



ICAO

ENVIRONMENT

A Focus on the production of renewable energy at the Airport site

ECO AIRPORT TOOLKIT



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1. FOREWORD

The Paris Agreement, adopted in December 2015 has the central aim to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Individual countries or Parties will have to nationally determine their contribution to these targets, and all sectors of society will need to contribute. Decarbonising society is an essential element of this strategy. Renewable energy sources, such as solar photovoltaic panels, wind turbines, and geothermal systems, are pivotal to its success.

In addition to the carbon emissions reductions, renewable energy sources are often lower in emissions of other air pollutants that impact local air quality. Implementing a renewable energy strategy has other potential benefits for airports such as utility cost savings, a more reliable source of energy, and positive community engagement.

The primary audience for this document includes States, civil aviation authorities, and airports including tenants, particularly those without dedicated environmental departments or staff. This document is the first in a series of practical and ready-to-use information documents to support the planning and implementation of airport infrastructure projects that envisage significant environmental benefits. Each of these publications will provide a high-level overview and introduction to a specific topic related to environmental planning at airports, including an extensive list of resources where more in-depth information can be found. The documents are intended to be readily updated as new information becomes available and will be accessible from the ICAO Environment website as an e-collection.

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What are some of the benefits of renewable energy for my airport?

- Produces fewer life-cycle emissions than fossil fuels.
- Can supplement the purchase of non-renewable energy.
- Can reduce operating costs.
- Can reduce your airport's carbon footprint.
- Can reduce uncertainty in power supply.
- Contributes to regulatory compliance.
- Offers potential for revenue generation.
- Offers potential local air quality benefit.
- Contributes toward climate resilience.

2. WHAT ARE RENEWABLE ENERGIES?

Renewable energy is defined as energy from a source that is not depleted when used. Solar, wind, geothermal, hydro, and some forms of biomass are common sources of renewable energy.

They differ from fossil fuels (i.e., petroleum, coal and natural gas), which result from the transformation of organisms over millions of years making them a non-renewable source of energy.

Renewable sources of energy are used to produce electricity, heating, cooling and to fuel various means of transportation. Electricity is essential for the operation of an airport, and renewable energy increases the options available to airports for their energy needs. Most airports in developed countries buy electricity from a power provider, making energy use a major operating cost for the airport. Ensuring energy is used efficiently is a basic cost control measure.

Renewable energy has additional benefits: it produces fewer emissions and reduces the environmental footprint¹. In addition, installing renewable energy generation technologies on site at an airport can lower the carbon footprint without the construction of a large-scale power plant. For example, when sited correctly, solar panels on rooftops can supplement the purchased electricity with minimal impact to airport operations. How airports can make maximum use of renewable energy depends on the type of airport, the geographic location, and resources available. Not all energy sources have the same technical and operational characteristics. Therefore, depending on the end usage, the source of renewable energy or the energy mix will differ. In some cases, power providers will offer both renewable and non-renewable energy contracts for purchase.

Decisions for increased investments in renewable energy result from a combination of factors. One potential factor is the increased difficulty of production and price volatility of fossil fuels, whereas governments or private companies may decide to enhance their energy security and minimise their financial risks by reducing their dependence on fossil fuels. In States with growing energy needs, energy security is considered an essential element of future growth and prosperity.

In parallel, the carbon footprint of fossil fuels is also a strong incentive to move towards a more environmentally sustainable energy mix. Burning fossil fuels results in the release of greenhouse gases that contribute to climate change and results in the release of local air pollutants that deteriorate local air quality.

In addition, the average costs of wind and solar electricity, two major sources of renewable energy, have been significantly decreasing in recent years and could fall 59% by 2025, according to a study published in June 2016 by the International Renewable Energy Agency (IRENA). This change in costs could incentivize airport operators to invest in renewable energy sources².

Concerns about future energy supply, climate change and air quality are significant for airports. As key components of the global transportation infrastructure network, airports are similar to other public and private entities in their strategic demand for a stable and sustainable energy supply. To explore how airports can achieve this, the following section introduces the airport sector's energy uses.

