots, frequent full-size articulated shuttle buses, and a high-capacity admissions pavilion are testament to the 1.2 million visitors who come to Eden each year. Two giant geodesic structures, called "biomes," house Eden's Mediterranean and tropical environments, the latter being the largest tropical conservatory in the world.



Figure 8: Overview of the Eden Project.

The plantings are diverse, impressive, and extraordinarily well maintained.

However, after spending some time at Eden, one becomes aware of something deeper than the spectacle of the facility and the plantings. Everything at Eden is aligned with the core message of sustainability. This message pervades the entire operation in various ways, several of which are highlighted below:

Staff. Interactions with four staff members from four different parts of the operation led to closely agreeing statements about the core messages Eden is trying to convey to its visitors and the value (and caveats) of its educational approach.

Exhibits. Throughout Eden, practically all of the exhibits, whether botanical, sculptural, object-based, or interactive, address the core message of sustainability in some way.

Services. All public services support the educational goals related to sustainability. The nine food service venues double as learning centers on local sourcing of food, the environmental impacts of various crops and animals, packaging and transportation,

recycling, and nutrition. The gift shop supports the message with its selection of books and the merchandise it offers from recycled materials.

Management of Facilities. Facilities decisions include both sustainability and education as integral components. At a micro scale, the electric hand dryers in the restrooms use energy-saving technology that works faster than conventional dryers, using less energy, and eliminating paper waste. A clear, easy-to-read sign tells the story for visitors. At a larger scale, the clear plastic material used to cover the extensive biomes was selected in part on the basis of its environmental footprint and the fact that it can be easily recycled if punctured by a bird or torn by the wind.

Support of Related Projects. Eden has a carbon offset program that actively supports more than ten sustainability projects around the world, providing financial contributions, information, and other forms of cooperation.

Despite its strong focus, Eden tries to avoid telling visitors what to do. For the most part, exhibits and signage provide information and seek to leave visitors with a thought-provoking question rather than a definitive answer or recommendation. The goal is for visitors to develop the ability to look in depth at the issues and information and make an informed decision on their own.

Through its triple strategy of providing an excellent visitor experience, aligning every aspect of its operation with its core message of sustainability, and encouraging visitors to think about the implications of their actions, the Eden Project leaves a deep impression.

Natural History Museum (Stockholm, Sweden) – *Mission: Climate Earth*

A number of years ago, a climate researcher and board member of the Natural History Museum, recommended that the museum develop an exhibition on global warming. The museum took the suggestion and opened *Mission: Climate Earth* in 2004. To date, this exhibition represents the largest permanent indoor exhibition on the topic among the 34 museums in the study group.



Figure 9: View of *Mission: Climate Earth* at the Natural History Museum, Stockholm.

The exhibition covers approximately 550 square meters and cost about \$1 million to develop. It uses a wide variety of exhibit techniques, including extensive text and graphic panels, interactive and non-interactive exhibits, objects, a multimedia theater, and a small stage. Visitors can pick up a free individually bar-coded CD of the video shown in the multimedia theater. Nine stations throughout the exhibition are fitted out with readers which, when scanned, send further information to a website that can be accessed by visitors at home using the PIN on the CD envelope. The museum was given the silver Muse Award in 2007 for its innovative use of technology by the American Association of Museums in its annual award competition.

Mission: Climate Earth is divided into a series of areas that cover:

- the Sun as the ultimate source of our energy
- the difference between weather and climate
- the greenhouse effect
- climate on a geologic timescale
- impacts of climate change on people throughout the world

- alternative sources of energy
- actions people can take to reduce their carbon footprint
- a professional, fast-paced multimedia video on global warming called *Eye of the Storm*

The exhibition includes several interactive exhibits, which help to enliven the environment for children and families; examples include a tornado, cloud vapor device, a model demonstrating the reason for seasons, and three spheres illustrating various average earth temperatures (10-14-18 degrees).

The museum's website includes the exhibition text, which is widely used by teachers in preparation for school group visits. Overall, staff report that the exhibition is used most frequently by schools and relatively little by family groups.

Norwegian National Museum of Science, Technology and Medicine (Oslo, Norway) – *Klima X*

In December 2007, the National Museum of Science, Technology and Medicine opened a provocative new exhibition on climate change entitled *Klima X*, which was under construction during my visit several months earlier. The exhibition shows the causes, effects and possible solutions to global warming. It aims at increasing the knowledge about human-induced climate change and promoting engagement and action from visitors.

The design is quite unusual. Lead by the Swedish architectural studio Codesign, the concept is to give visitors an unforgettable experience by stimulating all of the senses and to let interactivity play a key role. The exhibition will be open for two years through 2009 and is expected to draw 300,000 visitors.

Visitors begin by walking past a large wall rack with yellow waterproof boots. Visitors put on a pair, go through a doorway, and enter the exhibition, which is set in a room flooded with 100 mm of water to evoke images of rising seas.



Figure 10: Klima X: Visitors must first select a pair of waterproof boots before entering the exhibition.

Once inside, visitors see two huge blocks of ice measuring almost 2 m on a side. One cube has ice cores embedded to symbolize melting of Antarctic ice, while the other has an animation showing melting of Arctic sea ice.



Figure 11: Klima X: One of two giant blocks of ice.

The walls are covered with information posters and graphics about the causes, effects, and solutions of global warming. Visitors use remote-controlled boats to visit various geographical places around the world, which are depicted on columns around the room. By steering a boat into a small opening at the base of the column, visitors can trigger a short video clip with stories about how people at that location are being affected by climate change.



Figure 12: Klima X: Remote controlled boats.

Visitors are also presented with the opportunity to express their opinion about a series of questions related to global warming. By stepping on a “yes” or “no” footprint on a small pedestal extending just above the water level, visitors can “vote with their feet” and see the aggregate results of other visitors projected on the wall before them.

