Energy-Efficiency Improvement in the Japanese Hotel Sector

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Abstract

From the viewpoint of the rapid development of the world's economies, particularly of those developed countries, such as the US and Japan, their requirements for fossil fuel and construction materials suffer from the burden of maintaining high-demand life patterns and continuous economic growth. Because of the financial recession, Japan's enormous demand for energy and other fundamental materials has resulted in considerable cost escalations in relation to crude oil, construction steel and lumber, and greater expenditures on fossil fuel energy and electricity. This pattern is repeated in the tourism and hospitality industry, especially in relation to the accommodation sector.

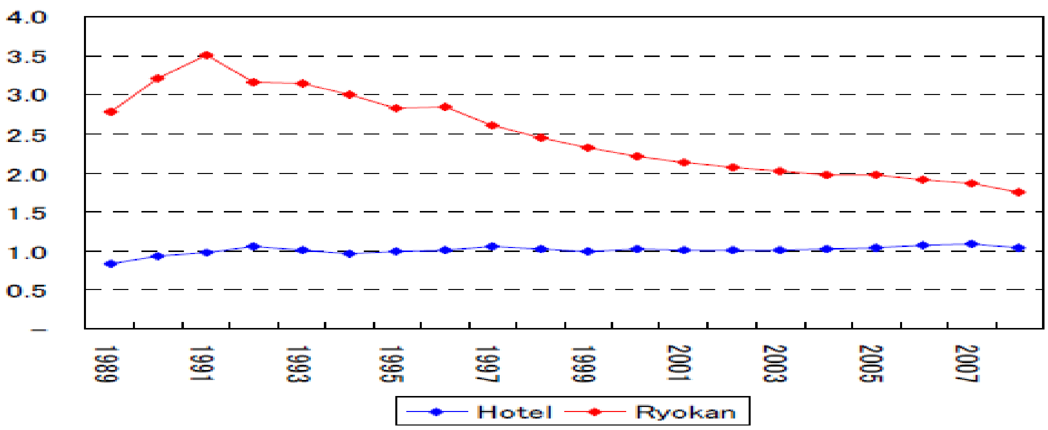
Japanese accommodation facilities consist of hotels that display an adoption of western culture and *ryokan* that maintain the traditional culture of Japan. To obtain explicit data on energy consumption, and to seek a better compliance with further energy efficiency analysis in the Japanese context, this research focuses on the hotel sector rather than on *ryokan*. In the latter, the wooden structures do not make it easy to apply a general standard of energy analysis for buildings and also have limitations for further energy improvement. Moreover, the Japanese government started to offer subsidies for the installation of photovoltaic (PV) power systems or passive solar power (such as PV panels and photovoltaic air-conditioning systems) from January of 2009 for modern buildings. In this promising situation, this paper attempts a holistic analysis of the current energy consumption of the hotel sector in Japan, which has been identified as one of the massive energy consumers amongst commercial buildings, and offers feasible approaches to achieve decreases in energy waste and adjusting the structure of energy management through a combination of policy suggestions and technological advances.

Keywords: eco-improvement, efficiency, energy, Japan hotels

An Introduction to the Hotel Market

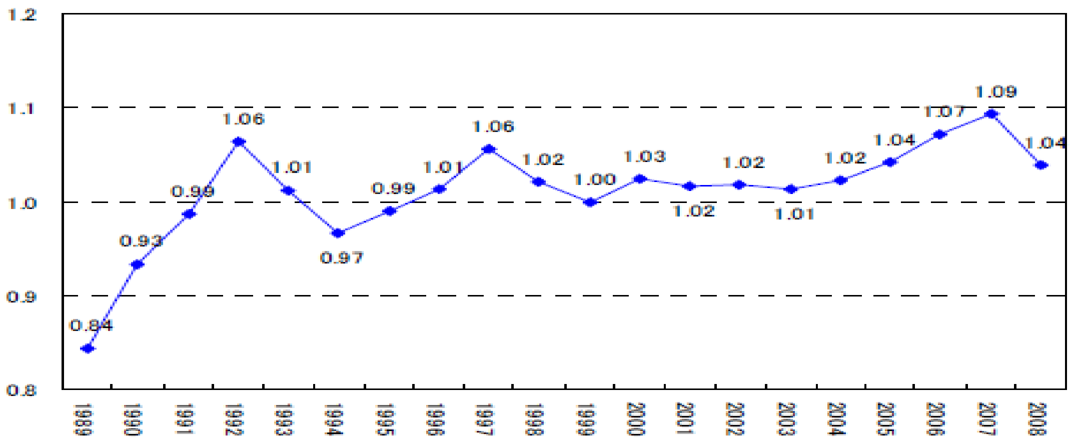
This paper demonstrates a general picture of the Japanese lodging market by bed occupancy and market scale, before assessing the potential for reducing hotel energy consumption. Due to the global financial recession, the market share of Japan's accommodation sector has been shrinking: the hotel market share in 2008 decreased by 0.05 trillion yen compared with the amount in 2007 (Figure 1). Before this turning point, the profits of the lodging market in Japan had demonstrated a stabilizing tendency in recent years, achieving 3.33 trillion yen in 2005. While the number of traditional *ryokan* guesthouses and inns has been declining, from 77,269 in 1989 to 55,567 in 2005, a decline of 28% (Figure 2), the number of hotels in Japan has been growing, from 8,363 in 2001 to 8,990 in 2005, a growth rate of 7%.

