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Waste Management at Airports

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1. INTRODUCTION

Every airport must manage waste, and implementing efficient and cost-effective waste management practices presents many challenges. There is a wide range of sustainable practices that can make the management of waste at airports more economic and better for the environment. Furthermore, successful airport waste management implementation has the potential to positively impact airport authorities, customers and the surrounding community at large.

Airports are local entities. Waste management at airports are therefore generally reliant on national/local regulation, drivers and realities. For instance, a municipality with waste reduction targets can influence an airport operator's waste management policy. Additionally, stakeholder's arrangements with the airport operator also vary from place to place (e.g. contracts, responsibilities) and may impact the ability of the airport operator to influence its stakeholders.

In this e-publication "Waste Management at Airports" general principles and approaches will be addressed. It will provide the basics of waste management at the airport site, including in particular environmentally friendly practices, and the new concept of circular economy, which can also minimize waste.

2. DEFINITION OF WASTE

For the purpose of this e-publication, waste will be considered as any type of "unwanted or unused" products/materials/substances that happen to be produced and/or arrive at the airport site and that needs to be given a proper treatment. Waste management, therefore, will be the process of handling the waste, which could come from aircraft (domestic/international), tenants, maintenance activities, aircraft and ground vehicles operations, offices, construction and so on, as well as dealing with the different requirements of these different types of waste.

However, in reality there is no single definition of waste, especially if one is trying to combine a common understanding of the different practices, regulations and levels of maturity of waste management, including environmentally sound performance around the globe. The Oxford dictionary defines waste, in general, as "Unwanted or unused material, substances and by-products"[1]. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal defines wastes as "substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law. It also defines what can be considered as an environmentally sound management of hazardous wastes or other wastes: practices that ensure that these wastes "are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes".

The majority of this document focuses on the extent to which the materials, substances, and by-products of the modern aviation system are waste and the choices airports have when deciding what to do with it.

For the aviation industry, two other considerations are of primary concern, 1) is the waste 'international,' and is it hazardous waste? States often have their own regulation defining specific treatment for international waste and airport operators must follow them. For example, the Canadian International Waste Directive defines International waste as any "waste removed from aircrafts … including things that are forfeited or voluntarily surrendered by international travelers arriving in Canada."[2] The Basel Convention deals with a specific type of international waste – hazardous, defining rules for waste that are explosive, flammable, toxic, corrosive or considered hazardous by their annexes or national laws of parties to the Convention.

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1 *Oxford Dictionary. Online, available at: https://en.oxforddictionaries.com/definition/waste*

2 *Canadian International Waste Directive*
http://www.inspection.gc.ca/animals/terrestrial-animals/imports/policies/general/2002-17/eng/1321050654899/1323826743862

This publication will provide the basics of waste management at the airport site, including in particular environmentally friendly practices, and the new concept of circular economy which can also minimize waste and give them a business model where they would be treated in a different fashion, challenging some definitions discussed above. Generally, hazardous waste falls into the category of "required by law wastes," and there are specific procedures for handling and disposal of this waste. Consequently, it is not discussed in detail in this paper.

3. TYPES OF WASTE

In practice, airport operations encounter various types of waste, including: Municipal Solid Waste (MSW); Construction and Demolition Debris (CDD); waste from aircraft flights (deplaned waste); compostable waste; hazardous and industrial waste; and lavatory waste. For MSW and CDD, airports have choices in how to manage collection, treatment, storage, and disposal. Those choices, when considered and carried out in beneficial ways, can improve airport operations and minimize environmental impacts

3.1 MUNICIPAL SOLID WASTE (MSW)

This is the type of waste that airports have the most choice in managing. MSW is made up of everyday items that are used and discarded, such as aluminum and steel cans, glass bottles and containers, plastic bottles and containers, packaging bags, paper products, and cardboard. Airport MSW comes from four primary sources as follows:

1. Terminal waste – from public areas and airport administrative offices;
2. Tenant waste – from terminal retail and concessions;
3. Airline waste – from airplanes and airline offices; and
4. Cargo waste – from cargo operations

3.2 CONSTRUCTION AND DEMOLITION DEBRIS (CDD)[3]

Another common type of waste at airports is Construction and Demolition Debris (CDD). CDD can come from land clearing, excavation, or – as the name implies – construction and demolition at the airport. CDD may include such materials as concrete, wood, metals, soil, bricks and masonry material, asphalt, rock, stone, gravel, and sand, roofing materials, drywall, carpet, plastic, pipe, and others.[4]

3.3 WASTE FROM AIRCRAFT FLIGHTS (DEPLANED WASTE)

Waste from airplanes (deplaned waste) is a specific type of MSW that is removed from passenger aircraft. Almost 20% of an airport's total MSW comes from deplaned waste after flights.[5] Deplaned waste includes "galley waste" – materials typically collected by airline caterers as part of the de-catering process, including compactor boxes, waste carts (bags), food carts, and bonded carts – which may be subject to more rigorous disposal methods.

3.4 INTERNATIONAL WASTE

Special attention has to be made for international waste. This is generally waste from international flights, but also can include the waste from the terminals that international flights service. When waste originates from countries with different policies and regulations, there is a risk of introduction of plant pests, diseases, and other contaminants. For these reasons, this waste is sometimes called quarantined waste (QW). Although international waste is often similar in material type to MSW, airports generally handle and process international waste separately from other waste types. In many cases international waste is incinerated on-site, or the airport arranges for it to be packaged and sent for disposal.

