GREEN AIRPORTS:

WAYS AIRPORTS CAN GO GREEN

By

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ABSTRACT

The goal of this research study was to help document the various sustainable technologies that are in use at airports today. Airports are a great place to promote sustainable living and lowering the carbon footprint. For this study, contact was secured with airports which have included sustainability practices in their operations, via a survey. In addition to the survey, web based research was performed in order to determine various sustainability initiatives currently in place at different airports. Changing the lighting at an airport to LED lighting was the most popular initiative and undertaken at almost all of the airports included in the research. Alternate fueled vehicles were also a big hit amongst the airports studied. The installation of a compressed natural gas station at one airport saved $269,275 over a five year period. Using solar roofs or green roof, de- icing fluid recycling or using energy efficient escalators were some initiatives that airports are incorporating.

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LIST OF ABBREVIATIONS

AC - Advisory Circulars

ACI-NA - Airports Council International – North America

ACRP - Airport Cooperative Research Program

AERCs - Airport Emission Reduction Credits

AIP – Airport Improvement Program

APU – Auxiliary Power Unit

ASDE – X - Airport Surface Detection Equipment,

Model X BIAS - Baylor Institute for Air Science

CAA - The Clean Air Act

CAFR - Comprehensive Annual Financial Reports

CDA - Chicago Department of Aviation

CPs - Construction Points

DEN - Denver international Airport

DOE - Department of Energy

DPs - Planning and Design Points

DR - Dominican Republic

ECM - Electronic Content Management

EMS – Environmental Management System

EPA – Environmental Protection Agency

ESCOs - Energy Service Companies

FAA - Federal Aviation Administration

GAIFA - Green Airport International Flight Academy

GAO - General Accounting Office

GHG – Green House Gasses

GRI - Global Reporting Initiative

GSA - Green Sustainable Airports

HVAC - Heating, ventilation and air conditioning

ICAO - International Civil Aviation Organization

IPCC - Intergovernmental Panel on Climate

Change IRB - Institutional Review Board

LAWA - Los Angeles World Airports

LEED - Leadership in Energy and Environmental Design

MCO - Orlando International Airport

MTSU - Middle Tennessee State University

NAAQS – National Ambient Air Quality

Standards NEPA - National Environmental

Policy Act of 1969 NJ – New Jersey

NJDEP - New Jersey Department of Environmental Protection

NPIAS - National Plan of Integrated Airport Systems

NY – New York

OEMs - Original Equipment Manufacturers

PCA – Pre Conditioned Air

PFC – Passenger Facility Charge

PSEG - Public Service Electric & Gas

RAFDC - Renewable Aviation Fuels Development Center

SAM – Sustainable Airport Manual

SEER - Specifying high energy efficiency

SFO – San Francisco International

Airport SMP - Sustainable Management

Plan SWF - Stewart International Airport

SWOT – Strength, Weakness, Opportunity, Threats

TEB – Teterboro Airport

TRB – Transportation Research Board US – United

States USGBC – United States Green Building Council

VALE– Voluntary Airport Low Emissions program

CHAPTER I: INTRODUCTION

Going “green” in today’s world is an often talked about concept, and is a commonly used term that means being environmentally friendly. Being environmentally friendly means utilizing renewable energy sources so that the use of non-renewable energies can be curtailed. A related term which should be defined is sustainability. Sustainable development is “the quality of not being harmful to the environment or depleting natural resources, and thereby supporting the natural ecological balance,” (Sustainability, n.d). Based on this definition sustainability means to use resources in such a way that the amount of depletion of natural resources is carefully managed. Sustainable development means reducing the carbon footprint, so the carbon balance in the world is maintained. Not only is it a relief for the environment but eventually, for the economy as well. A report released by the Intergovernmental Panel on Climate Change (IPCC) in 2007 and 2008 revealed that global warming is very much present and that human activity is most likely the source (Reisinger, 2007). Our planet has already started going through climate change as exhibited by the frequency of varying weather, ranging from extreme cold to extreme hot. This has given rise to different weather events including droughts, fires, floods, and the rapid melting of glaciers and ice sheets. If this melting continues, it will soon lead to rising sea levels, which could lead to the demise of many entire species and destabilize the ecosystem, which will threaten the very survival of future generations (Reisinger, 2007). The IPCC report stressed the necessity that humans make efforts to reduce greenhouse gas emissions so that the earth’s temperature rise can be contained within 2 Celsius degrees per year to prevent

catastrophe (Reisinger, 2007).

If necessary steps are not taken soon enough, the effects will be irreparable. The IPCC recommends the use of and promotion of research to develop environmentally friendly and sustainable technologies. It provides guidelines on how to maintain and reduce emissions with the help of land management, improved planning in transportation, introduction of more efficient vehicles, and building greener homes. One major source of conventional air pollution that leaves a carbon foot print, which has managed to evade most radar screens until recently, is aviation. Within the aviation industry, airports serve an important function as the facilities that enable passengers to connect with the air transportation system. Airports are also the entry passage to a city, and are open to all the public. They reflect the image of the city in which each one is located. For these reasons, airports are a particularly important part of the both the aviation industry and their local communities, and determining how to assist these facilities “go green” is a timely and important topic.

Literature Review

Aviation has a big role to play in today’s global economy, and because of that it is at the center of rising controversy regarding its contribution to greenhouse gasses and its potential to become one of the greatest causes of anthropogenic climate change (Zanin, 2007). Aviation has brought abundant jobs, growth and connectivity to many places. For these reasons and many more aviation is essential. However, the negative impacts need to be addressed. There have been a number of research projects in the past decade undertaken by the Renewable Aviation Fuels Development Center (RAFDC) and the Baylor Institute for Air Science (BIAS) at Baylor University. These studies have

been a catalyst in the development of similar programs and research across the country. One of the latest implementations to spark interest among stakeholders in aviation were the “Green Airport” and the Green Airport International Flight Academy (GAIFA) in the Dominican Republic (DR), which demonstrated the advantages of using bio-fuels and renewable energy at airports, a model that can be replicated in many areas (Zanin, 2007). This island had a plethora of natural resources which allowed it to become energy independent. Zanin’s study focused on the initial steps that need to be taken to implement this design, including the world’s first flight academy running solely on biofuels, to provide the foundation and gather support for the off-the-grid “Green Airport.” The study examined the effectiveness of using bio-fuels, especially for general aviation aircraft. The reasons why the DR was chosen as the site for this research effort were:

Abundant biomass and renewable recourses.

Developed aviation infrastructure and tourism (Zanin, 2007).

The study found that it improved the quality of life for both flora and fauna and also improved the economic conditions. It created more jobs and promoted using bio fuels in aviation. This implementation of an off-the-grid airport can act as a catalyst for the implementation of such technologies to be reproduced around the world.

In another effort to improve sustainability, a case study was done at Chicago O’Hare International Airport (Ruble, 2011), which was based on the premise that whatever policy an airport establishes has a chance to effect the quality of life in the future. Stressing sustainability at airports could leave a big impact on the world’s environment. Describing sustainable airport planning initiatives was the purpose of this

study. The research questions addressed were as follows: What are the current trends in sustainable airport planning in the United States? What are the current and future sustainable airport plans at Chicago O'Hare International Airport? (Ruble, 2011)

The methodology of the study was a literature review, which included the O'Hare Modernization program and a Sustainable Airport Manual (SAM), implemented at the O'Hare Airport (Ruble, 2011). The review included various scholarly articles and books related to sustainability and airport planning. Studies regarding other airports were also done. The Federal Aviation Administration's (FAA) documents on environmental airport planning issues were reviewed as well. Advisory Circulars (AC) of the 150 series, which includes the guiding principles of construction of an airport in considerable detail were reviewed, as was a General Accounting Office (GAO) release of a study regarding sustainability in aviation in September of 2010. Finally, the Airport Cooperative Research Program (ACRP) publications regarding sustainability at airports were also considered.

This study of O'Hare found that economics is a major driving force in making an airport sustainable. In order to promote sustainability to an airport, it must be seen that these methods will have great cost benefits in the long run. Any time an airport starts a federally funded project it has to go through an environmental assessment (Ruble, 2011).

A study conducted by the Airport Cooperative Research Program *(*ACRP) on airport sustainability practices was intended to inform airports and people involved in airport operations and businesses about the range of airport sustainability practices there are, gathered from a literature review and a web-based survey. This survey asked respondents to index their airports' information in relation to environmental

sustainability performances (Transportation Review Board [TRB], 2008). Respondents identified practices that were planned or were already in place at their airports. The article was published by the Transportation Research Board (TRB), under the ACRP. This survey was administered to 52 persons working at an airport within or outside the United States (US). The researcher targeted airports of different sizes and geographic locations so they received varied responses. It was self-assessment research using performance scales, and was sponsored by the FAA. The issues addressed by this research were environmental sustainability performance of airports, the social sustainability performance of airports, and the economic sustainability of airports (TRB, 2008).

The TRB survey exhibited that U.S. and non-U.S. airports are executing a number of initiatives that fit within the description of sustainability practices. Survey respondents cited regulations and airport policy as the key drivers for sustainability practices currently; they expect stakeholder concerns and global issues such as climate change to be the key drivers in the prospect. For both U.S. and non-U.S. airports, funding was the number one barrier to the implementation of sustainability practices. Other barriers were privation of staffing and management support, and the dearth of an environmental culture in their airport organization. Respondents identified that policies were a key driving force for sustainability (TRB, 2008).

There is a compelling need to address the environmental effects of air transportation, especially when both need and demand is increasing with the growing economy. The TRB survey points to a few practices that airports across the U.S. and one airport in Europe are utilizing in the areas of measurement and monitoring, water,

energy, climate change, land use, materials, waste, noise, energy and green building. One facility at the Munich Airport reprocesses the waste water from de-icing operations by the process of distillation. This resulting solution (approximately 65% propylene glycol) is recycled at a recycling facility and turned into de-icing agent. The 21st century water environment holds many complex and challenging problems, such as polluted runoff, suburban growth, drinking water security, groundwater/surface water interactions, invasive species, microbes in drinking water, and atmospheric deposition. Some of the practices to ensure water conservation and the efficient use of water are:

Low flow/automatic fixtures and toilets and waterless urinals.

Capturing and partially infiltrating rainwater.

Green roofs and limited landscaping that features drought-tolerant species.

Onsite storm water collection and treatment.

De-icing spots/pads, collection and treatment of de-icing fluids (TRB, 2008).

As the rules are becoming more stringent for industrial sources, airports are emerging as one of the major sources of air pollution – they are responsible for up to 10% of the total emissions in some urban areas. To receive regulatory approval, the airport must show that its growth will conform with the air quality plans for that region. Some of the practices to address the air quality are:

Particle filters on airport vehicles

Active dust control, permitting, and conformity analysis programs.

Planning for development that complies with the SIP and the Clear Air Act (TRB, 2008).

Waste management at airports is becoming increasingly important with the growth in passenger numbers. Portland Airport recycles foreign periodicals from

international flights to educational institutions that teach foreign languages. Some of the practices used at other airports are:

Compostable food service ware.

Restroom paper products with high recycled content.

Use of strawboard instead of gyprock.

Reuse of building materials onsite, very high use of concrete and asphalt during construction projects.

Reducing number of copier machines airport wide by 12% (TRB, 2008).

