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Opinion

Sustainable Energy Use in Buildings: A Leadership Opportunity for Gardens and Zoos

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Abstract: Cultural institutions hold a unique position of influence, serving as hubs of education and knowledge dissemination for the people they serve. Embracing sustainable energy use in buildings in zoos and botanical gardens is a commitment to environmental responsibility that reinforces these institutions as trusted sources of information and community leaders on climate change, one of the most vital issues of our time. Sustainable energy solutions can synergize operations with educational missions, allowing zoos and botanical gardens to lead by example and inspire visitors to adopt eco-friendly practices in their own lives. In this opinion paper, Phipps Conservatory and Botanical Gardens President and CEO Richard Piacentini discusses key elements in developing a sustainable building energy plan, reviews potential barriers to implementation, and makes a case for adopting regenerative thinking and new metrics for measuring success—citing example cases from Phipps' Center for Sustainable Landscapes (CSL) project. Additionally, the paper demonstrates how green building certification systems and peer-based resource networks like The Climate Toolkit can help guide institutions in the process.

Keywords: energy; climate toolkit; building certifications; OKR (objectives and key results); regenerative thinking

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1. Introduction: The Case for Climate Leadership

Every person in every country in every continent will be impacted in some shape or form by climate change [1]. The National Academy of Sciences position on climate change states that "human activities, especially the burning of fossil fuels (coal, oil, and gas), are responsible for most of the climate change currently being observed" [2].

Leading by example in reducing and ultimately eliminating fossil fuel-based energy in the buildings at zoos and botanical gardens is a commitment to environmental responsibility that reinforces these institutions as trusted sources of information and community leaders on climate change.

There are many evolving metrics that take a holistic view of the impacts of business practices on the climate and environment [3], but the construction and operation of buildings emerges as the most prominent area to address. Building construction and operations are responsible for about 42% of annual global carbon dioxide (CO_2) emissions. Of those total emissions, operations are responsible for approximately 27%, while the embodied carbon of just four building and infrastructure materials—cement, iron, steel, and aluminum—are responsible for an additional 15% [4]. This is why the first priority for institutional leaders on climate must be with their buildings, specifically eliminating their dependencies on fossil fuels, improving their energy efficiency, and utilizing renewable energy sources for the power they need.

Broadly speaking, zoos and botanical gardens are museums with living collections. Collectively, there are over 103,000 museums [5] around the world that reach hundreds of millions of visitors annually. These institutions are some of the most trusted organizations in each of the communities they represent, serving for decades or centuries as repositories for artifacts, public knowledge, and guidance. This level of trust and influence, combined with an existing commitment to protecting the natural world, makes zoos and botanical gardens ideal candidates to lead by example in demonstrating how they can transition their building infrastructure away from fossil fuels to renewable sources of energy. By interpreting their leadership for the public, zoos and gardens can demonstrate that this transition is not a sacrifice, but an aspiration towards making a healthier world for people and the planet.

Taking the initial steps to address climate change can seem overwhelming. It is a complicated subject with multiple avenues of opportunity. According to Architecture 2030, key considerations should focus on centering nature-based solutions, protecting natural resources and sensitive habitats, reusing materials, upgrading existing structures to zero out operational emissions, and considering construction-embodied carbon as well as whole-life carbon emissions within new buildings [4].

To be successful, a comprehensive path toward building efficiency should be based on the following three steps:

I. Assess baseline fossil fuel use.
II. Generate an action plan with appropriate measures of success.
III. Create a design that includes a plan for establishing performance standards.

2. Assessing Baseline Fossil Fuel Use

To start, organizations are encouraged to create a baseline for understanding their fossil fuel use and greenhouse gas emissions. The Greenhouse Gas Protocol Corporate Standard classifies emissions into three "scopes." Scope 1 emissions are direct emissions from buildings and on-site fuel sources. Scope 2 emissions are indirect emissions from the generation of purchased energy (of electricity, steam, heat, or cooling). Scope 1 and 2 emissions are directly related to building operations. Not included in this article are Scope 3 emissions, which are indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions [6]. Various resources exist to help institutions make these calculations, including self-assessment guides [7], partnerships with universities [8], and professional, contract-based assessments, making some form of baseline establishment possible for institutions at a variety of sizes and operating budgets.

