PRACTICES OF ENERGY EFFICIENT COLLECTION MANAGEMENT IN CALIFORNIA

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In

Museum Studies

by

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San Francisco, California

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CERTIFICATION OF APPROVAL

I certify that I have read Practices of Energy Efficient Collection Management in California by Aparna Suhas Dhole, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Arts in Museum Studies at San Francisco State University.

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PPRACTICES OF ENERGY EFFICIENT COLLECTION MANAGEMENT PRACTICES IN CALIFORNIA

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Museums are entrusted to preserve the artistic, scientific, and cultural achievement of humankind in the form of collections. As stewards of collections, museums work to provide optimal environmental conditions for the preservation of objects in their storage facilities, while aiming to create a sustainable future. In this thesis, the environmental sustainability and energy efficiency of museum collections care in California is investigated by focusing on Heat, Ventilation and Air Conditioning (HVAC) systems in museums. A survey of 100 museums in California that have a collections storage facility was conducted, resulting in a response rate of 62%. Key themes of energy efficient practices and resources for sustainability used by museums in California are discussed and then a set of conclusions and recommendations is presented. It is concluded that although there is need for more research regarding energy-efficient storage facility for museum collections, museum in California are making important contributions towards sustainability.

I certify that the Abstract is a correct representation of the content of this thesis.

Chair, Thesis Committee

5-9-19
Date

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Chapter 1 Introduction

Museums are entrusted to preserve the artistic, scientific, and cultural achievements of humankind in the form of collections. To meet this important responsibility, museums are tasked with the stewardship of objects. Sound stewardship of collections requires that collections are preserved under appropriate environmental conditions, which is often a challenge, given the sometimes limited budgets of museums and the need for expensive environmental control systems. If collections are not housed in appropriate environments, however, they begin to deteriorate, which results in a significant loss for humanity.

As stewards of collections, museums manage objects for the benefit of the public. Museums therefore have a social responsibility to provide the best possible care for the objects that they hold. As organizations that serve the public, museums also have a responsibility to practice sustainability in how they manage collections and to be aware of how much energy their operations consume. However, as the museum community has known for some time, maintaining certain environmental conditions, for collections care in particular, requires an enormous amount of energy and financial resources. As a result, collections managers often have to make difficult decisions: how can they balance the operating costs of environmental control systems with the need to preserve collections for the long term, considering both the environmental impact of the institution and the need to preserve collections?

Environmental sustainability can mean many different things-- from reusing materials to seeking carbon neutrality. In this thesis, the environmental sustainability and energy efficiency of museum collections care in California is investigated by focusing on Heat, Ventilation and Air Conditioning (HVAC) systems in museums. This is an important issue for museums in California because the HVAC systems require a significant amount of energy and are expensive to operate, as they are used 24 hours a day, 7 days a week. According to Image Permanence Institute (IPI), a 10,000 square foot collections storage area costs between $20,000 and $50,000 per year to function (IPI 2019).

By making HVAC systems as energy efficient as possible, museums can save money and put it to use in other areas of museum operations. Therefore, energy efficiency also helps museums to fulfill their broader mission to contribute to the development of society. Because the public are stakeholders in museums, museums must also make prudent use of all their resources as part of their responsibilities to the public.

In this thesis, a review of literature and a survey of museums in California will be conducted. The review of literature includes an overview of current research in the field regarding climate control systems and sustainable energy resources, while the survey explores how museums in California, a state that has long been a leader in environmental awareness, are responding to environmental issues such as climate change by planning for more energy efficient ways to preserve their collections.

The literature review consists of Chapter 2 and 3. Chapter 2 reviews the basics of environmental systems in collections management and the need for these systems in museums. First, this chapter outlines different components of HVAC systems and then discusses the impact of environmental factors on museum objects. It provides a justification for HVAC systems, which use a large amount of energy in museums, by describing the effects of humidity and temperature conditions on museum objects and outlines optimal environmental conditions for museum objects.

Chapter 3 reviews the best practices for making HVAC systems more energy efficient. Although certain environmental requirements exist for museum objects, these can be achieved while reducing energy consumption, with the help of the strategies mentioned in Chapter 3. This chapter also emphasizes the importance of planning for energy efficient collections management.

Chapter 4 outlines the methods used in this thesis. This chapter describes how the survey was created. It outlines each of the survey questions and describes why they were asked. Chapter 5 then presents the result of the survey by outlining responses to each question using figures and tables. The survey was sent to 100 museums in California.

Chapter 6 analyses the results of the survey and characterizes how museums are tracking the issue of environmental sustainability. First, this chapter summarizes the results, and then describes three key themes that emerged from the results. Chapter 7 then presents conclusions and recommendations based on the literature review and the results

of the survey.

Reducing energy use in museums is an important way to reduce an organization's carbon footprint and to practice sustainability. A central question for museums today, however, is how collections care practices in museums can balance appropriate environmental conditions for objects with energy efficiency and the wise use of the often-limited financial resources available to the museum. Energy efficient, sustainable practices can help museums meet their public trust responsibilities, reduce the cost of operations, and demonstrate that museums have an important part to play in efforts to create a more sustainable planet.

Chapter 2: Literature review: Collection Management and HVAC system

To be able to reduce energy usage in collections management, we first need to understand how this energy is used and why. This chapter outlines the role of Heat, Ventilation and Air Conditioning (HVAC) systems, which require a significant amount of energy as part of managing museum collections.

Two major factors are generally taken into consideration when considering the environment in which museum collections are housed: temperature and relative humidity (RH). These can cause deterioration of objects if they are not controlled according to the needs of the collection. Below, climate control systems in museums are discussed by outlining the components of HVAC systems and by reviewing the literature about how RH and temperature affect museum collections, followed by a presentation of relevant guidelines.

Mechanical components of HVAC systems

According to Image Permanence Institute (2012), a typical HVAC system consists of four mechanical components: air handling fans; cooling and dehumidifying coil; heating coil; air filter; and humidifier. These components control temperature and RH in the collections storage space. Air handling fans move air stream around through the coils and filters. The cooling coils reduce temperature of the air stream and dehumidify the air through condensation. Heating coils use electricity to increase temperature of the air. Air filters remove pollutants from air. Humidifiers add moisture to

the air (IPI 2012).

Use of Climate Control Systems

Monitoring, recording and analyzing data collected by data-logging devices in collections storage areas allows collection managers to assess the risks objects might face. These assessments help museums understand changes in temperature and RH, so that climate control systems can be adjusted to provide an optimal environment for collections. Adjusting climate control systems appropriately reduces the risk of damage to the collection. For example, the internal temperature of the storage facility can react to the changes in temperature outside of the facility. If environmental conditions outside the storage facility are monitored, its impact on indoor temperature can be analyzed. This type of information is important in developing a strategy for environmental controls, even without investing in installing an automated environmental system (Buck and Gilmore 2010).

Environmental factors that affect the deterioration of objects

Deterioration is a change in the condition of an object. This change could be chemical, physical or biological. Chemical deterioration of an object means a change in the chemical composition of an object has taken place. For example, bronze disease occurs on copper alloys, can corrode metal objects, and vinegar syndrome can affect cellulose acetate films. On the other hand, physical deterioration changes the physical structure of an object. Warping of paper, abrasions, and chipping caused by a collision

are examples of physical deterioration. Biological deterioration is caused by a biological agent, such as damage by insects, mold, and rotting of wood (NPS 2019).

The two environmental factors that play a major part in the deterioration of an object are relative humidity and temperature, as mentioned above. The following section outlines the impact of these factors in collections care and discusses how they are measured.

Relative Humidity (RH)

Relative humidity (RH) can be defined as the ratio (expressed in percent) between the mass of water vapor in a fixed volume of air and the maximum mass of water vapor that a fixed volume of air can hold at a fixed temperature (IPI 2012). Relative humidity indicates the amount of moisture in the air. At constant volume, if the temperature decreases without reducing the moisture content in the air, RH will increase.

Changes in RH can cause all three of the types of deterioration outlined above: physical, chemical and biological. Materials that can absorb moisture, such as wood and ivory, will swell with an increase in RH, and shrink when the RH decreases (NPS 2019). This fluctuation puts stress on an object and causes warping or splitting, depending upon the size of the object.

According to Thompson (1986), paintings are one of the most humidity sensitive objects. When RH decreases, the back-panel of a painting becomes dry and contracts. While the paint layer reacts less to the change in humidity, it can warp, which can turn

into cracks. This is an example of physical deterioration. Thomson (1986) divides the chemical deterioration of objects due to incorrect RH into two classes: corrosion of metals and fading of dyes. Metal has a high rate of reaction in the presence of humidity. Generally, low humidity does not affect metal objects. Many chemical reactions require water; thus, in high humidity, metals can go through oxidation and corrosion, and minerals such as marble can be affected by crystallization and hydration. Although dyes fade in the presence of light, fading is accelerated in high RH conditions. Additionally, the biological effect of high RH is an increase in bacteria and insect infestation in objects (Thomson 1986).

Michalski (2000) specifically highlights the effect of high humidity on objects, stressing that high humidity is more harmful to archival records than low humidity. High humidity softens the adhesives used in book-binding and deforms structure. Contrary to the common belief that only low humidity can cause fractures and cracks in an object, higher humidity can inflict the same damage. Higher humidity swells up layers of paper and makes them more susceptible to cracks and fractures. It also creates stress in other objects, which can take several years to return to the normal stage. Michalski (2000) also notes that some objects housed in high humidity environments are more susceptible to mold (Michalski 2000).

The National Park Services (NPS) Museum Handbook (2019) outlines the effect of changes in RH on museum objects by dividing them into two categories based on the

type of material: organic and inorganic. Organic materials are hygroscopic, meaning they have the ability to absorb and release moisture. On the other hand, inorganic materials do not have this ability and do not contain moisture. The hygroscopic materials react to the changes in the RH by absorbing moisture in high RH environments and by releasing moisture in low RH environments. This action causes deterioration in the structure of the objects. For inorganic materials, changes in RH primarily have an effect on the surface of the objects (National Park Services 2019).

Temperature

The NPS Museum Handbook (2019) defines temperature as "a measure of the motion of molecules in a material." The effect of changes in temperature is best understood by considering this movement of molecules. At higher temperature, the rate of chemical reactions increases and facilitates chemical deterioration, pests breed faster, causing biological damage, and the volume of objects increases to change their physical condition. At lower temperature, materials such as varnish and paint become brittle (National Park Services 2019).

The Canadian Conservation Institute (CCI) has published several online resources for preventive conservation of objects. One of these resources, written by Michalski (2019), specifically addresses the problem with inappropriate temperature in collections facility. Michalski acknowledges that maintaining a specific temperature in museum collections facilities can be expensive and that it can result in consuming a large amount

of energy. However, he emphasizes the need for set temperature with the help of detailed information regarding the effect of temperature on various materials. He provides a chart entitled "Lifetimes of Materials at Various Temperature", which details the drastic impact of temperature on museum objects. Even a change of 5 degrees in the temperature can remove decades from an object's lifetime (Michalski 2019).

Another table provides a detailed description of physical damage caused or accelerated by changes in temperature in a variety of materials. This table shows that generally, objects are less susceptible to deterioration in temperature between 10 to 30 degrees Celsius. The effect of fluctuations in temperature on RH is also outlined (Michalski 2019). As mentioned earlier in this chapter changes in RH have a major role in the deterioration of objects. Since RH depends on the temperature, fluctuations in temperature indirectly become a cause of deterioration. Five causes of incorrect temperature are: sunlight, outdoor climate, lighting system, HVAC, and moving objects (Canadian Conservation Institute 2019).