Figure 1: Market Scale of Japanese Hotel Market (Unit: trillion)



Source: Takeuchi (2010)

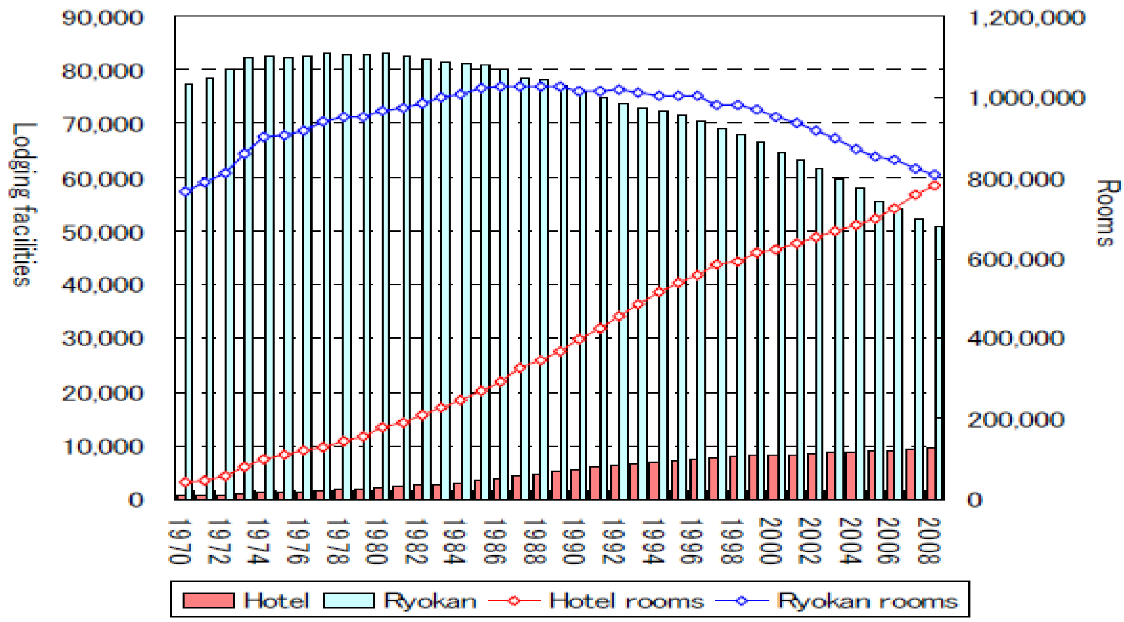
Figure 2: Market Share of Hotel and Ryokan (Unit: trillion)



Source: Takeuchi (2010)

Nevertheless, due to the inherent persistence of traditional culture and consideration of construction cost, the *ryokan* sector remains much larger than the market capacity of the hotel sector despite experiencing an on-going slump since 1991 (Figure 3).

Figure 3: Occupancy of Japanese Lodging Market



Source: Takeuchi (2010)

Although the Japanese traditional inns occupy the greatest market share in the Japanese lodging industry, with the stimulus from foreign direct investment or joint-venture collaboration, adequate financial supports are flowing into the hotel sector in Japan, accompanied by a fascination with western culture among Japanese young people. According to Japan's Hotel Industry Report (2007) and Real Estates Analysis Report (2010), there were 173 hotels and other lodging facilities financed through M&A (Mergers and Acquisitions) transactions with a declared value of about 2.80 billion US dollars during the period from 2000 to 2006, converted into Japanese yen at about 233.80 billion yen. Even faster development took place between 2000 and 2006, when there were 173 transactions and an announced value of $2.79 billion (approx. 274.59 billion yen).

The Major Tendencies in the Japanese Hotel Market

The approaching market saturation has attracted the attention of operators in the Japanese hotel industry, and competition will become much fiercer given the new hotels that have come onto the central Tokyo market since 2008. This increase is characterized by the cooperation of local airline or tourism companies with hotel companies (domestic and international) and has emerged as the dominant resistance to the intense competition from international hotel giants, who were trying to seize more market share in Japan's hotel market through establishing hotel chains.

Another kind of joint venture by capital restructuring is demonstrated by the share vending of Japan Airlines (JAL), who planned to actualize capital placing from the sale of Hotel Nikko Tokyo's holding company to an American investment fund. This capital change was designed to help JAL extricate itself from asset holdings that involve risk to put more attention on outsourcing business, and to benefit the centralization of resources on its airline business by implementing another vending of 30% of shares of JALUX Inc., the company in charge of shop business in JAL's air terminals. Multinational hotel chains have shown a desire to enter into the Japanese hotel market, with the target of high-class businessman and epicureans who are willing to enjoy luxury facilities and amenities without budget cares. Table 1 lists several newcomers run by multinational hotel chains, and dozens of other high-class hotels which have opened since 2002. Furthermore, these international hotel chains decentralized their business locations, covering an extensive range spreading from The Ritz-Carlton (Osaka) and Nagoya Marriott Associa Hotel (Nagoya), to the Grand Hyatt Fukuoka (Fukuoka).

However, these luxury hotels are huge energy consumers, sacrificing energy budgets to build up luxury for hotel occupants with various appliances. So how to maintain the refined environment for hotel occupants with lower energy consumption is the most crucial topic the hotel sector has to face, as the present research plans to explain.

Table 1: Examples of International Hotels in Tokyo

Hotel	Location	Opening time
Four Seasons Hotel Tokyo at Marunouchi	Marunouchi	Oct. 2002
Grand Hyatt Tokyo	Roppongi	April 2003
Conrad Tokyo	Shiodome	July 2005
Mandarin Oriental Tokyo	Nihonbashi	Dec. 2005
The Ritz-Carlton, Tokyo	Roppongi	Mar. 2007
The Peninsula Tokyo	Hibiya	Sept. 2007
Shangri-la Hotel, Tokyo	Marunouchi	Mar. 2009

Source: Above companies' official websites.

