ICAO

ENVIRONMENT

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

ECO AIRPORT TOOLKIT

Case Studies

Case Studies on Renewable Energy

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Case Study on Renewable Energy

Zurich Airport (ZRH)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Emanuel Fleuti
Organization/Company	Zurich Airport
Job Title	Head of Environment
Email Address	emanuel.fleuti@zurich-airport.com
Telephone	+41-43-816 21 81
Airport *(Name and 3 Letter Code)*	Zurich Airport, ZRH

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Photovoltaic Plant on Passenger Pier

Timeframe (e.g., start and end month/year if applicable): 2 years (2000-2002)

Description: A photovoltaic plant of total 5,800 m2 surface on the roof of passenger pier E provides approx 260 MWh/a

Purpose: Build an environmentally friendly passenger terminal

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(1) Environmental

(4) Political

(2) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Commitment to build an environmentally friendly passenger terminal

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

No.

Step 7: Which department is in charge of the renewable energy development in your organization?

Environment

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

The requirement for an environmentally conscious pier was stipulated in the scope of work for the architectural competition. The architect suggested – among other initiatives – the PV plant. The airport project steeringcommittee awarded the pier design to this architect, honoring all environmental initiatives planned for this pier.

Estimated Cost and Financial mechanisms available:

Initial Investment	CHF 3'000,000
Annual Running Cost	CHF 227,000
Annual Financial Savings	CHF 264,000

Images:

Results (Environmental Benefit/Cost Benefit):

- Energy/fuel benefits
- CO2 / GHG benefits
- Reduction of resource usage
- Community/Public Relations
- Income generation
- Benefit Metrics: 0.86 CHF/kWh
- Annual Energy Savings: 290MWh

Lessons Learned: No hurdles/disadvantages

Case Study on Renewable Energy

Kuala Lumpur International Airport (KUL)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Ir. Mohd Hakimi Uda Ahmad
Organization/Company	Malaysia Airports Holdings Berhad (MAHB)
Job Title	Manager, Energy Management Unit of Engineering MAHB
Email Address	hakimi@malaysiaairports.com.my
Telephone	603-877 77169
Airport *(Name and 3 Letter Code)*	Kuala Lumpur International Airport (KUL)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Solar Photovoltaic (PV) Power Generation System at Kuala Lumpur International Airport (KLIA) Timeframe (e.g., start and end month/year if applicable):

January 2012 – November 2013

Description:

This project is a Development, Design, Engineering, Supply, Installation, Testing, Commissioning, Operation, Management and Maintenance of 10MW Peak Photovoltaic Solar System at KLIA Long-Term Carpark and 4MW Peak Photovoltaic Solar System at KLIA Roof Top Satellite Building- Concession between MA (Sepang) Sdn.Bhd and Business Ventures.

Purpose:

To participate with government initiatives on Solar Photovoltaic power generation system with Feed-in-Tariff (FiT) program. The main purpose of this project is to reduce carbon emission and dependency of electricity grid while supporting the MAHB's Energy Policy in-line with 40% carbon reduction by 2020 as pledged by our Honourable Prime Minister in Copenhagen (COP-15) in December 2009. In Paris conference 2015, the new target reduction is 45% carbon emission by 2030.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(□) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

( ) Political

( ) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Environmental and economic factors are the biggest drivers that encourage MAHB to explore the field of clean energy generation. The environmental factor is strengthen up by MAHB's Energy Policy to improve energy consumption efficiency, reduce utility cost, optimize capital expenditure for energy efficiency and strive to become a world-class energy management in airports industry, which in-line with 40% carbon reduction by 2020 as pledged by our Honourable Prime Minister in Copenhagen (COP-15) in December 2009. While for the economic factors, the potential of the Solar photovoltaic generation revenue via Feed-in-Tariff (FiT) programme that obliged distribution licensee to buy energy from FiT holders based on electricity produced at an attractive rate. The power generated from solar PV system was injected into KLIA electricity grid and utilized for their electricity consumption.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

The MAHB's internal stakeholders engaged during this project are Engineering Division, Planning and Development (P&D), Legal, Procurement Division (PCD), Resident Electrical Engineer MA(S), Land Division, Commercial Division and Financial Division. The external stakeholders engaged during this project are Corporate Season Sdn Bhd and Silverstar Pavilion Sdn Bhd, Sustainable Energy Development Authority Malaysia (SEDA Malaysia)

Step 7: Which department is in charge of the renewable energy development in your organization?

Energy Management Unit of Engineering MAHB & Resident of Electrical Engineer MA(S)

Step 8: Please insert Text and Images of your project/case study below here:

Caption 1 – Installation Works

Caption 2 - Roof Top, Satellite Building KLIA

Caption 3 – Long Term Car Park KLIA (10MW)

Decision-Making Process:

The decision-making process has been done via Board Procurement Committee of MAHB

Estimated Cost and Financial mechanisms available:

The Estimated Cost for this project is at USD 44mil in 2013 and financial mechanism applied in this project was via Feed-in-Tariff program that obliges Distribution Licensees (DLs) to buy from Feed-in Approval Holders (FIAHs) the electricity produced from renewable resources (renewable energy) and sets the FiT rate. The DLs will pay for renewable energy supplied to the electricity grid for a specific duration. By guaranteeing access to the grid and setting a favourable price per unit of renewable energy, the FiT mechanism would ensure that renewable energy becomes a viable and for long-term investment for companies and industries.

Results (Environmental Benefit/Cost Benefit):

This solar photovoltaic project are able to generate electricity at an average of 18,638 MWh electricity per year which contribute to reduce 13,811 tCO_2 per year equivalent to 2,868 houses energy consumption for one year and avoid 6,989 ton of coals burned for power generation. The cost benefit for this project is equivalent to USD 0.6

Million of electricity reduction annually compare to year 2012 as baseline.

Lessons Learned:

The great benefits of this project in term of environmental and financial impact that helping our organization to reduce utilities cost and sustaining a high service level of power system. The CO_2 emission reduction will also contribute to reduce the impact of global climate changes. Therefore, MAHB plan to continue the implementation of this initiative to other airports and contribute towards a greener environment.