In the realm of noise pollution, today's aircraft are typically 75% quieter than jets in the 1960's. However, steps need to be taken in order maintain and improve this level of reduction in noise so it does not become a major issue again. Some of the practices that the airports and aircraft use are:

Limitation on taxiing and engine testing: engine run-up pads to attenuate noise from engine testing

Noise mitigation process for schools, residential areas and public offices.

Separate pricing for low-sound aircrafts (TRB, 2008).

Buildings on airports are direct contributors to the pollution experienced at each particular airport. Green buildings are designed, constructed and operated to boost environmental, economic, health and productivity performance. These green buildings prove to be beneficial for occupants, owners, the environment and society at large. These benefits includes measurable reductions of waste, energy saving, reducing operating and maintaining costs, and improvement in indoor air quality. Some of the practices used at or by airports are:

Building certified to Silver level of LEED (Leadership in Energy and Environmental Design)—the U.S. green building rating system.

Terminal building design is 30% more efficient than required under federal law —high-performance glazing, enhanced daylight, energy-efficient fixtures, efficient entryways, efficient ventilation, outside air economizer, energy management and control system, variable-flow chilled and hot water systems.

Grid-connected solar photovoltaic panels.

Ground landscaping composed of native plants and trees grown in local nurseries specifically for the airport (TRB, 2008).

Airports are embracing greener technologies with each passing day. These technologies are placed to reduce the environmental footprints and to help airport with long-term economic impact. Another ACRP study, in 2014, was conducted to find out the drivers and the outcomes of the green initiatives which have been installed at certain large airports. This study sought to find out the impact these green initiatives have had on the environmental front, the financial front, and in some cases the community surrounding the airport (TRB, 2014). The study was conducted including 15 large hub airports that have adopted sustainable technologies. Airport personnel were questioned about the drivers, barriers, and benefits to the green initiatives (TRB, 2014).

This study consisted of three parts: a literature review, an electronic survey of green airport practices, and the development of case examples to illustrate airport experience with specific green practices.

This survey gave a better understanding of what are the driving factors are behind airports opting for the sustainability initiatives. These drivers were considered using the

study done in 2010 by the ACRP. The responses to the survey indicated that compliance is the major driving factor followed by cost reductions, desire for improved sustainability performance, neighbors and community, and leadership in the industry. When asked about the governing body for their sustainability practices, all the airports responded their sustainability initiatives were founded by a sustainability policy. In addition to that, six airports stated that they use an environmental management system (EMS) to manage their green initiatives. These airports were also asked about the resources they had to rely on to implement these sustainability initiatives; all respondents reported relying on their internal environmental staff, which included airport operations or maintenance staff. External resources included external consultants and training providers. The airports involved were asked what they thought was the benefit that they received with these sustainability initiatives. Most of the respondents stated that the best benefit that they received was the improved sustainability performance, followed by the recognition of leadership in the industry and greater management confidence. The airports were asked about what barriers they had to face during the implementation process. Most of them replied saying that the insufficient recourses or staff was the greatest barriers. These were followed by lack of top management support (TRB, 2014).

The survey results, although primarily for large hub airports, established that about one- third of the airports had fully developed sustainability programs. The top five drivers for programs were compliance concerns; desire for improved sustainability performance; cost reductions; neighbours and community; and demonstration of leadership in the community. Airports have overcome barriers to implement practices

through creative approaches. For example, in overcoming limited funding, airport staff have turned to grants and other alternative financing mechanisms, such as energy service companies (ESCOs). Use of public-private partnerships was also cited as an effective way to overcome barriers.

Another study was undertaken by Leonie Tiben (2012), and the objective of this study was to find out the different green marketing and communication practices of the different Green Sustainability Airports (GSA).

The chief question addressed by the study was, what is GSA's marketing and communication policy with regard to sustainability? To find out a Strength, Weakness, Opportunity and Threats (SWOT) analysis was used that also forms the basis for a series of endorsements (Tiben, 2012). These recommendations or best practices, were put into practice by a "toolkit" that was applied at Groningen Airport Eelde. Technically, this paper was based on bith desk and field research. If it was to be summarized, it could be said that communication of Sustainability is very important both internally and externally. Staff and management aim for a change of attitude of their employees with regard to sustainability.

There are several factors that continues to push green marketing, such as social media, communication with protesters, politicians and neighbors, and attitude of staff marketing department. Different airports chose different social media platforms to broadcast their stories, for example, Facebook, Twitter and LinkedIn. It was the qualitative aspects of these platforms that determined their effectiveness. The use of social media is efficient, fast, and cheap in spreading the message. It allows outreach out to both customers and non-customers. The use of social media should be intensified,

according to the Lawrence study. One major key to spreading the message of sustainability is the attitude of the marketing staff. The department has to have a proactive attitude towards green marketing to be successful. It was also noted that the line between neighbors and protesters is very thin. The distinction was made in the survey because not everyone is at odds with the airport (Global Reporting Initiative [GRI], 2009).

In 2009 the Global Reporting Initiative (GRI) initiated a research project after being making an attempt to do so by numerous representatives from the aviation sector. Prior to initiation of this process, GRI conducted initial research to establish sustainability reporting trends in the airport sector (GRI, 2009). The analysis exposed various sector-specific themes which were usually reported by airports, but which are not covered amply or at all in the GRI Guidelines.

Literature review identified that there were a total of thirty nine different airports which have published a sustainability report, from which 17 sustainability reports were analyzed specifically covering sustainability performance for the year 2007. The results of this research were published under Global Reporting's authority. To gain vision into reporting trends and to launch the possible scope and issues that need to be addressed in the Sector Supplement, the analysis focused on the below questions:

- What is the incidence of reporting on GRI indicators in Airports Sustainability Reports?
- What sector themes were encompassed or not, and what is their association to existing GRI indicators? (GRI, 2009)

To begin with, GRI assembled a comprehensive list of sustainability reports

published to date from airports around the world, and then in turn evaluated a sample of sustainability reports from 17 airports for the year 2007 (GRI, 2009). Interpretations were made on trends in the use of GRI indicators by this sample group of sustainability reporters. The examination of the 17 reports allowed the identification of the trends that appear and their frequency. The three classifiers used were High, Medium and Low. High status were given if the theme was reported on more than 14 airports, Medium if between 7 to 13 airports and Low if reported by less than 7 airports (see Figure 1).

Sector theme	Frequency	Number of reporters
Air Quality	High	17/17[4]
Energy	High	17/17
Solid Waste Reduction and Recycling	High	17/17
Noise Abatement	High	16/17
Health and Safety	High	15/17
Water Conservation and Management	High	15/17
Community Investment and Development	High	14/17
Environmental Communication	High	14/17
Surface Access/ Transportation	High	14/17
Natural Resources Management	Medium	13/17
Green Initiatives, Buildings and Facilities	Medium	12/17
Traffic/Operational Figures	Medium	12/17
Climate Change	Medium	11/17
Customer Care	Medium	11/17
Labor /Sustainable Human Resources	Medium	11/17
Income-Generation and Distribution	Medium	9/17
Hydrocarbon spills	Medium	9/17
Winter Weather Management	Medium	7/17
Sourcing/ Supply Chain	Medium	7/17
Airport Expansion/Construction	Low	4/17

Figure 1: Trends in Sustainability. (GRI, 2009)

Examination of the 17 reports allowed the identification of the trends that appear and their frequency. Los Angeles World Airports (LAWA) has set forth its vision to become to the world's leader in sustainability at airports by building greener infrastructure and following the highest sustainability standards. With the development

of Sustainable Airport Planning, Design and Construction Guidelines (LSAG) it intends to provide airports across the globe guidelines for reference. It intends to provide expectations and also a transparent process on how to go about implementing sustainability. This program also streamlines the overall business strategy and operations at the airports. LAWA wants to promote sustainability with this program. It provides tools for tracking and reporting the measures taken (TRB, 2014).

LSAG builds upon previously built programs such as the United States Green Building Council (USGBC) and Leadership in Energy and Environmental Design (LEED). It identifies both horizontal and vertical projects. The LSAG program's rating system is divided into two areas, the Planning and Design Points (DPs) and the Construction Points (CPs). These points help them gain valuable LEED certification that can be Gold, Silver and Bronze depending on the scope of the project and how big a role it plays in reducing the costs and carbon emissions. The application and the issuance of the points in based on the scale of the project, segregating projects that are bigger than one thousand square foot from less than one thousand square foot. The points are granted if the project does not receive LEED certification (TRB, 2014).

An article published in "Airportmagazine.net" defines some successful strategies to achieve airport sustainability (Culberson & Reznar, 2012). The journey that an airport has to embark on to achieve sustainability includes the initial step of an idea, an opportunity or perhaps a regulatory, political or financial need. The starting place where such sustainability practices can be incorporated are new projects such as new buildings. Sustainability is, at the least, changing decisions that are made routinely day-to-day, and instead transferring them to long- term visionary decisions that promote future airport

growth (Culberson & Reznar, 2012).

Even though the journey to achieve sustainability varies, the trends that are revealed from those journeys show some common things that are needed to result in success. These include:

A clear vision of what the expected results are

A strong staff commitment

Airport leadership catapulting the effort

Building on success

The need to monitor and maintain (Culberson & Reznar, 2012).

Sustainability programs are rooted in the triple bottom line of environmental, economic and social considerations. Sustainability management programs makes the “futuristic decision making” a common thing. One of the major step to be taken is to develop goals, strive to achieve them, and also track progress towards them. The process of identification of the existing goals and aligning them to the concept of being sustainable is something that requires attention as well. The Culberson & Reznar article also stresses the need for strong leadership support. The responsibility for implementation of the whole process is on the staff and the stakeholders shoulders.

Funding for Green Initiatives

One of the programs that airports in the US can follow in order to achieve sustainability goals is the Voluntary Airport Low Emissions Program (VALE). The Century of Aviation Reauthorization Act, also known as Vision 100, was signed into law in December 2003. This Act created a voluntary program to reduce the airport noise and ground emissions at commercial use airports. This program helps the airport sponsors

meet their obligations under the Clean Air Act, as well as the requirements set forth by health-based National Ambient Air Quality Standards (NAAQS) (Voluntary Airport Low Emissions Program [VALE], 2010).

Vision 100 directs the FAA to issue certain rules and regulations and provides guidance by describing the eligible airport low emission activities. This was developed with the consultation of the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE). To govern the Vision 100 program, the FAA created the VALE program in 2005. The involvement in the program is completely voluntary. The main goal of the VALE program is to decrease the amount of regulated pollutants and other injurious air emissions generated at airports. To attain this, the program offers financial and regulatory incentives to increase their investments. It also promotes the use of domestically produced alternate fuels that are non-petroleum based. Airports are also encouraged to purchase alternative fuel vehicles (AFVs) and related equipment that are suited for the environment (VALE, 2010).

The funding comes from two different sources that support airports and provide assistance; the FAA Airport Improvement Program, which provides funds from an aviation trust fun, and the Passenger Facility Charge (PFC) which is a locally imposed fee paid by airline passengers for airport development. These programs provide substantial assistance to airports, but only if such activities represent a high priority for the airport. The VALE program provides regulatory enticements to complement FAA capital investments. The EPA issued national guidance in September of 2004 regarding how airports can receive Airport Emission Reduction Credits (AERCs) for VALE projects, and can then use these for future airport projects. The projects under VALE are

focused towards capital improvement projects and using cost effective methods that are commercially available. The eligibility requirements, guidelines and procedures that projects under VALE have to follow are based on Vision 100, the Clean Air Act, and the AIP and PFC program regulations (VALE, 2010). The VALE program offers benefits to all airports, the FAA, and state air quality agencies.