The unusual immersive design of *Klima X* is intended to create a transformative visitor experience by creating an entirely unexpected environment for the presentation of its content. It will be both fascinating and highly instructive for the entire museum field to see evaluation results documenting the change in visitor attitudes, knowledge, and behavior related to the exhibition’s theme.



Figure 13: Klima X: Video triggered by docking a remote-controlled boat.



Figure 14: Klima X: Visitors expressing their opinion on issues by stepping on a sensor.

B. TEMPORARY EXHIBITIONS

Techniquet (Cardiff, Wales)

Techniquet made global warming the theme for its summer 2007 special programming. For example, the programs included a large outdoor map with an accompanying staff-led activity in which visitors could assess the differences in CO₂ impact from various sources of foods. The program activities were supported by interactive exhibits inside that covered topics such as energy alternative energy, sustainable food sourcing, and the impact of personal actions such as reducing home thermostat settings.



Figure 15: Exhibits on sustainability at Techniquet.

Most of the temporary exhibits were removed after the summer; however, additional exhibits are planned for the future. The image above shows part of an indoor module remaining in the museum following the summer exhibition. In the summer of 2007, Techniquet produced three environmental programs for public audiences including: an interactive science show, *Grand Designs*, that focused on recycling; the *Solar Powered Workshop* that investigated the use of solar power; and the story time session, *Smoggish*, for under 7 year-olds that looked at caring for the environment and recycling waste. The three programs have been modified for primary school audiences and will be combined with another environment program, *MoMo Forest*, which looks at the environment and habitats, in Techniquet's outreach program starting in January 2008.

Palais de la Découverte – Arctic Adventure

In celebration of the 70th anniversary of explorer Paul-Émile Victor's research trip to the Arctic, the Palais de la Découverte created a special temporary exhibition about the poles. The exhibition has three main sections. The first section contains a number of mounted specimens from the north and south polar regions, including a polar bear, birds, and marine mammals. Visitors learn, for example, that polar bears live only in the Arctic, while penguins live only in the Antarctic.

The second section investigates the science of global warming through a series of displays and interactive exhibits. Staff indicated that developing new interactive exhibits on global warming was extremely challenging and that the one-year timeframe was too tight.



Figure 16: View of global warming exhibits in the temporary exhibition *Arctic Adventure* at the Palais de la Découverte, Paris.

The third area was devoted to Inuit culture and the impact climate change has already had on the Inuits. This section had a number of cultural artifacts, as well as poignant photographs comparing how life in polar regions has changed in the past several decades, as rapidly rising temperatures have caused dramatic shifts in lifestyle.

Cité des Sciences et de l'Industrie (Paris, France) – *ClimaX* and *A New Era*

In 2003, la Cité mounted a temporary exhibition on global warming called *ClimaX* that was intended to be provocative and make visitors aware that the climate is changing. The image below shows a view of a four-sided theater that immersed visitors in a constantly changing series of images related to global warming and its impact on people throughout the world.



Figure 17: Immersive theater showing images on global warming at la Cité, Paris.

In October 2006, la Cité in Paris mounted another temporary exhibition on global warming entitled, *A New Era*. Because public awareness of global warming in France is now significantly higher, this exhibition sought to help visitors envision a future in which they would still live comfortably, but with a much smaller expenditure of energy and other resources and have a significantly smaller ecological footprint. The exhibition covered common activities such as transportation, energy use, and food. The exhibition closed in August 2007.

Science Museum (London, England) – Antenna News

The Science Museum has an extensive program devoted to public understanding of current science and technology, called *Antenna News*. Produced by a full-time staff of eight, this program has larger kiosk-type exhibits that change semi-annually and smaller exhibits that change every few months. There is also a strong web presence that now accounts for one quarter of the hits to the Science Museum's website.

The small mini-exhibitions, referred to as “rapids”, have an interactive computer component based on a standard user interface that allows the museum to quickly change topics while offering a variety of video clips, text information, and visitor response opportunities. In general, these exhibits include some real objects related to the topic and one or more text/graphics panels.

One of these mini-exhibitions focused on a controversial proposal to remove CO₂ from the atmosphere by encouraging the growth of plankton in the oceans. This growth would be promoted by seeding the ocean with microscopic particles of iron, which is the limiting nutrient for plankton growth. The experiment could be carried out on a small scale and could be scaled up, if successful. Visitors have the opportunity to see video clips with views both pro and con, consider the science, economics, and politics of the proposal, and enter their own opinion for other visitors to read.



Figure 18: Temporary exhibit on global warming at the Science Museum.

C. TRAVELING EXHIBITIONS

Museum of Man and Nature (Munich, Germany) – *Everyone Can Protect the Climate!*

During the summer of 2007, the Museum of Man and Nature hosted a traveling panel exhibition on climate protection created by a regional consumer protection board. This exhibition takes a strong advocacy position and provides numerous recommendations on how consumers can reduce their contribution to atmospheric CO₂.

The exhibition has relatively little science content and goes straight to the bottom line of what individuals should do about global warming. There is one computer interactive matching game and a didactic video in which a professor answers questions about global warming from teens sitting in an alpine setting.



Figure 19: Traveling panel show on climate protection at the Museum of Man and Nature, Munich.

The exhibition consists primarily of text panels in which the text is exposed by opening doors. The sheer volume of text, the font size, and its low physical position on many of the panels makes it difficult to absorb much of the information. Perhaps the most useful part of the exhibition is the accompanying printed information, which visitors can take home and digest over time.

German Museum of Technology (Berlin, Germany) – Energy @ Home

Energy @ Home is a traveling panel exhibition, developed by the German Foundation for the Environment (www.dbu.de) and the German Energy Agency (www.dena.de), which seeks to help consumers save energy and protect the environment. The exhibition is divided into sections

that address how to save energy at home or make environmentally conscious decisions in the areas of:

- electrical power usage
- heating
- ventilation
- reducing infiltration of air
- alternative energy selection
- climate protection



Figure 20: *Energy @ Home* traveling panel show at the German Museum of Technology, Berlin.

