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Airport Energy Efficiency and Management

Kazunori Ishida

Safety and Security Management Department
Airport Operations Division
Narita International Airport Corporation
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1. Foreword

Energy consumption and protecting global environment are like two sides of a coin. The question of energy vs. environment is an eternal one for the aviation industry at large – for airports and for airlines alike. When we look at the world's energy situation, fossil-fuel-derived energy is being consumed in huge volumes against the backdrop of population expansion and economic growth in emerging nations. This has triggered such common issues as global warming and depletion of natural energy resources, which are seen by all nations as challenges needing urgent solutions. It follows, therefore, that we need to share our limited resources and use available energy more efficiently through the use of natural energy resources and through energy-saving efforts in order for the international community to continue achieving growth.

Such initiatives to address energy issues are part of a social obligation not only for airports, but also for local communities, airport-related businesses and other stakeholders alike. Environmental protection and energy conservation require a patient approach in carrying out common-sense initiatives rather than looking for short cuts to instant solutions.

In order to undertake these actions more effectively, we need to learn from the initiatives taken at other airports, identify problems and obstacles in our own undertakings and make appropriate improvements while, throughout this process, working together with other stakeholders through communication by dialogue, sharing our collective wisdom and striving towards a single goal. In so doing, I propose that the airport reach across the industry and take the lead.

2. Energy Issue vis-à-vis Sustainable Growth

An airport is a hub of human and freight movements, playing an essential role of basic infrastructure supporting the promotion of tourism, trade and other forms of economic activities, so that sustainable growth is a vital factor for airports. An airport is, at the same time, a member of the local community and, as such, cannot achieve growth without the support and understanding of the community. Consequently, the airport must make an earnest effort to improve the overall environment in terms of noise impacts, air and water pollution, as well as other issues that are brought about onto the local community as a result of the airport’s activities. Efficient use of energy is one solution to this. Improving environmental protection by promoting energy-savings and reduction of the volume of energy consumed by the airport as a whole and continuing along that path will not only gain the support of the local community but the results of such effort will add to the society's contribution to the energy issue.
In order to effectively address various environmental issues wrought upon the local community by an airport, a single unified framework should be formed, combining the airport with all airport-related stakeholders, to share their collective wisdom to reduce the environmental impacts. Bear in mind that creating such a framework is not the only goal. The full extent of potentials may only be achieved by an organization working closely together towards a single objective.

For that reason, stakeholders should proactively participate in the effort and collectively strive to achieve organizational management*¹ with particular emphasis on the communication of individual ideas. Since energy and environmental issues are something that cannot be ignored or dismissed by the local community, an airport will need to exercise a kind of environmental management that fully involves the local community as well as other industries and, by taking initiatives across the board with various stakeholders, an airport will have a positive impact globally, socially and environmentally.

*¹ The term “organizational management”, as used in this paper, refers to developing an organization to achieve lofty objectives.

3. Framework for Environmental Conservation Initiatives

When we look at airports in various parts of the world, we can see that standards such as ISO14001 (for environmental management system) set forth by the International Standards Organization, the Eco-Management & Audit System (EMAS) established by the European Commission, and the Airport Carbon Accreditation program launched by Airports Council International (ACI) have been broadly adopted not only in the West but also in Asia, and that there are frameworks whereby airports and airport stakeholders work together on their initiatives in accordance with the guidelines and environmental regulations already in place.

However, when a framework for environmental management is yet in a premature stage of formation, it might be dangerous to work under the ISO and other standards as they now stand – dangerous in that the true objective of forming such a framework to mitigate environmental impact is often lost in the urge to obtain a nominal international standards certification. Under such circumstances, creation of a structure tends to become the sole objective, rather than for the stakeholders to share common goals or to proactively participate in the required actions.

To avoid any misunderstanding and to clearly define the objectives, at Narita Airport, we are trying to create a platform on dialogue-based communication where all stakeholders may participate and share common goals in setting up a partnership structure to address environment-related issues.
4. Framework for Environmental Conservation Initiatives at Narita Airport

Because it is a landlocked airport, since its opening, Narita has always placed particular emphasis on initiatives focused on mitigation of noise impacts on the local community caused by aircraft movements. The initiatives initially included measures such as soundproofing of residences and compensations for relocation, carried out in accordance with the government guidelines and legislations.

