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50 pages | 8.5 x 11 | PAPERBACK

ISBN 978-0-309-44967-0 | DOI 10.17226/23644

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AIRPORT COOPERATIVE RESEARCH PROGRAM

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**ACRP SYNTHESIS 77**

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**Airport Sustainability Practices**

***A Synthesis of Airport Practice***

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## AIRPORT COOPERATIVE RESEARCH PROGRAM

Airports are vital national resources. They serve a key role in transportation of people and goods and in regional, national, and international commerce. They are where the nation's aviation system connects with other modes of transportation and where federal responsibility for managing and regulating air traffic operations intersects with the role of state and local governments that own and operate most airports. Research is necessary to solve common operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the airport industry. The Airport Cooperative Research Program (ACRP) serves as one of the principal means by which the airport industry can develop innovative near-term solutions to meet demands placed on it.

The need for ACRP was identified in *TRB Special Report 272: Airport Research Needs: Cooperative Solutions* in 2003, based on a study sponsored by the Federal Aviation Administration (FAA). ACRP carries out applied research on problems that are shared by airport operating agencies and not being adequately addressed by existing federal research programs. ACRP is modeled after the successful National Cooperative Highway Research Program (NCHRP) and Transit Cooperative Research Program (TCRP). ACRP undertakes research and other technical activities in various airport subject areas, including design, construction, legal, maintenance, operations, safety, policy, planning, human resources, and administration. ACRP provides a forum where airport operators can cooperatively address common operational problems.

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ACRP benefits from the cooperation and participation of airport professionals, air carriers, shippers, state and local government officials, equipment and service suppliers, other airport users, and research organizations. Each of these participants has different interests and responsibilities, and each is an integral part of this cooperative research effort.

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Once selected, each ACRP project is assigned to an expert panel appointed by TRB. Panels include experienced practitioners and research specialists; heavy emphasis is placed on including airport professionals, the intended users of the research products. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, ACRP project panels serve voluntarily without compensation.

Primary emphasis is placed on disseminating ACRP results to the intended users of the research: airport operating agencies, service providers, and academic institutions. ACRP produces a series of research reports for use by airport operators, local agencies, the FAA, and other interested parties; industry associations may arrange for workshops, training aids, field visits, webinars, and other activities to ensure that results are implemented by airport industry practitioners.

## ACRP SYNTHESIS 77

Project A11-03, Topic S02-14  
ISSN 1935-9187  
ISBN 978-0-309-38976-1  
Library of Congress Control Number 2016941222

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**Cover figure:** (*upper left*) Composting collection alongside waste and recycling in YVR food court (*Source:* Vancouver International Airport); (*upper right*) DFW employs an asset management team to manage its fleet assets (*Source:* Dallas/Fort Worth International Airport); (*lower left*) obsolete marking signage at ORD is transformed into high-end travel bag (*Source:* United Airlines); (*lower right*) HMSHost collects surplus packaged food for local food banks (*Source:* HMSHost).

## **ACKNOWLEDGMENTS**

The Principal Investigator wishes to acknowledge the airports, airport business partners, and other airport stakeholders that offered new insights into current airport sustainability practices through this project. Airport sustainability has advanced substantially in recent years largely as a result of the open and transparent sharing of experiences across the industry, and practitioners rely heavily on the airport community to provide guidance and lessons learned about the implementation of their sustainability programs. The Principal Investigator is grateful to the individuals that participated in this project by sharing their unique stories about their sustainability initiatives and by contributing to the ongoing enhancement of the Sustainable Aviation Guidance Alliance (SAGA) website. The contributors included:

- Peter Adams and Nate Kimball, Port Authority of New York & New Jersey
- Ted Anasis, San Diego International Airport
- Kim Galvin-Fix, American Airlines
- Shaye Folk-Blagbrough, Vancouver International Airport
- Bob Lucas and Kevin Lynch, Charlotte–Douglas International Airport
- Jim Schmitz, HMSHost
- Ryan Spicer, Dallas Fort–Worth International Airport
- Aaron Stash, United Airlines
- Todd Welty, Reno Tahoe International Airport
- Bryan Wagoner, Wayne County Airport Authority

These contributions are essential to maintaining a useful and relevant resource for airports and aviation in general.

## FOREWORD

Airport administrators, engineers, and researchers often face problems for which information already exists, either in documented form or as undocumented experience and practice. This information may be fragmented, scattered, and unevaluated. As a consequence, full knowledge of what has been learned about a problem may not be brought to bear on its solution. Costly research findings may go unused, valuable experience may be overlooked, and due consideration may not be given to recommended practices for solving or alleviating the problem.

There is information on nearly every subject of concern to the airport industry. Much of it derives from research or from the work of practitioners faced with problems in their day-to-day work. To provide a systematic means for assembling and evaluating such useful information and to make it available to the entire airport community, the Airport Cooperative Research Program authorized the Transportation Research Board to undertake a continuing project. This project, ACRP Project 11-03, “Synthesis of Information Related to Airport Practices,” searches out and synthesizes useful knowledge from all available sources and prepares concise, documented reports on specific topics. Reports from this endeavor constitute an ACRP report series, *Synthesis of Airport Practice*.

This synthesis series reports on current knowledge and practice, in a compact format, without the detailed directions usually found in handbooks or design manuals. Each report in the series provides a compendium of the best knowledge available on those measures found to be the most successful in resolving specific problems.

## PREFACE

*By Gail R. Staba  
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Airport sustainability has evolved considerably, and airports large and small and of most every geographic area are pursuing sustainability initiatives that span environmental protection, social responsibility, and contributions to local economies. In response to this evolution, the Sustainable Aviation Guidance Alliance (SAGA) website was developed to assist airport operators in developing sustainability programs. The website contains entries on more than 900 sustainability practices that were developed by SAGA’s initial stakeholder group. However, a large percentage of these entries do not contain actual practice data. Stakeholders of SAGA seek continued enhancement of the website, not only in its structure but in its content. This synthesis compiles data on 10 new sustainability practices and adds them to SAGA. It also provides guidance to those who have new data to input.

Case studies were generated by seven airport operators, two airlines, and one concessionaire from a range of geographic locations. The practice topics span issues relating to sustainability management, waste reduction, social responsibility, climate change, and water quality. Those who generated information entered the data into SAGA and provided usability information as to the ease of data entry and enhancements still needed for maximum ease of use.

Amy Malick, Haley & Aldrich, Inc., Oakland, California, collected and synthesized the information and wrote the report. The members of the topic panel are acknowledged on page iv. This synthesis is an immediately useful document that records the practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As progress in research and practice continues, new knowledge will be added to that now at hand.

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Note: Photographs, figures, and tables in this report may have been converted from color to grayscale for printing. The electronic version of the report (posted on the web at [www.trb.org](http://www.trb.org)) retains the color versions.

# AIRPORT SUSTAINABILITY PRACTICES

## SUMMARY

ACRP has conducted multiple research projects dedicated to documenting the sustainability endeavors of airports in the United States and beyond. Since the early 2000s, as shown by the proliferation of sustainability initiatives, projects, research, and funding (including the FAA’s Sustainability Master Plan program), airport sustainability has evolved considerably; and airports of all sizes and most geographic areas are pursuing sustainability practices targeting environmental protection, social responsibility, and contributions to local economies. In 2008, spurred by this evolution, the Sustainable Aviation Guidance Alliance (SAGA) website was developed by a coalition of aviation organizations to assist airport operators in developing sustainability programs. The goal of SAGA is to consolidate existing information about sustainability, including introductory material on what sustainability is and how it is applied at airports; processes for planning and maintaining sustainability programs; and sustainable design and construction practices. The website contains entries on more than 900 sustainability practices that were developed by SAGA’s initial stakeholder group. However, roughly two-thirds of these entries do not contain actual practice data. Stakeholders in SAGA have recognized the need for continued enhancement of the website, not only in its structure but in its content. This synthesis is intended to contribute to both of these objectives by generating data on 10 sustainability practices that have yet to be documented in SAGA, and by promoting use of SAGA by a new group of users.

The project includes case examples generated by seven airport operators, two airlines, and one concessionaire from facilities in a range of geographic locations. The practice topics span issues relating to sustainability management, waste reduction, social responsibility, climate change, and water quality, as follows:

Number	Practice	Case Example	Primary SAGA Practice Category
1	Develop an Asset or Infrastructure Management Plan	Dallas Fort–Worth International Airport	Economic Performance
2	Develop and implement an Environmental Management System to track progress in improving environmental performance	Reno Tahoe International Airport	Economic Performance
3	Integrate climate resilience considerations in airport development projects	Port Authority of New York & New Jersey	Economic Performance
4	Tie sustainability goals and objectives into the operations and maintenance and capital improvement program budget process	San Diego International Airport	Energy & Climate
5	Donate surplus equipment and other goods to charity	American Airlines	Engagement & Leadership
6	Donate surplus food to charity	HMS Host	Engagement & Leadership
7	Develop an onsite materials recovery facility	Charlotte–Douglas International Airport	Water & Waste
8	Use recovered glycol as a “feedstock” for reformulated aircraft de-icing fluid, vehicle anti-freeze, aircraft lavatory fluid, coolants, coatings, and paints	Wayne County Airport Authority or Denver International Airport	Water & Waste
9	Establish an Airport Composting Program	Vancouver International Airport	Water & Waste
10	Upcycle materials from indoor advertising	United Airlines	Water & Waste

These case examples describe sustainability practices useful to practitioners interested in promoting economic vitality, operational efficiency, natural resource protection, and/or social responsibility at airports. The case examples can be found online in the SAGA database.

Although SAGA is geared toward assisting airport practitioners in determining the potential replicability of successful sustainability practices, the universe of sustainability initiatives continues to expand, and the definition of “successful” practices continues to evolve. Sustainability professionals are often faced with the need to justify the business case for pursuing sustainability initiatives in terms of payback, return on investment, and revenue enhancement. However, airports are increasingly aware that their ability to operate and grow is directly connected to their success in fostering a positive sustainability reputation and generating goodwill. Thus, there appears to be an increased interest in community stewardship and social responsibility initiatives whose payback in financial terms is less clear than that of more traditional sustainability efforts such as energy efficiency projects. This evolution is illustrated in a number of the practices and case examples captured through this synthesis.

## CHAPTER ONE

**INTRODUCTION**

The objective of this synthesis is to compile information about airport sustainability practices, highlighting 10 case examples that have been previously unreported and presenting them in a readily accessible fashion; and submitting them to the Sustainable Aviation Guidance Alliance (SAGA) website ([www.airportsustainability.org](http://www.airportsustainability.org)). The case examples are intended to be presented in a manner that will promote continued and enhanced utility of the website.