Guidelines for environmental systems in museum collection facilities

The temperature inside a collections facility is affected by the outside temperature, and since RH is affected by temperature, experts like Garry Thomson recommend that RH inside facilities should depend upon the outdoor environment. In general, RH is recommended to be maintained at 50 ± 5% with a temperature of 20°C. (Thomson 1986) Thomson proposes 65% RH for humid and tropical climates, 55% in

Europe and Northern America, 45 to 50% at locations prone to condensation, and 40 to 45% in arid climates (Thomson 1986).

A list of organizations with recommendations for RH and temperature has been compiled by Michalski and is available on the Canadian Conservation Institute website (2019). This list includes organizations such as the Smithsonian, the American Institute of Conservation (AIC) and the Association of Art Museum Directors (AAMD). All of these organizations recommend RH of 45% to 55% and the temperature of approximately 20°C (Michalski 2016).

The National Park Services provides the guidelines specifically for the collection facilities in the United States. The NPS Museum Handbook recommends 45 to 55% RH for collections in the United States, with a temperature of 59 to 77°F (15 to 25°C). For climate zones with distinct seasons, the annual range of 40% to 60% RH is recommended with higher RH in the summer and lower in the winter. The guidelines also recommend RH levels for specific materials: less than 35% for metals; 35 to 45% for organic materials such as bones, and 30 to 40% for photographic materials (National Park Service 2019).

In conclusion, a slight variation in RH and temperature can have an adverse effect on the cultural and educational objects that museums care for. Hence, environmental control systems are necessary to ensure the appropriate care of collections. This type of controls requires an enormous amount of energy.

The following chapter will provide a literature review of best practices that can help reduce energy consumption in collections facilities.

Chapter 3: Literature Review: Energy Efficient Collection Management

Stewardship of collections is a major responsibility of museums. As mentioned in the previous chapter, to ensure the preservation of collections, specific environmental conditions are maintained in collections storage facilities. To maintain these conditions, Heat, Ventilation and Air Conditioning (HVAC) systems are used in collections facilities, which requires a large amount of energy. This chapter first reviews various best practices in planning for energy efficiency, and then, the approaches to using less energy in the operation of climate control systems.

Planning for Energy Efficiency

Planning and assessing are the first steps towards designing an energy efficient collections storage facility. This section reviews three best practices in planning for sustainability: planning for the type of building; planning for different zones inside the museum; and energy audits.

Type of buildings

Climate control system requirements are different for different types of building structures. A building's structure is the first level of protection from the outdoor environment. Thus, by considering the structure of the building, specific climate control strategies can be applied.

The Image Permanence Institute's (IPI) guide (2012) provides a classification of buildings in the following 6 categories. These categories can be used to assess the

environment control capability of a museum collections storage facility, and to choose appropriate HVAC system:

- Class One Structures: open structures with little or no potential for environmental control.
- Class Two Structures: sheathed post and beam structures, such as sheds; they normally only have the potential for ventilation to reduce heat and moisture. Outdoor and indoor environment is nearly the same.
- Class Three Structures: uninsulated structures with frames and walls, such as standard historic buildings. For these buildings, environmental systems can offer temperature control, but due to the lack of insulation, there is little possibility for RH control.
- Class Four Structures: uninsulated but tightly constructed structures, such as high-quality historic houses and civic buildings. They have limited RH and temperature control. However, certain areas of the building, such as the basement, can provide more control.
- Class Five Structures: newly built, insulated and tightly constructed structures with vapor barriers, such as standard museum buildings. These buildings can support a complete HVAC system
- Class Six Structures: double wall constructions with sealed and insulated walls built specifically for precision environmental controls.

The National Park Service (NPS) Handbook (2019) provides a simpler version of these categories: historic structures; adapted structures; and purpose built structures. For historic structures, collections can be stored in sealed cabinets or insulated modular structures to provide specific environmental conditions (National Park Service 2019)

Building Zones:

Another factor for planning for sustainable climate control strategy is dividing the museum building in different zones. It helps to achieve different environmental standards for different zones. Lord (2012) divides museum building in 5 zones, according to specific environmental requirements:

- Zone A: public non-collection areas, such as the lobby. They require environmental controls designed only to achieve human comfort level.
- Zone B: public collections area, such as galleries. They require environmental controls appropriate for collections while considering public use.
- Zone C: non-public collections area, such as collections storage facility. They require environmental conditions appropriate for collections and provide more control over the outside influence.
- Zone D: non-public non-collections areas, such as offices. Environmental controls are designed to be appropriate for staff.
- Zone O: outside areas, such as sculpture gardens. Environmental control is not

possible in this area.

Energy Audits:

Energy audits measure, predict, and improve energy usage. Brophy and Wiley describe energy audit as "one of the best, first activities of your green team" (Brophy and Wiley 2013, 43). Only by knowing the amount of energy the collections facility uses can energy consumption be reduced. Brophy and Wiley suggest using American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1Program. This program is one of the globally used benchmarks to set energy usage. It provides the minimum energy requirements for energy efficient building design (ASHRAE 2019).

Methods to reduce energy consumption

Although museum collections require specific environmental conditions and mechanical systems, there are few strategies that can be used to reduce energy usage without compromising preservation quality for the collection. This section outlines basics of three methods to reduce energy consumption: use of buffer materials; adjusting controls according to the regional climate conditions and seasonal changes; and controlling lighting system.

Use of buffer materials:

Buffer materials react to the relative humidity of the surrounding air. If humidity is removed from the surrounding air, these materials desorb water, and if humidity increases in the air, they absorb it. This effect is referred as the buffer effect. Padfield

(2019) proposes that about 3 cm of buffer material is sufficient to provide RH buffer to 40 cm of wall. He has developed a sodium bentonite clay buffer that can be applied on an existing wall. This buffer provides significant RH stability to storage facilities that are ventilated once per hour (Padfield 2019).

Another way of using buffer materials is "the Copenhagen Model" presented by Morten Ryhl-Svendsen (2011). The Copenhagen Model used buffer materials to save energy for collections storage environments. It proposes a single level, airtight "superstructure laid directly on a concrete floor" (Ryhl-Svendsen 2011, 2), powered by solar energy. The floor and insulated walls work as a temperature buffer, aided by solar-powered dehumidifiers to maintain RH levels. Due to airtightness, the dehumidifiers require less energy.

Rhyl-Svendsen provides an example of one such model in a building in Denmark. The walls of this building are built with wood insulation inserted between layers of bricks and concrete. The roof is made of wood and the concrete floor is uninsulated. These building materials provide a humidity buffer to maintain RH. However, in summer, when the temperature outside is higher than the temperature inside, RH in the facility increases. Hence, only in summertime the dehumidifiers are used. The temperature in this collections facility is maintained between 9°C and 15°C and humidity between 45% and 55%.

The only source of heat in this building is the heat exchanged through the floor.

Insulation is the major contributing factor in this model. The low air exchange rate also helps to reduce exposure of air pollutants to the objects. Overall, the Copenhagen model uses very little energy. However, due to the need of specific building structure, this model can only be used for a completely new storage facility (Ryhl-Svendsen 2011).

Seasonal change:

The seasonal change in the outdoor local climate has a significant influence in indoor climate control system. Due to the changes outside a collections facility, depending on the insulation, indoor RH and temperature changes. This requires use of climate control systems to maintain specified environmental conditions. As mentioned in the previous chapter, climate control systems are composed of air filtration systems and mechanisms that decrease and increase temperature and humidity as needed.

To reduce energy usage, environmental systems can be designed differently for different climate conditions by selecting a specific type of mechanisms. The NPS Handbook (2019) suggests that temperature and RH both outside and inside storage facilities should be monitored and compared for one year to adjust in the HVAC system. In general, RH should be higher in summer and lower in winter (NPS 2019).

Depending upon the environmental management requirements, Image Permanence Institute (IPI)'s (2012) guide to sustainability, divides various climates in the United States in 4 categories: continental, dry, and tropical climate. Continental climate requires the use of cooling and dehumidification in the summer and the opposite for the

winter. Dry climate regions require environmental systems to manage frequent wide fluctuations. Tropical climate requires moisture barriers, air circulation and dehumidification (IPI 2012).

According to Jensen et al. (2010), full air-conditioning to maintain the standard constant temperature requires the highest amount of energy and is unnecessary. They propose that since RH and temperature are codependent, humidifying or dehumidifying should be used to maintain temperature, as it requires the least amount of energy.

Seasonal variations can be achieved by determining seasonal setpoints and with simple mechanical controls. Without seasonal variation, the HVAC unit will be sometimes used unnecessarily instead of taking advantage of the outside climate conditions. For example, in winter, when outdoor temperature is lower, using lower set point for temperature and taking advantage of higher RH resulting from low temperature can avoid the use of the HVAC system. This results in lower energy usage for heating and humidification. The only drawback of this strategy is that it involves the intervention of experts who can determine the optimal setpoints for each month (IPI 2019).

Appropriate Lighting Systems:

Lighting systems can contribute to more than 10% of total energy consumption. Thus, by optimizing the lighting system, energy consumption can be reduced. Exposure of lights and the heat generated by them also damages museum objects. The IPI Methodology Guidebook suggests that switching from generally used florescent T12 light

bulbs to LED lights can eliminate the problem of heat generated by lighting systems and result in less work required from the HVAC system. Hence, considering the lighting system can reduce energy usage in the storage facility (IPI 2019).

Another way of reducing energy usage for lights is using occupancy and daylight sensors. In collections storage, the museum staff enters the facility only when needed. By using occupancy sensors, lights can be activated only while the people are present. Also, if the storage area receives daylight, the intensity of lights can be controlled accordingly (Brophy and Wiley 2013).

Conclusion:

With some time and effort, it is possible to provide optimal environments for collections while ensuring their preservation. These methods not only make the collections facility energy efficient, but also save money that can be put into better use elsewhere for the museum. The following chapters will present a survey of energy efficient practices in museums in California, discuss the result of the survey, and outline conclusions and recommendations.

Chapter 4: Methods

In this thesis, a survey of museums was conducted to analyze energy efficient collections management practices in museums in California. One important goal of this thesis was to supply an overview of sustainable collections management practices in museums in California, while focusing on assessment of their approach to energy efficient climate control systems, also known as heat, ventilation and air conditioning (HVAC) systems. To fulfill this goal, in addition to a review of literature, which is presented in chapter 2 and 3, 100 museums in California that hold object-based collections were surveyed. This chapter focuses on how the survey was developed and outlines each question and why it was posed.

It was decided to conduct a survey of energy efficient collections management in this thesis to supply an overview of current practices and also to focus on museums in the state of California, because California has a reputation for a concern with energy efficiency.

To develop a sample of museums to which the survey could be sent, a preliminary list of museums was created by selecting museums in California from the list of museums published on the website of the American Alliance of Museums (AAM 2019). The website of each museum on this preliminary list was reviewed and museums that did not house object-based collections, and hence, were not likely to be associated with collections facilities, were eliminated from the list. The remaining list of 125 museums

was compiled into a Microsoft Excel spreadsheet and a list of 100 randomly selected museums was generated by using random selection tools on "Microsoft Excel" software.

The survey consisted of 14 questions. Overall, questions asked about the budget of the collections department, environmentally sustainable collections management practices, and energy efficient use of the HVAC system. The survey has four main parts: basic demographic questions; museum policies regarding sustainability; sustainability practices regarding energy efficiency; and planning for sustainability.

Part I: Demographic Information

The survey began by asking three basic questions about the museum. Question 1 asked, "Which of the following category your institution fits into?" Possible responses included: anthropology museum; art museum/gallery; historic house; history museum/ historical society; natural history museum; science center and other. These categories were selected based on a review of the most common types of museums listed on the AAM website.

Question 2 asked, "What is the size of your institution's collection?" Possible responses included: small (less than 10,000 objects); medium (10,000 to 50,000 objects) and large (more than 50,000 objects). Question 3 asked, "What is the average annual budget for collection management at your institution?" Responses consisted of six options: less than $5,000; $5,000 to $10,000; $10,000 to $50,000; $50,000 to $100,000; $100,000 to $500,000 and more than $500,000.