For airports, which are an always changing and dynamic environment, the program offers financial and regulatory support, and the program sponsors planned for airports to seek balance between the growing public demands for airport services as well as environmental protection. Additionally, the VALE program aids all parties and the environment by:

Enabling dialog between airport sponsors and air qualityagencies

Accelerating the environmental review process for airport projects

Inspiring better identification and control of airport emission sources (VALE, 2010) The VALE program came to existence after much consultation and coordination from different agencies. For example, the DOE Clean Cities program provides information about alternate fuels, and the EPA provided essential support in several areas:

Identification of airports in nonattainment or maintenance areas

Vehicle low-emission standards

AERC guidance.

The FAA has partnered with many fuel industry associations which have provided technical suggestions. The FAA has also trusted on state air quality agencies, original equipment manufacturers (OEMs), energy companies, and environmental agencies to

help attain the correct balance between what is commercially obtainable and forward-looking emission standards. (VALE, 2010)

Two of the major federal regulations which are associated with the air quality concerns are the National Environmental Policy Act of 1969 (NEPA) and The Clean Air Act and its Amendments (CAA). Under NEPA, the federal government gives the opportunity for the public to comment on the proposed projects after carefully evaluating their effects on the environment. To meet the standards set by NEPA, the FAA has set forth the order 1050.1E, Environmental Impact: Policies and Procedures. Under this order the FAA describes how the agency complies with environmental laws and addresses specific impact areas such as noise, air, water quality, wetlands, wildlife protection and historic preservation. Since the projects under VALE are to improve the air quality permanently many projects can also be "categorically excluded" if there is no extraordinary environmental impact or circumstances associated with that project (VALE, 2010).

The projects that are entitled under the VALE program should be proposed by an airport under the FAA's National Plan of Integrated Airport Systems (NPIAS). Airports are designed to achieve emissions from stationary and ground transportation sources because of their operations. Vehicles recharging and refueling can be often found at airports. U.S. aircraft emissions standards are set forth by the EPA within an global framework under the International Civil Aviation Organization (ICAO). It should be noted that aircraft and engine manufactures need long lead-times to design aircraft due to many factors including aircraft safety, performance, fuel efficiency, noise and cost (VALE, 2010).

The VALE program requires an Airport Emission Reduction Credit (AERC) letter of Assurance from the state agency that deals with air quality prior to FAA approval and funding. Therefore, airports should consult with the state air quality agency when developing the formal project application. The agency can also provide more information on emission reduction strategies, talk about the alternate fuels available, and provide other examples of similar activities in the state or region (VALE, 2010). The earlier this coordination happens the better understanding the airport will achieve of the goals and responsibilities, and this will also allow early access to the resources available and facilitate relationships that will help with timely state and EPA reviews (VALE, 2010) (see Figure 2).

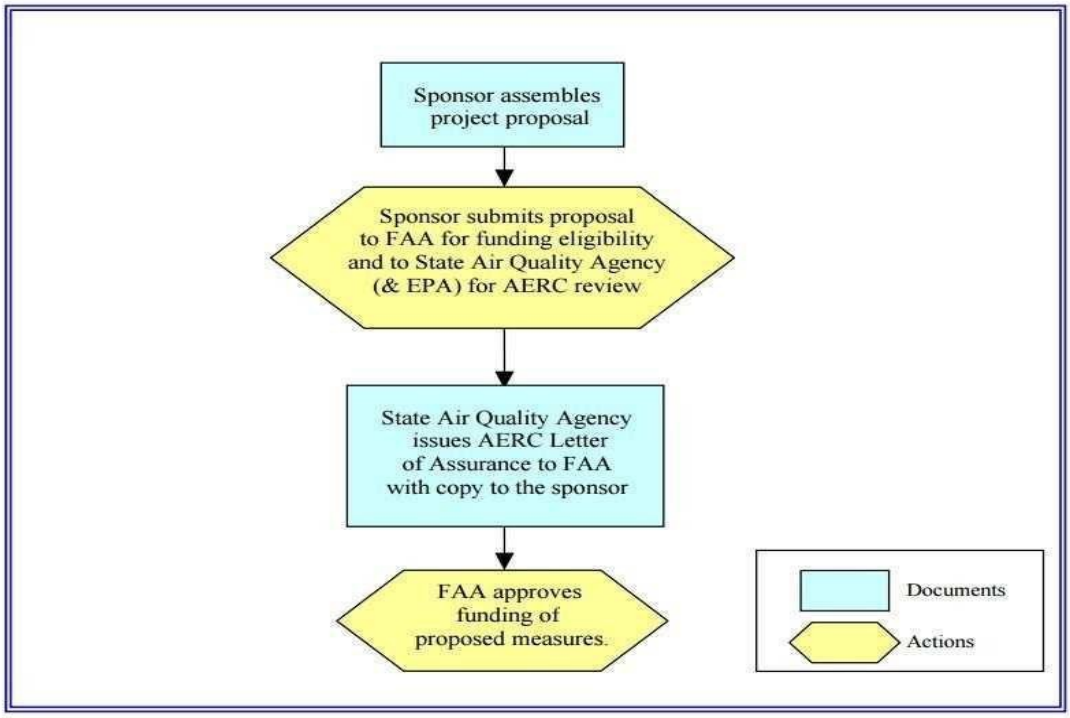

Figure 2: Flow Chart of Project Application Phase (VALE, 2010)

Other Funding Sources

Project eligibility for the PFC program is much broader when compared to the AIP eligibility. AIP funds are largely gathered from the Federal Airport and Airway Trust Fund, while the PFC funds are collected from passenger air fare. Because PFC is locally owned, the sponsors have more flexibility in allocating the money to the project they want. Since VALE projects are eligible for AIP or PFC funding there is no separate or dedicated budget for them. It is recommended that applicants plan ahead of time, as these projects are approved on a case by case scenario, based on their importance when compared to other eligible projects (VALE, 2010).

VALE projects must adhere to all AIP rules and regulations mentioned in *FAA Order 5100.38C* as well as the grant assurances. These VALE projects can be funded by the discretionary portion of the AIP fund which is set aside under “Noise and Air Quality.” These set aside funds give greater opportunity to the sponsor for VALE funding because it can only be used for noise or air quality projects. Any VALE projects funded through those funds does not affect airport entitlements (VALE, 2010). The management of the PFC funding follows the rules and regulations set in the AIP funding handbook unless otherwise specified. The airport has the authority to collect and use PFC revenues on approved projects. As the PFCs are considered local airport revenue, the funds can be used to finance one hundred percent of the cost of the project. These projects need to be financed from existing airport revenues prior to be reimbursement of PFC funds (VALE, 2010).

Statement of the Problem

One of the major challenges faced by airports is identifying the feasible and suitable

initiatives from an ever growing list of options (Culberson & Reznar, 2012). This study is focused towards cataloging these ever growing options. The overarching question is to find out what the different ways are that an airport can move to having less environmental impact, or go green. The specific research questions are as follows:

1. What are the different ways in which US airports have pursued sustainability initiatives?
2. What are the typical costs of sustainability initiatives, both in terms of technology/hardware and personnel/efforts?
3. What is the range of energy savings realized by various sustainability initiatives on an annual basis?
4. What is the range of cost effectiveness experienced by various airport's sustainability initiatives?
5. What other recommendation would current users of sustainability practices at airports suggest for airports that are considering embracing sustainabilityinitiatives?

CHAPTER II – METHODOLOGY

The primary research methodology utilized was a survey, which was sent out in the form of a written questionnaire. Surveys can be very beneficial in bringing out both the current status and emerging trends. Surveys can also be used to evaluate attitudes, opinions, practices and procedures (Gay, Airasian & Mills, 2012). Surveys are conducive to both qualitative and quantitative research, depending on the questions asked. Another method used in this study was a literature review of websites of airports with sustainability efforts. This method provided a comprehensive look at current initiatives, giving a world of knowledge and data at the click of a mouse. The website review process allowed insights on the topic, which assisted in the full understanding of efforts currently being made. Thus, this study utilized both the survey and literature review methods in the data collection process. The reason for choosing the method of surveys and literature over other research methodologies is that together they can provide specific answers to the research questions of this research study. The questionnaire was fast and efficient and allowed the research to be conducted across a span of several states. This study was approved by the Middle Tennessee State

University's (MTSU) Institutional Review Board (IRB) with approval number 15-351, which can be seen in Appendix A.

Participants

This project sought to examine the opinions of seventeen airport officials at seventeen different Part 139 certified airports. Emails were sent out to these seventeen people with a link to the survey and a short introduction as to the intent of the study. Two providers which provide recycled seating at the airports were also contacted; these

were referred by Chicago O'Hare airport management. The FAA website lists airports that have been investing in green technologies. These airports were a select few from that list, based on their geographic location in the United States. The reason behind the selection of these seventeen were this placement across the US, with the variety utilized to help get information from airports dealing with different geographic challenges. Geographic challenges might force an airport to choosedifferent sustainability technologies which would have greater benefit in a particular environment. Just because an initiative works at one airport, it is not necessarily true that it will work at other airports.

The airports and sustainability services that were selected were the Chicago Department of Aviation, Arnold Palmer Regional Airport, Dallas/Fort worth International Airport, Denver International Airport, Fort Lauderdale – Hollywood International Airport, George Bush Intercontinental airport, Nashville International Airport, Newton City County International Airport, Northeast Florida Regional Airport, Portland International Airport, Tampa International Airport, Smyrna County Airport, O'Hare Modernization Program, Waste Management (Sustainability Services), and Honeywell Aerospace

Survey Design

The survey was designed to find out what sustainability initiatives the airport has taken in order to curb the carbon foot print of the airport and also to save money. The survey was created keeping the primary research questions in mind. The survey questions were presented to the thesis committee for their input. They were then modified and altered to derive the desired information. The final product included fifteen

questions (see Appendix B).

In order to find out what the airport had invested in and how it was beneficial to them, participants were asked these fifteen questions. The first question asked when and why the airport started using sustainability initiatives, to provide information on the intention behind the inception of these initiatives. The second question asked the participant which sustainable energy methods were in use at that airport. The third question was about any drawbacks the airport had experienced with the implementation of the sustainability initiatives which had been implemented and what solutions they found for these drawbacks, as this could help with understanding what difficulties had been encountered and how to overcome them. The airports' personnel were asked who they chose to be their consultants for the sustainability projects and why. The fifth question asked what efforts are required for the maintenance of the initiatives.

Maintenance plays a huge role in the success of these initiatives so knowing what issues there are beforehand will provide the airports with a resource that they can use to preplan and be proactive in managing these projects and providing the most effective results. Another question asked was if the sustainability initiatives were subsidized by any form by state or federal funds, as this could give other airports the ability to plan their finances regarding how much the airport would have to set aside to get these projects started. The seventh question asked the airport if there was an established training program for the personnel to work around the sustainability projects.