In addition to extensive text and graphics panels, several interactive exhibits support the text panels. Included are an energy bicycle, a freezer demonstrating four different types of insulation on the lid, a working solar cell, and others. The exhibition strongly advocates personal actions to reduce energy consumption at home and encourages the use of renewable energy sources. A

series of printed brochures helps consumers with information to read at home on each of the topics covered in the exhibition. All exhibit text and brochures are in German only.

Natural History Museum (London, England) – *Ice Station Antarctica*

This large traveling exhibition was developed by the Natural History Museum in cooperation with the British Antarctic Survey, as part of the International Polar Year (2007-2008) and its focus on polar research. The exhibition seeks to introduce visitors to polar science and encourage younger visitors to consider a career in polar research by presenting them with information, personal stories of what current researchers actually do, clothing, research equipment and specimens, and challenging questions such as: “Could you survive the cold?”; “Could you dive under sea ice?”; “Could you collect seal poo?” The exhibition begins with a short visit to an ice room at -10 °C. Next, visitors learn about the clothing worn by polar researchers and can try on parkas and other items. Text panels provide interesting vignettes from actual researchers.

There is little mention of global warming, despite the concerns many polar scientists openly express. In the few instances where rising temperatures are mentioned, no connection is made to CO₂ or human activities. For example, one label states that: “Lots of sea creatures are adapted to the cold sea water in Antarctica. But the planet is getting warmer each year. Scientists are studying what will happen to the Antarctic sea creatures if the sea warms up, too.”



Figure 21: *Ice Station Antarctica* at the Museum of Natural History, London.

Teknikens Hus (Lulea, Sweden) – *Cold Poles, Hot Stuff*

This interactive traveling exhibition, which was created by Teknikens Hus for the International Polar Year, opened at the Swedish embassy in Washington, DC before its first European venue in Lulea.

The exhibition makes only minor references to global warming and focuses on helping visitors become more aware of the geography of the polar regions, the types of research being done at the poles, climatic conditions there, and a few highlights of polar science.

A pair of large floor maps lets visitors compare the Arctic and Antarctic and learn that the polar regions start at 60 degrees of latitude. Visitors can step into a small cold room, learn how ice cores provide clues to past climatic conditions, and try to build a small mechanical assembly wearing the bulky gloves worn by polar researchers. Matching games and simple challenges help visitors learn the differences between the kinds of animals and conditions at the two poles,

and a simulated deck of an ice breaker features several binocular-like viewers with projectors showing video clips from the poles.



Figure 22: Cold Poles, Hot Stuff at Teknikens Hus.

Nacka Nature School (Stockholm, Sweden) – Grasping Climate

Grasping Climate is a highly interactive traveling exhibition on global warming with a strong focus on renewable energy and the role of personal choice in reducing CO₂ emissions. The exhibition was created by Teknikens Hus in 2004 and has been on a European tour since its opening in Lulea, Sweden.

When visited, the exhibition was on display at the Nacka Nature School, one of about 80 nature centers supported by municipalities in Sweden. This nature center is one of 15 in the region around Stockholm. The staff of the center had seen the exhibition when it appeared at the museum of Science and Technology in Stockholm and thought it would help them anchor their planned fall 2007 theme on global warming. They requested a special extra allotment of \$40,000 from the community of Nacka and received immediate and enthusiastic approval.

The exhibition starts with a video on global warming that was created by the Science North science center in Sudbury, Canada. The video is narrated by a sheep cartoon character, who introduces the key issues in a way that is both entertaining and yet makes an impact. The exhibits help visitors experience and understand the science behind a variety of forms of renewable energy, including solar, wind, wave, hydroelectric, hydrogen fuel cell, and biomass systems. A Magic Planet globe shows a rotating view of the Earth from space that alternates between day and night, with the night view showing the dramatic amount of light emitted by our cities.



Figure 23: Exhibit demonstrating generation of wind energy from *Grasping Climate* at the Nacka Nature School, Stockholm.

The exhibition ends with a contemplative exhibit, challenging visitors to consider the amount of atmospheric CO₂ that could be saved by various personal actions. Visitors may record their pledge by dropping a pebble into a clear tube.

D. INDIVIDUAL EXHIBITS

Although a number of European museums did not have any major exhibitions related to global warming on display or planned, they nevertheless had one or more individual exhibits related to the topic. Several are described below.

Technopolis[®], the Flemish Science Center (Mechelen, Belgium)

At Technopolis[®], a Magic Planet spherical projection system allows visitors to view animated climate and other geophysical Earth data. Another exhibit lets visitors direct an overhead blower at various wind turbines to experiment with the efficiency of blade designs.



Figure 24: Exhibit comparing the efficiency of rotor blades at Technopolis[®].

Heureka (Vaanta, Finland)

Heureka has created several new interactive exhibits on recycling, reuse, and the energy used in common products and their packaging. The multilingual signage and exhibits help visitors learn about trade-offs in the selection of products, based on their source as well as their packaging.



Figure 25: Exhibit on energy and recycling of common food containers at Heureka.

E. PROGRAMS

Two museums in the study group have regular public programs that are not related to any exhibitions already described.

Technorama (Winterthur, Switzerland)

A regularly scheduled demonstration at Technorama uses devices to show small groups of visitors about the greenhouse effect and the ozone hole. The first demonstration, shown in the photograph below, has a small globe with a thermal sensor, a clear Plexiglas[®] box, and a heat lamp. After turning on the lamp, the temperature rises on an analog electrical meter, demonstrating the greenhouse effect. The demonstrator then pours CO₂ into the clear box (replacing the air within) and seals it. The temperature increases further, as shown by the meter. The demonstrator describes that this increase is due to the fact that CO₂ is a more effective greenhouse gas than regular air.



Figure 26: Regularly scheduled demonstration of the greenhouse effect at Technorama.