The first three questions were asked so that sustainable practices across different types, sizes of collection and budget of museums could be analyzed. The remaining eleven questions asked about the issue of sustainable practices, specifically concerning energy-related collections management practices and the storage conditions of objects.

Part II: Museum Policies

Question 4 asked, "Which of the following things are included in your museum's discussion of sustainability? On a scale of 1 to 5, where 5 is the most important and 1 is the least important, please rate the importance of each area outlined below to your institution's approach to sustainability." Respondents were provided with a list of ten ways museum collections can be more environmentally sustainable, with an option of "other." The 10 options were: reducing carbon footprint; using eco-friendly products; adjusting environmental controls depending upon local climate; waste reduction; water conservation; reducing electricity usage; locally sourced materials; fair trade practices; green waste disposal and LEED certification. The responders were allowed to answer this question with the help of a chart that was provided (see Appendix 2). This question was designed to assess what steps museum professionals are taking in their museum to develop sustainable museum practices.

Question 5 asked, "Was your museum's primary collection storage facility originally built specifically for collections?" and could be answered with a yes or a no. This question was designed to assess if collection facilities in California were created to

house collections, thus indicating if they had been planned originally to provide the best conditions for the collection.

Question 6 consisted of three parts. Part "a" asked, "When was the collection management facility last renovated?" Possible responses were: less than a year ago; one to five years ago; five to ten years ago and more than ten years ago. Part "b" asked, "Was planning energy consumption part of the renovation?" This question could also be answered with a yes or a no. If respondents answered yes, part "c" asked, what specifically had been altered. Question six was designed to assess the changes museum have made to be more energy efficient in their collection facilities.

Part III Sustainability Practices

Question seven consisted of two parts. Part "a" asked, "does your collections unit track local temperature outside the institution?". If part "a" was answered with yes, part "b" asked, "do you use this information to adjust controls of the HVAC system of the collections storage?" This question was designed to investigate whether the outside temperature is monitored by museums to reduce the energy usage of the HVAC system to provide suitable conditions for the collection while using the minimum amount of energy that is required.

Question eight also consisted of two parts. Part "a" asked, "Does your institution conduct energy audits?" If so, part "b" asked, "how often?" Possible responses were: two to four times a year; once a year; every five years and other. This question was

designed to understand the frequency of energy audits.

Part "a" of the question 9 asked, "does your collections unit track the energy consumption of the HVAC?" Part "b" asked, "does the collections unit use this information to adjust the energy consumption?" This question was designed to assess if and how museums reduced energy consumption of their HVAC unit.

Part IV Planning for Sustainability

Question 10 asked, "is your museum planning to take any steps to make its collections facilities more sustainable? If so, what steps?" This was an open-ended question. It was designed to assess current planning for sustainable practices in California. This information can also be used to analyze and possibly recommend sustainable museum practices in the future.

Question 11 asked, "has your museum consulted professional museum resources on sustainability? If so, please describe if possible." This question was designed to identify professional museum resources respondents used to address environmentally sustainable collection management. Question 12 asked, "Has your museum collections staff attended conferences or special training on sustainability? If so, please describe if possible." This question was designed to identify the kinds of professional training current museum staff have engaged in addressing energy efficient collections management practices.

Question 13 had three parts. Part "a" asked, "when was your collection

management policy last updated?" This question could be answered by selecting one of four options: within last one year; two to five years ago; one to two years ago and more than five years ago. Part "b" asked, "Have updates to your institution's collection management policy included sections on sustainability?" If this part was answered yes, part "c" was an open-ended question that asked, "in what areas?"

Question 14 asked, "On a scale of 1 to 5 please rate your institution's approach to sustainability, in relation to collections." To answer this question, respondents were asked to select a number from one to five, where five is the highest rating. This question was asked as a conclusion to the whole survey. It was designed to evaluate the readiness of museums to address sustainability.

The survey was limited to fourteen questions to keep the time needed for completion of the survey to about ten minutes. The survey was mailed to 100 museums on February 3, 2018 with a cover letter that outlined the topic of this survey, indicated that it was part of a thesis and with a request to complete the survey. The recipients were given three weeks to respond and were asked to return completed surveys to the Museum Studies Program at the San Francisco State University by February 24, 2018. Recipients were provided with a stamped envelope to return their responses.

As mentioned above, in addition to the survey, a literature review was conducted in chapters two and three. While chapter 2 outlined the role of HVAC system in a museum collections management facility, chapter 3 focused on the best practices of

reducing energy consumption to make museums more environmentally sustainable. The results of the survey are presented in chapter 5. A copy of the survey and the cover letter are supplied in Appendix 1 and 2.

Chapter 5: Results

This chapter will present the result of the survey. As mentioned in the previous chapter, 100 surveys were sent to the museums in California. Sixty-two museums, or 62% of the museum, responded, a high response rate (Table 1). Because most of the questions were multiple choice, percentage responses will be presented. For the open-ended questions, similar responses were grouped together, and percentages of grouped responses will be presented.

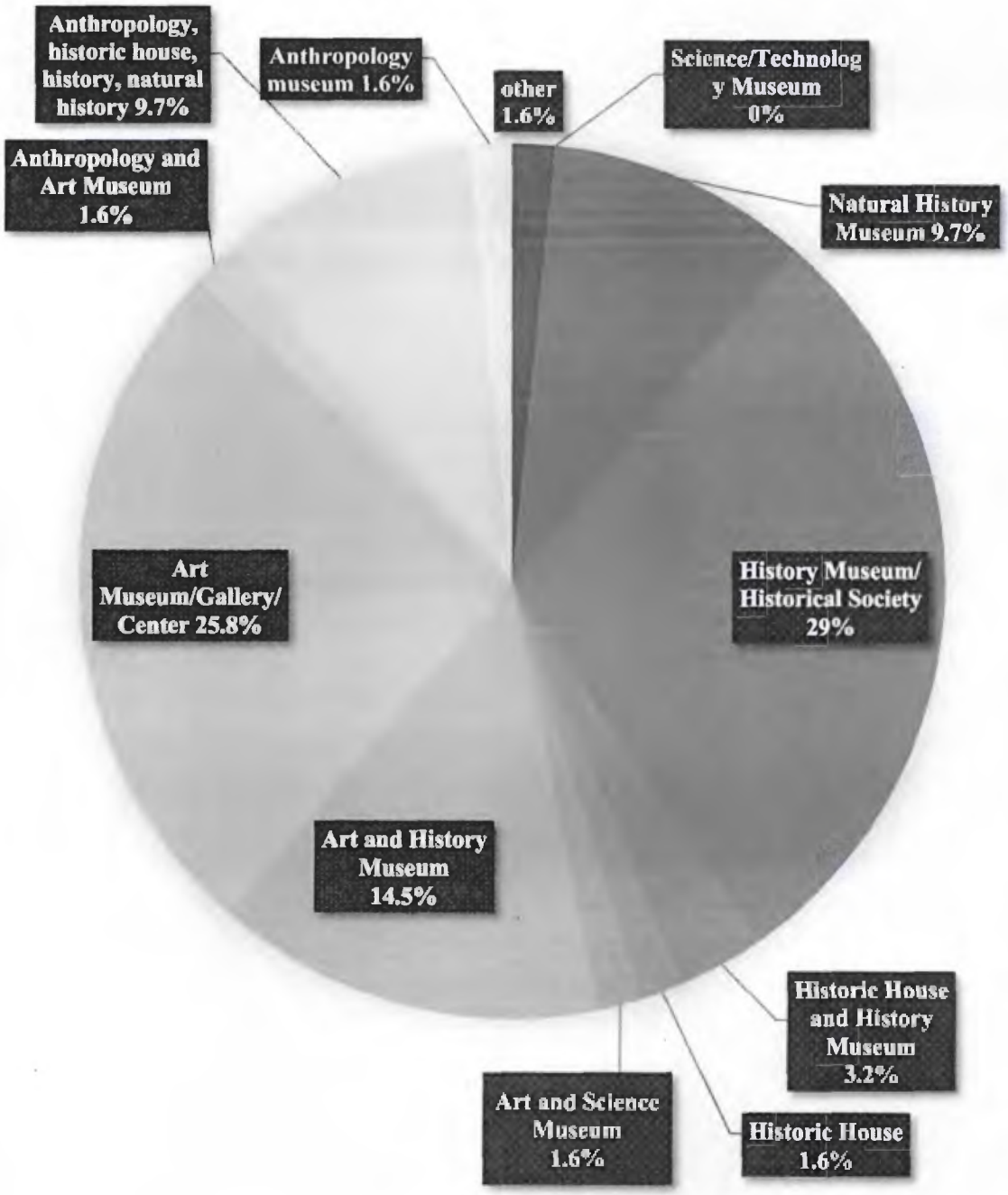
Table 1: Survey Response Rate

Number of Surveys Sent	Number of Respondents	Survey Response Rate
100	62	62%

Part I: Demographic Information

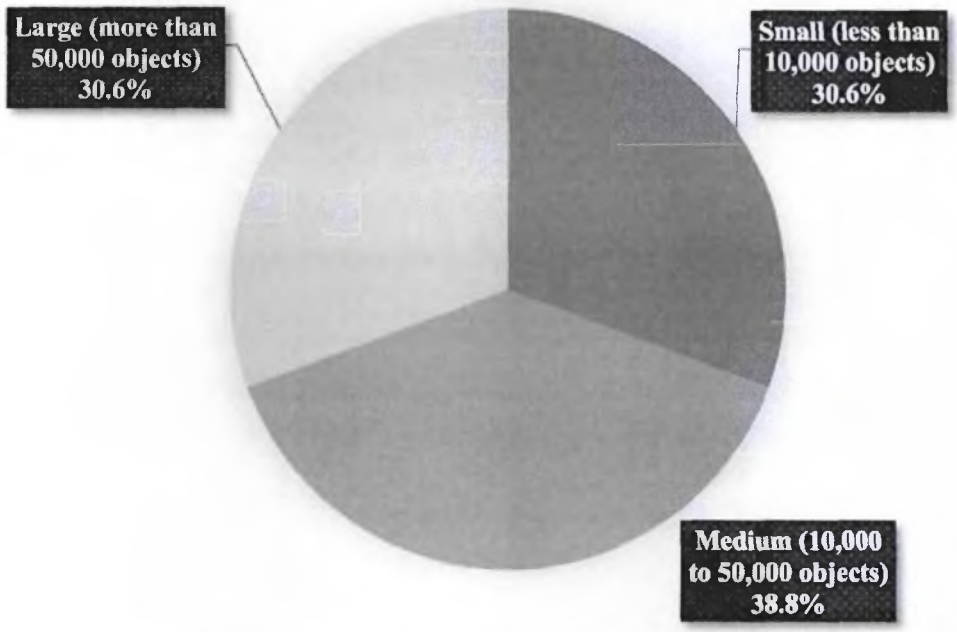
Question 1 asked, "which of the following category your institution fits into?" Of the 62 museums that responded to this question, as shown in Figure 1, 1.6% (1) answered Anthropology Museum; 9.7% (6) answered Anthropology, Historic house, History and Natural History Museum; 1.6% (1) answered Anthropology and Art Museum; 25.8% (16) answered Art Museum/Gallery/Center; 14.5% (9) answered Art and History Museum; 1.6% (1) answered Historic house; 3.2% (2) answered Historic House and History Museum; 29% (18) answered History museum or Historical Society; 9.7% (6) answered Natural History Museum; and 1.6% (1) answered Other.

