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Country Report on Building Energy Codes in Republic of Korea

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April 2009

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Foreword

Buildings account for about 30% of all energy consumption globally and a significant share of greenhouse gas emissions. Building energy codes help ensure that new buildings use energy efficiently, and this can reduce building energy use by 50% or more compared to buildings designed without energy efficiency in mind. This is important because buildings typically last 30-50 years, and it is much less expensive and time-consuming to design for energy efficiency than to retrofit a building later. Based on the experience of the Asia-Pacific region, it is clear that building energy codes, when implemented, save energy and improve comfort in new buildings. By design, most building energy codes are cost-effective, saving consumers significant amounts of money on their energy bills.

The Asia-Pacific Partnership on Clean Development and Climate (APP) is a public-private collaboration to accelerate the development and deployment of clean energy technologies. APP partners include Australia, Canada, China, India, Japan, Republic of Korea (South Korea), and the United States (the U.S.). APP countries account for more than half of the global economy, energy consumption and greenhouse gas emissions. APP's Buildings and Appliance Task Force (BATF) provides a forum for APP partners to work together on energy efficiency in buildings and appliances. This report was prepared under the framework of BATF, in particular a BATF project called "Survey building energy codes and Develop Scenarios for reducing energy consumption through energy code enhancement in APP countries" (BATF-06-24).

At the request of the U.S. Department of Energy, the Pacific Northwest National Laboratory's Joint Global Change Research Institute has prepared a series of reports surveying building energy codes in the seven APP countries. These reports include country reports on building energy codes in each APP partner country and a comparative report based on the country reports. This particular report is the country report on building energy codes in South Korea.

Acknowledgements

This report owes its existence to the Asia-Pacific Partnership on Clean Development and Climate. We would like to thank all the APP partner countries and experts who collaborated on this project. Dr. Seung-Eon Lee at the Korean Institute of Construction Technology leads the APP project under which this report was prepared (BATF 06-24). We would also like to thank Mark Ginsberg, Jean Boulin and Marc LaFrance from the U.S. Department of Energy for their leadership and financial support of this work.

Diana Shankle, manager of the PNNL Building Energy Codes Program, has provided moral and intellectual support for this project. Mark Halverson reviewed this report. Kate Williams provided editorial assistance. We would also like to express our gratitude to several other individuals who supported or participated in the APP building energy code assessment in various capacities including Hoeseog Cheong, Elly Lee, Kay Killingstad, Paulette Land and Kim Swieringa. And we would like to acknowledge the Korean Ministry of Knowledge Economy and the Korea Energy Management Corporation which supported the publication of this report.

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1. Introduction and Background

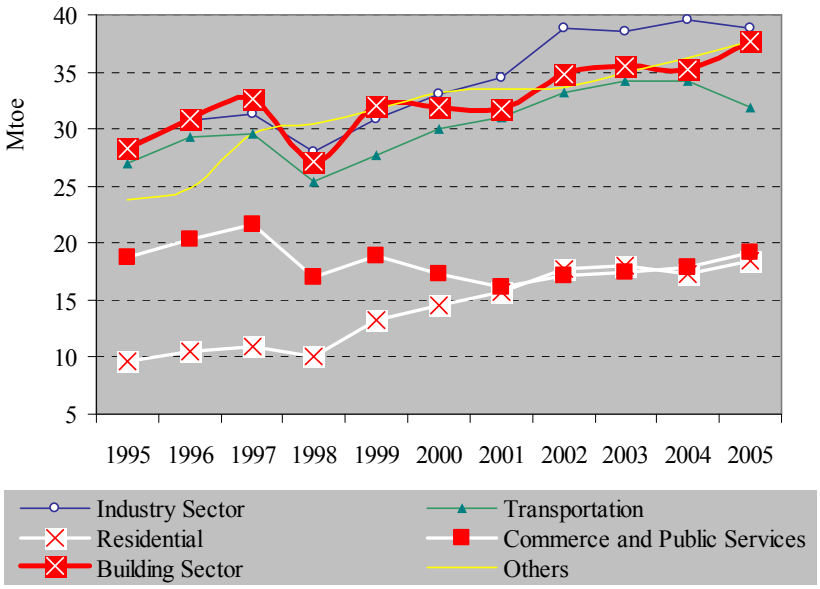
1.1 A Glance at the Economy and Energy

South Korea[1] has the world's thirteenth largest economy, with a gross domestic product (GDP) of US$1.4 trillion[2] in 2007 (IMF 2008; IMF 2008). Due to its limited domestic energy resources, Korea imports almost all of its coal, oil and natural gas. It is the world's second largest importer of coal, and one of the largest importers of oil and natural gas as well (EIA 2008). In 2006, Korea emitted 515 Mt carbon dioxide (EIA 2008).