Safety

Safety risk assessments should be performed, and operational impacts should be assessed before installation of any renewable energy source. For instance, "the Dutch Airline Pilots Association (ALPA) supports the use of renewable energy sources, considering that they operationally fit. However, they highlight that the design and installation should always be preceded by a risk analysis, specific

¹ Based on data collected from international airport Greenhouse Gas (GHG) inventories, building energy consumption is often one of the most significant sources of GHG emissions that is under the direct control of the airport.

² http://www.irena.org/News/Description.aspx?NType=A&mnu=cat&PriMenuID=16&CatID=84&News_ID=1452

for each installation."³ On the same line, the British 'Honourable Company of Air Pilots' has also published practical information for pilots regarding windfarms effects on radars.⁴

3. ENERGY USE AT AN AIRPORT: A SNAPSHOT

Airports are facilities similar to small or medium-sized cities. Accordingly, they need energy to operate their infrastructure and to provide their services. Airport systems have a high electrical energy demand due to unique requirements of airport buildings and facilities – such as terminal air conditioning, pre-conditioned air and power at gates, powering of many appliances, and other systems specific to airports such as baggage handling systems and airfield lighting. Airports are hubs of regional economic activity and are a critical link in regional transportation networks. Thus the safe, economic and most importantly, reliable provision of electricity at airports is of great importance.

Airports of all sizes must offer a minimum level of service requiring the use of energy to ensure the safe and efficient operation of flights. The most common energy uses at an airport are:

- Airport terminal: lighting, heating and cooling (air conditioning) and appliances (baggage handling systems, terminal bridges)
- Airport airside: runway lighting, auxiliary power units (APUs) and aircraft ground energy systems (AGES), ground vehicles (from airport operators, ground-handling companies and firefighting services) and airside facilities such as hangars.

An energy audit⁵ can help an airport operator to understand its energy usage, and be strategic about investments into energy efficiency technologies. For example, if the boilers that heat water are a large source of energy consumption for an airport, then replacing that system with a geothermal or solar water heating system could be of a high priority to reduce operational costs. Alternatively, an airport operator may wish to list energy conservation measures that it would like to pursue (to achieve cost or emission savings), and make sure that airport staff and management work towards and support those goals. Once an airport operator understands its energy usage and where the best and most cost-effective opportunities for improvements are, the airport may consider investments in renewable energy projects.

4. THE RATIONALE FOR INVESTING IN RENEWABLE ENERGY

Renewable energy projects are known to provide multiple benefits for an individual airport in addition to the environmental benefits stretching beyond the airport site itself. Benefits of renewable energy projects may include:

Operational reliability and risk mitigation

Depending on project design and ownership structure, operational reliability may be enhanced as a consequence of more consistent energy flows, making shortages and adverse effects on operational

³ Solar Panel Installations at Airports. Dutch ALPA. Available at: <https://www.vnv.nl/publications/solar-panel-installations-at-airports>

⁴ Windfarms and the Practical Pilot. The Honourable Company of Air Pilots.

Useful websites: <https://www.caa.co.uk/windfarms>

<https://www.nats.aero/serices/information/wind-farms/>

<https://www.gov.uk/mod-safeguarding>

<http://airspace-safety.com>

⁵ An energy audit is a study that indicates the largest uses of power at an airport, the origin of energies and energy transformations.

performance less likely to occur. If the renewable energy installation is owned or otherwise controlled by the airport, and the energy generated stays on-site (and is not dependant on an external electric grid), then it provides a risk mitigation measure to the airport and its wide range of users for whom a steady supply of energy is crucial.

If designed and developed with potential impacts from climate change are taken into account, renewable energy projects can increase the resiliency of an airport. A range of considerations should be taken into account when developing the airport's energy strategy and associated infrastructure, including:

- Potential for changing temperatures, which can affect airport infrastructure or the future energy needs of airports. That is, more extreme temperatures will either demand more cooling or more heating of airport buildings, and this is necessary to include in airport energy planning.
- More extreme weather such as higher levels of precipitation or increased storm surges, may be a concern for airports in many regions of the world.

Price volatility management

Price volatility of key commodities such as energy, can be a cause of frustration for any airport operator, particularly because airport operators have limited ability to predict or influence energy costs. In contrast, renewable energy generated on-airport is controlled by the airport and can be more predictable in terms of supply and cost.