Figure 1: Museum Type



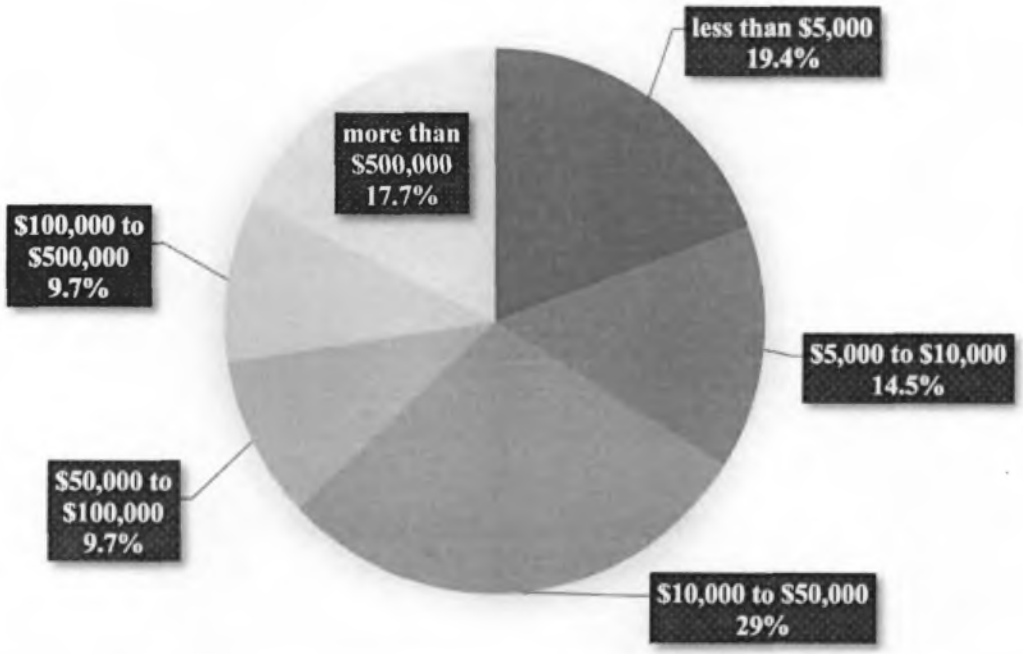
Question 2 asked, "what is the size of your institution's collection?" The three options to answer this question were small (less than 10,000 objects), medium (10,000 to 50,000 objects) and large (more than 50,000 objects). Of the 62 museum that responded, as shown in Figure 2, 30.6% (19) answered small, 38.8% (24) answered medium and 30.6% (19) answered large.

Figure 2: Size of the Collection



Question 3 asked, "what is the average annual budget for collection management at your institution?" Of 62 museum that responded to this question, as shown in Figure 3, 19.4% (12) answered less than $5,000; 14.5% (9) answered $5,000 to $10,000; 29% (18) answered $10,000 to $50,000; 9.7% (6) answered $50,000 to $100,000; 9.7% answered $100,000 to $500,00 and 17.7% (11) answered more than $500,000.

Figure 3: Annual Budget for Collections Management



Part II: Museum Policies

Question 4 asked, "Which of the following things are included in your museum's discussion of sustainability? On a scale of 1 to 5, where 5 is the most important and 1 is the least important, please rate the importance of each area outlined below to your institution's approach to sustainability." Table 2 provides the number of responses for each option. As shown in the Table 2, the highest percentage of high ratings, indicating high importance, was selected for "waste reduction" and "reducing electricity usage." On the other hand, the highest percentage of low ratings, indicating low importance, was given to "fair trade practices" and "LEED certification."

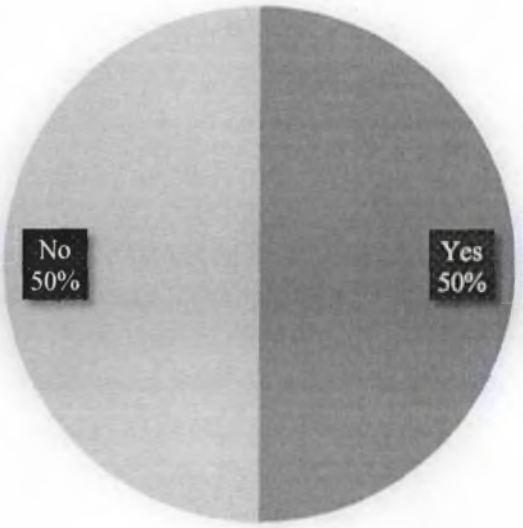
Table 2: Results of Question 4

Options	Approximate Percentage of Responses (Number of responses in parentheses)					Total
	1	2	3	4	5	
Reducing carbon footprint	18% (10)	9% (5)	30% (17)	25% (14)	18% (10)	56
Using eco-friendly products	9% (5)	9% (5)	23% (13)	36% (20)	23% (13)	56
Adjusting environmental controls depending upon	5% (3)	5% (3)	20% (12)	34% (19)	25% (14)	57

local climate						
Waste reduction	0% (0)	7% (4)	27% (15)	41% (23)	25% (14)	56
Water conservation	6% (3)	7% (4)	30% (16)	24% (13)	34% (18)	54
Reducing electricity usage	3% (2)	5% (3)	17% (10)	41% (24)	34% (20)	59
Locally sourced materials	18% (10)	22% (13)	21% (12)	30% (17)	9% (5)	57
Fair trade practice	26% (14)	17% (9)	25% (13)	17% (9)	15% (8)	53
Green waste disposal	11% (6)	17% (9)	18% (15)	28% (15)	26% (14)	50
LEED Certification	32% (16)	8% (4)	22% (11)	6% (3)	32% (16)	50
Total:	69	59	134	153	132	

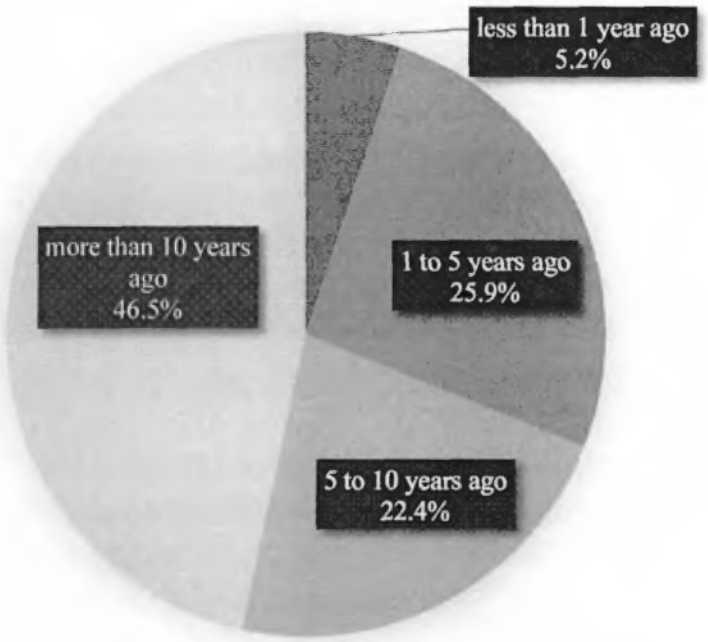
Question 5 asked, "was your museum's primary collection storage facility originally built specifically for collections?" Of the 62 museum that responded to this question, as shown in Figure 4, 50% answered yes and the remaining 50% answered no.

Figure 4: Collection Facility that was Originally Built for Collections



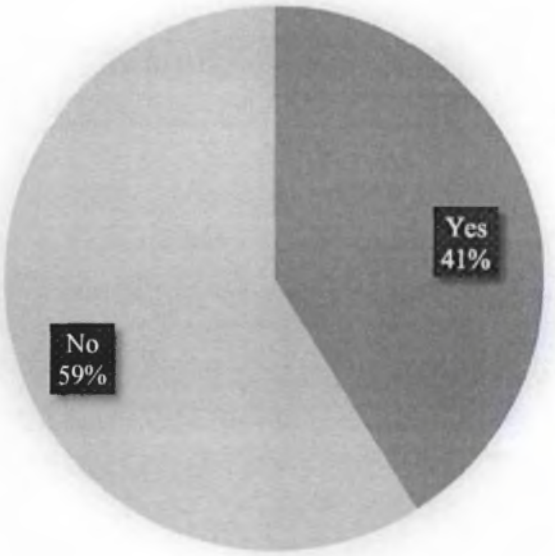
Question 6a asked, "when was the collection management facility last renovated?" It could be answered by choosing one of the 4 options given: less than a year ago; 1 to 5 years ago; 5 to 10 years ago and more than 10 years ago. Of the 58 museums that responded to this question, as shown in Figure 5, 5.2% (3) museums answered; "less than a year ago"; 25.9% (15) answered "1 to 5 years ago"; 22.4% (13) answered "5 to 10 years ago" and 46.5% (27) answered "more than 10 years ago.

Figure 5: Renovation of Collections Management Facility



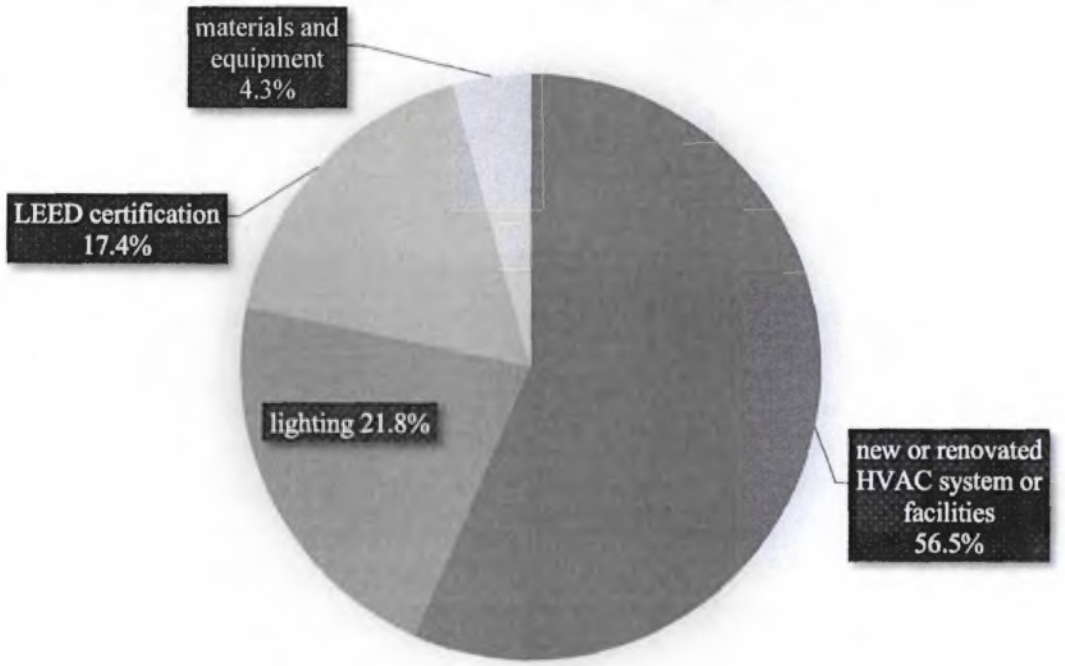
Question 6b asked, "as planning energy consumption part of the renovation?" Of the 56 museums that responded to this question, as shown in figure 6, 41% (23) answered "yes" and 59% (33) answered "no."

Figure 6: Planning for Energy Efficiency in Renovation of Collections Management Facility



If the answer to question 6b was "yes," question 6c asked, "what specifically was altered or updated?" As this was an open-ended question, the responders answered it in a variety of ways. All answers were divided into 4 categories: New/renovated HVAC system/facilities; lighting; LEED certification; and materials and equipment. Of the 23 museums that responded to this question, as shown in Figure 7, 56.5% (13) answered "new or renovated HVAC system or facilities"; 21.8% (5) answered "lighting;" 17.4% (4) answered "LEED certification" and 4.3% (1) answered "materials and equipment."