1.2 Buildings Sector

According to the International Energy Agency (IEA), the buildings sector in Korea consumed 38 million tons of oil equivalent (Mtoe) or 26% of final energy use[3] in 2005 (Figure 1). The residential and commercial sectors have very similar levels of energy consumption: 18.5 vs. 19.2 Mtoe. From 1990 to 2005, the average annual growth rate of building energy demand was 2.9%, which was the highest among APP countries during this period (IEA 2007).

Figure 1 Energy Consumption by Sector in South Korea, 1990-2005



Notes: Energy consumption in this figure refers to final energy use, which includes consumption of renewable and waste energy; the sector "Others" includes agriculture, forestry, fishing, and non-specified and non-energy use. *Source: IEA, 2007*

1.3 Relevant Regulations

In the wake of the oil crisis in the 1970s, South Korea established the Ministry of Power and Resources. The government then issued the Rational national law for energy

[1] This report uses the terms South Korea and Korea to refer to the Republic of Korea.
[2] Nominal GDP in current U.S. dollars. Korea's GDP based on purchasing power parity was US$1.2 trillion in 2007.
[3] Final energy use includes consumption of renewable and waste energy.

efficiency and conservation. It also established the Korean Energy Management Corporation (KEMCO) in 1980 to manage national energy efficiency programs and policies issued by REUA (Ahn 1998).

Recognizing that its economy is largely fueled by imported fossil fuels, South Korea has set the three E's (energy security of supply, economic efficiency and environmental protection) as its national goals for achieving sustainable economic development. The Ministry of Knowledge Economy (MKE), or the former Ministry of Commerce, Industry and Energy (MOCIE)[4], is in charge of national energy policy.

From the mid-1970s to the mid-1990s, South Korea focused on improving energy efficiency in the industrial sector. Since the late 1990s, the government has shifted gears to promote energy efficiency in the buildings and transportation sectors (Hong, Chiang et al. 2007). For example, the government set long-term energy conservation goals for the buildings sector. These goals focused on reducing emissions by 6% in this sector by 2020, as compared with business-as-usual emissions (IEA 2006).

South Korea issued its first mandatory building standard on insulation thickness in 1977, followed by building energy standards for several types of building in the next two decades. These standards covered offices, hotels, hospitals and residential buildings. The separate energy standards for respective building types were integrated into the Building Design Criteria for Energy Saving (BDCES) in 2001, which is mandatory for all types of buildings where high energy consumption is expected. The BDCES was a product of intensive revision of existing standards and review of building energy codes of several countries, including the U.S., the U.K., Germany, Japan and Canada. The South Korean government felt that complex codes like the U.S. ones may provide a detailed blueprint, but the government preferred a simple approach like the Japanese codes in order to ease implementation in South Korea (Lee 2006). The BDCES underwent several revisions after 2001, with the latest in November 2008. This document reflects the November 2008 version of the standard.

1.4 Implementation

The Ministry of Land, Transport and Maritime Affairs (MLTM) developed the building energy codes. Local government building officials execute the codes as part of the building permitting process for new buildings. The property owner must fill out an energy-saving worksheet and submit it to local governmental offices to obtain a building permit. The worksheet should be signed by three licensed professionals, including an architect, mechanical engineer and electrical engineer. The energy-saving worksheet may be reviewed either by the local office or by KEMCO. However, the local office has the responsibility for approving the energy-saving worksheet (Lee, 2006).

A new clause in the code called "Relaxed Zoning Restrictions on Building Size" also provides further incentives for maximum implementation of energy saving technologies. Buildings exceeding the standards in the code are allowed to be built larger than the

[4]The Ministry of Energy and Resources was established in 1978 after the oil crisis, and later was integrated into MOCIE.

standard zoning restrictions would otherwise allow. The standards provide detailed instructions on how to rate buildings to determine the extent to which a building exceeds the code, and the corresponding privileges. Local governments may audit the buildings after construction, and if any of the items in the energy-saving worksheet is not implemented, the officials may revoke the permit and order the building to be rebuilt according to the original zoning restriction. In addition, buildings that rate highly are eligible for financial incentives, like low-interest loans. About half of the new buildings sampled in a special inspection from 2003 to 2005 were found to have been built out of compliance with the energy efficiency codes (BAI, 2006). This is a relatively high enforcement rate this soon after the adoption of a building energy code; the new incentives should help improve compliance further.