Energy Consumption in Japanese Hotels

Heating, air conditioning and ventilation, hot water production, lighting, electronic appliances and cooking facilities comprise the essential aspects of energy consuming in the hotel sector. Electricity and natural gas are two kinds of energy consumed in the hotel sector, especially electricity. For example, hotels in Japan consumed about 3,421 MJ/m^2 annual load, including heating, cooling, hot water and electricity being respectively, 496 MJ/m^2, 271 MJ/m^2, 1,296 MJ/m^2 and 1,358 MJ/m^2 in 2008. The accumulated heat consumption is the highest among the six types of buildings shown in Table 2, and with respect to other kinds of energy consumption are usually the second highest or highest.

Table 2: Maximum, Minimum and Annual Loads for Various Buildings

Type	Load	Heating	Cooling	Hot water	Electricity
Hotels	Max (kW)	3072	2080	4320	3634
	Min (kW)	0	0	940	919
	Annual (GJ)	24786	13565	64791	67910
Apartments	Max (kW)	1734	506	2081	1117
	Min (kW)	0	0	0	228
	Annual (GJ)	6213	1019	11210	17134
Education facilities	Max (kW)	3853	1064	761	1439
	Min (kW)	0	0	0	102
	Annual (GJ)	10385	3183	754	16492
Offices	Max (kW)	4076	3278	212	2648
	Min (kW)	0	0	0	196
	Annual (GJ)	11798	13065	1776	38276
Hospitals	Max (kW)	6062	4036	5490	3439
	Min (kW)	0	0	0	473
	Annual (GJ)	23802	9818	50388	47235
Commerce buildings	Max (kW)	2387	3239	914	8015
	Min (kW)	0	0	0	407
	Annual (GJ)	7258	15240	5401	104019

Source: Ruan, et al. Proceedings of World Academy of Science, Engineering and Technology, Vol.43, 2008.

Electricity Consumption

Japan is famous for its electronic products. They have a great influence on people's lifestyles, but also result in a huge consumption of electricity in residential and commercial buildings, including hotels. Being willing to maintain a recreational environment by ignoring energy efficiency makes the energy consumption of hotels steep. The energy consumption by the hotel sector is approximately 15% of the total energy consumption (of buildings) in Japan. This amount of energy can be calculated from the average energy consumption per-floor (1,000 m^2) of buildings (in 2006) as being 43.6 crude oil equivalent KL/1,000 m^2, and the estimated total floor area of 94.87 million m^2, meaning that the hotel sector consumes 4.14 million KL of crude oil equivalent energy. As a result, it is crucial to find a combination of feasible technologies to reduce electricity consumption as well as look for other reliable renewable energies as a substitute to improve current energy consumption.

Natural Gas Consumption

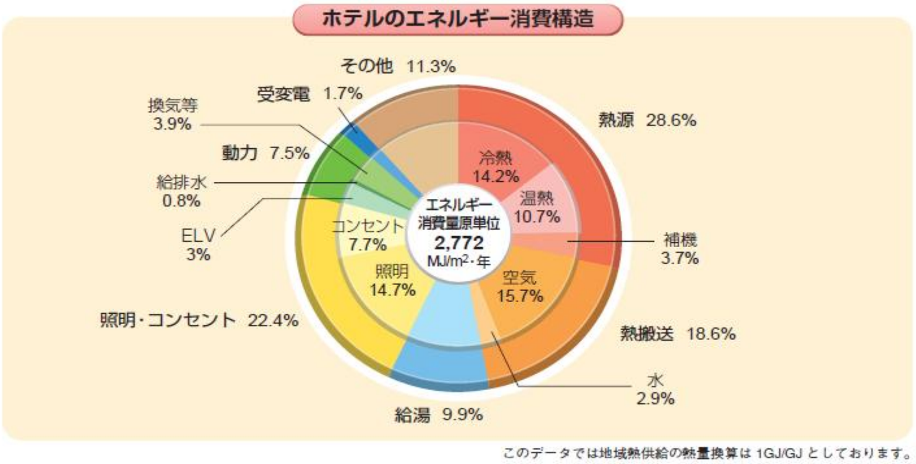
Natural gas, also called city gas in Japan, is providing a clean and comfortable lifestyle for Japanese society, and is regarded as clean energy to power the heating and cooling equipment in hotels. National natural gas consumption in 2009 was 94.67 billion m^3, about 4.22 times of the quantity of 10 years ago (Index Mundi 2010). The primary component of natural gas is methane, and when this element is burned it generates only small amounts of carbon dioxide and nitrogen oxide emissions, making its environmental impact acceptable and accounting for its growing popularity around the world. However, Japan still needs further motivation to make natural gas one of its principal energy sources.

Summary of Energy Consumption in Japan

High-intensity consumption of electricity and natural gas are diminishing the profits of the hotel sector in Japan. Energy consumed mainly by lighting, heating/hot water and air-conditioning systems in hotels (Figure 4), was respectively 22.4%, 28.6% and 18.6% of total consumption in 2009. In total, the hotel sector consumes 2,772 MJ/m^2 annually on average. However, if a comparison is made with the energy consumption of other kinds of commercial buildings, the higher intensity of energy consumption in hotels is very obvious. The energy consumption intensity (Figure 5) for offices, which accounted for the largest floor area in the commercial sector, was about 1,900 MJ/m^2 per year in

