SUSTAINABILITY PLAN

FINAL REPORT

FLAGSTAFF AIRPORT

GRAND DESTINATIONS

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Sustainability Definition and Mission Statement

The Flagstaff Airport is developing a Sustainability Plan in order to prioritize sustainability as a core objective in the airport's long-range planning efforts. Initiatives identified in the plan will help the Airport reduce costs, consumption and pollution, while providing net financial, operational, environmental, and social benefits to the region. The Plan will incorporate industry sustainability best practices and measures in order to accomplish this goal.

This project is made possible through funding received from the Federal Aviation Administration and Arizona Department of Transportation.

The first step in developing the Sustainability Plan is to discuss the Flagstaff Airport's vision. This requires defining "sustainability" relative to the Airport's priorities and needs. The next step is creating a sustainability mission statement. These terms establish the foundation of the sustainability approach, and are briefly defined below:

- The ***Definition of Sustainability*** identifies what sustainability means specifically to the Airport, relative to commonly used industry definitions.
- The ***Sustainability Mission Statement*** identifies the overall vision of the Airport in terms of sustainability and how it relates to social, financial, operational and environmental factors. It highlights the broad vision of the Airport in general as it relates to its facilities and its place in the community.

It is important to note that the definition and mission statement within this Plan are only a starting point for sustainability principles to be incorporated into the daily operation of the Airport. Sustainability planning by definition evolves over time to meet changing conditions. Therefore, these elements will likely evolve as priorities, conditions and technologies change.

1.1 Definition of Sustainability

There are several commonly used definitions of sustainability found within various industries. The applicability of a sustainability definition depends largely on the individual airport's environment and community. As a result, in order to create a successful sustainability plan, the airport staff must first determine how to describe sustainability on their terms while keeping in mind their existing vision statement and the individualized airport, environmental, and community characteristics. Equally important in the process of creating a sustainability plan for an individual airport is making sure that the definition of sustainability is in alignment with the City's Municipal Sustainability Plan.

Most airports that embark on sustainability planning use one of the more commonly cited sustainability definitions as a foundation and then develop a definition applicable to that organization to create an individualized sustainability policy. While there are several generalized definitions of sustainability, one commonly used definition by many airports in the United States is the Airports Council International – North

America (ACI-NA) definition, which was developed to be specifically applicable to airports. The ACI-NA definition is:

> *"a holistic approach to managing an airport so as to ensure the integrity of the Economic viability, Operational efficiency, Natural Resource Conservation, and Social responsibility (EONS) of the Airport."*

EONS is an acronym used to recognize: Economic/financial, Operational, Natural and environmental, and Social resources. While many definitions of sustainability refer to the triple bottom line (i.e., Social, Environment, and Economic), stewardship of EONS is well-rounded for airports because it also incorporates the importance of airport operational efficiency. For this reason, the Flagstaff Airport uses this definition as a base definition to build upon.

1.2 Resiliency

Building on the ACI-NA definition, the City of Flagstaff want incorporates resiliency to create a more unique sustainability definition for the Flagstaff Airport. The City defines resiliency as the capacity of the City to maintain its core purpose and integrity in the face of dramatically changing circumstances. With record warming temperatures, persistent drought-like conditions and severe precipitation events, the Airport's ability to adapt to changed circumstances while fulfilling its core purpose is essential in an age of unforeseeable disruption and volatility.

In 2012, the City of Flagstaff conducted a Resiliency and Preparedness Study to address how to reduce vulnerability and how to build local resilience to climate variability and weather related impacts. In the study the City investigated how the effects of local climate change could affect the operations of the City and provided recommendations on reducing risk and increasing resilience within municipal operations. According to the Study, potential impacts to the airport could include increases in flight cancelations and duration of delays. To plan for such potential impacts, and as an integral part of City operations, Flagstaff Airport is committed to promoting awareness and improving preparedness and resiliency to a changing environment.

As part of the Municipal Sustainability Plan, the City of Flagstaff sets goals to increase effectiveness, reduce consumption, and refine outdated processes within municipal operations. Resulting benefits have included new sustainable policies, improved software technologies, and enhanced tracking mechanisms to allow the City to monitor and address energy consumption more strategically. The 2013-2014 Plan sets goals to conduct additional energy audits of City facilities and water operations, reduce the City fleet, increase renewable energy generation, reduce natural resource consumption, and decrease recycling contamination. In drafting the Flagstaff Airport Sustainability Plan, the airport demonstrates its responsibility in complying with the guidance provided in the Municipal Sustainability Plan and exhibits its commitment to being a resourceful municipal resource. Therefore, resiliency is an important and unique element of the Flagstaff Sustainability Plan.

1.3 Flagstaff Airport Sustainability Definition

As mentioned previously, an airport's sustainability definition depends largely on the individual airport's environment and community. To define sustainability, the airport must first determine how to describe sustainability on its own terms, keeping in mind the existing vision and the individualized characteristics of the airport. The Flagstaff Airport has taken careful consideration to create a unique definition of sustainability that incorporates the ACI-NA definition of sustainability, yet includes resiliency, which is an important objective for the airport. The Flagstaff Airport definition of sustainability is:

A holistic approach to managing an airport so as to ensure the integrity of the Economic viability, Operational efficiency, Natural Resource Conservation, Social responsibility, and Resiliency of the Airport.

The definition of sustainability speaks to the values and goals of the Airport and its stakeholders. It aligns with the City's Municipal Sustainability Plan and its vision for resiliency and overall sustainability, and it allows the Airport to more narrowly define and measure its progress in achieving greater sustainability.

1.4 Flagstaff Airport Sustainability Mission Statement

After cementing a sustainability definition for the Airport, the next step in the Sustainability Plan process was to consider how the sustainability values can be embraced by creating a Sustainability Mission Statement for Flagstaff Airport. By determining what the objectives of the Airport are and how they might relate to sustainability, a series of initiatives can then be identified for how to meet the mission statement.

For a Sustainability Plan to be successful, the activities undertaken must balance the resources available, while meeting the definition of sustainability detailed above. In order for an initiative to be sustainable, it must not jeopardize the airport's ability to meet their fundamental responsibilities and this is incorporated into the Sustainability Mission Statement.

The City of Flagstaff recently initiated a citywide Sustainability Program that encourages the social well-being of current and future citizens through sustainability. The Program develops and implements policies, projects and programming directly related to municipal and community-wide sustainability. The following mission statement was created for the City of Flagstaff Sustainability Program:

"The Flagstaff Sustainability Program empowers Flagstaff to be resilient and resourceful."

This mission statement characterizes the purpose of the City of Flagstaff Sustainability Program and stresses the importance of resourcefulness. Sustainability incorporates working against depleting resources, while supporting ecological and social balance.

Identification of the Sustainability Mission Statement for the Flagstaff Airport drew upon the City's Sustainability Program mission statement, and evaluated this concept in combination with the Airport's values and goals. Therefore, while the mission statement created for the Flagstaff Airport Sustainability Plan reflects the individual objectives for the Airport, it also stands in unison with the City's vision for sustainability in the community. Additionally, stakeholders from the community participated in the development of the Airport's Sustainability Mission Statement, lending their perspectives and ideas as to what best characterizes the purpose of the Sustainability Plan. Using the City's sustainability mission statement as a guide, in combination with stakeholders' consultation, the following mission statement was created for the Flagstaff Airport Sustainability Plan:

"The mission of the Flagstaff Airport is to provide a safe, efficient, and resilient gateway for Flagstaff and Northern Arizona."

The ultimate goal of the mission statement for the Flagstaff Airport Sustainability Plan is to reflect the individual objectives for the Flagstaff Airport, while also complementing the City's vision for sustainability in the community. The Airport must demonstrate sustainability without sacrificing the utmost level of safety that has always been at the core of all airport operations, and must continue to promote environmental stewardship and economic development that is beneficial to the Airport and the communities that it serves.

Chapter 2
Baseline Inventory

A baseline inventory identifies existing conditions and trends at the Airport. The purpose of identifying a baseline is to be able to track and compare data over time, and measure how well the Airport is meeting its sustainability goals in the future. This chapter provides current data for a set of defined categories identified by the Airport and the City. These categories help narrow the focus of the sustainability plan to those elements that are most relevant and applicable to the Airport and the Flagstaff community. 2013 was established as the baseline year for the study because it included the most accurate data and is a reasonable representation of the Airport's annual activity. The categories chosen for this study include the following:

- **Air quality**
- **Energy**
- **Dark Skies**
- **Natural resource management**
- **Community well-being**
- **Land use and transportation**
- **Resiliency and preparedness**
- **Waste management**
- **Water**

CURRENT PRACTICES AND POLICIES

The City of Flagstaff has numerous sustainable practices and policies in place, some of which impact City operations at the Airport. One example pertains to the City's vehicle fleet. The City has created a Sustainable Fleet Purchasing Policy. The goal of the policy is to improve the average miles per gallon (MPG) of the fleet, improve the lifetime costs-to-purchasing price ratio, and increase the percentage of the City fleet that is capable of utilizing alternative fuels. The City also has in place a Fleet Utilization and Replacement Policy. The policy "is designed to assure that the City's fleet is appropriately sized to serve the operational needs of the City; that the vehicles/equipment are efficiently used in a manner that reflects the total cost of ownership and there is sound justification for retaining and replacing vehicles/equipment through City ownership." The Airport staff maintains and operates several City vehicles, thus these policies and practices would apply to the Airport.

Other overarching plans that can affect and/or alter operations at the Airport include the Municipal Sustainability Plan, City of Flagstaff Resiliency and Preparedness Study, the Energy Efficiency and Renewable Energy Resolution, the Resiliency and Preparedness Resolution, and the Flagstaff Regional Plan. Each of these plans addresses all modes of transportation and will be used as guides in the development of sustainability initiatives for the Airport.

2.1 Air Quality

An air quality baseline inventory documents existing air quality conditions and levels of criteria pollutant and greenhouse gas (GHG) emissions currently generated by activities and facilities at the Airport. Sources of criteria pollutants and GHG emissions at the Airport include aircraft, ground support equipment (GSE), and airport-based vehicles such as trucks and rescue vehicles. In addition, airport facilities and infrastructure such as airport boilers and fuel tanks contribute to air quality at the Airport.

BASE LINE INVENTORY

The air quality inventory was performed at the Airport to establish a benchmark for future energy efficiency improvement projects. The base year for the inventory was 2013. The inventory included direct and indirect emissions associated with operations at the Airport that are within the control of the airport operator (Scope 1 and Scope 2 emissions). Direct and indirect emissions from sources not owned or directly controlled by the Airport (Scope 3 emissions), such as tenant operations (e.g. aircraft) and/or consumer activities (e.g. ground travel by the public to and from the Airport), were not included. Scope 1 emissions are associated with fossil fuels burned on site or emissions from Airport-owned or leased vehicles. Scope 2 emissions are indirect GHG emissions resulting from the generation of electricity and heating and cooling consumed by the Airport. The following categories of emission producers comprise those that were included in the inventory:

- **Airport-owned vehicles**
- **Airport-owned buildings**
- **Airport employee commute**
- **Airport-owned generators**

An account of Airport-owned vehicles and combustion engine equipment directly controlled by the Airport (Scope 1 emissions) and included in the GHG emissions inventory are presented in **Table 2-1**.

Table 2-1 Existing Airport fleet

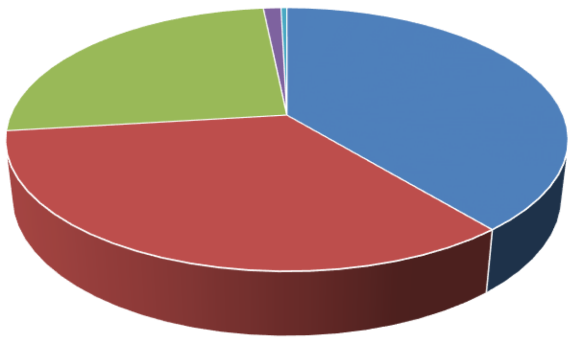
Vehicle Class	Subclass	Year	Make	Fuel Capacity (gallons)	Fuel Type	Approximate Miles	Approximate Hours
Light Duty Trucks and SUVs	3/4 Ton Pickup Extended Cab	2008	Ford	268	All	21,272	-
Fire Apparatus	Crash - Rescue	1989	International	1,782	Diesel	-	29,084
Minivans	Hybrid SUV	2008	Ford	1,127	Unleaded	45,926	-
Heavy Duty Trucks	Snow Blower Trucks	1993	Klauerman	2,348	All	-	27,754
Light Duty Trucks and SUVs	3/4 Ton 4x4 Crew Cab	2001	Ford	14,249	Unleaded	108,811	-
Heavy Equipment	Loader	1992	Caterpillar	4,515	All	-	8,116
Heavy Duty Truck	10 Wheel Dump Truck	1998	International	2,006	All	-	15,608
Miscellaneous	Mower	1997	John Deere	294	Diesel	-	865
Miscellaneous	Generator	1991	Kohler	127	Diesel	-	768
Miscellaneous	Generator	2004	Katolight	86	Diesel	-	210
Miscellaneous	Generator	2004	Kohler	34	Diesel	-	140

Source: Flagstaff Airport, August 2014

Note: The Airport has one walk behind snow blower, with a one-gallon tank, but does not track the annual usage because it does not have a hobs meter.

The results of the GHG emissions inventory are expressed in units of metric tons of carbon dioxide equivalent (CO_2e) gases per year for each emission source. The inventory concluded that approximately 742 metric tons of CO_2e gases were produced from GHG emissions in 2013. The largest airport-owned/controlled source which contributed to the emissions was the airport-owned buildings (electric and natural gas consumption, followed by airport-owned vehicles (fuel combustion). The airport employee commute and the back-up airport generators contributed the least. **Figure 2-1** illustrates the Scope 1 and Scope 2 emissions percentages for the Airport.

Figure 2-1 Flagstaff Airport GHG Emissions from Airport-Owned and Controlled Sources



***Source:* Mead & Hunt, Inc. 2014**

SUMMARY

As discussed above, the findings of the air quality inventory indicate approximately 59 percent of GHG emissions from airport-owned and controlled sources come from the airport building's electrical and natural gas consumption. Likewise, the second largest amount is produced by airport-owned vehicles such as trucks, tractors, mowers, and rescue vehicles. With regard to implementing sustainability, both the airport-owned building and vehicles present great opportunities for energy efficiency improvements. The Initiatives section of this report will include recommendations and suggestions for ways to improve these areas in order to help reduce the output of GHG emissions at the Airport.

2.2 Energy

Energy consumption is one of the largest expenditures at an airport. Energy conservation initiatives can therefore have a considerable and positive impact on both an airport's financial health and environmental footprint. As a part of this study, an energy audit was conducted on two Airport-owned buildings and the airfield lighting to identify areas for improvement in energy consumption and efficiency.

Sustainable Engineering Group, LLC (SEG) completed an ASHRAE (American Society of Heating, Refrigeration, and Air-Conditioning Engineers) Level 2 commercial energy audit of the passenger terminal, aircraft rescue and fire-fighting (ARFF) building, and airfield lighting at the Airport in September 2014, and provided the Airport with its findings in the form of a report entitled Energy Efficiency Assessment for Flagstaff Airport. Within each building, energy consumption from the building envelope, HVAC systems, domestic water heating components, and interior and exterior lighting (including the terminal parking lot) were analyzed. Airfield lighting comprising the runway, taxiway, and miscellaneous (in-pavement, threshold, and sign) lighting was analyzed for energy consumption. The remaining structures at the Airport are not owned by the City, and therefore are not part of this study. A copy of SEG's report can be found in the Energy Audit Appendix and will be described in later chapters.

TERMINAL BUILDING

Figure 2-2 Terminal Building (Airside View)
Source: Sustainable Engineering Group, LLC, November 2014

The existing 27,815 square-foot passenger terminal building was constructed in 1993 to serve the City of Flagstaff and surrounding northern Arizona communities. The terminal building consists of passenger ticketing and holding areas, common areas, baggage claim, counters for rental car companies, and concessions. According the Airport Master Plan, the original design of the terminal building included the ability to expand, based on demand, adjacent to the baggage claim and rental car area. For example, the security area has been added since the original construction of the building. **Figure 2-2** depicts the terminal building from the air operations area/aircraft ramp. **Figures 2-3** and **2-4** depict the passenger ticketing and baggage claim areas in the terminal building, respectively.

Figure 2-3 Passenger Ticketing Area
Source: Flagstaff Airport, February 2014

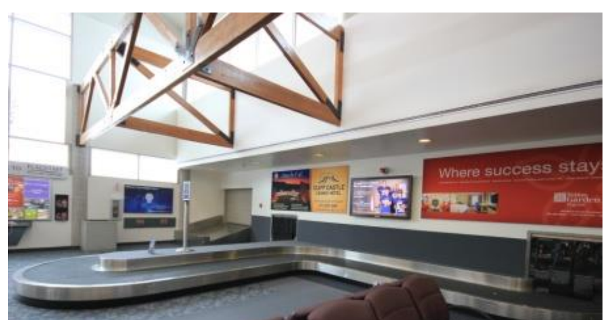
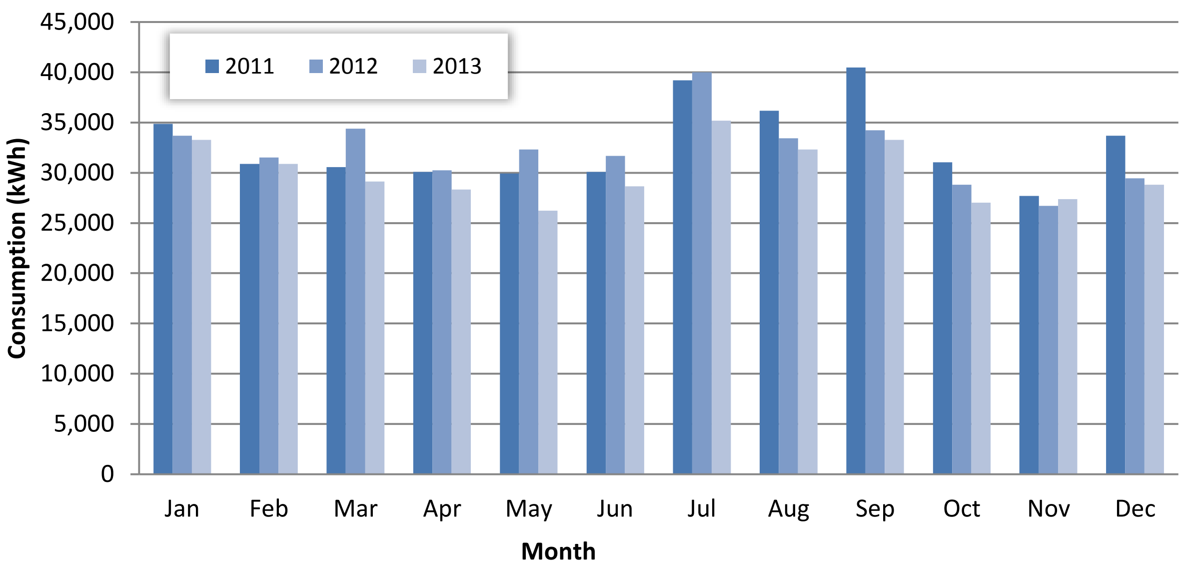


Figure 2-4 Baggage Claim Area
Source: Flagstaff Airport, February 2014

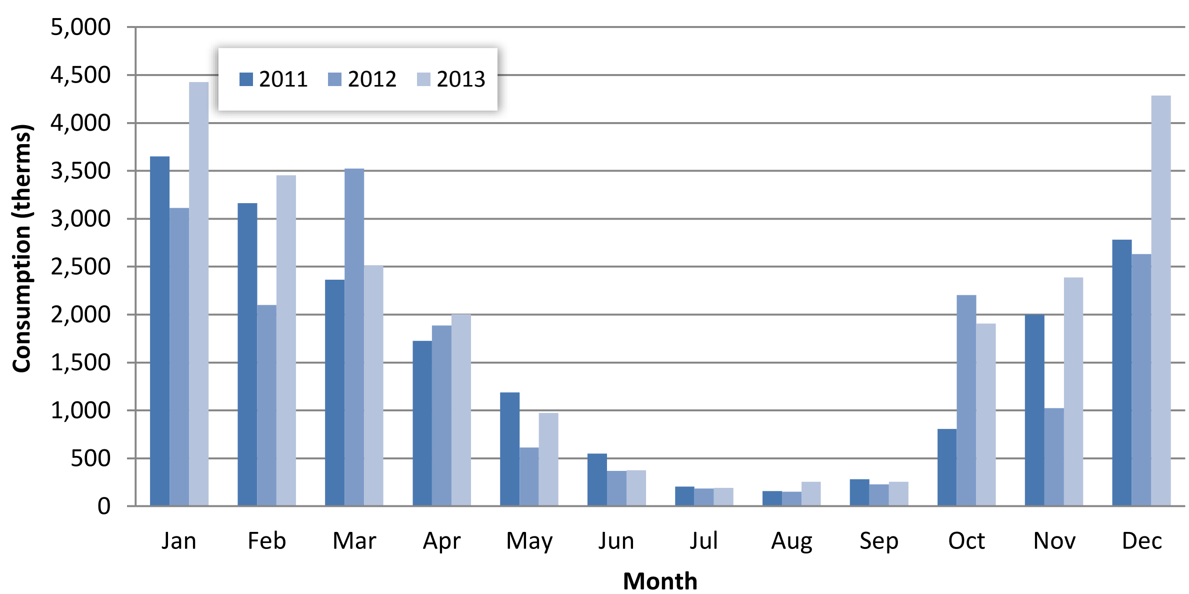
Historic monthly electric and gas utility data for the passenger terminal building from calendar years 2011 through 2013 are shown in **Figure 2-5** and **Figure 2-6**. Electrical consumption for the terminal has remained fairly consistent over the three year period, and the slight increase in summer electrical use is normal due to the increased cooling loads in the summer. Likewise, the natural gas consumption is greater in the winter months due to increased heating loads met by the gas furnaces, which is typical for a cold climate such as northern Arizona. There was also a spike in natural gas consumption in 2013 that appears to be linked to a change in set-points because the winter was not necessarily colder than average.

Figure 2-5 Electricity usage for the Terminal



Source: Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015

Figure 2-6 Natural Gas Usage for the Terminal



Source: Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015

AIRCRAFT RESCUE AND FIRE FIGHTING BUILDING

The 11,500 square-foot Aircraft Rescue and Fire Fighting (ARFF) building was constructed in 2005 to provide emergency services for the airport and its tenants. The ARFF personnel are the first responders to any emergency on the Airport. The two-story ARFF building contains living quarters for a crew of two to three firefighters with dormitory rooms, a workout room, offices and meeting areas, a kitchen, a living room, and bathrooms; the building is also comprised of two apparatus bays on each side of the living quarters which house the fire trucks, emergency vehicles, and snow removal equipment. **Figure 2-7** depicts the north face of the existing ARFF building. **Figure 2-8** depicts the kitchen area equipped with refrigerators, stove, microwave oven, and dishwasher, and **Figure 2-9** depicts an interior office. Some examples of the lighting (natural and fluorescent) and heating (gas radiant overhead heaters) found in the apparatus bays are shown in **Figure 2-10**.

Figure 2-7 ARFF Building (North Side)
Source: Flagstaff Airport, February 2014

Figure 2-8 Kitchen
Source: Flagstaff Airport, February 2014

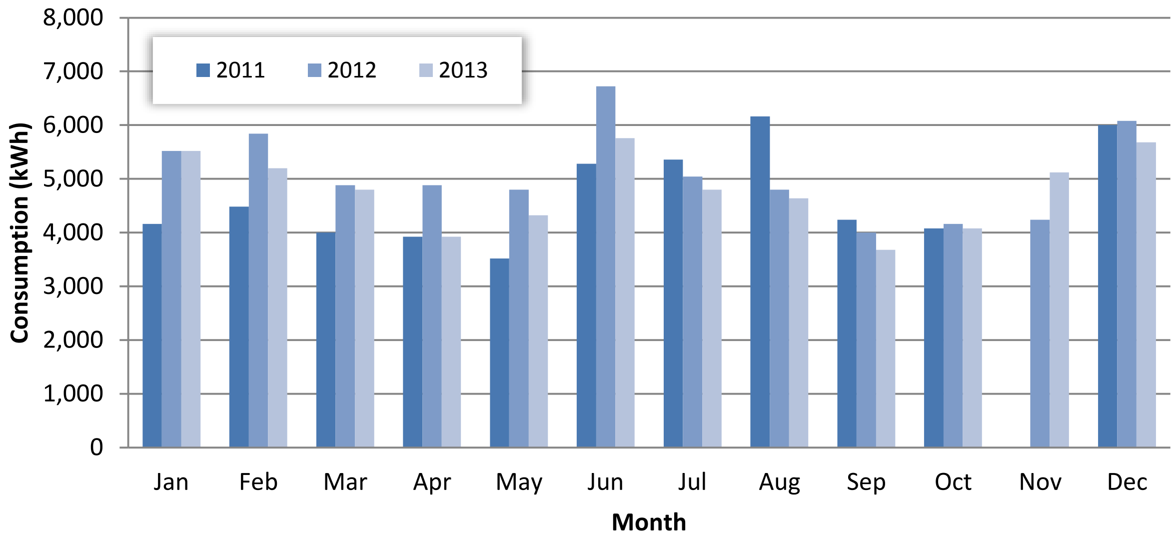
Figure 2-9 ARFF Manager's Office
Source: Flagstaff Airport, February 2014

Figure 2-10 Existing lighting and heating in ARFF apparatus bays

Figure 2-10 Existing Lighting and Heating in ARFF Apparatus Bays
Source: Flagstaff Airport, February 2014

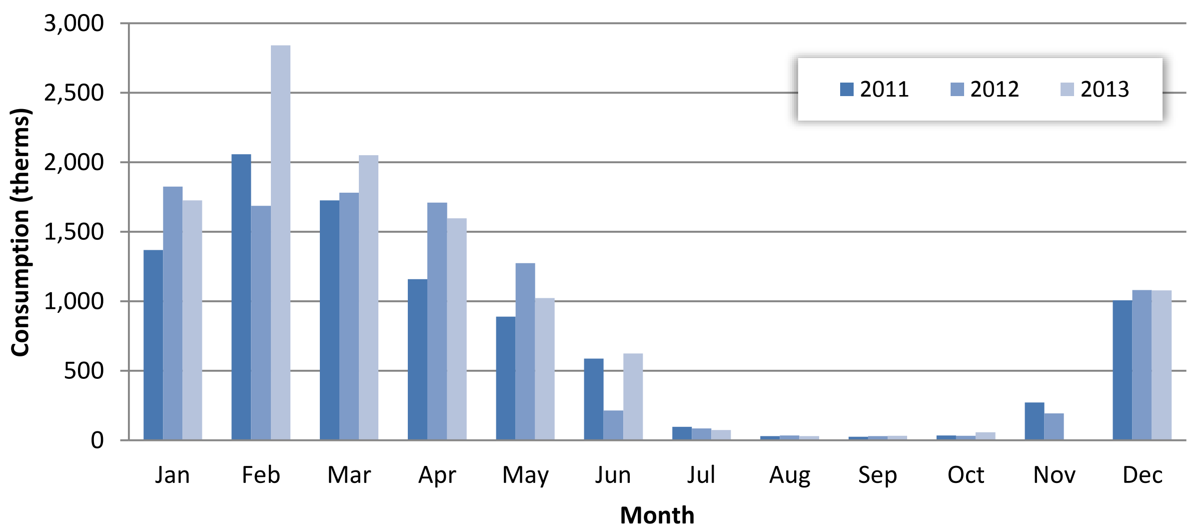
Historic monthly electric and gas utility data for the ARFF building from calendar years 2011 through 2013 are shown in **Figure 2-11** and **Figure 2-12**. Similar to the terminal building, electrical consumption for the ARFF building has remained fairly consistent over the three year period with a similar increase in the summer months. Furthermore, as with the terminal, the natural gas consumption is also greater in the winter months due to increased heating loads met by the gas furnaces, which is typical for a cold climate such as northern Arizona. However, it does appear that natural gas consumption has increased from 2011 in both 2012 and 2013, particularly in the months of January, February (2013), March, April, May, and December. According to the SEG energy assessment, the increase does not appear to be related to colder winters for those years (as 2012 was an unusually warm winter, for example), but possibly due to set-point changes or heating equipment running less efficiently than it should.

Figure 2-11 Electricity Usage for the ARFF Building



Source: Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015

Figure 2-12 Natural Gas Usage for the ARFF Building



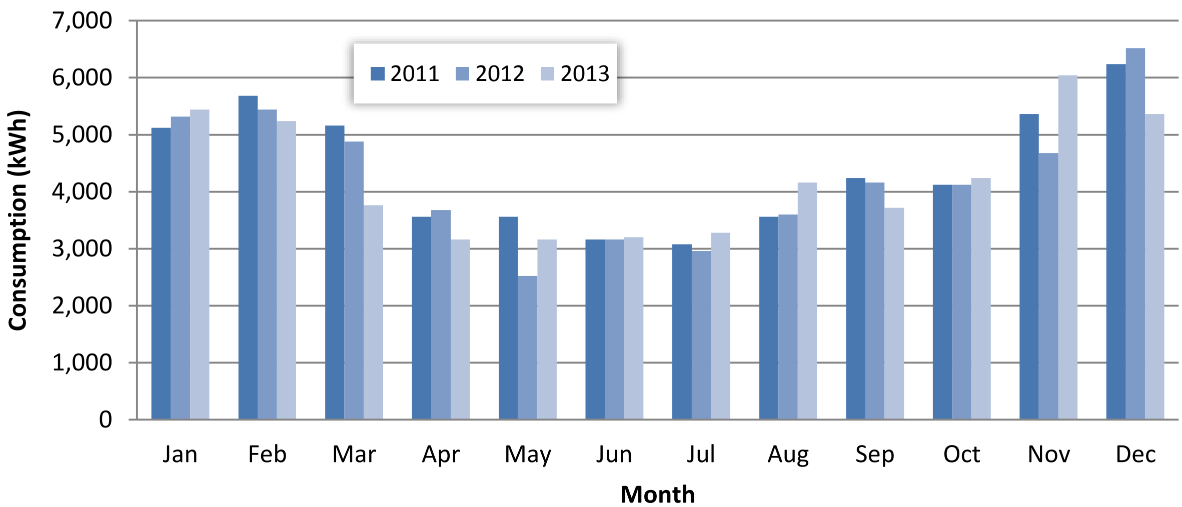
Source: Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015

AIRFIELD LIGHTING

As previously mentioned, the runway, taxiway, and other miscellaneous airfield lighting were also evaluated as part of the energy assessment. The airfield lighting is utilized based on schedule, visibility, and flight activity. During the day, the airfield lighting normally remains off, unless visibility is reduced due to weather events such as snow or fog. The airfield lighting is normally on from dusk until the air traffic control tower personnel leave for the evening; the tower is staffed until 7:00 pm October to April and until 9:00 pm April to October. At night when the control tower is unoccupied, the airfield lighting may be turned on manually and controlled by pilots via the pilot-controlled lighting system located at the Airport. According to the SEG energy assessment, the after-hours nighttime activity varies day-to-day, but it was estimated that the airfield lights are on an average of approximately one hour per night.

The historic monthly electric utility data from calendar years 2011 through 2013 are shown in **Figure 2-13**. Based on the times of day when the airfield lighting is used, it is logical that the higher electrical usage occurs when the days are shorter in the winter. Usage over the three year period also appears to be fairly consistent from each year to the next.