3.5 COMPOSTABLE AND BIODEGRADABLE WASTE

Airports generate waste that is biodegradable. Food waste from terminals: food that is not consumed, or waste generated during food preparation is one of these. Airport landscaping activities also generate green waste – trees, shrubs, and grass clippings, leaves, and similar vegetation generated by landscape maintenance. These types of organic wastes can be composted, but airports are now developing other creative means of disposal. These types of wastes can also be categorized as MSW, although these often have different treatment options than MSW.

3.6 HAZARDOUS AND INDUSTRIAL WASTE

These types of waste products consist of oils, solvents, and other chemical waste from activities such as aircraft and ground vehicle washing and cleaning, fueling operations, aircraft maintenance and repair including painting and metalwork, engine test cell operations, de/anti-icing operations, ground vehicle maintenance, and abandoned aircraft. These types of wastes tend to be closely regulated by state law, and require special treatment, storage, and disposal, and therefore this document does not address hazardous and industrial waste management.

3.7 LAVATORY WASTE

Lavatory waste is considered as a special type of waste and contains chemicals and potential enteric pathogens and can present risks to the environment and human health if not handled properly. Caution must be taken to ensure that releases of lavatory waste do not occur[6].

4. WASTE MANAGEMENT PRINCIPLES

Airport Council International's (ACI) Policy and Recommended Practices Handbook[7] provides guiding principles for waste management at airports; "Airports should promote the culture of avoiding solid waste generation and, where possible, extracting value from remaining waste with the ultimate goal of sending zero waste to landfills."

4.1 WASTE HIERARCHY

The ACI Policy Handbook provides a waste decision hierarchy, that shows – in order of decreasing priority – what constitutes the best overall environmental waste management choices: to avoid; to reduce; to reuse; to recycle; and finally, to dispose with the ultimate goal of eliminating waste going to landfills. By this decision hierarchy, the first consideration should be given to minimize the generation of waste at the

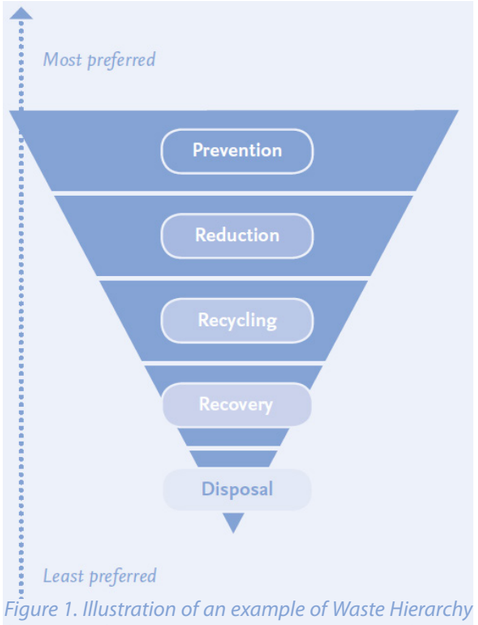


Figure 1. Illustration of an example of Waste Hierarchy from United Nations Environment Programme (UNEP)

3 *Note: there are various ways of referring to construction and demolition waste, as well as differing acronyms: CDD, C&D, CDW, CRD, etc*

4 *Adapted from: Guidance on Airport Recycling, Reuse, and Waste Reduction Plans. Memo from the Federal Aviation Administration September 30, 2014.*

5 *ibid*

6 *Ibid*

7 *ACI, ACI Policy and Recommended Practices Handbook (8th edition) 2016*

airport, and additionally, include opportunities for cost savings through improved management of waste, the feasibility of waste recycling at the airport, and the potential for generation of revenue from airport waste.

EU Directive (2008/98/EC) also describes a priority order of waste prevention and management legislation and policy options: prevention; preparing for re-use; recycling; other recovery; and disposal[8]. The directive recognizes that "waste hierarchy generally lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy", however sometimes it could be justified to depart from such hierarchy in order to address specific waste streams that would require correlating needs of technical feasibility, economic viability and environmental protection[9].

Waste hierarchy can differ in their nomenclature, however the main objective is achieved if one understands that the most important principle is to try to reduce waste to the minimal extent possible[10].

4.2 WASTE AVOIDANCE

Waste avoidance should be at the top of any waste management hierarchy, as it is in the ACI and EC policies on waste management (see figure 1). Waste avoidance refers to the measures to be implemented before a substance becomes waste.

4.3 WASTE REDUCTION

Reducing waste can contribute to airport sustainability and to cost savings. Some reduction efforts may include more economical use of materials, while some may divert to another process such as recycling. All processing of waste requires effort and energy, but by extension, any activity that might contribute to reducing the amounts of waste also decreases transportation emissions and energy necessary to process it.

4.4 WASTE REUSE

Airports may reuse and repurpose materials by using contractual requirements with tenants to require waste minimization activities, such as use of specific materials, cleaners, or paints. The reuse or repurposing of recovered materials also reduces the demand for new materials, for example reducing mining of aluminum ore.

4.5 WASTE RECYCLING

A common way to reduce the amount of waste is to establish a recycling program. Approximately 75 percent of the waste stream at airports is recyclable or compostable, with paper being the largest single category of MSW generated by the airline industry[11]. With recycling, residual waste is reduced and energy and materials are recaptured.

