Paper prepared on

**Airport Energy Efficiency and Management**

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1. Abstract

Aviation is one of the fastest growing sectors of the global economy and is being looked as a sector which could help in building the nation and economy. Airport sustainability is a holistic approach to manage an airport to ensure economic viability, operational efficiency, natural resource conservation and social responsibility. Many airports have stepped towards the energy savings and using the renewable sources in airport facilities to reduce the operating costs and also contributing in reduction of the carbon footprint. This paper provides a brief overview of energy management at different airports globally, the steps taken towards sustainable energy in balancing the environment profile, the growing challenges in the aviation sector and the probable solutions. The strategic approach in managing the energy effectively has been discussed for the future and existing airports.

Why energy management?

The energy management is in the present discussion which is not only limited to the aviation sector but also at all the industry levels due to the Instable prices of fossil fuels, depletion of energy supplies, increased Greenhouse gas (GHG) emissions and particularly the increased energy needs with time and the economic growth. Global aviation is expected to rise from 2 % up to 15 % of the total contribution to climate change by 2050. Hence, aviation’s contribution to global emissions is very critical due to its impact level and the growth which it is expected to rise. The international energy agency reported that in 2009 as a result of energy production from fuel combustion, the world in total produced 29 giga tons of CO2 emissions (IEA 2011). Of these 29 giga tons air transport sector is responsible of 750 mega tons of CO2 and is slated to grow.

The predicted graph shows that the global energy demand is increasing almost three times by 2035 with China & India accounting for 50% of the growth, shown in mtoe (million tons of oil equivalent) (credit: International Energy Agency). India aviation is expected to raise 450 million passengers which make India to stand as 3rd largest aviation market in the world by 2020 as stated by CAPA_SITA.
Having a serious concern pertaining to the economic issues, the impact to the environmental profile, the energy management is a controversial subject of conversation in the present market conditions and in specific, in the aviation sector.

2. Energy Management at Bangalore international airport (BIA) and global references

Bangalore airport, located in Karnataka is one of the power deficit states in the southern part of India. It is also one of the most electrical energy consuming states with an annual consumption of 36975.2 Million KWh (2010-11). This is being expected to rise in the near future due to the increased economic growth in the city thereby adding to energy demand requirements.

The Bangalore airport consists of a passenger terminal of approximately 73,347 square meters (Sq. mtr), 4,000 mtr runway and associated taxiways, landside facilities, an air traffic control tower, cargo facilities, and supporting facilities with other ancillary developments which are designed to cater to 12 Million Passengers Per Annum. Considering the increase in the passenger flow, handling the passenger movement during the delays at times due to the low visibility operations and to avoid further congestion at the existing terminal building, the T1 terminal has been expanded to an area of 1,50, 500 Sq.mtr.

Inspite of the transformation of the size of the terminal to almost twice, the passenger traffic flow remains more or less, the same. This expansion includes airport facilities such as Heating ventilation and air conditioning (HVAC), lighting and other installed loads as of the existing. This also has put additional loads on the airside facilities such as high mast lighting on the expanded area. The energy consumption at this juncture is a great concern which would lead to huge operational costs with no additional revenue generated from the passenger perspective immediately.

Although the retail market is being planned to develop to an extent to boost the airport revenue, the question on the other side is how the airport could manage its energy with double the size of the terminal while experiencing the similar traffic flow?

Also, the airport is targeting to cater for 55 million passenger i.e., nearly 4 times of the existing capacity by 2029-30. The construction of a second runway, second Terminal (T2), other ancillary and supporting facilities for the airport are to be established to meet its eventual Master Plan targets. This project would consist of an approximately 365,500 sq. mtr passenger terminal building on multiple levels and include a main terminal processor building and multi-level concourses built in two phases.

The point to be addressed is, are we really in a situation to face the projected energy demand, for such a huge infrastructure facilities in the future, where the conventional sources of energy are being exhausted day by day?

Knowing the circumstances, BIA has focused to evaluate all the possible maintenance practices in establishing the optimum energy practices for the existing and the expanded installations from the date of the operations.
2.1 Certifications and standards
We have committed towards the continuous energy management which has been the prime focus in the existing and the upcoming upgradation. The airport attempted to comply with various level of standards and certifications as a first step in a process of achieving continuous improvement such as environmental management system, energy management system, Leadership in Energy and Environmental Design (LEED) certification of existing terminal building, Greenco and very recently the Airport carbon accreditation at level 3 optimization in the year 2013.