Originally, the intended audience for this synthesis was perceived to be airport sustainability specialists, as well as maintenance, operations, planners, designers, asset managers, procurement, legal, and other staff. However, the audience for the SAGA website is more expansive, and that this report may be useful to a broader audience as well.

**SCOPE OF STUDY**

Since the early 2000s, airport sustainability has evolved considerably, and sustainability is no longer a consideration for only the larger, more resource-rich airports. Airports of all sizes and locations are pursuing sustainability initiatives, and in response to this evolution, a coalition of aviation professionals developed the SAGA website in 2008 by to assist airport operators in developing sustainability programs. Whether creating green construction guidelines or developing airport sustainability plans, airport sustainability practitioners recognized the frequent overlap and duplication of their efforts. SAGA was founded to pool resources and create consistent, comprehensive, and consensus-based sustainability resources that would be available to all airports.

SAGA offers the following definition of sustainability:

Most definitions of sustainability are founded in the principles set forth in the Triple Bottom Line (environmental stewardship, economic growth, and social responsibility). The airport industry, in particular, has adopted the “EONS” approach to sustainability (economic vitality, operational efficiency, natural resources, social responsibility), which expands the concept of the Triple Bottom Line by emphasizing operational efficiency. Applying the Triple Bottom Line and EONS means that we measure our success not only by the traditional financial bottom line, but also by our achievements in stimulating economic growth, protecting the environment and our natural resources, being good corporate citizens, and efficiently operating our facilities.

SAGA’s goal is to consolidate existing information about sustainability, including introductory material on what sustainability is and how it is applied at airports; processes for planning and maintaining sustainability programs; sustainable design and construction; and sustainable operations and maintenance practices. The website contains entries on more than 900 sustainability practices that were developed by SAGA’s initial stakeholder group, but suffers from a lack of actual practice data.

This synthesis is not intended to serve as a compendium of research related to airport sustainability, as a large body of work already exists to serve this purpose; rather, the data compiled through this research provides a high-level overview of the practices in alignment with other practices already documented on the SAGA website.

The scope of this study included the following tasks:

- Reviewing scope of work with research panel and identifying potential airport practices to include in synthesis;

- Conducting literature and SAGA review, and if necessary, conducting survey to identify new airport sustainability practice;
- Conducting initial outreach to select most appropriate case examples;
- Collecting information through interviews and investigating sustainability practice data for at least 10 diverse airport sustainability practices not previously included in the SAGA database;
- Entering practices data into the SAGA database through collaboration with airport practitioners;
- Interviewing practitioners about their experience in collecting and reporting information on the SAGA database using a survey supplied by the *ACRP 02-30: Enhancing the Airport-Industry SAGA Website* research team, which is also available on the SAGA website in the “Give Feedback” section.

## **METHODOLOGY**

### **Sustainability Practice and Case Example Selection**

The project objective included capturing data relative to airport sustainability practices that had yet to be included on the SAGA website. The project panel suggested that the types of sustainability practices and case examples demonstrate “big impact” projects that respond to broad sustainability themes, such as climate change and sustainability management; and emerging topics of increasing relevance, such as social responsibility, about which little guidance currently exists and which represent a range of sustainability topic areas. It also recommended that the case examples be diverse regarding airport size, geography, and operational structure, and include at least one cold-weather example practice; and generate participation from airports that are not regularly highlighted in ACRP-sponsored or other airport sustainability research initiatives. Finally, the panel indicated that it is important that practices and case examples reach beyond the airport sector.

Given the panel’s criteria regarding the selection of desired sustainability practices and case examples, options were somewhat limited. The highlighted practices were ultimately chosen based on the case example subjects’ availability and willingness to participate in this project, and on the documentable progress of their initiatives.

### **Data Collection, Input, and User Feedback**

Upon selection of the practices and case to be included in this synthesis, a survey was undertaken of the case example participants (see Table 1) to assemble data and narrative information for entry into the SAGA website. The participants were given guidance on entering their data directly into the website, following instructions outlined in Appendix A.

Participants provided data on their sustainability practices from the perspective of their own experience; therefore, the data, which were reported using pre-populated responses displayed in drop-down menus, are specific to those individual examples. These responses are subject to interpretation, and therefore may not accurately represent the potential outcomes of sustainability practices at other airports.

Upon completion of the data input process, participants provided verbal feedback, as summarized in chapter four and detailed in Appendix B.

## CHAPTER TWO

## SUSTAINABILITY PRACTICE DESCRIPTIONS, DATA, AND CASE EXAMPLES

Ten (10) airports and airport business partners agreed to assemble and share case example data regarding their sustainability practices. Five of these practices were new entries in the SAGA website, and five were existing entries with no data. The case examples were generated by seven airport operators, two airlines, and one concessionaire in a range of geographic locations. The topics span issues relating to sustainability management, waste reduction, social responsibility, climate change, and water quality, as summarized in Table 1. It should be noted that the practice data, case examples, and recommendations for improvements to the SAGA user experience cited in chapters two and three were provided by case example participants. As noted later in this report, participants provided data on their sustainability practices from the perspective of their own experiences.

### SELECTED PRACTICE DESCRIPTIONS AND CASE EXAMPLES

For each sustainability practice, a narrative description of the practice and case example was developed, and data assembled in accordance with the data fields in the SAGA website. These are presented accordingly here, organized by their respective primary practice categories as defined in SAGA.

Case examples address three primary topics: the problem or challenge; the solution implemented; and the outcomes of the solution.

### ECONOMIC PERFORMANCE PRACTICES

#### Practice 1: Develop an Asset or Infrastructure Management Plan

According to the Institute of Asset Management, an asset management plan (AMP) incorporates a systematic and coordinated set of activities and practices through which an organization optimally and sustainably manages its assets and asset systems, their associated performance, and risks and expenditures over their life cycles. Typically, an AMP will take a whole-system approach, covering more than a single asset. An AMP is a framework being widely adopted as a means to achieve sustainable infrastructure and minimize the total cost of owning and operating infrastructure while delivering desired service levels. AMPs can allow organizations to maintain asset data across departments and achieve better horizontal and vertical integration in asset management decision-making processes. Infrastructure asset management tends to focus specifically on the physical, rather than financial, assets. Generally, an AMP covers the following areas: (1) asset system description; (2) standard of service definition; (3) current asset performance; (4) planned actions; (5) costs; (6) benefits; and (7) potential improvements. The benefits of asset management may include:

- Prolonging asset life and aiding in rehabilitation, repair, and replacement decisions through efficient and focused operations and maintenance;
- Meeting consumer demands with a focus on system sustainability;
- Budgeting focused on activities critical to sustained performance;
- Meeting service expectations and regulatory requirements;
- Improving responses to emergencies;
- Improving the security and safety of assets; and
- Reducing life-cycle costs for both operations and capital expenditures.

Experience from other industries shows that an AMP can enable airports to do more with less; and to make better investment decisions, align managers, decision makers, and workers to a common

TABLE 1  
SUMMARY OF SELECTED SUSTAINABILITY PRACTICES AND CASE EXAMPLES

Number	Practice	Case Example	Primary SAGA	
			Practice Category	SAGA Status
1	Develop an Asset or Infrastructure Management Plan	Dallas Fort–Worth International Airport (DFW)	Economic Performance	Existing entry with no data
2	Develop and implement an Environmental Management System to track progress in improving environmental performance	Reno Tahoe International Airport (RNO)	Economic Performance	Existing entry with no data
3	Integrate climate resilience considerations in airport development projects	Port Authority of New York & New Jersey (Multiple Airports)	Economic Performance	New entry
4	Tie sustainability goals and objectives into the operations and maintenance and capital improvement program budget process	San Diego International Airport (SAN)	Energy and Climate	Existing entry with no data
5	Donate surplus equipment and other goods to charity	American Airlines (AA)	Engagement and Leadership	Existing entry with no data
6	Donate surplus food to charity	HMS Host	Engagement and Leadership	New entry
7	Develop an onsite materials recovery facility	Charlotte–Douglas International Airport (CLT)	Water and Waste	Existing entry with no data
8	Use recovered glycol as a “feedstock” for reformulated aircraft deicing fluid, vehicle anti-freeze, aircraft lavatory fluid, coolants, coatings, and paints	Wayne County Airport Authority or Denver International Airport (DTW)	Water and Waste	Existing entry with no data
9	Establish an Airport Composting Program	Vancouver International Airport (YVR)	Water and Waste	New entry
10	Upcycle materials from indoor advertising	United Airlines (UA)	Water and Waste	New entry

purpose. This results in solutions and decisions that create effective economic, service level, and risk exposure outcomes; and improve flexibility to respond to changes in the regulatory and commercial environment. Faced with changing facility needs to better serve passengers over time, meet evolving standards, and manage aging infrastructure, airport staff may benefit from an overarching asset management framework to promote long-term sustainability.

*Case Example: Dallas/Fort Worth International Airport (DFW)*

To better manage its growing list of assets in a manner that integrates sustainability into the capital decision processes, DFW implemented a robust, enterprise-level asset management system to track and monitor significant assets. Detailed data are created for each asset, allowing the organization to manage preventative and corrective maintenance schedules and evaluate performance-relative similar assets. Expenses associated with parts and labor are tabulated to evaluate total life cycle costs of particular assets, allowing the organization to make informed decisions on repair and replacement schedules and optimize return on investment.

An example of how DFW uses an enterprise asset management system can be observed in the tracking of fleet assets (Figure 1). Operating data such as miles driven or hours in use can be used to compare individual assets against the fleet average. Expenses associated with fuel, maintenance labor,



FIGURE 1 DFW employs an asset management system to manage its fleet assets (Source: Dallas/Fort Worth International Airport).

and replacement parts can be combined to determine the operational cost per mile or cost per hour for individual assets. Efficiency of maintenance activities can be measured in terms of preventative versus corrective maintenance, parts versus labor, and timeliness of maintenance tasks completed. Access to this combined data set enables the analysis required to make long-term operational and capital budgetary decisions with regard to repair, redistribution, redeployment, and replacement of vehicle assets.

