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Short Communications

Towards Net Zero Energy Library Buildings

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Abstract

This paper introduces the concept of "net zero energy," presents some historical milestones through the idea of sustainability by reviewing the relevant literature, and highlights some case studies to strengthen the viewpoints on moving towards a sustainable future with net zero energy buildings. Many net zero energy buildings are being developed around the world, as well as in the United States' communities, college campuses, and individual buildings. Libraries have also been supporting this initiative. For the next library renovation, librarians are encouraged to continue to leverage the net zero energy concept by developing net zero energy library buildings that produce their own renewable energy to meet the consumed energy demand, to safeguard a budget and energy-sustainable future.

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Introduction

Climate change can be defined as a change in climate patterns, such as a change in the average weather temperatures. Our earth is heating and we are witnessing this change as well as consequences of this change in our everyday lives. Every summer, we witness record-setting summer daytime temperatures in the United States (Fischetti, 2014). Rise in atmospheric temperatures is not something new; this warming trend has been occurring since 1880 (Christopherson & Birkeland, 2018). A rising concentration of greenhouse gases is one of the major reasons why the temperature is continuously rising. The rapid increase in the burning of fossil fuels, such as coal, petroleum, or natural gas, in the last couple of decades is one of the reasons that contributes to the accumulation of greenhouse gases. The Paris Agreement, drafted in 2015, provides a broad framework for reducing greenhouse gas emissions based upon voluntary commitments by the world's nations (United Nations Framework Convention on Climate Change, 2022). This landmark agreement committed the world to limiting temperature increases to 1.5 degrees Celsius above pre-industrial levels. The Paris Agreement represents an ambitious goal to reduce greenhouse gas in order to reach net zero carbon emissions.

The 2030 Agenda for Sustainable Development includes a set of 17 sustainable development goals (SDG) with 169 specific targets (United Nations, n.d.). The SDG 7 addresses affordable and clean energy. Our earth is in a precarious situation due to large-scale thresholds being reached such as ozone depletion, ocean acidification, climate change, population growth, and unsustainable lifestyle; we need to take immediate transformative action towards a sustainable future. The United Nations (UN) and individual nations, which signed the Paris Agreement, are leading a chorus of voices calling for action on climate change. While global action is essential, local action is crucial. Local action depends upon access within communities to knowledge and information resources about environmental sustainability and the roles communities can play. There is a significant need to protect and conserve the environment to preserve biodiversity. Protecting the planet is not optional anymore; it is a necessity because protecting nature means protecting ourselves. Library professionals belong to communities small and large which have made them agents for change in many spheres over the last century (Aytac, 2019). With the renewed commitment of the United States to the Paris Agreement, this is an opportune time for librarians to play a role in tackling and mitigating the climate crisis. Libraries should participate in the transition to an affordable, reliable, and sustainable energy systems by adopting clean energy infrastructure concepts such as “net zero energy” (Kolokotsa et al., 2012).

According to the U.S. Department of Energy (2015a), “a zero energy building produces enough renewable energy to meet its own annual energy consumption requirements, thereby reducing the use of nonrenewable energy in the building sector. This definition also applies to campuses, portfolios, and communities.” The concept of “Net Zero Energy” inspired by Le Corbusier’s idea of a house as a “machine for living,” was cited in multiple sources, and particularly in one published in *Energy and Buildings* by Iommi (2019). Although the emergence of net zero energy concept as an interdisciplinary research field originates from the beginning of 2000s, the modern idea of sustainability can be dated to the 18th century (Taylor, 2012). According to Taylor (2012), Thomas

Robert Malthus introduced the idea of sustainability in 1798 with "An Essay on the Principle of Population." However, the UN Conference on the Human Environment, which was held in 1972, was one of the most influential events in developing an understanding of the concept of a "sustainable society" (Dresner, 2008).

Consequently, the term "sustainable development" emerged (The International Union for Conservation of Nature and Natural Resources, 1980). However, the United Nations Conference on Environment and Development, also known as the "Earth Summit," was held in 1992, and the idea of "sustainable cities," became an international motto for sustainable development in 2002 with the "Melbourne Principles" (United Nations, 1992; United Nations Environment Programme, 2002). Finally, the National Science Foundation presented the single most important event in the chronology of the idea of sustainability in 2009 (Taylor 2012). Any sustainability efforts should be examined through the lens of Elkington's (1994) Triple Bottom Line (TBL) paradigm of (1) economy or profit, (2) environment or planet, and (3) society or people. This paradigm enables us to see any type of sustainability issue through the special lens of three major components of stakeholders: social constraints, economic impact, and the environmental consequences of an issue. Any research problem related to net zero energy buildings should be examined under the light of TBL paradigm. Further in this paper, some case studies were selected to examine their success in sustainability efforts.

Literature Review

Through literature, the authors examined the development, policy, definition, standard, and function of new zero energy buildings to gain a better understanding of how these factors are interrelated to each other.