There are many other airports which preferred the process of certifications in a similar fashion globally. To state a few, Incheon, Brussels and more airports have an Energy Management System (EMS) with full policies and procedures for energy management. Seattle-Tacoma International Airport and Logan Airport have buildings certified to (LEED) standards. Chattanooga airport’s new energy-efficient, terminal facility was awarded LEED platinum rating in February 2012, making it the first aviation terminal in the world to achieve this level of certification. Dallas-Fort Worth (Texas) International Airport is so energy-efficient that the alliance granted it the star of energy efficiency award in 2005.

2.2 Mapping
Energy Measurement, Monitoring & Reporting has been done at all the sub metering levels of the terminal and airside facilities at BIA. Total energy consumption is monitored & reviewed frequently. The energy balance report has been made on monthly basis for analyzing the gaps in the system. The mapping of the energy consumption helped in several ways by developing a structured approach to improve the energy management processes.

2.3 HVAC and Lighting facilities
Mapping has assisted in analyzing the major energy consumption facilities and found that the Heating ventilation and air conditioning (HVAC) loads are the one which consumes more energy.
The energy conservation through Variable frequency drive (VFD) is installed to control and operate the pumps as per required demand for pumps at our airport, thereby contributing to 8,09,159 units of energy as savings i.e., about $ 90,000 annually.

The HVAC consumptions have been taken as a serious concern at many other airports, be it a heating or cooling application. To cite some global efforts, the energy efficiency software for the Mineta San Jose International Airport has deployed high-performance energy efficiency software to manage the airport's HVAC system, yielding more than $35,000 in savings in the first five months of operation. The Chitose Airport terminal building in Hokkaido at Japan is utilizing a new cooling system which plans to collect snow during the winter. Of the snow collected throughout the winter, approximately 45% of the snow is preserved for the summer time through the use of heat-insulating materials. The collected snow would be used to chill the liquid of the building's cooling system.

The lighting loads are one of the installations where huge potential of energy savings have been recognized at BIA. The program has been taken during the preliminary design of the project to use the effective day lighting as a critical aspect in managing these lighting loads. Having abundant lighting, the construction has been made in a way that natural day light illumination is used for the terminal building during day time thereby contributing to huge amount of energy savings. Almost 80% of the terminal lighting is being switched off on account of this initiation.

The demonstration projects have been undertaken by BIA along with the vendor support before actually ascertaining over a large scale. Converting the halogen and other high consumption lights into LED at different areas within the airport facilities have resulted in energy savings over 2,00,000 units annually. Installation of lighting facilities with the renewable energy sources such as solar lights has been executed, wherever possible. Switching off of the light fittings at International arrival -based on occupancy sensors has been implemented after a detailed study of passenger flow. The lighting at the columns of the domestic terminal are made switched off during the off-peak hours after analysing the passenger movement at the defined area. This is being controlled by the timers in coordination with different departments internally saving 54,000 units annually.

To quote other examples, Armenia international airport also has 40% of the roof area which is glazed while a glass system reflects direct sun light, reducing heat but allowing in natural light. Natural Ventilation Systems at Honolulu International Airport was designed with natural ventilation so that occupants and travelers could comfortably experience the natural climate between the months of November through April. Boston-Logan International Airport followed nationally-recognized sustainability standards when designing a new terminal building.
On the other side, BIA has also laid emphasis on the airside installations such as street/perimeter lighting and airfield ground lighting as part of energy management drive. The expansion of the east apron has already got included with the LED taxi way edge lights in the recent project expansion works. Considering the initial investment and the payback period calculations, the conversion is planned in phase wise for the airside installations which could have savings of $32,630 annually which would also contribute to huge economical savings and reduced maintenance costs. BIA has committed to use the energy saving installations for all the airside and landside installation for all the future expanded facilities. These are also proven to be operationally efficient than the existing halogen type of fixtures with reduced maintenance cost due to the long life of LED.

Similar initiations, have been moved globally such as the installations of the LEDs in Hong Kong international airport in 2012, replaced 40,000 lights in the terminal building and planned to replace conventional lights and direction signs in the passenger terminals with 100,000 LEDs, saving about 15 million kilowatt hours (kWh). Albuquerque international airport has completed a comprehensive change over to LED. The airport have replaced 3000 traditional airside fixtures with brighter and more energy efficient LEDs i.e., about 87% of the light fittings have been converted to LED. Software control initiation for the renovated terminal at T.F. Green International Airport implemented an energy efficient and automated Total Lighting Control (TLC) system by General Electric. The system features programmable networked technology, controlling the internal and external lighting at the facility, including lights in the concourse areas, departure areas, baggage claims and outdoor parking areas.