**Practice Data**

*Economic Viability*

Capital Cost: Very expensive (>\$500,000 US)  
 Operations and Maintenance Cost: High (>\$100,000 US)

*Operational Efficiency*

Staffing Requirements: High (>200 hours per month)  
 Reportability of Metrics: Quantitative metric with baseline for comparison practices is already tracked

*Maturity of Practice*

Proven at multiple airports

*Natural Resources*

Energy Reduction: Decreases energy consumption  
 Environmental Benefits: Moderate environmental benefit

*Socioeconomic Responsibility*

Social Benefits: Moderate social benefit

*Characteristics*

Climate: Primarily hot  
 Primarily cold  
 Mixed hot and cold  
 Airport Type(s): Scheduled passenger service

*Categories*

Energy and Climate: Terminal building energy use  
 Overall airport energy use  
 Renewable energy use  
 Terminal building greenhouse gas emission reductions



	Overall airport greenhouse gas emission reductions
	Other indirect greenhouse gas emission reductions
	Climate change adaption
Ground Transportation:	Fleet vehicle fuel economy
Economic Performance:	Airport financial viability
	Risk management
Design and Materials:	Sustainable design and operation
Engagement & Leadership:	Tenant and vendor sustainability
Water and Waste:	Potable water conservation
	Water reduction
Natural Resources:	N/A
Human Well-Being:	N/A

*Related Links*

Institute of Asset Management, *What is Asset Management?*

**Practice 2: Develop and Implement an Environmental Management System to Track Progress in Improving Environmental Performance**

An Environmental Management System (EMS) helps organizations achieve environmental goals through a systematic approach toward regulatory compliance as well as sustainability issues such as energy and water management. An EMS allows organizations to clearly articulate regulatory requirements and voluntary goals, track compliance and progress, and manage data through an electronic database. This systematic approach can help reduce the risk of non-compliance; improve health and safety practices for employees and the public; enhance transparency about environmental practices; and support continuous improvement. An EMS can be tailored to meet the specific requirements and goals that apply to an organization, and does not imply that a particular level of achievement must be attained.

According to the EPA, basic elements of an EMS include the following:

- Reviewing the organization’s environmental goals;
- Analyzing its environmental impacts and legal requirements;
- Setting objectives and targets to reduce environmental impacts and comply with legal requirements;
- Establishing programs to meet these objectives and targets;
- Monitoring and measuring progress in achieving the objectives;
- Ensuring employees’ environmental awareness and competence; and
- Reviewing progress of the EMS and making improvements.

The most commonly used framework for an EMS is the one developed by the International Organization for Standardization (ISO) for the ISO 14001 standard. Established in 1996, this framework, based on the Plan-Do-Check-Act methodology, is the official international standard.

*Case Example: Reno–Tahoe International Airport (RNO)*

The Reno–Tahoe Airport Authority (RTAA) is the owner and operator of RNO and a general aviation reliever airport, Reno-Stead Airport (RTS). The RTAA believes that a healthy natural environment plays a crucial role in the strength of the local economy and the local community’s quality of life and is essential for the sustainability of the aviation industry. To meet the demands of sustainable aviation development and to protect the natural environment, the RTAA’s environmental programs endeavor to improve environmental practices, support pollution reduction and prevention, and foster environmental stewardship. This commitment goes beyond compliance with the law and encompasses the integration of sound environmental practices into daily decisions and activities.

Since 2008, RTAA has incorporated an EMS into its everyday practices to promote environmental awareness, resource conservation, waste reduction, reuse, and recycling. Aspects of the EMS include a terminal-wide recycling program at RNO which annually diverts approximately 60 to 80 tons of recyclables from the local landfill. Additionally, an asphalt/concrete deconstruction and re-use program for construction projects results in a 100% recycling of demolished pavement. An office supply reduction and green purchasing policy has helped reduce paper usage by approximately 10% and helps to ensure the purchase of products containing higher recycled content.

Using the EMS approach, the RTAA has also implemented projects that have resulted in substantial energy savings (Figure 2). This includes energy-efficient lighting retrofits involving replacement of existing lighting fixtures to light-emitting diode, which have resulted in an annual energy cost savings of more than \$250,000; heating, ventilation, and air conditioning (HVAC) upgrades that have resulted in considerable energy cost savings as well as operations and maintenance (O&M) cost reductions of approximately \$200,000 annually; and installation of alternative energy generation. Installation of a 135 kilowatt (kW) solar photovoltaic system at RNO’s Aircraft Rescue and Firefighting Facility reduces the annual purchased electricity usage by approximately 260,000 kW hours and reduces the annual electrical utility cost by approximately \$30,000. Lastly, the most effective provision of the RTAA’s EMS reaffirms the responsibility of each person to conduct activities in a manner that will promote protection of employees, the local environment, and sustainable aviation.

**Practice Data**

*Economic Viability*

Capital Cost: Low cost (\$5,000–\$100,000 US)  
 O&M Cost: Low (\$5,000–\$50,000 US)  
 Payback Period: Immediate (0–2 years)

*Operational Efficiency*

Staffing Requirements: Low (10–50 hours per month)  
 Reportability of Metrics: Quantitative metric with baseline for comparisons practices and is already tracked

*Maturity of Practice*

Proven at multiple airports



FIGURE 2 RTAA’s EMS Training Manual (Source: Reno–Tahoe Airport Authority).

*Natural Resources*

Energy Reduction: Decreases energy consumption and generates renewable energy  
 Environmental Benefits: Significant, multiple environmental benefits

*Socioeconomic Responsibility*

Social Benefits: Moderate social benefit

*Characteristics*

Climate: Mixed hot and cold  
 Airport Type(s): Scheduled passenger service  
 General aviation  
 Cargo  
 Military

*Categories*

Energy and Climate: Terminal building energy use  
 Overall airport energy use  
 Renewable energy use  
 Ground Transportation: Fleet vehicle fuel economy  
 Airside equipment fuel use  
 Alternative vehicle fuels  
 Economic Performance: Airport financial viability  
 Risk management  
 Design and Materials: Sustainable design and operation  
 Material selection  
 Construction waste diversion  
 Construction impacts mitigation  
 Recycled and bio-based content  
 Low-toxicity material  
 Environmentally preferable purchasing  
 Engagement and Leadership: Airport-wide stakeholder engagement  
 Public outreach  
 Community stewardship  
 Integrated sustainability management  
 Airport user engagement and outreach  
 Tenant and vendor sustainability  
 Water and Waste: Potable water conservation  
 Water reduction  
 Waste diversion  
 Natural Resources: Landscape and grounds  
 Airside stormwater quality  
 Human Well-Being: Chemicals and hazardous materials  
 Passenger experience  
 Employee development  
 Occupational health and safety  
 Universal design

*Related Links*

U.S. Environmental Protection Agency Environmental Management Systems Website

**Practice 3: Integrate Climate Resilience Considerations in Airport Development Projects**

The risks associated with a changing climate are diverse and pose a number of both subtle and dramatic impacts on airports. In some locations, increased precipitation will shut down runways and overwhelm stormwater systems. In other places, increases in temperature may damage runway

pavements and aircraft equipment. Airports are coping with the “new normal” of increases in severe storms, prevalence of drought, and other extreme climate conditions.

Given FAA’s statistic that 70% of airport delays are related to weather (Kulesa 2002), airports are particularly vulnerable to disruptions resulting from climate change, and are therefore increasingly considering resilience as it relates to airport projects and operations. Resilience includes effectively planning for, recovering from, and responding dynamically to hardship, change, or disasters while limiting impact on airport operations. Resilience is about planning to meet rapidly changing conditions to prevent issues before they arise, being able to meet challenges effectively during events, and being able to recover effectively to prevent future disruptions. Airports not only provide critical access to the regions they serve during extreme events, but also serve as a lifeline for supplies, aid, and other resources during disaster, furthering the importance of airport resilience.

The integration of resilience considerations into new airport development projects can help ensure that climate change impacts are taken into account at the time that major investments are made. It is widely accepted that planning and designing for natural hazards is far more cost-effective than retrofitting existing facilities or recovering from extreme events. The integration of resilience in design guidance can effectively address climate change impacts during the design and development phase for new airport infrastructure, and can aid in the prevention of future weather-related disruptions at potentially minimal cost to the airport.

#### *Case Example: Port Authority of New York & New Jersey Airports (PANYNJ)*

Given the high likelihood and high consequence of climate impacts on PANYNJ assets, PANYNJ has developed resilience design guidelines to address anticipated climate impacts when designing infrastructure and buildings. The guidelines consider several potential impacts, including higher temperatures, increased precipitation, sea level rise, and severe storms. As a result of the increased incidence of flooding of PANYNJ assets, the guidelines focus on avoiding flood impacts on future infrastructure through a 10-step approach. The approach encourages a collaborative effort, led by the project engineer or architect, with information and support from various agency departments, including the resilience and sustainability group. The guidelines establish the following steps:

1. Identify flood risks to project scope.
2. Determine the influence of any area or system-wide strategy to determine if the project is sufficiently protected.
3. Determine whether the project is part of an emergency plan or an enterprise risk plan and, if so, incorporate these plans into the project if applicable.
4. Review current codes to determine the minimum flood projection or elevation level required.
5. Determine funding source requirements/guidelines as projects receiving federal, state or local funding may need to incorporate specific flood resilience criteria.
6. Identify critical infrastructure.
7. Determine project life expectancy, which may be directly tied to the risk of occurrence.
8. Determine flood protection level: PANYNJ has developed flood protection levels which adjust for anticipated sea level rise based on the design life and criticality of the asset. The project team should utilize these elevations unless the project is proven to be cost-prohibitive based on the cost benefit analysis.
9. Perform benefit/cost analysis to weight the capital investment, the benefits associated with the mitigation strategy and the costs of not performing the investment over time.
10. Establish flood resilience criteria that can then be incorporated into the basis of design.

Although the guidelines were recently developed, PANYNJ has successfully incorporated resilient design elements into new projects as a result of the increased emphasis on managing flood risk. For instance, a substation at LaGuardia International Airport (LGA) was designed at a higher elevation to protect against flooding (Figure 3).



FIGURE 3 A substation was designed to a higher design flood elevation at LGA to alleviate flood risk (Source: Port Authority of New York & New Jersey).