There are two types of recycling found at airports that correspond to the two types of waste – MSW and CDD. MSW recycling can offer cost savings, but requires development and implementation of an effective recycling process by the airport, which will pose costs as well. CDD recycling can be a large source of savings in terms of materials and cost, but requires careful planning to realize those savings.

4.5.1 MSW RECYCLING

Recycling airport MSW can offer economic and operational savings. It will likely require training of staff, placement of special containers throughout the airport to collect recyclables, and procedures for sorting and shipping the recycled materials to the correct destinations. For a recycling effort to be successful, management support will be essential. The person leading the effort will have to coordinate with every sector of the airport to develop a process that works best. Strong leadership will result in a better process.

4.5.2 CDD RECYCLING

CDD from airport construction projects brings different considerations than MSW. A key consideration for airports is recycling of materials such as concrete and asphalt pavements, masonry, rocks and gravel, wood, and piping, generated during construction, demolition, renovation, maintenance, and repairs. Some of these materials can be reused on-site, while others may have a reuse within the community, thus contributing benefits locally. CDD recycling can have the following benefits:

- Economic – Provides cost savings from reduced material hauling, disposal fees, and fuel costs, and avoiding purchasing new materials. Construction recycling creates employment and economic activity that benefits local economies.
- Environmental – Reduces the amount of materials sent to landfills and the environmental impacts of extracting or producing new materials. The reuse of materials on-site reduces off-site hauling, and decreases transportation air emissions and fuel burn.
- Operational – Streamlines the quantification and organization of materials on-site, reducing impacts to airport operations. Less time and labor may be needed for hauling, installation and maintenance.
- Social – Reduces traffic in the surrounding community through reduced off-site hauling[12].

4.6 WASTE TO ENERGY

Waste recovery embraces the conversion of non-recyclable waste materials into more useful kinds of fuel that can be used to supply energy. This process is known as "waste to energy". The conversion of waste to energy can be in the form of heat, electricity, or fuel through several processes such as: combustion (incineration), anaerobic digestion, gasification and landfill gas recovery. The conversion of non-recyclable waste materials into energy generates a relatively clean source of energy compared to conventional (fossil fuel) sources by offsetting the need for conventional sources for energy and in that way reduces the total carbon emissions.

4.7 WASTE DISPOSAL

Ultimately, some airport waste must be disposed of. While waste management decisions such as reducing and reusing materials aim to minimize waste and recapture materials and energy, at the time of this writing, this is not always feasible. The landfill or incinerator are often the choice for airport waste that cannot be handled in other ways. In some cases the landfill utilities themselves are engaged in the process of 'waste-to-energy' recapture through incineration or other processes.

8 E.U Directive (2008/98/EC). Available online at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098

9 Ibid

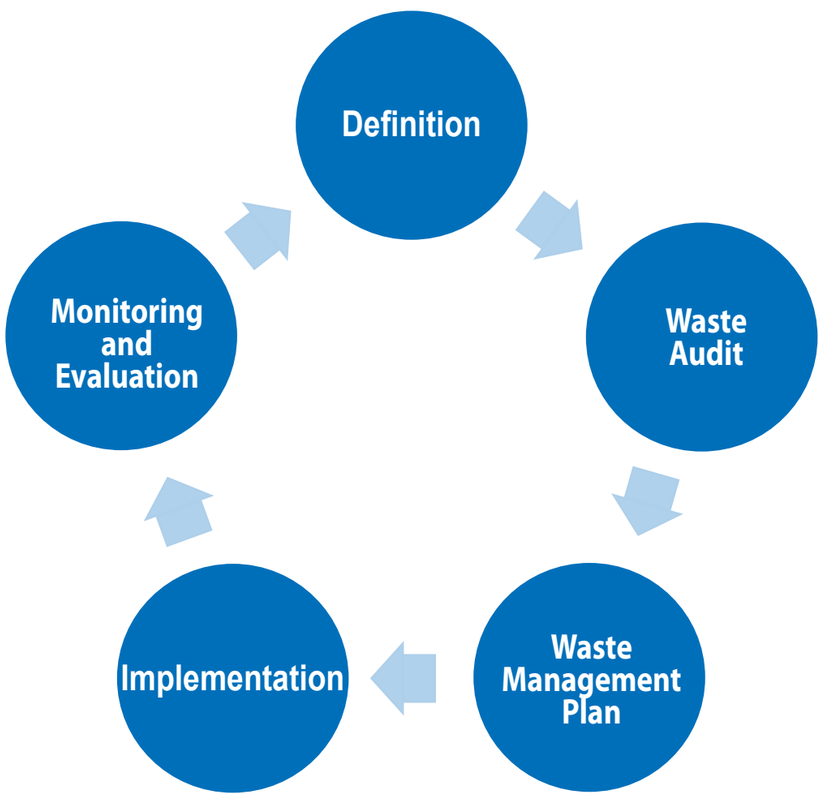
10 UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. Available at: http://cwm.unitar.org/national-profiles/publications/cw/wm/UNEP_UNITAR_NWMS_English.pdf
Different versions of the hierarchy have been adopted by different countries, although they are all broadly similar to that outlined above.

11 Hershkowitz, Allen and Darby Hoover, 2006, Trash Landings: How Airlines and Airports Can Clean Up Their Recycling Programs. A report by the Natural Resources Defense Council.