2.4 Efforts towards continual improvements
BIA has engaged an energy solution industry in analyzing the energy consumption pattern and to provide better solutions existing in the market. This initiation has been taken in the year 2013, in further analyzing the losses minutely and mapping the same at different facilities of the airport both airside and landside
facilities. The project is targeting to an additional 5% savings within the existing systems, with an improvements with relevant operation and maintenance practices.

2.5 Renewable energy sources and global efforts
With the present trend of increased growth in the aviation, the conventional energy resources are depleting and emphasis has been laid by the airport operators to use renewable energy. The technology has been widely spread and the state policy support is also being extended to use these energy resources. The potential of availability of these energy resources depends on the geographical and climatic conditions available. As a sustainable oriented organization, BIA has initiated the proposal for adopting the renewable energy by installation of the 100KW grid connected solar power system. Use of renewable energy sources from biomass or Wind Energy planned along with the master plan implementation during the terminal 2 expansion.

The interest towards the renewable energy has been shown across the globe irrespective of the countries economic position. Renewable energy Statistics states that about 200 Bn $ has been spent across the globe, towards new investment in renewable energy (Source: UNEP, Bloomberg New energy finance) and the difference of the investments towards renewable energy sources, from the richer to developing countries has dropped down to 17% from 250% in past 6 years.

A number of airports have taken the initiation in using the renewable energy sources. To state a few, Denver International Airport has implemented a renewable energy project that consists of a two megawatt solar panel system designed to generate over three million kilowatt hours of clean electricity annually. The London Heathrow terminal 2 has produced less than 40% less carbon emission than its predecessor by installing the photovoltaic solar panels on the roof to assist in decreasing the airports dependence on non-renewable energy supplies. A few airports purchase a portion of their electricity from renewable sources, including wind generation at Portland, renewable sources at Oakland, solar and geothermal at Zurich and solar at Austin-Bergstrom.

With these measures BIA is on the track of optimizing the efficient energy practices at the airport. An interest on the renewable sources, as the future energy sources is being the objective set for the future.

3 Challenges towards sustainability:
Having numerous options available towards energy saving practices, implementation of the same by the airport operators is not feasible in specific to aviation sector at times owing to the below constraints.

3.1 High capital investment
The financial implications certainly hold the major share in initiating the energy saving concepts. This mainly happens with the smaller airports, in sense, where the total enplanements are less than
25000. Complete optimization of the systems or the huge initial investment towards energy savings wouldn’t be feasible in driving the energy efficient systems.

Measures to be implemented

I. Energy audits and awareness programs shall be conducted.
II. O&M assessment need to be made yearly for the effective maintenance practices.
III. The design of building to be taken into consideration for best available natural resource options.
IV. Retrofits shall be used as a first step with minimum payback periods. Select optimal upgrade initiatives.

3.2 Regulatory requirements and policy frame work

Aviation is controlled by the regulatory bodies in terms of safety and security and is tighter in aviation than in most sectors around us. New amendments from a large variety of the regulatory bodies, including the aviation authorities, national and local governments, put pressures on airport operations. Safety and security costs have risen to almost 60 to 70 percent of airport operating costs. The regulatory requirements shall provide clear direction which needs to be approached effectively during the planning stage for ensuring a balance between energy management and compliance requirements.

Role of Global regulatory bodies and airport operators

The regulatory bodies across the world shall collaboratively work in for a better results and common understanding between different parts of the world. Airport operators should demonstrate their commitment and collaborate with manufacturers for compliant with their requirement and implement adoption of more energy efficient systems by getting the approval from the regulators.

![Fig 4. Key functions which needs to be looked towards achieving a sustainable aviation sector](image)
3.3 Airport image and expectations

The objective of the airport operator is to provide the facilities to passenger in terms of service, ambience, and support and enhance his overall his experience till he leaves the airport. The brand image of the airport and the raised people expectations are the challenges which are a difficult scenario to deal with. The growing competition tends the operator to compromise on the sustainable concepts.

Probable measures

I. Creating the awareness among the passengers during implementation of the sustainable and energy efficient practices in the airport.