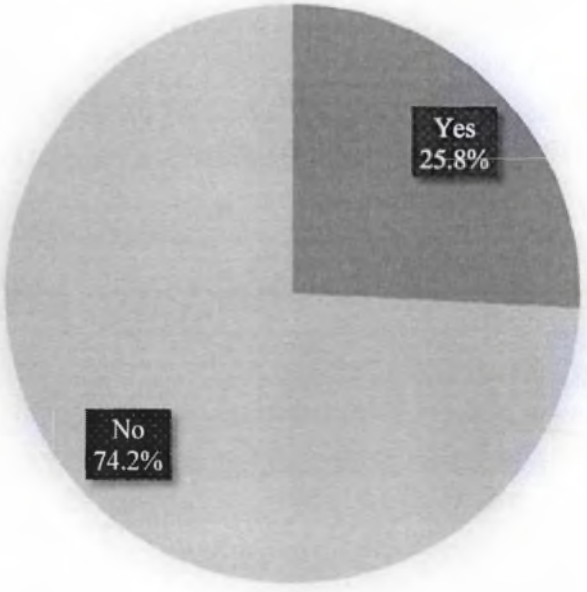
Figure 7: Changes Made During Renovation



Part III: Sustainability Practices

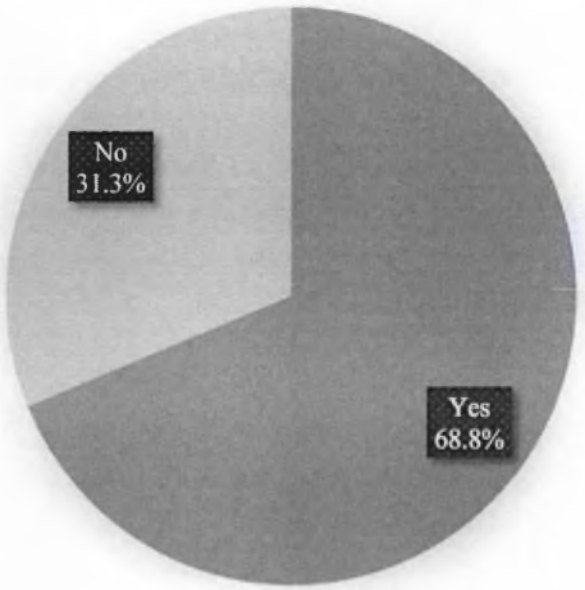
Question 7a asked, "does your collections unit track local temperature outside the institution?" Of the 62 museums that responded, as shown in figure 8, 74.2% (46) answered "no" and 25.8% (16) answered "yes."

Figure 8: Collections Unit that Track Local Temperature



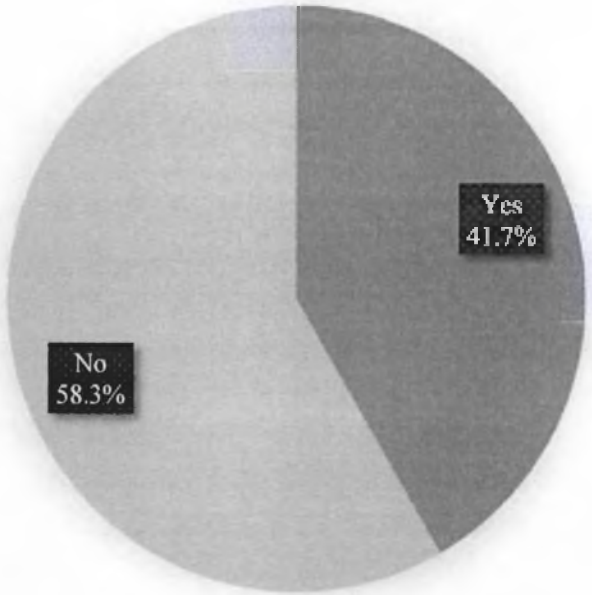
If the answer to question 7a was "yes," question 7b asked, "do you use this information to adjust controls of the HVAC system of the collections storage?" As shown in Figure 9, of the 16 respondents who answered "yes" to question 7a, 68.8% (11) answered "yes" and 31.3% (5) answered "no."

Figure 9: Tracking Outside Temperature to Adjust HVAC Controls



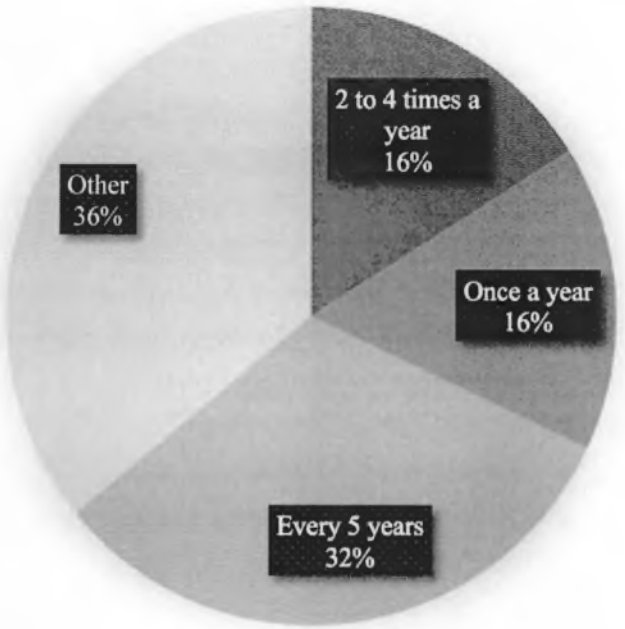
Question 8a asked, "does your institution conduct energy audits?" Of the 60 museums that answered this question, as shown in Figure 10, 41.7% (25) answered "yes" and 58.3% (35) answered "no."

Figure 10: Energy Audits



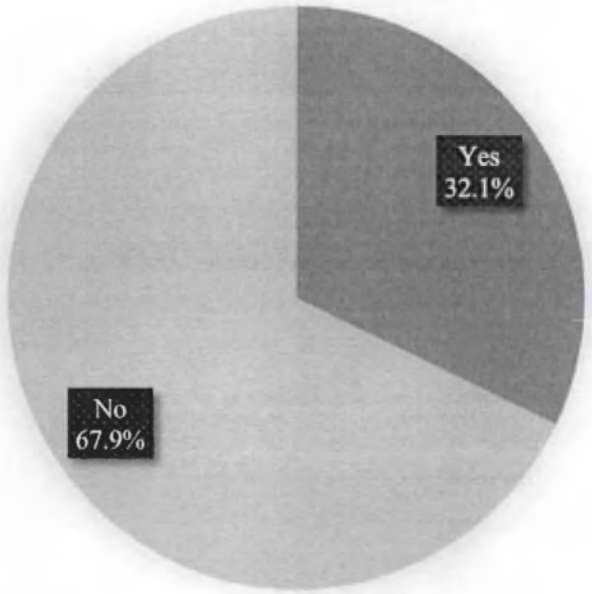
If the answer to question 8a was "yes," question 8b asked "how often?" To answer this question, respondents were asked to select one of 4 given options: 2 to 4 times a year; once a year; every 5 years; and other. Of the 25 respondents who answered "yes" to question 8a, as shown in Figure 11, 16% (4) answered "2 to 4 times a year"; 16% (4) answered "once a year;" 32% (8) answered "every 5 years" and 36% (9) answered "other."

Figure 11: Frequency of Energy Audits



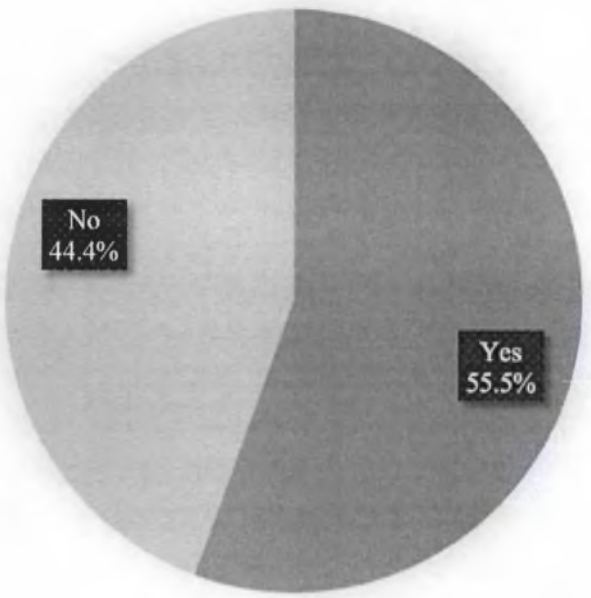
Question 9a asked, "does your collections unit track the energy consumption of the HVAC?" Of the 56 museums that responded to this question, as shown in Figure 12, 32.1% (18) answered "yes" and 67.9% (38) answered "no."

Figure 12: Tracking Energy Consumption of HVAC Unit



If the answer to question 9a was "yes," question 9b asked, "does the collections unit use this information to adjust the energy consumption?" Of the 18 respondents who answered "yes" to question 9a, as shown in Figure 13, 55.6% (10) answered "yes" and 44.4% (8) answered "no."

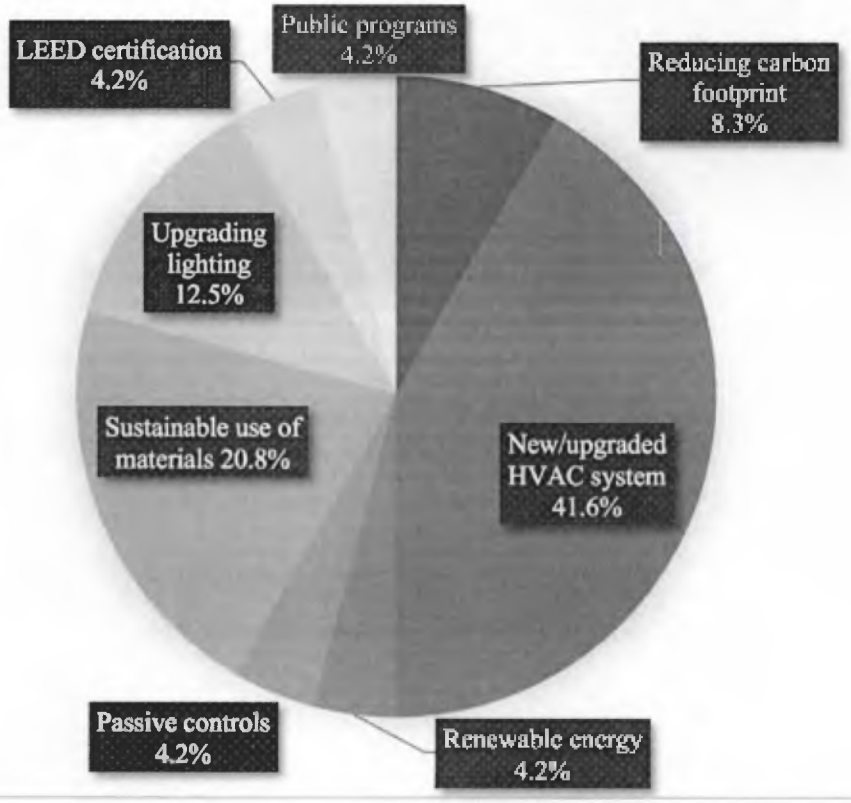
Figure 13: Tracking Energy Consumption to Adjust HVAC Controls