*Practice Data*

*Economic Viability*

Capital Cost: Marginal cost (<\$5,000 US)  
 O&M Cost: Moderate (>\$50,000–\$100,000 US)  
 Payback Period: Moderate (5–15 years)

*Operational Efficiency*

Staffing Requirements: Moderate (50–200 hours per month)  
 Reportability of Metrics: Qualitative metric

*Maturity of Practice*

Trial tested

*Natural Resources*

Energy Reduction: No effect on energy consumption  
 Environmental Benefits: Moderate environmental benefit

*Socioeconomic Responsibility*

Social Benefits: Significant, multiple social benefits

*Characteristics*

Climate: Primarily hot  
 Primarily cold  
 Mixed hot and cold  
 Airport Type(s): Scheduled passenger service  
 General aviation  
 Cargo  
 Military

*Categories*

Energy and Climate: Climate change adaption  
 Ground Transportation: N/A  
 Economic Performance: Airport financial viability  
 Risk management  
 Regional economic contributions  
 Design and Materials: Material selection  
 Engagement & Leadership: Airport-wide stakeholder engagement  
 Public outreach  
 Airport user engagement and outreach

Water and Waste:	N/A
Natural Resources:	Landscape and grounds Pervious surface
Human Well-Being:	Passenger experience Occupational health and safety

### *Related Links*

1. Kulesa, G., *Weather and Aviation: How Does Weather Affect the Safety and Operations of Airports and Aviation, and How Does FAA Work to Manage Weather-related Effects?*
2. Baglin, C., *ACRP Synthesis 33: Airport Climate Adaptation and Resilience*
3. Dewberry, *ACRP Report 147: Climate Change Adaptation Planning: Risk Assessment for Airports*

## **ENERGY AND CLIMATE PRACTICES**

### **Practice 4: Tie Sustainability Goals and Objectives into the Operations and Maintenance and Capital Improvement Program Budget Process**

Organizations often need to operate within the confines of aging infrastructure requiring repair, replacement, or expansion. According to the American Planning Association, a capital improvement program (CIP) is a road map for planning and funding public facilities and infrastructure. It typically addresses both the construction of new facilities and the rehabilitation or replacement of existing capital assets. The CIP is a statement of the organization's policies and its financial abilities to manage the physical development of the plan. It enables organizations to direct limited resources to high priority assets and sustain the long-term mission delivery capability of their asset portfolio, while achieving sustainability mandates. Capital planning is therefore a strategic way of incorporating current and future sustainability goals. The development of a CIP provides a systematic plan for providing infrastructure improvements within a prioritized framework. High-performance capital improvement projects save energy; increase the comfort, health and safety of users; and help husband valuable environmental resources. At airports in particular, effective O&M and CIP plans need not only to sustain the airport but meet the future requirements of airlines, cargo operators, and the traveling public.

#### *Case Example: San Diego International Airport (SAN)*

Asked to develop its first 20-year CIP and budget, the San Diego County Regional Airport Authority (SDCRAA) needed a way to look across San Diego International Airport's entire 661-acre campus system to collaborate and innovate, and to ensure that its outcomes were aligned with its sustainability goals.

SDCRAA implemented a multi-step approach to developing a sustainable asset management strategy that linked investments associated with SDCRAA's master plan, budgeting, capital investment, and day-to-day operations with sustainability efforts. The first step brought together department leaders, asset owners, and operations staff in a series of planning engagement sessions to identify the range of asset needs/wish lists for the airport campus and their associated costs. These stakeholders were specifically chosen because of their intimate knowledge of the airport's buildings, systems, infrastructure, and needs. Additional cross-departmental workshops were held to better understand how the different asset needs fit into the wider airport system and whether there were redundancies. During these meetings, participants developed criteria to rate and prioritize the various asset needs, with a special emphasis on sustainability. The prioritized list of projects subsequently formed the basis of a concise, user-friendly 20-year CIP with clear asset project sequencing to optimize the investment schedule while taking into account sustainability commitments (Figure 4).

By developing a more holistic asset management strategy and extending asset life cycles, SDCRAA is fostering multiple aspects of sustainability, and embracing the concept that the greenest, most economically viable buildings, infrastructure assets, and equipment are the ones that it does not have to build

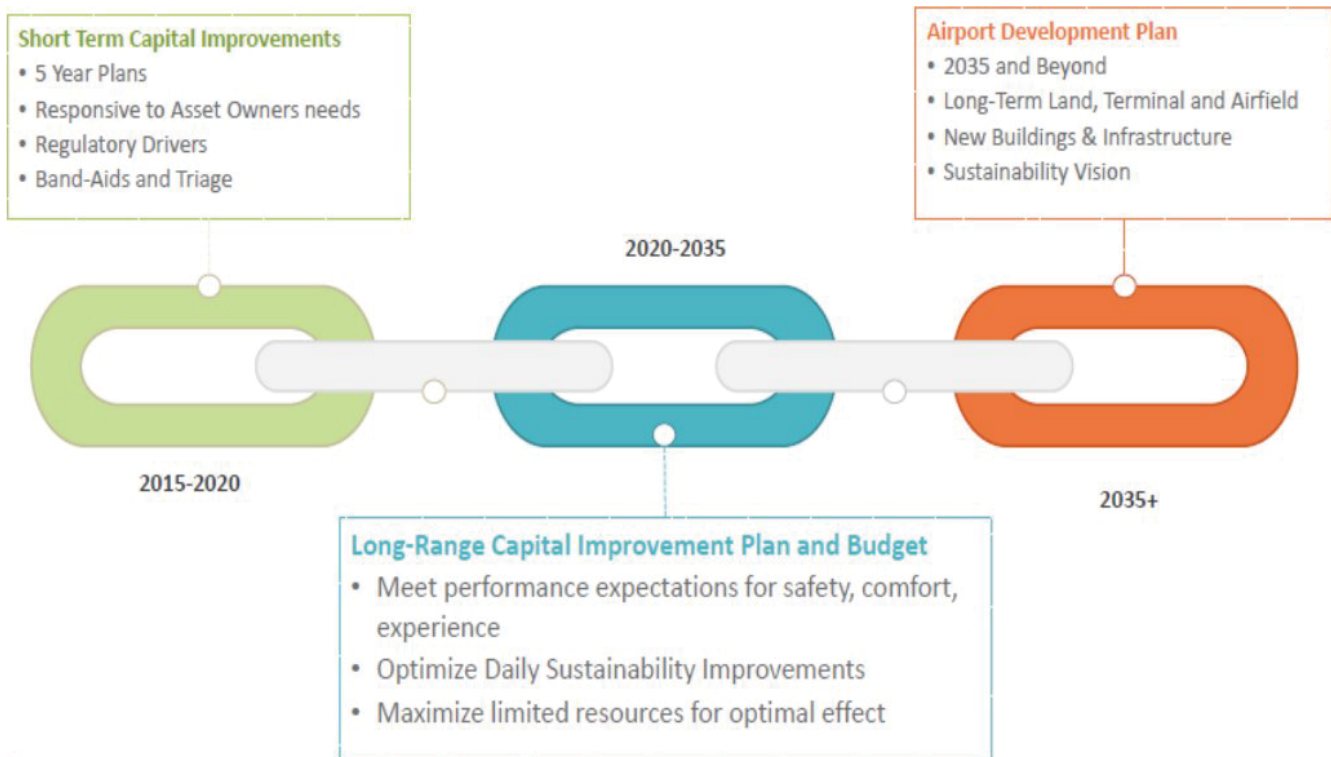


FIGURE 4 SDCRAA's depiction of the interrelationship of its CIP and Airport Development Plan (Source: San Diego County Regional Airport Authority).

or replace; and, when assets have reached the end of their life, there is a greater opportunity to find the most resource-efficient and resilient replacements.

**Practice Data**

*Economic Viability*

Capital Cost: Low cost (\$5,000–\$100,000 US)  
 O&M Cost: Low (\$5,000–\$50,000 US)  
 Payback Period: Short (2–5 years)

*Operational Efficiency*

Staffing Requirements: Moderate (50–200 hours per month)  
 Reportability of Metrics: Qualitative metric

*Maturity of Practice*

Trial tested

*Natural Resources*

Energy Reduction: Decreases energy consumption and generated renewable energy  
 Environmental Benefits: Significant multiple environmental benefits

*Socioeconomic Responsibility*

Social Benefits: Significant multiple social benefits

*Characteristics*

Climate: Primarily hot  
 Primarily cold  
 Mixed hot and cold  
 Airport Type(s): Scheduled passenger service  
 General aviation

Cargo  
Military

*Categories*

Energy and Climate:	Terminal building energy use Overall airport energy use Renewable energy use Terminal building greenhouse gas emission reductions Overall airport greenhouse gas emission reductions Other indirect greenhouse gas emission reductions Climate change adaption
Ground Transportation:	Fleet vehicle fuel economy Airside equipment fuel use Alternative vehicle fuels Alternative passengers transportation Alternative employee commute
Economic Performance:	Socially responsible financial investment Airport financial viability Risk management Regional economic contributions
Design and Materials:	Sustainable design and operation Material selection Construction waste diversion Construction impacts mitigation Sustainable site selection Local sourcing Recycled and bio-based content Low-toxicity materials Environmentally preferable purchasing
Engagement and Leadership:	Airport-wide stakeholder engagement Community stewardship Integrated sustainability management Airport user engagement and outreach Tenant and vendor sustainability
Water and Waste:	Potable water conservation Water reduction Waste diversion
Natural Resources:	Landscape and grounds Wildlife and habitat protection Pervious surface Airside stormwater quality Wildlife hazard management Heat island reduction
Human Well-Being:	Airport noise compatibility Workplace air quality Chemicals and hazardous materials Passenger experience Employee development Occupational health and safety Universal design

*Related Links*

1. American Planning Association, “Planning Fundamentals: Capital Improvement Planning”
2. *ACRP Report 110: Evaluating Impacts of Sustainability Practices on Airport Operations and Maintenance—User’s Guide and Research Report*



## ENGAGEMENT AND LEADERSHIP PRACTICES

### Practice 5: Donate Surplus Equipment and Other Goods to Charity

The daily business of airport and airline operations generates large volumes of waste, much of which is sent to landfills because of the challenges, both perceived and real, in recycling many of the materials used. Whether rehabbing an airport concession space, replacing passenger seating areas, upgrading office equipment, or rebranding company materials, airports and airlines are often faced with difficulties in managing their complex waste streams.

All too often, goods and equipment are deemed obsolete because of advancements in technology, stylistic changes, and marketing objectives. The reality is that many items that are replaced for these reasons are still in good working order and could be repurposed, or could be recycled through non-conventional channels. In particular, many charitable organizations accept surplus equipment and materials of many kinds, either for reuse or recycling, providing a socially responsible solution to landfill diversion. Airport operators, airlines, and other tenants can work with local partners to identify new uses for old goods and equipment, possibly providing opportunities for tax deductions for the donor organization and providing a triple benefit.

#### *Case Example: American Airlines*

American Airlines employs roughly 9,000 staff at Chicago O'Hare International Airport (ORD). Employees are provided new uniforms every five years, or any time changes to the American Airlines brand are made; and old uniforms are typically stripped of their logos and sent to landfill so as to avoid security concerns (Figure 5). In Chicago, where harsh winters prevail, the Chicago Coalition for the Homeless estimates that the population of the homeless in 2014 was approximately 125,000. American Airlines recognized the opportunity to provide assistance to Chicago's homeless by donating heavy winter coats and jumpsuits to the Jesse Brown Veterans Affairs Medical Center, which provides care for more than a thousand homeless veterans in Chicago. American's uniform shop applies a patch over old logos before sending uniforms out for donation. In three years, American has donated more than 2,500 winter coats to homeless veterans in Chicago.