National Museum of Science and Technology (Milan, Italy) – Energy i.Lab

One of the National Museum of Science and Technology’s many interactive laboratories (i.Lab) focuses on energy, with a significant emphasis on renewable energy. Through regularly scheduled public and school programs, staff members work with visitors on activities related to various aspects of energy. A bank of energy cycles lets visitors experience how much work it takes to charge various batteries. Other activities include making a solar pizza oven, experimenting with solar cells, and investigating the principles of hydroelectric power and hydrogen as an energy source.



Figure 27: Energy cycles in the *Energy i.Lab* at the National Museum of Science and Technology ‘Leonardo da Vinci’ in Milan.

At-Bristol (Bristol, England)

At-Bristol organizes a special *Gifted and Talented* day on climate change at local schools. Aimed at 11-14 year olds, the program includes presentations, exhibition trails, environmental workshops, and local university experts. Another At-Bristol school program, *Rot and Recycling* day, is designed to challenge students and give them opportunities to investigate waste,

recycling, and the human impact on the environment. The program includes hands-on recycling workshops, interactive trails around At-Bristol venues, and “Meet the Animals” and “Meet the Expert” sessions.

At-Bristol is also a member of the Bristol Natural History Consortium, an alliance of various local organizations, such as the Avon Wildlife Trust, the BBC Natural History Unit, and the World Wildlife Fund, UK. The Consortium promotes the understanding and appreciation of the natural world and organizes such activities as a large public festival, conferences, communications toolkits, and educational and outreach projects (e.g., *Think or Swim*, a film production project where young people made films about climate change for other young people).

F. EXHIBIT SIGNAGE MENTIONING GLOBAL WARMING

Several museums referred to global warming through the labeling of exhibits focusing on other topics. These references are described below and are significant in that they represent a willingness of the museum to go on public record with its concerns about global warming, even if the references do not represent a financial investment in the form of an exhibition or educational program.

Natural History Museum (Berlin, Germany)

In the summer of 2007, the Natural History Museum in Berlin hosted an impressive exhibition of color photographs related to sustainability. One section addressed global warming with the words:

“Through the use of fossil fuels and the destruction of forests, which in large part take up CO₂, the CO₂ in the atmosphere has increased exponentially during the past 250 years. Today we know that this increase leads to global warming and must be reduced.”

Universum (Bremen, Germany)

In a major permanent exhibition on the Earth that includes a section on weather and climate, Universum discusses changes in climate over geologic and human time scales. A cold room lets visitors touch a massive slab of ice; and signs on the wall make reference to climate change with such statements as:

“We used to be able to go sledding every winter...”

In a video, a professor describes her work with ice cores and how the data are used in reconstructing the state of the climate over time.

A text panel describes the greenhouse effect and the impact of our emission of CO₂ since the beginning of the Industrial Revolution. One portion of the panel reads:

“Through the anthropogenic greenhouse effect, not only will the climate zones probably move, but also the ocean currents will also change. There are indications that the Gulf Stream will weaken. For Europe, this will have the unpleasant result that it will become significantly colder.”

SiemensForum (Munich, Germany)

SiemensForum is a museum of Siemens’ products (primarily electrical) developed throughout its corporate history. In a gallery that highlights industrial and consumer products, the signage mentions the company’s concern about global warming and the energy efficiency of its products:

“...research in lighting and household appliances is increasingly being influenced by environmental considerations...”

Another label states:

“By 2030, the world’s population will reach about eight billion – almost one third more than today. And all of them will need energy. This, along with the rapid economic growth in Asia, will lead to an energy demand about double that of today. The constraints will stem more from the carbon dioxide emissions and their negative impact on the climate than from our limited energy resources.” (emphasis added)

Science Museum (London, England) – Meteorology Area

One of the Science Museum's old permanent exhibitions is on meteorology. It is primarily an historical treatment that documents the development of meteorological instruments throughout history. One otherwise unremarkable cabinet contains a poster behind glass entitled "Why Care about Climate Change?" Although unassuming in its design and placement, this poster is nonetheless provocative in its message, which states:

"Effects of climate change will cost some people their lives, some their homes and livelihoods and will cost the world billions of dollars... People will have to reduce emission of greenhouse gases if they want to reduce global warming. This will mean taking expensive decisions and choosing cleaner sources of energy. Governments might introduce higher taxes to encourage the reduction of greenhouse gas emissions."

Other sections of the panel discuss the predicted effects of climate change, such as altered patterns of precipitation, water shortages, and extreme weather, in addition to increased global temperatures.

G. IN DEVELOPMENT

Klimahaus Bremerhaven 8° Ost (8 Degrees East) (Bremerhaven, Germany) – New museum under construction (opening on March 1, 2009)

Klimahaus is a remarkable experiment in many ways. Conceived as an edutainment destination for the city of Bremerhaven, this \$100 million (€70 million) investment is focused entirely on global warming and is betting that 600,000 visitors per year will pay for the experience of learning more about it.

Under construction as of this writing, the building will be a striking glass-clad, pod-like structure that may evoke the image of a cloud to many people. There are few right angles inside, and almost all of the exterior glass panels are custom-sized. The image below shows the inner concrete structure of Klimahaus as of August 2007, with a high rise hotel under construction in the background. A webcam shows the construction site in real time.



Figure 28: View of Klimahaus under construction in Bremerhaven (with high rise hotel in background).

The museum will have three sections. The first section will tell the story of the lives of people in eight places located along the circle of longitude passing through Bremerhaven. Displays of cultural objects, artistic staging, and multimedia installations will show the impacts of climate on people living in these areas and how they have adapted to it. This biggest section is intended to let visitors experience the different climate zones.

The second section will look at the science of climate using as a metaphor the ancient Greek elements of Earth, Wind, Fire, and Water. This section will have a variety of hands-on interactive exhibits to help visitors understand concepts such as energy, albedo, hydrology, and other aspects of climate.