Part IV: Planning for Sustainability

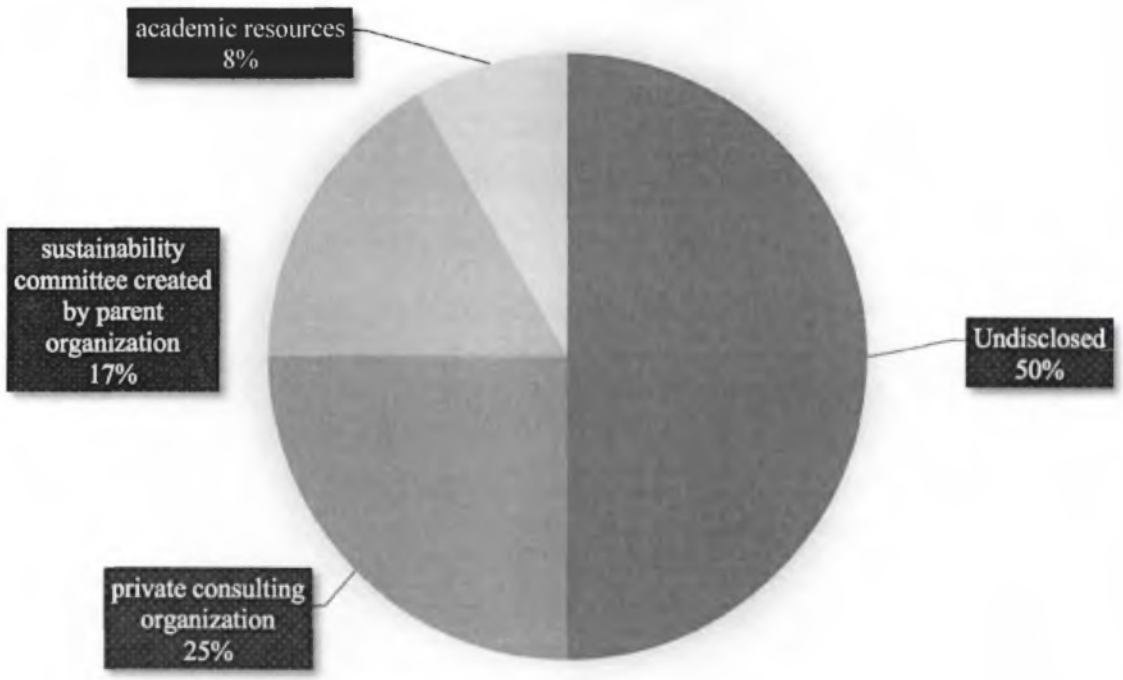
Question 10 asked, "is your museum planning to take any steps to make its collections facilities more sustainable? If so, what steps?" Of the 48 responses to this question, 50% (24) answered "yes" and 50% (24) answered "no." As this was an open-ended question, respondents answered it in a variety of ways. All answers were divided into 7 categories. As shown in Figure 14, out of the 24 affirmative responses, 8.3% (2) answered "reducing carbon footprint"; 41.6% (10) answered "new or upgraded HVAC system"; 4.2% (1) answered "using renewable energy"; 4.2% (1) answered "passive control system"; 20.8% (5) answered "sustainable use of packaging and storage materials";12.5% (3) answered "upgrading lighting system"; 4.16% (1) answered "LEED certification"; and 4.2% (1) answered "public programs to increase awareness regarding sustainability."

Figure 14: Future Plans for Sustainability



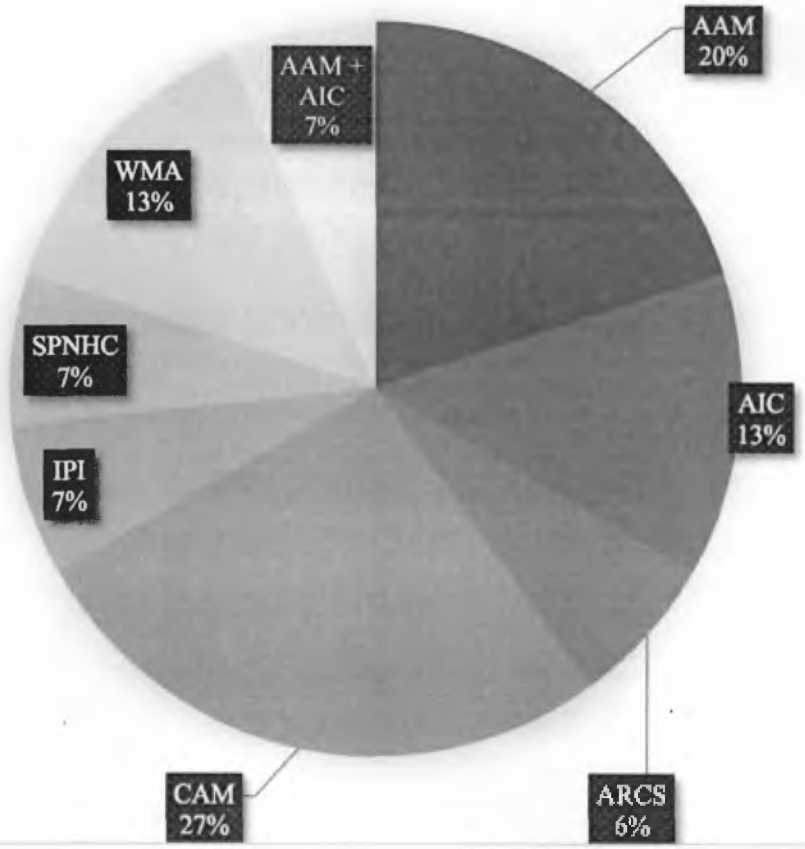
Question 11 asked, "has your museum consulted professional museum resources on sustainability? If so, please describe if possible." Of the 42 responses for this question, as shown in figure 15, 28.6% (12) answered "yes" and 71.4% (30) answered "no." All answers were divided into 4 categories. As shown in Figure 15, 25% (3) answered "private consulting organizations;" 16.7 % (2) answered "sustainability committee created by parent organization;" 8.3% (1) answered "academic literature" and 50% (6) chose not to answer.

Figure 15: Professional Resources on Sustainability



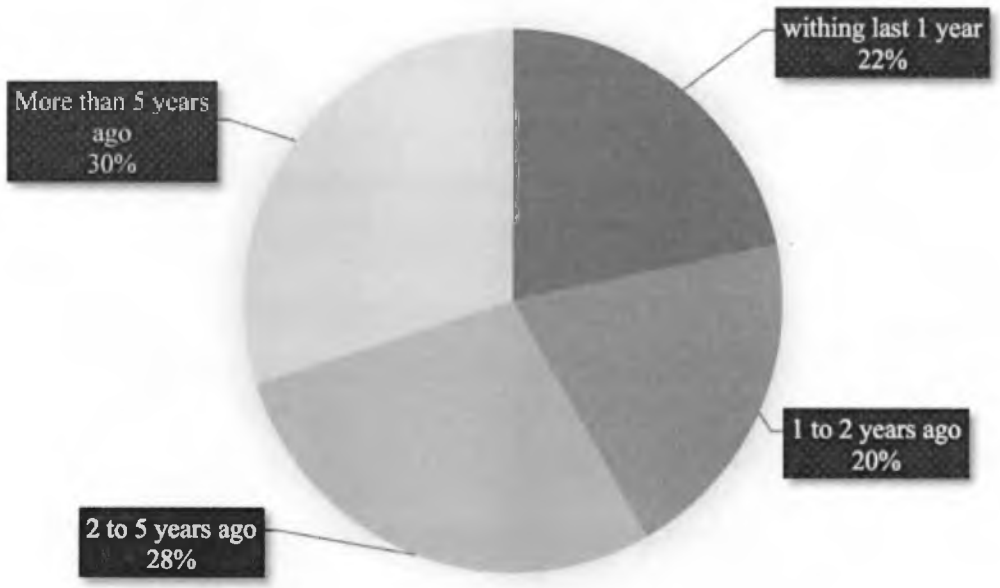
Question 12 asked, "has your museum collections staff attended conferences or special training on sustainability? If so, please describe if possible." Of the 44 respondents to this question, as shown in figure 16, 34% (15) answered "yes" and 66% (29) answered "no." As shown in figure 16, 20% (3) answered "American Alliance of Museums (AAM)"; 13.3% (2) answered "American Institute for Conservation (AIC) "; 6.7% (1) answered "Association of Registrars and Collection Specialists (ARCS) "; 26.6% (4) answered "California Association of Museums (CAM) "; 6.7% (1) answered "Image Permanence Institute (IPI) "; 6.7% (1) answered "Society for the Preservation of Natural History Collections (SPNHC) "; 13.3% (2) answered "Western Museums Association (WMA) "; and 6.7% (1) answered "AAM and AIC."

Figure 16: Organizations that Staff Attended for Special Training on Sustainability



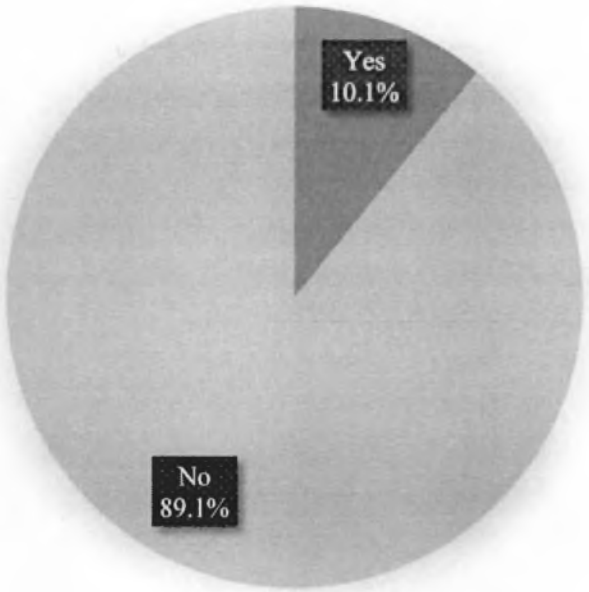
Question 13a asked, "when was your collection management policy last updated?" Of the 60 respondents to this question, as shown in Figure 17, 21.7% (13) answered "within last year"; 20% (12) answered "1 to 2 years ago"; 28.3% (17) answered "2 to 5 years ago"; and 30% (18) answered "more than 5 years ago."

Figure 17: Most Recent Update to Collections Management Policy



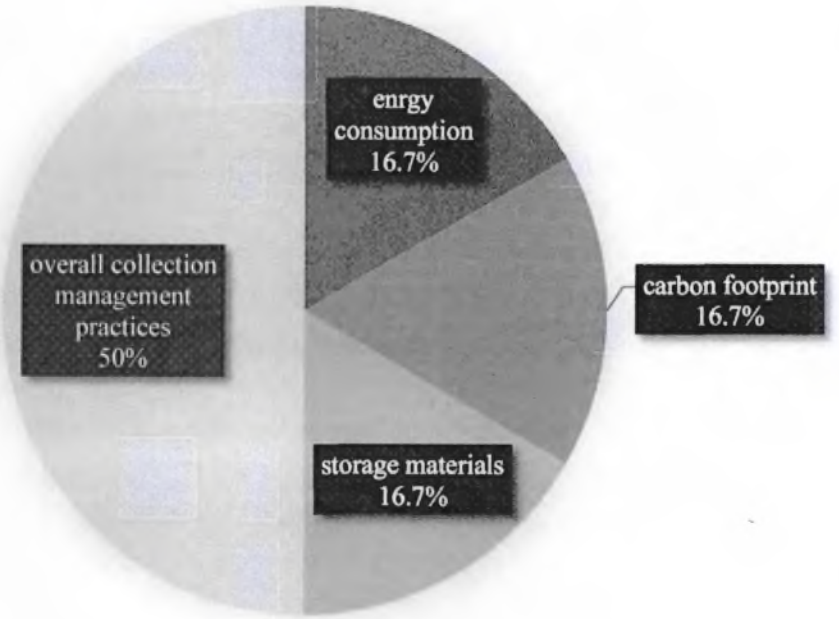
If the answer to question 13 a was "yes," question 13b asked, "have updates to your institution's collection management policy included sections on sustainability?" Of the 55 respondents to this question, as shown in figure 18, 10.1% (6) answered "yes" and 89.1% (49) answered "no."