12 From Recycling, Reuse and Waste Reduction at Airports: A Synthesis Document. Report prepared by the U.S. Federal Aviation Administration, 2013, page 18.

5 WASTE MANAGEMENT APPROACH - GOALS, ORGANIZATION AND RESPONSIBILITIES

Minimizing overall waste throughout airports' operation and value chain entails not only maximizing the amount of reused and recycled items from waste, but also the consideration of social, economic, environmental, and operational aspects of waste in the broader context of airport management. It is imperative to engage airport management and ensure their commitment, define clear roles and responsibilities of stakeholders involved as well as share overall objectives.



5.1 WASTE AUDIT

A waste audit is a study that characterizes the types of airport wastes, where they come from and where they end up. The audit should also specify amounts of waste and identify new opportunities for recycling, reuse, and waste reduction, and help evaluate the effectiveness of waste management over time. Carrying out a waste audit is an important first step in developing or refining a waste management plan. In particular, such information is crucial to developing a recycling program. A waste audit can reveal a lot about the patterns of people in the facility as well as their use and distribution of everyday items throughout the facilities and grounds. This would however require specific knowledge of airport operations and applicable regulations, as the situations that each airport faces are unique and highly dependent on its geographical and social condition.

5.2 WASTE MANAGEMENT AND REDUCTION PLAN

Using the waste audit, or other information on waste patterns within your airport, a plan should be designed for airport waste avoidance, reduction, reuse and recycling. Having a clear policy established by top management and in accordance with the national/regional regulatory framework is essential. Although the contents and scope of the plan will vary depending on the airport and its setting, in general practice, it should include goals and objectives of the waste management, list of essential stakeholders, characteristics of waste at the airport, waste reduction strategies to be implemented, and the description of the facility and its current waste processes.

The Waste Management implementation process should be described and documented within the airports standard procedures and operations. Although the level of details may vary according to the size of the airport, the principles should remain consistent, for example: Separation, Collection and Transportation. This plan may be included as part of a Master Plan for airport development, or as a component of an airport sustainability plan.

Plans to foster engagement with employees, managers, and contractors can also be included in the plan. Annex 1[13] provides a sample outline for an airport Recycling and Waste Reduction Plan.

5.3 IMPLEMENTATION

The successful implementation of a Waste Management Plan depends on different aspects that can influence its implementation. This should be part of a corporate strategy that should include coordination with all airport stakeholders, as they may be responsible for implementation within the area under their control. This policy should be reviewed periodically, and protocol adapted accordingly. Identifying economic incentives for reducing, reusing and recycling waste, and using these economic instruments to implement a cost-effective waste management approach are important elements to define the best implementation practices according to the airport local/regional characteristics. For instance, in some regions, it may be cheaper for the airport to directly get involved with all elements of separation, collection and transportation, while other may need to sub-contract.

Staff, tenants and passenger education campaigns should be included during the implementation program, in coordination with an implementation communication strategy, addressing both internal and external stakeholders. The airport website can be used as a vehicle for such communications, but other means to reach out to local communities should also be considered. Airports occupying premises in joint ownership with or employing workers from other organizations must establish effective means of consultation between the various interested parties over common problems of waste management. The benefits of implementing the waste management procedures are to be made public and to be sufficient motivator for employees to adopt the standard in its management system and daily operation.

5.4 MONITORING AND EVALUATION

A comprehensive monitoring and evaluation system should be implemented, for the airport operator to properly assess progress towards meeting the targets in the Waste Management strategy. Although the procedure may vary according to the level of details, the principles should remain consistent and compliant to other requirements applicable to the organization. Identifying common elements used in other areas of responsibility of the airport operator could help identifying the approach taken by the organization to monitor and evaluate operations. That should also be used, when appropriate to waste management. The foundation of a monitoring system could include but are not be limited to:

- Consistently measure and report waste data
- Collect data where required for assessing progress toward meeting targets
- The foundation of the evaluation could include, but are not be limited to:
- Easily Identifiable Key Performance Indicators (KPIs)
- KPIs should be able to be amended, if not accurate

13 *Annexes to this publication will be available soon.*

The proposed monitoring and evaluation system is to be based on several key information sources, as identified by airports and is to be continually maintained.

5.5 METRICS

Metrics are used to assess current situation, review policy and targets, and communicate results. Indicators using numeric value can facilitate the interpretation of the status and communication of results to both experts and non-expert audience. Indicators can also be used to benchmark progress over the years and compare results with other similar airports[14].

Common metrics used are weight and rate of different types of waste generated and diverted from landfill. (e.g. kg/tons of recycling; % of diversion). The metrics should be able to estimate the quantity and composition of waste generated. The United States Environmental Protection Agency (EPA) uses standard volume to weight conversion factors from Great Forest to assist with the conversion from volume to weight[15]. Costs can also be used as a metric, since planning for investment and return can also depend on the ability of to demonstrate cost-savings. EPA also provides guidance for organizations to estimate these cost-savings by defining waste removal costs as a baseline.

5.6 RISKS AND OPPORTUNITIES

The goal of the risk assessment process is to achieve acceptable risk through actions that would reduce the risks with considerations given to cost, feasibility and framework. These elements should be revised periodically.

Waste management risks are related to contamination. For instance, airports must have a proper waste management system in place to avoid contamination of airport sites and also to prevent the attraction of wildlife that could negatively impact the safety of operations. Contamination can also compromise recycling rates, as they can easily be reduced if recycling is mixed with organic material, for example.