The built environment impacts our daily life and the world that we live in (Charney & Aldrich, 2016). In the hopes of creating a sustainable future, the early form of a net zero energy building, the solar house, was developed and has been evolving until today (Hu, 2019). The 1970 energy crisis also helped with shaping the current design of the net zero energy buildings "to create positive impacts from the built environment" (Bilec, 2020; Hu, 2019).

Leading the change to having net zero energy buildings relied much on researchers' and policymakers' visions (Dermardiros et al., 2019) as well as legislative action (Heizer & Shelide, 2020). The U.S. Department of Energy (2015b) broadly defined that "an energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy." However, there was no one agreed-upon net zero energy building definition, as the metrics and standards might vary from one place to another, nationally and internationally (Hu, 2019). The International Living Future Institute, nevertheless, offered the Net Zero Building Certification, which assured that the stakeholders would achieve their goals of designing an energy efficient building (Charney & Aldrich, 2016). Two students at the Milwaukee School of Engineering and an undergraduate research assistant developed a web-based decision tool, Distributed Energy Resources and Systems, which "can be used by facilities directors on college or corporate campuses" to tackle the challenges of urban campuses incorporating net zero energy buildings (Damm et al., 2017).

The prominence of net zero energy buildings has been increasing in recent years. With reducing energy cost for a more predictable budget, libraries were no exception to the move towards becoming highly energy efficient while adopting a net-zero energy consumption concept (Aldrich, 2012; Brown, 2007). Under the influence of the UN's Sustainability Initiative, The Future We Want/Rio+20, the Valatie Free Library in Valatie, New York committed to investing in its new library facility with the aim of achieving near net-zero energy consumption (Aldrich, 2012). As evidenced, some libraries even became the first net zero energy buildings in their regions. In 2007, the Town of Chrisney received a grant for building a net zero energy library facility, which was opened to the public in April 2009 as the first net zero energy public library in Indiana producing "more kilowatt-hours (kWh) of energy than it consumed between April 1, 2009 and March 31, 2010" (Overbey et al., 2010). The new Alpine Library followed the same path and opened in May 2016 as the first net zero energy building in San Diego County, with the actual annual energy consumed less than or equal to the on-site renewable energy generated (Fox, 2016). Colorado College's library renovation went even further, making the library carbon neutral and net zero energy (Peet, 2018).

According to Pyloudi et al. (2015), the EU Directives requested reducing energy consumption by 20% and increasing the introduction of renewable energy sources by 20% for EU member states. To assist with meeting the goal set by EU, Pyloudi et al. (2015) presented a case study from their campus of the Technical University of Crete by using technology based on simulations to select the best situation of reducing the energy consumption of one of their university's current buildings to the point that it became a net zero energy building.

The library and information science literature revealed that policies and standards helped shape the development of net zero buildings which were then able to evolve and achieve an even higher sustainability level beyond net zero energy consumption.

Examples of Net Zero Energy Case Studies

In this section, the authors further examine some successful net zero energy case studies, including some about library buildings, to demonstrate how technological innovations and assessments were applied to enhance net zero energy building projects in multiple countries.

Gediz (2004) designed and proposed a library building, known as Gülbahçe Zero Energy Building, which would be built near their Izmir Institute of Technology campus and utilize natural energy resources such as geothermal water from an ancient cave, and solar and wind energy sources that are naturally occurring to the area around the building. Additionally, pipe length for the heating system was calculated by using the FLUENT software, and the hourly cooling load was calculated by using the Alarko-Carrier's HVAC Design Hourly Analysis Program. The renewable energy sources, the thermal energy system and other technologically advanced building materials allowed the library to be constructed according to Gediz's recommendations.

Attia et al. (2012) presented a decision support tool that can integrate energy simulation into early design of zero energy buildings. They also analyzed a case study from Egypt

to illuminate their support tool for the net zero energy building design. The researchers examined its strengths and limitations, as well as its comparison to the other tools.

Almazam (2017) used a verity of technologies to redesign their Main Library in Najran University campus in Najran to become an energy independent building. Technologies included the Quick Energy Simulation Tool (eQUEST) for analyzing the energy use in the building, the Revit software for simulating daylight inside and outside of the building, the COOLT software for simulating the ventilation, and the HOMER energy simulation software for other usages.

In 2011, Cornell University competed to develop an applied science and engineering campus on Roosevelt Island in New York City, today known as Cornell Tech, with a promise to build some of the academic units according to the concept known as net zero (Cardwell, 2017). In Cornell's 2001 plan of their Roosevelt Island campus, they proposed that their buildings would use as little energy as possible and make enough electricity to cover reduced load without using natural gas. They worked with architects and developers who used solar panels, geothermal heating and cooling system, and other innovative methods.