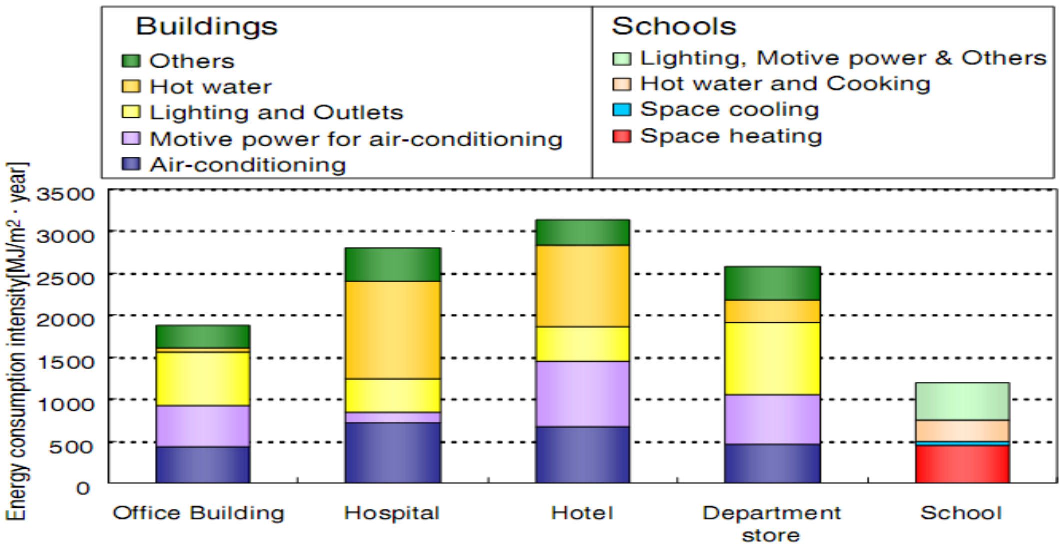
2009. Of this, about 50% was for air conditioning, 30% for lighting and office equipment, and 20% for elevators, hot water supply, and other uses. In hotels and hospitals, by contrast, hot water supply dominated the total energy consumed. Total energy consumption by hotels and hospitals is about 1.5 to 2 times greater than that of offices.

Figure 4: Energy Consumption Structure of Hotels (2009)



Source: Energy Conversation Center (2009)

Figure 5: Energy Consumption Intensity and End-Uses in Japanese Commercial Buildings in 2004



Source: Murakami, et al. Overview of energy consumption and GHG mitigation technologies in the building sector of Japan (2009)

Clean Technologies to Power Japanese Hotels

In this section I estimate the feasibility of different technological methods for enhancing the energy consumption structure for hotels in Japan; concentrating on the process of transforming its energy consumption structure from fossil-dependent to a renewable hybrid energy model.

Solar Power for Japanese Hotels

Japan was the largest producer of photovoltaic electricity (PV) before 2005, contributing 38% of the entire photovoltaic electricity generated worldwide. According to EPIA Global Market Outlook (2009), the PV market in Japan in 2008 added about 230 MW of installed PV power, reaching a cumulative capacity of 2,149 MW.

PV Arrays

Research suggests that semi-transparent PV (STPV) panels should be applied to a building facade or windows (see Figure 7), facing toward the south; or PV arrays made up of cost effective PV cells, such as thin-film cells, should be installed on the roof of a hotel in a greened roof system (Figure 6). Due to thermal disturbance, the efficiency of PV cells decreases while temperature is increasing so a greened roof is designed to provide a natural ventilation cavity, which is assigned to make a defined airflow in the middle between the bottom of PV panel and the heat-resistant surface of the hotel roof.

Hybrid Renewable Combination

Single renewable technologies are usually not reliable enough to provide a competent substitute, so a hybrid system is needed, such as a technological combination of solar power and other clean energies, such as wind power and cogeneration. Mayland Seaside Hotel (China), due to be completed in 2012-2013 is an exemplar for hybrid solar power systems in the hotel sector, on which the entire southern facade of the hotel will integrate 2,800 m^2 STPV panels with heat-isolated window glass to reach a capacity of 280,000 KWh. Besides the STPV installation, there will be 3 8-meter wind turbines that have a 300 MWh capacity horizontally installed on the tower (refer to Figure 7).