The third and final section will be on climate research, why climate has changed in the past, and how it will probably change in the future. By letting the protagonists from the places visited in the first section tell how their lives might change through the year 2050, the issue of climate change will be brought from “something that affects people somewhere else” to a more personal level. An extra section is intended to help visitors reflect on the question, “What can I do about

global warming myself?” If successful, the experience of Klimahaus will lead to a heightened awareness and an increased personal commitment to reduce greenhouse gas emissions.

Explore-At-Bristol (Bristol, England)

In 2008, At-Bristol plans to re-introduce several individual exhibits on sustainability and global warming from an outdoor venue it closed in 2007 and that were in storage at the time of this writing. According to staff, a group of interactive exhibits will be refurbished and brought back into one of its indoor galleries.

Techniquet (Cardiff, Wales)

Techniquet plans to develop a series of outdoor exhibits on sustainability that will include several exhibits on global warming. Staff members anticipate these exhibits will be completed by 2009.

Universeum (Gothenburg, Sweden)

Universeum has received major funding to develop a permanent exhibition on global warming. The first exhibits to open will focus on weather, including a live camera and green screen where visitors can try presenting a weather report. Other exhibit areas are currently in the conceptual stage.

Science Museum (London, England) – *Global Warming Exhibition*

The Science Museum is planning a major exhibition on global warming, which will open in several years in its Wellcome Wing. The museum’s new director is a distinguished polar

scientist who was previously at the British Antarctic Survey and who is deeply committed to positioning the Science Museum as a key player in the public understanding of global warming. Planning was still at the conceptual stage, as of this writing.

SECTION 4

INTERNAL SUSTAINABILITY INITIATIVES

Several museums in Europe have linked their internal operational procedures to environmental sustainability. This section describes a sample of what several museums are doing in this area. Because most museums have been recycling paper and other materials for many years, recycling is assumed and is not described below.

The Eden Project (Cornwall, England)

Running itself as a sustainable business is embedded in essentially all aspects of the Eden Project. Eden manages its resources, procures its food, administers its business, and enters into relationships guided by the set of core values it has identified for itself – to live as “lightly” on the Earth as it can. Its aim is to eventually be waste-neutral, carbon-neutral, self-sufficient in water, and to produce its own energy.

Three key elements of its sustainability efforts include:

- *Local Sourcing* – 61% of purchasing and 83% of food supplies are bought from sources in Cornwall.
- *Energy* – All electricity is purchased from renewable sources, and they have installed photovoltaic panels and a small wind turbine, and are working on a biomass boiler that will burn locally sourced wood. All net CO₂ emissions are offset through their carbon offset fund, which supports sustainability projects worldwide.
- *Waste* – Waste is constantly reviewed to look for ways to reduce it. Eden attempts to re-use whatever it can, recycle what’s left, and source items from recycled materials whenever possible.



Figure 29: Panels describing several of the Eden Project’s sustainability outreach efforts, which are funded by its own carbon offset fund.

In some cases, contractors are required to meet sustainability standards for products and services they supply. Visitors are strongly encouraged to travel to Eden by public transportation, if possible. Appliances, such as electric hand dryers in the restrooms, are low-energy, high-efficiency models, and signage helps visitors understand their advantages.

Through these measures, Eden seeks to reduce its own environmental footprint to a minimum and, by letting its visitors know what it is doing and why, inspire them to do the same.

Technquest (Cardiff, Wales)

Technquest designed its building with energy efficiency as a key factor. The long south side of the structure is composed of glass (right wall is the image below), which passively collects solar heat and significantly reduces heating requirements in the winter. Technquest has also installed high-efficiency lighting and a high-efficiency boiler. Originally, it attempted to identify a geothermal heating system, but concerns about possible water pollution at the time eliminated the geothermal option.



Figure 30: Passive solar energy collection and natural lighting at Technquest.

La Cité des Sciences & de l'Industrie (La Villette, Paris, France)

La Cité has hired a part-time sustainability coordinator to spearhead the development of internal operational practices that reduce waste and the organization's carbon footprint. The center has also begun to experiment with voluntary sustainability guidelines for its contractors. These

guidelines will likely become requirements in the future and may cover details such as acceptable materials for exhibits, chemicals used in cleaning, and other internal processes.

Universeum (Gothenburg, Sweden)

Universeum has a dual internal waste water system that separates restroom solids and liquids at the source and treats the liquids inside the building to a standard where they can be safely discharged outside. They have also prohibited the purchase or sale of bottled water on the premises.



Figure 31: Source separation of waste at Universeum, Gothenburg.

Tom Tits Experiment (Södertälje, Sweden)

Tom Tits Experiment has a commercial device it uses to compost all food waste from its restaurant and nursery school. In addition, the center has established a series of long- and short-term sustainability goals, which include:

- create one new exhibit on sustainability each year
- replace electric heaters with hot water from the city's distribution system
- reduce the number of chemicals used in operations
- increase the environmental awareness of visitors

The center has a five-year plan to reduce its contribution to atmospheric CO₂ through:

- encouraging visitors to use public transportation
- buying locally grown food for their restaurant, when possible
- increasing the level of insulation of the building
- continuing to compost all food waste
- evaluating the feasibility of wind generation of power and installing a system, if feasible

In addition, as a part of a ten-member group of municipal organizations, the center will seek certification according to a set of Swedish standards for sustainable business practices.



Figure 32: Composting machine handles all food waste year-round at Tom Tits Experiment, Södertälje, Stockholm.

Nacka Nature School (Stockholm, Sweden)

The Nacka Nature School maintains several building systems it uses to demonstrate the feasibility of alternative technologies to its school visitors. The center produces its own hot water with a building-mounted solar panel. It separates restroom wastes at the source and treats its own liquid waste water through a biological system. The tanks are located in one of the teaching classrooms and produce water clean enough to support fish and to be released into the Baltic Sea.



Figure 33: Solar hot water system at the Nacka Nature School, Stockholm.