Legislative and regulatory compliance

Some States may have legislative and regulatory compliance requirements that can be met or addressed with on-site renewable energy projects. By investing in a renewable energy supply, an airport may proactively address standards, policies and other compliance elements, whilst being at the forefront of the operating environment. Some States may also have regulatory incentives such as subsidies and tax-breaks for renewable energy that airport operators should consider.

Greenhouse gas (GHG) emissions reduction objectives

GHG emissions reduction objectives are goals for many airports around the world. Renewable energies such as solar and wind are free of direct emissions. By replacing all or a portion of the fossil fuels it uses, an airport can make significant progress towards its GHG emissions reduction goals⁶.

Corporate Social Responsibility (CSR) reporting and stakeholder communications

CSR reporting and stakeholder communications concerning the airport's environmental footprint and broader community engagement will be enriched by commitments to renewable energy. These commitments can demonstrate environmental leadership and underscore it with tangible and effective actions.

Opportunities for additional revenue generation

In rare cases an airport may be able to generate revenue with the production of renewable energy that exceeds its own needs. If enough energy can be generated, airports could sell clean surplus energy production to the surrounding community. This can prove particularly advantageous if nearby communities have different consumption patterns than the airport, such as daytime versus night-time use patterns. Additionally, airports may choose to allow third parties to generate energy on their property through land lease or other arrangements.

5. WHICH RENEWABLE ENERGIES, WHERE?

Investments in renewable energies should be considered alongside broader environmental management. Renewables, in conjunction with a wide range of energy-efficiency improvements, can form a robust framework of measures aimed at further reducing operating costs and diminishing the airport's environmental footprint. Therefore it is useful to consider the use of renewable energies within the context of established standards such as ISO 14001 on environmental management systems and ISO 50001 on energy management, as these are widespread in the airport community already.

Even though constructing a renewable energy installation can reduce an airport's GHG emissions, those measures are typically not the easiest, quickest or most cost-effective options. Frequently, it is more expedient and economically feasible for an airport to implement energy conservation measures. These measures can be done quickly, and reduce its energy demand. Some examples of energy conservation measures can be found in the list below:

- Short-term operational changes
 - » Night-time shut down
 - » Demand response
- Long-term infrastructure improvements
 - » Replacing conventional lighting systems with LEDs
 - » HVAC upgrades
 - » Building insulation/sealing

After considering energy conservation measures the next step is an evaluation of the possibility of producing and using alternative sources of energy. Several renewable energy options exist for airports, including:

- Solar
- Wind
- Biomass
- Hydro
- Geothermal

Initially, it is worth stating that the above energy options and their practical application to the individual airport depends on the airport's inherent physical settings (e.g. geography, geology and climate), combined with operational and economic realities.

Solar

Among the more common and widely applicable renewable energy projects at airport sites are photovoltaic (PV) systems, which convert sunlight into electricity. PV systems have been installed at well over 100 airports worldwide and are well-suited for many existing airport designs due to the vast horizontal surfaces on which they can be installed. They can be mounted on terminal buildings or placed on unused or otherwise unproductive airport property. Some airports have even used the harnessed solar energy to power ground vehicles or to deploy charging stations for electric cars in parking areas.

PV systems that supply power for at-gate operations have furthermore been granted eligibility under the Clean Development Mechanism (CDM) framework. For developing States, a PV project can apply for CDM eligibility and, if approved, earn saleable Certified Emission Reduction (CER)

⁶ The Airport Carbon Emissions Reporting Tool, available free through the Airports Council International can assist an airport in calculating its GHG emissions

credits. These are worthy of consideration as possible financing elements for investing in PV systems for eligible States.

For many airports, PV systems constitute an economically and technically feasible way to increase the share of renewables in the energy supply. In some cases, however, PV systems may present challenges with regards to solar glare, and the airport must consider the operational safety implications for their specific location and proposed project⁷.

Wind

Wind energy is another option for airports, but one that is still relatively novel in its application due to a number of technical barriers with respect to the safety of aircraft operations. Wind turbines, which transform the kinetic energy of the wind into electricity, are capable of meeting substantial electricity needs. Turbine installation and use necessitates extensive safety assessments, as they may be considered (alongside other tall objects) capable of penetrating the navigable airspace in close vicinity to airports and generate interference issues with safety critical communication, navigation and surveillance infrastructure. In light of this, alternative design options may be considered (e.g. wind turbines with vertical axes).