Figure 6: an integration of greened roof with PV array in Germany

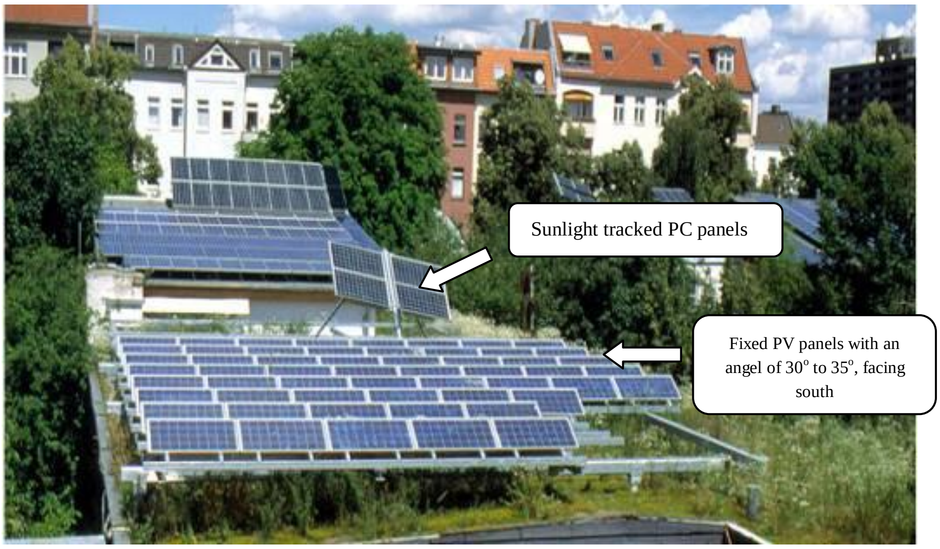
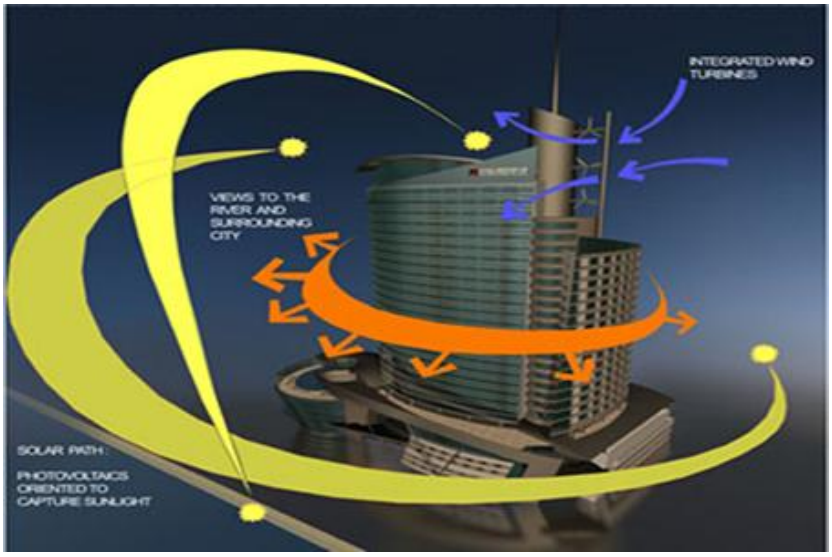


Figure 7: Schematic diagram operation of wind turbine in Mayland Seaside Hotel



Source: Green Lodging News Staff: Carbon-Neutral, Five-Star Hotel Planned in China (2009)

Obstacles and applicability

The storage of electricity generated from PV becomes a bottleneck for PV popularization, and the purchase of fuel cells or other reserving instruments is not usually possible for hotel mangers to accept. Furthermore, the generation capacity of PV is different according to latitude - hotels in the southern part of Japan are more suitable for solar power installation and hybrid systems due to the wind power potential.

Wind Power for Japanese Hotels

The Potential of Wind Power

It is possible to convert the kinetic energy from wind into electric energy with a wind turbine. The calculation of wind power is based on several crucial factors, such as swept area, average velocity, and density of air, generator efficiency and so on:

$$A = \prod (D/2)^2 \quad (1)$$

Where:
A : The swept area of the wind turbine blades;
$\prod$: Circumference ratio
D : The diameter of the wind turbine blades

And the calculation of available wind power is based on the kinetic equation:

$$P = \frac{1}{2} * \rho * A * V^3 \quad (2)$$

Where:
P : Power in watts;
ρ : Density of air (approx. 1.2 kg/m^3 at sea level, and decreasing along with altitude);
V : The wind speed (m/s)

The efficiency of wind energy is determined by conversion losses into other forms of energy, and the physically maximum coefficient of power performance is 59.26%. However, in practical operation, this proportion will be decreased by 25% ~ 45%. So the entire equation of actual wind power is:

$$P = \frac{1}{2} * \rho * A * V^3 * C_p * N_g * N_b \quad (3)$$

Where:
N_g: Generator efficiency (80%, or possibly more, for a permanent magnet generator or grid-connected induction generator);
N_b: Bearing efficiency (the efficiency of the shaft bearing is highly dependent on the configuration)
C_p: Coefficient of performance.

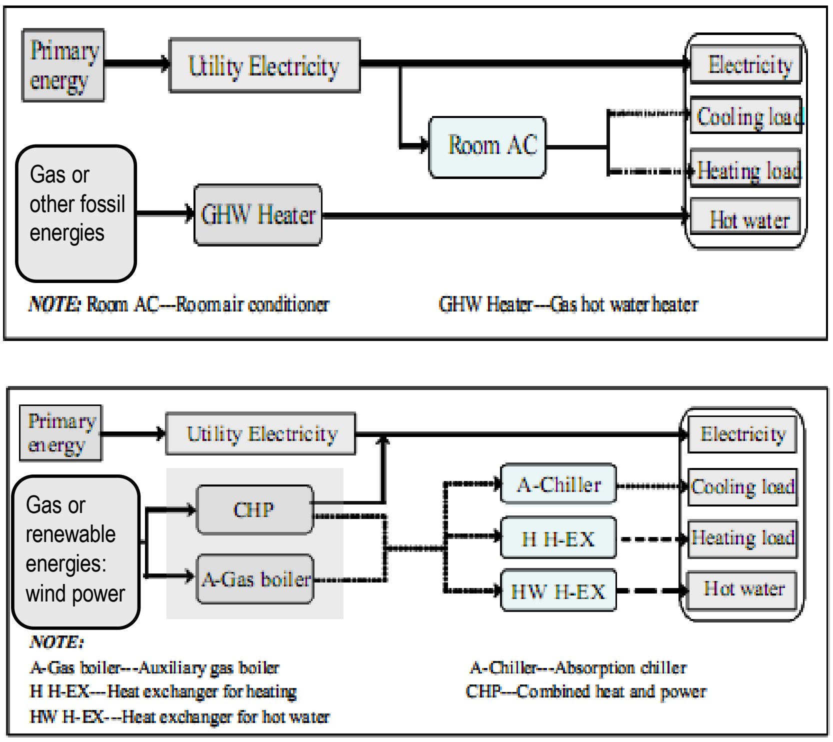
Based on the data from Renewable Information 2009, the adoption of wind power is being gradually expanded worldwide, especially in the US, China and Germany. Japan maintains an average level of wind power utilization: the accumulated capacity was