With the privatization of Narita Airport in April 2004, what we call the “Eco-Airport” concept was hammered out on the basis of dialogue with the community as well as a wide range of stakeholders. This concept called for a recycling-oriented and eco-friendly airport committed to mitigation of environmental burdens on the local community. The concept is incorporated in the company's management vision as "Environment-friendly Airport Contributing to Community Growth"; which positions promotion of environment conservation as a key corporate policy.

Diagram 1. Concept of Dialogue-based Communication

Implementation of initiatives should not only entail setting a vision and creating an organization. It is also important to do something to enhance a sense of ownership among the stakeholders and encourage constructive opinions. In realizing the “Eco-Airport” concept, therefore, we decided to start by creating a stronger partnership with businesses in the airport, established the Eco-Airport Development & Planning Council comprising airport-related businesses and formulated the Eco-Airport Master Plan as an environmental blueprint for the entire airport.
### Diagram 2. Structure of the Eco-Airport Master Plan

The Eco-Airport Development & Planning Council is an organization for promoting environmental initiatives throughout the airport and comprises members from 39 entities representing airport-related businesses. Members participate in discussions to set targets for the Master Plan and engage in studying and implementing initiatives to achieve the targets thus set out. The Council has sub-committees to promote individual initiatives. These sub-committees consist of businesses deeply associated with the individual initiatives, so that proactive participation of airport-related businesses may be attained. The Council not only enhances the common awareness of involvement in the environment by way of exchanges of information and interaction amongst members, but is also used as a platform for study sessions. Its potential as a venue for face-to-face merging of ideas is another factor in enhancing the awareness of the stakeholders.

1. It widens the circle of coordination and collaboration among the diverse range of stakeholders.
   \[ \Rightarrow \] From a small community (airport businesses) to a larger community (regional communities)

2. It is a participatory working group where stakeholders may freely and independently share ideas.
   \[ \Rightarrow \] Mutual understanding and mutual respect through dialogue-based communication

As a fruit of such initiatives, Narita adopted a noise-based international landing charge structure derived from the ACI Noise Rating Index, the first of its kind in the world. This scheme offers preferential international landing charges based on the noise level of aircraft, whereby Category A aircraft with the lowest noise level paying approximately 22% less than the noisiest Category F aircraft.

Aircraft noise is a major concern at all major airports around the world. There are actually cases at other airports where they impose noise surcharges or taxes in accordance with their own regulations. Preferential treatment to quieter aircraft was Narita’s approach. A factor behind this was the formation of partnership in the spirit of addressing issues with the same objectives through dialogue-based communication with stakeholders. By adopting this charging system, reduction of aircraft noise at Narita has been prominent, while it has had an added bonus of cuts in greenhouse gas emissions.
While the airport operator shares information on such environmental conservation initiatives through publications like Narita's Environment Report and through various other activities, the local community has also taken the initiative of volunteering and, by providing residents’ perspectives through various forums like the Symbiosis Committee, continues to be active in asking the airport to disclose information and issue PR publications. As a result, a practice has now taken root in which the local community and the airport operator may share information and properly recognize each other, and a foundation has been laid to support the concept of "symbiosis" to seek solutions based on mutual understanding. Furthermore, a forward-thinking idea of co-prosperity has taken a firm hold on the community with the objective of growth and development for the airport as well as the local community through regional expansion capitalizing on the airport's major potential for generating regional dynamism. It was this concept that paved way for a consensus on expanding the airport capacity.

5. Use and Management of Energy in Airport Environment Conservation

5-1. Issues Associated with Energy-Saving Measures in Airport Operation

Environment conservation and energy consumption are closely inter-related. When we think of energy-saving measures which will contribute to the conservation of environment, we will first need to look at reducing overall energy consumption at the airport.

Source of greenhouse gas (CO₂) emissions at Narita Airport may be broadly divided into aircraft and facility operations. When aircraft emissions are calculated on the basis of the LTO cycle*², 80% of emissions (60% from landing and take-off and 20% from taxiing and idling) will be attributed to aircraft operation, while facility operation is responsible for the other 20%.

To reduce this, Narita introduced measures including the installation of GPUs*³ at contact gates to cut down on emissions from idling and, by restricting use of APUs*⁴ while parking, we managed to reduce CO₂ and other air pollutant emissions as well as noise.

Our initiatives are mainly focused on aircraft where we may expect greater reduction effects. It, in turn, means that integrated management to reduce energy consumption is called for with the development,
management and operation of the airport. Since an airport is an essential social infrastructure, our energy-saving efforts must take into full account the benefits for the local community and other airport users.