3. Generating an Action Plan

Once one has established a baseline, the next step is to develop a plan of action that eliminates the highest sources of emissions. Here too, a variety of resources exist to serve as a guide. One such resource, The Climate Toolkit [9], was developed by Phipps Conservatory and Botanical Gardens [10] in partnership with the American Alliance of Museums, American Public Gardens Association, Botanic Gardens Conservation International, and the Association of Science and Technology Centers as a way for institutions to share, mentor, and learn from each other on ways to address climate change.

The Toolkit identifies nine different areas related to climate change: energy, water, waste, food service, transportation, investments, landscape and horticulture, research, and internal and external engagement. Within those nine different areas, there are specific actions that organizations could adopt to address climate change.

Just as every individual is unique, every organization is unique. The Climate Toolkit's focus areas are not meant to be prescriptive, but a starting point for institutions to develop plans that reflect the unique essence of their organizations and communities. As of March 2024, 156 institutions—representing botanical gardens, zoos, aquaria, and other types of museums—have developed climate plans and all are willing to share their experiences and resources with others.

As one develops a plan, it is important to start by defining areas that make the most sense for the organization and what their community needs. Starting with goals that feel most immediately achievable presents an opportunity to build enthusiasm among employees, supporters, and other stakeholders.

4. Measures of Success

In developing a plan, one of the first obstacles to present itself, particularly when looking at building infrastructure, is financial. This is because many organizations use traditional business metrics such as KPIs (key performance indicators) like ROI (return on investment), to measure success and guide them in their decision making. One major problem with using ROI is that it does not consider all the external costs, which can be significant. In the case of fossil fuels, for example, no ROI calculation appropriately factors in the human and environmental damage from extraction and combustion. This presents one with a grossly inaccurate basis for total cost.

The other major problem with ROI is that it is based on short-term analysis. It does not consider the impact on the future of the organization or future generations. Many institutions have existed for decades, some even centuries, and a priority in their decision making should be to ensure that their decisions put their institutions in the best position for being viable decades and centuries from now.

For zoos, botanical gardens, and other museums, values-based decision making using alternative measures like OKR (objective and key result) makes more sense. With OKR, one starts by defining their objective and then the key results they will use to measure their success. Phipps used this metric in developing the Center for Sustainable Landscapes (CSL) with an objective for it to be a zero-energy building. They then implemented cost-effective strategies that would result in their achieving annual renewable energy production exceeding the annual energy use of the building.

5. Taking a Long-Term View

Without a long-term frame of reference, one can easily steal from future generations. The smartest strategies to adopt are the ones that will lead to the greatest success over the long haul—and this is true of any institution with an interest in its own longevity, no matter how young or old.

Short-term myopic thinking is especially visible in building projects. In response to this, the Packard Foundation completed a study in 2002 (Table 1) [11] that compared the construction of a market-rate building to ones that were built to progressively higher green building standards, starting with LEED Silver and moving up to the Living Building Challenge certification, which is the most rigorous green building standard in the world.

Table 1. Upfront and long-term costs between living and market rate buildings.

The True Cost of Conventional Building: Operational and Maintenance Expenses				
Building Type	**Upfront Design and Build Cost**	**Net Present Value**		
		30 Years	**60 Years**	**100 Years**
Living building	USD 16.6 m	USD 18.7 m	USD 19.6 m	USD 20.8 m
Market rate building	USD 12.6 m	USD 22.7 m	USD 62.9 m	USD 348.9 m