1.88 GW, 13th in international ranking (2008); capacity growth stands at 0.36 GW, 12th in international ranking (2008).

Application of wind turbines

To reach a better synergy with Japanese hotel construction, small-scale wind turbines are preferable and acceptable for hotel managers or owners, and this research recommends integrating wind power with micro-CHP (Combined Heat and Power) for residential purposes as a hybrid power system, achieving an eco-friendly supplement toward GE (Gas Engine) as in Figure 8. This power system has been becoming popular in Japan[1] for years, with wide utilization coverage from community to manufacturer, in which GE, GT (Gas Turbine) and DE (Diesel Engine) are the three main technologies used to power a GHW heater. Moreover, residential CHP systems are favorable to avoid the on-site inspection by an authorized utility to reach relevant technical standards for grid feeding, based on related Japanese regulations to support small and micro-CHP systems.

Figure 8: Comparison of Operational Models: Energy Supply Plans of a Conventional System and a CHP System



Modified from Proceedings of World Academy of Science, Engineering and Technology, Vol.43, 2008.

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[1] In the Kyoto Protocol Target Achievement Plan adopted by the Cabinet in March 2008, the government set a target for additional natural gas CHP of between 4,980 and 5,030MW by 2010.

Geothermal Power for Japanese Hotels

Geothermal power is one of the abundant renewable resources in Japan. Tthere are 17 geothermal power plants with a total installed capacity of 413.4 MW (2004, International Geothermal Association). Three of them[2] are located in Oita prefecture, and two of them provide power for hotels: the Suginoi Hotel (3,000 KW, Beppu City, Oita) and the Kirishima Kokusai Hotel (100 KW, Makizono town, Kagoshima).

This special power resource is highly depended on local rock specification, crustal structure and quantity of hot water; the only difference is the geothermal potential capacity, which will be carried out based on the following equation:

$$Q_h = V * Q_s * (T_g - T_s) \quad (1)$$

Where:

Q_h: Quantity of heat;

V: Volume of rock of checking area;

Q_s: Specific heat of the rock at the deepest point;

T_g: Temperature gradient;

T_s: Mean temperature of surface.

However, the calculated quantity of heat is the theoretical maximum and only a small percentage of available thermal energy of the geothermal mass can be used to provide power for electricity generation. Geothermal development promotion surveys (New Energy and Industrial Technology Development Organization, 2006), suggest that there are 47 districts in Japan[3], which could benefit from local geothermal resources over 100℃ for the utilization of binary-cycle power, flash steam power and dry steam power.

[2] Geothermal power plants in Oita are: Ohdake Geothermal Power Plant (12,500 KW, started in 1967), Takigami Geothermal Power Plant (25,000 KW, started in 1996) and Suginoi Hotel (3000 KW, started in 1981). The first two are supported by Kyushu Electric Power Co., Inc., and the last one is privately supported.

[3] This survey covers following areas: Jozankei, Kunbetsudake and Musadake in Hokkaido; Kuwanosawa and Akinomiya in Akita Prefecture; Hohi-Nanbu in Oita Prefecture; and Tsujinodake in Kagoshima Prefecture. (source: Geothermal Energy Development Center, 2001)

Main Geothermal Power Technologies

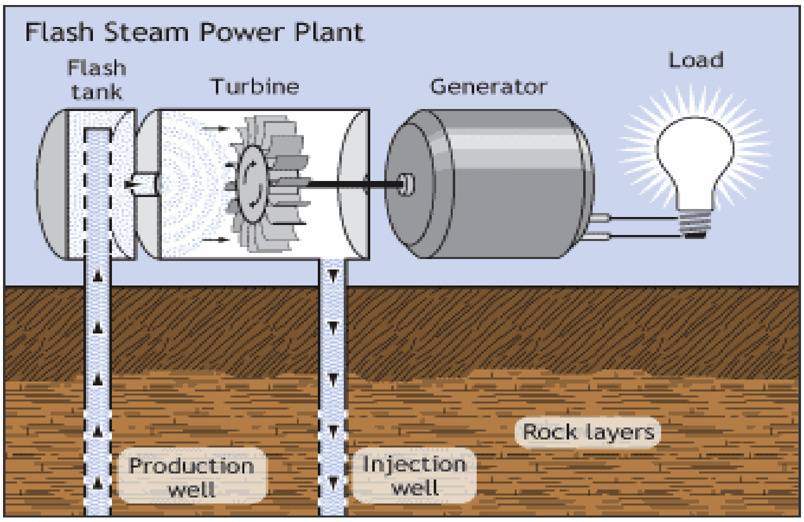
Dry steam power plant

This kind of power plant uses hydrothermal fluids from steam (only steam, not water) for circumrotating the turbine blades, and symbolizes the oldest type of geothermal power plant (but still very effective). Taking Calpine as example, this corporation occupied the largest market share and capacity among geothermal power producers in the U.S., reaching 725 megawatts of electricity generation to supply 725,000 homes, or a city the size of San Francisco. However, dry steam power technology requires special geothermal conditions, which only sprays steam without water as a by-product and this is rare in the world.

Flash steam power plant

This geothermal technology uses hot springs with a temperature above 182℃, and pumps to separation flash tanks. If any leftover geothermal liquid remains in the flash tank, a secondary tank for extracting more energy is operated (Figure 9). All of the water consumed in the flash steam power process is in turn circulated back to the hot water reservoir, achieving a water balance. This steam flash power technology has been employed at the Suginoi Hotel (3,000 KW) in Beppu, applied using a wet cooling tower integrated with a cooling pond.