American Airlines also partners with Avenues to Independence, a work center for adults with disabilities in the Chicago region. One of Avenues to Independence's programs is Recycling Avenue, which provides employment for disabled adults while keeping toxic electronic waste out of the



FIGURE 5 American Airlines collects e-waste for donation to Recycling Avenues (Source: American Airlines).

waste stream by collecting e-waste directly from commercial and other users. American Airlines donated a significant amount of obsolete electronic waste from its hangar at ORD to Recycling Avenue, which deconstructed and commoditized waste streams such as scrap metal and copper. The proceeds from the sale of a single e-waste collection event allowed Recycling Avenues to cover its payroll for six months.

**Practice Data**

*Economic Viability*

Capital Cost: Marginal cost (<\$5,000 US)  
 O&M Cost: Marginal or cost savings (<\$5,000 US)  
 Payback Period: Immediate (0–2 years)

*Operational Efficiency*

Staffing Requirements: Low (10–50 hours per month)  
 Reportability of Metrics: Qualitative metric

*Maturity of Practice*

Proven at one or two airports

*Natural Resources*

Energy Reduction: No effect on energy consumption  
 Environmental Benefits: Significant multiple environmental benefits

*Socioeconomic Responsibility*

Social Benefits: Significant multiple social benefits

*Characteristics*

Climate: Primarily hot  
 Primarily cold  
 Mixed hot and cold  
 Airport Type(s): Scheduled passenger service  
 General aviation  
 Cargo  
 Military

*Categories*

Energy and Climate: Overall airport greenhouse gas emission reductions  
 Other indirect greenhouse gas emission reductions  
 Ground Transportation: N/A  
 Economic Performance: Socially responsible financial investment  
 Airport financial viability  
 Risk management  
 Regional economic contributions  
 Design and Materials: Recycled and bio-based content  
 Engagement and Leadership: Public outreach  
 Community stewardship  
 Integrated sustainability management  
 Airport user engagement and outreach  
 Tenant and vendor sustainability  
 Water and Waste: Waste reduction  
 Waste diversion  
 Natural Resources: N/A  
 Human Well-Being: Employee development  
 Labor relations  
 Diversity and equal opportunity

### Practice 6: Donate Surplus Food to Charity

In the United States, 133 billion pounds—31%, nearly one-third—of the 430 billion pounds of the available food supply at the retail and consumer levels in 2010 went uneaten. The estimated retail value of this food loss was \$161.6 billion (U.S. Department of Agriculture Economic Research Service 2014). In 2014, one in seven Americans were relying on food banks and/or meal services to feed themselves and their families, according to Feeding America’s Hunger in America study series, the nation’s largest and most comprehensive study on charitable food distribution in the United States.

Within the airport context, food and organic waste constitute extraordinary volumes of waste—according to Vancouver International Airport, 68% of its waste stream is organic—and managing organic waste presents challenges for airports. Donation of unopened prepared foods is environmentally preferable to composting, and also addresses a major social need.

Airport concessionaires are essential to recovering surplus food, whether through composting programs or for donation to charitable causes. Many concessionaires have been leery of food donation because of liability concerns related to the consumption of expiring products and other food safety issues. However, the Federal Bill Emerson Good Samaritan Food Donation Act protects food donors against liability except in cases of gross negligence and/or intentional misconduct. With this protection, it has become easier for concessionaires to participate in donation programs. Airports can encourage surplus food donation programs by adopting green concessions policies or other initiatives that promote such practices. They can also enable streamlined food collection processes by providing centralized collection locations, facilitating security badging processes for outside food donation organization staff, and removing other potential barriers to food donation.

#### *Case Example: HMSHost*

Recognizing the significant volumes of waste generated by unsold food items, HMS began a food donation program that supports the three pillars of its startsomewhere® sustainability initiative, which are the environment, nutrition and wellness, and community partnerships. HMSHost donates excess product to local food banks from its operations in 55 U.S. airports through organizations such as Feeding America and the Food Donation Connection (Figure 6).

HMSHost trains management staff at its airports in the United States to participate in food donation efforts. Each of HMSHost’s locations works with local food donation organization to provide unused meals and prepackaged foods. The specific organizations collect the food from HMSHost at the facility and transport it or HMSHost may deliver the food to the organization.

HMSHost has been donating food to local food banks since 1992, and in 2014 it contributed more than 1.8 million food items across the country.



FIGURE 6 HMSHost collects surplus packaged food for transport to local food banks (Source: HMSHost).

**Practice Data**

*Economic Viability*

Capital Cost: Low cost (\$5,000–\$100,000 US)  
 O&M Cost: Low (\$5,000–\$50,000 US)  
 Payback Period: Immediate (0–2 years)

*Operational Efficiency*

Staffing Requirements: Low (10–50 hours per month)  
 Reportability of Metrics: Quantitative metric with baseline for comparison practices and is already tracked

*Maturity of Practice*

Proven at multiple airports

*Natural Resources*

Energy Reduction: No effect on energy consumption  
 Environmental Benefits: Significant multiple environmental benefits

*Socioeconomic Responsibility*

Social Benefits: Significant multiple social benefits

*Characteristics*

Climate: Primarily hot  
 Primarily cold  
 Mixed hot and cold  
 Airport Type(s): Scheduled passenger service

*Categories*

Energy and Climate: Other indirect greenhouse gas emission reductions  
 Ground Transportation: N/A  
 Economic Performance: Socially responsible financial investment  
 Design and Materials: N/A  
 Engagement and Leadership: Public outreach  
 Community stewardship  
 Tenant and vendor sustainability  
 Water and Waste: Water reduction  
 Waste diversion  
 Natural Resources: N/A  
 Human Well Being: Employee development  
 Labor relations

*Related Links*

1. U.S. Department of Agriculture Economic Research Service, *The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States* (2014)
2. Feeding America, *Hunger in America* (2014)
3. U.S. Government Publishing Office, *Public Law 104–210 Bill Emerson Good Samaritan Food Donation Act* (1996)

**WATER AND WASTE PRACTICES**

**Practice 7: Develop an Onsite Materials Recovery Facility**

*Practice Description*

Airport, airline, and tenant operations generate enormous quantities of solid waste; however, with proper systems in place, the vast majority is recoverable through recycling, composting, and other

means. Airports generally recognize the need to substantially improve the environmental performance of their waste handling programs, and often view recycling programs as an entry-point into broader sustainability issues. Recycling and waste management is one of the more visible and passenger-facing environmental initiatives that airports can undertake, and can deliver co-benefits including reduced greenhouse gas emissions, cost savings, and operational efficiencies. Most airports rely on waste haulers to manage recyclable and compostable materials. However, some airports and airlines manage these waste streams through specialized onsite materials recovery facilities (MRFs) that receive, separate and prepare recyclable materials for sale within the recycling market. A “clean MRF” accepts recyclable commingled materials that have already been separated at the source, while a “dirty MRF” accepts a mixed solid waste stream and then proceeds to separate out designated recyclable materials through a combination of manual and mechanical sorting.

Because of the sensitivity of bird attraction and overarching public health concerns at airports, FAA maintains strict requirements about the processing of waste on airport property (AC 150/5200-33B—*Hazardous Wildlife Attractants on or Near Airports*). MRFs are often viewed as incompatible at airports; however, with proper containment and other design considerations, they can successfully exist at airports, while reducing emissions produced by waste hauling and achieving increased waste diversion rates.

#### *Case Example: Charlotte–Douglas International Airport (CLT)*

CLT’s waste was initially transported to the city’s landfill near the Charlotte Motor Speedway for an annual fee of approximately \$450,000. In 2012, recognizing the opportunity to achieve higher waste diversion rates while reducing emissions from waste transport, CLT developed a 27,000-square-foot recycling center (Figure 7), a “dirty MRF” designed to process up to 10,000 tons of the airport buildings’ waste stream and capture all recyclable items, reducing environmental impacts and creating a more sustainable waste disposal program. CLT waste is transported to the MRF and processed through a conveyor operation.

Organic waste, including food, plant matter and trash such as paper towels, was composted onsite in a vermicompost system with 1.9 million worms inside five 50-foot-long composting bins. Organic waste was first heated inside a giant rotating drum for three days at temperatures between 130°F to 160°F in order to kill microbes and start the composting process. The worms then excrete nitrogen-rich castings, which can be used for fertilizer on selected areas of airport property.



FIGURE 7 Workers at CLT’s Recycling Center sort waste through a conveyor operation (Source: Charlotte–Douglas International Airport).

At the height of its operation, CLT estimated that approximately 6,500 of its 10,000 tons of waste could be recycled and put back into the marketplace, generating approximately \$200,000 annually, and employing up to 15 people to operate the MRF. Although prices for certain materials sold to recyclers fluctuate month-to-month (e.g., aluminum cans might sell for \$2,000 per ton one month and \$1,100 per ton a few months later), CLT initially anticipated that the payback for the capital invested (\$1,090,000) would be less than six years. CLT also offered quarterly recycling center tours to educate the public.

In late 2015, the recycling center was taken off line because of contractual challenges, but continues to serve as a model for on-airport recycling.