Another question, about the safety hazards pertaining to the sustainability technologies, was also asked. Questions nine to eleven were asked to establish any costs that were

incurred in the installation of hardware and as well as and any costs experienced on a monthly basis. The twelfth question was asked to get more information about how much money and energy is estimated to have been saved since the implementation. The next question asked if the airport could recommend any template that could be helpful for other airports who would like to follow their path. Following that question, the final question asked if a checklist could be provided indicating what steps should be considered prior to the start of sustainability implementation.

Procedure

The FAA's website provides a list of airports that have actively utilized sustainability practices at their airports. As mentioned previously, that list was retrieved and 17 airports were selected from that list based on their geographic location. Each airport's website was searched to find an email or phone number associated with the person in charge of sustainability, or anyone who could provide that information. E-mails were used as the medium by which to convey the link to this survey. An email was sent out to the particular person identified as in charge of sustainability per the website review. So, the identity of each participant was known for this study. Before the survey began, a short introduction was given about the topic (see Appendix C). Participants were also provided with the documentation which showed that the study was approved by the Middle Tennessee State University's (MTSU) Institutional Review Board (IRB) and the contact information of the researcher in case of any questions and concerns (see Appendix A). If a reply was not received in fifteen days, a follow up email was sent to that same email address. If the email was still not responded to in the next seven days, a follow up phone call was made to the associated person. In four cases the phone call did

make the difference and the email was responded to within a few days of the call. The responses were in Microsoft Word format, which were saved and analyzed when data collection was complete. The entire script that was used, including the introduction, disclaimer and the survey questions can be found in Appendix B.

Sometimes, if the person most related to sustainability was not available, a message was left with the receptionist or whoever answered the call; sometimes the receptionist gave another phone number or an email address that could be contacted. In this case, that phone number and the email address was noted and then the initial email was sent to that email, and that phone number was called if no response via the email was received. All the emails and phone numbers were documented in an Excel spreadsheet. The email responses were stored in a Word document grouped by airport.

The other essential aspect of this research was the web based research. This web based research used six different search engines to find the appropriate articles, journals and links to other websites related to sustainability at the airports. These search engines and databases used includes the following:

Google Scholar

Federal Aviation Administration

Transportation Research Board

Google Search Engine

Airports Council International – North America (ACI-NA)

Specific airport websites

Various airport's official website were visited and their financial data for that fiscal year was reviewed to get a sense of how much is being spent and how much is being saved over the years. Different case studies and published articles were also read to find out the current trends in sustainability. The Sustainability Airport Manual (SAM) which is a product of the Chicago Department of Aviation (CDA), different ACRP studies, and Comprehensive Annual Financial Reports (CAFR) of different airports were studied to determine the financial implications of the sustainability initiatives. Many presentations found on the web were also read. This enabled a perspective of what airports are moving towards. Web research is very dependent on the phrase searched for.

The search parameters for this effort included "Sustainability", "Aviation", "Green Airports", and "Sustainability Management Program." The following were the steps in shortlisting which literature was included in the study based of these searches, and which was excluded:

Topic of Focus: There were many articles found that talked about sustainability studies but were focused on airlines, railways, or different businesses. If the study was focused towards airports, that study was included, everything else was excluded.

Information Provided: Keeping in sight the topic of focus, the articles were shortlisted again based on the information provided in these articles. If after the review of the article, it did not answer in some way the research question, that study was excluded. The ones that were satisfying in some way a research questions set forth were included.

Many articles were found in the initial digital search. All these were saved in either Word or PDF files, to be examined later. Then, the process began to shortlist the ones that pertained to the topic of research. These were short listed by going through the

article abstracts or the summary to decide if the article should be included or excluded from the study. Some of the articles that were selected to be included in the study were directly related to the research study and some were closely related to the research study. The articles excluded from the study were excluded because they did not relate to the study or did not answer any research questions directly or indirectly. Information from the following articles were reviewed and included in this research:

A snapshot of Sustainability Reporting in the Airport Sector (GRI, 2009)

Status report on Sustainable Airports in the United States: Case study of Chicago O'Hare International Airport.

Airport Cooperative Research Program synthesis 53 – Outcomes of green Initiatives.

Stewart International Airport Sustainable Management Plan Achievements 2012.

Stewart International Airport Sustainable Management Plan 2016

Newark Liberty International Airport 2013 Sustainability report

Newark Liberty International Airport Sustainable Management Plan

Dallas/ Fort Worth Airport Sustainability Management Plan 2014

Chicago Department of Aviation – Sustainable Airport Manual

Seattle-Tacoma International Airport Environmental Strategy Plan

San Francisco International Airport 2014 Sustainability Report

San Diego County Regional Airport Sustainability Management plan

When all the data was collected from the survey and the web based research, all the information that was deemed fit to be in the study was saved in a Word file. This Word file included text from the email replies, links to valuable documents on the web,

tests from the web research and also tables and images which were beneficial for this study. This word file contained all the material which was focused towards this study. The process of shortlisting was done before including material in this Word file. The specific sustainability initiavtives were compiled by airports. Once all the initiavtives were received, they were sorted again to look for any repeating initiavtives that two or more airports had in common. This helped to find a theme amongst all the airports when their initiatives were compared. The sustainability initiative were classified into different categories which the reader will notice when going through the study. Examples of these categories are reduction of water consumption, energy conservation or waste reduction.

These are written as “Targets” in the study. Under these targets, the different sustainability initiative has been described, that falls into that category. When the Word file was finished, it was read through again and redrafted and reformatted to the point it was ready to be inserted in this study. At the end of the study a table was made in order to group all the airports by the sustainability initiative. In that table you could see what airports have what in common.

CHAPTER III – RESULTS

The survey responses received from the participating airports provided information on the questions asked. They outlined what had been done at each airport, what issues they have faced, and what training they provide. Three airports responded to the survey sent out. They were, Tampa International Airport, Dallas Fort/Worth International Airport and Denver International Airport. In addition to their response, more research was done on Port Authority of New York/New Jersey which includes LaGuardia, Newark, Stewart and Teterboro Airports. San Francisco international Airport and San Diego International Airport were also researched.

Tampa International Airport

The first response analyzed was from the Tampa International Airport. When asked when their airport started to move towards sustainability practices, their response was that sustainability is not new to TPA. The airport has made countless developments with a number of sustainability initiatives, such as the Airport-wide recycling program in 2009, use of reclaimed water for irrigation and cooling towers, and use of alternative fuels for fleet vehicles. In 2013, TPA was awarded a Federal Aviation Administration (FAA) grant to develop a Sustainable Management Plan (SMP) under the FAA's Sustainable Master Plan Pilot Program. In 2014, TPA developed and adopted an SMP which includes 15 performance metrics, 22 goals, and 36 initiatives.

Tampa International Airport was asked what specific sustainable energy methods they currently utilize. They responded by indicating that in 2013, an energy audit was performed using 2011 data to establish a performance baseline. The audit resulted in an Energy Survey Report which identified 17 Energy Conserving Measures (ECM's) for

further investigation. Currently, they do not have a formalized Energy Management Program (EMP), however TPA has implemented improvements to the building control system, including temperature setbacks, load shed programs, and lighting controls. In 2009, TPA began installing LED lighting on the airfield and in sign fixtures. Airside F lighting was replaced with new ceramic metal halide lighting technology. TPA implemented non-peak baggage system energy conservation improvements which resulted in an annual energy savings of approximately $60,000. All escalators in the main terminal are currently being replaced with energy-efficient escalators which are 32% more efficient. Additionally, their Sustainable Management Plan (SMP) includes an initiative to “Develop an energy management program and identify an energy manager responsible for managing and tracking ongoing energy use, evaluating opportunities for energy savings (e.g., through energy audits) and program improvements, identifying funding opportunities for energy initiatives, messaging energy achievements, and highlighting the benefits/value of the energy management program.”

When asked if they went through a dedicated sustainable airport consultant who could provide one stop solutions for the airport, they replied that Ricondo and Associates was the dedicated consultant for the development of TPA’s sustainable management plan. Ricondo was selected through TPA’s standard RFP process. When asked about the efforts required to maintain these initiatives the participant replied that the job functions within each department are responsible for routine day-to-day, weekly and monthly, and annual activities and maintenance of the facilities. The goal is to integrate sustainable practices within the organization so that it is not viewed as a separate component. TPA has a dedicated full-time Sustainability Manager within the Planning & Development

department who is responsible for coordinating sustainability initiatives across all departments. When asked what federal or state funds are provided, TPA replied the airport received a grant from the FAA for the development of the sustainable management plan. The grant was approximately $600k. When asked about a regular training program they replied that operator training occurs as part of the standard process currently established within the maintenance department. Educational training related to the Sustainable Management Plan occurs at the departmental level and is also included in New Employee Orientation.

When asked about the energy/money savings made with these initiavtives TPA replied with some examples, which include:

LED Airfield lighting – approximately 45% of incandescent cost

LED Art display/signage retrofits – Up to 80% energy savings when compared to incandescent lightning

High-efficiency variable speed escalators – 32% more efficient than standard escalators

Induction lighting at curbside drives – 10 year lamp life saves disposal of 30,000 lamps over 20 years; energy savings totals $57,000/year; 20-year life cycle cost savings $1.37M.

Airside F lighting replacement – energy savings totals $21,000/year; 20-year life cycle cost savings $435,000

Baggage system energy management – energy savings totals approximately $60,000/year

Compressed Natural Gas Station saved $269,275 over a five year period

Airport Co-mingled Recycling – savings of approximately $80,000 in disposal fees.

When the TPA official was asked if they could list some items that could be considered prior to the start of the implementation of sustainable projects, they replied with the following tips:

Sustainability should be demonstrated and supported from the top-down for an effective program.

Early involvement with stakeholders is important in establishing priorities and subsequent initiatives.

Common sense and practicality are important in determining goals andinitiatives.

Communicating the benefits of the triple bottom line and determining 'what's in it for me/my department' is helpful for audience participation.

Consider 'low-hanging fruit' or programs that may already be in place that can be captured within the sustainability plan.

Finding and explaining the balance among the social, environmental and economic factors can be challenging. Financial benefits are typically easiest to recognize. Environmental components can disengage stakeholders in some instances. Conveying the social component of sustainability is the most challenging as many times the information can be anecdotal versus quantifiable.

Dallas/Fort Worth International Airport

In addition to the responses from the Tampa International Airport, officials in Dallas/Fort Worth International Airport (DFW) responded to the survey. When asked when DFW started their actions towards sustainability they indicated it would be difficult to pinpoint an exact date or year when DFW started to implement practices that

would be classified as sustainability initiatives using the modern definition. However, the Airport formally adopted a Sustainability Policy and identified an enterprise Sustainability Officer in 2008. Also, in 2008, DFW developed a sustainability brand (logo and language) that could be used to identify and more effectively communicate new and ongoing initiatives which embodied the principles of sustainability. Initially, these initiatives were mostly composed of energy projects (renewables, energy efficiency) that improved the airport operating environment, yielded environmental benefits (mostly in the form of emissions reductions), and resulted in cost savings. In 2011, DFW began to more aggressively pursue sustainability in a broader sense, evidenced by the creation of a new position, the Enterprise Sustainability Programs Manager. The Sustainability Manager, working closely with the Sustainability Officer, represented a full time staff position dedicated to the development of DFW policies and initiatives across the organization.