Diagram 4. LTO Cycle

*1 GPU = Ground Power Unit: Facilities that supply preconditioned air and electricity to parked aircraft.
*2 APU = Auxiliary Power Unit: Used to start aircraft engines and also as an auxiliary unit to power air conditioning and electrical systems.

5-2. Energy-Saving Measures at Airports

Energy-saving measures may be divided into those relating to hardware such as equipment upgrades and installation of more efficient equipment/devices and those relating to software such as operational improvements like enhanced management methodologies and standards. Balancing these two will be important. Some key measures being adopted in countries around the world will follow:

**Hardware Initiatives**

1. Installation of high-efficiency equipment and devices (inverter controlled equipment, LED lighting, high-efficiency lighting)
2. Introduction of cyclical systems (community air-conditioning *5, co-generation systems)
3. Introduction of heat-storage type air conditioning
4. Use of natural energy sources (solar power, wind power, geothermal power, snow cooling *6)
5. Introduction of low-pollution vehicles (electric and natural gas vehicles)
6. Insulating glass, heat-shield paint

*5 Production of cold water, steam, warm water and other thermal byproducts in a single energy plant and integration of air-conditioning and hot water supplies to multiple buildings in a designated area
*6 System of storing snow from the winter and using it for cooling in the summer
Software Initiatives

① Rationalization of heating and cooling temperatures
② Control of lighting
③ Use of natural lighting
④ Restrictions on use of transport equipment (elevators, escalators, moving sidewalks, etc.)
⑤ Reduction of external air intake

Energy-saving measures in place at many airports around the world tend to rely only on hardware measures such as introduction of high-efficiency equipment and devices because they produce instant results. However, this approach will require sizeable investments and it is important from the cost-benefit point of view to consider adopting a good portion of software initiatives to maintain a good balance.

(1) Energy Saving at Narita Airport post Great Earthquake

Japan experienced a serious nuclear accident following the major earthquake of March 11, 2011. Since then, the energy situation (electricity in particular) underwent enormous changes. This not only demonstrated the vulnerability in stable supply of energy, but forced Japan to reconsider her energy policies and brought home the realization that securing stable energy supply was indeed a global issue.

Under these circumstances, Narita International Airport Corporation (NAA: the airport operator at Narita) proposed to the airport businesses through the aforementioned Council a range of specific energy-saving measures and asked for their cooperation. The airport businesses responded by implementing their own, independent approaches to these measures. Posters were used to seek the support and cooperation in energy-saving efforts from airport users.

As a result, temperature settings in the public areas were changed, lighting was turned down to a level that would not detract from security needs, and a range of other operational initiatives were put in place.

These initiatives were put into effect not only in the terminal buildings but throughout the airport. Eventually, demand for electricity dropped 20% below pre-earthquake levels. To assess possible extent of impacts of the initiatives, fact-finding surveys were conducted as to where energy was being wasted, what measures were most effective and which initiatives might present burdens to users. The survey revealed that the greatest reductions were achieved by changing the operation mode of air conditioning in large open spaces. Particularly effective with no impact on users seemed to be reduction of external air intake in relation to air conditioning.
When cooling, air conditioners take in a certain amount of outside air to prevent CO\textsubscript{2} concentration from rising. If the CO\textsubscript{2} level is kept within certain parameters, limiting external air intake can reduce the volume of energy used by air conditioners to cool down hot outside air. By changing to a system that restricted the amount of external air intake without allowing CO\textsubscript{2} concentration to exceed a certain level, we succeeded to drastically reduce energy consumption.

Since 2012, we abandoned drastic changes to temperature settings in the terminals, which had a marginal energy-saving effect in comparison to the level of discomfort on airport users, and implemented measures which took into consideration both energy saving and adequate level of comfort in each building. Even then, owing to energy savings in other areas, demand for electricity has dropped 15% below the pre-earthquake level.

(2) Lessons learned from Great Earthquake

① Importance of information dissemination

It is very important that the airport users as well as the airport businesses are fully informed of the objectives, details and effects of such energy-saving measures.

When we changed the temperature settings in 2011, even though the airport businesses had been informed of the change beforehand, there was a lack of full understanding about the objectives, details and, in particular, the effects, due to insufficient amount of information. In some cases, they even felt themselves being subjected to undue hardship.

To avoid such consequences, information should be disseminated in such a way as to encourage each and every airport employee to commit with willingness and interest. Information on the outcome should be widely promoted through a process of visualizing positive effects so that there is a broader understanding of the measures among stakeholders and in order to bring them to a continuous cycle of dialogue-based communication, as depicted in Diagram 1.