SECTION 5

ANALYSIS AND RECOMMENDATIONS

A. INFORMATION, ADVOCACY AND GLOBAL WARMING

Museums in the European study group, for the most part, view their role as helping visitors to become more aware of global warming as a phenomenon, understand the science, and learn to make decisions that will protect the environment, especially with respect to CO₂ emissions. Two trends, however, are affecting their response to these goals.

- ***Increasing speed of climate change.*** The public perception in Europe is that climate change is accelerating and that the window of opportunity for humanity to avoid a “point of no return” or runaway global warming scenario may be narrower than most people have previously thought. This perceived shortening of the time available to address global warming has introduced a new sense of urgency for both visitors and staff.
- ***People want answers.*** Seeing a dramatic increase in the number of media stories related to global warming, people are seeking advice on what they can do at a personal level. As one museum staff member put it, “Rome is burning, and we (the museum community) are still teaching the science of combustion.”

These two factors are pulling museums away from their traditional role of providing irrefutable and well-accepted information about science and moving them toward advocating actions to reduce global warming. A number of museums expressed that this change in emphasis is proving uncomfortable and that they feel a need to act soon but are reluctant to risk compromising the public trust that museums have.

Some museums have booked traveling exhibitions that advocate specific actions to mitigate global warming; however, as noted, these exhibitions are insufficient to generate change if they come for a few months and then leave with no apparent change in the organization itself or its operations.

Overall, museums in Europe appear to be gradually ramping up their level of advocacy with regard to global warming solutions in a conservative way that makes use of relatively well-established concepts and does not expose them to criticism from stakeholders who are unconvinced that global warming is a problem.

B. INCREASING THE IMPACT OF EDUCATION ON GLOBAL WARMING

Based on observations at the museums of the study group, there are several ways that public education on global warming can be made more effective. While several recommendations below (1 and 2, in particular) could apply to almost any educational activity at a museum, they are particularly relevant to education about global warming, where the intended impact extends beyond knowledge and understanding and enters the realm of visitor actions and changes in behavior.

1. *Start with the intended impact.*

A surprising number at exhibitions and programs on global warming do not “connect the dots,” leaving significant gaps between what the designers intended and what the audience actually experiences. To reduce these gaps, designers may want to develop a “logic model” during the planning phaseⁱⁱⁱ, use formative evaluation during development, and ensure that a summative evaluation is conducted at the end of the project. Logic models provide a simple way to start with the intended impact of a project and work backward to determine a logical sequence of exhibits, programs, and/or other educational activities that will lead to the desired results.

2. *Look beyond today.*

Good exhibitions take years to develop. With the field of global warming changing rapidly, almost everything a museum creates on the topic has a limited shelf life. Museums therefore should look several years out by analyzing trends, forecasting likely audience needs, and designing exhibitions accordingly.

3. *Walk the talk.*

Efforts to educate the public, whether through information or advocacy, have more impact when an organization “walks its own talk” or practices itself what it presents to visitors. For example, museums that encourage their visitors to use green power and buy locally sourced food (to reduce the CO₂ emissions associated with transportation) will be much more credible if they use green power themselves and use locally sourced food in their own restaurants and vending machines (and let their visitors know about these choices).

In many cases, walking the talk costs extra: recycled stationery is more expensive than non-recycled, and wind-generated power costs more than power from fossil fuel. However, the message from European museums was clear: aligning an organization’s own actions with its educational message is a key part of effectively delivering the message. In most cases, this requires top-down vision and financial support from the board and director, as well as bottom-up buy-in from staff, who are often in the best position to identify potential improvements in sustainable practices. In addition, staff involved in recommending changes are more likely to support their implementation.

4. *Identify the “elephants in the room.”*

If museums hope to have maximum impact, they should make sure they identify the key issues related to climate change and address them in their exhibitions and programs. This requires stepping back and looking for the “elephants in the room,” i.e., important issues related to climate change that may otherwise be missed or avoided. For example:

- What are carbon offsets? Where does the money actually go? How do carbon credits work? How effective are either of these in reducing global warming?
- What are the pros and cons of switching from a carbon-based to a hydrogen-based energy economy?

- To what extent is global warming related to world population, and are museums willing to address this potentially contentious issue?

5. *Focus on what museums do best.*

What unique value-added can museums offer in the effort to reduce global warming and its impacts? The media have effectively brought the issue of global warming to the attention of the public. Many newspapers and news networks are now averaging more than one article on global warming per day, and many non-profits have emerged to provide information, advocacy, and resources for further information.

Museums have unique capabilities and attributes, such as:

- Providing a non-political public forum for the discussion of confusing and/or controversial issues
- The ability to help people understand the science behind the headlines
- A high level of public trust
- Providing experiences with real things, such as historical objects and hands-on interactive exhibits
- Providing an engaging environment where children, adults, and families can come, learn, and share experiences together

Museums should make use of their strengths and avoid spending scarce resources on activities that other types of organizations can do better and/or with greater impact.

6. *Build a positive future.*

Global warming, like many environmental issues, does not invite celebration in the same way that space exploration and nanotechnology do. Predictions of a gloomy future are more likely to cause people to simply move on to another exhibition in the museum, rather than inspire them to make personal changes to reduce global warming. Exhibits or programs have the best chance of inspiring changes in visitor understanding and behavior if they tell a compelling story that: 1) convinces visitors that there is a problem without scaring them, 2)

provides hope and a roadmap to a sustainable future, and 3) helps visitors understand how their personal actions can make a difference.

7. Separate information from advocacy.

There is growing debate on whether science museums and centers should take a position on global warming, similar to the way in which zoos and aquaria advocate for wildlife and ocean conservation, or in which scientific organizations like the American Association for the Advancement of Science (AAAS) advocate action to reduce global warming.

Representatives of many European museums indicated that, although they normally are not comfortable in the role of advocate, on this issue they feel increasingly compelled to advocate action by those they serve. The transition from information provider to advocate involves shades of gray, and museums need to be clear about the alignment between their message and their mission.