When asked about what specific energy saving methods are being utilized at the airport, DFW officials replied that there are many, but some specific examples include: Optimization of new and existing energy systems (lighting, heating/ventilation/air conditioning)

Alternative fueled vehicles

Photovoltaics

Solar thermal heat exchangers

Geo-thermal HVAC systems

Centralized Pre-conditioned air systems (for aircraft docked at DFW terminals)

Day-lighting and daylight sensors

Occupancy sensors

As far as drawbacks or difficulties experienced thus far with the implementation of these initiatives, the DFW official indicated that with all new technologies, there are many learning curves. For example: in order to deploy an Airport owned, roof mounted photovoltaic array, airport staff had to learn how to properly maintain and operate the system and how to best integrate the system into preexisting building energy systems. Additionally, airport staff had to navigate the procurement process (including grant funding) and modify the existing Airport contract with its electricity vendor. When asked if they contacted a green consultants who could provide one stop solutions to the sustainability needs, the official at DFW replied that in general, the answer would be "No," due to the fact that DFW is quite large relative to other airports, and has robust and talented staff. However, this varies from project to project as subject matter experts (architects, engineers, project managers, grant administrators, vendors) who carry necessary credentials or have proprietary knowledge may be required to launch or play a key role in the conceptualization of sustainability initiatives.

DFW was then asked what efforts they have in terms of maintaining the airport's initiatives; to this they indicated that the Sustainability Manager and Sustainability Administrator (new position added in 2013) manage the day to day responsibilities, which in large part include the coordination of various projects at different stages that are being explored or implemented by other airport departments or business groups. Efforts that follow an annual schedule include sustainability reporting, carbon measurement and reporting, Sustainability Management Plan measurement, reporting, and coordination. Additionally, participation with peers from other airports, trade

associations (Airports Council North America and the American Association of Airport Executives) and industry research bodies (Airports Cooperative Research Program of the Transportation Research Board of the National Academies) tend to follow an annual schedule of conferences and meetings. When asked about any help with funds from the federal or state government, they said it is only on a project by project basis. Examples include $600,000 from the FAA to develop and Airport Sustainability Management Plan (2014) and approximately $1million in combined grants from the State Energy Conservation office of Texas and Oncor (local electric utility delivery company) to fund an onsite photovoltaic array (2010). The participant added that they would estimate that cost savings associated with energy efficiency and alternative fuel projects have accumulated to between $10 million-$20 million over the past 10 years.

When DFW asked if they could recommend a template of sustainability initiavtives, they said that it is important to remember that sustainability is a way of approaching business. The results of this approach (outputs) such as renewable energy programs, alternative fueled vehicles, water conservation programs, etc., will vary from organization to organization depending on several factors including, but not limited to: geographic location, organizational governance, community involvement, political environment, regulatory environment, economics, etc. That being said, the process that DFW uses to identify sustainability priorities and materiality (not much different from strategic planning) could be used by almost any organization as a starting point.

Denver International Airport

Denver international Airport (DEN) also responded to the survey with valuable information. As to when the airport started to move towards sustainability, the officials

at DEN replied that as they are one of the nation's most recently constructed airports, DEN was designed with many sustainable features in mind. At the time, these features may not have been identified as "sustainable" (as that term had not yet entered the public lexicon), but were the type of forward-thinking business decisions that formed the framework for DEN's sustainable operations. The airport made a more formal push towards sustainability through two main activities – the creation of an ISO 14001-certified Environmental Management System in 2004, and participation in city government-wide sustainability activities starting in 2006. Ultimately, sustainability was pursued as good business practice – considering all relevant criteria in decision-making to ensure that economic, environmental, and social benefits are maximized. As far as what they currently utilize, the officials at DEN replied that they utilize several sustainable energy methods, including energy efficiency practices, use of compressed natural gas as a vehicle fuel, and hosting 10 megawatts of solar photovoltaic panels across four arrays. The biggest challenge that the airport faced was resource allocation, with limited funding available and significant competition across the airport to get projects funded.

When asked if they received any federal or state grants, the DEN official said that they received a $600,000 FAA grant to support development of a Sustainability Management Plan. Beyond that, there has not be significant state or federal funding except on the project side (EV charging stations, FAA VALE grants, etc.). When asked about the savings made in terms of energy or money, the DEN official said that given the wide range of sustainability projects currently implemented at DEN (energy efficiency, renewable energy, waste diversion, green purchasing, water efficiency, storm

water, etc.), the volatility of energy costs, weather, passenger counts, etc., as well as the significant number of projects/policies/activities that have tertiary sustainability benefits, it is challenging to estimate a single number over the airport's 20-year history. But given DEN's scale, the individual project numbers can be significant – for example, DEN's recent LED retrofit of their parking garages is projected to save over $300,000 per year, and their aircraft deicing fluid recycling system saves the airport over $2 million annually in avoided wastewater charges. Denver International Airport recommends that any airport that is considering sustainability initiavtives identify baselines and goals, ensure executive-level support, prioritize those sustainability elements that are most relevant to their airport and community, consider long-term life-cycle costs and savings, engage external stakeholders, and ensure that systems are in place to manage sustainability beyond individual projects.

Additional Airports Research

In addition to the survey responses gathered from the three airport officials across the United States, as discussed in Chapter 2, additional research was done through online searches. This effort was undertaken to determine the initiatives that airports take in order to take steps towards a greener future, and in response to the low participation rate on the distributed survey. Results are grouped by airports to provide structure in the examination of current efforts. The first set of examples comes from the Port Authority of New York and New Jersey, covering the Newark Airport, LaGuardia Airport, Teterboro Airport, and Stewart International Airport.

Newark Airport and LaGuardia Airport

These airports approach to sustainability is found in the "Targets" or goals each

of these airports have set, which are referenced below.

Target: Reduce aircraft idling, taxing, and approach times.

One of the major efforts being made at Newark and LaGuardia Airports is the identification and implementation of methods of reducing aircraft idling, taxing, and approach times. Coordination with the FAA was done to identify and implement modified approach procedures. Due to the congested airspace, some approaches are several miles longer than necessary, causing excessive aircraft fuel use. There are also some approaches that fly over sensitive areas. To maximize the fuel efficiency and reduce the approach times, the airport management works with the FAA to support the development of procedures that will demonstrate environmental benefits including fuel savings, emission reductions, and area noise reductions. With this collaboration, various new procedures were drafted that add GPS and poor- weather capability to existing flight paths. The Port Authority of NY and NJ have been working with the FAA to implement these modified approaches.

Also, any aircraft awaiting departure release consumes fuel while idling. Implementation of the automatic release procedures provides advance notification of anticipated departure times for the pilots. If the pilots have a defined wheels up time, pilots can minimize fuel burn by delaying engine start until the appropriate time. Since 2013, the percentage of automatic departures have dramatically increased. Delays due to the individual aircraft delays have decreased by a large percentage (Port Authority of NJ and NY, 2014).

Teterboro Airport

Target: Improve the efficiency of the airport utility use by 10% for electricity and by 5%

for natural gas.

Another project taken up by the Port Authority was to evaluate roofing projects for their potential solar/green roof/white roof installation. White roofs provide benefits that may allow decreases in ambient air temperature. It can also reduce the summer energy use. Teterboro airport installed 137,000 square feet of white roof on its administration building. It was completed in December 2013 with an estimated cost of $4 million. That white roof has a solar reflective coefficient (SRC) of greater than seventy eight. The SRC is a value that indicated that the roof reflects most of the heat and reduces building heating in the summer. The R-value, which denotes the capacity of insulating material to resist heat flow, has been increased to an average of 80, whereas the R-value was 8 prior to the white roof installation (Port Authority of NJ and NY, 2014).

Target: Address the impacts of projected changes in climate and weather for smoother operations.

On October 29, 2012, Superstorm Sandy dealt a blow to the Teterboro (TEB) operations. The airport experienced extensive inundation during the storm, and large areas both airside and landside were flooded. The airport, despite this setback, was back up and operating three days after the storm hit. TEB did not wait for another storm to hit before taking action to protect its most vulnerable infrastructure. In 2013, the airport installed a protective flood barrier around three critical areas: the airfield lighting vault, an emergency generator, and a diesel tank which is used to fuel up critical airport vehicles. The airport incorporated a removable AquaFence to allow access to the facilities when needed (Port Authority of NJ and NY, 2014).

To address its contributions to climate change and air pollution emissions, the Port

Authority has conducted pollutant inventories for TEB since 2006. It also worked closely with the New Jersey Department of Environmental Protection (NJDEP) to complete a detailed study of the air quality at the airport. In addition to the policies, studies and inventories, the Port Authority and its tenants have instigated several initiatives to lessen emissions. Fuel Management and energy tactics, together with dropping energy demand, upping the use of renewable energy and alternate fuels and segue to more efficient equipment and aircraft have been successful in dropping emissions related with fuel use (Port Authority of NJ and NY, 2014). Between this switch and implementation, total facility CO2 emissions have been decreased by 12.3% since 2009. These following initiatives have been already implemented at the airport:

Use of hybrid-electric light duty vehicles

Use of biodiesel for all heavy duty diesel equipment

LED lighting for Taxiways

Automatic light controls to increase energy efficiency

Adjusted temperature set points to reduce energy usage (tenant initiative)

Target: Reduce Port Authority-controlled use of energy at the Airport

In cooperation with tenants, the Port Authority has developed and implemented a program to reduce the idling of vehicles at the airport. The goal is to reduce the emissions and make the local air quality better. The program requires all the diesel and gasoline vehicles that run idle for more than three minutes while on the airport property to be turned off, unless in an emergency. Signage was placed for the tenant facilities. Anti-idling stickers' area also placed on the steering of the vehicles to remind the driver of the policy (Port Authority of NJ and NY, 2014).

Target: Increase recycling and landfill diversion by 10%

At TEB, the FBOs generate the majority of solid waste. Certain FBOs have instituted the following activities to recycle and reduce waste:

Segregate waste streams on site for recycling (paper, bottles and cans, cardboard)

When feasible, segregate newspapers taken off aircraft for recycling

Send cardboard box packaging from outside catering companies back to flight kitchen or catering facility to minimize this waste stream onsite.

Target: Funding for Sustainability.

The economic sustainability of any airport is very important to the economic health of that region. For the airport to be successful, the Port Authority and its partners have to continue to make capital investments for any growth that has been forecasted be it in terms of passengers or cargo. The airport depends on four mechanisms for funding capital projects: Public/Private Partnerships (P3), , Passenger Facility Charge (PFC) revenue, bond financing and Airport Improvement Program (AIP) grants. The PFC is a program which allows the airport to collect a fee of $4.50 per enplaned passenger, which is the maximum fee that can be charged. The Port Authority is in favor to raise the cap to $8.50 and indexing it to inflation so that the airport can increase customer satisfaction, reduce delays and enhance the airport facility. While the other mechanisms do help, the airports rely on the PFC for success. The Port Authority spent almost $717 million on 137 airport projects in 2014.

Target: To address regional greenhouse gas emission and improve air quality.

The Port Authority has piloted pollutant inventories and greenhouse gasses for its

airports since 2006. The Port Authority has applied many ingenuities to cut emissions. Fuel management and energy management strategies, coupled with dipping energy demand and increasing the use of renewable energy and using alternate fuels to move aircrafts have been really successful in reducing emissions related with fuel and energy use. JFK had incorporated a ground management program in 2010, using Airport Surface Detection Equipment, Model X (ASDE – X) technology that can locate the location of the aircraft on ground. This program helps the central dispatcher to assign aircrafts into departure buckets as and when runway is available. This allows the aircraft to be at the gate longer with their engines off which saves energy and conserves fuel.