**Practice Data**

*Economic Viability*

Capital Cost: Very expensive (>\$500,000 US)  
 O&M Cost: High (>\$100,000 US)  
 Payback Period: Moderate (5–15 years)

*Operational Efficiency*

Staffing Requirements: High (>200 hours per month)  
 Reportability of Metrics: Data not entered

*Maturity of Practice*

Trial tested

*Natural Resources*

Energy Reduction: No effect on energy consumption  
 Environmental Benefits: Moderate environmental benefit

*Socioeconomic Responsibility*

Social Benefits: Low social benefit

*Characteristics*

Climate: Mixed hot and cold  
 Airport Type(s): Scheduled passenger service  
 General aviation  
 Cargo  
 Military

*Categories*

Energy and Climate: Overall airport greenhouse gas emission reductions  
 Other indirect greenhouse gas emission reductions  
 Ground Transportation: N/A  
 Economic Performance: Socially responsible financial investment  
 Design and Materials: Sustainable design and operation  
 Sustainable site selection  
 Local sourcing  
 Engagement and Leadership: Public outreach  
 Community stewardship  
 Integrated sustainability management  
 Tenant and vendor sustainability  
 Water and Waste: Waste diversion  
 Natural Resources: N/A  
 Human Well Being: Employee development  
 Labor relations

*Related Links*

FAA, AC 150/5200-33B—*Hazardous Wildlife Attractants on or Near Airports*

**Practice 8: Use Recovered Glycol as a “Feedstock” for Reformulated Aircraft De-icing Fluid, Vehicle Anti-Freeze, Aircraft Lavatory Fluid, Coolants, Coatings, and Paints**

Recovered glycol may be reformulated as aircraft de-icing fluid after meeting all Society of Automotive Engineers AMS 1424 specifications. Glycol has many applications, including antifreeze in cooling and heating systems, in hydraulic brake fluids, and to de-ice airport runways and aircraft. Four different types of aviation de-icing fluids are identified in applicable standards; for example, SAE AMS 1424 and AMS 1428:

1. Type I fluids have a low viscosity, and provide only short-term protection because they quickly flow off surfaces after use. They are typically sprayed on hot (130°F–180°F/55°C–80°C) surfaces at high pressure to remove snow, ice, and frost. Usually they are dyed orange to aid in identification and application.
2. Type II fluids are pseudoplastic, to prevent their immediate flow off aircraft surfaces. Typically the fluid film will remain in place until the aircraft attains approximately 100 knots. The high speeds required for viscosity breakdown means that this type of fluid is useful only for larger aircraft. The use of Type II fluids is diminishing in favor of Type IV.
3. Type III fluids’ viscosity, which lies between that of Type I and Type II fluids, are intended for use on slower aircraft.
4. Type IV fluids meet the same AMS standards as Type II fluids, but they provide a longer hold-over time. They are typically dyed green to aid in the application of a consistent layer of fluid.

The de-icing of aircraft and airfield surfaces is necessary to ensure the safety of passengers; however, when performed without discharge controls in place, airport de-icing can result in environmental impacts. The toxicity of de-icing chemicals is known to pose potential aquatic life and human health impacts. For example, the biodegradation of glycol in surface waters can greatly impact water quality, including significant reduction in dissolved oxygen levels, leading to fish kills. Although disposal of de-icing fluid through discharge to sewers is possible, this is not viewed as a sustainable solution. De-icing fluids may instead be recycled where suitable facilities exist. Special pads may be installed with a recovery system that channels de-icing fluid into large subterranean tanks. Airports and airlines also contract glycol recovery providers to employ recovery vehicles at the location where de-icing occurs. The collected mixture is then trucked to a recycling facility where it undergoes a series of mechanical and chemical refinement operations and is then distilled additives are introduced to produce regenerated de-icing fluid.

*Case Example: Detroit Metropolitan Airport–Wayne County Airport Authority (DTW)*

Facing unpredictable winter weather, tightened safety requirements for aircraft de-icing, and insufficient capacity at its local water treatment facility, DTW realized the need to manage spent aircraft de-icing fluid runoff (SADR) to protect nearby waterways. DTW’s de-icing recycling program allows SADR to be collected at four dedicated remote de-icing pads. The pads contain a total of 28 slots in which approximately 90% of all aircraft de-icing at DTW occurs. Airlines are permitted to conduct event de-icing at gates under certain circumstances, and are permitted to conduct all “defrost” de-icing at gates, as little collectable SADR is generated during this type of de-icing.

All SADR containing more than 2% propylene glycol (PG) is collected by a vendor under contract to the Wayne County Airport Authority. This SADR is hauled to an off-site recovery facility where it undergoes evaporation and distillation, yielding a higher than 99.5% pure industrial-grade PG that is suitable for use in all non-food, non-pharmaceutical products. Most PG recovered at DTW is used in the manufacture of paints and plastics.

Between 250,000 and 500,000 gallons of pure PG is recovered from SADR each winter at DTW. The cost of the SADR program to the Wayne County Airport Authority is approximately \$250,000 per year, which includes all labor, transportation, and processing costs. DTW estimates that conventional treatment methods would cost more than \$2 million per year (Figure 8).



FIGURE 8 Aircraft are de-iced at a remote deicing pad during inclement weather at DTW (Source: Wayne County Airport Authority).

**Practice Data**

*Economic Viability*

Capital Cost: Very expensive (>\$500,000 US)  
 O&M Cost: High (>\$100,000 US)  
 Payback Period: Short (2–5 years)

*Operational Efficiency*

Staffing Requirements: High (>200 hours per month)  
 Reportability of Metrics: Quantitative metric with baseline for comparison practices and is already tracked

*Maturity of Practice*

Proven at multiple airports

*Natural Resources*

Energy Reduction: Decreases energy consumption  
 Environmental Benefits: Significant multiple environmental benefits

*Socioeconomic Responsibility*

Social Benefits: Moderate social benefit

*Characteristics*

Climate: Primarily cold  
 Mixed hot and cold  
 Airport Type(s): Scheduled passenger service  
 Cargo

*Categories*

Energy and Climate: Other indirect greenhouse gas emission reductions  
 Economic Performance: Airport financial viability  
 Risk management  
 Regional economic contributions  
 Design and Materials: Sustainable design and operation  
 Recycled and bio-based content  
 Engagement and Leadership: Integrated sustainability management  
 Airport user engagement and outreach  
 Water and Waste: Water reduction  
 Natural Resources: Airside stormwater quality



### *Related Links*

1. Society for Automotive Engineers, *Standard Test Method for Aerodynamic Acceptance of SAE AMS 1424 and SAE AMS 1428 Aircraft De-icing/Anti-icing Fluids*
2. CH2M Hill, et al., *ACRP Report 14: De-icing Planning Administration Guidelines and Practices for Stormwater Management Systems*
3. Gresham, Smith and Partners, *ACRP Report 99: Guidance for Treatment of Airport Stormwater Containing Deicers*

### **Practice 9: Establish an Airport Composting Program**

In 2015, food and organic waste amounted for nearly 32% of the overall terminal waste stream and 58% of the overall restaurant waste stream at Portland International Airport (*Source*: Port of Portland). Airports are increasingly seeking solutions to managing organic waste through composting programs, which typically are managed offsite by waste haulers or other providers.

Given that a large percentage of airport organic waste is generated by concessionaires, composting programs require substantial coordination and likely involve policy measures that encourage or mandate participation in collection of organic waste by concessionaires. Composting programs typically involve either or both “back-of-house” and “front-of-house” waste streams. Back-of-house programs are focused on collecting pre-consumer food waste generated in the food preparation process (or in the case of sit-down food services, may also involve post-consumer food waste that is collected by a server). Front-of-house programs are passenger-facing and require customers to sort their waste upon disposal. In both cases, infrastructure, signage, and training are essential to reducing contamination of non-organic materials in the organic waste stream. Programs that eliminate the degree to which non-organic food packaging may be sold at airports can reduce contamination, but typically must meet standards set by the composting facility.

Spent food oil recycling programs also provide a form of organics waste management. Recycled food oils can be converted to biofuels for use in vehicles and equipment, and can provide a source of revenue for airports and concessionaires.

#### *Case Example: Vancouver International Airport (YVR)*

Metro Vancouver has adopted aggressive regional waste diversion targets and plans to achieve an 80% diversion rate by 2020. The diversion includes the regulatory measure of banning organics from landfills. In January 2015, as a response to this regulatory requirement, YVR commenced a terminal-wide organics waste diversion program to complement its existing recycling program. The first days of the program focused on concessionaires’ back-of-house organic material. This is the “low-hanging fruit” and the least complex component of an organics diversion program because concessionaire staff, rather than passengers, are trained to recognize and separate organics from other waste streams.

YVR has six food courts, and each food court’s back-of-house waste program was introduced one at a time approximately every two weeks. This systematic approach allowed support staff and waste haulers to manage the unknown increase in organics over a period of weeks as opposed to days.

To get concessionaires diverting organics immediately, YVR staff provided composting kits, which included wheeled green totes for capturing back-of-house compostables, sorting signage, and information on the organics program—the where, why, and how of the program. Providing green bins to concessionaires was critical as it provided tools for capture and served as a reminder to divert organics. Once green bins were delivered, concessionaires began composting and results were immediate.

The more complex component has been front-of-house waste diversion at food courts. Food court waste receptacles were redesigned to accommodate the organics waste stream. Food patrons deposit their remaining food waste, along with their recyclables (containers and paper), into labelled openings. This element required the most planning and support from food court staff because patrons are



FIGURE 9 Composting collection alongside waste and recycling in a food court at YVR (Source: Vancouver International Airport).

often not local and are not acquainted with the requirement to divert their waste. A waste audit and survey indicated that patrons do have difficulty sorting their waste, and so additional support staffs were brought in at peak times to help with sorting at the food court waste receptacles. Because the airport has a substantial number of non-English speaking patrons, YVR opted for the use of pictograms, as opposed to language, to explain diversion at the waste receptacles (Figure 9).

As a result of the positive and quick uptake by the concessionaires, and hands-on support from YVR, the program has been remarkably successful. Within the first eight months, YVR diverted more than 223 tonnes of organic waste—not including the diversion of paper and containers streams. This figure will continue to grow as staff and patrons adjust.

**Practice Data**

*Economic Viability*

Capital Cost: Moderately expensive (> \$100,000–\$500,000 US)  
 O&M Cost: High (>\$100,000 US)  
 Payback: Data not entered

*Operational Efficiency*

Staffing Requirements: High (>200 hours per month)  
 Reportability of Metrics: Quantitative metric with baseline for comparison practices and is already tracked

*Maturity of Practice*

Proven at one or two airports

*Energy and Climate*

Energy Reduction: No effect on energy consumption

*Natural Resources*

Environmental Benefits: Significant multiple environmental benefits

*Socioeconomic Responsibility*

Social Benefits: Significant multiple social benefits

*Characteristics*

Climate: Primarily hot  
 Primarily cold  
 Mixed hot and cold

Airport Type(s): Scheduled passenger service  
Military

*Categories*

Energy and Climate:	Other indirect greenhouse gas emission reductions
Ground Transportation:	N/A
Economic Performance:	N/A
Design and Materials:	Sustainable design and operation Recycled and bio-based content Environmentally preferable purchasing
Engagement and Leadership:	Airport-wide stakeholder engagement Public outreach Community stewardship Integrated sustainability management Airport user engagement and outreach Tenant and vendor sustainability
Water and Waste:	Waste reduction Water reduction
Natural Resources:	N/A
Human Well-Being:	N/A

**Practice 10: Upcycle Materials from Indoor Advertising**

*Practice Description*

Indoor advertising is big business for airports. Although many advertisers are moving toward electronic formats, the high turnover of marketing campaigns, coupled with the large physical scale of indoor advertising installations, can generate large volumes of waste, much of which may not be easily recycled because of the mixed materials used. With an increased focus on achieving high diversion rates for airport waste, airports and airlines are looking for creative ways to manage their complex waste streams. “Upcycling” is the process of transforming by-products, waste materials, and useless and/or unwanted products into new materials or products of better quality or greater environmental value. A common example of upcycling is the use of plastic milk bottles as composite material for park benches and playground equipment. Similarly, wood reclaimed from demolition projects of all kinds is used in the creation of high-end furniture, and metal from retired aircraft is transformed into artwork. Upcycling of materials from indoor advertising and many other activities is a practical and cost-effective way to achieve improved waste diversion rates and educate consumers about sustainability. Airports can facilitate and promote upcycling through programs and policies that apply to tenants and concessionaires.