Case Study on Renewable Energy

Cochin International Airport Limited (COK)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	A Chandrakumaran Nair
Organization/Company	Cochin International Airport Limited (CIAL)
Job Title	Airport Director & ED-Operations
Email Address	acknair@cial.aero/apd@cial.aero
Telephone	0484-2610004
Airport *(Name and 3 Letter Code)*	Cochin International Airport Limited (CIAL)-COK

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: 12 MWp Solar PV Power plant at Cochin International Airport

Timeframe (e.g., start and end month/year if applicable): NA

Description: ------

Purpose: To see whether the solar power generation can be effectively used for offsetting the huge electricity bills of the airport as well as a message to the world that sustainable energy of the future is solar PV

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(*) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic

(3) Environmental

( ) Political

(2) Social

( ) None

( ) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

The power supply provided KSEB Ltd had increased the cost of the power supplied to the airport around 50% during the revision of power tariffs. Also CIAL had been promoting green initiatives. Hence the subsidy available during that period from Indian Government had been availed to set up a trial plant of 100 kWp for observation purpose. The above plant had been installed successfully during March 2014 and the performance of this plant gave a confidence to further increase the capacity.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

No

Step 7: Which department is in charge of the renewable energy development in your organization?

CIAL have formed a wholly owned subsidiary company named CIAL Infrastructures Ltd for developing such kind power projects which mainly was focussing on generation of power from renewable resources.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: - The proposal from lower management would be approved by the higher management team after discussing the same in details which in turn would be submitted for the approval of the Board of Directors. After the approval of the Board, the work would be tendered after advertising in the newspapers, websites etc. Thereafter opening the tender on the prescribed date, in the normal case lowest bidder would be awarded with the work.

Estimated Cost and Financial mechanisms available: Estimated cost of the work would be assessed primarily based on the market survey and after getting budgetary quotes from vendors. The average estimated cost for the solar installation when it was tendered had been 5.1 Cr per MWp. After opening of the tenders, the final rates would be verified by the financial approval committee and approval would be provided for the work.

Images:

Results (Environmental Benefit/Cost Benefit): The solar PV power is considered as the greenest form of electricity and is a renewable source. Hence is the most environmental friendly installation. According to the environmental protocol, by using solar PV energy, the production of carbon dioxide would be reduced and due to this the presence of it in the atmosphere would come down. This decreases the global warming process which is harmful to the earth's environment. The present cost of the solar PV power has come down to the equivalent of coal power. Hence, it is almost come at par with the normal grid power cost.

Lessons Learned:

1. CIAL had lot of land kept unutilized for years. This land is converted to the solar field which when in need may be after a span of 15years or so can be replaced to the roof tops. By the time the solar plant might have given its payback. So effective land utilization.
2. By decreasing the dependency on the grid, we can help in reducing the carbon emission process

3. Kerala's climate had been believed to be non-solar friendly. But in fact there is not much reduction in the solar irradiation even during the monsoon. It was assumed that due to the extended monsoon season of Kerala solar production would be uneconomical. This myth was busted although some percentage of the productivity would be affected during the cloudy times.

4. The effective use of solar power can actually reduce the losses in the transmission and help in preserving the hydel energy for non-solar time.

5. All the house hold roof tops can be effectively utilised for the production of solar PV power and can become self-sufficient.

6. Where land is not available or costly, the lakes, dams and canals in the state can be utilized for the solar power generation by laying the solar panels above these.

7. The conversion of car parking area with solar powered roofs have advantage that besides getting shadow to the car, electric power can also be produced from the roof.

8. The solar plant area can also be utilized effectively for cultivation for different agricultural products by effectively using the space.

9. The water used for cleaning of the solar modules to wash dust and dirt can be utilised for watering the agricultural plants below.

The land which was previously required to have financial expenditure has turned to revenue earning.

Case Study on Renewable Energy

Narita International Airport (NRT)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Kazuya Tamaki
Organization/Company	Narita International Airport Corporation
Job Title	Senior Manager
Email Address	k-tamaki@naa.jp
Telephone	
Airport *(Name and 3 Letter Code)*	Narita International Airport (NRT)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Solar Power Generation

Timeframe (e.g., start and end month/year if applicable): In operation

Description: The approximately 2,000kW Solar Plant located on airport land adjacent to Narita International Airport began operations in March 2015.

Purpose: Selling electric power

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1is a high priority and 6 is a low priority.

(1) Economic

(2) Environmental

(4) Political

(3) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Feed-in tariff system guarantees that the power supplier buys the photovoltaically-generated electricity. The buying rate of electricity depends on when you join the program. Those who introduced PV earlier can sell electricity for higher price than the later-comers.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Step 7: Which department is in charge of the renewable energy development in your organization?

Department in charge of facility management.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: N/A

Estimated Cost and Financial mechanisms available: N/A

Images: Visit our website to refer Environment Report.

Global Environment Initiatives - Solar Power Generation (Page 23)

http://www.naa.jp/en/environment/environment.html

Results (Environmental Benefit/Cost Benefit): N/A

Lessons Learned: N/A

Case Study on Renewable Energy

Kansai International Airport (KIX)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Hiroya Shintani
Organization/Company	Kansai Airports
Job Title	Manager
Email Address	hiroya.shintani@kansai-airports.co.jp
Telephone	+81-724552176
Airport *(Name and 3 Letter Code)*	Kansai International Airport (KIX)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: KIX Clean Power Energy (Solar and wind)

Timeframe (e.g., start and end month/year if applicable): Operation since February/2012

Description: There are almost 77,000 Photovoltaic panels on the ground and rooftops in the airport and three small window turbines. The total capacity is approximately 12MW. It is possible to reduce almost CO_2 emission by 4600tons/year.

Purpose: To ensure a stable supply of electricity and contribute to prevent global warming. Including the currently running solar power generation, clean energy accounts for 9.5% of the total electricity in the airports. Solar power generation is based on the Feed-in Tariff System for renewable energy. The power by the small window turbines are supplied to some of the street lights.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(*) Solar PV

( ) Solar Thermal

(*) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(4) Economic

(1) Environmental

(2) Political

(4) Social

(6) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

We lease the space for the solar power generation and receive the rental fee form the generator company.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

We set up the environmental policy and engaged to install the renewable energy power inside the airport.