8. Share successful practices through museum networks.

European museums are currently experimenting with a wide variety of innovative exhibits and programs related to global warming. Using networks such as the British Interactive Group <http://www.big.uk.com> or the Association of Science-Technology Centers listserv ISEN-ASTC-L, www.astc.org/profdev/listserv.htm, museums can get ideas and feedback from other museum professionals and educators. Museums can share what has worked best, to help others zero in on what approaches will have the greatest impact.

Another useful resource for museums developing exhibitions on global warming is ExhibitFiles.org, an online community for exhibit designers and developers. Users can share information, write and check reviews of existing exhibitions, and post blogs.

IGLO (International Action on Global Warming) is a program of ASTC that provides a broad forum for sharing resources, including an extensive online toolkit of floor demonstrations, exhibits, programs, web links, and other educational materials. The IGLO toolkit is available

at: www.astc.org/iglo. As museums develop exhibits and programming related to global warming, they should consider posting their best exhibit and program practices on the IGLO Global Warming Toolkit for others to use. These resources can be especially valuable for smaller museums and organizations lacking the ability to develop programming on their own.

C. “SUSTAINABILITY INDEX” SELF-ASSESSMENT TOOL FOR MUSEUMS

The study group demonstrated a wide variety of exhibits, programs, management practices, and other operational aspects related to sustainability. Many institutions were working diligently to incorporate sustainability into both their management practices and educational offerings, but there was relatively little evidence of communication between institutions regarding progress, issues, and sharing of best practices.

It became clear that a simple tool, addressing the special characteristics of museums, would both help museums assess where they are with respect to sustainability and assist them in charting a well-defined course for future investments.

To facilitate such assessment and communication, both within and among organizations, the Museum Sustainability Index (MSI) was developed. Table 2 suggests criteria and ratings that range from 0 to 5 for both the internal (management) and external (educational) aspects of sustainability. The tool is simple enough to yield a result in a few minutes.

The rating works best as a group activity. The facilitator should introduce the exercise, define terms such as “sustainability” and “triple bottom line.” It works well for groups of 2-3 individuals to do the rating and then for the facilitator to go quickly around the room and ask for the ratings (without comments) to get a sense of the variability. Open discussion usually follows.

Internal and external ratings should be expressed as integers (only). They should be listed separately (not summed or averaged) for both the current status and the desirable future status (goal), such as: “Current: 3-2; Goal: 4-4” At one end of the scale, an organization with no interest or concern for sustainability in either its management practices or educational offerings might rate itself as 0-0. At the other end of the scale, an organization with a highly integrated, well-developed, and continuously improving approach to sustainability could give itself a rating

of 5-5. Note that at the highest level (5), being sustainable is a process of continually getting better and becoming more aware of opportunities, rather than a final destination to be identified and reached.

The Museum Sustainability Index tool aims, in large part, to promote conversations within an organization. It is therefore advantageous to invite as many staff, board, and other stakeholders as possible to rate the organization. The MSI requires no measurements or surveys and is also an assessment of how well existing sustainability efforts are being communicated.

As used in the MSI, “internal” refers to management and operational practices that visitors see only occasionally, if at all. The MSI takes a broad approach to the definition of sustainability, including economic and human resource considerations as well as environmental considerations.

- Most people think first about the environment when they think of sustainability. Museums have adopted a wide range of environmentally friendly practices, from recycling paper and beverage containers to buying green power, sourcing food locally, and using green materials and cleaning product wherever possible.
- A museum with a viable 5-10 year business plan and relatively stable, long-term sources of revenue has greater financial sustainability than those that plan from year to year. For example, applying net revenues from one-time blockbuster exhibitions to special one-time projects represents a more sustainable approach than relying on such revenues to make up a structural deficit in a given year.
- Staff represent the largest expense category for most museums, and those museums having a positive working climate and effective human resource procedures to train, develop, evaluate, and retain employees have a more dedicated workforce and a significant long-term advantage in the knowledge-based economy of the 21st century.

The term “external” refers to outward-directed educational efforts that include exhibitions, programs, publications, websites with substantive information, podcasts, and other types of communication that reach target audiences with educational messages. External efforts can include sustainability in a variety of ways, ranging from modification of existing programs or exhibit labels to new exhibitions and programs on topics specifically related to sustainability.

Most educational (external) offerings by museums related to sustainability address environment issues, although some museums have created exhibitions or programs on economics, money, and finance.

The MSI can help an organization assess itself in several ways, including:

- **Position:** the extent to which the organization currently incorporates sustainability into its internal management systems and external educational offerings.
 - **Momentum:** the extent to which it strives to continuously improve its sustainability-related practices and level of emphasis on sustainability in its educational offerings.
- Goals:** where an organization would like to be in the future with respect to sustainable practices.
- **Alignment:** the extent to which staff, board, and other stakeholders agree in their ratings. Differences in ratings between stakeholder groups may indicate the need for better communication or reflect differences in goals.

Table 2. Museum Sustainability Index

Instructions:

Use the accompanying table to rate your organization with respect to:

- A. Internal management practices (things visitors normally don't see)
- B. External educational offerings (activities aimed at visitors)

Rate the current status and a goal for where you would like the organization to be positioned in the future.

Use whole numbers only.

Some useful definitions:

SUSTAINABILITY: *Meeting the needs of present generations without compromising the ability of future generations to meet their own needs.*

TRIPLE BOTTOM LINE: *When making management decisions at a museum, taking into account the interconnectedness of environmental issues, economic concerns, and the wellbeing of staff and other stakeholders.*

Record your ratings here:

	A. Internal Management Practices	B. External Educational Offerings
Current Status		
Future Goal		

Table 2. Museum Sustainability Index (cont).

Choose the number that best describes your organization.