*Case Example: United Airlines*

In 2013, United Airlines introduced a new “Fly the friendly skies” advertising campaign. More than 20 fabric banner advertisements, 14 feet high by 7 feet wide, printed on double-sided fabric with specially commissioned aerial photographs of United’s hub airports, were placed at Chicago O’Hare in support of this campaign. In early 2015, the Chicago Department of Aviation modified the allowable size of advertising units, which rendered these hanging banners obsolete.

The United Eco-Skies team used this opportunity to upcycle the banner material into a line of up-cycled travel bags created through a three-day course and contest conducted by Columbia College Chicago’s Fashion Studies program (Figure 10). The guidelines for the contest were as follows:

1. The travel bag should be designed for a day/overnight trip based on one of the following themes.
  - a. *Theme 1—Technically speaking:* The bag should carry all of the essential gadgets and gear needed to survive in the urban jungle—tablet, phone, chargers, adapters, camera, and a change of clothes for the flight home.



FIGURE 10 Obsolete marketing signage at ORD is transformed into high-end travel bags (Source: United Airlines).

- b. *Theme 2—Off the beaten path:* The bag should carry all of the essentials needed for a hike or trail run just outside of town—water bottle, phone/GPS, camera, sunglasses, running shoes, and the next day’s clothing.
- 2. The bag must fit under an airplane seat and the dimensions must not exceed 9 inches by 10 inches by 17 inches (22 cm × 25 cm × 43 cm).
- 3. It should be economical to make, be attractive, with a retail cost between \$100 and \$200.
- 4. It should be durable and wearable.
- 5. It must include upcycled fabrics from United’s “Fly the friendly skies” advertising campaign.

Two of the winning designs were fabricated by Re:new, a Chicago-area non-profit that employs women refugees living in the United States. Since 2011, more than 120 refugee women have received training or employment at Re:new. Local refugee artisans are trained to create and sew handmade products in an encouraging environment that allows the women an opportunity to flourish in a safe, nurturing, and empowering community.

The result was a line of approximately 100 high-end, upcycled travel bags (Figure 10), which sold out almost immediately on the Internet; and Re:new was compensated for the labor its trainees provided. The proceeds above the manufacturing cost were donated to United’s Eco-Skies CarbonChoice carbon offset program. In this case, all of the proceeds went to the Alto Mayo project in Brazil.

**Practice Data**

*Economic Viability*

Capital Cost:	Marginal Cost (<\$5,000 US)
O&M Cost:	Marginal or Cost Savings (>\$5,000)
Payback Period:	Immediate (0–2 years)

*Operational Efficiency*

Staffing Requirements:	Moderate (50–200 hours per month)
Reportability of Metrics:	Qualitative metric

*Maturity of Practice*

Trial tested

*Natural Resources*

Energy Reduction:	No effect on energy consumption
Environmental Benefits:	Low environmental benefit

*Socioeconomic Responsibility*

Social Benefits:	Moderate social benefit
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*Characteristics*

Climate:	Primarily hot Primarily cold Mixed hot and cold
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Airport Type(s): Scheduled passenger service  
 General aviation

*Categories*

Energy and Climate:	N/A
Ground Transportation:	N/A
Economic Performance:	Socially responsible financial investment Regional economic contributions
Design and Materials:	Sustainable design and operation Material selection Local sourcing Recycled and bio-based content
Engagement and Leadership:	Public outreach Community stewardship Airport user engagement and outreach Tenant and vendor sustainability
Water and Waste:	Water reduction Waste diversion
Natural Resources:	N/A
Human Well-Being:	N/A

## CHAPTER THREE

## REPORTING SUSTAINABILITY PRACTICES THROUGH THE SUSTAINABLE AVIATION GUIDANCE ALLIANCE (SAGA) WEBSITE

### DATA ENTRY PROCESS

One-on-one webinars with the 10 project participants were administered to capture the data assembled for each of the sustainability practices. Prior to these sessions, participants assembled data on their practices in accordance with the SAGA data categories. Participants were then directed through a simplified six-step process:

1. Go to [www.airportsustainability.org](http://www.airportsustainability.org) on your web browser;
2. Log in as yourself or as a guest;
3. Go to the “Search” function and search for your practice (for existing practices) or click the “Add a Practice” button (for new practices);
4. Open your data collection file;
5. Enter data through drop-down menu responses; and
6. Provide feedback on data entry process.

The data entry procedure is detailed in Appendix A.

### FINDINGS ON USABILITY OF THE SAGA WEBSITE

At the conclusion of each data entry session, participants were asked to provide feedback regarding their experience using SAGA, as summarized in Appendix B. Participants were asked how much time had been required to complete their practice entry, including data assembly. The responses ranged from 15 minutes to three hours, with the majority of users stating that they completed the work in 30 to 60 minutes.

Although feedback was requested in accordance with the standard questionnaire used on the SAGA website, most participants had limited experience using the website and were therefore unable to respond to survey questions regarding the various features of the website. This indicates that there may still be a large untapped audience for the SAGA website. Therefore, each feedback session was tailored to the level of participant experience using SAGA, and participants generally provided feedback concerning website navigation/technical issues and interpretation of SAGA data categories.

#### Website Navigation

In general, participants found the website easy to navigate. Most had not used SAGA prior to this project and were unfamiliar with its features; however, all but two were able to successfully navigate the data entry process on the first attempt. As outlined in Appendix A, successful completion of data entry in a sustainability practice should be indicated through a pop-up message that states, “Thank you for your input! Your edits will be reviewed by a SAGA administrator soon and will be posted upon their approval. You will be contacted with any follow-up questions.”

Respondents noted that the color coding of SAGA’s various features (search, plan, share, etc.) works well and aids navigation.

### Technical Issues

Respondents noted the following issues during the data entry process:

- Responsiveness: The website is slow to respond during navigation.
- Use of filters: The “search” function in SAGA allows users to filter sustainability practices by airport characteristics, practice categories, and practice details. One user commented that the use of filters does not appear to sort results. This is primarily because one applies multiple filters to noticeably narrow the results from the total number of practices in SAGA. In any case, the user noted that the results are not organized in a clear manner upon filtering.
- Connectivity problems: In two cases, participants were unable to navigate past the home page, and encountered a connectivity problem upon attempting to use the “search” feature of the website. Both users attributed this connectivity to outdated Internet connections at the workplace as well as stringent firewalls. In both cases, the data for these participants was entered while they verbally responded while observing via webinar.

While it appeared that these users had simply lost connectivity during the data entry session, the users confirmed that there was a problem with the site by testing their connections on other websites. This may be resolved through future improvements to SAGA that have been identified in other website testing instances.

- Error messages: Several of the users whose sustainability practices were already entered in SAGA, but who had no corresponding data, encountered errors upon completing the entry of their case examples blaming an internal server error. However, after refreshing the webpage, their case examples appeared correctly. In addition, these users did not receive a pop-up message after submitting their practice data stating that an administrator would review their entries. It appeared as if their data were lost; whereas there was simply a lag time between the data entry process and the data being published on the site. These problems have been corrected.
- Length of title field: The length of the title field on the case example data entry page is not long enough.

### Interpretation of SAGA Data Categories

The second category of feedback received relates to the users’ interpretation of the data requested in SAGA. The practice data collection page in SAGA is essentially a series of data types with corresponding multiple-choice, drop-down responses. Several users indicated that it would be helpful if there were more “set-up” to explain what the user is being asked to respond to, and perhaps actual questions would serve this purpose.

The most common issue noted by participants was in response to the data category called “Reportability of Metrics.” Nearly every participant commented in one way or another that it was unclear what was being queried. In each data entry session, the participant was allowed to talk through the potential responses, and in most cases it was clear that the user was struggling to choose a response. In the end, because many of the practices captured by this synthesis are unique and/or do not result in quantitative results (e.g., social responsibility practices), many participants chose “qualitative metric.” These user experiences may bring into question the overall utility of this data category.

The next most common issue encountered by participants relates to the “Airport Characteristics” data. Many users were unsure whether they were being asked to describe their airport’s characteristics, or whether the intent was to help other users determine whether the practice might apply to their own airports. For instance, while a glycol recovery program may be equally relevant to scheduled passenger service, cargo, general aviation, and military airports, the subject of the case example for this practice selected only “schedule passenger service” and “cargo,” presumably because they do not operate general aviation or military facilities. A simple descriptor that states “Could your practice be applied to the following airport types?” could alleviate this confusion and yield more consistent responses across the practices catalogued in SAGA.

Other miscellaneous comments were noted, as follows:

- The case examples and map function offer excellent networking opportunities.
- Adding precipitation levels to the climate characteristics field would be useful, particularly as SAGA expands its inventory of climate resilience practices.
- The program costs captured for practices can be misleading, and do not account for scalability. A full-scale program at a large airport may cost substantially more than a pilot program of the same nature at a small airport; this may dissuade practitioners from pursuing new practices.
- Very little about the website branding suggests it is aviation/airport-related; it appears more generically geared toward sustainability.



## CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

### SUCCESSFUL AIRPORT SUSTAINABILITY PRACTICES

As the universe of airport sustainability practices continues to expand, so have the ways of evaluating their success. Although sustainability professionals may constantly be faced with the need to justify the business case for pursuing sustainability initiatives in terms of payback, return on investment, and revenue enhancement, airports and their business partners are increasingly aware that their ability to operate and grow is directly connected to their success in fostering a positive sustainability reputation and goodwill. Thus, there appears to be an increased appetite for community stewardship and social responsibility initiatives whose financial return is less clear than that of more traditional sustainability efforts such as energy efficiency projects. This is evidenced by a number of the practices and case examples captured through this synthesis.

In addition, airport sustainability practitioners are increasingly focused on engaging airport stakeholders and business partners, and many programs are undertaken by airlines, concessionaires, and other airport tenants either on their own or in partnership with airport operators. Sustainability practitioners can learn as much from these entities as from the more traditional network of peers.