Step 7: Which department is in charge of the renewable energy development in your organization?
Environment management section

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: N/A

Estimated Cost and Financial mechanisms available: N/A Images:

Results (Environmental Benefit/Cost Benefit): Reduction of 4600t Co2

Lessons Learned: N/A

Case Study on Renewable Energy

La Palma Airport (SPC)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Manuel Cantos Sánchez
Organization/Company	Aena, S.A.
Job Title	Quality and Environmental Department
Email Address	Ctra. La Bajita S/N
Telephone	+34 922 42 61 77
Airport *(Name and 3 Letter Code)*	La Palma SPC

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Wind turbines in the Airport of La Palma

Timeframe (e.g., start and end month/year if applicable): Starting in the year 2003 (second semester) until nowadays

Description: Implementation of 2 wind turbines to supply electricity to La Palma Airport.

Purpose: Use of renewable energies instead of non-renewable ones contributing to the sustainable development of La Palma island, declared by the UNESCO as a World Biosphere Reserve.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

( ) Solar PV

( ) Solar Thermal

(X) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(3) Economic

(1) Environmental

( ) Political

(2) Social

( ) None

( ) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, were there any available incentives for the development of such programs? Can you describe it? There weren't incentives for the implementation of this project.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

On 1998 a collaboration agreement was signed between Aena and the Spanish National Aerospace Institute ("Instituto Nacional de Técnica Aeroespacial", INTA) to foster the use of renewable energies and to introduce innovative technologies (solar thermal, photovoltaic and wind power) in Aena´s airports' network.

This framework of reciprocity, allowed Aena to count with an institution of technical prestige, such as INTA, capable of providing the necessary experience to guarantee the quality required for the development of this action.

Another collaborating entity was "Navegación Aerea", the air navigation service provider in Spain, in order to establish the viability of the project in relation to its possible interference with aircrafts operations.

Step 7: Which department is in charge of the renewable energy development in your organization?

Directorate of Planning and Environment of Aena

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

La Palma Airport is located next to the Atlantic Ocean and is exposed to the trade winds with a constant direction and intensity. These conditions facilitate an optimal performance for wind turbines. Therefore, the airport decided to install two 660 kW nominal power wind turbines, that started to generate energy on May 2003 and have not stopped since, making La Palma Airport the first airport in Spain powered by wind energy. The location of this small wind farm on the East zone of the airport does not interfere with the safe operation of the airport.

The energy supplied by these wind turbines is directly used to cover the airport´s electricity demand. However, in order to make full use of the whole energy generated by the wind turbines, La Palma Airport has signed a power supply contract with the local electricity supplier by which all power surplus generated by the airport is then sold

to the electricity supplier and can be resold to other customers. If the power generated by the wind turbines is not enough ‘per se’ to cover the airport’s energy demand, then the local supplier provides electricity to the airport.

The wind turbines facility at La Palma Airport is so successful that the airport is planning to increase the power range of the wind turbines to cover its full energy demand, thanks to the latest technology developments.

Estimated Cost and Financial mechanisms available: N/A

Images:


Taxi
Bus
Public
Car Rental
Europcar
Hertz
AVIS
Sixt

Results (Environmental Benefit/Cost Benefit):

Shown below is the energy balance of La Palma Airport since the entry into service of the wind turbines. Globally,

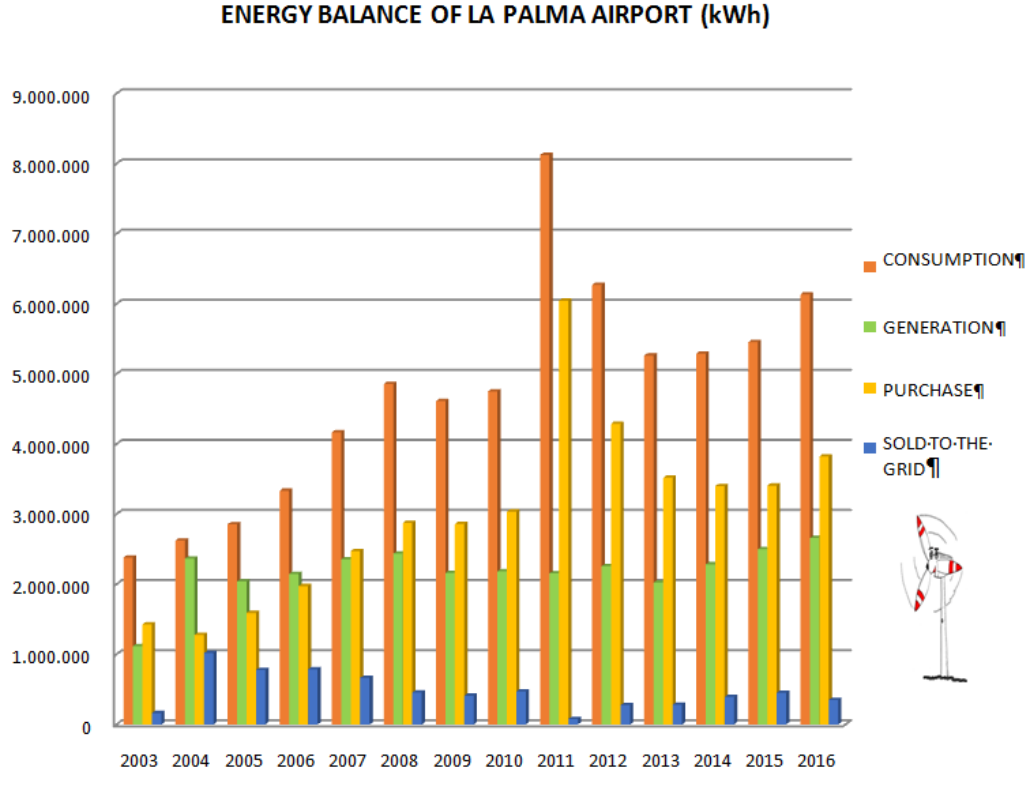
46.4% of the electricity consumption at the airport's facilities is covered by wind energy.