Figure 9: Configuration of Flash Steam Power Plant (without secondary tank and water reservoir)

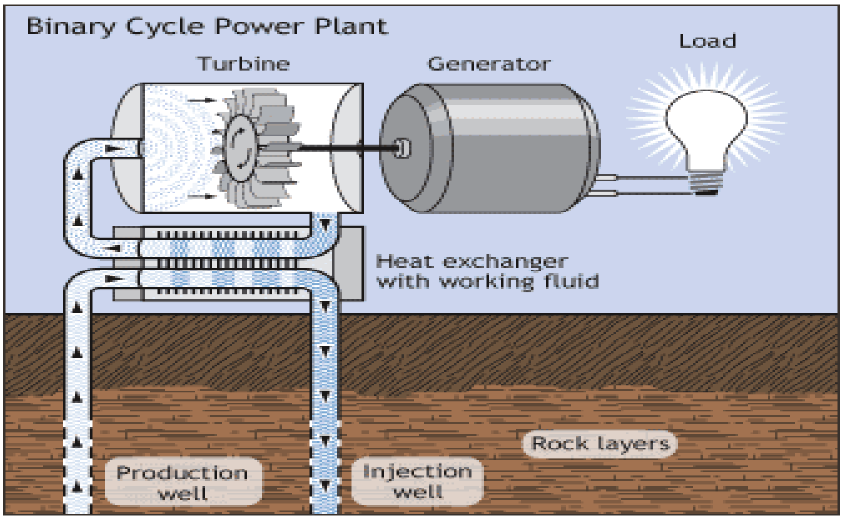


Source: Geothermal Technologies Program: Flash Steam Power Plants (2010)

Binary-Cycle Power Plants

In this technology, geothermal fluid is pumped from moderate-temperature hot spring resources with temperatures that range from 37℃ to 150℃. The hot water is channeled through heat exchangers, which transfer heat to another flow of fluid with a lower boiling point. And this auxiliary fluid will be vaporized to impulse turbines, based on physical properties, and the condensation of steam is recycled in a benign closed-loop system (Figure 10).

Figure 10: Configuration of Binary Cycle Power Plant



Source: Geothermal Technologies Program: Flash Steam Power Plants (2010)

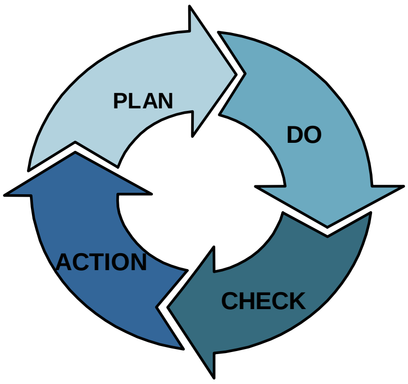
Improvement of Energy Efficiency in Japanese Hotels

The best application of renewable energies in Japan is mainly in the beginning phase of construction, in cooperation with green building design and other professional fields, and the results from improving the energy supply structure are much more effective than installing or replacement of energy-saving devices.

The PDCA Cycle

There are several kinds of processes for targeting energy consumption to assess its potential for delivering eco-improvements in Japan, but the best is the PDCA Cycle. This problem-shooting process consists of Plan, Do, Check and Act, a method that helps a project manager to clarify how the project proceeds, and this has been usually applied in building eco-improvement projects in Japan. The individual elements of this cycle are explained from the point of view of a hotel energy efficiency project.

Figure 11: Schematics of PDCA



PLAN

With a holistic perspective a reasonable plan is comprised of benchmarking analysis, target review, major obstacle review, technological feasibility, implementation and risk management, all based on data collection and analysis. Usually the planners prefer a plan that specifically concentrates on a certain energy efficiency drawback or process, mainly due to the consideration of project investment and later maintenance.

DO

After launching a feasible plan, cooperation between the hotel management team and any external consulting or auditing team is expected to implement this plan step by step, starting from small scale device replacement on an experimental basis.

CHECK

On the checking and verification phrase, hotel management teams and consulting teams examine the use of advanced energy-saving devices or processes, meanwhile comparing the outcomes against the expected results to determine any discrepancy.

ACT

Based on the analysis, the energy efficiency improvement project continues by utilizing technological enhancements or better energy management.

Improvements in Main Energy-consuming Areas in a Hotel

Generally, in a Japanese hotel energy is consumed mainly by lighting, heating/hot water and air-conditioning systems and research has demonstrated approaches to facilitate a better energy-saving performance in hotels through a consideration of seasonal influence. Within the energy consumption structure in the hotel sector, we intend to classify the energy consumers into four major groups based on serving different functional usages: air conditioning systems, hot water systems, lighting systems and life necessary supporting system (kitchen, cleaning and laundry[4]). First of all, as the biggest energy consumer, air conditioning systems will consume 30% ~ 40% of total electricity to serve both cooling and heating demand, by central-controlled air-conditioning systems, electricity-based heating devices and fans. Secondly, the energy used for providing sufficient hot water in a hotel is usually powered by electricity, natural gas or kerosene in Japan. Thirdly, lighting effects and performance are considered to establish a very comfortable atmosphere for occupants, so most lighting devices in the public areas are operating 24/7. Even if the light bulbs are replaced by eco-bulbs or CFL, the immense electricity consumption due to lighting systems is non-ignorable. The last group of energy consumers in the hotel sector is those appliances supplying life necessities in dining, cleaning and information. Natural gas and electricity are two main energies often used in kitchens to power refrigerators or other instruments; except for laundry, hotels are obligated to follow applicable sanitation regulations to achieve better living quality through providing a tidy accommodation; information systems in hotels consist of televisions, central computer systems for monitoring and sensors, and audio/video players. Above all, this research plans to demonstrate specific technology or applications, focusing on these major energy consuming groups.