Source: BNIM for the Packard Foundation

In the study, a USD 12.6 million market-rate building was compared to a same-sized building built to the Living Building Challenge standard (USD 16.6 million), representing an initial construction premium of USD 4 million. Many owners, based on traditional metrics such as return on investment or payback period, would select the market rate building. However, if they were to look at the cost to operate that building over the next 100 years, they would see that the market-rate building would cost USD 348 million to operate compared to USD 20 million for the Living Building Challenge building, owing most significantly to electricity, water, and fossil fuel costs coupled with the need for replacement of equipment and materials (as market-rate buildings are currently designed with a life span of 40 years compared to an expected 100 years for living buildings). For a garden or zoo, that means an additional USD 320 million to potentially put towards programming, collection care and more, instead of energy and other expenses—and that comes before factoring in the environmental damage avoided and ecosystem services that would be provided. Twenty-two years later, the case has only strengthened as the up-front cost of building green has come much closer to that of the market rate as more companies and designers have become familiar with the concepts.

Zoos and gardens need to move beyond focusing on immediate payback and start considering the long-term impacts on their institutions and stakeholders (investors, users, co-creators, community, and planet) over the long haul. This kind of thinking requires an entirely new frame of reference—a new lens through which to see the world.

6. Regenerative Thinking

One such lens is regenerative thinking, a mindset which seeks to go beyond sustainability to embrace tenets of inter-connected dynamic relationships and capacity building. One of the best ways to understand this concept can be found in the work of author, educator, and regenerative practitioner Carol Sanford, who contextualizes regeneration by identifying four different paradigms of how we can interact with the world [12].

Sanford first presents the ’Extractive’ paradigm. A person who exists in this way of thinking sees the world as fragments there for the taking. It is all about “me”; a person with an extractive mindset takes what they need without awareness or consideration for who or what is hurt in the process. Colonialism constitutes an extreme example of this paradigm, and versions of it remain dominant in Western societies.

The next paradigm is called ’Less Bad’. A person with a ’Less Bad’ mindset still sees the world as fragments but now is concerned with stabilizing and minimizing the damage. It is not just about “me” anymore; in a ’Less Bad’ paradigm, there is some recognition of interconnectedness. ’Less Bad’ is where the environmental movement started back in the 1970s, with the call to action of reduce, reuse, and recycle.

The third paradigm is called ’Do Good’. In ’Do Good’, the world is still seen as fragments, but there is motivation and understanding that the fragments can be improved; the idea of reciprocity comes to the fore. This paradigm sounds good at face value but falls short of embracing a shared understanding of our existence and requires someone to determine what good is and then impose that on other people, irrespective of the unique essence of their institutions, communities, and bioregions.

The last paradigm is called ’Regenerative’. With a ’Regenerative’ perspective, one does not see the world as fragments; they see it as wholes, nested within wholes. They perceive everything as being connected, with their decisions and strategies arising from an awareness and reverence for the fact that each person is acting in relationship to one another, other species, and everything else on the planet. Regenerative thinking evolves from a systems-thinking perspective that the role of humankind is not to merely recognize the system and stay out of its way but to actively add vitality, value, and capacity—in short, to add life—to all other living systems. This transformational way of thinking is similar to the way many Indigenous people have long seen the world, as evidenced by many Indigenous perspectives, where people are seen as not separate from nature, but part of an interconnected nested system based on respect, responsibility, and an on-going reciprocal relationship with everything else in the natural world [13]. It is a perspective with a long history on this planet, and embracing it is a form of reawakening.

Adopting a regenerative way of interacting with the world can have a significant impact on the decision-making process, as it provokes consideration of areas of impact and potential that conventional considerations often ignore.

7. Creating a Design and Establishing Performance Standards

Just as the Climate Toolkit can help with creating a plan, building certification systems can help a design team and contractors create a design that coalesces around agreed upon goals and metrics. Currently, more than 100 building certifications systems exist around the world [14]. While most of these systems are based on a Less Bad or Do Good view of the world, they can be a helpful starting point for those new to building construction and performance. Choosing a building standard that aligns with the values of an organization will help them select a design team with the experience to meet their goals. Among the most prominent systems focused on energy are three with which Phipps has worked.