The generation of more than 30,000,000 kWh has allowed the airport to be less dependent on external power supply, which in the case of La Palma Island is derived from fuel burnt in a thermal power plant, and thus preventing the emission of more than 10,285 t CO^2

YEAR	ELECTRICITY CONSUMED	ELECTRICITY GENERATED	ELECTRICITY PURCHASED FROM THE	ELECTRICITY SOLD TO THE GRID (kWh)
2003	2,381,717	1,117,367	1,426,854	162,504
2004	2,623,936	2,366,896	1,275,596	1,018,556
2005	2,856,036	2,041,305	1,590,904	776,173
2006	3,334,726	2,148,791	1,974,160	788,225
2007	4,167,446	2,357,175	2,474,046	663,775
2003	2,381,717	1,117,367	1,426,854	162,504
2004	2,623,936	2,366,896	1,275,596	1,018,556
2005	2,856,036	2,041,305	1,590,904	776,173
2006	3,334,726	2,148,791	1,974,160	788,225
2007	4,167,446	2,357,175	2,474,046	663,775
2008	4,857,621	2,436,542	2,876,475	455,396

2009	4,613,204	2,163,220	2,860,342	410,358
2010	4,751,933	2,184,952	3,038,310	471,329

YEAR	ELECTRICITY CONSUMED	ELECTRICITY GENERATED	ELECTRICITY PURCHASED FROM THE	ELECTRICITY SOLD TO THE GRID (kWh)
2011	8,124,736	2,157,724	6,045,449	78,437
2012	6,271,186	2,257,912	4,289,157	275,883
2013	5,263,420	2,025,519	3,519,967	282,066
2014	5,290,859	2,285,360	3,399,393	393,894
2015	5,455,383	2,500,156	3,407,605	452,378
2016	6,134,676	2,660,905	3,823,924	350,153
TOTAL 2003-	66,126,879	30,703,824	42,002,182	6,579,127



Lessons Learned: Use of wind power at La Palma Airport meant a substantial change in the understanding of power generation in the airports, where reliability of electricity supply is core for safety in aircrafts movements.

Thus, initially it was not an easy project because the acquisition and installation of wind turbines at the La Palma Airport, entailed a great challenge to an organization accustomed to the supply of electricity through the conventional means. Even so, the project went ahead being La Palma airport suitable for the development of wind energy facilities, where trade winds provide high wind potential.

In conclusion, this is a project whose results have had a double benefit. On the one hand, an economic benefit, due the savings obtained by consuming the energy self-generated and on the other hand, an environmental benefit, by the use of a renewable source instead of other non-renewable resources, avoiding the emission of greenhouse gases.

Case study on Renewable Energy

Montreal Pierre Elliott Trudeau International Airport (YUL)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Lyne Michaud
Organization/Company	Aéroports de Montréal
Job Title	Assistant-Director, Environment and Sustainability
Email Address	Lyne.michaud@admtl.com
Telephone	514-633-2698
Airport *(Name and 3 Letter Code)*	Montreal Pierre Elliott Trudeau International Airport

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Closed Loop Geothermal Heat Pump for the Non Passenger Screening Vehicles Building

Timeframe (e.g., start and end month/year if applicable): 1 year (2016-2017)

Description: Construction of a new non passenger screening vehicles (NPSV) building which includes four closed loop geothermal wells of 604.8 ft. deep each amounting for a nominal cooling load of 12 tons.

Purpose: Build an environmentally friendly non-passenger screening vehicles building.

Step 3: Please identify which renewable energy technologies are used at your airport:

(x) Geothermal

( ) Solar PV

( ) Solar Thermal

Step 4: Please identify and prioritize the driver(s) for the renewable energy project.

Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(3) Political

(4) Social

( ) None

( ) Other

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

Commitment to develop an environmentally friendly non passenger screening vehicles building in a lot used as golf course by the municipality.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Yes.

Step 7: Which department is in charge of the renewable energy development in your organization?

Engineering and Terminal Maintenance

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

Taking into account the environmental, social and economic challenges, the geothermal energy feasibility study was conducted by ADM's engineers. A complete life cycle analysis including the payback, energy savings and return on investment calculations was presented to the executive committee.

Estimated Cost and Financial mechanisms available:

Initial Investment	165 000 $ CAD (for the geothermal system)
Annual Running Cost	4 855 $ CAD (energy and maintenance cost)
Annual Financial Savings	9 800 $ CAD

Images:

Results (Environmental Benefit/Cost Benefit):

- Energy benefits
- CO2 / GHG benefits
- Reduction of resource usage
- Community/Public Relations

Lessons Learned:

Geothermal energy is beneficial on a long term horizon. Initial cost is higher than other design options. However, the cumulative cost over the life cycle of the installation is the lowest. This was a pilot project and Aéroports de Montréal is looking ahead to incorporate this technology into various future projects.

Case Study on Renewable Energy

Mumbai International Airport (BOM)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Manisha Barrow
Organization/Company	Mumbai International Airport Pvt. Ltd.
Job Title	
Email Address	
Telephone	
Airport *(Name and 3 Letter Code)*	Mumbai International Airport (BOM)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Installation of roof top solar power plant at Airport premises in BOOT (Build, Own, Operate and Transfer) model.

Timeframe (e.g., start and end month/year if applicable):

Phase	**Locations**	**Capacity (kWp)**	**Date of Completion**
Phase 1	Terminal 1	650	Mar-15
Phase 2	Terminal 2 & Cargo Complex	413	Jun-16
Phase 3	Terminal 1 and Airside (CCR)	1,501	Mar-17
Total		**2,564**	

Description: MIAL being a Brownfield airport, there is shortage of vacant land for installing solar modules. Vacant rooftops of various buildings have been used for installation of solar power plant. The system has been installed on RCC rooftops, metal sheet roofs of Terminal 1, Terminal 2 and Cargo complex buildings.

Purpose: To continually improve the carbon footprint of airport operation and decision of aggressively pursuing solar power installation is a step to promote ecologically sustainable growth and also constitute a major contribution to the global effort to meet the challenges of climate change.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Environmental

(2) Social

(3) Economic

(4) Political

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

The major drivers were environmental and economics. The solar plant is helping in reducing carbon-dioxide emissions by about 2,600 tonnes annually. This is equivalent to planting 4 lakh mango trees and avoiding smoke emitted from 2,000 small cars in a year. This has also reduced our Electricity Bills.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

We have our internal team comprising of E&M, Environment, Procurement, Cargo, Terminal Operations involved in different stages of Project.

The system has been built under the 'build-own-operate-transfer' financial model. The solar plant is owned by a third-party investor and they sell green power to MIAL on per unit basis. The system was installed in 3 phases. Each phase is owned by different investor. The system installation is done by Sunshot Technologies who also taking care of the operation and maintenance of the solar power plant.