Figure 18: Updates to Sustainability in Collections Management Policy



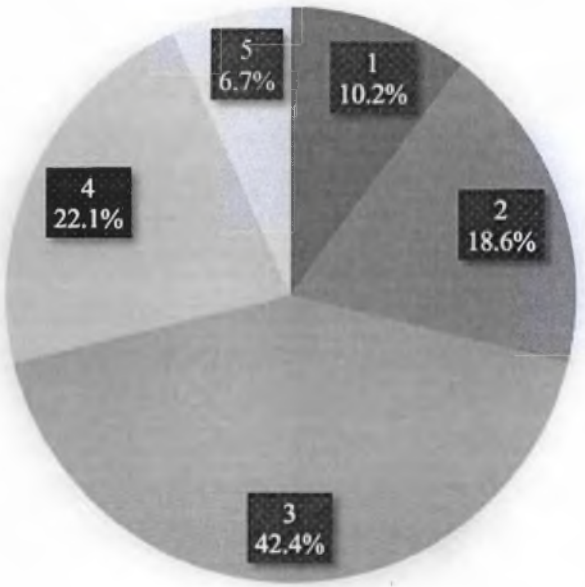
Question 13c asked, "in what areas?" Since this was an open-ended question, all the answers were divided into 4 categories. As shown in Figure 19, out of the 6 responses, 16.67% (1) answered "energy consumption"; 16.67% (1) answered "carbon footprint"; 16.67% (1) answered "storage materials"; and 50% (3) answered "overall practices in collection management."

Figure 19: Sustainability-Related Updates to the Collection Management policy



Question 14 asked, "on a scale of 1 to 5 please rate your institution's approach to sustainability, in relation to collections" (where five is the highest rating). Of the 62 museums that responded, as shown in Figure 20, 10.2% (6) chose 1; 18.6% (11) chose 2; 42.4% (25) chose 3; 22.1% (13) chose 4, and 6.7% (4) chose 5.

Figure 20: Rating for Institution's Approach to Sustainability (5 is Highest Rating)



These responses provide an overview of the sustainable practices in California museums and indicate that most of the museums surveyed in California consider sustainability an important issue. The next chapter will summarize the survey results and identify themes to discuss sustainable collection management practices in California

museums. It will be followed by a chapter where conclusions and recommendations are presented, based on results of the survey and the review of literature.

Chapter 6: Discussions

The survey discussed in this chapter was sent to 100 museums in California, out of which 62 responded, resulting in a 62% response rate. This chapter presents an overview of the results of the survey, followed by identifying key themes concerning energy use and sustainable collections management in museums today.

Analysis of Survey Sections

In the first section of the survey, the response rate was 100%, i.e., all 62 respondents answered the first three questions. The majority of respondents belonged to the category of art or history museums, with the highest percentages identified as history museums (29%), art museums (25.8%), or both art and history museums (14.5%). The size of the collections for an average museum was 10,000 to 50,000 objects, indicated by the highest percentage, 38.8%. More than one-fourth of the respondents (29%) also had an annual collections management budget of $10,000 to $50,000.

In sum, the average respondent to this survey was an art or history museum, housing 10,000 to 50,000 objects and with annual budget of $10,000 to $50,000 for collections management.

The second section asked about Museum Practices. The results of this section demonstrate the existence of general sustainability-related practices in museums. Specifically, the results of question 4 indicate that the most important topics of discussion regarding sustainability in collections management for the respondents were "waste

reduction" and "reducing electricity usage."

Results regarding up-to-date collections facilities, if they were originally built to house collections, how recently they were updated, and if the renovations included planning for sustainability, indicated that half of the museums had collections storage facilities originally built to house collections, while almost half had their collections storage facilities renovated more than 10 years ago. Roughly 40% of museums responded that the renovations included planning for sustainability, with the highest percentage of updates, more than 50%, for climate control systems.

Next, section 3 asked specific questions about energy efficiency strategies that are described in the literature review, specifically, chapter 3. These strategies include tracking outdoor climate to make changes in environmental controls and conducting energy audits. Nearly three-fourths of the respondents answered that they do not track outdoor temperature. A high percentage of respondents, more than two-thirds, responded that in tracking outdoor temperature, they also adjust the controls of their HVAC unit.

For energy audits, less than half of the of the respondents conduct energy audits, and of those that do, these take place every 5 years (32%) or more (36%). Roughly one-third of the respondents answered that they specifically track energy consumption of their HVAC unit, and more than half use that information to adjust HVAC controls.

The last section of the survey asked about planning for sustainability in the future. Almost a half of the respondents answered that they are planning to upgrade their climate

control systems to make their collections facility more sustainable, which was one of the 7 categories of responses. This section also shows that a large number of respondents, almost three-fourths, are actively consulting professional and academic resources to incorporate sustainability in their collection management, and 25% of these respondents consult with private consulting organizations. As expected, the highest percentage of respondents attend professional development workshops and lectures offered by the American Alliance of Museums (AAM) and the California Association of Museums (CAM), with most attending CAM.

Regarding recent updates to the collections management policy, the responses were somewhat evenly distributed between the 4 possible options, indicating that there is no set time when policies are updated: within the last year (22%); 1 to 2 years ago (20); 2 to 5 years ago (28%); and more than 5 years ago (30%). However, only one-tenth of the respondents indicated that the updates to the collections management policies included sections on sustainability, and half of these respondents answered that sustainability was included in overall practices in the collections management policy. These answers demonstrate that most of the museums are inclined toward following sustainable practices, but few of them mention sustainability specifically in the collections management policy.

Key Themes of the Results

After reviewing the results of the survey, three key themes about sustainability

and energy efficient museum practices emerge. First, specific practices adopted by museums to make their collection facilities more sustainable can be identified. Second, renovating HVAC systems to reduce energy consumption is important to museums in California. And third, resources that museums in California use to create energy efficient collections facility can be identified. The following section of this chapter will analyze these three themes, while also considering the review of literature from previous chapters.

Theme I: Specific practices adopted by the surveyed museums to make their collection facilities more sustainable:

One of the outcomes of the survey was information about what is considered to be sustainable practices in museum collections facilities. For example, it was the aim of question 4 of the survey to ask,"Which of the following areas are included in your museum's discussion of sustainability? On a scale of 1 to 5, where 5 is the most important and 1 is the least important, please rate the importance of each area outlined below to your institution's approach to sustainability."

While the response rate was nearly same for all the options, the highest rated responses were for adjusting environmental controls depending upon local climate, waste reduction, and reducing electricity usage. On the other hand, the lowest percentage of rating were for locally sourced materials, fair trade practices, and LEED certification. Overall, these results indicate that museums are working towards best practices identified in the literature review for energy efficiency and for making their collections facilities

more sustainable. However, it is surprising that LEED certification was a very lowly rated, compared to other energy efficiency related options.

Theme II: Importance of renovating HVAC systems to reduce energy consumption

Most of the questions in the survey were designed to assess practices adopted to reduce energy consumption. Responses to all of these questions showed that energy efficient climate control system was a goal for most of the responding museums. The highest percentage of respondents rated reducing energy usage as the most important topic in their museum's plan for sustainability.

When asked, "what specifically was altered or updated?" in the renovation of collections storage facility, most museums mentioned new or updated HVAC systems, while in the planning for sustainability section, the highest percentage of responses indicated that new or upgraded HVAC systems were part of plans for a more sustainable storage facility. These results indicate that energy efficient HVAC systems are one of the goals of museums in California when it comes to sustainable collections care practices.

Theme III: Resources used to create energy efficient collections facility:

The review of the literature outlined several professional and academic resources that provide detailed research about strategies used for reducing energy usage for climate control systems in museums. However, only one-third of museums indicated what resources they relied upon. Of the resources listed, the most important were the California Association of Museums (CAM) and the American Alliance of Museums

(AAM). These results suggest that rather than using resources from organizations that specifically address sustainability and energy efficiency, the respondents refer to organizations, such as CAM, that discuss general museum related issues.

Overall, although most of the questions in the survey did not specifically ask about the strategies mentioned in the review of the literature, the results of the survey indicate a significant percentage of museums in California are taking steps towards making their collections storage facilities more sustainable by reducing their energy usage.

The next chapter will present conclusions and recommendations.

Chapter 7: Conclusions and Recommendations

Museums are non-profit organizations that have access to limited financial resources. As organizations created for the benefit of society, they are also under constant scrutiny to follow best practices and be prudent stewards of resources. Therefore, sustainable collections management is not just a responsibility for museums, it is also a necessity.

This chapter considers the review of the literature and the results of the survey to draw conclusions and to outline recommendations about sustainable collections practices in the area of energy efficiency. The recommendations address how museums can become more energy efficient in their care of collections.

Summary of Survey Results

Overall, the results of the survey indicated that many museums are considering updating their HVAC systems to make their collections storage facilities more energy efficient. Surprisingly, LEED certification is not a part of a plan for sustainability for many museums. From the responses, it is also evident that, although most museums are not currently using any specific strategies in the area of energy efficiency, they are planning to make significant changes in the future to make their collections management facility more energy efficient. By comparing the responses for what sustainability practices museums in California are currently following with their future plans, it can be concluded that most museums are in their initial phase of addressing sustainability.

Conclusions

After considering the results of the survey, three conclusions can be drawn about the readiness of museums in California to achieve energy efficiency in collections. First, the museum community in California considers sustainability to be an important issue. Second, many museums are not applying strategies for reducing energy consumption in climate control systems for collections. And third, the collections management policies of many museums in California do not yet appear to include sustainability.

Conclusion I: Museum Community in California Considers Sustainability to be an Important Issue

The survey results show that sustainability is an important issue in museums in California. The same is also indicated by the high response rate to the survey. As expected for museums in California, a state that has had electricity crises, energy efficiency issues were prioritized by many museums. The results indicate that most of the museums are planning for sustainability by updating their HVAC systems. Energy efficiency also received the highest rating in the question regarding what is included in museum's discussions on sustainability.

The results also indicate that many museums are investing in consultations with private sustainability consultants. Museum professionals are also actively participating in professional development workshops and conferences offered by museum associations such as the AAM and CAM.

Conclusion II: Many Museums are not Applying Strategies for Reducing Energy Consumption in Climate Control Systems for Collections.

Several questions in the survey asked specifically if museums were applying strategies to reduce energy consumption that were mentioned in the review of the literature. The results indicated that a small percentage of respondents track outdoor environmental conditions to adjust HVAC control and conduct energy audits. Of those museums that do track, an even smaller percentage of respondents used that information to adjust their HVAC controls.

The literature review outlined best practices and strategies recommended by museum professionals and research organizations, such as Image Permanence Institute (IPI). It is surprising that although other questions had high responses in favor of sustainability, few museums followed practices mentioned in the literature review, suggesting that educational efforts on the topic should be deepened.

Conclusion III: The Collections Management Policies of Many Museums in California Do Not Yet Appear to Include Sustainability.

One of the questions in the survey asked if sustainability and energy efficiency was included in a museum's collections management policy. Only 10% of the respondents answered that their collections management policy included sections on sustainability. This was also one of the lowest percentage of responses concerning sustainability practices. A sustainability section should be included in a Collections

Management Policy, as outlined below.

Recommendations

After considering the literature review, survey results and the conclusions outlined above, four recommendations can be offered to improve energy efficiency in museums in California. First, museums should plan their approached to sustainability and energy efficiency. Second, museums should work to reduce the energy consumption of HVAC systems. Third, sustainability should be in a museum's collections management policies. And fourth, museums should avail themselves of low-cost resources and research in the area of sustainability and energy use.