Figure 2-13 Electricity usage for the airfield lighting



***Source:* Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015**

SUMMARY

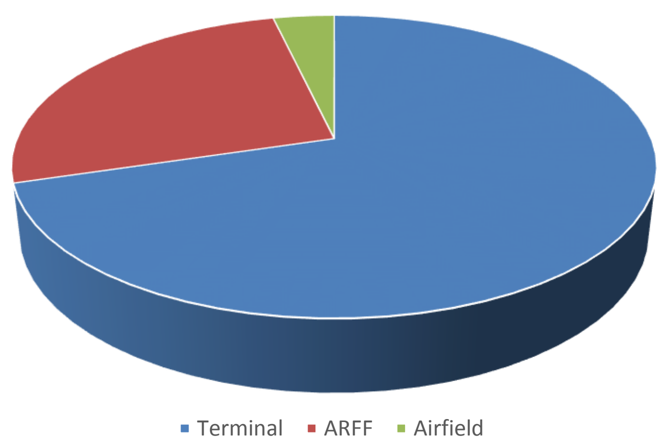
The on-site inventory and review of the historical electric and gas utility data was helpful in establishing a baseline to help identify measures to reduce consumption, as will be detailed in later chapters. **Table 2-2** illustrates the average annual utility data for the terminal, ARFF building, and airfield lighting for the years 2011 through 2013. It is important to note that in order to compare the total site energy, the units of energy used to measure gas and electricity were normalized to one unit of measure (British thermal units (kBTU)). The total energy consumption by location is also illustrated in **Figure 2-14**.

Table 2-2 Average Annual Utility Data for the Terminal, ARFF Building, and Airfield (2011-2013)

Building or Area	Natural Gas			Electricity			Total Site Energy			
	Usage (Therms)	Virtual Rate ($/Therm)	Cost ($)	Usage (kWh)	Cost ($)	Total Energy (kBTU)	Total Energy (kBTU)	Total Cost ($)	Energy Use Intensity (kBTU/ft²)	Cost Intensity ($/ft²)
Terminal	19,978	$0.99	$19,739	373,173	$0.110	$41,049	3,271,101	$60,788	118	$2.19
ARFF	10,117	$1.14	$11,533	57,960	$0.158	$9,158	1,209,426	$20,691	105	$1.80
Airfield	-	-	-	49,760	$0.264	$13,137	169,781	$13,137	-	-

***Source:** Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015*

Figure 2-14 Total Energy Consumption by Location (kBTU)



***Source:** Mead & Hunt, Inc. 2014*

2.3 Dark Skies

Due to Flagstaff's unique natural conditions and resources for observing astronomy, it is vitally important to the City of Flagstaff to limit light pollution and maintain their dark sky. On October 24, 2001, the City of Flagstaff was recognized as the world's first International Dark Sky City by the International Dark Sky Association (IDSA). The City has a comprehensive outdoor lighting ordinance in place to regulate the types of fixtures and lamps that are used throughout the city that balances the need to preserve Flagstaff's dark sky resource with the need for safe lighting practices.

The Flagstaff outdoor lighting ordinance is defined in the Flagstaff Zoning Code, Chapter 10-50, Division 10-50.70, and parts of Chapters 10-20 (Administration, Procedures, and Enforcement), 10-50.100 (Sign Standards), and 10-80 (Definitions). According to the code, three Lighting Zones have been established with varying development standards specific to their location within the City. According to the outdoor lighting standards, Lighting Zone 2 requires all commercial, industrial, and multi-family residences a maximum total (which includes fully shielded and partially shielded light fixtures) outdoor light output of 50,000 lumens per net acre; likewise, single-family residences are allowed 10,000 lumens per parcel of maximum total outdoor light output. The Flagstaff Airport falls within Lighting Zone 2, as shown in **Figure 2-15**.

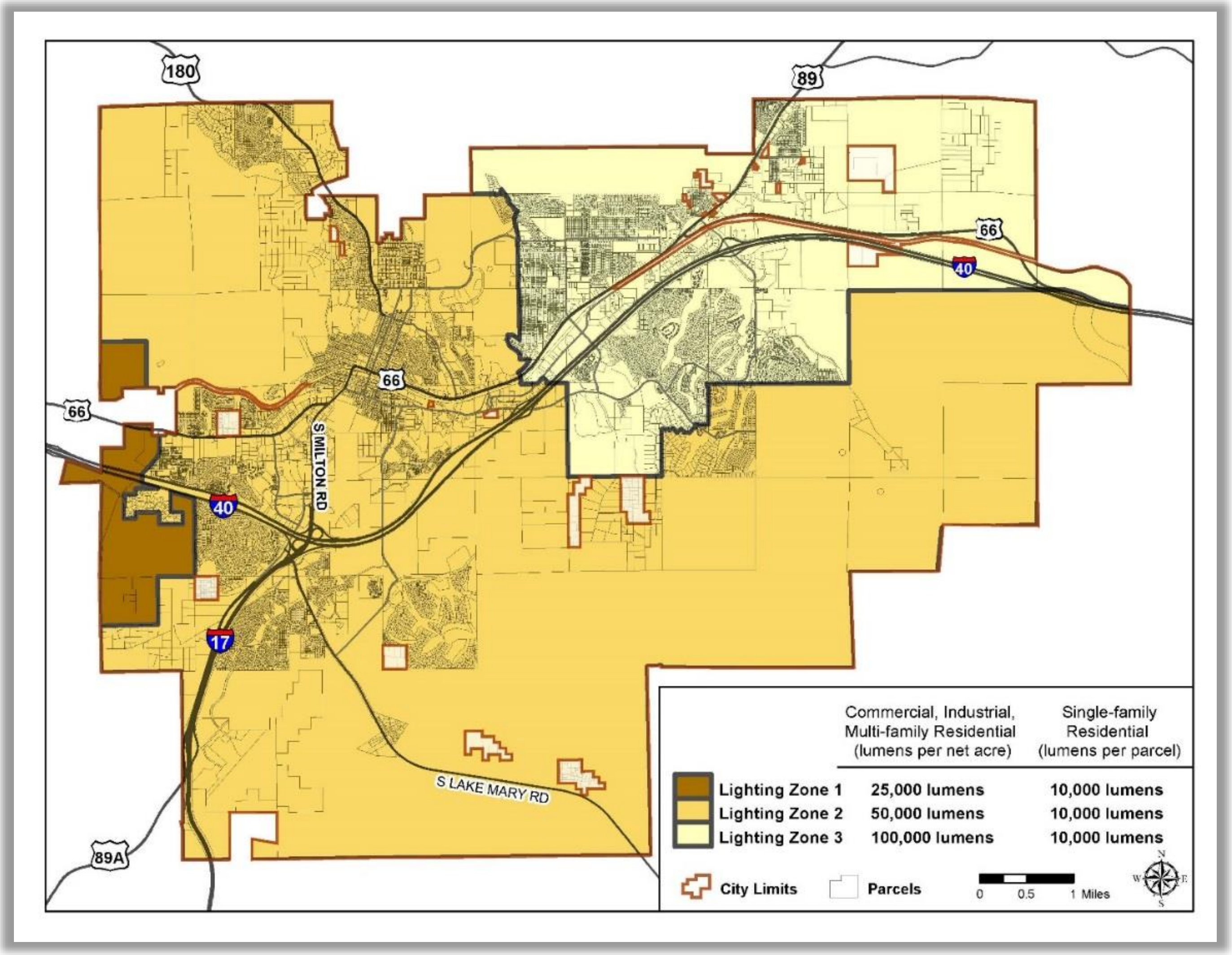
The intent of the lighting code developed for the City of Flagstaff is to encourage lighting practices and systems that will:

- **Minimize artificial sky glow, glare, and light trespass;**
- **Conserve energy and resources while maintaining night time safety, utility, security, and productivity; and**
- **Curtail the degradation of the nighttime visual environment.**

Although the City of Flagstaff's goal is to encourage these lighting practices throughout the whole city, large portions of the Airport are exempt from these standards. The Federal Aviation Administration (FAA) has strict lighting regulations for airports related to airfield lighting. Therefore, modification to airfield lighting to reduce illumination and glare cannot be considered; however, the Airport is still examining ways to reduce energy consumption of the airfield lighting by considering FAA approved energy efficient lighting such as LEDs. Due to the FAA's requirements for airfield lighting, Section 10-50.70.080 of the City's Outdoor Lighting Standards includes an exception with regards to airport lighting. The exception states:

> "Required navigational lighting systems at airports for the safe and efficient movement of aircraft during flight, take off, landing, and taxiing is exempt from the provisions of this Division. Lighting used for illumination of aircraft loading, unloading, and servicing areas is exempt from the lumens per acre limits provided in Section 10-50.70.050.C, although it must conform to all other requirements of this Division. All other outdoor lighting at the airport facilities shall comply with the provisions of this Division. (pp. 50.70-14)"

Figure 2-15 Lighting Zone Map



Source: City of Flagstaff, retrieved from www.flagstaff.az.gov, September 2014

Although the Airport is largely in compliance with Flagstaff's Outdoor Lighting Standards (with the exception of the aforementioned airfield and navigational lighting that fall under FAA regulations), management expressed an interest in ways to continue to improve areas where light pollution can be mitigated in order to promote the Dark Sky Initiatives and Standards endorsed by the City. Areas of the airport where outdoor lighting was evaluated during the SEG energy assessment include the building exteriors, parking lots, aircraft aprons, and shade/hangar lighting. The results of SEG's evaluation of these areas on the airport and their compliance with Dark Sky requirements are shown in **Table 2-3.**

Table 2-3 Flagstaff Airport Non-Airfield Lighting Summary and Dark Sky Requirement Compliance

Location	Lighting Type	Fixture Shielding	Light Color	Lighting Amount	Dark Sky Compliant	Recommendation
Terminal Parking Lot	Pole Mounted Low Pressure Sodium	Fully Shaded	Warm/Amber	2-foot candles	Yes, but possibly over lit	Dual light levels based on occupancy
Hangar Lights	Wall Mounted Low Pressure Sodium	Fully Shaded	Warm/Amber	N/A	Yes, but too much light on building	Replace with forward throw fixture
Shade Lights	Linear Fluorescent T8	Partially Shielded	White	N/A	No, not shielded	Add occupancy sensor so usage is minimalized
GA/FBO Apron	Pole Mounted Metal Halide	Partially Shielded	White	N/A	No, not shielded	Replace with fully shielded LED product
Main Terminal Apron	Pole Mounted High Pressure Sodium	Partially Shielded	Warm/Amber	N/A	No, not shielded	Replace with fully shielded LED product

***Source:* Energy Efficiency Assessment for Flagstaff Airport, Sustainable Engineering Group, LLC, January 2015**

SUMMARY

The Dark Sky Initiatives set forth by the IDSA are an important way of life for the City of Flagstaff. The City has committed to preserve one of its great natural resources by implementing and promoting Outdoor Lighting Standards. Although airports generally have exemptions to many municipally mandated lighting standards and codes due to the authority of the FAA, the Airport is committed to showing leadership and demonstrating good stewardship with regard to keeping Flagstaff's skies dark as much as possible.

2.4 Natural Resource Management

The City of Flagstaff and its outlying communities are located within the Coconino National Forest. The Airport itself is located directly west of a large portion of public forest land. The City's proximity to the national forest increases the possibility of wildfires occurring in or near the surrounding forests of Flagstaff; therefore, the Flagstaff Fire Department (FFD) has a dedicated Wildland Fire Management Division. Their mission is to promote, create, and maintain a sustainable, healthy forest ecosystem and a "Firewise" community1, thereby protecting and enhancing public safety and community well-being.

The City of Flagstaff participates in the Firewise Communities/USA Recognition Program sponsored by the National Fire Protection Association (NFPA); it is a citizen based program that teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses of property. Participants learn Firewise practices that are specifically tailored to individual and community needs to gain knowledge and skills to prepare for a wildfire before it happens.

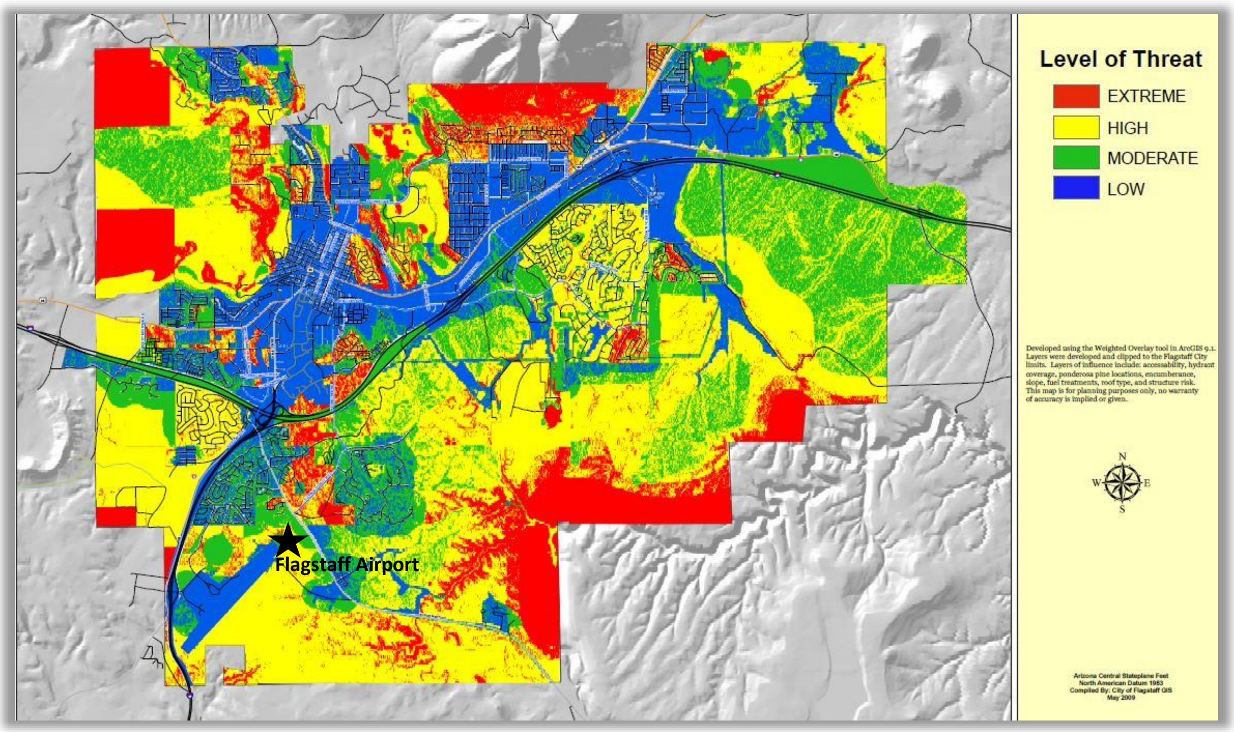
According to the City of Flagstaff Wildfire Threat Analysis Map (May 2009), the Airport is located in an area with a low threat of wildfire; however, the land adjacent to the Airport, which includes the large area of public forest land, is classified as an area with a high to moderate threat level of wildfire (see **Figure 2-16**). The Airport is mindful of its location relative to high threat level areas and actively maintains airport property with

1 http://www.firewise.org/?sso=0

regards to the pruning of dead trees and brush. Additionally, there are programs dedicated to the mitigation of the threat of wildfires in the national forest adjacent to the Airport.

For example, the FFD received a 2009 Wildland Fire Hazardous Fuels grant to selectively thin 300 acres of City-owned property around the Airport. Objectives of the Wildland Fire Hazardous Fuels Project include reducing wildfire risk and increasing health of the forested area for nearby communities and wildlife through thinning/pruning and manageable scheduled burns. The project is also mindful of the Tassel Eared squirrel population residing within Coconino Forest; specifically, the project establishes Tassel Eared squirrel winter core areas (areas used frequently by the squirrel during winter months) to evaluate treatment prescriptions that address wildfire risk reduction needs and also benefit wildlife. A report detailing the purpose, process, and outcomes of the Wildland Fire Hazardous Fuels Project can be found on the City of Flagstaff's Website on the Wildland Fire Management publications page.

Figure 2-16 City of Flagstaff Wildfire Threat Analysis Map



***Source:* City of Flagstaff GIS, retrieved from www.flagstaff.az.gov, September 2014**

SUMMARY

The continuous risk of wildfire exists in Arizona, and the Coconino National Forest surrounding Flagstaff is no exception. Raising awareness and taking practical steps to ensure that the City manages the forests is critical to the sustainability of the National Forest and the well-being of the community. The Airport, as a part of the community, also has a shared responsibility to help maintain its property in order to help prevent wildfires, while also being mindful of the wildlife habitats that surround the facility.

2.5 Community Well-Being

The Airport strives to be a visible and valued member of the community. Aside from transportation access, the Airport provides essential services such as aircraft rescue firefighting, emergency medical response, and hazmat first response. Additionally, the Airport is an economic engine for the community. By transporting people and goods in and out of the area, the Airport facilitates commerce and supports the local and regional economy. According to the Flagstaff Regional Plan, the number of visitors to the City of Flagstaff is projected to increase by 6.62% over a ten year period (from 2.59 million in 2010 to 2.77 million in 2020). Tourists that travel through the Airport to visit the Grand Canyon and other recreational areas create an economic multiplier effect by spending money on hotels, food, transportation, retail and recreational activities. According to The Economic Impact of Aviation in Arizona, 2012, commercial service airports in the state of Arizona generate a direct economic impact of $12.1 billion dollars with a direct and indirect economic impact (including indirect and induced employment) of over $20.5 billion. Based on the year of the report, Flagstaff Airport operations represent approximately 3% of the total aircraft operations at commercial service airports in the state, representing approximately $363 million in direct economic impact, and $615 million in direct and indirect economic impact to the surrounding communities for 2012.

SUMMARY

Comprehensive measures of community involvement are difficult to quantify. However, the value that the Airport brings to the local and regional community, including transportation access as well as safety and economic benefits, is extremely important. To improve its status as a good neighbor, the Airport can continue to improve its outreach, promote education and enhance communication with the community. These and other initiatives that can address the Airport's commitment to community well-being are discussed in the Initiatives chapter.

2.6 Land Use and Transportation

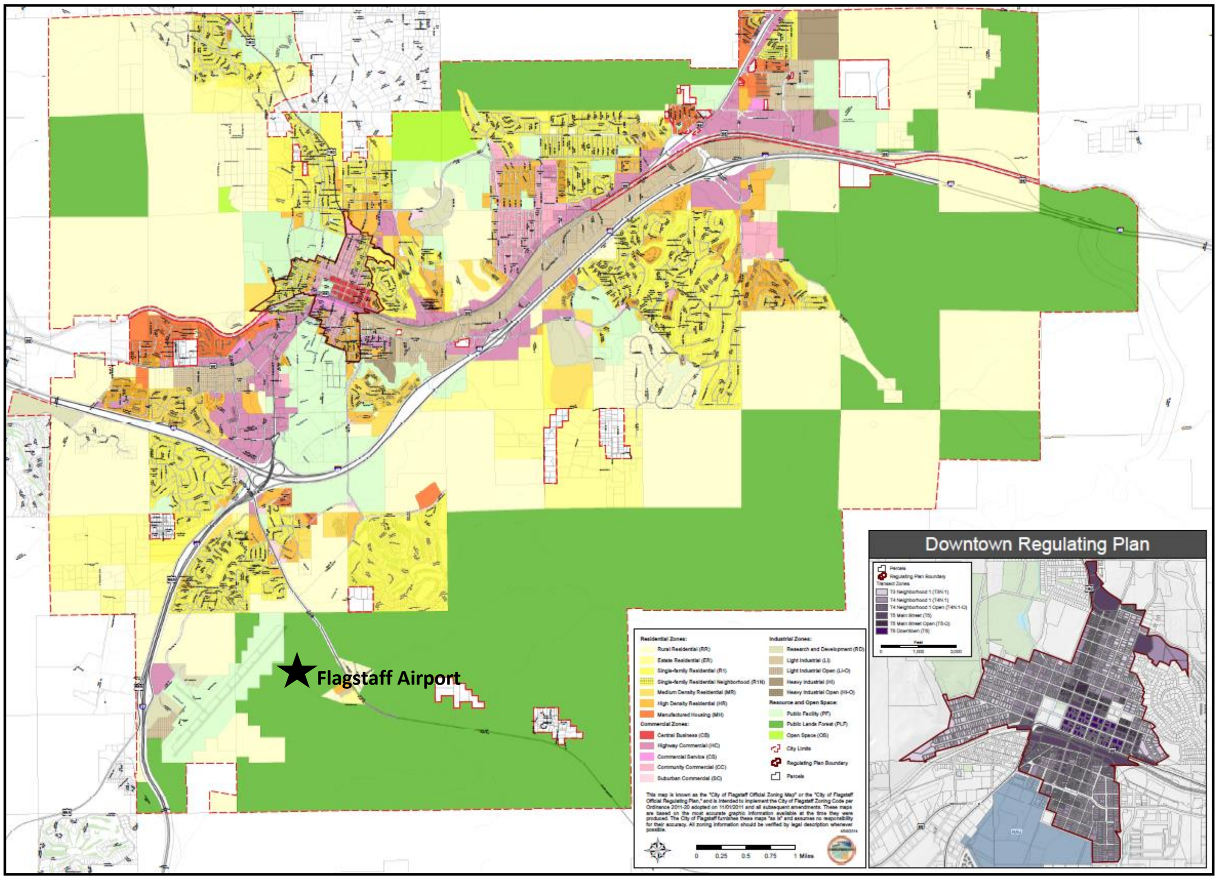
There are federal statutes, policies, guidance documents, and regulations relating to land use compatibility around airports. These guidelines provide a basis for assessing the compatibility of the current land uses on and off the airport property. The compatibility of existing and planned land uses in the vicinity of an airport is typically determined by the safety and noise impacts associated with the airport. According to the Flagstaff Airport Master Plan, the majority of the land surrounding the airport is vacant and under the control of the United States Forest Service (USFS). This section will present a summary of both on and off airport land uses.

Exploring the effectiveness of transportation as it relates to sustainability at Flagstaff Airport is important because opportunity may exist to enhance the passenger experience while achieving other environmental benefits. This section will also identify the existing transportation related services available at the Airport.

BASE LINE INVENTORY (LAND USE)

According to the City of Flagstaff Official Zoning Map (adopted on 11/01/2011), the Airport is zoned as Public Facility (PF) use. Other land uses adjacent to and in the near vicinity of the Airport include Public Lands Forest (PLF), Rural Residential (RR), Research and Development (RD), Light Industrial (LI) and Light Industrial Open (LI-O), Single-family Residential (R1), and Highway Commercial (HC). The City of Flagstaff has also developed an Airport Overlay Zone which encompasses the airport property as well as extends approximately one mile beyond each runway end. An Airport Overlay Zone is a planning tool often implemented at airports in order to limit incompatible land use and promote safety. Its purpose is to establish standards to promote air navigational safety and prevent hazards and obstructions to air navigation and flight. The existing land uses on and in the vicinity of the Airport are illustrated in **Figure 2-17.**

Figure 2-17 City of Flagstaff Zoning Map



Source: City of Flagstaff, retrieved from www.flagstaff.az.gov, September 2014

BASE LINE INVENTORY (TRANSPORTATION)

There are some options for ground transportation services at the Airport. Several car rental agencies are located within the airport terminal building including Alamo, Avis/Budget, Enterprise, Hertz, and National, and a large number of taxi companies in the Flagstaff area provide service to and from the Airport. At this time, no public transportation services (i.e. transit authority buses) are available at the Airport. Additionally, there is a paved Flagstaff Urban Trail (Ponderosa Trail) that extends south from Ponderosa Trails Park to the airport. However, due to the nature of airport use and the general need for baggage, this trail is not likely used consistently for access to the airport beyond recreational purposes.

The Airport provides 400 free parking spaces for both short and long-term parking for the flying public. The parking area is located directly north of the terminal building. It has been observed that the parking area is very constrained and, on some occasions, vehicles are required to park along the entrance road to the Airport.

SUMMARY

The existing land uses and available modes of transportation associated with the Airport are important and should be taken into consideration in the baseline inventory. As of today, the zoning and land uses on and in the vicinity of the Airport seem to be compatible, and it is essential for the City and Airport management to continue to monitor compatible uses for the land surrounding the airport as the City's growth evolves and changes in the near to long-term future. Encouraging compatible land use and limiting noise impacts on and in the vicinity of the Airport demonstrates the Airport's effort to be a good neighbor within the community while at the same time ensuring the safety of the Airport and its operations are maintained. The Initiatives chapter will identify areas where suitability measures could be implemented in order to enhance the land uses and transportation modes associated with the Airport.

2.7 Resiliency and Preparedness

The City of Flagstaff conducted a Resiliency and Preparedness Study to better understand how the impacts of local climate changes will directly affect City operations. The primary focus of the study was to help address the question, "How can we reduce our vulnerability to, and build local resilience against, risk from climate variability and weather related impacts?" The City published the results of the study in September 2012. The study analyzed the level of vulnerability, the degree of risk, and the potential impacts of the City's operations that are exposed to local climate variability.

The study team identified 115 elements of City operations that could be affected by changes in climate. The elements were categorized into primary systems and key planning areas. The Flagstaff Airport was classified as a key planning area that falls within the Transportation primary system. A vulnerability and risk assessment was conducted for each planning area and system. According to the Study, vulnerable operations are those that are highly exposed to climate conditions, face current and future (non-climate) stresses, and have little ability to adapt to changing climate conditions. Also according to the Study, the most at risk key planning areas (e.g. the Airport) affect critical functions, impact many citizens, pose threats to human life, and are associated with high costs of recovery once impacts are felt.

The study concluded that the Airport scored medium to high in terms of vulnerability and scored low for degree of risk. Thus, some potential climate impacts to transportation operations could have an effect on the Airport infrastructure and flight operations. For example, warmer temperatures combined with higher altitude reduces overall aircraft lift, which means the need to potentially extend the runway ends for larger aircraft may exist. Further, changes in climate conditions (temperature and precipitation) can affect wind direction and intensity, which is an integral factor for landing and take-off of aircraft. Ultimately, climate variability could cause an increase in the frequency and duration of flight cancelations and delays. **Table 2-4** shows future projections for temperature and precipitation in Flagstaff (for the year 2100).

In addition to climate factors, non-climate factors, like the migration of forest dwellers, were taken into account. It was determined that the projected changes in climate factors would likely result in an increase in migration of homeless people from warmer communities to forest areas (like those located near the Airport).

Table 2-4 Climate Projections for the City of Flagstaff

Climactic Factor	Timeframe	Change from Existing Conditions	Anticipated Impacts
Temperature	2100	+5 to +8 degrees Fahrenheit	Longer growing season Fewer frost days More heat waves Increased forest fires Greater water challenges
Average Annual Precipitation	2100	5% decrease in annual average by 2100 compared to 1970 - 2000 for Northern Arizona.	Greater water challenges Increased flooding events

Source: City of Flagstaff Resiliency and Preparedness Study, 2012

SUMMARY

The outcome of the study included a recommended resiliency and preparedness vision, values, and seven resiliency and preparedness policy recommendations. The incorporation and integration of sustainability principals and planning into all aspects of City operations was noted within the recommendations of this Study. Using the City's Resiliency and Preparedness Study from 2012 as a guide, the Airport plans to create and implement its own recommendations to use specifically at the Airport. The Airport will look at ways to incorporate sustainability principals and planning in order to adhere to the City's goal of sustainability initiatives present in all aspects of City operations.

2.8 Waste Management

A detailed waste audit was not conducted as part of this study, however one was conducted as part of a City wide audit and those results are summarized here. Additionally, the airport management completed an Airport Solid Waste Recycling Plan Survey (in August 2014) that was used to in supplement the City waste audit with additional information. The survey was intended to gain a general understanding of waste at the airport, along with any operational and maintenance needs of managing waste at the airport. Along with the survey, the baseline assessment was complemented by observations made by the consultant team and discussions with airport management.

WASTE ASSESSMENT

All waste generated from inside the passenger terminal and ARFF building, including waste generated by tenants and airline personnel, is disposed of in two City waste dumpsters at the Airport. Waste generated by hangar tenants is also disposed of in these City waste dumpsters. Waste services are contracted through Waste Management., which collects and hauls waste twice a week from the Airport to the Cinder Lake Landfill. The City of Flagstaff covers all costs for the Airport's waste collection and transport. The Fixed Base Operator (FBO), however, manages its own waste and disposal needs, using its own containers and contracted services. There are no policies or requirements currently in place (via lease agreement) related to waste management by the FBO.

The Café at the Airport comprises most of the food waste. The Café uses plastic baskets for serving food along with ceramic plates, bowls and cups. A paper sheet is placed in the plastic basket to separate the food from the basket. Plastic cups are used for soft drinks and the bar uses glass. All silverware is made of metal and paper napkins are also used. Dishwashing is all done by hand. All grease generated by the kitchen is disposed of in a tank adjacent to the dumpsters outside. The grease is recycled by a local vendor approximately twice per year.

Recognizing that a waste assessment was not conducted, the type of waste generated at the Airport cannot be determined. Although, a general characterization of the types of waste typically found at airports include:

- **Corrugated cardboard**
- **Newspaper**
- **Office paper (computer, copier, etc.)**
- **Mixed paper (glossy inserts, junk mail, etc.)**
- **Glass containers**
- **Other glass (light bulbs, etc.)**
- **Metal food and beverage cans**
- **Scrap metal (ferrous and non-ferrous)**
- **Plastic containers (#1-#7 type bottles and jugs)**
- **Other plastics (stretch wrap, strapping, etc.)**
- **Food waste**

According to Airport management, a recycling program is in place at the Airport. There is one dumpster at the Airport that is dedicated to recyclables. Recycling bins are located in the passenger terminal building next to each trash can (**Figure 2-18**) and are emptied into the recycling dumpster. Additionally, all tenants and airline personnel have access to the recycling dumpster. A receptacle for recycling aluminum cans exists at the ARFF building; however, other types of recycling receptacles (e.g. glass or paper) were not present in the building. **Figure 2-19** depicts the types of waste disposal containers and recycling containers currently in use at the ARFF building. Recyclables are collected and hauled from the facility at the same time as waste (twice a week). As mentioned previously, the FBO has its own waste disposal services and therefore does not participate in the Airport's recycling program. Similar to waste services, the City covers all costs to have recycling removed from the facility.

Figure 2-18 Typical Waste and Recycling Containers in Terminal Building *Source: Flagstaff Airport, February 2014*

Figure 2-19 Typical Waste Containers in ARFF Building *Source: Flagstaff Airport, February 2014*

Based on the 2014 City waste audit, of the five City facilities surveyed for this audit, a total recycling rate of 58 percent was calculated, with a contamination rate of 19 percent. The contamination rate of these facilities was similar to that of 2011 (23 percent). Compared to the other facilities within the audit, the Airport had a much higher than average recycling contamination rate at 39 percent (see **Table 2-5**). Common contaminants were coffee cups, glass, paper towels, and food waste. An audit of the Airport's landfill dumpster revealed that 15 percent of its contents were recyclable. This largely consisted of paper, newspaper, and plastic water bottles.

Due to the lack of a waste audit conducted in 2012 and inconsistent sampling methodology in 2013, the Airport waste audit data does not provide consistent insight into waste and recycling conditions at the Airport. However, the data that does exist suggest that much of the contamination appears to be food related. Initiatives such as increased signage in the food court area and education of food court employees may be a strategy to decrease recycling contamination, and these will be discussed in future chapters.

Table 2-5 Recycling Rate and Contamination Rate 2013-2014

Year	Airport Recycling Rate	Airport Recycling Contamination Rate
2011	38%	14%
2014	24%	39%

Source: City of Flagstaff Waste Audit

SUMMARY

Waste management is primarily the responsibility of the airport management for the passenger terminal, ARFF building, and tenants. The FBO manages their waste collection and disposal at the Airport. The high contamination rates and the relatively low recycling rates show that additional improvements can increase the effectiveness of this program. Improvements, which will be discussed in the initiatives chapter, include standardizing recycling/trash bin colors and labeling, ensuring proper bin placement, and providing additional education to restaurant staff and janitorial staff. There is also potential to work with U.S. Airways to ensure proper disposal of incoming inflight waste and recycling.

2.9 Water

The City of Flagstaff's water is supplied mostly from wells (Lake Mary well, Woody Mountain well, and local "in-city" wells). In 2013, approximately 82% of the City's water came from wells, while in 2014 88% of water came from wells. The remainder of the supply came from surface water at Lake Mary.

The potable water supply for the Airport is provided from the City by a six inch water line from Lake Mary Road, north of the airport to the passenger terminal building. According to the approved 1991 Airport Master Plan, the existing pipeline capacity is estimated at 500-600 gallons per minute.