Step 7: Which department is in charge of the renewable energy development in your organization?

Engineering and Maintenance

Step 8: Please insert Text and Images of your project/case study below here: Decision-Making Process:

The project feasibility report is being prepared by Engineering and Maintenance department after thorough study of available area for solar installation. This is presented to top management through Environment department. Top Management approves the project for execution; accordingly MIAL procurement in consultation with E&M decides the suitable Agency for project.

Estimated Cost and Financial mechanisms available:

-Per MWp cost varies from Rs. 6 to 8 Crores depending on site constraints and unique design specifications.

-Project installed under BOOT model where, third party invest in the project and operate the plant as per MIAL requirements, however, MIAL make the payment on monthly basis to investor based on generation and power purchase agreement.

Images:

Results (Environmental Benefit/Cost Benefit):

- The solar plant is helping in reducing carbon-dioxide emissions by about 2,600 tonnes annually
- Reduced the electricity demand from distribution company which result in net saving in energy cost by approx 1.8 Crore annually.

Lessons Learned:

- We should always go for the latest PV solar panels having maximum efficiency.
- The roof top solar plants should be planned at the time of construction of the building. This will enable us to get maximum benefit.

Case Study on Renewable Energy

Vienna International Airport (VIE)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	DI Stefan Kovacs
Organization/Company	Vienna International Airport
Job Title	Facility Management Dept.
Email Address	s.kovacs@viennaairport.com
Telephone	0043-1-7007-22392
Airport *(Name and 3 Letter Code)*	Vienna International Airport (VIE)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Installation of 3 PV at VIE

Timeframe (e.g., start and end month/year if applicable): 2016/2017

Description:

1st Unit: roof mounted on object 836, start-up at 22nd of June 2016, 236kWp

2nd Unit: roof mounted on object 239 (Hangar 7), 22nd of June 2016, 273kWp

3rd Unit: roof mounted on object ACC-Ost, start up in October 2017, 715kWp

Purpose: To show our efforts on environmental issues and to reduce VIE´s CO2-footprint.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(X) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(6) Economic

(3) Environmental

(1) Political

(2) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it? VIE has not, and will not get any incentives for installing photovoltaics.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with. No.

Step 7: Which department is in charge of the renewable energy development in your organization? The facility management department is in charge of all supply and disposal issues, and the power supply – and in this case the PV – is part of it.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:N/A

Estimated Cost and Financial mechanisms available:

1st Unit: EURO 400.000

2nd Unit: EURO 430.000

3rd Unit: EURO 1.100.000

Images: N/A

Results(Environmental Benefit/Cost Benefit): amortization time >18years

1st Unit: -180 t CO2/a

2nd Unit: -200 t CO2/a

3rd Unit: -500 t CO2/a

Lessons Learned:

The big challenges are the building permit and the costs of a PV plant on the airport. There are lots of regulations, which have to be fulfilled (working regulation, fire regulation, evacuation regulation, electrical regulation). All these requirements can be achieved, but the side effects are the rising costs of such PV plant. There are also an important issue which has to be careful take into consideration, as the direct glare of pilots and the control tower. These two issues show, that not every roof on an airport can be used for a PV power plant.

Another big cost issue is the connection to the electrical network. If the way to the next input station is too far or difficult to reach (long cable ways, road works, cable ducts) the costs will be higher for such PV plant. These costs can be so high, that the payback period is too long for such investment. The main rules for such PV construction are" the substructure must be simple and cheap - the roof space must be used very efficient (max. capacity kWp) - the ways to the electric network must be short".

Case Study on Renewable Energy

San Diego International Airport (SAN)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Brendan Reed
Organization/Company	San Diego County Regional Airport Authority
Job Title	Director of Environmental Affairs
Email Address	breed@san.org
Telephone	619-400-2785
Airport *(Name and 3 Letter Code)*	San Diego International Airport (SAN)

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: SAN Solar Photovoltaic Project (Phases 1 & 2) Timeframe (e.g., start and end month/year if applicable): 2014-2017

Description: In total, approximately 5.5 megawatts of solar photovoltaic arrays were installed on building roofs and in parking lots

Purpose: The project's purpose was to reduce the San Diego International Airport's greenhouse gas emissions (Scope 2), while reducing long-term utility costs and improving SAN's resilience to utility service disruptions.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(X) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(4) Political

(5) Social

(6) None

(3) Other _Resilience_____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

As a public agency in California, greenhouse gas (GHG) emissions are an increasingly important topic in regards to community concerns and state regulations. Since electricity use is the largest contributor to airport-controlled GHG emissions, renewable electricity represents a significant opportunity to reduce these emissions. In addition, the Airport spends approximately $9 million annually on electricity costs, with rates expected to rise considerable over the next 10 years. The new solar panels (though the Power Purchase Agreement) lock in SAN's electricity rates for a 20 year term, helping to stabilize rates in the long term.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

A variety of internal and external stakeholders were engaged as part of the Solar PV project's development. Key internal stakeholders included airport departments, especially environmental affairs, finance, real estate, facilities development/engineering, and facilities management. Externally, SAN engaged the utility company (for interconnection agreement), a local nonprofit organization (who administers the state incentive program), and the regional planning agency's Environmental Working Group (to share project highlights & benefits).

Step 7: Which department is in charge of the renewable energy development in your organization?

The Environmental Affairs Department is the lead in developing and implementing the Airport's Strategic Energy Plan, which establishes renewable energy priorities and targets.

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: SAN issued a formal Request for Proposals to select a contractor to design and install the onsite solar photovoltaic systems.

Estimated Cost and Financial mechanisms available: While SAN did consider an option to purchase the system outright, the Airport eventually decided to enter into a Power Purchase Agreement with a third-party, who would install, operate, and maintain the system for a 20-year term. In exchange, the Airport would purchase all of the system's generated electricity at a flat rate.

Images:

Results (Environmental Benefit/Cost Benefit): With the new solar photovoltaic arrays, SAN is annually generating approximately 9.3 million kWh of renewable electricity on site (about 20% of the Airport's total energy consumption).

Lessons Learned: Important lessons learned include (1) carefully siting solar energy systems due to their long-term nature, (2) quantifying expected and actual project benefits to help inform and reassure decision-makers, and (3) communicating early and often with the utility company on project details and interconnection needs.