Waste Management can also introduce new practices that could provide several opportunities, including: reducing costs, increasing recycling rates, improving the sustainable image of the airport, providing a better outreach to the communities and even positively influencing social related activities in the region.

A risks and opportunities assessment review should be an integral part of reviewing and balancing the suitability, adequacy, and effectiveness of the Waste Management System. The outcome of the Risks and Opportunities of the Waste Management system is to be compiled with the general system of Risks and Opportunities of the airport. The results of the risks and opportunities assessments are significant aspects that can be addressed by the organization through actions such as coordinating with different departments regarding possible impacts, setting an objective and waste management improvement program[16].

6 IMPLEMENTING A WASTE MANAGEMENT PROGRAM

6.1 STAKEHOLDER ENGAGEMENT AND EDUCATION (COMMUNICATIONS)

All waste reduction efforts require good communications and outreach efforts among airport stakeholders. Airports may publish highlights, data and metrics of their achievements and efforts. Such communication activity will foster motivation of relevant stakeholders, and also demonstrate the airports' commitment to sustainable business practices and corporate responsibility, leading to a more positive media coverage and public relations with the surrounding community.

Essential Stakeholders[17]

- Passengers passing through public areas, parking lots, garages, curbside pickup and drop off areas, restrooms, holding areas, and food courts
- Tenants such as businesses, airlines, and concessions (including taxi, hotel, rental cars, flight kitchens, and other industries that operate at the airport)
- Airline employees (including ground crew, cabin cleaning crew, catering);
- Employees of airport authorities, government offices, business agencies, etc.
- Maintenance operations and support facilities
- Contractors of the airport and its tenants, including aircraft cleaning and service, janitorial services, waste haulers, and construction contractors
- City or County solid waste management.

6.2 WASTE SURVEYS, AUDITS, STATISTICS WITH PROPER METRICS[18]

Before you develop a recycling plan, understand what waste is generated and collected at your airport by performing a waste assessment. A waste assessment provides qualitative and quantitative data. It also provides a baseline to measure progress in the future.

A waste assessment will help you answer the following questions:

- What areas of the airport generate waste?
- What recyclable material is generated?
- What type of waste is generated in each area of the airport?
- How much waste is generated by each area of the airport (airlines, airport offices, customers, concessions, etc)?
- What are the waste-related costs for trash and recycling containers, hauling, disposal recycling and labor (in equipment dollars and worker time)?

There are three primary approaches to conducting a waste assessment:

- Records Examination
- Facility Walk-Through
- Waste Sort

The type of assessment you choose is based on the size of your airport, the existing knowledge of your waste stream, the goals of the program, and the resources available.

14 https://www.iges.or.jp/en/archive/wmr/pdf/activity20121213/1-3_Visu_WM.pdf
15 https://www.epa.gov/sites/production/files/2016-03/documents/conversions.pdf
16 https://www.epa.gov/sites/production/files/2016-03/documents/estimate.pdf

17 https://www.faa.gov/airports/resources/publications/reports/environmental/media/RecyclingSynthesis2013.pdf
18 *Content draws largely from: EPA Developing and Implementing an Airport Recycling Program (2009) (I like this document quite a bit). Also used parts from: FAA Recycling, Reuse and Waste Reduction at Airports (2013), .FAA Memo - Guidance on Airport Recycling, Reuse, and Waste Reduction Plans (2014)*

Records Examination

A records examination provides information on the quantity of waste generated, as well as costs, for labor, equipment and services. If you don't have a centralized waste management system, try to compile all the waste data from the different haulers that service your airport. The records that may be useful include:

- purchasing, inventory, maintenance, and operating logs;
- supply and equipment invoices; and,
- waste hauling and disposal records and contracts.

Facility Walk-Through

A facility walk-through provides qualitative waste information through observation of staff and customers. The primary benefit of a facility walk-through is the first-hand observation of waste handling practices. The types and amounts of waste generated at the facility can be observed at this time. Track how waste moves through the airport. Assess existing space and equipment available for storage of waste, processing of recyclables, and other collection tasks. Also, talk to staff about their waste generation and disposal habits. The custodial staff is an excellent source of information in a facility walk-through.

Waste Audit

The most comprehensive and resource intensive waste assessment is a waste sort or "audit". A waste audit looks at the contents of waste receptacles throughout the airport to evaluate what and where material is disposed. Waste audits should include all areas under direct control of the airport and, when applicable, areas over which the airport has influence (tenants including: food services, retailers, car rental agencies, etc). Waste audits should include:

- Identification of what can and cannot be recycled in the region.
- Locations in the airport that generate waste.
- Types of wastes generated in each area, such as paper, scrap metal, plastic, etc.
- Identification of which materials that can be reduced, reused, and recycled
- Quantity of waste generated by each area of the airport (airlines, administrative offices, enplaned and deplaned passengers, concessions, etc.).
- Commodity rates for recyclable materials.
- Expenses for processing recyclables
- Costs for hauling, disposal and labor of landfill bound waste.