The passenger terminal and the ARFF buildings are metered separately for water. The Airport does not irrigate the landscaping surrounding the passenger terminal building or the ARFF building. Landscaping around the buildings appears to be mostly drought tolerant plants. Existing toilets, urinals, and lavatories in the passenger terminal building are not low-flow fixtures. In addition, low-flow fixtures are not present in the café located in the terminal building. However, all water fixtures in the ARFF/Maintenance building are low-flow and are approximately 10 years old. **Table 2-6** identifies the number of water fixtures at the Airport. **Table 2-7** shows water usage data for the passenger terminal building and the ARFF building from calendar years 2010 through 2014.

Table 2-6 Number of Water Fixtures at the Airport

		Toilet	Urinal	Sink	Shower	Water Spigot	Washer/Dryer	Dishwasher
Passenger Terminal Building	Janitor's Closet	-	-	1	-	-	-	-
	Men's Room (downstairs)	3	3	4	-	-	-	-
	Ladies' Room (downstairs)	6	-	4	-	-	-	-
	Men's Room (upstairs)	1	1	1	-	-	-	-
	Ladies' Room (upstairs)	2	-	2	-	-	-	-
	Café	-	-	6	-	-	-	-
	Exterior of Building	-	-	-	-	-	-	-
ARFF/Maintenance Building	Kitchen	-	-	1	-	-	-	1
	Janitor's Closet	-	-	1	-	-	-	
	Bathroom (unisex)	3	-	3	3	-	-	-
	Laundry Room	-	-	-	-	-	1	-
	Vehicle Bay	-	-	-	-	4	-	-
	Exterior of Building	-	-	-	-	2	-	-

***Source:* Flagstaff Airport, September 2014**

Note: all water fixtures in the ARFF/Maintenance Building are low-flow. Fixtures in the terminal building are not low-flow.

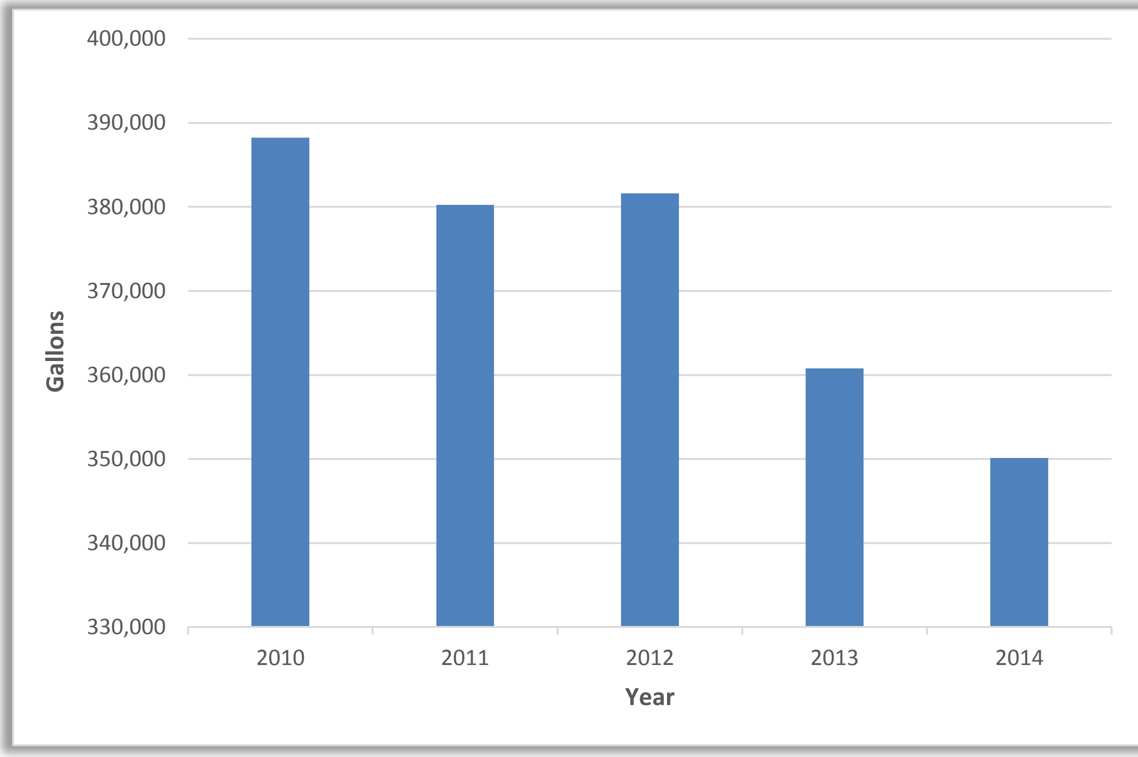
Table 2-7 Water Usage for Passenger Terminal Building and ARFF Building (2010-2014)

Calendar Year	Water Usage (in Gallons)	Percent Change from Prior Year (%)	Water Usage (in Gallons)	Percent Change from Prior Year (%)
	Terminal Building		ARFF Building	
2010	343,400	**-**	44,840	**-**
2011	335,900	**-2.1**	44,330	**-0.01**
2012	337,000	**0.3**	44,610	**0.007**
2013	307,000	**-8.9**	53,770	**20**
2014	302,000	**-1.6**	48,130	**-11.7**

***Source:* Flagstaff Airport, retrieved September 2014**

The total water consumption for the passenger terminal building and the ARFF building is illustrated in **Figure 2-20**. Total water usage for the last five years averaged 372,196 gallons per year with 2014 being the lowest total water usage over the period with the terminal and ARFF combined.

Figure 2-20 **Total Water Consumption (2010-2014)**



Source:* *Flagstaff Airport, 2010-2014.

SUMMARY

Overall, water usage for the passenger terminal building and ARFF building combined has steadily decreased in the past five years. While this trend reflects increased water conservation awareness, no specific measures were identified that led to this reduction. However, inventory of the specific facilities (toilets, faucets, etc.) indicate there are water-related initiatives that can be implemented to further reduce total water use.

OVERALL SUMMARY

The collective baseline inventory sought to understand the existing character of the Airport in order to establish a starting point for implementing future sustainable initiatives and practices. The data collected and analyzed within this chapter was organized into categories the City of Flagstaff and airport management identified as being of primary interest for the Airport and community. These categories included air quality; energy and lighting; Dark Sky initiatives; natural resource management; land use and transportation; resiliency and preparedness; waste management; and water. The baseline inventories within each category captured the available data and resources that will ultimately allow for the formulation of meaningful sustainable goals and initiatives which will be detailed in later chapters.

Chapter 3
Sustainability Goals

As discussed in Chapter 1 **(Sustainability Mission Statement)**, the Airport and the Stakeholder Committee members collaborated on developing a Mission Statement for the Airport. The Mission Statement, along with the Baseline Inventory, provide the framework for the Flagstaff Airport Sustainability Plan goals. The Sustainability Goals relate to airport-controlled facilities.[1] In the future, the goals will be incorporated into future contracts that will support the overall goal of sustainable practices at the Airport and within the City.

SUSTAINABILITY CATEGORIES

According to the scope for the Flagstaff Airport Sustainability Plan, and input from the stakeholder committee and public, the following sustainability categories were identified as key focus areas for the Airport:

- **Air Quality**
- **Community Well-being**
- **Energy**
- **Dark Skies**
- **Natural Resource Management**
- **Land Use and Transportation**
- **Planned Development**
- **Resiliency and Preparedness**
- **Waste Management**
- **Water**

These categories overlap with and complement the City of Flagstaff Municipal Sustainability Plan and Flagstaff Regional Plan, and were identified as priority focus areas for the Airport.

SUSTAINABILITY GOALS

For each sustainability category, a set of goals was developed to articulate specific targets for sustainability at the Airport. These goals were vetted through stakeholder and public review and reflect the values of the Flagstaff community. Each goal identified in the following sections provides a broad aspirational directive for the Sustainability Plan.

The goals presented below are consistent with the Municipal Sustainability Plan and the Flagstaff Regional Plan. Boxes to the right of each Sustainability Category show those Municipal and Regional goals related to the category and how the goals of the Airport work within and complement goals in the larger pictures of the City of Flagstaff and Regional planning efforts.

- ***Goals that are Airport-specific Goals consistent with the Municipal Sustainability Plan and City requirements.*** These overlapping goals were considered as a stepping off point to develop specific goals that are airport-specific.
- ***Goals consistent with the Flagstaff Regional Plan.***

[1] For the purposes of this plan, airport facilities include the terminal building and the Aircraft rescue and firefighting (ARFF) buildings.

SUSTAINABILITY METRICS

Metrics are the mechanisms (such as kWh consumed, or $/sq. ft.) used to measure progress towards the goals over time. For each goal a list of potential metrics is also provided. Metrics provide a means to measure if/how a goal is being met over time.

3.1 Air Quality

- Reduce criteria air pollutants emitted from Airport owned and controlled sources to improve public health and reduce environmental impact
  - Metric: Attainment/non-attainment of National Ambient Air Quality Standards (NAAQS)
- Reduce airport owned and controlled greenhouse gas emissions (Scope 1 and 2 emissions) by 5% below current levels (2013 baseline) by 2020
  - Metric: Tons of CO2/year per passenger

> Reduce greenhouse gas emissions generated by municipal operations
>
> Proactively improve and maintain the region's air quality
>
> Reduce greenhouse gas emissions

3.2 Community Well-being

- Enhance Awareness of the community benefits of the Airport
  - Metric: Number of community events held
  - Metric: Number of social media blasts regarding Airport events
- Enhance user experience at the Airport
  - Metric: Number of enplanements
  - Metric: Number of complaints received
  - Metric: Survey results regarding user experience

> Improve transportation safety and efficiency for all modes

- Provide a safe and efficient airport
  - Metric: Number of safety incidents
  - Metric: Number of wildlife strikes
  - Metric: Number of complaints received
- Build and maintain community partnerships
  - Metric: Number of airport-related community events
  - Metric: Number of community collaborations
  - Metric: Number of opportunities provided to community (i.e., internships, tours)
- Support the community by being an economic driver
  - Metric: Estimated economic impact per passenger[2]

2 Number of passengers multiplied by average economic impact per operation for State of Arizona aviation.

3.3 Energy

- Reduce electricity use at Airport by 15% below 2013 levels by 2020 (consumption per square foot)
  - Metric: Annual kWh/square foot
- Reduce natural gas use at Airport by 2% below 2013 levels by 2020 (consumption per square foot)
  - Metric: Annual therms of gas/square foot
- Secure 35% of electricity used in buildings and operations from renewable sources by 2020
  - Metric: Percent (%) of kWh purchased renewable/Total kWh
- Net Zero by 2030
  - Metric: Site energy
  - Metric: Annual energy utility costs
  - Metric: Annual energy emissions

> - Effectively manage and reduce energy use
> - Increase energy efficiency in Airport office operations
> - Increase renewable energy generation
> - Increase energy efficiency
> - Expand production and use of renewable energy

3.4 Dark Skies

- Become the most "International Dark-Sky-compliant" (according to the International Dark-Sky Association (IDSA) standards) commercial service Airport in the nation
  - Metric: Percent (%) of light bulbs that meets or exceeds Dark Sky Standards

> - Preserve dark skies as an unspoiled natural resource, basis for an important economic sector, and core element of community character

- Improve lighting in areas at the Airport to meet and, if possible, exceed the goals of the IDSA and the Flagstaff City Outdoor Lighting Standard, as permitted by FAA regulations
  - Metric: Flagstaff City Outdoor Lighting Standards

3.6 Natural Resource Management

- Manage the airport property to protect habitat, where able, while ensuring the safe and efficient operation of the Airport
  - Metric: Annual check of the wildlife management plan
- Minimize wildlife hazards to enhance safety for aircraft operations
  - Metric: Number of wildlife strikes
- Reduce potential for fire hazards on Airport through community partnerships
  - Metric: Number of fires reported by pilots
  - Metric: Number of coordination events

> - Protect, restore and improve ecosystem health and maintain native plant and animal community diversity across all land ownerships in the Flagstaff region
> - Protect, manage, and enhance the region's Special Planning Areas to benefit the whole community

3.7 Land Use and Transportation

- Continue to encourage local jurisdictions to enable aviation/land use compatibility around the Airport currently and in the future
  - Metric: Number of Land Use Compatibility issues
- Work with surrounding communities to proactively address aircraft noise issues
  - Metric: Number of noise complaints

> - Provide transportation infrastructure that is conducive to conservation, preservation, and development goals to avoid, minimize, or mitigate impacts on the natural and built environment

- Increase connectivity between the Airport and the community to allow for multi modal alternatives for transportation
  - Metric: Number of days the parking lot is full
  - Metric: Number of alternative modes of transportation to and from the airport

3.8 Planned Development

- Develop and maintain facilities and infrastructure at the airport to support long-term, compatible, efficient, and flexible growth
  - Metric: Upkeep on current planning documents
  - Metric: Pavement Condition Index (PCI)

> - Provide sustainable and equitable public facilities, services, and infrastructure systems in an efficient and effective manner to serve all population areas and demographics

- Integrate sustainability into all major airport planning documents and contracts, where applicable
    - Metric: Number of contracts/documents that consider sustainability
- Enhance sustainability practices for all airport activities (e.g. O&M, administration, procurement, design/construction/post-construction) as conducted by all involved in the operation of the airport
    - Metric: Number of airport projects and or tenants that include sustainability practices

3.9 Resiliency and Preparedness

- Increase operational resiliency and preparedness to the changing climate
    - Metric: Number of coordinated events with the community partners related to resiliency
    - Metric: Cost of extreme events to the Airport annually (include: cost of replacing pavement more than normal, fire support, etc.)
    - Metric: PCI
- Enhance the level of organizational and individual preparedness through education and training
    - Metric: Number of education/training events related to resiliency
- Incorporate resiliency and preparedness principles into Airport operations
    - Metric: Number of completed resiliency initiatives at the Airport

- Increase resiliency and preparedness of Airport operations
- Enhance the level of organizational and individual preparedness through education and training
- Incorporate resiliency and preparedness principles into Airport operations
- Work across all government operations and services to prepare for the impacts of natural and human-caused hazards

3.11 Waste Management

- Reduce the volume of solid waste (per enplanement) sent to a landfill by the Airport by 50% by 2025
  - Metric: Annual tons of waste/enplanement
- Promote sustainable procurement in airport operations, including for tenants
  - Metric: Number of projects (tenants) that include sustainability elements
  - Metric: Percent (%) of sustainable Airport office supplies and materials purchased
- Become zero waste by 2035
  - Metric: Amount of waste sent to landfill

> - Increase paper use efficiency in Airport office operations
> - Increase recycling awareness and participation among Airport employees and visitors
> - Increase recovery rate of recyclable materials and reduce overall contamination rate

3.12 Water

- Reduce the potable water consumption to 5% below 2013 levels by 2020
  - Metric: Gallons of potable water used
  - Metric: Annual water costs

> - Effectively manage and reduce water consumption
> - Integrate available science into policies governing the use and conservation of Flagstaff's natural resources
> - Satisfy current and future human water demands and the needs of the natural environment through sustainable and renewable water resources and strategic conservation measures
> - Manage watersheds and storm water to address flooding concerns, water quality, environmental protections, and rainwater harvesting

Chapter 4
Sustainability Initiatives

Through the development of the Sustainability Plan, "initiatives" were drafted to recognize specific measures and actions needed to achieve sustainability-based goals. The purpose of each initiative is to track progress toward reaching and maintaining goals. The goals were created with a consciousness regarding impacts on the environment, society, and the city and regional area.

The project team developed a list of sustainability initiatives in order to achieve the Airports goals. Initiatives fell into one of ten selected categories: Air Quality, Community Well-being, Energy, Dark Skies, Natural Resource Management, Land Use and Transportation, Planned Development, Resiliency and Preparedness, Waste Management, and Water.

Several initiatives are included in more than one categories as they fit multiple goals. Choosing initiatives that fall into multiple categories closely follows the definition of sustainability: to meet financial, social, operational and environmental goals. The best way to understand the initiatives, track changes, and view progress is to reference the Initiatives Prioritization spreadsheet included in the plan.

As part of the Sustainability Plan, a stakeholder committee meeting was conducted to review, revise, and prioritize a draft list of sustainability initiatives. Each initiative has been specifically chosen for the Flagstaff Airport.

As sustainability initiatives are completed, refined, or suspended, Flagstaff Airport will track and monitor progress in the tracking spreadsheet. The implementation itself should serve as a tool to enable the Airport to evaluate actions and projects to determine if they incorporate sustainability values. The following is a list of first tier initiatives organized by sustainability category. It is expected that the list below will be supplemented, refined and changed as implementation progresses.

4.1 First Tier Sustainability Initiatives by Category

AIR QUALITY

- In the Airport Terminal:
  - Review HVAC controls and set points
  - Install appropriately timed occupancy controls on secure area lighting
  - Install vending machine misers
  - Replace linear fluorescents with low wattage T8s or LED bulbs
  - Replace pendant can lamps with LED
  - Install daylighting controls on atrium lighting with a timer/sensor
- In the ARFF:
  - Replace dimmable can lamps with dimmable LEDs
  - Replace emergency light fluorescents with LEDs

- Replace outdoor lighting fixtures and/or add directional shades on lights in hangars
- Decrease the number of atrium lights that are on all the time
- Install LED PAPI
- Add sheer shades or tinting to windows
- Offer stationary bikes that generate energy when pedaled for users to recharge personal electronics and workout
- Include a placard in all airport-owned vehicles requesting that the vehicle operator not leave the car idling.

COMMUNITY WELL-BEING

- Add sheer shades or tinting to windows
- Offer stationary bikes that generate energy when pedaled for users to recharge personal electronics and workout
- Develop a sustainability "Report Card" to promote to the public
- Examine parking needs within the Airport Master Plan as it relates to user experience, keeping parking costs low and walk time short
- Use social media to promote the airport and its sustainability accomplishments, issue alerts, travel tips, traffic information, weather updates, flight cancellations, etc.
- Add a sign to security denoting a place where not-allowed-items can be recycled
- Coordinate and communicate with local businesses regarding the parking situation at the Airport
- Offer specially designed informational materials that discuss the Airport's role in Dark Skies and how it is going above and beyond to be Dark Sky compliant
- Collaborate with the city for the annual Lights Out Flagstaff event and install educational displays/videos for promotion
- Increase the amount of visitor parking to improve the overall user experience
- Prepare a Crisis Communication Plan that outlines the roles, responsibilities and protocols that will guide the airport in promptly sharing information with all audiences during an emergency or crisis
- Implement a composting program at the airport
- Re-bin the Airport with Boxana recycling containers (co-located containers) to make it easier for users to sort waste and recyclables.
- Install a water bottle fill station at the airport and work with concessions to sell only reusable water bottles
- Install 1.0 gallon per minute (gpm) faucet aerators on the bathroom sink faucets to conserve water use
- Conduct a water audit of the Airport and it's irrigation system
- Support the Dark Sky cause by becoming an active collaborator and participant in local Dark Sky events and organizations. Ensure that the Airport is represented at such events.
- Educate airport users regarding the importance of water conservation and protecting the region's natural resources

ENERGY

- In the Airport Terminal:
    - Review HVAC controls and set points
    - Install appropriately timed occupancy controls on secure area lighting
    - Install vending machine misers
    - Replace linear fluorescents with low wattage T8s or LED bulbs
    - Replace pendant can lamps with LED
    - Install daylighting controls on atrium lighting with a timer/sensor
- In the ARFF:
    - Replace dimmable can lamps with dimmable LEDs
    - Replace emergency light fluorescents with LED
- Replace outdoor lighting fixtures and/or add directional shades on lights in hangars
- Decrease the number of atrium lights that are on all the time
- Install LED PAPI
- Add sheer shades or tinting to windows
- Replace outdoor lighting fixtures and controls

DARK SKIES

- Replace outdoor lighting fixtures and/or add directional shades on lights in hangars
- Offer specially designed informational materials that discuss the Airport's role in Dark Skies and how it is going above and beyond to be Dark Sky compliant
- Collaborate with the city for the annual Lights Out Flagstaff event and install educational displays/videos for promotion
- Support the Dark Sky cause by becoming an active collaborator and participant in local Dark Sky events and organizations. Ensure that the Airport is represented at such events.

NATURAL RESOURCE MANAGEMENT

- No first tier initiatives. Please reference chart for second and third tier

LAND USE AND TRANSPORTATION

- Increase overall visitor parking to improve overall user experience.

PLANNED DEVELOPMENT

- Examine parking needs within the Airport Master Plan as it relates to user experience, keeping parking costs low and walk time short
- Coordinate and communicate with local businesses regarding the parking situation
- Develop "sustainable tenant lease" language for use in lease negotiation
- Create and incorporate specific contract language requiring sustainable practices for future contracts and projects
- Increase the amount of visitor parking to improve overall user experience

RESILIENCY AND PREPAREDNESS

- In the Airport Terminal:
  - review HVAC controls and set points
  - install appropriately timed occupancy controls on secure area lighting
  - install vending machine misers
  - replace linear fluorescents with low wattage T8s or LED bulbs
  - replace pendant can lamps with LED bulbs
  - install daylighting controls on atrium lighting with a timer/sensor
- In the ARFF:
  - replace dimmable can lamps with dimmable LEDs
  - replace emergency light fluorescents with LEDs
- Add sheer shades or tinting to windows
- Offer stationary bikes that generate energy when pedaled for users to recharge personal electronics and workout
- Include a placard in all airport-owned vehicles requesting that the vehicle operator not leave the car idling
- Develop "sustainable tenant lease" language for use in lease negotiation
- Create and incorporate specific contract language requiring sustainable practices for future contracts and projects
- Conduct a review of existing and back-up power and determine if redundancy is needed
- Prepare a Crisis Communication Plan that outlines the roles, responsibilities and protocols that will guide the airport in promptly sharing information with all audiences during an emergency or crisis

WASTE MANAGEMENT

- Add a sign to security denoting where not-allowed-items can be recycled
- Implement a composting program at the airport
- Re-bin the Airport with Boxana recycling containers (co-located containers) to make it easier for users to sort waste and recyclables.
- Install a water bottle fill station and work with concessions to sell only reusable bottles
- Change from liquid hand soap to foam hand soap.

WATER

- Install 1.0 gallon per minute (gpm) faucet aerators on the bathroom sink faucets to conserve water use
- Change from liquid hand soap to foam hand soap Conduct a water audit
- Educate airport users regarding the importance of water conservation and protecting the region's natural resources

Chapter 5
Sustainability Implementation Plan

This section identifies steps for implementation of the Flagstaff Airport Sustainability Plan. For purposes of this chapter, "**implementation**" of Sustainability includes more than just the physical act of putting projects into play. For a sustainability plan to be sustainable, it needs to have a method to track progress to determine if the actions are helping meet the goals set out earlier. Perhaps more importantly, the implementation plan allows for "course" corrections if actions are not meeting the desired results, or if technology or other conditions change. It also provides a guideline for coordination between the other plans (i.e., City of Flagstaff Municipal Sustainability Plan and Flagstaff Regional Plan 2030) to allow for greater synergy between actions occurring within the City and the Region. Simply put, this section acts as a roadmap for how to implement the sustainability initiatives and find future paths forward based on changing conditions.

This chapter includes:

- Process and guidelines for putting the sustainability initiatives and projects into action
- Methods for tracking their progress
- Methods to increase effectiveness of the actions by responding to future conditions
- Methods to overlap with City and Regional plans, and future Airport Master Plan Update

This section also includes a discussion of the purpose and functionality of the Sustainability Tracking Tool. The Tool is intended to build upon the planning process discussed in the previous chapters outlining the sustainability goals and initiatives, to evaluate the performance and attainment of sustainability goals and initiatives, and to help the Airport navigate through the sustainability process moving forward.

It is important to note that this Sustainability Plan captures a moment in time, goals and initiatives were chosen based on the existing conditions of when this report was developed. While the elements presented earlier are the basis for the best sustainability goals and actions for the Airport now, the Sustainability Implementation Plan and Sustainability Tracking Tool are intended to help the Airport ensure that sustainability goals continue to be relevant in future planning.

5.1 Integration with the Municipal Sustainability Plan and the Future Airport Master Plan Update

The City of Flagstaff is unique in that it has a well-developed Municipal Sustainability Plan that identifies existing sustainability goals. The Flagstaff Airport Sustainability Plan should integrate elements of implementation with the City sustainability planning efforts to maximize the overall community, environmental, operational, and financial benefits. Specific steps in the implementation plan will be labeled with graphics to identify whether a step requires specific coordination with the City or Region:

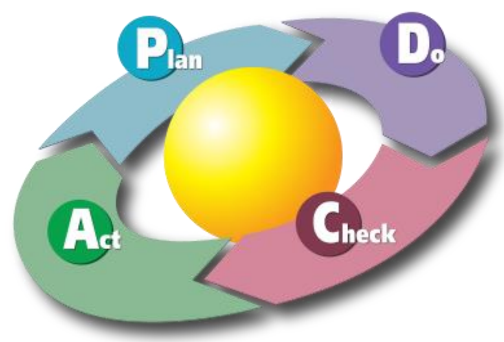
City Coordination:

Regional Coordination:

Additionally, the Airport intends to complete an Airport Master Plan Update on the heels of this sustainability process. By combining a traditional Master Plan with the sustainability elements from this project, the Airport can create a long-term development vision that considers economic, environmental, operational and social factors. Because the Master Planning and Sustainability Planning processes are intricately linked, this Sustainability Plan will be used to assist in decision making when considering current and future actions reviewed and analyzed in the upcoming Master Plan Update. Although the sustainability implementation process is somewhat distinct from that of the Master Planning elements, there is nonetheless integration and overlap between the two. It is anticipated that the goals within this Sustainability Plan will act as screening criteria for alternatives in the upcoming Master Plan, and that a number of the sustainability projects will be integrated from this report into the Airport's Capital Improvement Plan (CIP). Therefore, this plan recommends that during the annual CIP review, sustainability initiatives be examined to determine if any can be integrated into the CIP during the Master Plan.

5.2 Implementation Approach

The general process for implementation is described below, followed by a detailed list of steps within the process. The primary process used for implementation in sustainability planning is called the Deming Cycle, also known as the "**Plan, Do, Check, and Act**" cycle. The idea behind this cycle is that after the planning elements and projects are (initiated or) completed, the sustainability planning process is not over.



Instead, the entire "Plan, Do, Check, Act" process guides implementation of sustainability initiatives, tracks their success over time, and highlights ways to improve the program in the future. This allows for "course" corrections as conditions change.

Each step in the "Plan, Do, Check, and Act" process is described in detail below:

PLAN – This Sustainability Plan represents the first step in the "Plan" phase of the process. Defining sustainability for Flagstaff Airport, establishing sustainability categories, collecting baseline information, identifying current goals and objectives, and identifying initiatives are all a portion of the planning aspect of this cycle. In the future, as subsequent steps in the cycle occur, additional consideration of categories/issues, baseline conditions, goals and initiatives will likely be needed.

DO (IMPLEMENT) – Implementation of the initiatives represents the "Do" phase of the process. This step involves putting into action the recommendations in this document and making progress toward goals and objectives. By "Doing," the Airport will be building upon the City of Flagstaff's culture of sustainability and will begin to reshape the practices and processes for completing operational, maintenance, and capital improvement tasks.

CHECK (Report) – After implementing initiatives, the "Check" phase begins. This phase encompasses the reporting aspect of the implementation process. As initiatives are implemented, the next step is to track and check the progress toward meeting the goals and objectives. This step requires the use of tools for tracking success and identifying areas that may need additional required effort. This project has developed a Sustainability Tracking Tool to aid the Airport and the City in tracking progress. Evaluating and documenting the progress of the implementation is imperative.

ACT (Refine) – The "Act" phase represents acting upon what was learned during the "Do" and "Check" steps. This involves answering the question of, "What did we learn and how can we do it better next time?" by re-evaluating the issues/categories, goals, and objectives and metrics. During this stage of the cycle, adjustments to goals, initiatives and implementation measures are often identified.

5.3 Steps for Executing the "Plan, Do, Check, and Act" Process

By developing this Sustainability Plan, the Airport has already commenced in the first several steps of the "Plan, Do, Check, and Act" cycle.

The first four steps detailed below have already been completed as part of this Sustainability Plan.

PLAN

Step 1: Identification of Categories of Interest or Concern – Areas of existing issues, concerns, or interest regarding sustainability were identified based on stakeholder and community concerns (detailed in **Goals Chapter** of this report).

Step 2: Development of a Baseline Inventory – Based on the categories of interest identified in Step 1, a baseline inventory was. The information gathered in this step (**Inventory Chapter**) provides the existing conditions, or baseline, for monitoring progress toward achieving the sustainability goals described in the next step.

Step 3: Identification of Sustainability Goals – The sustainability categories (Step 1) were paired with the baseline information (Step 2), along with input from the Stakeholder Committee and public, to help identify goals for achieving sustainable improvements. Goals highlight specific areas of improvement that are measurable so that progress can be tracked and reported (**Goals Chapter**). Goals for this Sustainability Plan were also reviewed to make sure they fit within the broader context of the city and regional sustainability goals, and were consistent with the Municipal Sustainability and Regional Plans.

Step 4: Development of Initiatives – Specific actions, called initiatives, were identified to meet the goals outlined in Step 3. The initiatives were developed with input from the Stakeholder Committee and public. They are sorted by category and include general considerations such as relative cost and potential benefits (**Initiatives Chapter**).

DO (IMPLEMENT), CHECK AND ACT

Steps 5 through 8 discussed below represent the next steps for implementing the sustainability initiatives and achieving the sustainability goals. Steps 5 through 8 are designed to be completed by the Airport and the City Sustainability staff as it continues through its sustainability process. These steps primarily represent stages in the "Do, Check, and Act" phases of the cycle. These are the steps that the Airport and City may wish to adjust in subsequent iterations of the cycle as lessons are learned. ***A proposed schedule and indication of parties responsible for these steps are identified in the last section of this chapter.***

Step 5: Tracking Metrics Associated with Goals/Initiatives – After identifying categories, goals, and initiatives, it is important to log metrics used to track progress on those features on a regular basis. A Sustainability Tracking Tool was developed as part of this project to assist with this step and subsequent steps in the implementation process. In general, the information within the Tool needs to be updated on either a monthly or annual basis (see **Proposed Schedule** section below). The Sustainability Tracking Tool assists with both identifying the information useful for tracking sustainability, as well as providing a mechanism for tracking and a location to maintain the data. A detailed overview of the Tool can be found in the next section of this chapter.

Step 6: Check Success against the Metrics – This step examines the information within the inventory (Step 2) in concert with the metrics tracked (Step 5) to determine if the initiatives had the predicted effect in meeting the goals. For example, if new energy efficient lighting was installed as an initiative, the utilities would be examined to determine if the bill and kWh use went down. If usage/costs decreased, then the Sustainability Tracking Tool would show a net benefit toward energy efficiency and financial goals. If there was no corresponding decrease, then that result should be noted before proceeding to Step 7. This step also helps to identify any future initiatives or changes to initiatives that would be feasible and most effective based on consideration of existing conditions such as funding, time/effort requirements, and prioritization. The Sustainability Tracking Tool is used to examine the changes, either positive or negative, that were a result of implementing initiatives under the Plan.

Data analyzed in this step will include a summary of:

- **List of initiatives implemented over the past year**
- **Key metrics for the year with a comparison to recent past years**
- **Airport and the City Sustainability Staff to review the summary of initiatives considered and their relative value toward meeting the sustainability goals**

It is important that the baseline information is maintained and kept up to date. Step 6 allows for the examination of this information to review the progress, benefits, and changes brought about by implementation. It is recommended that the Airport/City prepare an annual metrics review report to identify key metrics, initiatives implemented, progress, and planned initiatives. The focus of the report should be on the goals, progress made toward achieving the goals, and an indication of any barriers that may have prevented progress.

Step 7: Review and Improve – This step involves reviewing the tracked data to identify those aspects of the process that can be improved. The Airport/City will examine the results of the annual metrics review report created as part of Step 6 to determine if any changes should be made to the sustainability categories, goals, initiatives, or metrics. In some cases, assessment will be quantitative (i.e., achievement of specific energy goals) and in other cases it will be qualitative (i.e., whether public involvement meetings benefited the community). In all cases, the conclusions should be documented so as to be transparent. The Sustainability Plan can be revised both formally through revision to the Plan documents, and informally through addendums or notes. Each component of the Plan will be scrutinized as the implementation progresses to determine where improvements can be made or where changes are needed based on updated conditions.