Case Study on Renewable Energy

Darwin International Airport (DRW)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Rhett Nothling
Organization/Company	Northern Territory Airports
Job Title	Head of Projects
Email Address	Rhett.nothling@ntairports.com.au
Telephone	+61 437 984 235
Airport *(Name and 3 Letter Code)*	Darwin International Airport DRW

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title: Darwin International Solar

Darwin Solar Stage 1

Timeframe (e.g., start and end month/year if applicable):

Start date December 2015 - completed May 2016

Description:

Airport Development Group is 'lighting the way' towards a more sustainable future.

In May 2016, Darwin International Airport (DIA) flicked the switch on its new 4MW (megawatt) photovoltaic (PV) solar array, which now provides a significant proportion of the airport's power.

Purpose:

Airport Development Group has made a long term commitment to using renewable energy across its three Northern Territory based airports in Darwin, Alice Springs and Tennant Creek. The Board is mindful of the contribution the aviation industry makes to greenhouse gas emissions, and is keen to lead the way for other airports – both national and international – by reducing its carbon footprint.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

(x) Solar PV

( ) Solar Thermal

( ) Wind

( ) Other

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic with Economic and Environmental being equal

(2) Environmental

(3) Innovation

(4) Political

(5) Social

(6) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, were there any available incentives for the development of such programs? Can you describe it?

DIA's ability to manage and control ongoing costs together with the environmental management and sustainability benefits were the key drivers for this project. The solar farm sits upon a previously cleared area within the OLS (Obstacle Limitation Surface) which needed ongoing maintenance and was problematic due to invasive weeds and pioneer species. The clearing and stabilisation of the site removed the habitat for invasive weed species and the associated surface drainage works moved water off site in a controlled manner. Work included earthworks, storm water drains, access roads and solar modules, with the construction being completed in an impressive period of only five months.

In addition the land was not required for alternative aviation activities, and therefore able to be repurposed, giving both economic return and environmental benefits. Hence the two equal and key drivers are environmental and economic aspects.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Darwin Solar Stage 1was a team effort across Darwin International Airport project managers environment teams, external consultants (Cat Projects) and Head Contractor (UGL) for the project delivery component.

CAT Projects is a Northern Territory based indigenous-owned company which conceived the development and acted as owner, engineer and project superintendent. Engineering and property Services Company UGL engineered, procured and constructed the solar farm.

Extensive negotiations were undertaken by DIA with the Australian Defence Force to ensure compliance with orientation of the PV Array as well as detailed agreements with the local Power and Water authorities to ensure the correct power management strategies were in place to accommodate the array.

Step 7: Which department is in charge of the renewable energy development in your organization?

Infrastructure, Planning and Environment with the project being delivered by DIA's Project Team.

Step 8: Please insert Text and Images of your project/case study below here:

Images: attached at the end of the document. Additional high res images are available upon request.

Click here to view a short film on our solar project http://www.darwinairport.com.au/corporate/c-environment#accordion-0-2

Decision Making Process

DIA is always mindful of its energy use as well as forecasted demand for power associated with future development projects. The key criteria for decision making in this significant capital expenditure was motivated by DIA's ability to manage and control future ongoing costs associated with its energy use.

Some considerations in the decision making process included:

- Project and site selection that would provide maximum benefit and capital return (roof top install vs in ground in situ installations);
- Maximising land use and in this case land considered to have minimum or limited commercial value for development (due to location);
- Maintaining control over costs associated with ongoing energy costs forecast to increase significantly;
- Reduce DIA's carbon footprint in alignment with other energy saving project initiatives;
- Demonstrate commitment to sustainable investment;
- Direct capital costs to DIA's specific initiative and avoid 3rd party substation upgrades to support the airport and airport precinct;
- Reducing and managing peak demand periods; and
- Continuous improvement on similar successful project initiatives recently completed on other Northern

Territory Airport's sites.

Estimated Cost and Financial mechanisms available:

Northern Territory Airports is one of the Territory's largest private sector investors, with its parent group Airport

Development Group owning and operating airports in Darwin, Alice Springs and Tennant Creek.

Its pioneering investment in solar energy is unparalleled for an airport operator in the southern hemisphere. The total value of Darwin Solar Stage 1 was over $10 million and investment in the overall project will be $13million upon completion. The solar array in Darwin is entirely financed by private sector investment and is expected to reduce the airport's power bills by $2million per annum based on current peak tariff rates.

Results (Environmental Benefit/Cost Benefit):

Not only do the environmental benefits manifest with a 25% reduction in carbon emissions from stationary energy, the significant investment of capital towards this project, enables DIA to hedge the exposure of the airport to fluctuations in electricity prices thus providing greater certainty for the broader airport community and interested investors, partners and stakeholders.

Moreover the project provides a basis for the Darwin International Airport Board and Executive to focus attention on energy and how it works as an enabler. This new provision of energy has boosted development for Darwin International Airport and the broader user group and will continue well into the future.

Upon completion of Darwin Solar Stage 2, the system is forecast to meet up to 100 per cent of the airport's peak energy demand in the middle of the day and to generate 25 per cent of the airport's overall energy needs. It will produce electricity equivalent to the consumption of 1,000 average Australian households.

Lessons Learned:

The challenges with a project such as this, and particularly one developed entirely by the airport, are extensive. Darwin International Airport is a joint-user airport with active military users, including international military partners, and a strategic facility as part of Australia's Defence Infrastructure. As such, this project required a level of stakeholder management and engagement unparalleled by other civilian airport projects in Australia.

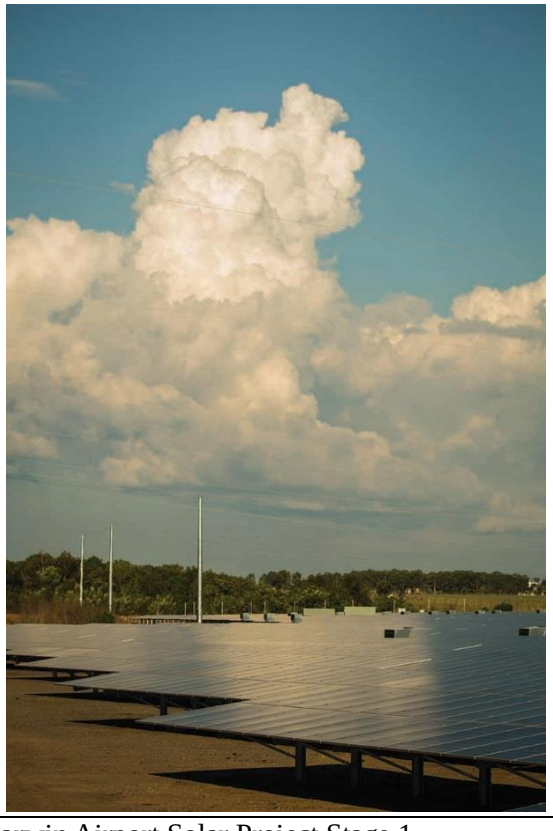
For example, sophisticated glare and glint monitoring tools developed specifically for the project's unique requirements were used; extensive consultation and planning throughout the project, and technical elevation of the design was required.