Lighting Systems

To impress occupants for longer accommodation or recommendations to public, a splendid indoor atmosphere is established by various lighting effects for every need. An eco-retrofit project on lighting improvement must therefore take several technologies together in combination:

<u>De-lamping Program</u>

The most cost-effective way to reduce lighting levels is a strategic de-lamping program, an arrangement of lamp fixtures for illuminating appliances, such as 36-Watt CFLs (Compact Fluorescent Lamps). This rescheduled lighting system plus automatic dimmers will greatly cut electricity usage.

<u>Computerized Control System</u>

A building automation system (BAS) is capable of separating the entire operating system in a hotel into several function-orientated sections, such as cooling, water boiling and lighting, and each section has a computerized controller for managing and monitoring.

[4] Laundry services in Japanese hotels are usually outsourced to a professional laundry company, which is responsible for changing beddings periodically on a contract basis.

Energy-saving Devices

Due to the latitude of Japan, the duration of natural lighting is distinct from place to place; nevertheless, installation of simple energy-saving devices helps to overcome inherent flaws in lighting system design. To achieve the elimination of unnecessary electronic lighting, timer and photocell sensors on the lighting systems in hotel lobbies are recommended. Photocell sensors should be calibrated to reach the specific demand of certain lighting levels with a control timer. In this case, the operating hours for lighting in the lobby of the hotel can be lessened by 8.5 hours per day.

Heating/hot water Systems

According to a survey conducted by The Energy Conservation Center, Japan (ECCJ) in 2010, energy-efficiency improvement projects in heating/cooling systems in Japanese hotels range from advanced boiler systems to modifying the air ratio in combustion facilities.

Condensing boilers

Boilers in hotels are usually fueled by natural gas, and for a conventional boiler, fuel is burned to vaporize steam exhausting into a heat exchanger, from which a large amount of heat will be transferred to water. Avoiding the waste of latent heat from steam, a condenser extracts additional heat to accomplish an efficiency increase of 10% ~ 12%. Moreover, the production of condensate also requires installation of a heat exchanger condensate drainage system, compared with a non-condensing boiler.

Air ratio in combustion

Within the boiler system, the combustion process requires a mixture supply of natural gas and air, which sometimes leads to insufficient burning. Air ratio is the proportion of practical air supply to theoretical air supply, adjusting the quantity of practical air supply will help to reach a higher level of combustion ratio and reduce natural gas consumption. Taking a Japanese hotel as example, after enhancing the air ratio from 1.6 to 1.3 when emitted gas temperature is constant, the natural gas consumption declined 2.1% and saved 30,938 m3 of gas annually.

Air-conditioning Systems

Energy consumption highly corresponds to seasonal changes of occupancy. For example, the electricity consumption of air conditioners accounts for about 18% in May, and 58% in September of the total electricity consumption of an average Japanese hotel. However, retrofit of air-conditioning systems is possible using the following technological improvements.

Air distribution control

In the public areas of hotels, such as corridors and garages, the aeration is air-conditioned 24/7, causing unnecessary electricity consumption. By installing carbon monoxide sensors, the aerators or exhaust fans can be shut off when not needed. In addition, variable frequency drives (VFDs) also allow fan speed to be adjusted to more closely match ventilation needs, reducing fan operating costs. Moreover, a collaboration of variable speed drives (VSDs) or bypass damper tackled air handling units (AHUs) with advanced electronic control systems will help to match the demands of ventilation from corridors and indoor public places without large-scale reconstruction.

Advanced cold water pumps

Air-conditioning systems serving a cooling purpose will control the speed of cold water pumps and the flow of chiller water to the coils in the air handling units (AHUs). However, the burden of a cold water pump is aggravated in correlation with the increasing load of air-conditioning. With an inverter installation and establishment of closed-loop circulation, the efficiency of a cooling system will increase, prolonging the lifetime of pumps and avoiding unanticipated breakdowns.

Sound central control

For a good building envelope effect, most corridors, banquet rooms and other indoor divisions try to maintain a constant temperature as their primary aim, without concerning themselves with airborne flow, and heavily depend on centrally-controlled air-conditioning. To overcome this situation, a Building Automation System (BAS) combined with carbon monoxide sensors to moderate the balance between fresh air supply and indoor air can be used to create a flexible air-conditioning system through the use of automated controls to reduce energy use.

Conclusion

The hotel business has given a positive contribution toward both domestic and international tourism in Japan, but this is accompanied by an immense amount of energy being consumed due to ignorance. From energy use data made public in 2008, the hotel sector in Japan consumes about 3,421MJ/m2 annual load, including heating, cooling, hot water and electricity, and is the largest energy consumer amongst commercial buildings. Now this burden has become more serious due to economic pressure on the sector from the recent decline in tourism and the government’s refusal to proceed on the 2nd phase of the Kyoto Protocol during the recent Cancun Conference.

This paper has attempted to offer a coherent path to the promotion of energy efficiency improvements in Japanese hotels, through technological suggestions to enhance current energy consumption structure with renewable energies, and techniques for accomplishing better eco-performance of major energy consuming facets of hotel operations. Furthermore, fiscal incentives from government or enterprises in order to persuade hotel managers to improve energy efficiency are anticipated to be required in a mutual-benefit market, such as carbon trade marketing, and to support efforts from academia, hotel enterprises, and tourists to achieve greater energy savings in the future.

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