Step 8: Adjust Steps as Necessary – Step 8 uses analysis from the previous steps to adjust the process as necessary, to improve implementation based on what was learned in the previous iteration of the process. This step is extremely important, as it refines and adjusts the process to better meet sustainability goals, and to better carry out the process in the future. All of the key components of this Sustainability Plan should be re-evaluated at least once every year.

5.4 Sustainability Tracking Tool

As mentioned above, concurrent with development of this Sustainability Plan, a Sustainability Tracking Tool was developed to assist with the implementation of the Plan. The purpose of the Tool is to assist with the evaluation of initiatives, tracking, and reporting aspects of the Plan. The Tool will help Airport and the City Sustainability staff visualize the relationship between initiatives and goals and determine a balanced approach to addressing the goals. Like this Plan, the Tool serves as a starting point and will need to be maintained, updated, and refined to incorporate lessons learned and improve its functionality and usefulness. The more consistently the Tool is applied, the more useful it is likely to be in the future.

The Tool is intended to provide the following capabilities:

- **Assess progress in sustainability categories.**
- **List and track initiatives identified to meet the sustainability goals.**
- **Visualize success of initiatives that meet or do not meet goals.**
- **Track and summarize the relative benefits and/or impairments of sustainability initiatives (i.e., does an initiative meet its related goal?).**
- **Track key metrics.**
- **Visualize, summarize and report change in metrics over time.**
- **Determine the success of the Plan and potentially highlight areas for improvement.**

The Sustainability Tracking Tool is split into four primary areas which are color-coded in the Excel Spreadsheet: Introduction (**BLUE** tabs); Testing Tabs (**GREEN**) Sustainability Initiatives Evaluation (**PURPLE** Tabs); and Sustainability Tracking (**ORANGE** Tabs). The description of each tool component is followed by instructions on how to use the tool with regard to that component (or whether it updates automatically). These instructions are included in blue italic font below each section and are also included in the Sustainability Tracking Tool itself.

INTRODUCTION TABS: BLUE tabs provide information that will help in operating the Sustainability Tracking Tool and implementing the Sustainability Plan:

- **Info Tab:** This tab gives a short overview of the tabs, as contained in this document as well. The Info tab also provides a list of acronyms that are used within the Tool.
- **Goals Tab:** This tab shows the list of goals for the Airport, organized by category.
- **Initiatives Tab:** This tab is the location to input any potential sustainability initiatives and indicate when they were implemented, or if they were not implemented.

  Instructions: The Airport enters new initiatives as they are implemented, and assigns each initiative a value of "yes" or "no" in the gray cells based on its annual implementation status.

TESTING TABS: GREEN tabs contain methods for the Airport and the City Sustainability staff to use to help evaluate the sustainability initiatives:

- **Test – Initiatives Tab**: This tab constitutes a general "test" of an initiative against the goals/objectives for each sustainability category. The Airport would fill in "positive," "negative," or "neutral" for each goal or objective and the Tool would provide a general "score" of how well the initiative meets the overall sustainable vision (economic, operations, natural environment, and social). If all the boxes in this test are generally shaded neutral or green, then the initiative generally passes this test and, if implemented, it is marked as implemented and becomes part of the official sustainability initiative list for that year. Although this test provides a good way to identify and narrow potential initiatives, it is important to note that there may be a compelling reason to implement an initiative that may not be favorable in all categories. For example, an energy efficiency initiative could score negatively in one category (i.e., Dark Skies), but score positively in other categories (i.e., Energy), thereby outweighing the negative impacts. In general, the Tool will assist the Airport in identifying the best potential sustainability initiatives with respect to the full list of overall goals and objectives for the Airport.

  Instructions: As initiatives come up for review, add the initiative and its key purposes in the gray upper cells. Then, using the drop-down menus in the main cells, assign each initiative a value of positive, negative, or neutral for each goal. Results are tallied at the bottom for achievement in the four EONS categories.

- **Test-Payback Period:** This tab is a generalized payback period calculator to help further screen initiatives. If initiatives pass the general test against the goals for the Airport (in the Test-Initiatives Tab), this tab can then be used to do a simple payback calculation. It takes into account initial investment, estimated project lifespan, and a change in the cost annually. Using these numbers it then calculates an estimate in total savings over the project lifetime and a payback period in years. While there are many complicated methods to calculate financial viability of initiatives, generally a simplistic payback calculation can help screen initiatives using a small amount of information that is easily obtained.

Instructions: As initiatives come up for review, fill out the initial initiative investment. Then fill out the estimated project lifespan in years. Then, fill out either the percent reduction in annual cost with the total annual costs for the project OR the total savings per year. Results will be given in the total savings over the project lifetime and payback period (years).

SUMMARY TABS: **PURPLE** tabs are the summary tabs. These tabs include the summary of the Sustainability Tracking Tool metrics in graphical and numerical/percent change format.

- **Summary – Graphics Tab**: This tab provides a summary of the **ORANGE** tabs. It contains a graphical depiction of a number of metrics that were identified to help measure the success of implementing sustainability initiatives relative to the goals. The graphics in this tab allow the Airport to visually see the data that is input in other areas of the Tool. Not all categories are included in this section, because some of the categories are best tracked in tabular (not graphic format). Those metrics are included in the Metrics Tab.

  Instructions**: **This tab updates automatically from the data entered into the** **ORANGE** **tabs.

- **Summary – Metrics**: This tab also represents a summary of the **ORANGE** tabs. It tracks a summary of the sustainability metrics identified for each major sustainability category. This portion of the Tool allows the Airport to review the success of the initiatives (Step 6), identify areas of improvement (Step 7), and update the process as necessary (Step 8).

  Instructions: This tab updates automatically from the data entered into the** **ORANGE** **tabs.

TRACKING TABS: **ORANGE** tabs represent the tracking of the sustainability metrics identified for each category or other background information needed in order to calculate metrics. These tabs should be updated as new annual information becomes available.

Instructions: Metric tracking data should be entered into the Tool using these tabs. Data is entered in the blue cells.

5.5 Proposed Schedule for Implementation

Action will be required on a regular basis to ensure that the process becomes a part of the Airport's culture and is integrated within the City's sustainability processes. The following items identify the actions that would be conducted by Airport and the City Sustainability staff over a calendar year, and the management actions to be taken at each interval. It describes each activity, followed by the responsible party.

Monthly Activities

- Use the Sustainability Tool for review and screening of initiatives, as needed.
- Input monthly data (e.g., electricity, gas, and water use and cost) into the Sustainability Tracking Tool.
- Review and supplement implemented sustainability initiatives in the Sustainability Tracking Tool, as needed.

Check-Up Activities

- Meeting with Airport and the City Sustainability staff to review sustainability initiatives reviewed by Airport staff during the previous months. Three formal check-ups are recommended during the course of the year. At least one of these check-ups will occur in the fall to coincide with the annual development of the Airport Capital Improvements Plan.

Annual Activities

- Input annual data (i.e., annual operations, energy, financial data, etc.) by staff into the Sustainability Tracking Tool by end of-January for the prior year.
- Produce an Annual Report by end of first quarter that:
    - Documents initiatives reviewed during the prior year and their ratings relative to the established sustainability goals.
    - Report historic and current performance metrics relative to sustainability categories.
    - This can be done using the **PURPLE** tabs.
- Conduct an annual report meeting between Airport and the City Sustainability staff to review performance and goals, and identify/update a cohesive and feasible list of suggested initiatives for the upcoming year.

Biennial Activities (every two years)

- Reconsider the sustainability goals and initiatives and adjust as necessary.
    - Ask questions like: *Are these goals still valid? Are there any changing conditions that could allow us to update these goals?*
- Review the Sustainability Tracking Tool and adjust as necessary.
    - Look for items such as additional categories or items that Airport and the City Sustainability staff would like to track, any metrics that are outdated and could be removed, etc.
- Improve quarterly and annual reporting templates, if warranted.
    - Ask questions like: *Are there other graphics that could help staff, stakeholders or the public to visualize this information and improve upon it?*
- Evaluate these implementation steps, and revise as necessary.

Table 5-1: Example Calendar for Sustainability Plan Implementation

Month	Actions to be Undertaken	Primary Responsibility
Every Month	• Input monthly utility data • Use the tool to test new initiative ideas • Use the tool to track/list implemented ideas, as initiated	• Airport staff/City Sustainability staff
January	• Input year end data for prior year into the Sustainability Tool • Input final list of updated initiatives implemented from previous year • Complete Annual Sustainability Report	• Airport staff/City Sustainability staff
February	• Set meeting with City Sustainability staff and Airport to review previous year Annual Report (Meeting Q1) • Update list of proposed Initiatives for current year • Create initiatives action plan (6 months) • Resiliency training	• Airport staff/City Sustainability staff
March	• Schedule City Council Update meeting	• City Sustainability staff
April		
May	• Meet with Airport/City Sustainability staff to review and present initiatives for the next 3-months (Meeting Q2).	• Airport staff/ City Sustainability staff
June		
July	• Set a meeting with Airport/City Sustainability staff and Region to check in on sustainability partnership opportunities	• Airport staff/City Sustainability staff and Regional leaders
August	• Set a meeting with Airport/City Sustainability Staff to discuss CIP (Meeting Q3)	• Airport staff/City Sustainability staff
September	• Cement CIP recommendations and sustainability overlap	• Airport staff

Through the above implementation process, the Airport/City Sustainability staff will track progress toward its sustainability goals. While annual reports and checks should be performed, a comprehensive review of the categories, goals, initiatives, metrics, and reporting procedures should be conducted (at least) every two years. The purpose of the biennial review is to make adjustments based on experience, lessons learned, changing conditions, input from stakeholders, and changes in the needs of the categories.

Greenhouse Gas Inventory

FLAGSTAFF AIRPORT

Flagstaff, Arizona

October 2014

be resourceful
Flagstaff Sustainability Program

FLAGSTAFF AIRPORT

Contents

1. Introduction

As part of the Sustainability Plan for the Flagstaff Airport, the Airport has voluntarily developed a baseline Greenhouse Gas (GHG) Inventory for airport operations. While the City of Flagstaff updates its emissions inventory annually, it calculates GHG emissions generated from the Flagstaff community-at-large. This inventory provides a benchmark specifically for the Airport to use when measuring energy efficiency improvement projects and tracking progress toward reaching emission reduction related goals. Having set goals to conserve and enhance the region's natural resources for future generations, Flagstaff Airport is committed to conducting operations in a manner that will minimize environmental impacts while enhancing regional mobility. Ultimately, this baseline inventory will guide the Airport in developing strategies to reduce GHG emissions.

The base year for the inventory is 2013, which was selected because it is the most recent full year with readily available data. The inventory includes direct and indirect emissions associated with operations at the airport (Scope 1 and Scope 2 emissions – emissions that are within control of the airport operator), but does not include direct and indirect emissions associated with tenant operations and/or consumer activities (Scope 3 emissions). The protocol used for developing the inventory is based on two guidance publications: 1) FAA/US Air Force's "*Air Quality Procedures for Civilian Airports and Air Force Bases*" (revised July 2014); and 2) Transportation Research Board of the National Academies' Airport Cooperative Research Program (ACRP) *"Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories"* (April 2009).

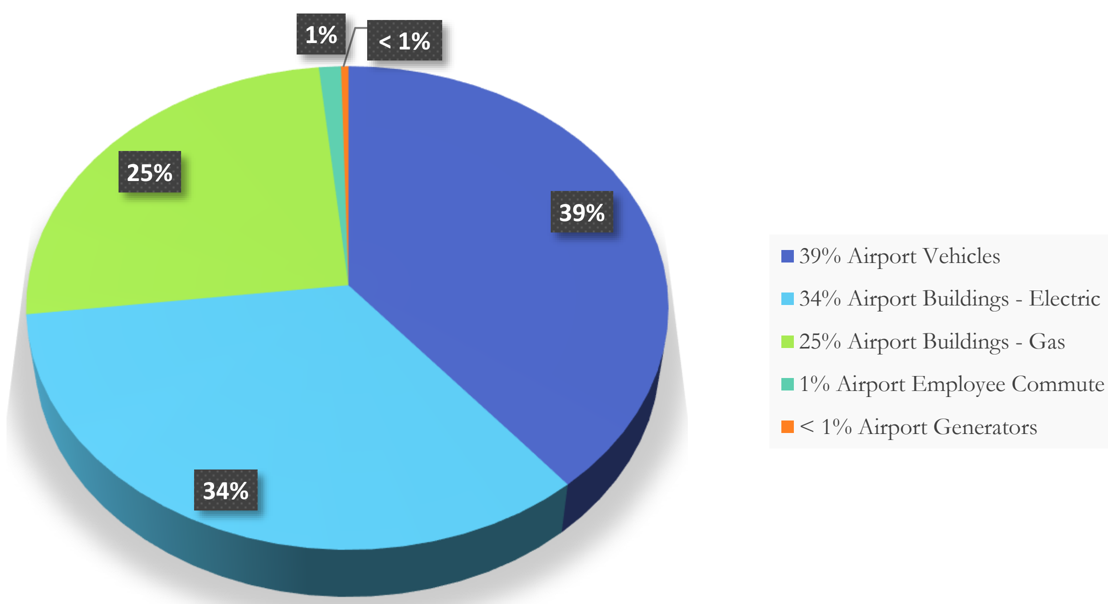
This report estimates that the Flagstaff Airport's GHG emissions in 2013 totaled 742 metric tons of carbon dioxide equivalent (CO2e) gases. Most of these emissions were the result of vehicle fuel combustion from airport vehicles (39%) and electric and natural gas consumption in airport facilities (34% and 25%, respectively). See **Table 1**, *Baseline Greenhouse Gas Emissions Inventory (Tons/Year)* and **Figure 1**, *Flagstaff Airport GHG Emissions from Airport Owned and Controlled Sources (Scope 1 and Scope 2 Emissions)*.

Table 1: Baseline Greenhouse Gas Emissions Inventory (Tons/Year)

Source	CO_2e*	Percent of Total**
Airport Vehicles	290	39%
Airport Buildings - Electric	253	34%
Airport Buildings - Gas	188	25%
Airport Employee Commute	9	1%
Airport Generators	3	< 1%
GRAND TOTAL	743	100.00%

Source: Mead & Hunt, Inc. 2014
* CO_2 equivalent measurement as discussed in IPCC Fourth Assessment Report
** Totals are rounded to the nearest whole percent

Figure 1: Flagstaff Airport GHG Emissions from Airport Owned and Controlled Sources (Scope 1 and Scope 2 Emissions).



BACKGROUND

Greenhouse Effect and Greenhouse Gases

The greenhouse effect involves naturally-occurring atmospheric gases that help to regulate the global climate by trapping solar radiation within the earth's atmosphere. However, empirical evidence suggests that modern human activity is artificially intensifying the greenhouse effect, causing global average surface temperatures to increase. This intensification is caused by activities such as the burning of fossil fuels (for transportation, electricity, and heating) that release anthropogenic (man-made) greenhouse gases into the atmosphere. These gases include water vapor (H_2O), carbon dioxide (CO_2),[1] methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Because CO_2 constitutes the majority of greenhouse gases, other greenhouse gases can be reported as "carbon dioxide equivalent." For the purpose of simplicity, this report uses this CO_2 equivalency method, which describes how much global warming potential a given type and amount of non-carbon dioxide greenhouse gas may have, using the functionally equivalent amount or concentration of carbon dioxide.[2]

Sources of GHG Emissions at Airports

With a direct link between fuel consumption and greenhouse gas emissions, there are numerous ways that an airport can affect the amount of pollutants in the atmosphere. Sources that require power/fuel at an airport and that can contribute to the amount of greenhouse gases in the atmosphere include:

- **Aircraft**
- **Auxiliary Power Units (APUs)**
- **Ground Support Equipment (GSE)**
- **Airport facilities and infrastructure (i.e., via purchased electricity and/or natural gas use)**
- **Airport and airline maintenance activities**
- **Airport construction projects**
- **Ground Access Vehicles**
- **Vehicle Fleets**

1 All greenhouse gas inventories measure carbon dioxide emissions, but beyond carbon dioxide different inventories include different greenhouse gasses (GHGs).

2 The *IPCC Fourth Assessment Report* has assigned the following CO_2e values: 1 for CO_2, 25 for CH_4, and 298 for N_2O

Organizational Boundaries

Organizational boundaries define the limits of an inventory by identifying the operations owned or controlled by the Airport and determine which activities should be included in its GHG inventory. Boundaries for the Flagstaff Airport were established to associate only those emissions owned or controlled by the airport. Those boundaries created the following categories to be included in this inventory

- **Airport-owned vehicles**
- **Airport-owned buildings (purchased electricity and consumed natural gas)**
- **Airport employee commute**
- **Airport-owned generators**

By providing distinct boundaries for the ownership of the emissions, the Airport is made aware of the emissions totals for which it is responsible. This inventory does not calculate emissions associated with tenant buildings or any aircraft.

Operational Boundaries

Operational boundaries in a GHG Emissions inventory refer to the specific types of emission sources that the Airport, as defined by the inventory's organizational boundary, possesses and will include in its GHG Inventory. This involves identifying the emissions associated with the operations within the organizational boundary, and categorizing them as Scope 1, Scope 2, or Scope 3 emissions.

- **Scope 1** emissions are direct GHG emissions from sources that are owned or controlled by the Airport. Scope 1 can include emissions from fossil fuels burned on site, emissions from Airport-owned or Airport-leased vehicles, and other direct sources.
- **Scope 2** emissions are indirect GHG emissions resulting from the generation of electricity, heating and cooling consumed by the Airport.
- **Scope 3** emissions include indirect GHG emissions from sources not owned or directly controlled by the Airport, but are related to the Airport's activities. Examples of Scope 3 emissions include all emissions associated with the tenants and ground travel by the public to and from the Airport, as well as aircraft emissions.

Data Availability

While every effort was made to find and use the most appropriate and accurate information regarding sources of emissions, some industry accepted generalities were used (such as average passenger vehicles achieving 23.9 miles per gallon, and emission rates per gallon of diesel fuel and unleaded gasoline). The results presented here reflect the use of best available data and the guidance contained in the ACRP Guidebook. Additionally, an airport employee survey was conducted. The survey provided the information on employee commute distances and methods. Hard copy surveys were distributed to airport employees and returned to the consultant.

EMISSIONS INVENTORY

Airport-owned and Controlled Emissions

Airport-owned Vehicles

The Airport owns and operates a fleet of 13 vehicles including pickup trucks, tractors, mowers, and ARFF vehicles. Table 2 summarizes the fuel types and annual consumption for all airport-owned vehicles. The annual consumption was multiplied by the following fuel specific emissions factors:

- Diesel = 22.384 lbs. CO2/gallon of fuel3
- Gasoline = 19.564 lbs. CO2/gallon of fuel4

This equates to 579,116 pounds or 289.56 tons of CO2e annually.

Table 2: Airport-Owned Vehicle Fuel Consumption

Fuel Type	Annual Consumption (gallons)	Lbs of CO_2 per gal. fuel	Total CO_2 from fuel (lbs)	Total CO_2 from fuel (tons)
Diesel	12,433	22.38	278,300	139.15
Unleaded Gasoline	15,376	19.56	300,816	150.41
			GRAND TOTAL $CO_{2}e$ (tons)	**289.56**

Buildings

By far, the largest airport-owned or controlled sources, which contributes to the Airport's emissions, are the Airport buildings. Accounting for 60% of the airport-owned total, the airport-owned buildings are the easiest target for energy efficiency improvements.
In order to calculate the emissions associated with the electrical consumption at the Airport, an emissions factor was obtained for the local area. The U.S. Environmental Protection Agency (EPA) has reported that for 2010, the AZNM WECC Southwest eGRID Sub-region had the Carbon Dioxide Equivalent factor of 1,182.89 lbs per megawatt hours (MWh).

The annual electrical consumption for airport-owned buildings multiplied by this region specific emissions factor provides the annual emissions associated with the Airport's electrical consumption. **Table 3** provides the breakdown of usage and emissions associated with natural gas consumption per airport-owned building

3 Emissions rates provided in ACRP Report 11

4 Emissions rates provided in ACRP Report 11

by pollutant, while **Table 4** provides the breakdown of usage and emissions associated with electrical consumption per airport-owned building.

Table 3: Airport-owned Buildings Natural Gas Consumption

CO2

Building Area	Annual Total (therms)	Annual Consumption (cubic feet)	CO_2 Emissions Factors (lb./1,000 cu. Ft)	Total CO_2 (pounds)	Total CO_2 (tons)
Airport Terminal	20,176	1,991,371	120.59	240,145	120.07
ARFF	11,326	1,117,876		134,808	67.40
			GRAND TOTAL (tons)		**187.47**

Source: IPCC 2006

CH4

Building Area	Annual Total (therms)	Annual Consumption (BTUs)	Annual Consumption (Joules)	Annual Consumption (TeraJoules)	Grams of CH4	lbs of CH4	CO2e lbs	CO2e Tons
Airport Terminal	20,176	2.E+09	2.12817E+12	2.13	10,640.86	23.46	586.48	0.29
ARFF	11,326	1.E+09	1.19467E+12	1.19	5,973.36	13.17	329.22	0.16
						GRAND TOTAL (tons)		**0.45**

Source: U.S. EPA 2008

N2O

Building Area	Annual Total (therms)	Annual Consumption (BTUs)	Annual Consumption (Joules)	Annual Consumption (TeraJoules)	Grams of N20	lbs of N2O	CO2e lbs	CO2e Tons
Airport Terminal	20,176	2.E+09	2.12817E+12	2.13	212.82	0.47	139.82	0.07
ARFF	11,326	1.E+09	1.19467E+12	1.19	119.47	0.26	78.49	0.04
						GRAND TOTAL (tons)		**0.11**

Source: IPCC 2006

Table 4: Airport-owned Buildings Electrical Consumption

Building Area	Estimated Annual Electricity Consumption (kWh)	Annual Consumption in MWh	CO_2e Emissions Factors (lb./MWh)	Total CO_2e (pounds)	Total CO_2e (tons)
Airport Terminal	369,120	369.12	1,182.89	436,628	218.31
ARFF	58,800	58.8		69,554	34.78
			GRAND TOTAL (tons)		**253.09**

Source: U.S. EPA eGRID Emissions Factors for AZNM WECC Southwest Sub-region

Airport Employees

Airport employees commuting to work travel approximately 21,114 miles per year. Using the average miles-per-gallon and emissions rates per gallon as suggested in the ACRP Guidebook, a total of 17,283 lbs. or 8.64 tons of CO_2e are directly attributable to airport employee commutes. **Table 5** summarizes the factors used to calculate the associated emissions.

Table 5: Airport Employee Commute

	Miles Traveled per year	Fuel Consumed (gallons)	Total CO_2 from fuel (lbs)	Total CO_2 from fuel (tons)
Passenger Vehicles	21,114	883.4	17,283	8.64

Source: U.S. EPA 2005

Airport Backup Generators

The airport reported that approximately 247 gallons of diesel fuel was consumed in airport generators in 2013. The applicable emissions rates for diesel consumption were obtained from the EPA and then applied to provide an annual total for the airport generators. As depicted in **Table 6**, a total of 2.76 tons of CO_2e are attributable to the Airport-owned backup generators.

Table 6: Airport-Owned Backup Generators

	Fuel Consumed Annually (gallons)	Diesel Emissions Factor (lbs. CO_2/gal fuel)	Natural Gas Emissions Factor (lbs CO_2 per 1,000 cu/ ft. gas)	Total CO_2 from fuel (lbs)	Total CO_2 from fuel (tons)
Diesel Generator	247	22	NA	5,529	2.76
				GRAND TOTAL CO_2 (tons)	**2.76**

Recycling and Waste Management Plan

FLAGSTAFF AIRPORT
Flagstaff, Arizona

August 2015

be resourceful
Flagstaff Sustainability Program

FLAGSTAFF AIRPORT

Contents

1. Introduction

This Recycling and Waste Management Plan has been developed for Flagstaff Airport (FLG) in accordance with current Federal regulations. This plan describes relevant regulatory guidance and terminology, an overview of the baseline inventory of the existing waste and recycling practices at the Airport, recommendations for improving the program, and potential cost savings or practical revenue generation opportunities.

REGULATORY HISTORY AND GUIDANCE

Through the Federal Aviation Administration (FAA) Modernization and Reform Act of 2012 (FMRA), the FAA expanded the definition of airport planning to include "developing a plan for recycling and minimizing the generation of airport solid waste" consistent with applicable state and local laws. The FMRA requires airports preparing a master plan to "address issues related to solid waste recycling" by evaluating the feasibility of solid waste recycling, minimizing the generation of solid waste, identifying operations and maintenance requirements, reviewing waste management contracts and identifying the potential for cost savings or generation of revenue. This Recycling and Waste Management Plan has been prepared as part of the Flagstaff Airport Sustainability Plan rather than a traditional master plan; nonetheless, because the Airport anticipates that it will complete a Master Plan Update in the near future, this document has been written in accordance with the FMRA as well as other resources as noted in the following pages. It is intended to be included in the future Master Plan Update to meet the FMRA requirements. The inventory of existing conditions included in the main body of the Sustainability Plan is repeated here so this Appendix can act as a stand-alone plan and will be attached to the upcoming Master Plan Update when it is completed to meet the current Federal Regulations.

ABOUT THIS PLAN

The goals of the Airport's Recycling and Waste Management Plan are to collect baseline information on and assess the Airport's existing waste management program, and include recommendations for improving the program. This plan is organized into the following sections:

- Waste and Recycling Definitions
- Waste and Recyclable Material Generation at FLG
- Recommendations
- Conclusion

This plan includes areas on the Airport that are "under the Airport's control," specifically the passenger terminal, Aircraft Rescue and Firefighting (ARFF) building, and tenants located in the passenger terminal. The Fixed Base Operator (FBO) manages their own waste collection and disposal at the Airport. This plan does not include the activities of the commercial air service airline at the Airport; although U.S. Airways disposes of their waste in City's waste dumpsters, the Airport does not have control over the airline's waste and recyclable materials management practices. However, the Airport is working with U.S. Airways/American Airlines to provide additional recycling areas to increase recycling. This initiative is also included as one of the recommendations in this Plan.

A detailed waste audit was not conducted as part of this study; however one was conducted as part of a City wide audit and those results are summarized here. The airport management also completed an Airport Solid Waste Recycling Plan Survey that was used to supplement the City waste audit with additional information. Along with the survey, a baseline assessment was complemented by observations made by the consultant team and discussions with airport management.

WASTE AND RECYCLING DEFINITIONS

Waste and recyclable materials are generated by passengers, airport administration and other personnel from a variety of activities at an airport. Passengers will typically discard reading material, food scraps and other items prior to entering security and customs checkpoints. As security and customs restrictions limit carry-on toiletries, fluids and other objects, these items are frequently thrown away at security and customs checkpoints. Airport administration and other personnel (rental car, airlines, etc.) use and dispose of office supplies and the parts and cleaning products required for the maintenance and upkeep of an airport. If an airport undergoes a construction or renovation project, tackles a major purge of stored items or hosts a special event, special wastes or increased volumes will likely be generated. Other activities at an airport, for example those conducted by a fixed based operator (FBO) or commercial airline, may also generate waste at an airport. The following waste and recycling terms and phrases related to airport waste will be used throughout the remainder of this plan and are defined below.

Waste – Waste is any discarded, rejected, abandoned, unwanted or surplus matter, whether intended for disposal, incineration, or treatment, or for recycling, reprocessing, or recovery.

Municipal Solid Waste (MSW) – Also called “trash” or “garbage”, municipal solid waste consists of everyday items thrown away by homes, schools, hospitals and businesses. MSW is a type of non-hazardous waste.

Recyclable Material – A recyclable material is one that can be removed from a waste stream and reused or reprocessed into new products in order to reduce the consumption of raw materials.

Waste Stream – A waste stream is the collective flow of waste materials from one source. For example, an airport’s waste stream includes all of the waste generated at the airport (all the paper, all the aluminum cans, all the food waste, all of the plastic) whether these materials are recycled or disposed of in a landfill.

Construction and Demolition (C&D) Waste – Construction and demolition waste is the non-hazardous solid waste generated by activities such as land clearing and excavation, and construction, demolition, renovation or repair of structures, roads and utilities. C&D waste may include concrete, wood, metal, drywall, carpet, plastic, pipes, land clearing debris, cardboard and salvaged building components. C&D waste is a type of MSW.

Deplaned Waste – Deplaned waste is the waste material removed from passenger aircraft. Deplaned waste may include beverage containers such as bottles, cans and cups, newspaper, magazines and other mixed paper, disposable silverware, napkins and other food service items, food waste and paper towels. Deplaned waste is a type of MSW.

Food Waste – Food waste consists of waste generated and discarded during food preparation activities and food that is not consumed. Food waste is a type of MSW.

Green Waste – Also called "yard waste", green waste consists of tree, shrub and grass clippings, leaves, weeds, small branches, seeds, pods and similar debris generated by landscaping activities. Green waste is a type of MSW.

Hazardous Waste – Hazardous waste is waste which exhibits one or more hazardous characteristics (ignitability, corrosivity, reactivity or toxicity) or is specifically listed by the United States Environmental Protection Agency (US EPA) as hazardous.

Universal Waste – A category of hazardous waste containing materials that are very common, such as batteries, pesticides, mercury-containing equipment, and bulbs (lamps).

Non-Hazardous Waste – Non-hazardous waste is waste which does not exhibit any of the hazardous characteristics (ignitability, corrosivity, reactivity or toxicity) and is not specifically listed by the U.S. Environmental Protection Agency as hazardous.

2. Waste and Recyclable Materials Management at FLG

Flagstaff Airport (FLG) is a City-owned public-use airport located in the City of Flagstaff in Coconino County, Arizona. To assist with the development of this plan, Airport management completed an Airport Solid Waste Recycling Plan Survey in August 2014. The survey provided baseline information about the Airport's waste management plan including how waste is managed and what current education efforts are in place.

This plan includes management of municipal solid waste (MSW) and excludes hazardous, universal, and other types of waste as defined herein.

HOW WASTE IS MANAGED

According to airport management, a recycling program is in place at the Airport. As described in the Baseline Inventory chapter, there is one dumpster at the Airport that is dedicated to recyclables. Recycling bins are located in the passenger terminal building next to each trash can (see **Figure 1**) and are emptied into the recycling dumpster. Additionally, all tenants and airline personnel have access to the recycling dumpster. A receptacle for recycling aluminum cans exists at the ARFF building; however, other types of recycling receptacles (e.g. glass or paper) were not present in the building. **Figure 2** depicts the types of waste disposal containers and recycling containers currently in use at the ARFF building.

Figure 1 Typical Waste and Recycling Containers in Terminal Building

Source: Flagstaff Airport, February 2014

Figure 2 Typical Waste Containers in ARFF Building

Source: Flagstaff Airport, February 2014

All waste generated from inside the passenger terminal and ARFF building, including waste generated by tenants and airline personnel, is disposed of in two City waste dumpsters at the Airport. Waste generated by hangar tenants is also disposed of in these City waste dumpsters. Waste services are contracted through City of Flagstaff Environmental Services, and the City of Flagstaff covers all costs for the Airport's waste collection and transport. The Fixed Base Operator (FBO), however, manages its own waste and disposal needs, using its own containers and contracted services. There are no policies or requirements currently in place (via lease agreement) related to waste management by the FBO.

The Café at the Airport comprises most of the food waste. The Café uses plastic baskets for serving food along with ceramic plates, bowls and cups. A paper sheet is placed in the plastic basket to separate the food from the basket. Plastic cups are used for soft drinks and the bar uses glass.

All silverware is made of metal and paper napkins are also used. Dishwashing is all done by hand. All grease generated by the kitchen is disposed of in a tank adjacent to the dumpsters outside. The grease is recycled by a local vendor approximately twice per year.

CURRENT EDUCATION EFFORTS

Labels/signs on waste and recycling containers direct passengers, employees, public, and tenants where to place items for disposal. Airport maintenance employees receive on-the-job training regarding waste and recycling procedures, including transferring contents of waste and recycling containers to the dumpsters and the use of the grease disposal tank.