Biomass

Biomass energy is another option for airports depending on the availability of feedstock supply chains. Biomass is an organic material consisting of plant and animal-based residues typically from forestry and agriculture waste. Biomass can also be produced, but sustainability and ethical requirements need to be addressed. Biomass is converted into fuel offering a variety of applications at the airport site, including heating and cooling of terminal buildings and electricity generation.

The fact that biomass derives from a comprehensive (and progressive) list of materials makes it necessary for the individual airport operators identify the relevant sources that are most feasible to its operational and commercial context. For example, biomass waste at an airport can be transformed into energy for subsequent heating and cooling applications, while another airport can obtain energy from locally-sourced abundant resources such as wood waste (proper management of biomass is important to prevent issues related to wildlife management).

Hydro-power

Hydro-power is also a potential source of renewable energy at airports. The electricity is created in a process by which high water pressure forces a turbine to spin. The water flow can be controlled and electricity output altered to match the airport's needs. This option would require a location near a water source.

Geothermal

Finally, geothermal energy systems are diverse in terms of energy extraction methods and end-uses and are capable of heating and cooling airport buildings. For terminal heating and cooling, airports can pump low-temperature water from underground water tables for circulation in on-site air heating and cooling systems. If the water reservoir is boiling hot (usually in the very deep underground) the steam can be captured to drive a turbine for electricity generation. However, these options are highly contingent on the airport's geological conditions. The greater part of these systems are below the ground and therefore do not disrupt aeronautical operations (provided that the facility above ground is not blocking visual and navigational aids), though, they are often complex to install. Consequently, airport projects with geothermal energy are typically most worthwhile executing in combination with the construction of new facilities or a major refurbishment of existing airport structures.

Accessing renewable energies

The different types of potential renewable energy projects described in this document will have varying levels of complexity, economic feasibility and benefits for individual airports. It is clear from the brief outline of these options that launching a renewable energy project is a complex task. Renewable energy projects can have implications on core aeronautical operations, or may be impractical for financial and technical reasons. As a result the airport should consider all these perspectives before pursuing changes to energy production and consumption within airport boundaries.

If development of an on-site renewable energy project is not financially or operationally feasible, an airport can buy alternative energy from off-site producers or their utility provider through a power purchase agreement or through the purchase of renewable energy credits, e.g. district heating from biomass or electricity from an adjacent wind farm. These considerations are also underscored by the degree to which energy storage is available for the different forms. It might therefore be useful for the airport to adopt a portfolio-based approach to fulfilling its energy needs and utilizing multiple sources of energy. These decisions will often be influenced by the airport's regulatory environment.

6. BEFORE YOU START

This section includes a range of elements to consider prior to launching a renewable energy project at an airport. First and foremost, it should be stated that safety concerns are absolutely paramount in any decision-making process. The costs, benefits and risks of each type of project should be fully considered and alternative design options may need to be explored.

Embarking upon an airport renewable energy project requires project management. It necessitates thorough planning and clear objectives from inception. Since airports are sophisticated self-contained communities with myriad stakeholders and operators, any project should clearly outline responsibilities of the individual agents along with the required action. In this process, it is critical that airports understand and comply with their regulatory requirements.

The environmental benefits that the project is expected to yield should be accounted for as accurately as possible and weighted against the economic costs involved, in order to assess the cost-effectiveness of the chosen measure(s). It is important that the project is viewed from a holistic perspective to detect any adverse impacts that may arise as a consequence of the measure. Finally, the project should consider practical matters such as a realistic timeframe and deadlines. For a more structured description of how an airport renewable energy project can be prepared, please consult Table 1 below.

Element	Content
Situation	States the baseline or the problem to be addressed.
Goals	Describes the energy initiative and the anticipated goals.
Responsibilities	Identifies who is responsible for the implementation (airport operator, concessionaire, external contractor).
Interfaces/partners	Describes which other partners are involved or need to be addressed.
Legal compliance	Confirms legal compliance or describes initiatives required to achieve it.
Airfield Safety	Assesses the impact on the safety at the airfield and confirms conformity.