Irulegi et al. (2017) surveyed users' temperature preference in a seminar room to determine the most effective energy saving strategies for the Faculty of Architecture at the University of the Basque Country. Based on the comfort analysis in real conditions, the university conducted an energy efficiency analysis for the summer and used energy simulations to modify the summer and winter months' indoor temperatures, with recommendations to reduce the energy consumption of the Architecture Faculty building.

A high school library space in Essendon, Victoria (near Melbourne) Australia undertook a retrofitting process to improve its functional as well as environmental features (Luther et al., 2018). The case study reported the pre- and post-measurements of building performance. The purpose of this measurement process was to assist in the movement towards nearly net zero energy buildings, to assure their quality of performance and to become quite an energy-efficient space. Furthermore, Wells et al. (2018) aimed to explore the existing net zero energy building models, assess the progression of net zero energy building literature, and identified key policies encouraging net zero energy building development and research in the Australian context.

Doubleday et al. (2019) presented an integrated framework for Peña Station NEXT, a new 100 building district on a 1200-node distribution feeder, in Denver, Colorado. The researchers conducted multiple analyses for calculating the district's distributed energy resources to achieve their net zero energy goal.

Asaee et al. (2019) presented multiple strategies to support conversion of Canadian houses into net zero energy buildings by using the Canadian Hybrid Residential End-Use Energy and GHG Emissions Model (CHREM) for retrofitting analysis.

Hirschfeld et al. (2020) presented an evaluation framework called the Regional Fingerprint to assess the parameters of any governance system's adaptive capacity. Net-

zero buildings can only be meaningful and sustainable in a larger context in which adaptive capacity to climate change exists. Therefore, this study is a good example of such a system to measure any city's adaptive capacity.

The above case studies encapsulated the concept of a net zero energy building in an international context. Achieving the goal of a net zero energy building is a huge challenge and requires knowledgeable library and information professionals to enable transformative change in sustainable development within libraries and the communities they serve. Additional resources of a few videos and a guidebook were listed in Appendix I.

Discussion / Conclusion

Library and information professionals can play a vital role in transforming our world into a more environmentally sustainable one. The authors found in the literature and case studies that more than two decades ago, many sectors such as policy makers, local government, industry, public, and academia have already been working collaboratively to reduce budgets and to help shape an energy sustainable future. Developing a net zero energy building is not an easy task, and it involves various challenges. It requires detailed planning to meet the energy codes and standards. Success stories are on the rise. It is encouraging to find that librarians have been playing a pivotal role in embracing and advocating for the net zero energy concept; public and academic libraries are moving towards the concept of net zero energy library buildings. When considering library renovations to provide a comfortable and modern space to library users, library administrations can lead, and commit to, developing net zero energy buildings, by using renewable energy to meet the buildings' own energy consumption. Through challenges and responsibilities, a promising, better built environment will be fulfilled by cooperative efforts in the future.

Libraries should urgently investigate options for sustainable development and potential benefits of net zero energy library buildings. We suggest that future research should investigate the possibility of starting a comprehensive program for net zero energy buildings. Libraries vary considerably in their resources. A new bike rack in front of a library building (contributing towards walkable cities), the creation of a green roof for a cooler library building, and free, fresh fruits and vegetables supported with a seed library project could all be evidence of the broad impact of libraries to reduce greenhouse gas, in order to reach net zero carbon emissions to fight climate change, which disproportionately affects the poor and minorities.

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Appendix I: Additional Resources

Videos

- U.S. Department of Energy. (2017, July 12). *What is a zero energy building?* [Video]. YouTube. https://youtu.be/FysJKq5yCfg In this YouTube video, U.S. Department of Energy scientists explain what is a zero energy building in nonprofessional terms.
- U.S. Department of Energy. (2013, June 4). *What is the smart grid?* [Video]. YouTube. https://www.youtube.com/watch?v=JwRTpWZReJk This YouTube video presents the basics on how smart grid technology influences everyone.
- Danson, T. (2016, October 19). *Building below zero: The net zero plus transformation* [Video]. PBS. https://www.pbs.org/video/building-below-zero-net-zero-plus-transformation-building-below-zero-net-zero-plus-transfo/ Actor and environmentalist Ted Danson narrates this examination of the Net Zero Plus Transformation: buildings that produce and store more energy than they consume, lowering greenhouse gas emissions and potentially influencing global climate change.

Guidebook

- Attia, S. (2018). *Net zero energy buildings (NZEB): Concepts, frameworks and roadmap for project analysis and implementation* (1st ed.). Elsevier. https://www.elsevier.com/books/net-zero-energy-buildings-nzeb/attia/978-0-12-812461-1 This guidebook presents multiple aspects of the Zero Energy (NZEB) Building including the definitions, NZEB performance indicators, and thresholds. This is a great book to provide a road map to anyone interested in NZEB. The book first presents the NZEB definitions and related concepts, followed by the context of high-performance buildings, overviews of NZEB, the performance thresholds for efficient buildings, materials, micro-grids and smart grids, construction quality, and performance monitoring.