WASTE COLLECTION CONTRACTS AND COSTS

The Airport does not pay for its waste collection service; rather, the City of Flagstaff covers all costs for the Airport's waste collection and transport. As a result, the Airport's waste and recycling management services are included in a city-wide contract. The City is contracted with Norton Environmental for waste and recyclable materials marketing. City of Flagstaff Environmental Services collects and hauls waste twice a week from the Airport to the Cinder Lake Landfill. Because collection is contracted through the City, the Airport does not have direct control over its waste collection services and any changes to this contract would have to go through the City. Thus, there are no waste collection contracts or monthly invoices to review as part of this plan.

WASTE AND RECYCLABLE MATERIAL COMPOSITION AT FLG

A general characterization of the types of waste typically found at airports include:

- **Corrugated cardboard**
- **Newspaper**
- **Office paper (computer, copier, etc.)**
- **Mixed paper (glossy inserts, junk mail, etc.)**
- **Glass containers**
- **Other glass (light bulbs, etc.)**
- **Metal food and beverage cans**
- **Scrap metal (ferrous and non-ferrous)**
- **Plastic containers (#1-#7 type bottles and jugs)**
- **Other plastics (stretch wrap, strapping, etc.)**
- **Liquid**
- **Food waste**

Recyclables are collected and hauled from the facility at the same time as waste (twice a week). As mentioned previously, the FBO has its own waste disposal services and therefore does not participate in the Airport's recycling program. Similar to waste services, the City covers all costs to have recycling removed from the facility.

Based on the 2015 City waste audit, of the five City facilities surveyed for this audit, a total recycling rate of 38 percent was calculated, with a contamination rate of 19 percent. The contamination rate of these facilities was similar to that of 2014 (19 percent) and 2011 (23 percent). Compared to the other facilities within the audit, the Airport had a much higher than average recycling contamination rate at 26 percent (see **Table 1**). Common contaminants were liquid, coffee cups, glass, paper towels, and plastic wrappers. A follow up waste audit determined that on an average day, 22 pounds of liquid waste are thrown in the landfill dumpster and five pounds of liquids are thrown into the recycling receptacle. An audit of the Airport's landfill dumpster revealed that 33 percent of its contents were recyclable. This largely consisted of paper, stacks of magazines, partially used condiment bottles and plastic water/soda bottles.

Due to the lack of a waste audit conducted in 2012 and inconsistent sampling methodology in 2013, the Airport waste audit data does not provide consistent insight into waste and recycling conditions at the Airport. Waste audits conducted in 2014 and 2015 used the same methods. However, the data that does exist suggest that much of the contamination appears to be food or liquid related. Initiatives such as increased signage in the food court area, installation of a liquid disposal station at the TSA checkpoint, and education of food court employees may be strategies to decrease recycling contamination, and are discussed the *Recommendations* section of this plan.

Table 1 Recycling Rate and Contamination Rate 2011-2015

Year	Airport Recycling Rate	Airport Recycling Contamination Rate
2011	38%	14%
2014	24%	39%
2015	44%	26%

Source: City of Flagstaff Waste Audit

3. Recommendations

Based on the information presented in the previous chapters, the Flagstaff Airport has the opportunity to improve landfill diversion and reduce waste generation at its facilities. According to the baseline assessment and discussions with airport management, some recyclable materials are being disposed of in waste containers. The United States Environmental Protection Agency (EPA) promotes the following hierarchy of waste management: Source Reduction and Reuse (most preferred), Recycling/Composting, Energy Recovery, and lastly Treatment/Disposal (least preferred). The Airport can improve its source reduction efforts while fine-tuning the recycling program and exploring options for composting and sustainability policies. The high contamination rates noted in previous audits and the relatively low recycling rates show that additional improvements can increase the effectiveness of this program. Recycling and waste management strategies recommended for implementation at the Airport are described below.

- **Implement a composting program at the Airport (off-site partnership):** Implement a food composting program at the Airport terminal, partnering with a local composting program. This initiative would likely include back of house recycling at the Café in the short term.

- **Collect landscaping materials for composting:** Collect any landscaping materials, including clippings, etc. and compost materials.
- **Use reusable glassware in Airport administration office(s):** Purchase re-usable cups and coffee mugs (glass or ceramic) for use in meetings in the Airport offices. Print them with the Airport or City Sustainability logo.
- **Install a recycling area for airline use (airside):** Place recycling containers on the airside and work with the airline to promote their use.
- **Continue to recycle used grease from the Café:** There is a viable market for used grease so therefore the used grease from the passenger terminal building Café should continue to be recycled.
- **Create a recycling/liquid disposal station at the TSA checkpoint:** Create a dual disposal area at the TSA checkpoint for liquid disposal and recycling to prevent liquids and waste from being tossed into the garbage and having recyclable bottles confiscated by the TSA at the checkpoint.
- **Install a water bottle filler station:** Install a water bottle fill stations adjacent to the existing water fountains in the passenger terminal building and in the gate area.
- **Sell reusable water bottles at the Café.** This will reduce plastic waste at the Airport and future passenger destinations.
- **Change from liquid hand soap to foam hand soap:** Liquid soap results in more waste, more water use, and more maintenance. All of the restrooms in both the passenger terminal building and the ARFF should have foam hand soap available for use.
- **Develop a Sustainability Policy for Tenants:** Develop and implement a sustainability policy for the tenants at the airport, including concessions to reduce waste such as requiring the use of reduced or compostable food packaging (if composting becomes available at the Airport), electronic receipt option for airlines and concessions, etc.
- **Continue to Adhere to the City's Sustainable Purchasing Policy:** Adhere for the City Sustainable Purchasing Policy for materials used in the Airport offices, including purchasing, re-use of materials, and double-sided printing.
- **Develop "sustainable tenant lease language" as a baseline for use in lease negotiation with tenants:** Leases should be reviewed and revised periodically to remain current with industry trends related to sustainable practices and procurement.

4. Potential Cost Savings or Revenue Generation

Because waste and recycling collection costs are covered by the City of Flagstaff, estimates of cost savings and revenue generation developed for this plan are described in qualitative terms. Overall, any strategies to increase recycling and reduce waste will contribute to preserving space in the Cinder Lake Landfill. Although preservation of landfill space would not have a direct financial benefit to the Airport, it is a worthwhile goal in support of the local community, especially as the Landfill gets closer to capacity. Implementing a composting program would require a fee-based pickup of composting materials but has the potential to significantly reduce the Airport's waste volume through diversion of food waste and other compostable materials.

Many of the recommendations listed above would require Airport personnel time to implement and maintain, as well as the initial cost for materials and equipment. However, some recommendations would result in a positive (non-monetary) return on investment for the Airport in a relatively short period of time through incorporation of reusable items and sustainable policies, including using reusable cups/mugs and switching to foam hand soap. Other recommendations would not necessarily provide a monetary return on investment but would be highly visible to the public and would help to raise the Airport's sustainability profile in the community. The recycling/liquid disposal and water bottle filling stations fall into this latter category.

The Sustainability Policy for tenants and the City Sustainability Purchasing Policy would be unlikely to generate revenue or result in significant cost savings for the Airport, and could require initial and on-going airport personnel time to develop, maintain, and promote the policies. But again, such policies would emphasize the Airport's commitment to sustainability to the community and the broader community of airports nationwide.

Waste reduction, whether through simple reduction practices or through diversion of waste to a recycling program, has the potential to decrease the cost of collection service to the City. As the Airport fine-tunes its recycling program, "right-sizes" its dumpsters, and adjusts the collection schedule, there may be some savings resulting from reduced pickups (trips by the contractor). Reduced waste pickups could therefore provide a cost savings benefit to the City depending on the fee structure, but not directly to the Airport.

In summary, there are opportunities for a small amount of cost savings but no known means of revenue generation through implementation of the recycling and waste management policies recommended in this plan for the Airport and the City of Flagstaff. All of the recommendations would offer intangible benefits helping to raise awareness of the Airport's sustainability values.

5. Conclusion

The recommendations contained in this Recycling and Waste Management Plan are in alignment with the City of Flagstaff' Municipal Sustainability Plan. Many of the recommendations will directly contribute to the short, mid and long term goals presented in the City's plan.

Flagstaff Airport is located in a recycling-friendly area of the County and has an active, inclusive recycling program. With the implementation of some or all of the above recommendations, the Airport can further improve its waste and recycling program while reducing its impact on the environment.

Energy Audit

FLAGSTAFF AIRPORT

Flagstaff, Arizona

January 2015

be resourceful
Flagstaff Sustainability Program

FLAGSTAFF AIRPORT

Contents

ENERGY EFFICIENCY ASSESSMENT

ASHRAE Level 2 Energy Audit

FLAGSTAFF AIRPORT
FLAGSTAFF, AZ

FLAGSTAFF AIRPORT
GRAND DESTINATIONS

JANUARY 30, 2015

EXECUTIVE SUMMARY

SEG completed an ASHRAE Level 2 energy audit of the Terminal, aircraft rescue and firefighting (ARFF) building, and airfield lighting for Flagstaff Airport (FLG). Exterior lighting was examined for ways to exhibit leadership in reducing light pollution and comply with FLG's Dark Sky initiative.

The tables below summarize the energy efficiency measures (EEMs) that have been identified in the mechanical, lighting, domestic hot water, and building envelope systems at each building, and the Dark Sky Measures (DSMs) that were developed to reduce light pollution. Approximately $40,000 per year of combined energy and maintenance savings have been identified, but note that the measures are not necessarily additive due to overlap or interaction between some measures. Upon review and discussion of the measures outlined in this report, the next step is to develop an implementation plan to move forward with the selected measures.

#	EEM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Total O&M Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
1	Terminal – Review HVAC controls and setpoints	3,622	525	$923	$500	0.5
2	Terminal – Install occupancy controls on security area lighting	20,971	0	$2,427	$2,000	0.8
3	ARFF – Replace dimmable can lamps with LED	3,200	0	$554	$630	1.1
4	Terminal – Install vending misers	4,140	-77	$378	$500	1.3
5	Terminal – Relamp linear fluorescent with low wattage T8	10,329	0	$1,137	$2,112	1.9
5.1	Terminal – Relamp linear fluorescent with linear LED	26,180	0	$3,329	$8,200	2.8
6	Terminal – Replace pendant can lamps with LED	19,272	0	$2,178	$4,160	1.9
7	ARFF – Relamp emergency light fluorescent with LED	12,614	0	$1,574	$3,010	1.9
8	Terminal – Install daylighting controls on atrium lighting	7,173	0	$789	$2,000	2.5
9	Terminal – Install furnace economizing	46,414	0	$5,106	$20,000	3.9
10	Terminal – Install high efficiency furnaces	0	2605	$2,605	$15,400	5.9
11	Airfield Lighting – Replace incandescent lamps with LED	33,100	0	$24,820	$400,000	16.1
12	ARFF – Install controls on hot water recirculation pump	55	24	$33	$300	9.1
13	Terminal – Upgrade exterior lighting controls	4,477	0	$493	$5,000	10.1

#	DSM	Electricity Savings (kWh/yr)	Total O&M Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
1	Hangars – Replace outdoor lighting fixtures	0	$0	$21,000	-
2	Shades – Replace outdoor lighting fixtures and controls	18,072	$2,204	$15,000	6.8
3	Aprons – Replace lighting fixtures with LED	11,508	$1,686	$12,600	7.5
4	Terminal Parking Lot – Install dual level lighting controls	6,934	$763	$17,500	22.9

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INTRODUCTION

Sustainable Engineering Group (SEG) performed an ASHRAE Level 2 Energy Audit on Flagstaff Airport (FLG) in Flagstaff, Arizona. The energy audit was conducted to identify potential opportunities for enhancing energy efficiency, determine cost effectiveness of these measures, and examine ways to decrease light pollution relative to FLG's Dark Sky initiative.

The audit included meeting with airport staff, conducting on-site observations, and reviewing documentation of the systems for the following areas of the airport campus:

- Airport Terminal
- Aircraft Rescue and Fire Fighting (ARFF) Building
- Airfield Lighting

The following systems for each of the buildings have been studied:

- Building Envelope
- Heating, Ventilation, and Air Conditioning (HVAC)
- Domestic Hot Water
- Lighting

As part of the study, SEG evaluated the energy savings, implementation costs, and payback periods of the most significant energy saving opportunities and created a list of Energy Efficiency Measures (EEMs). Some measures have been identified that reduce light pollution but have limited cost effectiveness based on energy savings alone. These measures were categorized as Dark Sky Measures (DSMs). A third type of measure that was examined was Facility Improvement Measures (FIMs). These are aimed at increasing equipment service life, improving occupant comfort, and reducing facility maintenance.

AIRPORT OVERVIEW

Flagstaff Airport (FLG) is a regional airport that serves Flagstaff and northern Arizona communities. FLG currently services one airline making approximately five flights per day and transporting 120,000 – 150,000 passengers per year between Flagstaff and Phoenix. FLG's growth plan is to add a second airline in the future and double the passengers served in 7 years.

The aerial images below show the two buildings included in this study:

- Terminal building, 27,815 ft² – Constructed in 1993
- ARFF building, 11,500 ft² – Constructed in 2005

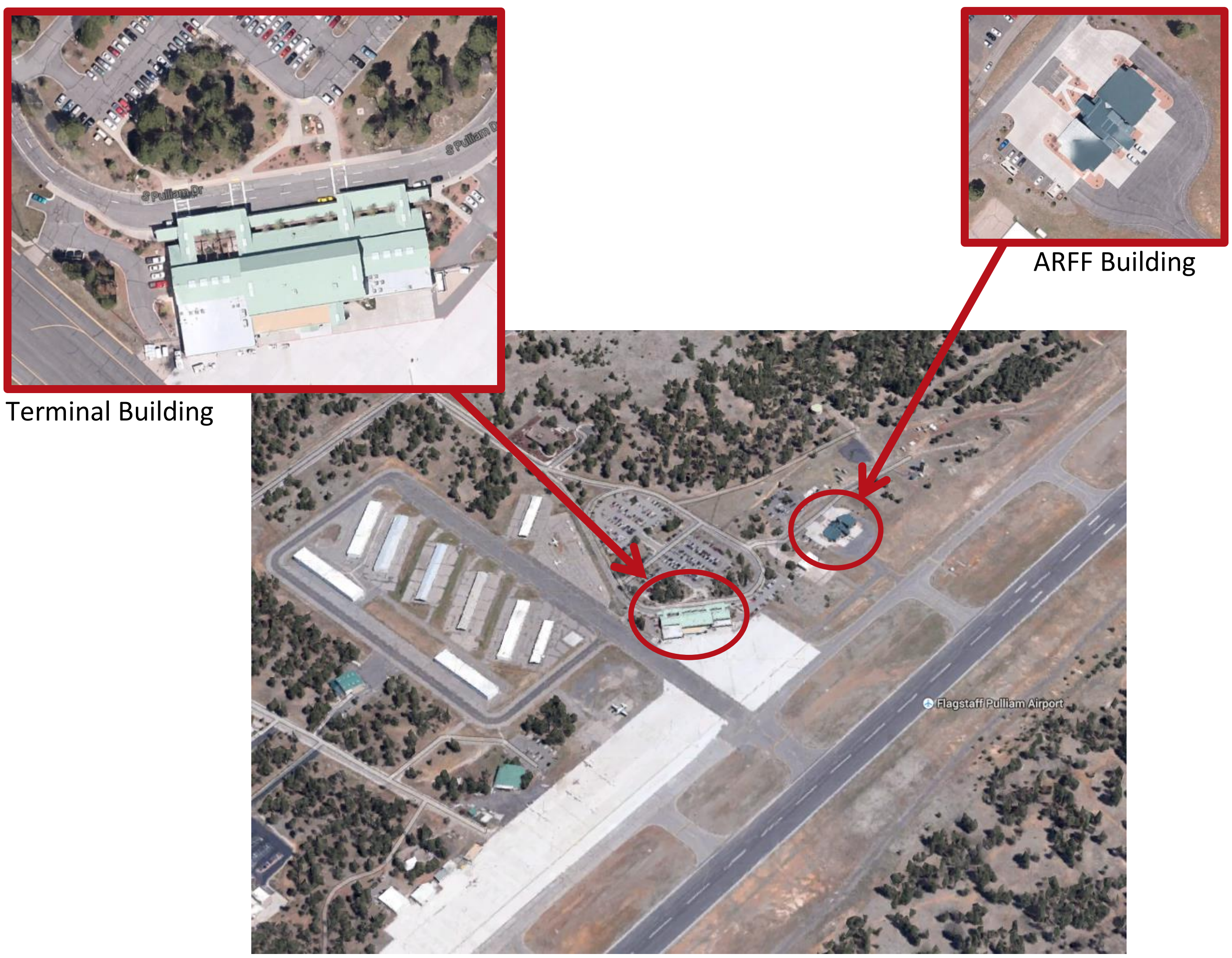

Figure 1 – An overview of the airport buildings showing locations of the Terminal and ARFF.

PRELIMINARY ENERGY-USE ANALYSIS

Historic electric and gas utility data have been reviewed for the Terminal, the ARFF building, and the airfield lighting. These utility usage and cost data for 2011 – 2013 are tabulated and included in Appendices A through C. A summary table is included in Table 1.

Building or Area	Natural Gas			Electricity			Total Site Energy			
	Usage [Therms]	Virtual Rate [$/Therm]	Cost [$]	Usage [kWh]	Virtual Rate [$/kWh]	Cost [$]	Total Energy [kBTU]	Total Cost [$]	Energy Use Intensity [kBTU/ft^2]	Cost Intensity [$/ft^2]
Terminal	19,978	$0.97	$19,333	380,533	$0.110	$41,896	3,296,213	$61,229	119	$2.20
ARFF	10,299	$0.99	$10,207	58,507	$0.158	$9,209	1,229,491	$19,416	107	$1.69
Airfield	-	-	-	51,947	$0.273	$13,635	177,242	$13,635	-	-

Table 1 – Average annual utility data for the Terminal, ARFF building, and airfield for 2011 – 2013.

A building's historic energy usage can be used to establish a baseline for comparison to other similar buildings. This analysis will assist in identifying potential opportunities to reduce energy waste. Since gas and electricity are expressed in different units of energy (therms of gas and kWh of electricity), it is useful to combine them into one unit and to normalize it for building area. The standard unit used for this and the unit used in this report to describe total energy will be kBTUs. One kBTU is equal to 1,000 BTUs, 0.29 kWh, or 0.01 therms. This is converted into energy use intensity (EUI) by dividing the total annual kBTUs by the total area (in square feet) of the building, resulting in kBTU/ft^2/yr.

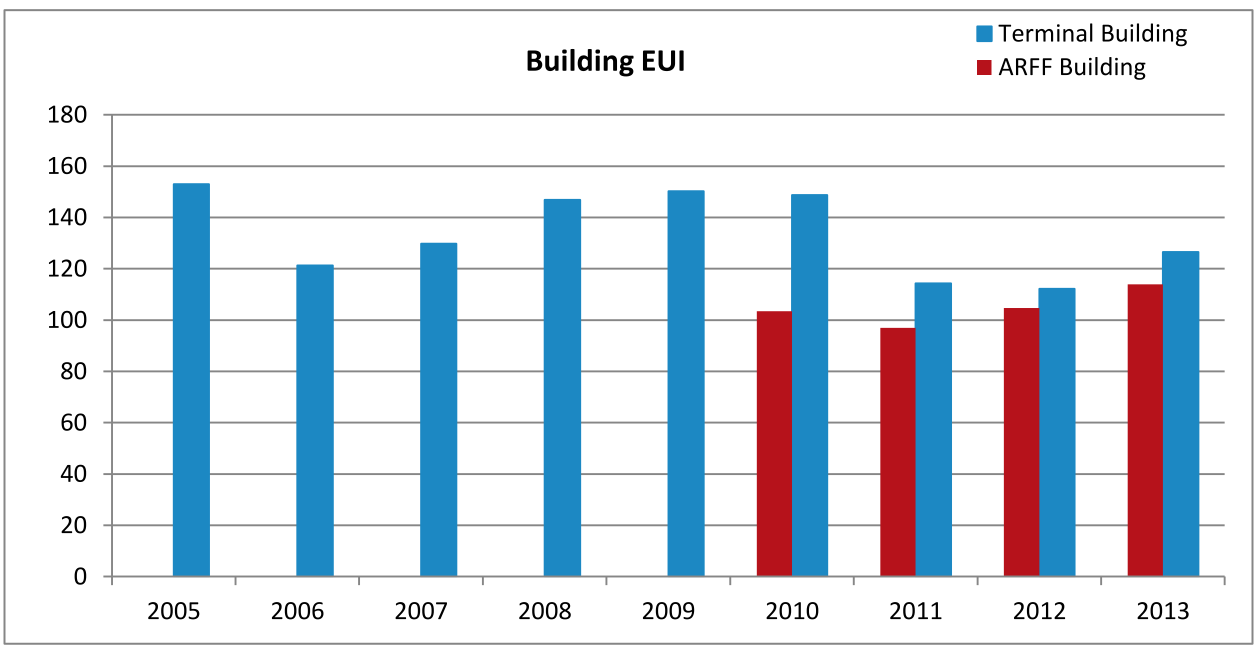

Figure 2 – Building EUI trend for the Terminal and ARFF buildings.

The Terminal EUI has undergone a significant reduction since 2010. The gas usage has remained fairly even, but the electric usage has decreased during this period. This may be attributed to energy efficiency measures already implemented by FLG and the City of Flagstaff, such as decreasing lighting intensity in the main atrium of the Terminal, replacing condensing units with more efficient units, and improving setpoint control.

The ARFF building EUI shows some increase in recent years. Further investigation shows this increase is due to increasing gas usage between 2011 and 2013. This does not appear to be a case of colder winters than average (2012 was a particularly warm winter), so it is possible this increase in energy usage is due to setpoints of heating equipment, or heating equipment running less efficiently than it should.

Figure 3 below indicates a comparative analysis of FLG's Terminal annual EUI relative to five other regional airports. This graph shows that FLG uses slightly less energy per square foot than one other airport (Regional Airport B) in the same climate zone. On the other hand, there is one airport (Regional Airport A) that is in a more extreme weather climate and achieves a lower EUI, showing that there is room for improvement for FLG.

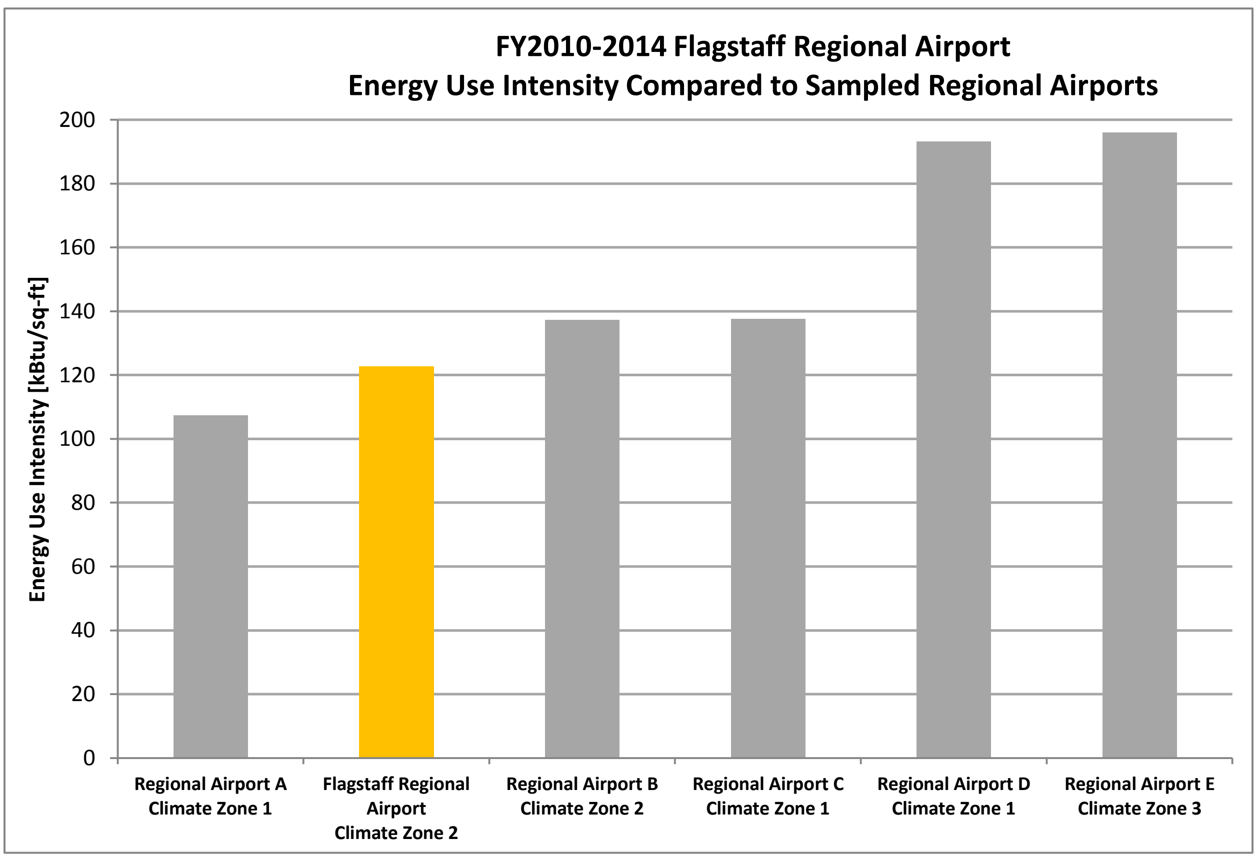

Figure 3 – Graph of Flagstaff Airport Terminal EUI compared to other regional airport terminal buildings.

The definitions for the different climate zones in the EUI comparison in Figure 3 are in terms of cooling degree-days (CDD) and heating degree-days (HDD). CDDs are a measure of how hot a climate is in the summer (resulting in cooling energy) and HDDs are a measure of how cold a climate gets in the winter (resulting in heating energy). A map with the definitions of the climate zones is included in Figure 4.

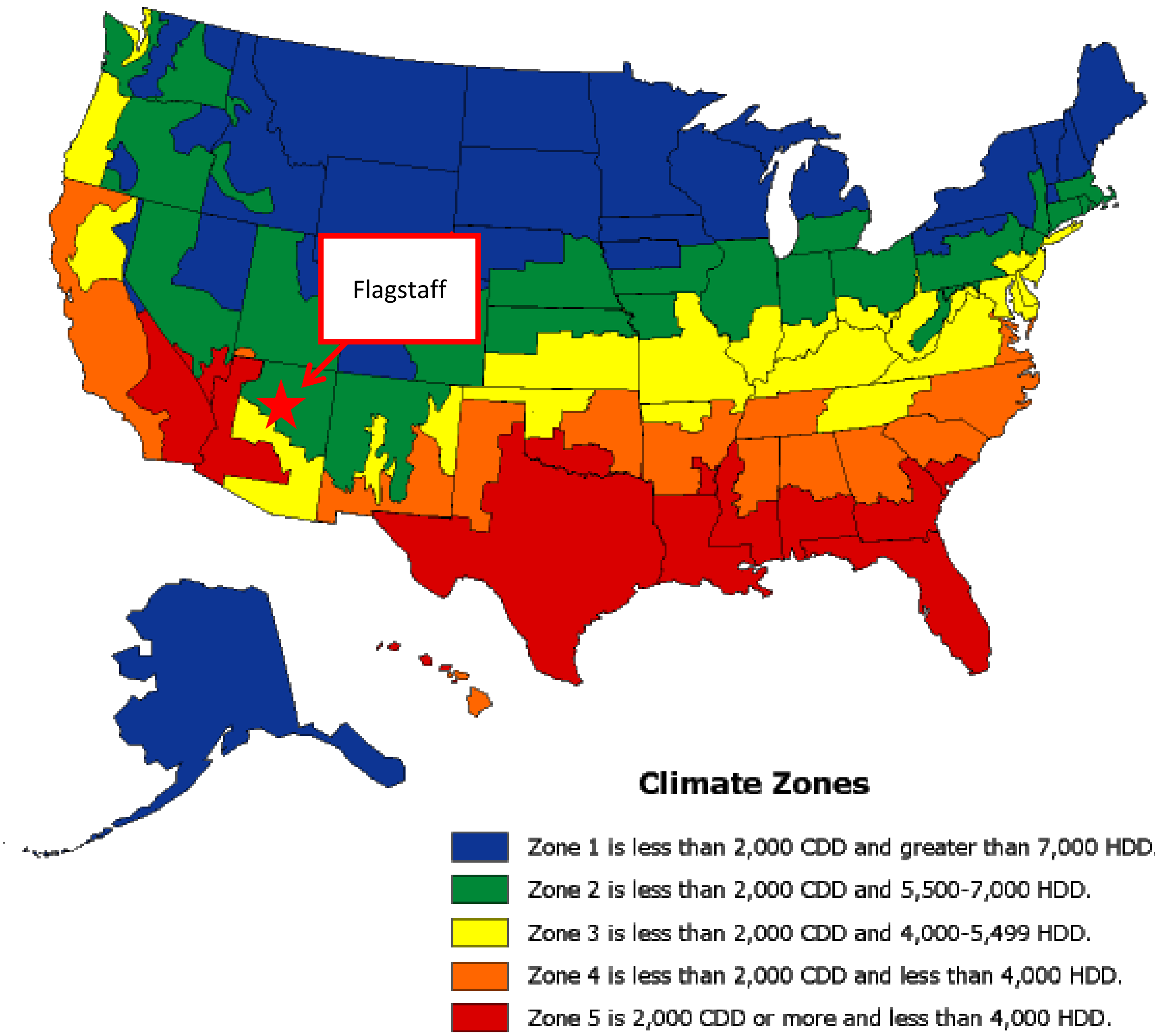

Figure 4 – Map of U.S. Climate Zones, from www.eia.gov/consumption/commercial/census-maps.cfm.

The monthly utility data are graphed in the figures below. The natural gas consumption shown below in Figures 5 and 6 follows the expected usage profile for a cold climate such as northern Arizona. It is typical for gas usage to be higher in the winter due to increased heating loads being met by the gas furnaces.

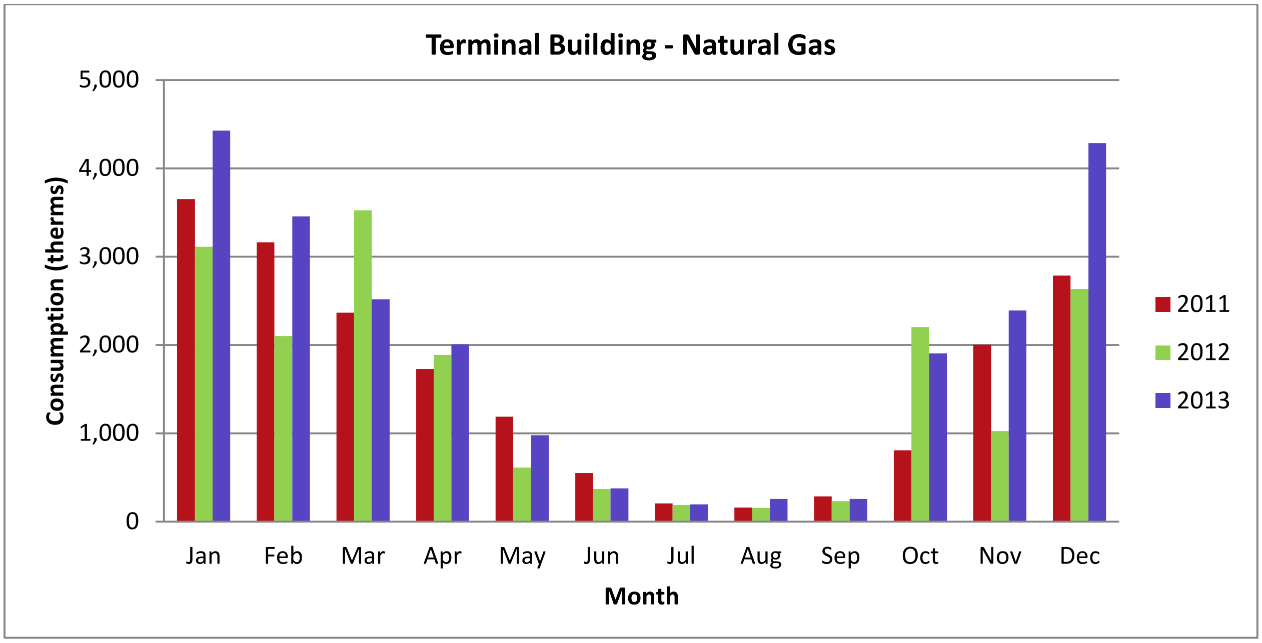

Figure 5 – Natural gas usage for the Terminal.