- Living Building Challenge: The Living Building Challenge is one of the most rigorous certifications, emphasizing regenerative design and models living systems. The Living Building Challenge has a strict requirement for net-zero energy use. Projects must generate 105% of their energy needs on-site from renewable sources.
- LEED (Leadership in Energy and Environmental Design): LEED focuses on energy efficiency, water conservation, materials selection, and indoor environmental quality. LEED emphasizes energy performance and encourages the use of renewable energy sources.
- BREEAM (Building Research Establishment Environmental Assessment Method): BREEAM is a widely used international certification system that evaluates asset performance—the building itself, construction, fixtures, and installation services as well as management performance—operations and management of the building.

Other popular standards to consider include ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), Green Globes, GBTool (Green Building Tool), and CASBEE (Comprehensive Assessment System for Built Environment Efficiency).

8. Other Considerations

While the following recommendations appear in no particular standard, each is vital to ensuring an effective building design process.

Clearly defining the project goals early in the project is crucial. It is preferable that a specific building standard is identified to inform the selection of a design team with expertise in that area for the project. Connect with green building organizations in the project's region to determine which certifications are used and which architects and engineers have the most experience with energy-efficient buildings. Check references and previous projects. Seek out those who emphasize passive-first design strategies, which focus first on leveraging the nature surrounding the site and the optimization of the architectural design. In a passive-first approach, maximizing features like daylighting and natural ventilation help conserve energy use; the building's overall energy needs are reduced, and net-zero energy becomes more easily achievable. Innovative technology and smart systems could also play an important role, and there are cost-effective ways to employ them. Ample consideration should also be given to the use of the least carbon intensive building materials, operating with zero emissions energy sources, centering nature-based solutions, and building for climate resilience.

Green building strategies need to be site and context-specific, so it is important for one to understand their bioregion and their particular site and features. The types and combinations of passive and active design features employed will vary greatly based on the location. This is an area where The Climate Toolkit can connect one with other institutions operating in similar environments to discover strategies that they found to be effective.

Integrate renewable energy into plans for heating, cooling, and power. Power sources like solar panels may have a higher first cost than other conventional strategies, but over the long run they will more than pay for themselves with no energy bills and lower maintenance costs, not to mention all the positive impacts on reducing global carbon emissions by avoiding the use of fossil fuels [15,16].

Focus on energy efficiency. When selecting building equipment make sure the design team knows how important it is to specify the most efficient equipment appropriate to the project.

Prioritize nature in design. Examine how buildings were designed in the project's region centuries ago, before the introduction of mechanical heating and cooling systems. These buildings were often designed to take advantage of the natural features and climate.

Use natural, native, and locally sourced materials in buildings wherever possible. This helps to minimize some of the embodied carbon found in manufactured materials and it also minimizes energy use in transporting heavy materials long distances.

Conserving water may not be the first thing that comes to mind when thinking about green buildings; however, the purification and transport of water as well as the treatment of any wastewater from the site uses an enormous amount of energy. Explore and implement strategies that minimize potable water use. Emphasize rainwater harvesting, if appropriate, as well as treating wastewater for non-potable uses.

Regarding existing structures, Carl Elefante, former president of American Institute of Architects, said that "the greenest building is the one that already exists." Most of a building's embodied carbon—the amount of greenhouse gas emissions associated with the extraction, production, transportation, and manufacturing of a product—is accounted for by the foundation, structure, and envelope. For this reason, it typically makes sense to reuse these parts of a building rather than to demolish (which also emits carbon and air pollution) and rebuild.

Even some of the most inefficient and unattractive buildings can be transformed into spaces that are good for people and the planet. The Exhibit Staging Center at Phipps Conservatory and Botanical Gardens, a former 1960s public works building transformed into a Living Building Challenge-, LEED-, and WELL-certified building for maintenance laborers, is one such example [17].

Commissioning is an important collaborative systematic process that focuses on verifying and documenting that a building and all its systems are working the way they were designed and that they were planned, inspected, and installed correctly. Commissioning is fundamental to the overall success of a project and delivers many measurable benefits to the owners and occupants, as well as the environment. A commissioning consultant should be independent from the architect and engineering consultants and should be brought onboard at the start of design.