Waste Assessment Approaches

Strengths	Limitations
Records Examination • Provides weights and volumes of waste generated • Tracks major potential waste from the point of origin • Identifies the expensive or valuable components of an organization's waste • Documents financial benefits of reuse and recycling including total revenues and avoided disposal costs • Requires the least time and effort • Establishes baseline for metrics	• Lack of quantitative data for specific waste components • Does not provide qualitative data on how or why wastes are generated • Substantial effort necessary to collect and analyze data
Facility Walk-Through • Requires less time and effort than waste sorts • Allows first-hand examination of facility operations • Provides qualitative information about major waste components and waste-generating processes • Reveals waste reduction activities • Develops appreciation of logistics and obstacles tenants encounter in their efforts to recycle	• Limited identification of wastes generated • Multiple attempts may be necessary for comprehensive evaluation • Relies on estimates of waste generation
Waste Sort • Provides quantitative data on total waste generation and specific waste components • Allows problem solving and design of recycling program to be site specific	• Requires more time and effort than other approaches • Multiple attempts may be necessary for comprehensive evaluation • Does not provide qualitative data on how or why wastes are generated

Source: USEPA, Business Guide for Reducing Solid Waste, 1993.

Waste information provides baseline information that can be used to identify recycling, reuse, and waste reduction opportunities and priorities, and gauge program effectiveness over time. The simplest and most easily understood waste metric is the diversion rate (or % diversion). The diversion rate is the total weight of recyclable material that is "diverted" from the material that is disposed of as garbage.

It is calculated as:

$$\text{The diversion rate (\%)} = \frac{\text{weight of recyclable materials}}{\text{weight of recyclable materials + weight of garbage}} \text{ x100}$$

6.3 WASTE INFRASTRUCTURE WITH SIGNAGE (COLORS, ICONS, TERMS)

The use of consistent waste signage (colors, icons and terms) helps the user to quickly identify and sort their recycling, which in turn, can assist with reducing contamination and increasing recycling rates[19].

The color and general signage should be easily identifiable by airport passengers, other stakeholders and staff. A common challenge that international passengers (and maybe domestic passengers too) face are different colors, icons and terms used by different airports, due to local regulation and culture. The lack of international waste signage standards is therefore a challenge for airports receiving international passengers and should be considered when designing signage. For instance, the use of icons can be considered user friendly, independent of the language of the passenger, if they are able to successfully pass the message to the end user in terms of quickly sorting their waste.

Another important element for the airport operator to consider is an assessment of passenger behavior, to better identify cultural behavior that could be addressed by an improved signage. Defining the most common items purchased at the airport and cross-checking if the waste bins can properly fit them is a simple exercise that can be helpful to increase recycling rates.

Finally, the airport operator should try to be consistent with both signage and education for all stakeholders and all facilities and points of collection and delivery at the airport.

6.4 ECONOMICS: INTRODUCTION OF "POLLUTER-PAYS-PRINCIPLE"

The Polluter Pays Principal was first established by the OECD in 1972 and is defined as:

"The polluter-pays principle is the principle according to which the polluter should bear the cost of measures to reduce pollution according to the extent of either the damage done to society or the exceeding of an acceptable level (standard) of pollution." (ref 1)

The principle is that environmental costs should be internalized by the producer of environmental damages, in other words that the costs of goods and services should incorporate the costs of pollution incurred during production and consumption. Many international declarations and regimes have now incorporated the polluter pays principal, for example the Helsinki Convention on the Marine Environment which states that contracting parties shall apply the polluter pays principal and the Rio Declaration which requires National authorities to promote the internalization of environmental costs on the basis that the polluter should bear the cost of pollution.

7. WASTE RECYCLING: DEVELOPMENT AND DESCRIPTION OF THE PROCESS

Recycling is the process of taking materials that have been discarded and reprocessing them into something new. The two main categories of airport waste, MSW and CDD, can be readily recycled, and airport waste management plans will generally include plans for how to collect and manage recycling materials at the airport. However, each type of waste has different recycling considerations that relate to the types of materials involved, how those materials are to be recycled, and the processes that go along with that.

7.1 MSW RECYCLING

19 http://www.metrovancouver.org/services/solid-waste/recycling-signage-campaigns/recycling-signage-colours/Pages/default.aspx

MSW recycling involves items like cans, bottles, and cardboard. The materials they are comprised of – aluminum, glass, and paper pulp – can generally be reprocessed into new materials. Recycling has many environmental benefits, including conservation of energy, lower greenhouse gas emissions, and reducing the need for landfills and incineration. A study from the United States found that aluminum accounts for only 1 percent of the air travel industry's waste stream, however the energy and emissions reduction benefits of recycling aluminum are disproportionately large; the energy benefits of recycling one ton of aluminum are 11 times that of recycling one ton of newspaper and eight times that of recycling the same amount of plastics[20].

This requires collecting of materials, and getting it to the right destination. In busy urban areas trash collectors will collect this type of 'recycling' separate from other trash. In some cases these different materials must be sorted into separate bins, and sent to different places for recycling. However, it is now common to see 'single stream' recycling in which cans, bottles and paper products can all be collected and sent off together.

Recycling of MSW is common at large airports. How the MSW recycling process is organized and managed is generally dependent on what systems are available to the airport for recycling. Considerations for MSW recycling may include state or local policies, logistical considerations such as space for trash compactors, contract issues with both staff and tenants, costs such as 'tipping' fees (the cost to dump a load of material at a facility), and operational requirements. The management of a recycling process involves collections of waste items in bins, and getting the materials to the right disposal points. If the local trash hauler accepts single stream recycling, the process is simplified somewhat. The airport can have bins for recyclables, and a second type for all other waste. Generally airports pair waste collection bins with recycling bins around the airport. The bins can be marked with images that show what should go in them, making it easier for travelers to know what goes where. In some cases bins are color coded to indicate what they accept, however there is no standard for use of colors so this can sometimes be confusing. If single stream recycling is not available from your waste hauler and recycling must be sorted, then more bins are necessary for the different types of recyclable materials to be collected. Additionally, the bags of recyclable materials must be gathered and staged according to material type for the waste hauler to collect.