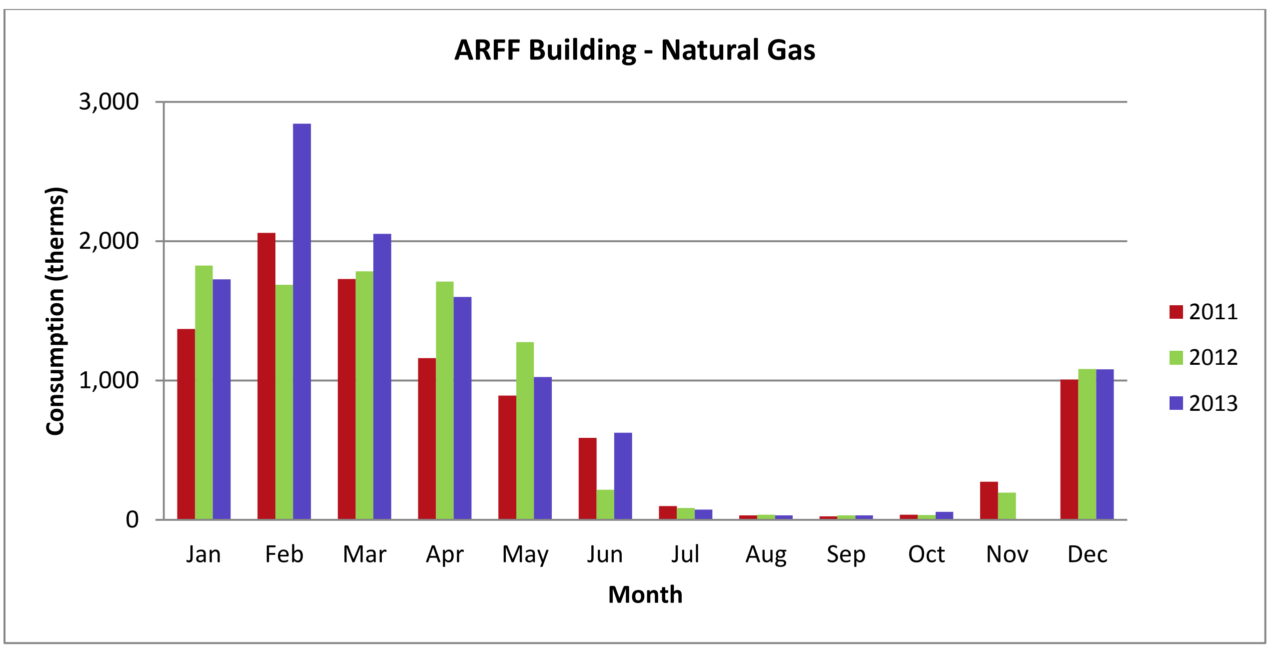

Figure 6 – Natural gas usage for the ARFF.

The electrical consumption for the Terminal and ARFF shown below in Figures 7 and 8 indicate a fairly consistent base electrical load throughout the year. Although some increase in the summer months can be seen for these two buildings, it is normal for summer electrical use to be slightly higher than winter electrical use due to increased cooling loads in the summer. A lack of seasonal fluctuation typically indicates that more electricity is being used by lighting and fans, and that there are likely opportunities for reducing the electrical consumption and demand in the building.

Electrical load for the airfield lighting is shown in Figure 9. The airfield lighting does not operate during daytime hours (except during low visibility events), but it operates during the early morning and late evening hours when the air traffic control tower is occupied. Thus, airfield lighting runtime is longer when the days are shorter in the winter, leading to higher electrical usage.

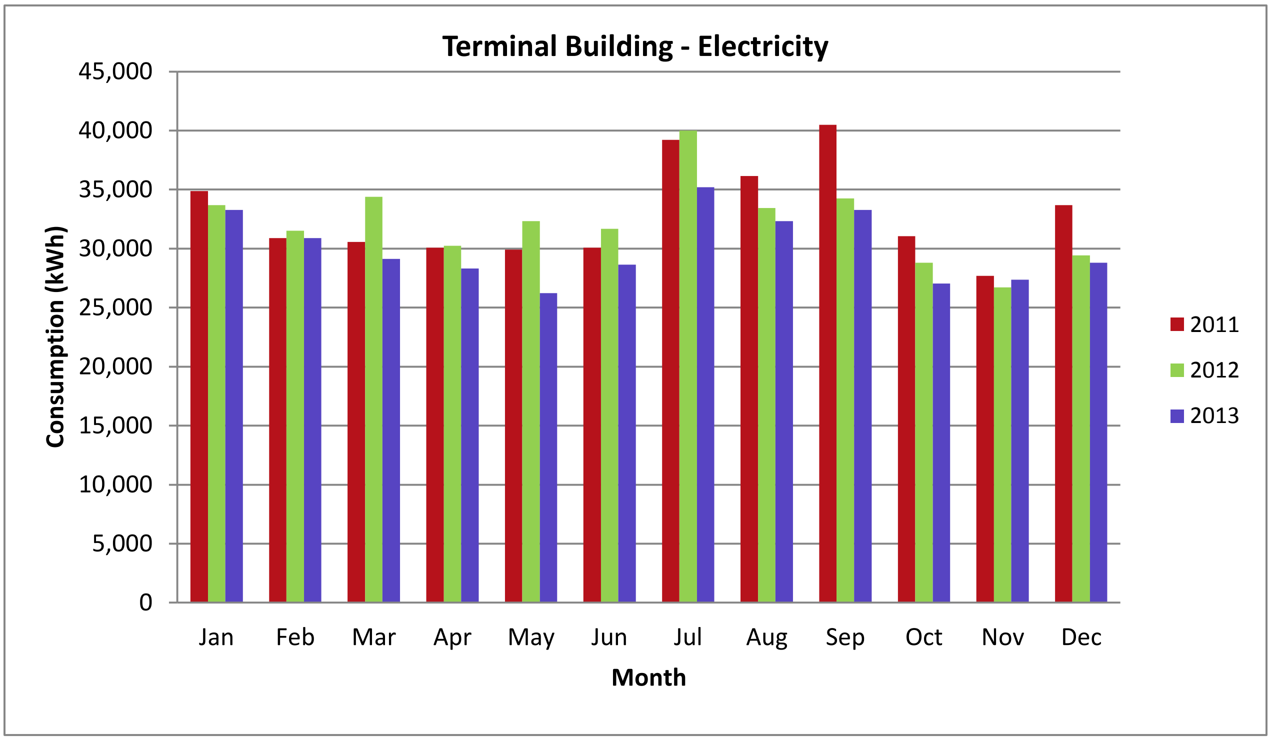

Figure 7 – Electricity usage for the Terminal.

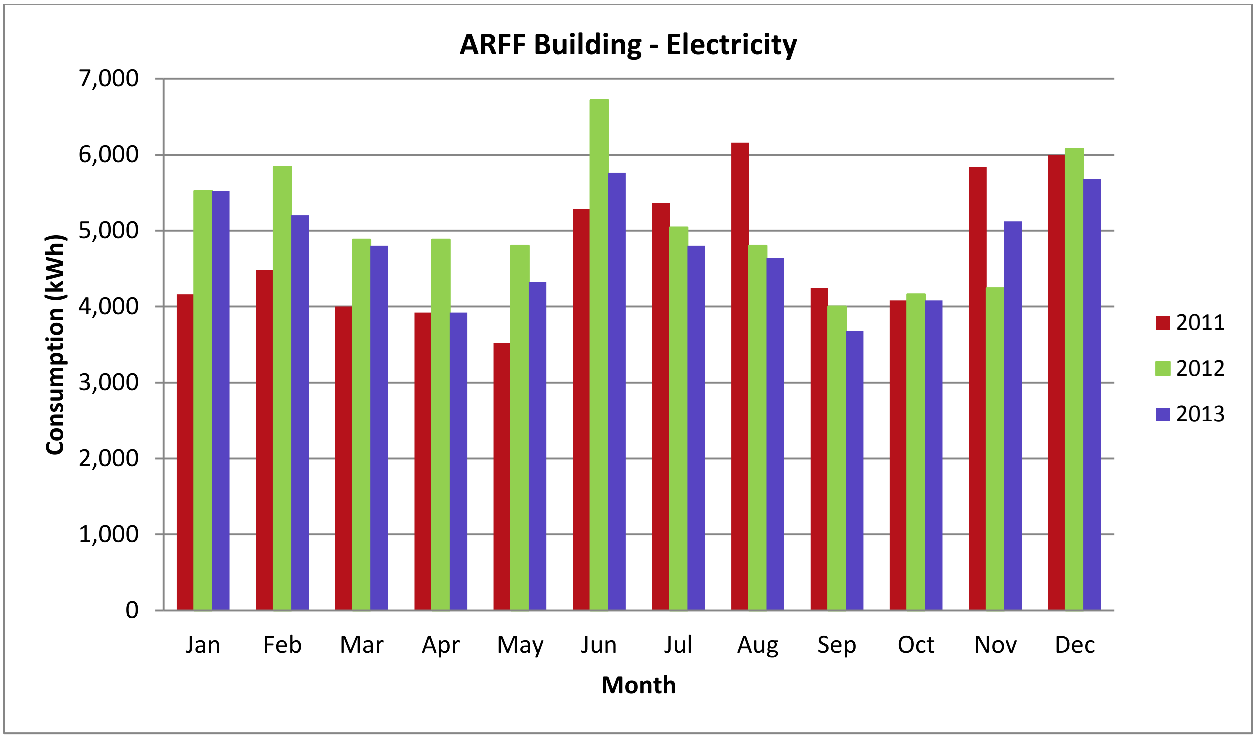

Figure 8 – Electricity usage for the ARFF.

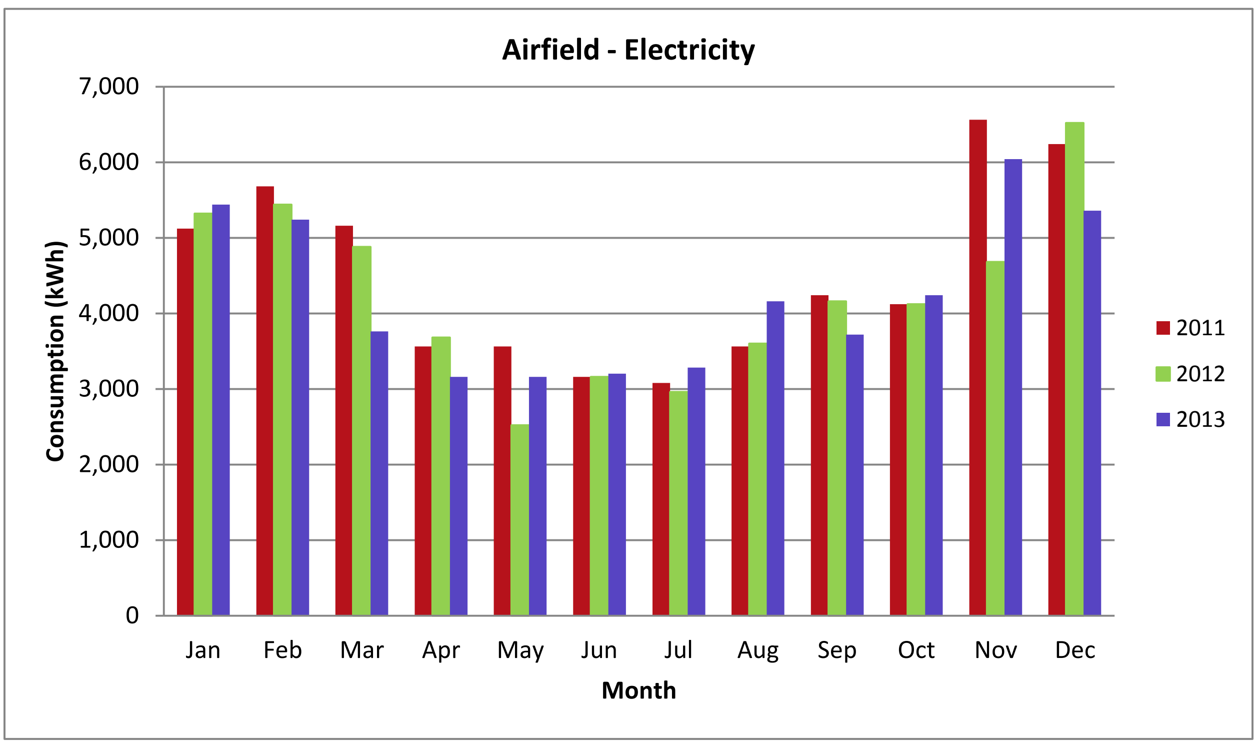

Figure 9 – Electricity usage for the airfield lighting.

TERMINAL BUILDING

The terminal building was originally constructed in 1993 and is 27,815 ft². An addition/remodel has been done on the security area since the original construction, but other building changes have been minor, including replacing HVAC and lighting as needed.

ENVELOPE

The Terminal is a combination of steel, concrete, and wood structural elements. Wall and roof assemblies were observed in sampled areas around the building. The wall assemblies were found to be steel stud cavity walls with R-19 fiberglass batt insulation. The wood truss roof is insulated with R-30 fiberglass batt insulation. In many locations the fiberglass insulation is not adequately supported in a roof or wall assembly and sections of fiberglass have fallen out. These areas of the building are also without air and vapor barriers, resulting in energy loss and condensation in some areas.

The majority of the windows throughout the Terminal are aluminum framed, double-glazed with an aluminum spacer. These windows are a mix of operable and fixed windows, but the operable windows typically remain closed throughout the building. Upper windows located in the atrium appeared to have some automatic opening controls but these controls are not used.

Windows located in the second floor administrative area are single pane with a storm window covering on the exterior. Frames on several of the administrative area windows are not airtight due to deteriorating gaskets around the glazing and openings at the joints around the frames.

There are four main entrances at the front of the building. Each entrance contains a vestibule with motion-activated sliding doors. The gaskets on these doors appeared to be functional.

Figure 10 – Typical wall-to-roof insulation detail in areas of the building with a pitched roof.

Figure 11 – Typical roof insulation detail in areas of the building with a flat roof.

Figure 12 – Example of air gap in window frames in the administrative area.

Figure 13 – Double pane window typical throughout the non-administrative areas of the Terminal.

Figure 14 – Automatic window controls on the upper windows in the atrium that have been abandoned.

Figure 15 – One of the four sliding door vestibules.

HVAC

There are eleven furnaces (F-1 through -11) that are of varying vintages to supply heating and cooling to the majority of the Terminal. Each unit serves a single zone controlled by a single thermostat. The units are atmospheric vented, non-condensing gas-fired with 150 MBH capacity burners for heating. Cooling is provided by cooling coils with 5 Ton (60 MBH) roof mounted condensers (C-1 through -11).

Two of the furnaces are installed above the administrative area ceiling to serve the second floor lobby and administrative spaces. These furnaces are hard to service or replace and are the only original furnaces remaining in the terminal.

The remaining nine furnaces serving the first floor of the Terminal are installed in four mechanical closets distributed around the building. These furnaces have been replaced in varying phases between 2006 and 2011, and condensers have been replaced at the same time as the furnace units. The furnaces in the mechanical closets have a plywood and sheet metal plenum box on their return that is shared in common between two or three furnaces. The plenum boxes have had outside air intakes in the past for ventilation air, and it appears that economizer controls had been fitted to these outside air intakes, but it was observed that many of the damper controls are disconnected and the outside air intakes are blanked off.

Two rooftop units (RTU-1 and -2) serve the security area next to the central lobby. The units contain 150 MBH gas-fired burners for heating and 6 Ton (72 MBH) integral cooling coils. Each unit has a 1 HP supply fan and is controlled by a single thermostat on the west wall of the security area. These units were installed when the security area was remodeled in 2008. The rooftop condenser units appear to be well maintained and in working order, though some of the rooftop condensers fins are exposed to the weather and show weather or hail damage.

Figure 16 – Example of two furnace units.

Figure 17 – RTU-1 and RTU-2 serving the security area.

Figure 18 – Example furnaces with return plenum box and outside air damper.

Figure 19 – The typical programmable thermostats for furnace and rooftop unit control.

Figure 20 – An example of an outside air intake for a return plenum box that has been blanked off.

Figure 21 – The typical rooftop condensers serving the furnaces.

Equipment[1]	Serves	Heating Fuel	Heating Capacity [MBH]	Estimated Efficiency	Cooling Capacity [MBH]	Estimated Efficiency [SEER]	Date Installed	Remaining Lifespan [yrs][2]
Rooftop Units								
RTU-1	Security Area	Natural Gas	150	81%	72	10.5	2008	14
RTU-2	Security Area	Natural Gas	150	81%	72	10.5	2008	14
Furnaces and Condensers								
F-1 / C-1	Kitchen	Natural Gas	150	80%	60	10	2011	15
F-2 / C-2	Car Rental Offices	Natural Gas	150	80%	60	10	2011	15
F-3 / C-3	Baggage Claim Offices	Natural Gas	150	80%	60	13	2011	15
F-4 / C-4	Baggage Claim Lobby	Natural Gas	150	80%	60	13	1993	0
F-5 / C-5	Security Area	Natural Gas	150	80%	60	13	1993	0
F-6 / C-6	Central Lobby	Natural Gas	150	80%	60	13	2008	12
F-7 / C-7	Ticketing Lobby	Natural Gas	150	80%	60	13	2008	12
F-8 / C-8	Ticketing Offices	Natural Gas	150	80%	60	13	2009	13
F-9 / C-9	TSA Offices	Natural Gas	150	80%	60	13	2009	13
F-10 / C-10	2nd Floor Lobby	Natural Gas	150	80%	60	10	2006	10
F-11 / C -11	2nd Floor Admin	Natural Gas	150	80%	60	10	2006	10

[1]Some of these unit tags may not be consistent with the tags used in the building. There appears to be an inconsistency between the drawings and the installed units. Since some units are not tagged at all or some units may have been tagged mistakenly during replacement, this report will refer to the units as they are tagged in the drawings.

[2]Equipment average lifespans for air handling units, furnaces, and condensers are from 2011 ASHRAE Handbook—HVAC Applications, Chapter 37 Owning and Operating Costs, Table 4 "Comparison of Service Life Estimates,"included in Appendix D. These estimates are based on statistical averages found, and the lifetimes of specific units may vary significantly.

Table 2 – An inventory of the Terminal mechanical equipment.

DOMESTIC WATER HEATING

There are three electric water heaters in the terminal building: one each for the lobby restrooms, kitchen, and second floor administrative area. The water heater serving the lobby restrooms is original and the kitchen water heater is about one year old. The unit serving the second floor is in the ceiling and it has been shut off, drained, and abandoned due to a leak.

The water heaters are within close proximity to the areas they serve, and no domestic hot water recirculation pumps are installed.

Equipment	Serves	Heating Fuel	Volume [Gal]	Heating Capacity Upper/Lower [Watts]	Estimated Efficiency	Date Installed	Remaining Lifespan [yrs][1]
WH-1	Lobby Restrooms	Electric	30	4500/4500	98%	1993	0
WH-2	Kitchen	Electric	40	4500/4500	98%	2014	12
WH-3	Administrative	Electric	(Abandoned)				

[1]Equipment average lifespans are published in the Equipment Life/Maintenance Cost Survey, which is part of the ASHRAE Owning and Operating Cost Database at www.ashrae.org/database. These estimates are based on statistical averages found, and the lifetimes of specific units may vary significantly.

Table 3 – An inventory of the domestic water heating equipment in the Terminal.

Figure 22 – The water heater for the lobby restrooms.

Figure 23 – The water heater serving the kitchen.

LIGHTING

The lobby areas (1st and 2nd floors) are lit by a variety of lighting types. There are pendant can lights mounted at the ceiling, recessed can lights, up-lights, and decorative street lamps. Half of the pendant light and up-light fixtures have been disconnected at this time based on a previous energy study.

The TSA, car rental, ticketing, administrative, security, and kitchen areas are all lit with 4 foot T8 linear fluorescent lamps. Some of these lamps appear to have been replaced with different color temperature T8 lamps.

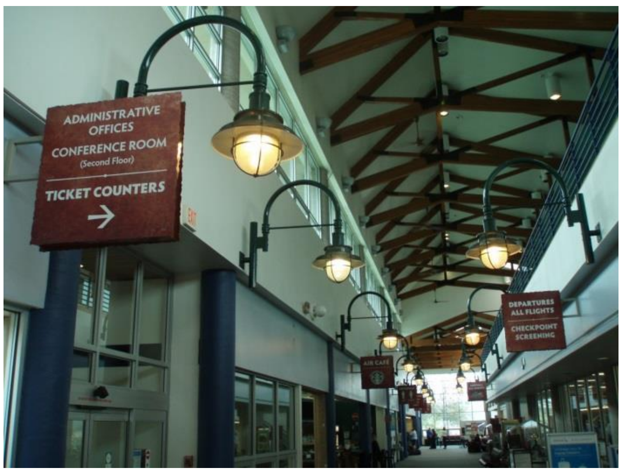

Figure 24 – A variety of lighting types serve the main terminal lobby, including the street lamps and pendant can lights.

Figure 25 – Recessed can lighting in the lobby.

Figure 26 – Linear fluorescent T8 lighting in the ticketing area.

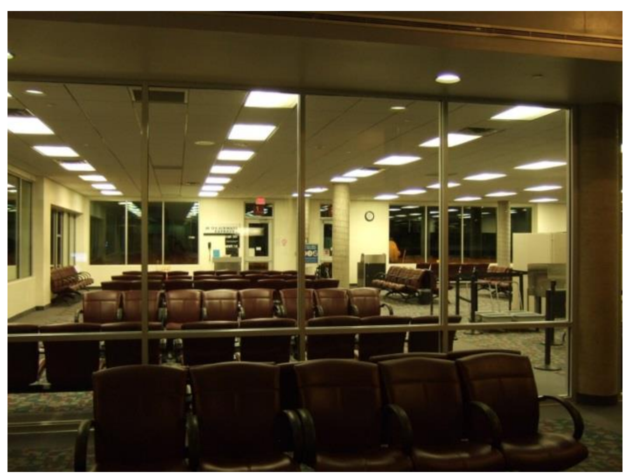

Figure 27 – Linear fluorescent T8 lighting in the drop ceiling in the security area.

Exterior lighting for the terminal includes the entrance canopy lighting and parking lot lighting.

The entrance canopies are lit with compact fluorescent lamps in pendant can fixtures. The terminal parking lot lighting consisted of approximately 50 pole mounted fixtures with low pressure sodium (LPS) lamps. These fixtures appeared to be fully shielded, with the lamp and lens completely recessed into the fixture. Foot candle level in the parking lot at night was measured at 2 footcandles, and lighting was monochromatic orange/yellow typical of LPS.

Figure 28 – An example of pendant can lights in the entrance canopies.

Figure 29 – Entrance canopy lighting at night.

Figure 30 – The LPS fixtures in the parking lot.

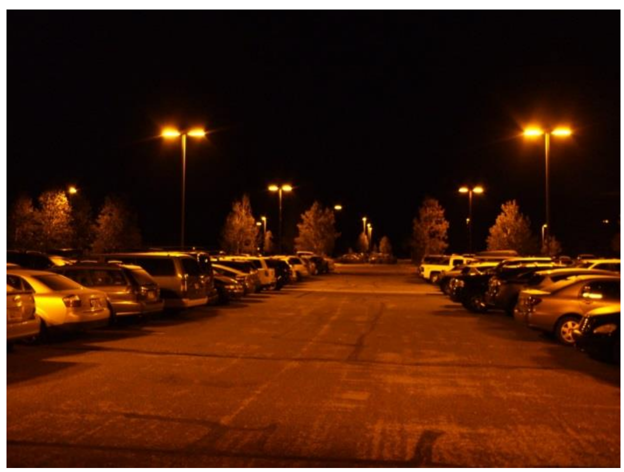

Figure 31 – Parking lot lighting at night.

Interior lighting has local switch control. Occupants are responsible for turning off lighting in offices and other work areas. Lobby lights stay on continuously. Exterior canopy lighting appeared to be controlled by a mix of timer and photocell controls. Exterior lighting in the parking lot is controlled by a photocell sensor located in the north side of the building. This sensor can remain shaded in the late morning hours, and lights were observed on when they are not needed.

Figure 32 – Lighting timers and controls for interior and exterior lights.

Figure 33 – Photocell sensor for parking lot lighting.

Location	Qty	Fixture Type	Nominal Power (W)	Total Power (kW)	Est. Operation (Hrs/Yr)	Energy Used (kWh/yr)
Atrium	58 (half disconnected)	Can Pendant MH	100	2.9	8,760	25,400
Atrium	22	Uplights	Disconnected	0	0	0
Atrium	16	Street Style CFL	23	0.4	8,760	3,200
Atrium	25	Recessed CFL	52	1.3	8,760	11,400
Entries-Interior	19	Recessed CFL	52	1.0		0
Security Area	58	T8 4' Linear Fluorescent	64	3.7	8,760	32,500
Security Area	2	T8 2' Linear Fluorescent	34	0.1	8,760	600
Car Rental	20	T8 4' Linear Fluorescent	64	1.3	5,110	6,500
Restaurant	42	T8 4' Linear Fluorescent	32	1.3	5,110	6,900
Restrooms	4	Recessed CFL	52	0.2	8,760	1,800
Restrooms	10	T8 4' Linear Fluorescent	32	0.3	8,760	2,800
Restrooms	2	T12 3' Linear Fluorescent	30	0.1	8,760	500
2nd Floor Offices	8	T8 4' Linear Fluorescent	64	0.5	2,250	1,200
Entries-Exterior	68	Pendant CFL	13	0.9	5,000	4,400
Parking Lot	49	Pole Mounted LPS	90	4.4	5,000	22,100
Total	-	-	-	**18.4**	-	**119,300**

Table 4 – An inventory of the interior and exterior lighting at the Terminal.

AIRFIELD RESCUE AND FIREFIGHTING (ARFF) BUILDING

The Airfield Rescue and Firefighting (ARFF) building was constructed 2005 and is 11,500 ft². No renovations or equipment replacements have been done since construction. The ARFF building is a slab-on-grade building containing a two-story living quarters for a shift of two to three firefighters on a 24/7 basis. The living quarters consists of dormitory rooms, a workout room, offices and meeting areas, a kitchen, a living room, and bathrooms. The living quarters is flanked by an apparatus bay on each wing of the building for the fire trucks, emergency vehicles, and snow removal equipment.

Figure 34 – The Flagstaff Airport ARFF Building.

ENVELOPE

The ARFF building utilizes CMU wall construction and a mix of steel beam and steel truss structural elements for the roof and other clear span areas like the overhead doors. The walls are insulated with a mix of 2½" rigid foam (approximately R-13) and R-19 batt insulation. The roof is insulated with a mix of 2 ½" rigid foam, R-19 batt, and R-38 batt insulation. The windows are aluminum framed, double glazed.

HVAC

The living quarters is mechanically conditioned by non-condensing furnace units that are gas fired for heating. Cooling is provided by cooling coils with outdoor condensers. These units are controlled by single zone thermostats.

Each apparatus bay is heated by two gas radiant heaters suspended from the ceiling, which heat the space based on a heating call from the wall thermostat. There are also two exhaust fans in each apparatus bay that run for a short period of time after the overhead door closes.

All mechanical equipment is original to the construction in 2005. No issues are currently reported with this equipment.

Figure 35 – Typical furnaces serving the ARFF living quarters area.

Figure 36 – The condenser units on grade next to garage bays.

Figure 37 – Example furnace wall thermostat.

Figure 38 – Gas unit heater serving the garage shop space.

Figure 39 – Radiant heaters in apparatus/equipment bays.

Figure 40 – Apparatus/equipment bay exhaust fans.

Equipment	Serves	Heating Fuel	Heating Capacity [MBH]	Estimated Efficiency	Cooling Capacity [MBH]	Estimated Efficiency [SEER]	Date Installed	Remaining Lifespan [yrs][1]
Furnaces and Condensers								
F-1 / C-1	First floor living	Natural Gas	100	80%	53	12	2005	9
F-2 / C-2	First floor offices	Natural Gas	100	80%	53	12	2005	9
F-3 / C-3	Second floor living	Natural Gas	60	80%	33	12	2005	9
F-4 / C-4	Second floor living	Natural Gas	60	80%	33	12	2005	9
F-5	Laundry room	Natural Gas	40	80%	--	--	2005	9
Unit Heaters								
UH-1	Garage Shop	Natural Gas	45	80%	--	--	2005	4
Radiant Heaters								
RH-1	Equipment bay	Natural Gas	125	80%	--	--	2005	4
RH-2	Equipment bay	Natural Gas	125	80%	--	--	2005	4
RH-3	Apparatus bay	Natural Gas	100	80%	--	--	2005	4
RH-4	Apparatus bay	Natural Gas	100	80%	--	--	2005	4

Table 5 – An inventory of the ARFF building mechanical equipment.

Equipment	Serves	Date Installed	Remaining Lifespan [yrs][1]
EF-1	First Floor Restroom	2005	11
EF-2	Laundry room	2005	11
EF-3	Fire Garage Bay	2005	11
EF-4	Fire Garage Bay	2005	11
EF-5	Equipment Garage Bay	2005	11
EF-6	Equipment Garage Bay	2005	11
EF-7	Second Floor Restroom	2005	11

Table 6 – An inventory of the exhaust fans throughout the ARFF building.

[1]Equipment average lifespans for furnaces, unit heaters, and exhaust fans are from 2011 ASHRAE Handbook—HVAC Applications, Chapter 37 Owning and Operating Costs, Table 4 "Comparison of Service Life Estimates,"included in Appendix D. These estimates are based on statistical averages found, and the lifetimes of specific units may vary significantly.

DOMESTIC WATER HEATING

There are two non-condensing, atmospherically vented gas water heaters in the ARFF building. One serves the kitchen, bathrooms and showers in the living quarters, and the other serves the laundry and garage wash basin areas that are located off of one of the apparatus/equipment bays. The living quarters water heater has a 1/40 HP recirculation pump without controls such as an aquastat or timer.

Figure 41 – Living quarters water heater.

Figure 42 – Laundry and garage wash basin water heater.

Equipment	Serves	Heating Fuel	Volume [Gal]	Heating Capacity [BTU/hr]	Estimated Efficiency	Date Installed	Remaining Lifespan [yrs][1]
WH-1	Living Quarters	Natural Gas	80	180,000	80%	2005	6
WH-2	Garage Wash Basin/Laundry	Natural Gas	65	55,000	80%	2005	6

[1]Equipment average lifespans are published in the Equipment Life/Maintenance Cost Survey, which is part of the ASHRAE Owning and Operating Cost Database at www.ashrae.org/database. These estimates are based on statistical averages found, and the lifetimes of specific units may vary significantly.

Table 7 – An inventory of the domestic water heating equipment in the ARFF building.

LIGHTING

Interior lighting is primarily linear fluorescent T8 fixtures in the garage bays and living quarter corridors and offices. There are a variety of other lighting types in the living quarter areas including can lights, up lights, and ceiling fan fixtures. It was noted that the emergency lighting fixtures required by code provided more than enough light and the wall switches were rarely used.

Figure 43 – High bay fluorescent lighting in the apparatus bay. Some lights stay on for emergency lighting.

Figure 44 – Linear fluorescent lighting with fan ceiling fixture lighting in the office spaces.

Figure 45 – Living quarter lighting includes a wide variety of lighting, including sconce uplights on vertical wall surfaces, recessed can lights in areas with hard ceilings, and ceiling fan lights.

Figure 46 – The kitchen area includes spot lights near the seating area.

Exterior lighting includes a few pole mounted lights, wall pack perimeter lighting, and can lighting. According to the lighting schedules in the construction drawings, this lighting was designed in compliance with the Flagstaff City exterior lighting code and Dark Sky recommendations.

Figure 47 – Exterior recessed canned light with compact fluorescent lamps.

Figure 48 – Exterior recessed canned light with a halogen lamp.

Figure 49 – A fully shielded LPS wall pack fixture.

Figure 50 – A fully shielded LPS pole mounted fixture.