II. Customer feedback management services shall be initiated to address the concerns of the passenger

III. Advertising the sustainable practices and making the passengers to understand the importance of energy management. Common platform shall be established that only the energy which is being wasted is saved and not which is paying for. BIA is successful in making the stake holders and passengers to understand the energy conservation programs with stakeholders, vendors and suppliers.

Fig 5. Advertise the efforts towards energy savings within the airport system

3.4 Geographical constraints

The local conditions and the physical geometry of the airport location wouldn’t be appropriate to use certain energy management practices. The renewable energy solutions for the same are minimal, owing to the constraints of the location of the airport.

What are the possible solutions?

Operation and maintenance practices to be managed effectively using energy efficient systems which could have a significant impact on the overall energy consumption.
I. The use of technology which is critical component for facilitating the business transformation could be great help in initiating the energy management processes in these cases.

II. If the airport is in the design phase strategy need to be worked to identify better location of airport where one or the other renewable sources of energy is available. Technical experts view to be taken in this juncture.

III. Alternative renewable solutions shall be looked into.

3.5 Limitations of the existing installations

The Airports are established structures which are built based on the requirements and technology available at the time of their establishments. The Airports usually expand and refurbishment of the same would take quite a lot of decades. Inspite of the technology available in the market, using these with the existing installation would be a challenging task as there would be huge operational impact.

What is airport operator's responsibility in managing the energy of existing installations?

I. The energy efficient systems shall be considered for additional equipment and installations.

II. The expansion phase of the airport shall be planned strategically in making the best use of the natural resources and with energy efficient equipment's installed.

III. Study the possible improvements within the airport through innovative ideas. Case studies at other airports may be referred in this context. Energy audits and engagement of energy solution industries would provide better solutions.

These challenges have created an almost overwhelming mandate for change. Airports must transform themselves and their business models to overcome the current challenges they face and thrive in the 21st century. They must become smarter airports in a way to establish the best energy practices.

4. Strategies for implementation

Now, let us discuss towards a holistic approach in managing the energy at an airport which could establish a balanced profile. Ensuring the comfort of the passenger throughout his altogether is our main objective. Any initiative which doesn’t deviate from the objective is a feasible option to execute.

4.1 Energy Mapping, Utilization Indices and Benchmarks

Before getting down into specific upgrades, the first step towards upgrading an existing property is to understand its current status in order to establish the airport system baseline. Energy Audit is the one of the key to a systematic approach for decision-making in the area of energy management. It quantifies energy usage according to its discrete functions. Although many airports include the audit schedules as a part of their certification renewals and approvals, self-audits by the technical experts frequently help in understanding and analyzing the energy minutely in all the aspects. The airport shall set the specific
performance metrics such as Specific energy consumption per passenger etc., the energy base line or the benchmark shall be established for the individual systems within the airport facilities.

I. Encourage the airport employees to turn into internal auditors which would be beneficial in continuous monitoring of the system.

II. Engage the energy solution industry for understanding the latest trends and technologies available in the market.

III. Involve the stake holders and concessionaries at all stages of energy management implementation.

4.2 Management of the critical loads

Knowing the passenger requirement would help in assessing the energy management process. At times there were complaints stating that the terminal is too chilled than required when the author working with building management system at an airport. This may not be the case with all the airports. The author want to stress here is, are moving the passenger into the discomfort zone by consuming more energy. As said, this may not be true with all airports but strategies to be worked out with the passenger community in understanding his requirements mainly towards the facilities driven by airport operators. The mindset of the passengers shall be studied closely by effective tools such as survey, plotting of the areas against the facilities at different times and climatic periods to provide the sufficient requirements. The usage area of the terminal such as check-in, boarding area shall be dynamic and the zones shall be designed to specific requirements. Through such studies there could be definite energy savings also enhancing the passenger experience.

The design of the terminal building shall be considered as a critical aspect for leading the future energy management practices. The building orientation, envelope, local climate, wind speed and direction shall be analyzed in deciding the orientation of the building, type of controls to be used. The direction shall set to provide a first class experience to the users in a sustainable and environmentally- friendly manner.

The cooling system could be addressed to some extent by using the vegetated roofs and glazing surfaces so as to minimize the HVAC losses within the building. Studies have shown that temperatures up to 10 deg c could be improved using the vegetated roofs. Installing a high albedo and the vegetated roof for at least 50% of the roof area would show better results in minimizing the temperature within the terminal building. Vegetation could also be a part of the airport structure within, also enhancing the passenger experience.