This has been a very popular program at JFK. It's estimated that airlines save 4.2 million gallons of fuel per year and 14,800 hours of wasted passenger and crew time.

Stewart International Airport

Additional efforts at Stewart International Airport (SWF), also under the Port Authority, was completion of a comprehensive GHG study in 2009, which breaks down the sources of emissions at the airport. The majority of the emissions come from aircraft (taxi, takeoff, or landing), and from passengers and employees traveling to and from the airport. The Port Authority has no control over either of the two. But, with agency-wide efforts and working with the airlines on adoption of the aviation biofuels, the Port Authority is constantly evaluating solutions in these areas. The main energy cost drivers are building energy use and fleet vehicle use. The airport has saved $54,000 in utility costs due to the completion of the energy efficient lighting in four buildings.

Currently, there are no charging stations available for customers driving electric vehicles. SWF is searching for opportunities to bring electric service to the parking lot via solar installations, and to connect solar power to an electric vehicle charging station (Port Authority of NJ and NY, 2016). The airport has also purchased hybrid or alternate fuel vehicles (AFVs) for most of its light duty fleet. This will establish a step in vehicle buying process where the purchasing party will evaluate the per-mile operating cost and carbon footprint of vehicle(s) before purchase. There is currently dense brush around SWF. Clearing the brush is time consuming and labor intensive as operating machinery can be difficult. Some airports like Chicago O'Hare International have deployed grazing animals to clear brush and to provide a gasoline and labor free way of performing grounds maintenance. This could support local business and provide pasture for livestock.

Over the past years, the Port Authority has advanced lighting specifications for the airfield, and now almost all the new lighting on the airside is comprised of energy efficient light- emitting diodes (LEDs) by default. LED lighting requires less maintenance, they are more durable and consume less electricity than standard incandescent lighting (The Port Authority of NJ and NY, 2016). Vehicle washing consumes potable water resources at SWF. A cost effective and simple solution for vehicle washing is to collect non-potable rain water in a cistern.

Assuming 100 gallons are used per vehicle wash and each of SWF's 70 vehicles are washed three times per year, this initiative would save 21,000 gallons of water annually.

Target: Minimize Non-recyclable waste generated at SWF

There is an average of 13.27 tons of waste and 1.41 tons of recycling generated

45

per month at SWF. The majority comes from terminal and deplaned waste, with only 14% coming from the administration buildings. Different buildings have different recycling rates. The terminal has a recycling rate of 30%. With just more education and improved on-boardrecycling, the airport has a potential to achieve a 56% recycling rate with no change to the current waste system. A shortage of markets for excess dirt and expensive disposal costs have hampered development of project risk assessment for SWF. With this initiative, a process will be established through which the airport will work with tenants and the engineering department to establish an effort to balance and reuse earthwork for redevelopment projects or find a market to sell it.

Target: Reduce airport paper purchases by 5% by 2015

In the office environment, paper is a resource that is highly valued and constantly used. With the onset of a system upgrade for the office computers, the new printer settings allow for double-sided printing procedures as the default setting. When any employee hits “print” or “copy,” their default print setting is double sided. Airport employees have saved fuel and reduced emissions by deploying web-based meeting capabilities such with the use of tele- and videoconferencing technology. This reduces the time spent commuting to other Port Authority facilities and improves employee productivity. There are “smart” meeting facilities at the main administration building at EWR that can be used to share presentations and videoconference with other airports or the Port Authority central office in New York City.

Target: Have in place a deicing chemical use, collection and action plan that responds to the airport industry’s voluntary Pollution Reduction Program and accentuates abated chemical use and maximum deployment of environmentally friendly substitutes.

During the 2013-2014 winter season, there was a total of 2,192,744 gallons of neat Type I propylene glycol deicing fluid applied at EWR, and an additional 264,571 gallons of neat Type IV propylene glycol deicing fluid. Minimizing the amount of deicing fluid that enters local waterways is a priority. United Airlines, which is the largest carrier at EWR, has been capturing spent deicing fluid by blocking drains on its deicing pad, and capturing and recycling fluid rather than letting deicing fluid enter the local waterways. The FBO, Signature Flight Support, has added the capability of capturing the deicing fluid as a part of the larger project to renovate the general aviation ramp at EWR. The Port Authority is planning a major redevelopment project that will replace or substantially renovate the current Terminal A. Currently, the design for Terminal A specifies that deicing fluid can be captured and collected as needed, through the drainage system on the ramp. This would dramatically increase the amount of deicing fluid captured and diverted at the airport.

Target: Reduce greenhouse gasses (GHG) emissions by 10% by 2016 to help meet the overall Port Authority goal of an 80% reduction by 2050

All gates at the Stewart International Airport employ gate power (400 hz) and most gates provide preconditioned air (PCA) to reduce the use of aircraft auxiliary power units (APUs) and mobile ground power units at the gates. Gate Power and PCA reduce the need for aircraft to use APUs to supply electricity while waiting at the gates. Anecdotal field observations at Port Authority airports indicate that some aircraft continue to operate APUs while connected to ground power and PCA. The APU survey found that often the APU, PCA and ground power units (GPU) are all used concurrently when the aircraft is parked by the jet bridge. Surveys of airline operations' managers indicate that if ground operations are not precisely coordinated, aircraft can get excessively hot or cold and will require the use of the APU to supplement the

PCA. This results in unnecessary emissions as well as easily avoided consumption of energy. As a result of the survey, the Port Authority is conducting the following steps: developing an inventory of airline APU rules and guidance; and working to establish best practices guidancefor ground operations staff, as well as communications for pilots, to minimize the unnecessary useof APUs.

Target: Increase the production and/or use of energy from sustainable sources at the airport to 200 kilowatts

Construction began on the first of four solar photovoltaic power generating facilities at EWR. Total rated capacity across all installation sites is approximately 630 kilowatts; average annual production is estimated at 747,000 kWh. The Port Authority has made no contributions toward project capital costs, but will purchase all power output through a 20-year power purchase agreement at a discount to utility grid-power. Project savings are achieved through the use of the Public Service Electric & Gas (PSEG) Solar Loan program and the elimination of utility delivery charges (power will be generated and delivered on-site, bypassing the electric grid). Because roofs make up a large portion of airport property and can contribute to storm water runoff and the heat island effect, using roof space to house solar photovoltaic cells is a great option that helps generate electricity for the building. It minimizes the detrimental effects that roofs have on the environment by using the space productively. This project is being completed in accordance to the Port Authority Sustainable Building Guidelines.

Target: Reduce vehicle fuel consumption of Port Authority Vehicles at the airport by 10% per employee by 2016

In 2012, 63% of EWR's fleet vehicles were alternative fuel vehicles. In 2013,

82% of EWR vehicles were alternatively fueled. The Port Authority is committed to converting its entire light duty fleet to alternative fuel vehicles. Several types of alternative vehicles are available, including electric vehicles, plug-in hybrid electric vehicles, compressed natural gas, biodiesel- capable, flex-fuel, and bi-fuel. When purchasing vehicles, the Port Authority chooses technologies that help it meet its Green House Gases (GHG) reduction goals while satisfying the operational needs of the airport. The Port Authority aims to ensure that vehicle technologies provide the lowest life cycle costs compared to other technologies, and reduce the agency's exposure to fluctuating energy costs to the maximum extent possible. In 2013, 100% of new vehicle purchases were alternatively fueled (The Port Authority of NJ and NY, 2014).

Target: Reduce vehicle fuel consumption by operators providing access to the airport (Taxis, hotel and rental car shuttles) by 10% by 2030

There are many companies providing ride services to the airport for customers. These service transport ten to fifteen passengers to the airport for a fixed price, and in turn pay a fee to the airport. In 2013, the Port Authority developed language for all future permits that allow for a fee reduction if the operator uses alternately –fueled vehicles. The fee reduction is allowed for Compressed Natural Gas (CNG), hybrid-electric, or full electric vehicles only (The Port Authority of NJ and NY, 2013).

Develop sustainability standards for off-airport parking shuttles

The Port Authority awarded formal permits with operators providing parking services outside the airport's property. These operators transport passengers to the airport terminals using vans or other vehicles, and this practice was previously not

regulated by the Port Authority. The initial permits stated that no vehicle operated by such parking facilities shall be more than seven years old, in order to provide optimum customer service and reduce air emissions from older vehicles. Upon permit extension, the Port Authority will incorporate additional sustainability standards.

Target: Agree on key performance metrics and implement a data reporting system at the Airport to track the progress towards the targets set for sustainability and report back to the stakeholders.

This report serves as Port Authority's first internal and external report on sustainability performance. Metrics used include internal Port Authority developed sustainability metrics as well as general guidance using the reporting framework established by the Global Reporting Initiative G3.1. This report on sustainability performance includes reporting on Port Authority's organizational profile, governance, and performance indicators. Performance indicators include economic, environmental, and social categories.

San Francisco International Airport

Target: To reduce the air quality effects from aircrafts and concomitant grounds service equipment (GSE), fleet vehicles and shuttle buses at the Airport.

The elements of San Francisco International Airports (SFO) air quality improvement program include:

Finalizing a three-year pilot incentive program for passengers and rental car companies to escalate the accessibility and use of fuel efficient rental cars.

Altering SFO's fleet vehicles and shuttle buses to clean fuels, such as compressed natural gas (CNG) and biofuel, and by attaining hybrid/electric vehicles.

Incentivizing the practice of natural gas or hybrid engines in commercial ground transportation automobiles comprising all shared-ride vans, off – Airport parking shuttles, hotel courtesy shuttles and taxis.

Encouraging employees and passengers to use alternate transportation by giving efficient public transportation access to the Airport and proposing employees' incentives to use public transport.

Encouraging aircraft single-engine taxiing, electrifying its Ground Support Equipment (GSE), and providing airside alternative fueled service vehicles.

Plummeting air pollutant emissions resulting from airside operations by providing 400Hz ground power and preconditioned air to aircraft at the gates.

SFO announced in 2014 the installation of its clean vehicle infrastructure, which outlined the plans for installing four high-speed electric vehicle (EV) chargers at the Airport's Cell Phone Lot. The installation of this 480-volt "Fast Chargers", which can fully charge most EVs in about 30 minutes, which was possible with the grant from the California Energy Commission (CEC) to the Bay Area Air Quality Management District (BAAQMD), which will supply the units to SFO.

Target: To reduce the water consumption and to promote water conservation at the Airport.

SFO's rigorous water conservation program has brought about a drop in total Airport water use by 16 percent since FY 2008, total water use at SFO when stated on a per passenger basis has gotten a new low of 9.2 gallons per passenger, down from 14.7 gallons per passenger in FY 2008. This decline in overall water use could be accredited to a number of applied water conservation measures, such as:

High-tech and low-flow sensor-operated fittings in SFO's washrooms, which considerably lower water use in all bathroom fixtures

Use of native florae and drought-tolerant landscaping, also known as xeriscaping, to keep irrigation demands to least possible.