Location	Qty	Fixture Type	Nominal Power (W)	Total Power (kW)	Est. Operation (Hrs/Yr)	Energy Used (kWh/yr)
Living/Dining Area	2	Sconces	60	0.1	0	0
Living/Dining Area	5	Recessed Lighting	52	0.3	2,920	800
Ceiling Fans	3	Incandescent	140	0.4	2,920	1,200
Offices, corridors, closets	27	T8 4' Linear Fluorescent	96	2.6	1,000	2,600
Offices, corridors (24/7)	11	T8 4' Linear Fluorescent	96	1.1	8,760	9,300
Offices, exterior	16	Recessed Incandescent	50	0.8	500	400
Corridors	10	Recessed CFL	52	0.5	1,000	500
Living Quarters	4	T8 4' Linear Fluorescent	64	0.3	1,000	300
Emergency Bay	27	T8 4' Linear Fluorescent	96	2.6	500	1,300
Emergency Bay (24/7)	9	T8 4' Linear Fluorescent	96	0.9	8,760	7,600
Snow Removal Bay	27	T8 4' Linear Fluorescent	96	2.6	500	1,300
Snow Removal Bay (24/7)	9	T8 4' Linear Fluorescent	96	0.9	8,760	7,600
Wallpacks	8	High Pressure Sodium	50	0.4	4,100	1,600
Bollards	4	High Pressure Sodium	50	0.2	4,100	800
Soffit Lighting	13	Recessed CFL	52	0.7	4,100	2,800
Total	-	-	-	**14.4**	-	**38,100**

Table 8 – An inventory of the interior and exterior lighting at the ARFF building.

AIRFIELD LIGHTING

The airfield lighting includes runway, taxiway, and miscellaneous (in-pavement, threshold, and sign) lighting. The vault powering the airfield is located near the ARFF building and Air Traffic Control Tower.

The airfield lighting consists of incandescent 24-inch elevated runway lighting and taxiway lighting. There are approximately (100) runway lights and (260) taxiway lights. A complete airfield lighting inventory is included below.

Figure 51 – An example of a 24-inch runway light fixture.

The airfield lighting is controlled based on schedule, visibility, and flight activity. During the daytime the airfield lighting is normally off unless there is low visibility due to weather events such as snow or fog. After dusk, the airfield lighting is normally on while the air traffic control tower is occupied, which is until 7:00pm October to April and until 9:00pm April to October. At night when the control tower is unoccupied, the lighting is able to be turned on manually via a signal from the pilots of incoming flights. Pilots can select runway lighting power to one of five brightness settings. This after-hours nighttime activity varies day-to-day based on medical, search and rescue, and private/corporate flights, but it was estimated that the airfield lights are on an average of approximately one hour per night.

Location	Qty	Fixture Type	Nominal Power (W)	Total Power (kW)	Est. Operation[1] (Hrs/Yr)	Est. Energy Used (kWh/yr)
Runway	100	Incandescent	120	12.0	1,100	13,200
Taxiway	260	Incandescent	45	11.7	1,100	12,900
In-Pavement	45	Incandescent	200	9.0	1,100	9,900
In-Pavement	6	Incandescent	105	0.6	1,100	700
Threshold	12	Incandescent	200	2.4	1,100	2,600
Signs	180	Incandescent	48	8.6	1,100	9,500
Runway Distance Remaining Signs	9	Incandescent	62	0.6	1,100	600
Total	-	-	-	**44.9**	-	**49,400**

[1]The estimated operating hours was calculated based on the number of tower-occupied hours after dusk, an estimated number of low visibility hours, and an estimated number of nighttime hours.

Table 9 – An inventory of the airfield lighting.

ENERGY EFFICIENCY MEASURES

OVERVIEW

The following energy efficiency measures (EEMs) are recommendations based on observations and conversations from the site visit, as well as information sourced from the drawings. The EEMs were selected based on economic return and overall energy reduction impact.

#	EEM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
1	Terminal – Review HVAC controls and setpoints	3,622	525	$923	$0	$500	0.5
2	Terminal – Install occupancy controls on security area lighting	20,971	0	$2,307	$120	$2,000	0.8
3	ARFF – Replace dimmable can lamps with LED	3,200	0	$512	$42	$630	1.1
4	Terminal – Install vending misers	4,140	-77	$378	$0	$500	1.3
5	Terminal – Relamp linear fluorescent with low wattage T8*	10,329	0	$1,137	$0	$2,112	1.9
5.1	Terminal – Relamp linear fluorescent with linear LED*	26,180	0	$2,881	$448	$8,200	2.8
6	Terminal – Replace pendant can lamps with LED	19,272	0	$2,120	$58	$4,160	1.9
7	ARFF – Relamp emergency light fluorescent with LED	12,614	0	$1,388	$186	$3,010	1.9
8	Terminal – Install daylighting controls on atrium lighting	7,173	0	$789	$0	$2,000	2.5
9	Terminal – Install furnace economizing	46,414	0	$5,106	$0	$20,000	3.9
10	Terminal – Install high efficiency furnaces	0	2605	$2,605	$0	$15,400	5.9
11	Airfield Lighting – Replace incandescent lamps with LED	33,100	0	$9,000	$15,820	$400,000	16.1
12	ARFF – Install controls on hot water recirculation pump	55	24	$33	$0	$300	9.1
13	Terminal – Upgrade exterior lighting controls	4,477	0	$493	$0	$5,000	10.1
	Total:	**165,367**	**3,077**	**$26,714**	**$16,674**	**$455,612**	**10.5**
* EEMs #5 and #5.1 are mutually exclusive with each other. EEM #5 has been assumed for total savings calculations.							

Approximately $40,000 per year of combined energy and maintenance cost savings have been identified, but note that the measures are not necessarily additive because a couple of the measures may carry some overlap or interaction with each other. The estimated installed costs and calculated payback periods do not include external sources of funding, such as federal grants or utility incentives.

EEM #1: Terminal – Review HVAC controls and setpoints

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
3,622	525	$923	$0	$500	0.5

The constant volume furnaces in the Terminal building are currently controlled by single programmable thermostats. These thermostats were installed as part of a previous energy efficiency project, in which unoccupied mode was added and setback temperatures were used. Initially, the setbacks were too aggressive in the cold months and pipe freezing was an issue, resulting in less of a setback.

During the site visit it was noted that several of these thermostats were placed in close proximity of one another and they appeared to control the space temperatures to locally adjusted setpoints. In one location, it was observed that one thermostat was cooling to 68°F and in on an adjacent wall another thermostat was heating to 74°F. This simultaneous heating and cooling may produce a comfortable environment, but at the cost of wasted energy.

There is currently network control of these thermostats, and it is recommended to write an advanced sequence for large spaces with multiple thermostats so that the units serving that space are in sync with one another. Another option would be to remove local control from these thermostats and set them based on a global setpoint so all would be heating and cooling to the same setpoints.

Figure 52 – An example of thermostats in close proximity to each other.

EEM #2: Terminal – Install occupancy controls on security area lighting

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
20,971	0	$2,307	$120	$2,000	0.8

It was observed that the security area lighting in the terminal was on regardless of occupancy or ambient light from the windows. Travelers are only allowed in this space immediately prior to active boarding of flights (within about an hour of each flight). This area is secured and locked during all other times in between flights, so this area is a good candidate for occupancy control. This could be implemented with a motion sensor within the security area or a latch sensor on the security gate that would turn lighting on when the security gate is opened and turn lighting off when the space is vacant.

If some light is needed within the security area for safety or emergency requirements, it is suggested that occupancy controls are installed on as many fixtures as possible.

There is some daylight that enters the space near the perimeter windows, and daylighting controls is an option as well. However, occupancy controls are more cost effective to implement because they would be lower cost to implement, they would affect more light fixtures, and they would turn the lights off for more hours per day.

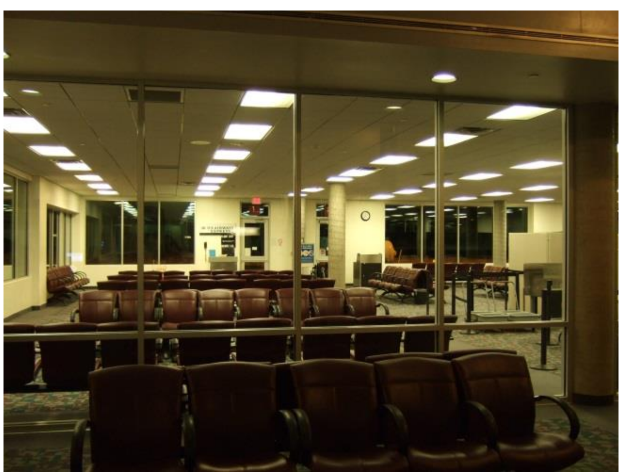

Figure 53 – Security area lights remain on at night, even when the space is empty.

Figure 54 – Security area lights near the windows are candidates for daylighting controls, but this was determined to be less cost effective than occupancy controls.

EEM #3: ARFF – Replace dimmable can lamps with LED

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
3,200	0	$512	$42	$630	1.1

The ARFF building perimeter interior lighting uses incandescent lamps with a dimmer control. A dimmable LED replacement lamp will maintain the dimmable features and save significant energy when these are used.

When changing to a new lamp type such as an LED, it is suggested to try a few at first to determine light output and color temperature requirements. Typically a color temperature of approximately 3000K is used to achieve the warm color of incandescent and halogen lamps. With dimmable LEDs, some dimmer switches need to be checked for compatibility with the LED lamps.

Figure 55 – The current lamps in place for perimeter lighting in the ARFF.

EEM #4: Terminal – Install vending misers

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
4,140	-77	$378	$0	$500	1.3

One of the three vending machines located in the security area had an occupancy sensor (sometimes called a vending miser) currently installed on it. The other two vending machines could use the same strategy, turning the refrigeration off at night and on again for the day.

Vending machines dissipate heat to the surrounding space when they run. Reducing the runtime therefore reduces the cooling load of the space during the summer, but it also increases the heating load of the space. The electricity and gas savings reflect the difference in operation of the cooling and heating systems.

Figure 56 – This soda vending machine would use less energy if it turned off at night with an occupancy sensor.

Figure 57 – The food vending machine on the right contains an occupancy sensor, but the soda machine on the left does not.

EEM #5: Terminal – Relamp linear fluorescent with low wattage T8 or linear LED

#	EEM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
5	Terminal – Relamp linear fluorescent with low wattage T8*	10,329	0	$1,137	$0	$2,112	1.9
5.1	Terminal – Relamp linear fluorescent with linear LED*	26,180	0	$2,881	$448	$8,200	2.8

Currently the Terminal uses 32W T8 4-foot lamps in the linear fluorescent fixtures located in the security, offices, car rental, ticketing, TSA, and restaurant areas. New low wattage T8 lamps use 25 or 28 watts and produce the same illumination as a standard 32 watt T8. Ballast compatibility will need to be checked, but should not stand as a barrier to implementation. At approximately 20 years of life, the lighting system (both lamps and ballasts) starts to fail more frequently and a group re-lamping can be cost effective for energy and maintenance reasons.

Another lighting technology that is viable at this time is linear LEDs, designed to directly replace linear T8 fluorescent lamps. These lamps can run with the existing linear fluorescent ballast in place, have long lifespans, and have dimmable capabilities when paired with correct controls.

Although linear LEDs save more energy and have longer lifetimes, it is recommended to relamp with low wattage T8 fluroescents due to the lower upfront cost and shorter payback.

Figure 58 – T8 fixtures located in the security area.

Figure 59 – T8 fixtures located at the ticketing and TSA areas.

EEM #6: Terminal – Replace pendant can lamps with LED

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
19,272	0	$2,120	$58	$4,160	1.9

Of the 50 pendant can lights hung in the main atrium of the Terminal, 25 have been disconnected by a previous energy initiative. Measuring the light levels at night in the terminal revealed adequate lighting in the space.

The remaining pendant can lights can be changed to more efficient LED lamps to save additional energy and reduce maintenance time for changing failed lamps.

When changing to a new lamp type such as an LED, it is suggested to try a few at first to determine light output and color temperature requirements. Typically a color temperature of approximately 3000K is used to achieve the warm color of incandescent and halogen lamps, but 5000K may be desirable in open spaces like the atrium to get closer to daylight color.

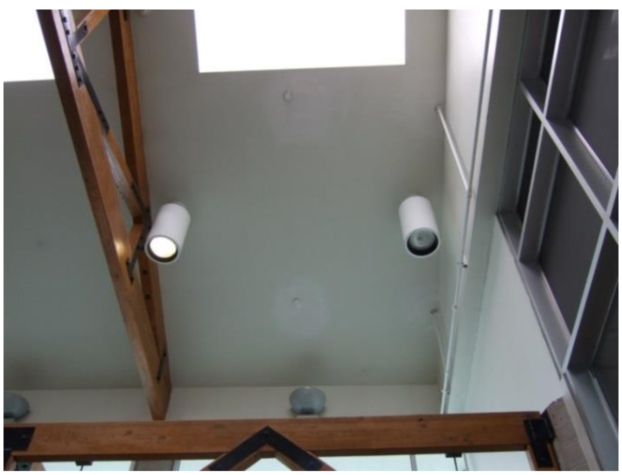

Figure 60 – The pendant can lights in the atrium. Half have been disabled for energy efficiency.

EEM #7: ARFF – Relamp emergency light fluorescent with LED

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
12,614	0	$1,388	$186	$3,010	1.9

Currently the ARFF building uses 32W T8 4-foot lamps in the linear fluorescent fixtures located on the emergency circuit. Because these lights stay on continuously, they are the best candidate for a relamp project with a high efficiency option. Linear LEDs are designed to directly replace linear fluorescent lamps, can run with the existing linear fluorescent ballast in place and have long lifespans. Color of the LED lamps can be matched with the fluorescent fixtures (likely 3500 – 4000K) so a uniform lighting look is achieved.

Figure 61 – The linear fluorescent lights that are on in this photo are a good candidate for relamping with linear LED.

Figure 62 – An example of a T8 linear LED replacement lamp. (Image source: www.cree.com.)

EEM #8: Terminal – Install daylighting controls on atrium lighting

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
7,173	0	$789	$0	$2,000	2.5

The Terminal has large areas of glass, and during the day receives a lot of daylight. Current indoor lighting stays on regardless of light available through the windows. It is recommended to install daylight sensors and switching controls so that atrium lighting is turned on and off to maintain a minimum illumination level depending on available daylight.

Figure 63 – Atrium lighting that could be switched off during the day.

Figure 64 – Overhead windows in the atrium allow daylight to enter the space.

EEM #9: Terminal – Install furnace economizing

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
46,414	0	$5,106	$0	$20,000	3.9

The furnaces currently serving the terminal building were originally designed and built with the ability to bring in outside air. These furnaces originally had a damper and controls that appeared to bring in outside air to economize (i.e., cool the building with the outside air) when conditions were right, for example when the outside air is below 65°F. It is possible these dampers and controls may have also had a minimum position to bring in ventilation air. These outside air openings have since been blocked off and the damper actuator/controls abandoned. Current staff were not sure why these were blocked, but a number of reasons could lead to blocking off these openings:

- Cold outside air temperatures may have resulted in freeze stat trips
- Outside contaminants (jet exhaust, dirt, or other smells) may have been brought into the building due to poor outside air opening placement
- Economizer controls may have failed and brought in air on hot days, overheating the building

Any one of these conditions may have led to the decision to blank off these outside air openings, and must be addressed before economizer operation is started again. Each of these problems can be remedied with proper design and maintenance of the economizer equipment. Because of the Flagstaff's climate, economizing operation could significantly reduce the amount of electric energy need to cool the buildings throughout the year, taking advantage of cool nights in the summer and mild temperatures in the spring and fall.

Figure 65 – Outside air damper and controls.

EEM #10: Terminal – Install high efficiency furnaces

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
0	2605	$2,605	$0	$15,400	5.9

The current furnaces that heat the terminal, even the most recently replaced ones, are standard efficiency (approximately 80% efficient) RUDD units, meeting minimum code efficiency requirements. When the time comes to replace the next group of furnaces, higher efficiency models should be considered. These condensing units can also have variable speed fans to further save energy, increase comfort, and reduce noise. The estimated installation cost of this measure assumes that the high efficiency furnaces would be installed at the end of the current units' service lifetimes. Therefore, the estimated cost is the incremental cost between a high efficiency furnace option and a low efficiency furnace option.

The estimated installation cost includes additional improvements that would be required. High efficiency furnaces are typically power vented and have specific venting requirements (typically 2 to 4-inch PVC pipe) to the exterior, and may also have specific air intake requirements. Furthermore, another condensate drain would need to be installed to discharge combustion condensate to a nearby drain.

Figure 66 – A standard efficiency existing furnace.

EEM #11: Airfield Lighting – Replace incandescent lamps with LED

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
33,100	0	$9,000	$15,820	$400,000	16.1

Current airfield lighting (runway and taxi lighting) is incandescent. Upgrading the airfield lighting would require replacing the existing incandescent fixtures with entirely new LED fixtures. It is assumed that existing wiring and controls would remain the same.

LED lighting has been used in many airfields in the United States and worldwide with a solid track record. They are FAA-approved, durable and long lasting, come in all aviation signal light colors, give off a saturated color appearance, and have low energy requirements. These characteristics lead to reduced maintenance, reduced energy use, and improved airfield visibility.

Figure 67 – LED airfield lighting is available in elevated models like these, as well as in-pavement lights, runway guards, taxiway signs, and many other commonly used types of airfield lights. (Image source: www.ledinside.com).

According to one survey of 22 airports with LED airfield lighting, "Issues With Use of Airfield LED Light Fixtures," (Airport Cooperative Research Program, 2012):

- Airports are experiencing tens of thousands of hours of service life with LED lighting, compared to 2,000 hours for incandescent lighting.
- Airports are using about two-thirds less energy with LED lighting than with incandescent.
- Airports report that LEDs appear more visible to pilots, particularly with blue, green, and white LEDs.

Because the narrowband wavelength results in very little to no infrared heat being given off directly by the LED light, one concern in the industry (including at FLG) has been that LED airfield fixtures might not generate sufficient heat to melt snow and ice, potentially making them less visible in some conditions. This does not appear to be an inherent issue with LED airfield lights because substantial heat can be generated in the LED junction, which must be conducted away from the chip for efficient operation of the light source. Redesigned LED lights that conduct heat from the chip through a heat sink that makes contact with the fixture lens were found to be particularly effective (ACRP, 2012).

Many airports are trying LED lighting out on their taxiways before their runways, and this would be a sensible plan for FLG as well. This would enable the airport to gain familiarity with the lighting in all types of weather conditions, like snow, freezing rain, fog, and various temperatures. It would also provide experience with longevity and compatibility with the existing electrical infrastructure.

EEM #12: ARFF – Install controls on hot water recirculation pump

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
55	24	$33	$0	$300	9.1

The domestic hot water recirculation pump that serves the living quarters of the ARFF building has switch control and currently runs all the time. By placing this pump on an aquastat control, the pump will automatically switch on and off as necessary to maintain the temperature of the hot water loop. Aquastats turn the pump off when the temperature of the water being circulated is hot enough, and turn the pump back on when the temperature needs to be boosted again. These devices are as simple to wire as a switch on the pump, and would have a temperature sensor that would be attached to the insulated hot water return pipe to control the pump.

Figure 68 – The current domestic hot water recirculation pump.

EEM #13: Terminal – Upgrade exterior lighting controls

Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Cost Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
4,477	0	$493	$0	$5,000	10.1

Current lighting for the Terminal parking lot is controlled by a photocell sensor under an overhang on the north side of the Terminal building. It was observed that this sensor location results in the parking lot lights remaining on late in the morning when they provided no additional illumination to the area. The terminal canopy lights also were on during day lit hours, but seemed to be on a different control than the parking lot lighting.

It is recommended to replace the current control panel with a more advanced controller with an astronomical clock. This would allow all exterior lighting (parking lot, canopy, and building exterior) to be controlled together and turn on and off based on changing sunrise/sunset times throughout the year more accurately than a photocell sensor.

The advantage of the photocell sensor is that it can turn lights on during the daytime during low visibility events, such as snowy or foggy conditions. However, LPS lighting does not generally contribute noticeable light during daytime low visibility events, so SEG recommends operating the lights on astronomical clock only. If the airport desires to turn the lights on during the daytime for fog or snow, a photocell sensor could be retained and integrated with the new control panel for this function. The photocell sensor should be relocated or adjusted to measure ambient light levels more accurately.

Figure 69 – The current photocell location under an overhang.

Figure 70 – Parking lot lights remain on late in the morning due to the photocell location.

DARK SKY INITIATIVE MEASURES

This energy audit includes recommendations for outdoor lighting to help the airport become more compliant with or exceed the minimum Dark Sky standards for reducing nighttime light pollution. Due to Flagstaff's unique natural conditions and resources for observing astronomy, it is vitally important to Flagstaff to limit light pollution and maintain their dark skies. Flagstaff was the first International Dark Sky City, and the city has a comprehensive lighting ordinance in place to regulate the types of fixtures and lamps that are used throughout the city. Although FLG is largely in compliance with Flagstaff's ordinance and the Dark Sky standards, the airport has expressed that they are looking for ways to continue to be a good steward and to be a leader by demonstrating Dark Sky best practices. In SEG's discussion with Chris Lugimbuhl, formerly of the Naval Observatory Flagstaff Station, the exterior lighting priorities for dark skies are as follows:

1. Lighting fixtures are to be fully shielded
2. Light emitted is to be in the amber spectrum
3. Light levels are to be no more than necessary for space use

Since FAA regulations pertain to the runway and taxiway lighting at the airport, the Flagstaff lighting ordinance provides an exception for airfield lighting and it was not considered for Dark Sky compliance. However, there are several other areas that are lit – including the building exterior, parking lots, aircraft aprons, and shade/hangar lighting – that were all evaluated for meeting the goals of the Dark Sky initiative as well as the Flagstaff City Outdoor Lighting Standard. Many of the areas of outdoor lighting at FLG already meet the standards for Dark Sky lighting, but some areas can be improved. The results of this evaluation are tabulated below.

Location	Lighting Type	Fixture Shielding	Light Color	Lighting Amount	Dark Sky Compliant	Recommendation
Terminal Parking Lot	Pole Mounted Low Pressure Sodium	Fully Shielded	Warm/Amber	2 foot-candles	Yes, but possibly overlit	Dual light levels based on occupancy
Hangar Lights	Wall Mounted Low Pressure Sodium	Fully Shielded	Warm/Amber	N/A	Yes, but too much light on building	Replace with forward throw fixture
Shade Lights	Linear Fluorescent T8	Partially Shielded	White	N/A	No, not shielded	Add occupancy sensor so usage is minimalized
GA/FBO Apron	Pole Mounted Metal Halide	Partially Shielded	White	N/A	No, not shielded	Replace with fully shielded LED product
Main Terminal Apron	Pole Mounted High Pressure Sodium	Partially Shielded	Warm/Amber	N/A	No, not shielded	Replace with fully shielded LED product

Table 10 – A summary of the non-airfield exterior lighting falling under Dark Sky requirements.

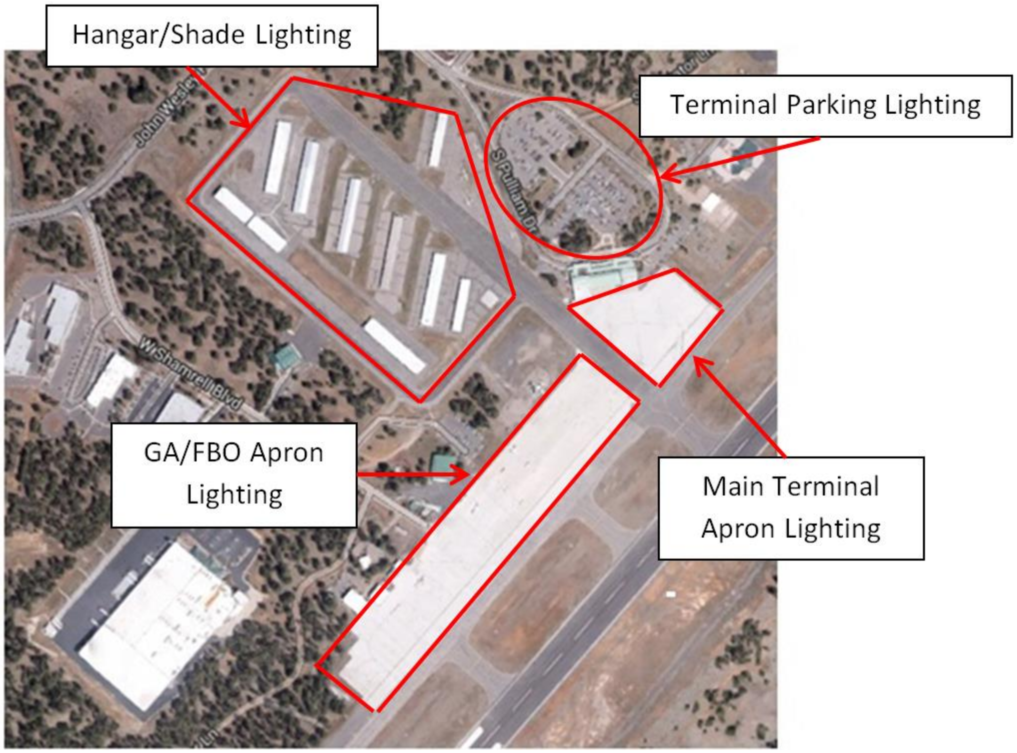

Figure 71 – An aerial photo showing areas of exterior site lighting.

Several recommendations are made in regards to exterior lighting that have an impact on FLG's Dark Sky initiative. These are referred to as Dark Sky Measures (DSMs) because they are evaluated not only on energy and maintenance savings but also by how well they reduce light pollution. The recommendations described attempt to balance implementing shielded fixtures, appropriate lighting color spectrum and illumination levels, and ease of maintenance and energy savings.

#	DSM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
1	Hangars – Replace outdoor lighting fixtures	0	0	$0	$0	$21,000	No Energy Savings
2	Shades – Replace outdoor lighting fixtures and controls	18,072	0	$1,988	$216	$15,000	6.8
3	Aprons – Replace lighting fixtures with LED	11,508	0	$1,266	$420	$12,600	7.5
4	Terminal Parking Lot – Install dual level lighting controls	6,934	0	$763	$0	$17,500	22.9
	Total:	**36,514**	**0**	**$4,017**	**$636**	**$66,100**	**14.2**

DSM #1: Hangars – Replace outdoor lighting fixtures

DSM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
Hangars – Replace outdoor lighting fixtures	0	0	$0	$0	$21,000	No Energy Savings

The hangar lighting consists of LPS wall packs that light the entrances to the hangars. These are fully shielded, but throw much of their light onto the hangar walls. This increases the amount of light that contributes to horizontal glare and does not light the walkway in front of the hangar. A good replacement fixture would be a fully shielded, forward throw wall pack that would provide less light to the hangar wall and more to the walking surface in front of it.

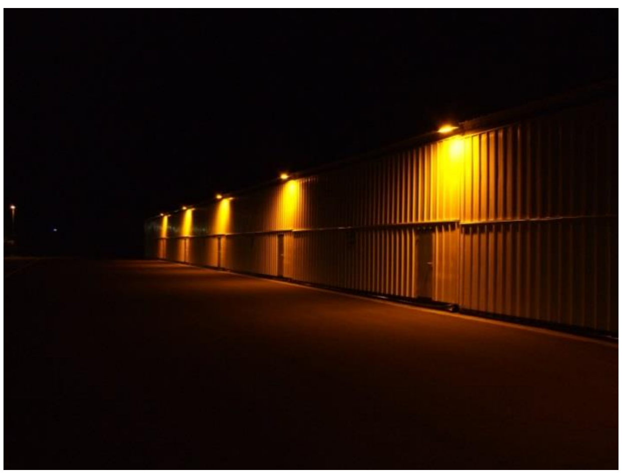

Figure 72 – Example of wall pack lighting around hangars. Much of the light is hitting the walls, which allows it to reflect out to the sky instead of down on the walkway.

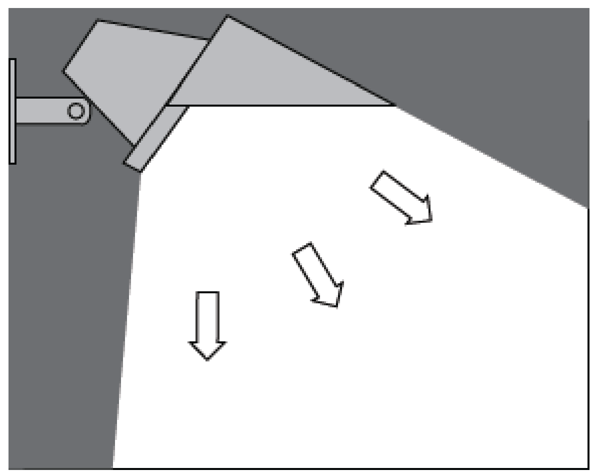

Figure 73 – Fully shielded, forward throw wall pack fixture. This fixture type shields light from the wall and is recommended for the hangars. (Image source: LEED Reference Guide for Green Building Design and Construction, 2009).

DSM #2: Shades – Replace outdoor lighting fixtures and controls

DSM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
Shades – Replace outdoor lighting fixtures and controls	18,072	0	$1,988	$216	$15,000	6.8

The shades are lit with linear fluorescents that are mounted above the parked airplane stalls. It is recommended to install fully shielded LPS fixtures in this area for general lighting and put the linear fluorescent fixtures on occupancy controls. These occupancy sensors would need to be located and adjusted so that any vehicle or person approaching the shade would activate the lights, and leave them on for an adequate time. Upon a time delay, the fluorescent lights would turn back off and the LPS fixtures would provide general lighting.

Figure 74 – Example of linear fluorescent lighting under the shades. These fixtures are unshielded, largely outside of the amber light spectrum, and could benefit from occupancy controls. The LPS lights seen in the background are part of the hangar lighting.

DSM #3: Aprons – Replace lighting fixtures with LED

DSM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
Aprons – Replace lighting fixtures with LED	11,508	0	$1,266	$420	$12,600	7.5

The General Aviation/Fixed Base Operator (GA/FBO) plane apron and parking area is lit with twelve metal halide lamps in pole mounted flood fixtures. These fixtures appeared to be partially shaded with a bezel to limit horizontal throw of the light, but some horizontal glare was still present. The best option to limit horizontal glare from these fixtures would be to move the poles into the apron space, limit the pole height as much as possible, and use fully shielded, downward throw fixtures.

High quality light is recommended in this location for pilot safety. Dark Sky guidelines and the Flagstaff lighting ordinances allow a maximum 10 percent of lumens to come from non-LPS light sources, such as LED, and these non-LPS lumens could be allocated in this location. It is recommended to replace the current fixtures with fully shielded LED fixtures that would provide the right cutoff angle and color spectrum for the needs of the pilots and still preserve the goals of the Dark Sky initiative.

The Main Terminal apron is lit with five high pressure sodium lamps in pole mounted flood fixtures. These two fixtures have many of the same problems with horizontal light glare as the GA/FBO apron. A similar fully shielded LED fixture replacement could be considered for maintenance reasons, while the light output might need to be increased for the larger area needing to be lit.

Figure 75 – The GA/FBO apron is lit with pole fixtures with metal halide lamps.

Figure 76 – The Main Terminal apron is lit with high pressure sodium flood lamps.

DSM #4: Terminal Parking Lot – Install dual level lighting controls

DSM	Electricity Savings (kWh/yr)	Natural Gas Savings (Therm/yr)	Energy Savings ($/yr)	Maint. Cost Savings ($/yr)	Estimated Installed Cost ($)	Payback (yrs)
Terminal Parking Lot – Install dual level lighting controls	6,934	0	$763	$0	$17,500	22.9

It was noted that the parking lot is rarely used late at night or early in the morning (after the last flight arrives and before the first flight starts boarding), but all parking lot lights remain on. This is a good candidate for occupancy sensor controls. The occupancy sensors could be active after the last flight and before the first, and control a portion of the lights so that the light level is low when no one is present and brought up to a higher luminance when motion is detected. Multiple motion sensors would need to be installed and the parking lot lighting split into two circuits for two light levels.