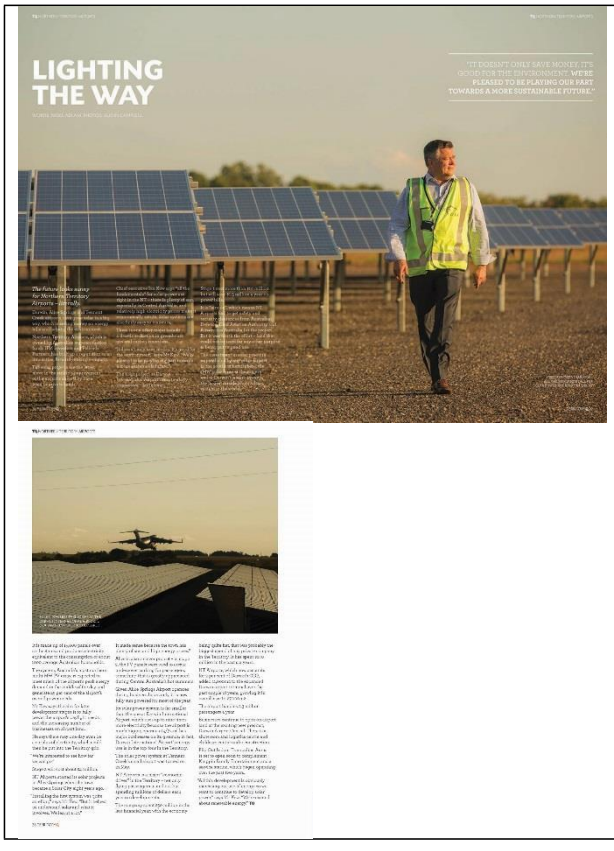
An environmental plan which accounted for the joint-user status was developed, with special consideration of the land being used. As a former wartime airbase and considering the history of Cyclone Tracy, there was a risk of environmental waste being present on the site. As such, ground penetrating radar equipment was used to judge the potential risks of repurposing the land for solar.

To further enhance the environmental benefits of the project, all millings from a previous Runway Resurfacing Project were re-utilised at the solar farm. This highly innovative approach will prevent erosion due to the proposed sediment control and prevent weed growth in the area. By compacting the millings and re-using them on site, DIA also eliminated the need to further store the water on airport land.

The environmental considerations which led to the development of such measures is particularly pertinent considering the airport's close proximity to urban Darwin and conservation buffer zone around Marrara swamp.

The environmental stewardship demonstrated by Darwin International Airport for Darwin Solar Stage 1 further enhances the value of this significant project.

	
Darwin Airport Solar Project Stage 1	Darwin Airport Solar Project Stage 1, before and after



LIGHTING THE WAY

"IT DOESN'T ONLY SAVE MONEY, IT'S GOOD FOR THE ENVIRONMENT. WE'RE PLEASED TO BE PLAYING OUR PART TOWARDS A MORE SUSTAINABLE FUTURE."

Case Study on Renewable Energy

East Midlands Airport (EMA)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Adam Freeman
Organization/Company	Manchester Airport Group
Job Title	Environment Advisor
Email Address	Adam.freeman@manairport.co.uk
Telephone	+44-161-489-3595
Airport *(Name and 3 Letter Code)*	East Midlands Airport, EMA

Step 2: Please provide the following basic information of your Project/Case Study:

Project/Case Study Title:

Wind turbines at East Midlands Airport

Timeframe (e.g., start and end month/year if applicable):
Installed 2011

Description:

Two 45 metre 250kW wind turbines, generating 5% of the airport's electricity needs and reducing annual carbon emissions by 150 tonnes CO_2 each year.

Purpose:

Contribute to the airport company's commitment to carbon neutral operations from 2012 by producing renewable electricity on site.

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

( ) Solar PV

( ) Solar Thermal

(X) Wind

( ) Other _____

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(2) Economic

(1) Environmental

(4) Political

(5) Social

( ) None

(3) Other Securityoverenergysupplyandcost

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentives for the development of such programs? Can you describe it?

In 2006 East Midlands Airport committed to make its ground operations carbon neutral by 2012. The wind turbines helped the airport achieve this target. Whilst the airport's priority is to reduce energy demand, the wind turbines enable the generation of low carbon electricity on site. The project is supported by the UK Government's feed-in-tariffs and provide increased security over both energy supply and cost, generating attractive returns on investment (Internal Rate of Return >11%).

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

A range of stakeholder engagement was necessary to deliver the project.

Internal consultation was extensive, particularly with our engineering and air traffic control teams – who needed to ensure compatibility with electrical networks, and no adverse impacts on radar or communications and that the turbines would not be an obstacle to safe aircraft operations.

Externally, our local community were consulted and found to be supportive of the proposal – they had been engaged with our environmental strategy and carbon neutral commitment through our community relations programmes. Extensive engagement was also needed to demonstrate no risk to aviation safety to the regulator, the UK Civil Aviation Authority.

Step 7: Which department is in charge of the renewable energy development in your organization?

Asset Management

Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process:

In 2006 the airport committed to make its ground operations carbon neutral by 2012. This target was the first of its kind from a UK airport, and followed extensive public consultation on the airport's Master Plan. The plan set out our ambition to become more energy efficient, before sourcing renewable – low carbon – energy and fuel, and then compensating for residual emissions through the purchase of carbon offsets.

After working with wind turbine manufacturers, utility companies and the Civil Aviation Authority to demonstrate a business case for investment – a capital project of £1.1m was approved.