⁷ See Solar Panel Installations at Airports. Dutch ALPA. Available at: <https://www.vnv.nl/publications/solar-panel-installations-at-airports>

Element	Content
Environmental benefits	Qualifies and quantifies the emissions reductions by this measure (GHG and local air pollutants).
Economic costs	Quantifies the costs associated with the implementation of the measure or combination of measures (investments and operating costs) under consideration and the relative cost-effectiveness of available options, noting that there could also be cost savings associated with the measure.
Interdependencies	Describes potential trade-offs or interdependencies (GHG emissions vs primary energy demand) and provides options to mitigate them.
Implementation	Gives some limited guidelines on how to implement the measure.
Time frame	Sets time frames or even deadlines for implementation.
Evaluation	Gives an evaluation of the measure and a recommendation for implementation.

Table 1 - Structured description of measures (modified from the ICAO Doc 9889)

- Are there any potential trade-offs, interdependencies or non-benefits?
- What is the timeline and deadlines?

Case studies can be found from the following airports:

- Aéroports de Paris
- Stockholm-Arlanda Airport
- Cochin International Airport
- Denver International Airport
- Galapagos Seymour Airport
- Austin-Bergstrom International Airport
- Portland International Jetport (Portland, Maine)
- San Diego International Airport:
- Vancouver International Airport

7. RENEWABLE ENERGY CASE STUDIES

While the information presented in this document provides an overview of the reasons to consider renewable energy and the different types of renewable energies currently available, each airport's individual circumstances are unique, and States and individual airport operators will need to conduct an analysis of their specific situation to determine which projects are feasible and / or desirable.

To illustrate the range of different projects available, a series of case studies follows demonstrating a number of renewable energy initiatives from around the world. While these examples are specific to the locally available sources of energy produced and the regulatory environment in those specific locations, they provide an overview of considerations, costs and benefits, and lessons learned.

Key questions to consider as you review the case studies:

- What are the largest users of power at your airport? Consider an energy audit to identify them.
- What are your top energy conservation priorities? Don't consider renewable energy in isolation - consider a wider energy management framework.
- Who is responsible and who needs to be involved? Identify and engage the right stakeholders.
- What are your objectives? Do you want to generate your own or purchase renewable energy?
- Which renewable energy sources do you have access to implement or purchase?
- Which will work best for you? How expensive? Carry out a cost-benefit analysis.
- Will it work in practice? Carry out a safety assessment and project feasibility study.

ANNEX I: AVAILABLE SOURCES OF INFORMATION

The global airport industry, along with many other industries or organizations have developed and published many materials with respect to renewable energy or the energy management at airports in general. A very short selection is displayed in the following table.

Title	Description
ICAO	ICAO Doc 9184 Airport Planning Manual , Part 2
ICAO	ICAO Environmental Report 2016 http://www.icao.int/environmental-protection/Pages/ENV2016.aspx
IEA	International Energy Agency http://www.iea.org/
IRENA	International Renewable Energy Agency http://www.irena.org/home/index.aspx?PriMenuID=12&mnu=PriPriMenuID=12&mnu=Pri
WBCSD	World Business Council for Sustainable Development http://www.wbcsd.org/home.aspx
Airport Carbon Accreditation	http://www.airportcarbonaccreditation.org/
ACI PRP Handbook	Airport Council International: Policy and Recommended Practices Handbook (2016) http://www.aci.aero/About-ACI/Policies-Practices
SAGA Database	Sustainable Aviation Guidance Alliance: Database containing more than 900 sustainability initiatives, or 529 initiatives on environment; approximately 100 case studies are spelled out. http://www.airportsustainability.org/
ADV	German Airport Association: Climate mitigation initiatives of German, Austrian and Swiss airports (2015) http://adv.aero/fachbereiche/umwelt/klimaschutz/ http://adv.aero/wp-content/uploads/2015/12/ADV_Klima_2015_Web.pdf
World Bank	World Bank Transport Papers: Air Transport and Energy Efficiency (TP-38, 2012) http://siteresources.worldbank.org/mwg-internal/de5fs23hu73ds/progress?id=2iHryE6UcaEvBz2bsXkQgzvqx9CQ2S4ol3DeQ1BLOGw
TRB ACRP	Transport Research Board/Airport Cooperative Research Program: Report 141 Renewable Energy as an Airport Revenue Source Report 151 Developing a Business Case for Renewable Energy at Airports



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