Some of the challenges of airport recycling include decentralized waste management practices, recycling of airplane waste, and motivating tenants to recycle. Airports may have tenants arrange their own waste disposal, but MSW recycling works best when an airport centralizes all waste for disposal for the entire airport. While a centralized system requires more coordination with airlines and tenants, and more waste handled, it also offers efficiencies of scale such as lower hauling fees for larger loads. If waste is managed separately, then each system would need to include recycling. In terms of incentives to encourage recycling, some airports have offered prizes or recognition for the tenants who recycle the most. Establishing a recycling program may have costs for purchasing bins, as well as the labor costs to empty them. Depending on the hauling fees, the system could be an economic saving for the airport, but certainly have environmental benefits.

7.2 CDD RECYCLING

Airports can realize substantial financial savings from CDD recycling. Much of the cost savings come from reusing materials such as asphalt, concrete, and rebar onsite. The process for managing CDD recycling is very different from that of MSW. Construction usually involves contractors, and developing an effective CDD recycling process requires early planning to engage contractors in the process. Prior to undertaking a development project, airports need to consider the CDD recycling goals they would like to achieve from the process. In many cases this means establishing standards and/or specifications, and making sure these are included in the 'requests for proposal' as well as subsequent contracts for work.

20 *Hershkowitz, Allen and Darby Hoover, 2006, Trash Landings: How Airlines and Airports Can Clean Up Their Recycling Programs. A report by the Natural Resources Defense Council. p. V.*

Working with the construction contractor to develop a Construction Waste Management (CWM) plan is one way to be clear about expectations for reuse and recycling of CDD during a project. CDD recycling goals can also be integrated into an airport's Environmental Management System or sustainability plan to help track and manage them effectively. A CWM plan should identify the types and quantities of materials to be diverted from disposal, as well as the processes to be used to transport, store, and sort materials during the project. The plan should also consider how 'earthworks' associated with the construction, such as soils and cleared vegetation, will be handled.

A good CWM plan will help track the reuse of materials and may assist – when necessary – with reporting on material reuse or disposition. Training workshops for contractors, subcontractors and airport employees can help clarify expectations and roles among the project participants. Incentives can be designed into contracts to encourage reuse and recycling, and potentially offer a financial bonus when goals are met or exceeded. When materials can't be reused onsite, it may be possible to donate them to a charitable organization for reuse. Donation will not only minimize wastes but benefit others in the community.

When new materials must be procured, the airport and its contractors should consider replacing materials with recycled materials. For example, concrete, steel rebar and copper wire are products available with high-recycled content. Recycling concrete offers the largest potential volume on recycled materials.

Other factors that can affect the ability to recycle CDD may include state or local policies, and logistical considerations such as staging areas for materials, and locations to dispose of soils or other material types.

Existing waste management contracts and costs should be considered, in comparison with the tenant leases and contracts, potential cost of landfilling waste, and potential recycling and reuse costs. Commodity prices for the recycled materials, as well as costs for hauling, processing, and disposing of materials need to be taken into consideration. Understanding local and regional recycling services available in the area is also important as any airport recycling process will have to work with the collection systems available in the area.

7.3 ORGANIC WASTE: DESCRIPTION OF VARIOUS PROCESSING ROUTES

Organic waste, such as food and green waste, can be used as a resource in several processes. There are several processes for the recycling of organic waste, some of them are composting, anaerobic fermentation, and biorefinery.

- **Composting:** Organic waste often can be composted for use as fertilizer or soil improvement. This can be outsourced or executed in-house in a compost facility on the airport.
- **Anaerobic Fermentation:** Organic waste can also serve to produce biogas through the process of anaerobic fermentation. This process leads to the production of biogas and a digestate (a wet residue), which could be used as fertilizer (for more info: https://www.wur.nl/en/show/Anaerobic-fermentation.htm)
- **Biorefinery:** Another use for organic waste is as a source to produce bio-based products. Through chemical extraction processes valuable components can be extracted from organic for use in pharma, cosmetics or chemical industries. For example, soaps can be made from orange peels.

8. RESIDUAL WASTE (WHAT'S LEFT?)

While the best environmental objective is to minimize the amount of waste sent to landfills and incinerators, the fact remains that materials cannot always be recycled and airports cannot always implement waste management principles to the maximum efficiency. The residual airport waste is sent to landfills and incinerators. Both landfill and incineration often require pre-treatment and may pose a number of environmental threats and risks, from emissions of gaseous pollutants to infections. Therefore, disposal should be the last renders of resort in waste management practice for airports. Waste should only be disposed of in landfill when no other options are available.