Estimated Cost and Financial mechanisms available:

Over its 20 year life time, the project provides an 11% internal rate of return.

Images:

Results (Environmental Benefit/Cost Benefit):

- Providing certainty over secure energy supply, at a known and stable cost
- Generating 5% of airport's electricity requirements from on-site renewable technology
- Reducing annual carbon emissions by 150 tonnes CO_2
- Highly visible statement of the airport's commitment to sustainability.
- Supporting education initiatives by the airport, providing case studies for schools and colleges using the on-site education facility.

Lessons Learned:

- Local community more supportive of the project than expected
- Early engagement with regulator is key to success

Case Study on Renewable Energy

Stockholm Arlanda Airport (ARN)

Step 1: Please provide your contact details in case further information is needed.

	Respondent
Name	Henrik Fröjd
Organization/Company	Swedavia Energi AB
Job Title	Energy production engineer
Email Address	henrik.frojd@swedavia.se
Telephone	0734054209
Airport *(Name and 3 Letter Code)*	Arlanda (ARN)

Step 2: Please provide the following basic information of your Project/Case Study: Project/Case Study

Title: Aquifer storage for heat and cold production at Arlanda airport Timeframe (e.g., start and end month/year if applicable): 2006-2008

Description: Project with the aim to make storage of heat and cold for the airport possible, and therefore decreasing the production peaks and need for extra cooling machines. Mainly used for cooling.

Purpose: Storage of heat and cold for the airport

Step 3: Please identify which renewable energy technologies are used at your airport:

( ) Geothermal

( ) Solar PV

( ) Solar Thermal

( ) Wind

(x) Other Aquifer

Step 4: Please identify and prioritize the driver(s) for the renewable energy project. Number 1-6, where 1 is a high priority and 6 is a low priority.

(1) Economic

(1) Environmental

(4) Political

(4) Social

( ) None

( ) Other _____

Step 5: Please give more details on the driver(s) chosen in the previous question. For instance, was there any available incentive for the development of such programs? Can you describe it?

Company environmental goals with the aim to decrease CO2 emissions. Need for extra cooling capacity due to more buildings / larger area to cool and increased traffic / more people at the airport.

Step 6: Did you engage with internal and external stakeholders? If so please identify which stakeholders you engaged with.

Not sure.

Step 7: Which department is in charge of the renewable energy development in your organization?

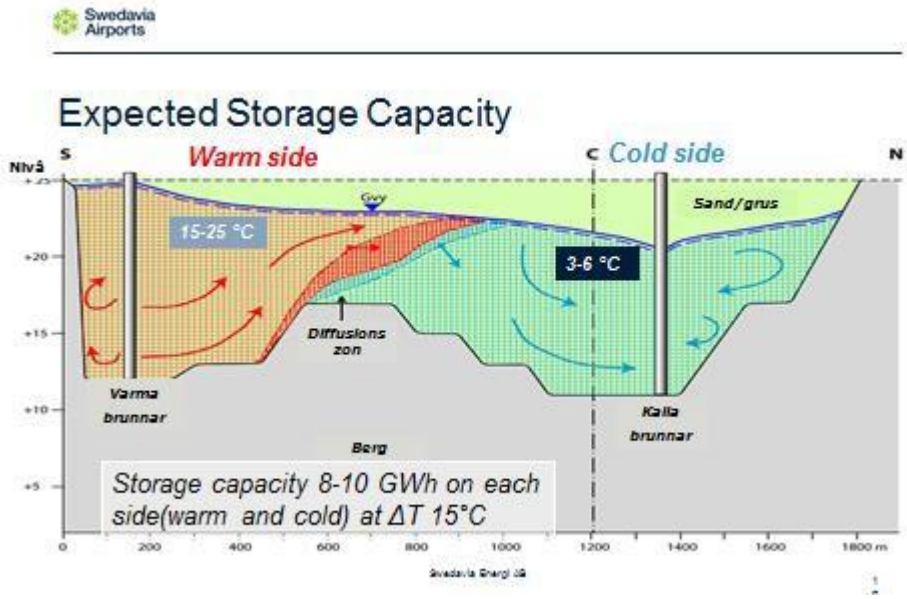
Corporate Engineering Department – Energy - Comfort

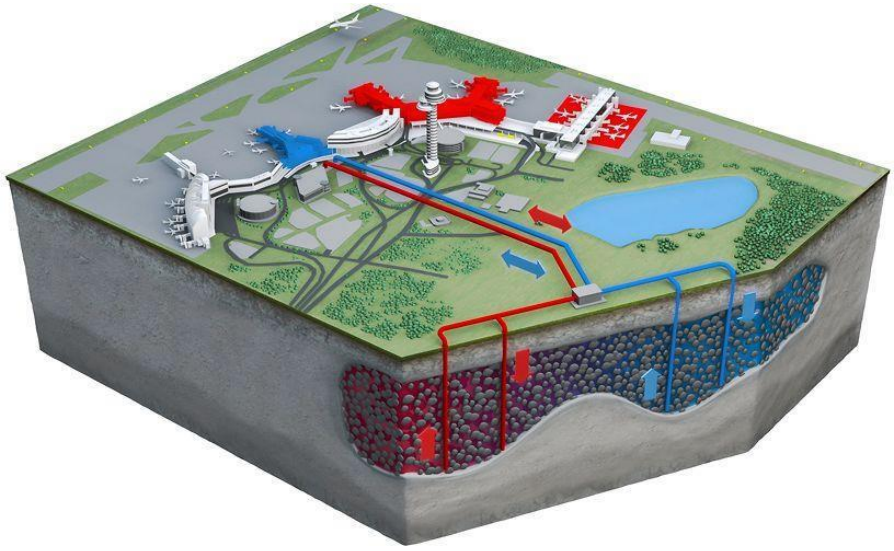
Step 8: Please insert Text and Images of your project/case study below here:

Decision-Making Process: Not sure.

Estimated Cost and Financial mechanisms available: 52 MSEK

Images:





Results (Environmental Benefit/Cost Benefit): Direct payback time approx. 8 years (annual savings about 7 GWh /

7 MSEK). Service costs approx. the same as for cooling machines with equal capacity.

Lessons Learned: Sand filter installed after problems with sand damaging heat exchangers. Real capacity is somewhat less than expected. Low temperature heat less useful than expected. But overall a good investment.