LPS lighting takes a while to warm up, so they would not work well with this strategy. It is recommended to change the lights on occupancy sensor control to an instant-on lamp, such as an LED product. In the interest of FLG's Dark Sky initiative, replacement fixtures should match the existing LPS fixtures in color temperature. A narrow band amber LED or similar would be recommended to achieve this. This concept of using lighting control to reduce light pollution is not included in any current ordinance, and would show leadership and initiative from the airport in keeping lighting levels low at night.

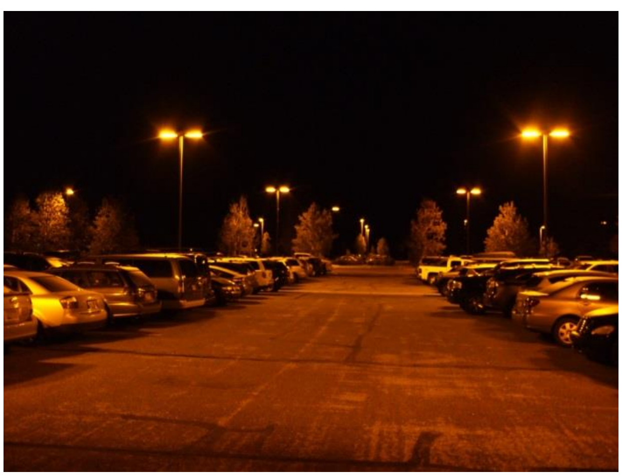

Figure 77 – Pole mounted LPS lamps in the Terminal parking lot.

FACILITY IMPROVEMENT MEASURES

In addition to the measures in the previous section which focused on energy efficiency, this report includes measures to improve the operation and maintenance of the Terminal and ARFF buildings through the following Facility Improvement Measures (FIMs). Some of the recommended measures in this section may carry an impact on reducing energy use, but they were not cost effective on energy savings alone to be listed with the EEMs. However, these FIMs are important in increasing occupant comfort and reducing long-term maintenance costs through equipment and system longevity. The FIMs are not assigned estimates of energy savings, upfront cost and economic return because they are operation and maintenance items that should be considered regardless of energy efficiency. Some measures, particularly FIMs #9 and #10, would be relatively extensive projects that would require further analysis to determine energy savings, upfront cost, economic return, and overall feasibility.

The additional recommended operation and maintenance FIMs include:

#	FIM
1	Terminal – Air balancing
2	Terminal – Air seal doors
3	Terminal – Repair hail damage to condenser
4	Terminal – Repair refrigerant piping insulation
5	Terminal – Repair condensate piping on furnaces and install condensate traps
6	Terminal – Investigate ice buildup on furnace and piping
7	Terminal – Repair water heater exposed electrical terminals
8	Terminal – Install water heater T&P valve
9	Terminal – Replace 2nd story windows
10	Terminal – Add roof ventilation
11	Terminal – Review operation of the heat trace
12	Terminal – Separate kitchen return air from car rental office

FIM #1: Terminal – Air balancing

Several complaints were made in various spaces of the Terminal with regard to too much or too little heating and cooling. Upon reviewing the ductwork design and installation, many of the problems appear to stem from poor air distribution balance at the different diffusers. By hiring a qualified balancing contractor to systematically review the airflows and furnace distribution, flow corrections can be made to make the spaces comfortable with the existing equipment.

Figure 78 – An example of a linear supply air diffuser in 2nd floor lobby (the aluminum register located near the top of the wall and just below the decorative metal roof). No air could be felt moving from these diffusers.

FIM #2: Terminal – Air seal doors

The current baggage claim doors have leaks around the edges that show daylight through them. Repairing or replacing these door seals will reduce the air gaps and provide a tighter envelope against heat loss/gain and drafts.

Other exterior doors in the facility, such as the doors that lead out to the Main Terminal apron, showed air gaps through the weather seals. In addition to letting cold or hot air in, this may contribute to airplane fuel smells in the terminal when planes are waiting to taxi on the apron. These doors appear to be in good shape otherwise, and a cost effective measure would be to replace or add weather seals on these doors.

Figure 79 – Baggage claim door with air leaks around the perimeter.

Figure 80 – Gaps resulting in air leakage were observed on exterior doors, such as this one leading to the apron.

FIM #3: Terminal – Repair hail damage to condenser

Some of the rooftop condenser units with South facing fins show signs of weather and hail damage. This damage will reduce cooling capacity and efficiency of the condenser unit. It is recommended to repair fins with a comb where applicable, and consider replacing coils where damage is severe and beyond repair. A weather screen erected around exposed units would prevent damage in the future.

Figure 81 – An example of weather/hail damage on rooftop condensing units.

FIM #4: Terminal – Repair refrigerant piping insulation

The insulation on the refrigerant piping in several areas throughout the facility was observed to be damaged. One example of this is above the administration office ceiling. The refrigerant piping operates at cold temperatures and it results in condensation, water damage, and possible mold growth when the piping is left exposed. This insulation (and all refrigerant insulation throughout the facility) should be repaired so that it is fully vapor tight to prevent condensation.

Figure 82 – Refrigerant pipe insulation that is damaged above the administrative area. This is resulting in condensation dripping onto the ceiling tiles below.

FIM #5: Terminal – Repair condensate piping on furnaces and install condensate traps

The condensate drain piping from the cooling coil in the furnace serving the TSA office (furnace F-9) is disconnected. This may be resulting in condensate discharge onto the furnace which could damage the furnace. This should be repaired to allow for proper draining of condensate when the unit is in cooling mode.

A second issue with the cooling coil condensate piping that was observed through the facility was that the condensate drains were installed without traps. This results in the loss of conditioned air through the pipe.

Condensate pipes were also observed unsupported, sagging, and pitched improperly. Pipe supports should be added as necessary to achieve this.

Figure 83 – The cooling coil condensate pipe is disconnected from furnace F-9.

Figure 84 – The furnace manufacturer recommends condensate traps to be constructed to the dimensions shown in this diagram.

FIM #6: Terminal – Investigate ice buildup on furnace and piping

Ice and condensation were observed forming on the surface of the refrigerant piping insulation entering the cooling coils of furnaces F-4 and F-5, which serve the baggage claim lobby and the security area, respectively. Ice and condensation were also observed on the furnace cabinet of the cooling coil section of furnace F-4.

It appears that the cooling coil in F-4 is not insulated enough from the furnace cabinet or is in too close of contact with the furnace cabinet. This allows the moisture to collect on the exterior of the cabinet, which will eventually cause pre-mature corrosion.

A second point to investigate with this furnace is that the cabinet wall and insulation surface are achieving cold enough temperatures to freeze the condensation. This symptom is typically due to insufficient airflow through the furnace, incorrect refrigerant charge (possibly due to a refrigerant leak), or a malfunctioning expansion valve. Both the air and refrigerant sides of the system should be investigated. These two furnaces and condensers are the oldest units in the facility (dated from 1993) and it may be time for replacement with high efficiency units.

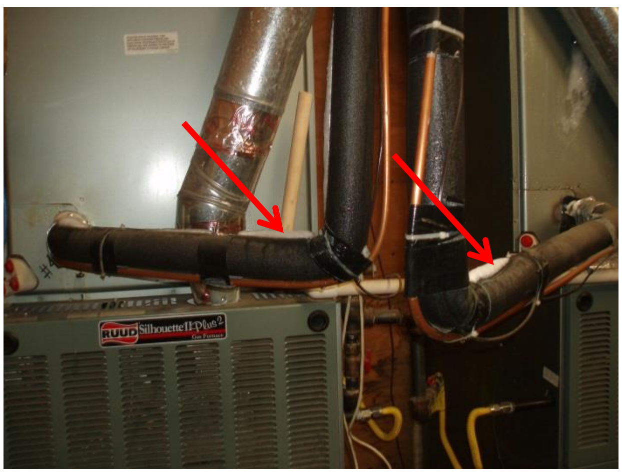

Figure 85 – Ice forming on the surface of the insulation.

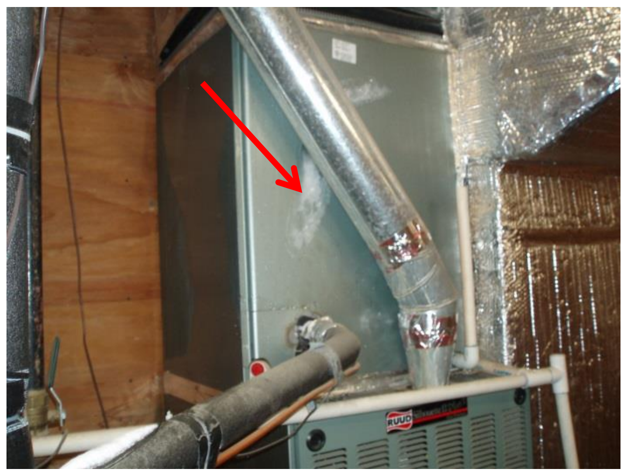

Figure 86 – Ice forming on the exterior of the cooling coil section of furnace F-4.

FIM #7: Terminal – Repair water heater exposed electrical terminals

The water heater serving the 1st floor restrooms has its 240V electrical connections for the lower thermostat and heating element exposed. The manufacturer's electrical cover should be replaced to ensure occupant safety and normal operation of the water heater.

Figure 87 – The main lobby restrooms water heater with exposed heating element electrical terminals.

FIM #8: Terminal – Install water heater T&P valve

The water heater serving the kitchen was replaced within the last year and has been installed without its temperature and pressure (T&P) relief valve. This is a safety device that is designed to discharge water when there are over-pressure or over-temperature events. This is an unsafe operating condition for a water heater and risks occupant safety and property damage.

T&P valves normally come with this type of water heater, so it is unclear why it was not included in the installation. Sometimes the T&P valve discharges water on the floor and causes flooding or water damage. If this was the problem, sometimes it is possible to route the discharge pipe to a nearby sink or drain. Kitchen staff should be notified to watch out for the valve leaking so that the valve can be replaced right away. Local codes should be considered with the installation of T&P valves and their discharge pipes.

Figure 88 – The water heater serving the kitchen is without its T&P valve.

FIM #9: Terminal – Replace 2nd story windows

Airport staff reported cold drafts coming from the second story windows in and near the administrative area, and large gaps were observed around the window frames. These windows are single glazed with a storm window attached to the exterior frame.

There are several options to consider when replacing these windows. One option would be to replace the whole window curtain wall, including the frames. This would allow for the installation of a thermally broken window frame and a high performance glazing system that would provide the most energy savings. The size of the replacement windows could be reduced (meaning that the insulated wall assembly area would be increased), leading to additional energy savings. The cost of the replacement window is unlikely to pay back on energy savings alone during the lifespan of the window or building, but would result in greater occupant comfort.

Another option would be to keep the current framing and replace the glazing area with double pane windows. This would be less invasive to the window system and would cost less, but would leave the uninsulated frames in place, would be less energy efficient, and may not eliminate the convective drafts when it is very cold.

To determine cost effectiveness of this measure, or to determine which of these options would be more cost effective, further investigation would be required. Local window providers should be contacted for options and pricing, and an energy engineer should be consulted to calculate the energy savings and possibly build an energy model.

Figure 89 – 2nd floor conference windows with single panes and storm window coverings.

Figure 90 – Daylight can be seen through gaps between the window and frame, resulting in air leakage.

FIM #10: Terminal – Add roof ventilation

The Terminal roof has several current issues regarding maintenance, energy efficiency, and occupant comfort. Perimeter offices frequently have cold complaints, and ice damming and roof leaks are issues when snow accumulates on the roof. The existing roof design is vented in such a way that the exterior soffits are vented but not the ceiling area, increasing the frequency of ice damming.

Pitched roof insulation was observed in areas of the terminal that have drop ceilings, such as the administrative area and the car rental offices. In many areas, the roof insulation has degraded or fallen out of its cavity, allowing outside air under the roof insulation and into the ceiling areas. This keeps the roof colder and reduces ice damming, but it also results in a poorly insulated roof and increases the energy used to maintain a comfortable environment indoors.

Figure 91 – A view of the pitched roof above the administrative area.

Figure 92 – An example of failing insulation below the roof, allowing cold air to circumvent the thermal barrier. The steel stud wall cavity seen here insulates the space above the ceiling from the space in the overhang.

Ice damming occurs on pitched roofs when snow melts on the insulated portion of the roof and the water refreezes when it reaches the cold overhang. The most important step in reducing the snow melting is to build roofs with a ventilation space between the insulation and roof deck. This allows the insulation to do its job of a thermal barrier, while the ventilation space keeps the roof deck cold and limits the amount of snow melting.

An alternate way to correct ice damming is to add insulation to the roof system. Adding insulation results in less heat loss and less snow melting, but the level of insulation required for this depends on climate and is not well studied. Most guidelines recommend at least R-50 (currently the roof is R-30), but even more insulation may be needed in higher snowfall areas like Flagstaff.

Ideally, some combination of both the ventilation and insulation approaches would be used, but this is also the most expensive route to take. If the project cost proves to be a barrier, it may be more cost effective to implement either the ventilation or insulation strategy instead of both. Due to the lack of data on the amount of insulation required to prevent ice damming, it is recommended to prioritize good ventilation in this roof system over the insulation.

Due to the cathedral ceilings throughout the Terminal, the only way to add ventilation and/or insulation would be to build up from the existing roof deck. This should be investigated and included in any plans for future roof replacements. After the metal roof has been removed, insulation panels, ventilation channels, and additional roof decking can be field assembled before the new roof is installed. Several companies make roof products specifically for the application of adding insulation and ventilation, but this project is still not without challenges. Local builders who are familiar with Flagstaff's climate and experienced with correcting ice damming problems should be consulted for this project.

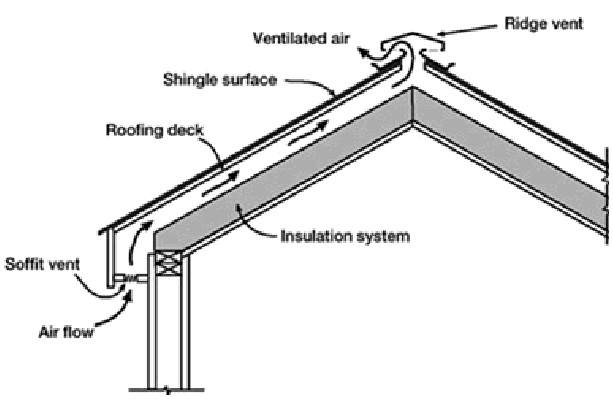

Figure 93 – Ventilation between the insulation system (thermal barrier) and the roof deck helps mitigate ice dams.

FIM #11: Terminal – Review operation of the heat trace

Heat trace has been added to the north eves of the terminal building to help prevent ice damming. Review of the system operation in September showed a few of the heat trace elements were still heating when no snow or freezing weather was present.

Currently, these heat trace circuits are manually turned on and off as needed. It is recommended to install an automatic control that would use outside air temperature and snow detection sensors to switch the heat trace circuits on and off. This recommendation could become obsolete if a roof design correction project was implemented (FIM #10) and ice damming was no longer an issue.

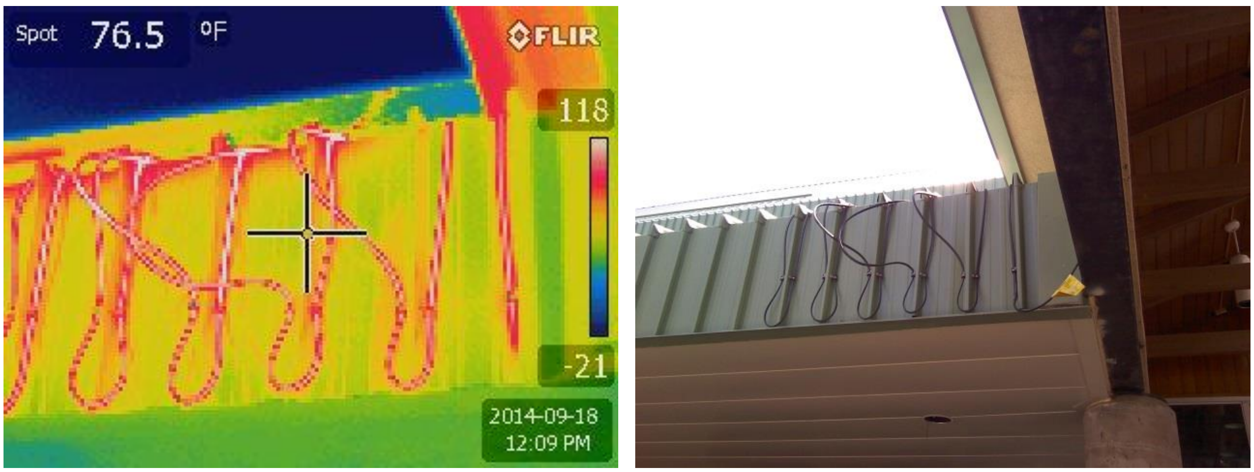

Figure 94 – Infrared thermal image (left) shows that the heat trace (right) is still active when no snow is present.

FIM #12: Terminal – Separate kitchen return air from car rental office

SEG noted that food odors were present when walking through the car rental offices. Occupants reported that this was typical. Upon investigating the kitchen furnace, it was discovered that the two furnaces serving the kitchen and car rental areas shared a common plenum box. Return air from the kitchen is pulled into the plenum box where it is mixed and can be distributed through either of the two furnaces.

Best practice for air distribution would typically isolate the kitchen airflow to the kitchen and not allow it to mix with other spaces. The presence of food odors may be an indicator that other air contaminants such as humidity and combustion byproducts (gases and particulates) are also getting distributed. It is recommended to keep the kitchen return air duct dedicated to its furnace, so that any indoor air contamination generated in the kitchen is isolated to that space and removed through its exhaust and makeup air system.

Figure 95 – The furnaces serving the kitchen and car rental areas share a common return plenum box.

APPENDIX A: UTILITIES FOR TERMINAL, 2011-2013

		Natural Gas		Electricity				Total Site Energy			
	Month	Usage [Therms]	Cost [$]	Usage [kWh]	Cost [$]	Demand [kW]	Cost [$]	Total Cost [$]	Total Energy [kBTU]	kBTU/ft²	$/ft²
2011	Jan-11	3,651	$4,083	34,880	$3,241	70	-	$7,324	484,111	17.4	$0.26
	Feb-11	3,163	$3,417	30,880	$2,895	64	-	$6,312	421,663	15.2	$0.23
	Mar-11	2,365	$2,533	30,560	$2,941	66	-	$5,474	340,771	12.3	$0.20
	Apr-11	1,725	$1,853	30,080	$2,880	64	-	$4,733	275,133	9.9	$0.17
	May-11	1,187	$1,248	29,920	$3,501	67	-	$4,749	220,787	7.9	$0.17
	Jun-11	548	$589	30,080	$3,665	74	-	$4,254	157,433	5.7	$0.15
	Jul-11	206	$233	39,200	$4,581	90	-	$4,814	154,350	5.6	$0.17
	Aug-11	158	$182	36,160	$4,392	90	-	$4,574	139,178	5.0	$0.16
	Sep-11	283	$313	40,480	$4,743	90	-	$5,056	166,418	6.0	$0.18
	Oct-11	807	$861	31,040	$3,868	77	-	$4,728	186,608	6.7	$0.17
	Nov-11	2,001	$2,104	27,680	$2,877	66	-	$4,982	294,544	10.6	$0.18
	Dec-11	2,783	$2,905	33,680	$3,029	0	-	$5,934	393,216	14.1	$0.21
2012	Jan-12	3,112	$3,210	33,680	$3,029	0	-	$6,239	426,116	15.3	$0.22
	Feb-12	2,101	$2,158	31,520	$2,966	0	-	$5,124	317,646	11.4	$0.18
	Mar-12	3,523	$3,519	34,400	$3,053	0	-	$6,572	469,673	16.9	$0.24
	Apr-12	1,886	$1,871	30,240	$2,842	0	-	$4,714	291,779	10.5	$0.17
	May-12	612	$584	32,320	$3,736	70	-	$4,320	171,476	6.2	$0.16
	Jun-12	368	$356	31,680	$3,783	83	-	$4,139	144,892	5.2	$0.15
	Jul-12	185	$188	40,000	$4,610	75	-	$4,799	154,980	5.6	$0.17
	Aug-12	153	$159	33,440	$4,001	78	-	$4,161	129,397	4.7	$0.15
	Sep-12	229	$227	34,240	$4,123	67	-	$4,350	139,727	5.0	$0.16
	Oct-12	2,203	$1,986	28,800	$3,524	59	-	$5,510	318,566	11.5	$0.20
	Nov-12	1,024	$936	26,720	$2,725	58	-	$3,661	193,569	7.0	$0.13
	Dec-12	2,632	$2,365	29,440	$2,834	58	-	$5,199	363,649	13.1	$0.19
2013	Jan-13	4,426	$3,943	33,280	$3,017	61	-	$6,959	556,151	20.0	$0.25
	Feb-13	3,454	$3,126	30,880	$3,200	59	-	$6,327	450,763	16.2	$0.23
	Mar-13	2,516	$2,242	29,120	$3,067	53	-	$5,309	350,957	12.6	$0.19
	Apr-13	2,004	$1,766	28,320	$2,894	56	-	$4,660	297,028	10.7	$0.17
	May-13	975	$863	26,240	$3,324	72	-	$4,187	187,031	6.7	$0.15
	Jun-13	375	$361	28,640	$3,818	86	-	$4,179	135,220	4.9	$0.15
	Jul-13	193	$189	35,200	$4,594	80	-	$4,783	139,402	5.0	$0.17
	Aug-13	254	$242	32,320	$4,255	80	-	$4,497	135,676	4.9	$0.16
	Sep-13	254	$242	33,280	$4,326	66	-	$4,568	138,951	5.0	$0.16
	Oct-13	1,905	$1,677	27,040	$3,571	56	-	$5,248	282,760	10.2	$0.19
	Nov-13	2,388	$1,950	27,360	$2,883	53	-	$4,834	332,152	11.9	$0.17
	Dec-13	4,286	$3,518	28,800	$2,897	54	-	$6,415	526,866	19.0	$0.23
Avg. per mo		**1,665**	**$1,611**	**31,711**	**$3,491**	**60**		**$5,102**	**274,684**	**9.9**	**$0.18**
Avg. per yr		**19,978**	**$19,333**	**380,533**	**$41,896**	**N/A**		**$61,229**	**3,296,213**	**119**	**$2.20**

APPENDIX B: UTILITIES FOR ARFF BUILDING, 2011-2013

	Month	Natural Gas		Electricity		Total Site Energy			
		Usage [Therms]	Cost [$]	Usage [kWh]	Cost [$]	Total Cost [$]	Total Energy [kBTU]	kBTU/ft^2	$/ft^2
2011	Jan-11	1,368	$1,544	4,160	$606	$2,149	150,994	13.1	$0.19
	Feb-11	2,059	$2,316	4,480	$653	$2,968	221,186	19.2	$0.26
	Mar-11	1,727	$1,878	4,000	$590	$2,468	186,348	16.2	$0.21
	Apr-11	1,160	$1,254	3,920	$653	$1,907	129,375	11.3	$0.17
	May-11	890	$987	3,520	$591	$1,578	101,010	8.8	$0.14
	Jun-11	587	$334	5,280	$854	$1,187	76,715	6.7	$0.10
	Jul-11	98	$120	5,360	$856	$976	28,088	2.4	$0.08
	Aug-11	30	$49	6,160	$948	$996	24,018	2.1	$0.09
	Sep-11	25	$43	4,240	$721	$765	16,967	1.5	$0.07
	Oct-11	36	$55	4,080	$612	$666	17,521	1.5	$0.06
	Nov-11	273	$303	5,840	$807	$1,110	47,226	4.1	$0.10
	Dec-11	1,007	$1,070	6,000	$813	$1,883	121,172	10.5	$0.16
2012	Jan-12	1,825	$1,916	5,520	$785	$2,701	201,334	17.5	$0.23
	Feb-12	1,687	$1,752	5,840	$813	$2,565	188,626	16.4	$0.22
	Mar-12	1,782	$1,837	4,880	$730	$2,567	194,851	16.9	$0.22
	Apr-12	1,710	$1,721	4,880	$828	$2,550	187,651	16.3	$0.22
	May-12	1,274	$1,273	4,800	$813	$2,086	143,778	12.5	$0.18
	Jun-12	215	$219	6,720	$1,009	$1,228	44,429	3.9	$0.11
	Jul-12	85	$99	5,040	$849	$948	25,696	2.2	$0.08
	Aug-12	36	$54	4,800	$816	$870	19,978	1.7	$0.08
	Sep-12	30	$49	4,000	$688	$736	16,648	1.4	$0.06
	Oct-12	33	$52	4,160	$628	$680	17,494	1.5	$0.06
	Nov-12	195	$196	4,240	$642	$838	33,967	3.0	$0.07
	Dec-12	1,081	$987	6,080	$829	$1,815	128,845	11.2	$0.16
2013	Jan-13	1,726	$1,558	5,520	$835	$2,393	191,434	16.6	$0.21
	Feb-13	2,842	$2,538	5,200	$810	$3,348	301,942	26.3	$0.29
	Mar-13	2,052	$1,865	4,800	$766	$2,632	221,578	19.3	$0.23
	Apr-13	1,598	$1,431	3,920	$710	$2,142	173,175	15.1	$0.19
	May-13	1,024	$913	4,320	$771	$1,684	117,140	10.2	$0.15
	Jun-13	624	$560	5,760	$965	$1,525	82,053	7.1	$0.13
	Jul-13	73	$94	4,800	$852	$946	23,678	2.1	$0.08
	Aug-13	30	$48	4,640	$828	$875	18,832	1.6	$0.08
	Sep-13	32	$50	3,680	$662	$711	15,756	1.4	$0.06
	Oct-13	57	$71	4,080	$650	$722	19,621	1.7	$0.06
	Nov-13	546	$496	5,120	$800	$1,296	72,069	6.3	$0.11
	Dec-13	1,079	$893	5,680	$846	$1,739	127,280	11.1	$0.15
Avg. per mo		**858**	**$851**	**4,876**	**$767**	**$1,618**	**102,458**	**8.9**	**$0.14**
Avg. per yr		**10,299**	**$10,207**	**58,507**	**$9,209**	**$19,416**	**1,229,491**	**107**	**$1.69**

APPENDIX C: UTILITIES FOR AIRFIELD LIGHTING, 2011-2013

Year	Month		Electricity Usage [kWh]	Electricity Demand [kW]	Electricity Cost [$]		Total Site Energy Total Cost [$]	Total Site Energy Total Energy [kBTU]
2011	Jan-11		5,120	47	$1,133		$1,133	17,469
	Feb-11		5,680	47	$1,201		$1,201	19,380
	Mar-11		5,160	47	$1,152		$1,152	17,606
	Apr-11		3,560	45	$1,031		$1,031	12,147
	May-11		3,560	47	$1,056		$1,056	12,147
	Jun-11		3,160	44	$978		$978	10,782
	Jul-11		3,080	47	$1,002		$1,002	10,509
	Aug-11		3,560	44	$1,042		$1,042	12,147
	Sep-11		4,240	45	$1,139		$1,139	14,467
	Oct-11		4,120	47	$1,067		$1,067	14,057
	Nov-11		6,560	0	$1,335		$1,335	22,383
	Dec-11		6,240	0	$1,284		$1,284	21,291
2012	Jan-12		5,320	0	$1,197		$1,197	18,152
	Feb-12		5,440	0	$1,226		$1,226	18,561
	Mar-12		4,880	0	$1,164		$1,164	16,651
	Apr-12		3,680	0	$1,075		$1,075	12,556
	May-12		2,520	37	$828		$828	8,598
	Jun-12		3,160	38	$921		$921	10,782
	Jul-12		2,960	54	$1,096		$1,096	10,100
	Aug-12		3,600	48	$1,097		$1,097	12,283
	Sep-12		4,160	44	$1,111		$1,111	14,194
	Oct-12		4,120	49	$1,094		$1,094	14,057
	Nov-12		4,680	48	$1,140		$1,140	15,968
	Dec-12		6,520	52	$1,379		$1,379	22,246
2013	Jan-13		5,440	51	$1,304		$1,304	18,561
	Feb-13		5,240	51	$1,283		$1,283	17,879
	Mar-13		3,760	51	$1,123		$1,123	12,829
	Apr-13		3,160	47	$1,061		$1,061	10,782
	May-13		3,160	48	$1,066		$1,066	10,782
	Jun-13		3,200	47	$1,061		$1,061	10,918
	Jul-13		3,280	49	$1,094		$1,094	11,191
	Aug-13		4,160	50	$1,222		$1,222	14,194
	Sep-13		3,720	50	$1,161		$1,161	12,693
	Oct-13		4,240	50	$1,153		$1,153	14,467
	Nov-13		6,040	50	$1,352		$1,352	20,608
	Dec-13		5,360	50	$1,279		$1,279	18,288
Avg. per mo			**4,329**	**47**	**$1,136**		**$1,136**	**14,770**
Avg. per yr			**51,947**	**N/A**	**$13,635**		**$13,635**	**177,242**

APPENDIX D: AVERAGE SERVICE LIFE FOR MECHANICAL EQUIPMENT

Equipment Item	Median Service Life, Years: Abramson et al. (2005)	Median Service Life, Years: Akalin (1978)	Equipment Item	Median Service Life, Years: Abramson et al. (2005)	Median Service Life, Years: Akalin (1978)	Equipment Item	Median Service Life, Years: Abramson et al. (2005)	Median Service Life, Years: Akalin (1978)
Air Conditioners			**Air Terminals**			**Condensers**		
Window unit	N/A*	10	Diffusers, grilles, and registers	N/A*	27	Air-cooled	N/A	20
Residential single or split package	N/A*	15	Induction and fan-coil units	N/A*	20	Evaporative	N/A*	20
Commercial through-the-wall	N/A*	15	VAV and double-duct boxes	N/A*	20	**Insulation**		
Water-cooled package	>24	15	**Air washers**	N/A*	17	Molded	N/A*	20
Heat pumps			**Ductwork**	N/A*	30	Blanket	N/A*	24
Residential air-to-air	N/A*	15[b]	**Dampers**	N/A*	20	**Pumps**		
Commercial air-to-air	N/A*	15	**Fans**	N/A*		Base-mounted	N/A*	20
Commercial water-to-air	>24	19	Centrifugal	N/A*	25	Pipe-mounted	N/A*	10
Roof-top air conditioners			Axial	N/A*	20	Sump and well	N/A*	10
Single-zone	N/A*	15	Propeller	N/A*	15	Condensate	N/A*	15
Multizone	N/A*	15	Ventilating roof-mounted	N/A*	20	**Reciprocating engines**	N/A*	20
Boilers, Hot-Water (Steam)			**Coils**			**Steam turbines**	N/A*	30
Steel water-tube	>22	24 (30)	DX, water, or steam	N/A*	20	**Electric motors**	N/A*	18
Steel fire-tube		25 (25)	Electric	N/A*	15	**Motor starters**	N/A*	17
Cast iron	N/A*	35 (30)	**Heat Exchangers**			**Electric transformers**	N/A*	30
Electric	N/A*	15	Shell-and-tube	N/A*	24	**Controls**		
Burners	N/A*	21	**Reciprocating compressors**	N/A*	20	Pneumatic	N/A*	20
Furnaces			**Packaged Chillers**			Electric	N/A*	16
Gas- or oil-fired	N/A*	18	Reciprocating	N/A*	20	Electronic	N/A*	15
Unit heaters			Centrifugal	>25	23	**Valve actuators**		
Gas or electric	N/A*	13	Absorption	N/A*	23	Hydraulic	N/A*	15
Hot-water or steam	N/A*	20	**Cooling Towers**			Pneumatic	N/A*	20
Radiant heaters			Galvanized metal	>22	20	Self-contained		10
Electric	N/A*	10	Wood	N/A*	20			
Hot-water or steam	N/A*	25	Ceramic	N/A*	34			

*N/A: Not enough data yet in Abramson et al. (2005). Note that data from Akalin (1978) for these categories may be outdated and not statistically relevant. Use these data with caution until enough updated data are accumulated in Abramson et al.

Source: 2011 ASHRAE Handbook—HVAC Applications, Chapter 37 Owning and Operating Costs, Table 4 "Comparison of Service Life Estimates."

SUSTAINABILITY PLAN

FINAL REPORT

Mead & Hunt

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