4.3 Research and innovation

Researches shall be aimed towards using the innovative transformations in the energy sector. Additional efforts in Research and development could help us in using the new modes of energy. For an instance, researchers at Rice University in Texas has “Demonstrated a mechanism by which they can create steam in just seconds by focusing sunlight on a mixture of water/ice and nanoparticles within 5 to 20 sec”. The research is still in labs but making of these concepts into reality would really pave our path.
towards an efficient energy systems. The heating application is an area where the energy is being consumed in a large portion. Using of the above technology with a change in the design of terminal building could improve the managing aspects of energy.

The technology could be conceptualized to a model below. The collection of water from the roof of the buildings is being implemented at some of the airports already. The same water source could be heated with the above technology until it reaches temperature of 90 deg C (Taken as a reference, shall be analyzed in detail). The water shall be controlled through valves in the next level immediately in a thermally insulated container and use when required. Through convection this heat could be made to provide enough heating in the passenger movement area within the terminal, which would be monitored by temperature sensor continuously. The water would be recycled again to the roof level there by contributing to water management and ultimately establishing a better energy management system. Also, the concept could be integrated with the existing HVAC system for boiled water.

![Fig 6. Rain water collected on the terminal building](image1)

![Fig 7. Model- Heating concept from the roof of terminal](image2)

*Keeping the viability of the idea apart, the fundamental core of above concept is to set off hope for the future aviation industry that research and development on renewable energy sources could definitely have huge potential of better energy management.*

**4.4 Airport master plan development concepts**

The energy efficient systems may not contribute to the future energy demand completely. It could only adjourn the circumstances. The only potential for successful future development is to generate the energy within the airport premises using the natural resources and then to manage them efficiently. Further support could be extended to the local communities thereby contributing to the social needs.

There is high potential for generation of renewable energy from various sources- wind, solar, biomass, and small hydro and cogeneration plants. Karnataka, India is the second main state where the maximum potential of the renewable sources are found. To speak in particular about the airports, the master
planning of the airport is estimated to be almost four times of the immediate usage of the airport. In general airports would be located in several acres of land, out of which the immediate usage would be very minimum. It would take a minimum of 20-30 years in turning out the master plan into reality. Huge potential of energy savings and abundant land resources wouldn’t be used for many years. The vacant portion shall be assessed for cultivation of those trees/plants which could be used to generate energy, also not creating any safety breach, based on the prevailing soil conditions. The concept of green initiatives, non-polluting and renewable energy sources shall be evaluated and included in the master planning options based on the geographical and meteorological conditions. These areas to be reserved during the planning stage itself and need to be effectively integrated into existing or evolving energy systems. Natural energy resources such as solar, wind and bio mass would be a feasible step to start with the collaboration of nearby communities. This would also give the financial stability in crisis as the operation and maintenance costs would be considerably reduce by using these.

Recent innovations have proven that the solar system could be embedded as fabric of structures. The custom made solar panels are available which are similar to the façade of the buildings. This enhances the aesthetics of the buildings and embodies an architectural expression that favors both environment and economy. These also could be used for the airports which are planned with smaller infrastructure facilities with less available land resources.

Fig 8. Typical image of the master layout in managing the energy resources

Dependency on the conventional sources of energy shall be minimized at airports. Airports having abundant resources shall strive to generate their own energy to meet the future demands.
5. Conclusion

Efficient management of energy at airports significantly contributes towards sustainability and growth in the present depleted global environmental scenario. Every airport, be it large, medium or small has the potential to save and manage energy in a more efficient manner and implement sustainable practices. The first step is to realize the impact, understand the gaps and ‘get going green’ with the many available options. Situational awareness, technical knowhow and understanding the impact on future generation would kick start the process at all levels. This will not only benefit the airports but also contribute towards overall global economic and environmental standards. After fulfilling the energy management practices for sustainability, we have to focus on renewable energy practices and tap the biofuel resources. Necessary ‘Research and Development’ will provide better alternatives in energy efficient practices and products. Innovative and promising technology would help the aviation sector in managing energy efficiently. Many International airports have already led path towards this and set examples and high standards.

In this paper, attempt has been made to study the various aspects of sustainability, impact on business operations and provide practicable suggestions for implementation. While there is no limitation for innovation and technology, value addition in each field is a true trend setter for sustainability and progress on a long term basis.

Maintaining of these with the available natural resources and the best energy practices is the responsibility of all the communities associated with the airport infrastructure development.

Get wise, devote today for a better tomorrow!

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