② Different measures for different operations

The fact that one energy-saving measure is effective in a certain instance does not mean the same strategy will apply in the same way anywhere. For example, at transfer passenger screening points, congestion may occur only at certain times of a day. At such places, the temperature will rise with congestion and may become a cause of complaints, which means that we may need to slightly modify and improve our measures by changing temperature settings to suit certain time periods of a day.
When evaluating the effectiveness of measures, we may need to adjust the way the measures apply at specific locations. For such analysis, visualization of data or effects will be useful.

3. **Diversification of energy sources**

To generate electric power, there are a variety of sources such as gas-fueled co-generation systems, diesel-fueled generators and solar power generators that use natural energy. Relying on one single source could totally disable an airport from functioning during emergencies, particularly in case of a major earthquake. We need to look at not only solutions to environmental issues but also at securing alternative energy resources.

A co-generation system, for example, may be used not only to generate electricity but also to provide air conditioning by heat emission. As it can be a useful tool as an environmental measure as well as a lifeline provider in times of emergency, it is a step worth adopting in countries with vulnerable infrastructures. Needless to say, care should be taken to study economics and environmental benefits in advance.

6. **Proposals on Energy Saving**

6-1. **Steps for Examining Energy-Saving Measures**

The following procedure has been devised taking into account our earthquake experience. Visualization of energy consumption should be born in mind when developing possible energy-saving measures.

1. **Find out the ratio of energy consumed throughout the airport by the type of business activity.**

Energy-saving measures will vary from business to business depending on their requirements. Therefore, the airport facilities should be classified by the type of activity into passenger terminal facilities, cargo handling facilities, back offices and so on, to find out the ratio of energy consumed. At the same time, we can find the ratio of energy consumed by each facility.

2. **Find out the ratio and characteristics of energy consumed by usage at each individual facility.**

The characteristics of energy used in buildings will vary by usage, time and other operational factors. The energy consumed in each building should be classified by the usage, such as heat source, lighting, air conditioning, etc., and the ratio of energy consumed during different times of the day (e.g. - while operating, while not operating, during business days, during weekends) should be ascertained. Find out the ratio of energy consumed with each piece of equipment. This means, at a heat source for example, the ratio of consumption with each boiler, freezer, feed pump, etc.
3. **Consider most effective energy-saving measures.**

Begin with those measures that have the greatest energy-saving effects. By analyzing ① and ②, it is easier to find out the characteristics of the entire airport and to identify effective measures. Consider cost effectiveness on the hardware, while characteristics of the business type and mode of operation should be taken into the consideration on the software side.

4. **Make it known that energy-saving measures are in place and evaluate the effects.**

Strong support and cooperation of the stakeholders are essential when implementing energy-saving measures. Thoroughly familiarize the stakeholders with anticipated effects and impacts when deliberating these measures and ensure that there is no shortage of information. Measure energy consumption levels before and after implementation, evaluate actual effects, analyze any unexpected impacts and work on improving the action. Once the results are obtained, inform the stakeholders so that they may also share in the merits and demerits of the action.

### 6-2. Visualization of Energy Consumption

The PDCA cycle plays a major role in ensuring effective measures to continue. By means of this management method, it is possible to identify measures that are suitable for any specific facility and the results will enable energy saving without too much burden. In order to see the status of “Plan” and “Check” components, visualization of energy consumption is essential. Implementing energy-saving measures without knowing the actual situation is meaningless, because then effectiveness of the measures cannot be adequately measured. By visualizing the volume of energy consumption before and after implementing saving measures, one can easily see how effective those measures have been. Application of the PDCA cycle on the basis of visualized data will enable optimization of the results from these measures.
In order to operate the PDCA cycle more efficiently, it is recommended that a management/operation manual be used. The manual should include specific details on the following to ensure that energy saving is carried out in a rational manner:

1. Improvement targets and management structure
2. Standard operating & management procedure on temperature and lighting control for each building or location while maintaining a comfortable environment
3. Inspection and maintenance guidelines for each set of equipment installed

This manual will enable continuation of operations with the same energy-saving effects even in case of future personnel and management changes.

Even if effective measures are identified on the basis of the PDCA cycle, it will be meaningless unless these measures are put into practice. It is a good idea to first create an environment where these measures may be fully utilized. In other words, in order to ensure organized management of energy resources, it is important to raise awareness of the airport users and the airport employees by providing ample information on the ongoing undertakings.