Even the most brilliantly designed building will fall short of efficiency goals if it is not operated properly. It is important that occupants understand how the building works and how they play a vital role in achieving the established performance metrics. When Phipps opened the CSL, they developed a handbook called "How to Live in a Living Building" which communicated this message and served as a resource to occupants. This included information on how the heating and cooling systems in the building worked and when to use natural ventilation. Instructions also included directions for minimizing plug loads and ensuring that equipment was turned off when not actively being used. Monthly lunch and learns were held so that employees could understand how building performance was tracking against expectations. This also gave staff the opportunity to engage with the building and its operations and suggest changes and other ways to be more effective and efficient.

9. Case Study: The Center for Sustainable Landscapes

Sustainable buildings are often viewed as places of compromise, particularly when it comes to aesthetics and occupant comfort. Nobody desires to be uncomfortable. If the goal is to have people aspire to these types of high-performance buildings, they need to see that they are better than conventional buildings.

The Center for Sustainable Landscapes (CSL), an education, research, and administration facility, was conceived and designed based on regenerative thinking and using OKR metrics to guide decision making. This approach made it possible to attain multiple certifications related to building efficiency and human and environmental health. The CSL is a zero-energy building and the only building in the world to meet the Living Building Challenge, LEED Platinum, WELL Platinum (first), SITES Platinum (first), BREEAM Outstanding (first in US), Zero-Energy, and Fitwel 3-Star certifications. The initial objective was to create a zero-energy building using the Living Building Challenge certification as a framework. Once that objective was set, a design team was hired that could design the most cost-effective ways to achieve that objective. The Net Positive Energy Imperative was first accomplished by using passive design strategies. The CSL's orientation maximizes southern sun exposure, and light shelves, louvers, and overhangs contribute to 80% daylight autonomy while minimizing summer cooling loads and contributing to heating in winter. The building envelope and high-performance wall and roof insulation reduce heating losses and cooling loads. Low-emissivity windows provide state-of-the-art solar and thermal control and energy efficiency, while admitting maximum daylight. Fourteen 155-m-deep geothermal wells provide a 65% reduction in heating and cooling energy needs. While geothermal wells have a high up-front cost, they have extremely long lifespans [18].

A large atrium, primarily constructed of concrete, acts as a heat sink by helping regulate the temperature throughout the course of the day. Phase-change material, a special substance that releases/absorbs energy when it solidifies or melts to provide useful heat or cooling, lines the atrium walls and passively modulates temperature. Computational fluid dynamics studies determined placement of occupant-controlled windows to maximize natural ventilation. These passive strategies permitted a downsized mechanical system.

A building management system (BMS) monitors, controls, and provides feedback to ensure efficiency. The building operates at 57.4kWh/m^2/yr, a fraction compared to traditionally designed office spaces. Its energy is provided by photovoltaic arrays and a vertical axis wind turbine, together capable of producing up to 130,000 kWh/yr. Surplus power is directed to other campus facilities. BREEAM In-use certification was used to verify building performance.

The CSL has produced more renewable energy from on-site renewable resources than it uses over the past 12 years. It was built taking a long-term view and is expected to have lower operating costs over the next one hundred years than a conventional building, allowing for additional resources to support collections and programs. The CSL is built to the highest standards of human and environmental health and demonstrates that these types of buildings are better for people and the planet than conventional buildings. The CSL has served as a source of inspiration to Pittsburgh and beyond and has motivated other organizations to adopt similar high-performance goals.

A more detailed look at the CSL project can be found in the book *Building in Bloom* [19] and on the Phipps website [20].

10. Conclusions

Zoos and botanical gardens should lead by example in addressing climate change in a positive way that engages their audiences in their communities. One of the most impactful areas to do this work is with building infrastructure and operations. Doing so requires a thoughtful approach that starts with a baseline understanding of fossil fuel use followed by a values-based action plan based on appropriate measures of success. Peer-based resource networks and building certification programs can shorten the learning curve. Ultimately, however, success will be directly related to the lens the organization uses to see their role in the world.

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