The sustainability practices and case examples collected through this research indicate their continued innovation. Despite an already large inventory of practices captured in the Sustainable Aviation Guidance Alliance (SAGA) website, new approaches to managing an array of environmental, economic, and social considerations continue to emerge.

These case examples describe sustainability practices useful to practitioners interested in promoting economic vitality, operational efficiency, natural resource protection, and/or social responsibility at airports. The case examples can be found online in the SAGA database.

Number	Practice	Case Example	Primary SAGA Practice Category
1	Develop an Asset or Infrastructure Management Plan	Dallas Fort–Worth International Airport	Economic Performance
2	Develop and implement an Environmental Management System to track progress in improving environmental performance	Reno Tahoe International Airport	Economic Performance
3	Integrate climate resilience considerations in airport development projects	Port Authority of New York & New Jersey	Economic Performance
4	Tie sustainability goals and objectives into the operations and maintenance and capital improvement program budget process	San Diego International Airport	Energy & Climate
5	Donate surplus equipment and other goods to charity	American Airlines	Engagement & Leadership
6	Donate surplus food to charity	HMS Host	Engagement & Leadership
7	Develop an onsite materials recovery facility	Charlotte–Douglas International Airport	Water & Waste

Number	Practice	Case Example	Primary SAGA Practice Category
8	Use recovered glycol as a “feedstock” for reformulated aircraft de-icing fluid, vehicle anti-freeze, aircraft lavatory fluid, coolants, coatings, and paints	Wayne County Airport Authority or Denver International Airport	Water & Waste
9	Establish an Airport Composting Program	Vancouver International Airport	Water & Waste
10	Upcycle materials from indoor advertising	United Airlines	Water & Waste

**SUCCESSFUL REPORTING OF SUSTAINABILITY PRACTICES THROUGH THE SAGA WEBSITE**

SAGA continues to evolve as a tool for sharing of data and most effective practices. Its catalogue of sustainability practices is extensive and continually expanding. Although most airport staff are faced with full schedules and may not believe they have time to contribute to the website, this synthesis concluded that a reasonably informative SAGA entry typically required less than one hour to construct, and much less than that if the practice data are readily available. However, if it is desired that SAGA entries are more detailed than those collected in this synthesis, the workday demands of airport staff may limit the expansion of SAGA content.

It should be noted that the practice data contributed to SAGA by case example participants was provided from the perspective of individual airport users, and provided using pre-populated responses displayed in drop-down menus. These responses are subject to interpretation, and may not accurately represent the potential outcomes of sustainability practices at other airports.

This synthesis also concluded that SAGA users would benefit from a bit of guidance on the practice data that is sought on the website in order to generate more consistent responses. This consistency would be particularly useful in improving the search feature and resulting “prioritization score” that is generated by means of the data inputs for each sustainability practice.

**LESSONS LEARNED AND EVOLVING ISSUES: EXPANDING THE SAGA AUDIENCE**

The synthesis panel emphasized the importance of generating participation by new users in this project, rather than focusing on airports and individuals that are known leaders in airport sustainability. Although this project was successful at generating such participation, it is unclear whether this will result in long-term engagement in SAGA. The airport sustainability community is somewhat of a “niche,” and just as sustainability practitioners are constantly searching for ways to break down silos and integrate sustainability across their organizations, those individuals who do not perceive themselves as directly responsible for sustainability may not take ownership of initiatives such as SAGA.

In particular, it was observed that some of the airport operations staff whose roles were not overtly environmental in nature did not appear likely to re-engage in SAGA (for instance, by declining to set up a username and password) because it may be construed as an academic exercise. This mirrors a common challenge faced by airport sustainability practitioners in engaging stakeholders across the airport ecosystem.

**SUGGESTIONS FOR FURTHER RESEARCH**

While SAGA was initially developed primarily as a tool for airport operators, the applicability of airport sustainability has expanded to a broader audience that includes airport business partners, tenants, and other stakeholders. This synthesis provided a glimpse into the sustainability practices undertaken by airlines and concessionaires. The airport sustainability community may benefit from a more comprehensive review of what airport stakeholders are doing to advance sustainability in the

aviation sector. This research might also be complemented by an effort to enhance the orientation of SAGA as a resource for aviation more broadly.

Given the continuing evolution of airport sustainability practices, a second phase of this work could allow for the entry of additional practices into SAGA. Further research into specific practice types, such as integration of sustainability in winter operations, may also be warranted. In particular, additional research into social sustainability initiatives could be useful in addressing some of the constraints faced by airports in implementing such efforts, such as prohibitions on donation of public goods.

Finally, the SAGA website could benefit from additional resources to provide expanded learning opportunities on topics of special and emerging interest, such as climate resilience.

## ACRONYMS

AMP	Asset Management Plan
CIP	Capital Improvement Program
CLT	Charlotte–Douglas International Airport
DFW	Dallas/Fort Worth International Airport
DTW	Detroit Metropolitan Airport–Wayne County Airport Authority
EMS	Environmental Management System
HVAC	Heating, ventilation, and air conditioning
kW	kilowatt
LGA	LaGuardia Airport
MRF	Materials Recovery Facility
ORD	Chicago O’Hare International Airport
PANYNJ	Port Authority of New York and New Jersey
PG	Propylene glycol
RNO	Reno–Tahoe International Airport
RTAA	Reno–Tahoe Airport Authority
RTS	Reno–Stead Airport
SADR	Spent Aircraft De-icing Fluid Runoff
SAGA	Sustainable Aviation Guidance Alliance
SAN	San Diego International Airport
SDCRAA	San Diego County Regional Airport Authority
YVR	Vancouver International Airport

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## APPENDIX A

### Navigation of the Data Entry Process

- Step 1.** Navigate to the Sustainable Aviation Guidance Alliance (SAGA) homepage by entering [www.airportsustainability.org](http://www.airportsustainability.org) in the address bar of your web-browser.
- Step 2.** Log In as a Guest or with your Log In details (if available).
- Step 3.** Select “Sustainable Practices” from the list of options located at the top left of the page (please be patient as it may take up to 1 minute for the next page to load).
- Step 4.** To add a new practice, select the blue button labeled “+ Add a Practice.”

#### OR

To edit an existing practice, Search Sustainable Practice, and then click Edit Selected Practice.

- Step 5.** Enter text into the “Practice Name” and “Practice Description” text box fields.
- Step 6.** Provide practice details (Practice Information & Characteristics) by selecting options listed in drop down menus.
- Step 7.** Review the “Categories” list located in the top right corner of the page. Click on each main category to see a list of subcategories (checkboxes). Expand all categories that are applicable to the practice and check all the boxes that are applicable to the practice.
- Step 8.** Add comments, links or case examples by selecting the corresponding blue button located in the bottom right hand corner of the page. A pop-up screen will appear and prompt you to enter practice-specific details. Click the “Submit” button when all information has been entered.
- Step 9.** Submit the Practice for public viewing or save as a private entry by clicking the corresponding buttons in the lower right-hand corner of the page. If you prefer your submission to be anonymous check the appropriate box before submitting/saving your entry. A pop-up window will appear to indicate that your submission has been received and will be reviewed by an administrator.

## APPENDIX B

### Usability Surveys

<b>1. What is your main reason for using the SAGA website and does the website help you to achieve your goals?</b>
I've used it to search practices, and have used most of the features. I've used Learn, Plan and Search.
I like to see what other airports are doing and how they are using the site. I can then contact airports for more detailed questions and have a point of contact. I don't really use the website to learn about particular sustainability practices.
I love the case examples and networking opportunities.
I've browsed it in the past, but never used it for any specific purpose
SAGA has come up in my work but I haven't really looked at the website. I am new to waste, before that I was working on aircraft noise. I was under the impression that the website might be USA focused. I am located in Canada, so some components might not be applicable.
I've used it to search practices to see what others are doing. I've entered practices and we plan to enter a lot more with our new sustainability person on board. Our Public Affairs person uses it a lot.
<b>2. Please share any comments, thoughts or suggestions for improving the website.</b>
Title in case example not long enough. Data entry did not work. Reportability of metrics is confusing—what does it mean?
I like to know who is doing what. A lot of the practices are incomplete or are missing information. Some also seem expensive based on the information on the website. However, the practices can be scalable to other airports with smaller cost implications, therefore being much more affordable to other airports. Inputting the information into the website is valuable but the costs might scare people. The questions on the submittal form can be confusing. I am not always sure which perspective I need to take: do the questions apply to my airport specifically, or do they apply to airports in general? A simple question, information and/or definitions to set me up would be helpful. Provide more detail on definitions and terms use. It would be nice to be able to select more than one choice on the drop down menu when inputting a practice/case example. It is not clear what link to provide when asked to provide one when adding a case example.
Not sure what "reportability of metrics" is supposed to mean.
Pretty easy to use
Reportability of metrics confusing. Climate type confusing. Default selection is weird. Should be some guidance to developing title. Should be some additional messaging around adding a case example. User guide to adding practice and case example? Should be more of a push to add practices (share function should be stronger)—if this is your first time using SAGA, need more direction. Site is a little slow.

Looks to be focused around buildings and maintenance—maybe could be expanded to look more broadly at sustainability initiatives and community stewardship.
Do not understand reportability of metrics question.
Why are climate conditions only hot vs. cold; i.e., why not precipitation levels?
<b>3. How long did it take you to create your entry?</b>
30 min total (5–10 min for data assembly)
30 min sitting down with a colleague to collect data; 15 min writing up the summary; 15 min to upload the information.
Probably about a half an hour.
15 minutes to upload. A few hours (3 hours) to collect information for and write up case example.
Just a few minutes, but the data that we get from the program take a long time. Our auditors collect the data.
30 min to assemble data. Was unable to enter it in SAGA.
I knew the data, so it only took as long as our phone call.
<b>4. Do you have a bug or performance issue to report?</b>
Yes. The form didn't accept all my inputs. I got an error message upon submittal.
My data was not saved and I received an error message upon submitting my case example, but when I refreshed the entry my case example was there.
The practice did not upload properly. Multiple questions are broad so they are easy to answer. However some questions need clarification. Writing up the program in 2–3 paragraphs is pretty hard.
Messaging is annoying upon completion of data entry. When you filter by airport characteristics, there is no sorting of results.
Could not connect—got shut out after homepage.
Clear to use, no problems to report.
Could not connect beyond homepage.



*Abbreviations and acronyms used without definitions in TRB publications:*

A4A	Airlines for America
AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI-NA	Airports Council International-North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FAST	Fixing America's Surface Transportation Act (2015)
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
MAP-21	Moving Ahead for Progress in the 21st Century Act (2012)
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TDC	Transit Development Corporation
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation

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ISBN 978-0-309-38976-1



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