6-3. Specific Methods of Visualization

(1) Means of Providing Information
One way of providing information is to put up posters in the terminals. This method, however, is not only onerous but lacks speed when it comes to updating information. For better results, an option would be to utilize digital signage*, an advertising medium which is already installed in noticeable locations.

Diagram 6. PDCA Cycle using a Management Manual
throughout the airport.

*7 An advertising medium utilizing digital technology used in public facilities to provide advertising and information using LCD displays and projectors.

(2) Information Provided

The airport may provide information on its targeted goals and typical initiatives to achieve them, or differences in energy consumption when energy-saving measures are implemented and when not implemented. Another method will be to encourage airport stakeholders to send in comments regarding places where they feel energy is being wasted and the reasons for that. It will be a good idea then to respond to such suggestions with examples and details on what has been done based on their suggestions, as a way of promoting dialogue-based communication.

Not only will this promote greater understanding of initiatives taken by the airport operator, it will also improve the airport's reputation for its positive stance towards energy conservation efforts, and may even motivate some airport stakeholders to work more closely to develop and promote the airport. The synergy effect thus created will enable provision of a comfortable environment in which airport stakeholders will not see any drop in service levels under well-harmonized energy saving.

6-4. Cost Reduction Effects

It goes without saying that the larger the scale of a facility, the greater the cost of maintenance and operation. From the management’s perspective, on the other hand, it is not desirable to have a structure in which the costs increase as the business expands. Energy-saving activities are indispensable in curbing operating costs associated with the expansion of an airport. I would like therefore to recommend that we introduce "energy consumption rate" as an indicator to verify the effects of energy-saving measures implemented at the airport. A typical "consumption rate" at an airport will generally relate to the volume of energy required to operate a single flight.

Otherwise, at an airport, energy consumption occurs mainly in the passenger terminals and cargo terminals. Energy consumption at these facilities is closely linked to the scale of demand variation factors such as facility size (total floor space), number of aircraft movements, passenger numbers, cargo volume and fuel supplied.
By managing factors that affect energy consumption in the operation of an airport, it is possible to determine the increase in energy consumption as the airport expands over time. The "energy consumption rate" may be used as a tool that will help assess the increase or decrease in energy consumption according to the size and scale of a facility or a business.

Narita Airport’s energy consumption rate is calculated in accordance with Formula B in Diagram 7, in which we use the "number of aircraft movements" in addition to the “facility floor space” as factors closely related to the amount of energy consumed. Our target is to improve the consumption rate by 1% each year from the benchmark year of 2009. The results are shown in Diagram 8. Despite various facility upgrades to expand the airport's capacity during this time, reduction in energy consumption exceeded the targets, largely owing to progress in energy-saving measures in place after the earthquake.

### 7. New Initiatives Utilizing Natural Energy Sources

The environmental value of natural energy sources which do not generate CO₂ is expected to increase even further in the years ahead. Transition to a recyclable energy society in which natural energy replaces fossil fuels may not be so far away.

Building a mega solar power plant* on the vast airport site and utilizing the energy generated in the areas
around the airport, or running trials in smaller facilities to use such natural energy to reduce consumption of fossil-fuel-derived energy close to zero and create a "zero-energy building" are some of worthy efforts.

* A large-scale solar power plant with an output of 1 megawatt (1000 kilowatts) or more, requiring a vast area of land for its construction but is expected to become a core source of renewable energy.

Because an airport possesses functions comparable to a large city, in addition to promoting integration of energy consumption such as regional air conditioning as a way of efficiently reducing the environmental impacts, we should try and improve our energy self-sufficiency through the use of mega-solar generators, thermal generators and other forms of natural energy utilization. Generation of electricity from the vast amounts of garbage discharged from aircraft and introducing electricity-powered ground service vehicles are other examples of initiatives we can take.

8. Conclusion

To achieve sustainable development, an airport must gain the understanding and support of the surrounding community. It is therefore essential for an airport to address and resolve environmental issues affecting the local area. "Efficient utilization of energy" through the use of natural energy resources and energy conservation actions are some of the means to achieve this.

Creating an environment where all parties concerned may freely and proactively voice their opinions, and working together towards the same goal while maintaining communication with other stakeholders will be an important consideration. An airport needs to be at the center of such a drive.

There are no short cuts to solving energy consumption and environmental conservation issues. Patience is required in continuing a steady cycle of planning measures, verifying their effects and reviewing those measures all over again. I hope that the suggestions and recommendations made in this paper will serve as a reference to other airports seeking to tackle and solve the same challenge.