8.1 LANDFILL AND INCINERATION

While waste can be shipped to landfills and incinerators, some airports prefer to manage waste by having these facilities on site. A landfill is an area of land, sometimes graded or otherwise prepared, where waste is disposed of. Landfills are a common means of disposing of waste, however, it is generally believed that landfills attract birds. Landfills in the proximity of airports can increase the risk of collisions between aircraft and birds. Having a landfill on site can be advantageous and cost effective in some circumstances, but the potential for wildlife collisions must be considered. Airport operators considering establishment of a landfill on or near their airport should conduct a wildlife hazard assessment to understand the wildlife in the area and minimize the risk of collision with aircraft.

Some airports have incinerators to dispose of waste. As with landfills, incinerators are one of the least desirable choices for waste management. Nevertheless, they have their role in disposing of airport waste. In many states, it is a requirement that waste from international flights be incinerated so as not to introduce contaminants between countries. As technologies have improved, most modern incineration plants incorporate heat recovery as well as power generation facilities to recover the heat energy in the waste.

Both landfills and incinerators are effective for managing airport waste, but must be cited with certain considerations in mind. Consider the vehicles and routes needed to transport wastes to these facilities from the gates and terminals, and plan them carefully so they do not disrupt aircraft operations. In many cases the incinerator stacks have to comply with technical requirements (e.g. minimum heights) which might infringe with obstacle limitations and aviation safety. Incinerators give off emissions, and also can give off heat plumes which can affect aircraft flight performance. Facilities would need to be cited with consideration of flight paths into or out of the airport.

The decision whether or not to construct new facilities on site could include financial considerations as well. Airports that have developed waste disposal facilities often charge tenants for waste disposal, or factor it into the lease agreements.

9. CIRCULAR ECONOMY

Disposal of waste has historically been seen as the end stage of a process. However, the concept of circular economy now characterizes it as simply one more transformation in a product lifecycle, and one that can be anticipated and planned for.

What is a circular economy?

A **circular economy** is an alternative to a traditional linear **economy** (make, use, dispose) in which we keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate products and materials at the end of each service life. (www.wrap.org.uk/about-us/about/wrap-and-circular-economy)

Circular economy is beyond waste management

Waste management is an important component in a circular economy. However, the circular economy is a broader concept than waste management and provides holistic approach on elevating waste management into new economic business model:

- The circular economy entails a **new economic mode**l with new circular business models

(e.g. product-service systems) where the value of products (assets) and services is maintained as high as possible;

- The circular economy involves **all stages** of a product or asset lifecycle (product design, production, use **and** waste management).

In such, circular economy products are designed for reuse, disassembly, refurbishment, remanufacturing and/or recycling (Ellen McArthur Foundation, 2017). This results in minimized use of primary (virgin) materials and minimized waste production.

Airports have more opportunities for value creation

Airports are a gathering place for businesses, shops and people and encompass the characteristics of a small city. Airports and the surrounding airport city constitute a broad range of services, products and activities. A circular approach in their waste management and an all-encompassing waste management for the airport will provide room for innovation. This will result in potential cost savings and more value creation opportunities.

Application of circular economy in airports

First step: Analysis of material flows

To grasp circular economy opportunities, the first step is to map the material flows that go in (e.g. fuel, food, products, building materials, water, land) and out (e.g. waste, used products, used building elements, products, waste water, waste land). Of these flows performance data, must be gathered, e.g. on the percentage of recycled or bio-based content and/or percentage of carbon emission reduction.

Second step: Identification of areas for improvements

Second, to find areas with most potential for circular business models, performance data of the use of products must be gathered, such as average lifetimes of products, utilization rates, multifunctionality (number of alternative functions per asset) and resource efficiency (kg/€ or kg/functional unit and/or g CO2/kWh).

To gain further insight in the environmental performance, the environmental impacts of resource flows can be measured using the Lifecycle Assessment (LCA) methodology. The international norm EN15805 is the current prevailing norm to perform LCA studies.

This way the circular performance of the airport and its stakeholders can be measured. When the flows are measured, goals for improvement can be set.

Third step: Implementation of circular business models

To grasp circular economy business opportunities, beneficial for both the financial and environmental performance of airports, new designs of products must be implemented (procured), often together with new business models and new suppliers and value chains. The following six circular business models can be used to facilitate this:

1. **Circular supplies:** fully recyclable materials that are used, for example in drinking cartons and coffee cups, are made from recycled material and can consequently be recycled again. This way input is from secondary resources and output is again an input for another product, replacing the single-lifetime input and thus reducing primary material use.
2. **Dematerialization:** reduce material use with new technologies, such as digital airline tickets that replace paper tickets.
3. **Resource recovery:** food waste and other organic waste can be digested to biogas and the residue of the digestion can be used as fertilizer.
4. **Product as a service:** "Buy light, not lamps". Products don't have to be bought but instead you can pay for the service they provide (for instance light). By paying for a product as a service this will enhance the quality of a product and its lifetime as these benefits the producers of the goods that provide in the service, ultimately will increase the resource efficiency.
5. **Sharing platforms:** Increased utilization rate of a products by sharing. When car owners leave their car at the airport and catch a flight, they can rent it to another person who is arriving at the airport. Instead of paying for parking the car owner now gets paid from the traveller who rents the car.
6. **Product life extension:** Extend working lifecycle of products and components. Buildings and products are modular, demountable and flexible. This improves the ability to adapt, reuse and recycle.

For these various business models hundreds of cases are available which can improve the ecological footprint of the travellers and the stakeholders of the airport and airport city. Within a circular economy approach waste management can play an essential role to avoid, reuse, reduce and recycle the waste on airports. In turn reducing primary material use and costs.

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