	A. Internal management practices		B. External educational offerings	
<i>“Off the Radar”</i>	0	Sustainable management practices of little or no concern	0	Educating the public about environmental sustainability of little or no concern
<i>“Tuning In”</i>	1	Sustainable practices of slight interest ; small steps taken (e.g., paper, bottles are recycled)	1	Educating the public about sustainability of slight interest ; small steps taken (e.g., one-time exhibition or presentation)
<i>“Beginning”</i>	2	<p>Growing awareness of sustainability as an issue</p> <ul style="list-style-type: none"> • May have formed a study group or “green team” to advise on next steps 	2	<p>Actively planning exhibits, programs, publications, or other educational offerings</p> <ul style="list-style-type: none"> • May have prototyped an exhibit or program idea • May have hosted a temporary exhibition
<i>“Developing”</i>	3	<p>Demonstrated initial progress on one or more:</p> <ul style="list-style-type: none"> • Museum systems that protect or improve the environment • Budget that ensures long-term financial stability of the organization • Human resource practices that foster the development & retention of all employees • Use of triple bottom line in management 	3	<p>Demonstrated initial progress on one or more:</p> <ul style="list-style-type: none"> • Permanent exhibits • Regular programming • Publications, web sites, or other communications • Workshops, events, or other educational offerings
<i>“Integrating”</i>	4	<p>Demonstrated substantial progress on three or four:</p> <ul style="list-style-type: none"> • Museum systems that protect or improve the environment • Budget that ensures long-term financial stability • Human resource practices that foster the development & retention of all employees • Use of triple bottom line in management 	4	<p>Demonstrated substantial progress on three or four:</p> <ul style="list-style-type: none"> • Permanent exhibits • Regular programming • Publications, web sites, other communications • Workshops, events, or other educational offerings
<i>“Whole-Body”</i>	5	<p>Integrated approach, including sustainability in all areas of internal management:</p> <ul style="list-style-type: none"> • 0.5% or more of annual operating budget is earmarked for environmental sustainability • Triple bottom line is part of all decisions • Identifying & implementing new sustainable practices is a regular, ongoing process • Internal sustainability efforts are actively shared both internally and externally 	5	<p>Sustainability actively incorporated into many educational offerings:</p> <ul style="list-style-type: none"> • Exhibits, programs, publications, etc. • Triple bottom line is part of all decisions • Identifying & implementing new ways of educating about sustainability is a regular, ongoing process • Educational efforts about sustainability are actively both shared internally and externally

Potential specific applications for the MSI include the following:

1. ***Fostering conversations about where you are and where you might want to go.*** By having staff, boards, advisors, and other stakeholders rate an organization's MSI, management can quickly assess the current status of the organization with respect to both the internal and external aspects of sustainability. The scale provides a simple set of benchmarks so that managers can discuss how far and how fast they want to proceed with sustainability efforts.
2. ***Assessing how well an organization is communicating its sustainability efforts:*** By comparing MSI ratings from groups of staff, board, and visitors, an organization can quickly identify gaps in its educational messaging. With relatively little investment, an organization can more effectively promote its sustainability efforts (which may be considered itself an educational goal).
3. ***Setting internal and external priorities:*** Setting priorities is challenging. Individuals often differ on what is most important. Some may feel that educational programs and exhibits are more important, while others might feel that getting the organization's house in order, reducing its energy usage and setting a good example with green operational practices is more important. The MSI provides a quick assessment of where the biggest and easiest gains are likely to be made.
4. ***Progressing from project-based to institutionalized sustainability:*** When beginning to pursue sustainability, there is a tendency to view the effort as a project with a beginning and an endpoint. For example, an exhibit may be conceived, built, and put on display; or light bulbs may be changed from incandescent to compact florescent as a project. However, sustainability is better viewed as a continuous, ongoing process of improvement with no endpoint, similar to innovation or diversity. The MSI addresses both the continuous process and improvement aspects of an effective sustainability program.

D. CONCLUSIONS

This study was conducted to see how European science museums, science centers, and related organizations represented sustainability and the issue of global warming to their audiences at a particular point in time. The study involved visits to 34 organizations in 10 European countries and led to three main results:

1. A snapshot summary of exhibits, programs, and other activities related to global warming and sustainability in the summer and fall of 2007. The picture was changing rapidly, even during the course of the study, and will be dramatically different in a few years. The exhibitions, programs, and practices described in this report can be thought of as a baseline, against which future developments can be compared.
2. A set of eight suggestions on how to increase the impact of educational efforts to communicate global warming and sustainability to public audiences. To achieve the closest match between the educational goals of the museum and the experience of visitors, museums should:
 - a. Start with the intended impact
 - b. Look beyond today
 - c. Walk the talk
 - d. Identify the elephants in the room
 - e. Focus on what museums do best
 - f. Build a positive future
 - g. Separate information from advocacy
 - h. Share successful practices through museum networks
3. A new self-assessment tool for museums and other informal educational organizations called the “Museum Sustainability Index (MSI).” MSI fosters communication within and between organizations relative to sustainability and helps

in evaluating competing demands, setting priorities, and assessing the results of investments in sustainability.

Museums enjoy a unique position in society as trusted sources of information and accessible places where the public can experience real things, such as historical objects or hands-on exhibits. To the extent that museums can leverage their position and resources effectively, they can make a significant impact on the future by contributing to the development of a new generation that is prepared and inspired to create a sustainable future.

Endnotes:

ⁱ A description of sustainability is provided in <http://en.wikipedia.org/wiki/Sustainability>

ⁱⁱ An extensive survey of museums and public trust was conducted for the American Association of Museums in 2001 http://www.nationalmuseums.org.uk/images/publications/parents_attitudes.pdf. The results indicate that museum were by far the most trusted source of information when compared with newspapers, radio, television, magazines, and books.

ⁱⁱⁱ For a helpful summary of logic models see for example: <http://www.uwex.edu/ces/pdande/evaluation/evallogicmodel.html>