Recommendation I: Planning for Sustainability and Energy Efficiency

To make collections storage facilities more sustainable and energy efficient, the collections manager has to consider the environmental requirements of objects, energy consumption, and the financial resources available for collections. Therefore, museums need to plan their approach to sustainability and energy. For example, Chapter 3 of the literature review outlined several areas that can be considered in addressing the energy efficiency of HVAC systems.

Although facilities managers understand the engineering aspects of environmental control systems, they might not have specific information about collections. Therefore, with the help of facilities managers, collections managers should learn the basics of how the components of HVAC systems work and plan environmental controls accordingly.

Together, they should also create floor plans based on the material composition of objects and consider how objects are used. For example, an archival collection that is accessed by visitors requires different environmental conditions than a collection of metal objects that are only needed for specific exhibitions. A step-by-step guide created by IPI can assist museum staff in making their museums more energy efficient (IPI 2012).

Recommendation II: Methods to Reduce Energy Consumption of the HVAC System

The survey showed that many museums conduct energy audits; however, a lower percentage of respondents used that information to adjust HVAC controls. Brophy and Wiley (2013) recommend several online tools to conduct energy audits specifically for reducing energy consumption, such as Energy Star and ASHRAE 90.1. They also recommend consulting energy service companies to help with reducing energy consumption (Brophy & Wiley 2013). Museums should consult these resources.

HVAC controls can be adjusted based on the local climate to avoid using electricity when it is not necessary. The survey results indicate that only about one-fourth of the respondents tracked their local temperature to adjust HVAC controls. Although this method may require consultations from experts, it can reduce energy consumption significantly.

Other methods to reduce energy consumption are outlined in the review of literature include the use of buffer materials and appropriate lighting systems. Use of buffer materials does not require much electricity, and can be easily integrated into a new

collections facility. For lighting systems, using LED lights and sensors to control lights can reduce energy usage. These methods can also help to avoid heat generated by the lights.

Recommendation III: Collections Management Policies and Sustainability

As mentioned previously in this chapter, only a small percentage of respondents responded that their collections management policies included sections on sustainability. Including sustainability in collections management policies shows a museum's commitment to the topic. It can also be useful for acquiring funding from donors and foundations to create more sustainable collections facilities.

Recommendation IV: Use Low-cost Resources and Research

The survey results indicate that although most of the respondents consider sustainability an important issue, and many of them attend professional development workshops and conferences regarding sustainability, they are not able to integrate recommendations from these resources into their collections management facilities. The survey also indicates that average annual budget for collections management is only $10,000 to $50,000. Considering IPI's statistic of average annual cost for HVAC system of $20,000 to $50,000 (IPI 2019), it appears that some museums are using a significant portion of their financial resources for HVAC system. Therefore, the current resources available for museums might not be able to address the need for museums to become more sustainable. There should be more research to develop strategies for museums to

acquire funding, specifically for sustainability.

Closing Comments

Creating a sustainable future is one of the most important responsibilities of our society. Museums can share in this goal in many ways, such as by promoting sustainability through educational programs, use of eco-friendly materials, and through ensuring they are energy efficient in collections care and in all areas of museum operations. There is much to be done to make museums more sustainable. As this study shows, however, museums in California are beginning to make important contributions towards sustainability.

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Appendices

Appendix 1: Cover Letter for Survey

Aparna Suhas Dhole
Museum Studies Program
San Francisco State University
1600 Holloway Avenue
Fine Arts Building, Room 293
San Francisco, CA 94132
E-mail: adhole@mail.sfsu.edu

Date: February 2nd, 2018

Dear Museum Director/Collection Manager,

My name is Aparna Suhas Dhole and I am conducting a project on environmental sustainability of museum collection facilities. The information gathered will be used to analyze the how the museums in California follow energy efficient practices. I am hoping that I might have approximately ten minutes of your time to complete the enclosed survey.

The data collected from this survey will be used for the completion of a Master of Arts degree in Museum Studies at San Francisco State University. You have been contacted because your museum contains collections, and because you are an expert in the best practices of collection management. If you agree to complete the survey, please understand that any information provided by you may appear in the final written thesis. However, note that you need not supply any information on the response that links your museum to the survey.

If you are not the most appropriate person in the museum to answer the survey, it would be most appreciated if you could forward it along to someone in the museum who can respond. In addition, a self-addressed envelope has been supplied. I would greatly appreciate the return of the survey by February 24th, 2018.

If you have any questions or concerns regarding this project, please contact my research advisor, Professor Edward Luby at emluby@sfsu.edu. The title of my thesis is "Practices for Energy Efficient Collection Management in California."

Thank you for your assistance.
Sincerely,

Aparna Suhas Dhole

Appendix 2: Survey Questions

Survey Questions

1. Which of the following category your institution fits into? (Select all that apply)

□ Anthropology Museum

□ Art Museum/Gallery/Center

□ Historic House

□ History Museum/ Historical Society

□ Natural History Museum

□ Science/Technology Museum

□ Other:

Specify_____

2. What is the size of your institution's collection? (select one)

□ Small (less than 10,000 objects)

□ Medium (10,000 to 50,000 objects)

□ Large (more than 50,000 objects)

3. What is the average annual budget for collection management at your institution? (select

one)

□ Less than $5,000

□ $5,000 - $10,000

□ $10,000 - $50,000

□ $50,000 - $100,000

□ $100,000 - $500,000

□ More than $500,000

4. Which of the following things are included in your museum's discussion of sustainability? (select all that apply) On a scale of 1 to 5, where 5 is the most important and 1 is the least important, please rate the importance of each area outlined below to your institution's approach to sustainability.

□ Reducing carbon footprint	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Using eco-friendly products	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Adjusting environmental controls depending upon local climate	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Waste reduction	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Water conservation	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Reducing electricity usage	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Locally sourced materials	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Fair trade practice	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Green waste disposal	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ LEED Certification	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A
□ Other: _____	□ 1	□ 2	□ 3	□ 4	□ 5	□ N/A

5. Was your museum's primary the collection storage facility originally built specifically for collections?

□ Yes □ No

6. a) When was the collection management facility last renovated? (select one)

□ Less than a year ago

□ 5 to 10 years ago

□ 1 to 5 years ago

□ More than 10 years ago

b) Was planning energy consumption part of the renovation?

□ Yes □ No

c) If yes, what specifically was altered or updated?

7. a) Does your collections unit track local temperature outside the institution?

□ Yes □ No

b) If yes, do you use this information to adjust controls of the HVAC system of the collections

storage?

□ Yes □ No

8. a) Does your institution conduct energy audits?

□ Yes □ No

b) If yes, how often? (select one)

□ 2 to 4 times a year

□ Once a year

□ Every 5 years

□ Other, specify _____

9. a) Does your collections unit track the energy consumption of the HVAC?

□ Yes □ No

b) If yes, does the collections unit use this information to adjust the energy consumption?

□ Yes □ No

10. Is your museum planning to take any steps to make its collections facilities more sustainable? If so, what steps?

11. Has your museum consulted professional museum resources on sustainability? If so, please describe if possible.

12. Has your museum collections staff attended conferences or special training on sustainability? If so, please describe if possible.

13. a) When was your collection management policy last updated? (select one)

□ Within last 1 year

□ 2 to 5 years ago

□ 1 to 2 years ago

□ More than 5 years ago

b) Have updates to your institution's collection management policy included sections on sustainability?

□ Yes □ No

c) If yes, in what areas?

14. On a scale of 1 to 5 please rate your institution's approach to sustainability, in relation to collections. (select one)

□ 1 □ 2 □ 3 □ 4 □ 5

Appendix 3: List of Survey Recipients

Agua Caliente Cultural Museum, Palm Springs
Agua Mansa Pioneer Cemetery & Museum, Colton
Art, Design & Architecture Museum, Santa Barbara
Asian Art Museum, San Francisco
Autry Museum of the American West, Los Angeles
Bakersfield Museum of Art, Bakersfield
Berkeley Art Museum & Pacific Film Archive, Berkeley
Bolinas Museum, Bolinas
Bonita Museum & Cultural Center, Bonita
Bowers Museum, Santa Ana
California Academy of Sciences, San Francisco
California Museum of Photography University of California, Riverside
California State Railroad Museum, Sacramento
Campbell Historical Museum, Campbell
Cantor Arts Center, Stanford
Channel Islands Maritime Museum, Oxnard
Claremont Museum of Art, Claremont
Community Memorial Museum of Sutter County, Yuba City
Crocker Art Museum, Sacramento
de Saisset Museum, Santa Clara
de Young Museum, San Francisco
Exploratorium, San Francisco
Folsom Historical Society - Folsom History Museum, Folsom
Fresno Art Museum, Fresno
Haggin Museum, Stockton
Hayward Area Historical Society Museum of History and Culture, Hayward
Hammer Museum, Los Angeles
Healdsburg Museum, Healdsburg

Hearst San Simeon State Historical Monument, San Simeon
Hi-Desert Nature Museum, Yucca Valley
History San Jose, San Jose
J. Paul Getty Museum, Los Angeles
Janet Turner Print Museum, Chico
Japanese American National Museum, Los Angeles
Kern County Museum, Bakersfield
Lancaster Museum of Art and History, Lancaster
Legion of Honor, San Francisco
Lindsay Wildlife Museum, Walnut Creek
Long Beach Museum of Art, Long Beach
Magnes Collection of Jewish Art and Life, Berkeley
March Field Air Museum and Foundation, Riverside
Martinez Historical Society and Museum, Martinez
Mills College Art Museum, Oakland
Mingei International Museum, San Diego
Mission Inn Museum, Riverside
Monterey County Agricultural and Rural Life Museum, Monterey
Monterey Museum of Art, Monterey
Museum of American Heritage, Palo Alto
Museum of Contemporary Art Los Angeles, Los Angeles
Museum of Contemporary Art, San Diego
Museum of Latin American Art, Long Beach
Museum of Photographic Arts, San Diego
Museum of Sonoma county, Santa Rosa
Museum of Ventura County,
Museum on Main Street, Pleasanton
Natural History Museum of Los Angeles County, Los Angeles
Oakdale Museum and History Center, Oakdale

Oakland Museum of California, Oakland
Orange County Museum of Art, Orange County
Pacific Grove Museum of Natural History, Pacific Grove
Palo Alto History Museum, Palo Alto
Pasadena Museum of History, Pasadena
Phoebe A. Hearst Museum of Anthropology, Berkeley
Pomona College Museum of Art, Claremont
Raymond M. Alf Museum of Paleontology, Claremont
Riverside Art Museum, Riverside
Riverside Metropolitan Museum, Riverside
Robert and Frances Fullerton Museum of Art, San Bernardino
Robert Louis Stevenson Museum, St Helena
Rosicrucian Egyptian Museum and Planetarium, San Jose
Sacramento History Museum, Sacramento
Saint Mary's College Museum of Art, Moraga
San Diego Air & Space Museum, San Diego
San Diego History Center, San Diego
San Diego History Center, San Diego
San Diego Model Railroad Museum, San Diego
San Diego Museum of Art, San Diego
San Diego Museum of Man, San Diego
San Diego Natural History Museum, San Diego
San Francisco Maritime National Historical Park, San Francisco
San Francisco Museum of Modern Art, San Francisco
San Jose Museum of Art, San Jose
San Jose Museum of Quilts & Textiles, San Jose
San Mateo County Historical Association, San Mateo
Santa Barbara Historical Museum, Santa Barbara
Santa Barbara Museum of Art, Santa Barbara

Santa Barbara Museum of Natural History

Santa Cruz Museum of Art & History

Santa Cruz Museum of Natural History

Santa Ynez Valley Historical Museum

SFO Museum

Society of California Pioneers

Tenderloin Museum

The History Center of San Luis Obispo County

UCLA Meteorite Gallery

University Art Museum - California State University, Long Beach

USC Fisher Museum of Art & International Museum Institute

USC Pacific Asia Museum

Walt Disney Family Museum

Los Angeles County Museum of Art