The Airport Mel Leong Treatment Plant (MLTP) delivers recycled water for irrigation and industrial use at the plant. In 2014, SFO introduced a new initiative to also use MLTP recycled water for street sweeping and dust control.

Decline in airport vehicle washing

Substituting aging and dripping water pipes and faucets.

To protect and preserve the wetlands and habitat around the airport, SFO has executed a habitat improvement program on 150 acres of SFO property for garter snakes and red-legged frogs, two federally-listed endangered and threatened species, under the direction of the California Fish and Wildlife Department. As extenuation for the Airport's Master Plan construction projects, SFO has improved 558 acres of wetlands and tidal marshes (including the creation of 84 acres of new wetland) throughout the Bay Area, committing more than $20 million to this effort. Over the past ten years, SFO has also established approximately 50 acres of landscaping around the Airport. In whole, the Airport has planted 2,020 trees of more than 15 different species, which sequester an estimated 120 metric tons of carbon dioxide per year.

To reduce the tonnage of waste sent to landfills and recycling of solid waste as much as possible provides financial benefits to SFO by eliminating the disposal fees of about $140 per ton and generating revenues, contingent on the type of recycled materials. Recycling also diminishes the demand for virgin materials, thereby dropping

global greenhouse gas emissions. In 2013 SFO generated about 10,586 tons of solid waste. SFO carries out one of the leading recycling and composting programs in San Mateo County and continues to demonstrate exemplary performance in recycling and waste reduction. Notably, the Airport has improved the solid waste recycling rate from 51% in 2002 to a striking 80% by mid-2014, well ahead of a 2015 target date. SFO's recycling operations comprise of composting about 35% of Airport waste. SFO continues to recycle virtually all of the construction and demolition waste produced at the Airport, with an unswerving recycling rate of over 90%. In FY 2013 solid waste recycling contributed to greenhouse gas emission reduction at SFO of 3,060 metric tons.

San Diego International Airport

Target: Waste reduction and Recycling

Every day at the San Diego International Airport is taking steps to curb the amount of waste generated at the airport, while increasing what is being recycled. The airport has implemented a recycling program in 2002 which was single stream. This directly contributed to an increase in recycled waste from 107 tons in 2002 to more than 1,052 tons in fiscal year 2014. Reducing waste has also become part of their regular business operations. For example:

Recycled paper is utilized throughout the Airport Authority offices.

Most external and internal newsletters, are now circulated electronically instead of being printed and being mailed.

Annual reports are created electronically.

The Airport Authority was named recycler of the year for the ninth time by the City of

San Diego at the 21st Annual Waste Reduction and Recycling Awards in fiscal year 2013.

Target: Water Conservation.

Water is a precious resource in the arid region of Southern California. The Airport Authority has taken some important steps to reduce the airport's water usage through measures including:

Satellite water-tracking system – This state-of the-art system analyzes data from more than 18,000 weather stations to determine needs of the airports. This saves estimated nine million gallons of water each year.

Xeriscaping – Environmentally friendly landscaping is utilized at the airport, comprising of a variety of indigenous and drought-tolerant plants, shrubs and ground cover.

Low-flow fixtures – Replacement of 1.5-gallon per-flush urinals with 0.125-gallon-per-flush units saves roughly 15 million gallons of water annually. In addition to the water conservation, the airport has dedicated to thwart and diminish the discharge of polluted storm water into surrounding environment, especially given its location on the shore of San Diego bay.

Target: Energy Conservation

The San Diego Airport is open 365 days a year, 24 hours a day, creating unique challenges as the airport seeks to minimize the airport's energy needs. Energy efficiency efforts include:

Energy-efficient lighting has been fitted in all operational areas of the airport, ensuing in annual energy savings in excess of 2.3 million kWh, enough to power 300 homes for one year.

Heating, ventilation and air conditioning (HVAC) systems in the terminals have been upgraded to reduce energy consumption.

Escalators have been modernized to deliver energy savings.

Motion detector sensors have been mounted in Airport Authority offices, so lights go off automatically.

The Airport Authority was honored by San Diego Gas & Electric (SDG&E) as an Energy Champion for its exceptional results in energy efficiency and conservation at the 8th Annual San Diego SDG&E Energy Showcase event. The Airport Authority worked with SDG&E to accomplish savings of nearly 3.5 million kilowatts of power in calendar year 2012. Numerous sustainability initiatives at SDIA were emphasized for contributing to the energy savings including:

Nearly $1 billion Green Build terminal expansion program, which sought a minimum of LEED Silver certification from the United States Green Building Council

20 electric vehicle charging stations at SDIA.

Involvement in SDG&E Retro commissioning (RCx) program to apprise older terminals and central plant at SDIA to facilitate performance on par with newly constructed Green Build facilities.

Phoenix International Airport

Target: Improve Air Quality

The Aviation Department at Phoenix International Airport is committed to doing its part to improve air quality and has a long history of supporting air quality initiatives. Through existing policies, nearly two-thirds of the aviation department's vehicles (accounting for more than 90% of the fuel consumed) are currently powered by clean

fuels or use other low emission technologies. The Aviation Department also works with tenants at the Phoenix airports to reduce emissions (City of Phoenix Aviation Department, 2015). Accomplishments include:

Setting clean vehicle and alternative fuel standards for the Aviation Department's fleet vehicles and ground transportation providers

Improving mass transit by connecting Phoenix Sky Harbor to Valley Metro Railthrough the new PHX Sky Train®, which has LEED Gold and Silver Certified train stations

Establishing a Rideshare Program to reduce Aviation Department employee vehicle trips

Reducing ground-based jet engine emissions by electrifying aircraft gates at Phoenix Sky Harbor and promoting single-engine aircraft taxiing practices for all commercial flights (City of Phoenix Aviation Department, 2015).

An important part of the Aviation Department's constant efforts to improve air quality is collaborating with airlines and other tenants to lesser emissions from their operations. Past successes from this collaboration comprise of the ample adoption of single-engine aircraft taxiing at Phoenix Sky Harbor and the installation of preconditioned air and 400 Hz power outlets at virtually all aircraft passenger gates. The result is that aircraft use less fuel during ground operations, which reduces emissions and enhances the passenger experience. Further, per existing policy, the Aviation Department requires certain commercial ground transportation service providers, including taxis and shared ride van services, to use alternative and clean fuel vehicles (City of Phoenix Aviation Department, 2015). The Aviation Department has an initiative in motion to expand the current trip fee program to other classes of passenger ground

transportation service in order to decrease curbside traffic and emissions.

Target: Conserve Energy

Given the sizes of the Phoenix Airport and the number of passengers served, it is no surprise that the airport is a significant energy consumer. Recognizing this, the Aviation Department emphasizes energy efficiency in all its construction decisions and has an extensive track record of implementing energy efficiency and renewable energy projects. Recent successes include:

Installing 5.4 megawatts of photovoltaic electric generating capacity at Phoenix Sky Harbor

Installing sun-tracking skylights and lighting control sensors in passenger terminal concourses

Replacing older lighting fixtures in parking garages and on the airfield with energy efficient light emitting diode (LED) fixtures

Specifying high energy-efficiency (SEER) equipment and upgrading controls for efficient system usage

Installing low-friction baggage belts and installing sleep mode capability formoving walkways and escalators during periods of low traffic (City of Phoenix Aviation department, 2015)

The Aviation Department Sustainability Management Plan seeks to increase the energy efficiency of existing buildings by 20% over five years – an effort that is estimated to save over $3.0 million in annual operating expenses. To increase energy efficiency, the Aviation Department will implement a new system to monitor and

manage usage, develop a Strategic Energy Management Plan, and apply for grants to fund energy efficient investments.

The Aviation Department has already taken significant steps to promote sustainability in its policies and contracts. For example, to incorporate sustainability into its construction activities, the Aviation Department uses LEED certification requirements for building construction projects, maintains a robust training and accreditation program on LEED for staff, and promotes the use of cleaner, quieter construction equipment through its Design and Construction Services (DCS) Green Guide for non-LEED certified projects (City of Phoenix Aviation Department, 2015). This Sustainability Management Plan includes five goals for incorporating sustainability into specific policies and contracts, emphasizing the application of the DCS Green Guide, reducing construction waste, tracking the purchase of environmentally- preferred products, and promoting sustainability during airport tenant construction projects and in airport capital improvement decisions.

Target: Reuse waste and Recycle

As hubs of industrial and commercial activity, airports can generate a significant amount of solid waste. Much of this waste, including cardboard, paper, glass bottles, aluminum cans, and organic materials, can be recycled or reused rather than sent to landfills. As a result of waste reduction efforts undertaken by the Aviation Department, currently 28% of the waste generated by tenants and passengers at Phoenix Sky Harbor is recycled (City of Phoenix Aviation Department, 2015). Examples of waste reduction efforts include:

- Co-locating recycling bins with trash cans in the passenger terminals

- Recycling and reusing asphalt and construction waste
- Developing innovative solutions for recycling runway rubber waste
- Providing recycling infrastructure to tenants

Target: Water Conservation

The Phoenix region's arid, hot climate places a significant premium on water, especially during Phoenix's summer months. Conserving water is essential for the long-term sustainability of the Phoenix metropolitan area. Water conservation is especially important for the Aviation Department (City of Phoenix Aviation Department, 2015). With total consumption exceeding an average of 30 million gallons per month, past conservation efforts include the installation of low- flow plumbing fixtures and automatic shutoff valves in public restrooms and the addition of low- irrigation xeriscape landscaping at Phoenix Sky Harbor.

Orlando International Airport

Target: Reduce Solid Waste to Landfills

The Orlando International Airport (MCO) collects waste from all the passengers that are travelling though the common corridors of the airport terminal or parking area. The food service contractors that work at the terminal are governed by private independent contractors, in which they are responsible for their own waste. Same goes for all the airline operating in and out of the Orlando international airport. To reduce the solid waste MCO has implemented the following:

Conventional public recycling program in the landside terminal

Recognized centralized recycling program for all airport staff offices

Established recycling plans for airline and other back of the house areas

Electronic Content Management (ECM) plans and evaluation process implemented for all new construction projects

Electronic Project Management document stowage and filing systems applied

Reinvest waste budget savings on future diversion projects

Supplementary training to end users

Additional recycling containers for public areas

Marketing of sustainability efforts to traveling public

Target: Reduce energy use intensities

The airport functions year-round and never shut down. Over 35 million passengers annually pass through Orlando International Airport and these passengers use the 60 elevators, 50 escalators, 20 moving sidewalks, 8 trains, and over 50 thousand lights required to drive the facility.

An additional challenge is that the airport is over 30 years old and is growing (Orlando International Airport, 2014). Using models that merely look at decreasing energy will not amply portray the success of the airports energy practices. MCO practices models that evaluate energy use intensity (EUI), a model that looks at energy use much like vehicles use miles per gallons (MPG). Thus, they can benchmark EUI against other airports or other facilities in order to match their energy reduction efforts.

Fitted occupancy sensors in large areas that are subject to phases of low occupancy. These sensors control lighting as well as temperatures

Mounted carbon dioxide sensors in large meeting rooms to regulate the amount of

outside air being introduced during periods of occupancy

Exalted approximately 75% of airfield edge lighting to LED lamps, and Upgraded approximately 35% of taxiway centerline lights to LED lamps

Installed high efficiency LED fixtures in baggage make-up area

Upgraded all of the streetscape ambiance lighting in the East Atrium fromincandescent to LED lamps

Exalted all lights on the Tram Tubes from incandescent to LED lights

Switched all light fixtures in the landside terminal loading dock and service road with high efficiency fixtures (Orlando International Airport, 2014)

Target: Reduce Water Consumption

In Florida, drinking water is considered real valuable resource and the staff at MCO is devoted to conserve it. Different tactics are proposed to conserve the drinking water by finding alternative ways to use water for cooling and irrigating and in other areas too where using these alternative options wherever possible.

The following has been accomplished to diminish water consumption:

Changed 90% of bathroom fixture to low flush fixtures.

Using more competent base load chillers for cooling, reducing the water demand at the cooling towers

Taking prompt actions for any leaks.

Target: Review alternate energy strategies

There are challenges to alternative energies in any environment, and it is no different at Orlando International Airport or Orlando Executive Airport. The use of solar arrays must be carefully studied in order to evade any hazards to aircraft operations (Orlando

International Airport, 2014). Current accomplishments made by MCO are: Solar power is being used for small applications, such as traffic signal devices Taxies and shuttle busses are using biofuels.

Summary of Data Analysis

The data collected from this study provides some interesting insights on what airports are incorporating into their day to day operations to reduce energy consumption and reduce the carbon foot print made by the airport. There were many initiatives that more than two airport have undertaken. A detailed analysis in a tabular form has been created below to summarize what airports have in common in terms of green initiatives, as well as their benefits (see Table 1).

Table 1. *Summary of Green Initiatives at Airports*

Initiative	Airports	Cost	Estimated Benefits
Using LED lighting	TPA, MCO, DFW, DEN, PHX, SAN, TEB, SWF	Not available	$21,000 in a year and $435,000 in a 20-year life cycle
Non-peak Baggage System	TPA, MCO	Not available	$60,000 a year
Energy Efficient Escalators	TPA, DFW	Not available	32% more efficient
Energy Audits	TPA	Not available	Evaluating opportunities for further energy savings
Compressed Natural Gas stations	TPA	Not available	$269,275 over a five year period

Table 1 (cont.)

Alternate Fueled Vehicles	DFW, MCO, SAN, EWR, LGA, TEB, SWF	Not available	Help in reduction of emissions at a large scale
Geo-Thermal HVAC System	DFW, BNA	Not available	Uses ground temperature to cool or heat the terminal
Occupancy Sensors	DFW, SAN	Not available	$35,000 in a year
Pre-Conditioned Air and Power	TPA, DFW, DEN, SAN, SWF, EWR, LGA, MCO, SFO	Not available	Conserves energy and reduces operating costs
De-icing fluid recycling	DEN, SWF, LGA, EWR	Not available	Over $2 million annually
New approaches to reduce fuel	EWR, LGA	Not available	Maximize the fuel efficiency and reduce the approach times
Automatic release procedure	TEB	Not available	Pilots can minimize fuel burn by delaying engine start until the
Solar green roof/white roof	TEB, TPA	$4 million for 137,000 square feet area	Reduce the energy use, get rebates on electricity usage fee

Table 1 (cont.)

Segregate waste from recycle	TEB, SWF	Not available	Helps recycle more and $80,000 in disposal fees.
Reduce paper	TEB, SWF, TPA	Not available	Helps conserve trees
Low Flush sensor operated fixtures	MCO, SAN, SFO	Not available	30% more efficient
Habitat improvement	SFO	Not available	120 metric tons of carbon dioxide avoided per year

CHAPTER IV - DISCUSSION

This study was designed to find out the initiatives undertaken by airports across the US in order to reduce the emissions produced in and around the airport. It also sought to gather information regarding what cost benefits an airport received with such initiatives. The result of this study, as discussed in Chapter Three, was an understanding of many of the different initiatives that are currently being utilized at different airports. From using more natural light in the terminal to using a geothermal method of providing cool air in the terminal and everything in between, airports are taking different steps to curb their energy consumption and reduce their emissions in the day to day operations at the airport.

The first research question of this study was to determine the different ways in which airports are pursuing sustainability initiavtives. Table 1, at the conclusion of Chapter 3, provides a comprehensive listing of the initiatives that were found. Some of the most common include using LED airfield lighting and using alternatively fueled vehicles or battery operated vehicles. Providing aircrafts with pre-conditioned air and power was also a very popular initiative. However, there many initiatives discovered which were specific to only one or a small number of airports.

The second research question sought to determine the typical costs of sustainability initiatives in terms of hardware, training and personnel. The cost of the hardware was not able to be found out by this study, as it varied from project to project and from airport to airport. The third and fourth research questions were to determine the energy savings and cost savings that the participating airports had experienced with their

initiatives. Again, savings varied widely, as stated in the Chapter Three. As examples, TPA estimated annual savings of approximately

$60,000 using variable speed escalators, and with the airside lighting replacement to LEDs the airport saved $21,000 in a year and $435,000 in a 20-year life cycle. Using compressed natural gas the TPA airport saved around $249,275 within a fiscal year. Denver International Airport has savings associated with energy efficiency and using alternative fueled vehicles of between $10M-$20M in the past ten years. Solar roof or green roof was incorporated by TEB and TPA which costed approximately $4M for a 137,000 square foot area. DFW and SAN installed the occupancy sensors, de-icing fluid recycling was also installed by multiple airports. Once again, with the cost of implementation, it was difficult to obtain data on many of the initiatives.

The fifth question sought to answer what surveyed official would recommended to other airports which are considering embracing sustainability initiatives. One of the recommendations that they gave was to have early involvement with stakeholders, which is important in establishing priorities and subsequent initiatives, and also to consider 'low-hanging fruit' or programs that may already be in place that can be captured within the sustainability plan. As one of example of advice, Denver International Airport recommended that any airport that is considering diving into sustainability initiavtives identifies baselines and goals, ensure executive-level support, prioritize those sustainability elements that are most relevant to the airport and community, consider long-term life-cycle costs and savings, engage external stakeholders, and ensure that systems are in place to manage sustainability beyond individual projects.

Limitations

One of the biggest limitations of this study was the lack of survey response with only three being received. Due to the lack of the survey responses, additional web research was done to determine green initiatives. It is possible that the number of questions and the subjective answers required from the participants on the survey, were the main reasons of replies were not received. While this study was designed to determine the types, costs, and benefits involved in airport sustainability initiavtives, it may have been more practical to choose one or two airports and thoroughly examine its green efforts. This approach may have yielded more complete information, and the results have been more detailed. A second limitation is that there is such a variety of initiavtives taking place at airports across the U.S., which makes it difficult to conclude what initiatives may be appropriate for different airports across the country. The variety seems to be necessary based on the local needs and geography, but this makes it difficult to make generalizations.

Recommendations for Future Research

For future research, selecting one or two airports that are actively involved in promoting sustainability at their airport and conducting a case study to determine the cost and benefits of their sustainability initiavtives would be valuable. An extensive review of these airports' financial records could also yield data indicating the cost and benefits of sustainability initiatives. Continuing to catalog and evaluate the efforts of airports to move towards sustainability should continue to be pursued, so valuable lessons learned can be continued. While not all initiatives are appropriate for every airport, insights regarding possible applications of green technology can be gained.

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APPENDICES

APPENDIX A: IRB APPROVAL

IRB

INSTITUTIONAL REVIEW BOARD

Office of Research Compliance,

010A Sam Ingram Building,

2269 Middle Tennessee Blvd

Murfreesboro, TN 37129

EXEMPT APPROVAL NOTICE

7/10/2015

Investigator(s): Salil Rai Department: Aerospace

Investigator(s) Email: sr4j@mtmail.mtsu.edu

Protocol Title: “Green Airports” Protocol ID: 15-351

Dear Investigator(s),

The MTSU Institutional Review Board, or a representative of the IRB, has reviewed the research proposal identified above and this study has been designated to be EXEMPT..

The exemption is pursuant to 45 CFR 46.101(b) **(2) Educational Tests, Surveys,**

Interviews, or Observations

The following changes to this protocol must be reported prior to implementation:

Addition of new subject population or exclusion of currently approved demographics Addition/removal of investigators

Addition of new procedures

Other changes that may make this study to be no longer be considered exempt

The following changes do not have to be reported:

Editorial/administrative revisions to the consent of other study documents Changes to the number of subjects from the original proposal

All research materials must be retained by the PI or the faculty advisor (if the PI is a student) for at least three (3) years after study completion. Subsequently, the researcher may destroy the data in a manner that maintains confidentiality and anonymity. IRB reserves the right to modify, change or cancel the terms of this letter without prior notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board

Middle Tennessee State University

APPENDIX B: QUESTIONNAIRE

1. Why and when did your airport started to act towards sustainabilitypractices?
2. What specific sustainable energy methods are currently utilized at your airport?
3. What drawbacks have you experienced thus far in the implementation of your sustainability initiatives? What do you see as the solutions to these drawbacks?
4. Did your airport investigate if there are dedicated green airport consultants, who can provide one stop solutions to the sustainability initiatives at an airport? If so, did your airport use any such consultant in your initiative?
5. What is the effort required in its maintaining your airports sustainability initiatives. In terms of:

a. Routine / Daily
b. Weekly
c. Monthly
d. Annually

6. Are your sustainability efforts subsidized in any form by your state or thefederal government? If so, please indicate the funding source and the amount.
7. Do you have a regular training program for the personel operating these technologies?
8. Are there any safety or security hazards pertaining to these sustainabletechnologies?
9. What was the initial cost of the sustainability installations in terms of hardware?
10. What was the initial cost of the sustainability installations in terms of personnel?
11. What was the operational cost of your airport's sustainability efforts on a monthlybasis?
12. How much energy and money is estimated to have been saved since the implementation

of your airport's sustainability initiatives?

13. Can you recommend a template of sustainability initiatives for an airport the size of yours?

14. Could you provide a list of items that should be considered prior to the start of implementation of sustainability efforts at an airport?

15. Again, if your airport did use a provider, has the airport entered into any annual maintenance contract with the providers? If so, how much was the initial and the recurring costs?

APPENDIX C: EMAIL SENT TO PARTICIPANTS

Dear Sir/Ma'am,

I am a graduate student pursuing my Masters in Aviation Administration at MTSU (Middle Tennessee State University).

In order for me to graduate, I need to undertake a thesis and defend it at my university. This email is one of my initial steps in that effort. I am attaching a set of questions with this email, the answers to which will provide me with data to address my thesis research questions. My thesis is on sustainability at airports. I would like to get data as to how an airport can go green, including the things that need to be considered before an airport incorporates sustainability technologies. The end product of my thesis will be a guide for those airports who are in the decision phase of whether to go green or not. My thesis will provide information such as cost estimates, how much energy can be conserved annually, etc. I have selected your airport along with seventeen others from the Federal Aviation Administration's list of airports that have gone green.

I would like to request that you kindly help me with my project by providing answers to a questionnaire that I have attached. Any additional information is more than welcome. Moreover, I would be pleased to schedule a phone interview with you if you feel that would be easier. The first part of the questionnaire provides additional information on the purpose of this research study. By completing the questionnaire, you are providing your informed consent to participants in this study.

I urge you to take out a few minutes, and please provide me with the information and your wisdom, to help me complete my thesis.

Kindly find attached the Questionnaire and the approval letter for this research.