KEMCO has developed simple software to help with compliance and calculating whether a building reaches the minimum 60-point requirement. The calculation tool is called Energy Performance Index (EPI) and it is web-based.[5] Use of the tool is optional.

Korea also has detailed procedures for testing and certifying every product for which specific energy efficiency values are given in the building energy code. This includes insulation, windows, mechanical equipment, lighting and most major appliances. There are several independent testing facilities certified to conduct tests under the Korea Laboratory Accreditation Scheme (KOLAS). The testing facilities and certification process helps ensure that builders and code enforcement agents know the energy rating of a product, and hence, are able to build building to meet the standard.

In the future, it is expected that the government will likely adopt a performance-based building energy code which will limit energy use per unit area in new buildings, and set higher insulation standards over time (Lee 2006).

The government has also launched policies to promote energy efficiency in existing buildings. In 2007, the government mandated that energy audits should be conducted every five years for buildings where annual energy use is over 2 thousand tons of oil equivalent (ktoe). Buildings deemed energy efficient under the voluntary Korean Energy Efficiency Rating can be exempted from this requirement (IEA 2006).

2 Building Design Criteria for Energy Saving (2008)

2.1 Overview

The building envelope requirements in the BDCES, such as insulation material standards, are mandatory for all new buildings. More detailed provisions regulate large new buildings[6], including: (1) apartment/condominium buildings with over 50 households, (2) education/research or office buildings greater than 3,000 square meters, (3) hotels/motels and hospitals over 2,000 square meters, (4) public bathhouses and swimming pools over

[5] The calculation program is available free of charge at: www.kemco.or.kr/building/v2/.
[6] Henceforth, we focus on the detailed regulations on the large buildings, as large buildings the primary target of the code.

500 square meters, (5) wholesale/retail stores (e.g. department stores) with a centralized cooling/heating system and over 3,000 square meters, or (6) performance halls, town halls and stadiums with total floor area over 10,000 square meters.

The BDCES is a prescriptive-based building energy standard. It contains four main sections (Table 1): "Construction Design," "Machinery Design," "Electric Facility Design" and "Renewable Energy Facility Design". Each section outlines "mandatory items" and "recommended items." In addition, there are "Supplementary Rules" mandating that multi-purpose buildings be approved for each relevant purpose.

For new buildings, the property owner and the construction company must submit an energy-saving worksheet before construction begins to demonstrate compliance with the BDCES. Each building must satisfy all mandatory items and reach at least 60 points for both mandatory and recommend items combined to comply with the standard. For buildings that score more than 70 points by adopting additional recommended items, the property owners are allowed to build buildings larger than otherwise allowed under the local zoning regulations.

Table 1 Essential Features of the BDCES

Section Number and Title	Description
1. General Information	Purpose, application scope and terminology
2. Energy Saving Design Criteria	
2.1. Construction Design Criteria	Mandatory and recommended items
2.2. Machinery Design Criteria	Mandatory and recommended items
2.3. Electric Facility Design Criteria	Mandatory and recommended items
2.4. Renewable Energy Facility Design	Mandatory and recommended items (if applicable)[7]
3. Energy-Saving Worksheet Criteria	Energy-saving worksheet preparation, judgment on mandatory items in energy-saving design criteria, and judgment on energy performance index review
4. Relaxed Zoning Restrictions on Building Size	Procedures and rules governing relaxation of zoning restrictions on building size for buildings exceeding the standard
5. Supplementary Rules	Preparation of an energy-saving worksheet sheet for multi-purpose buildings; implementation clause of the energy-saving worksheet

Source: BDCES 2008

2.2 Construction Design Criteria

The section on construction design criteria in the BDCES covers similar building envelope requirements as other APP countries. The Construction Design Criteria section includes both mandatory items and recommended items (Table 2).

[7] The Renewable Energy Facility Design provisions are not mandatory. However, if property owners decide to install renewable energy facilities, it is mandatory to follow certain steps.

The mandatory items cover thermal insulation and heat resistance requirements for the building envelope, such as regional U-factor values[8] by building envelope component (Table 3) and region-specific thicknesses of insulating materials. The recommended items provide suggestions on building orientation, sealing, active use of natural lighting, shading and natural ventilation for energy conservation.

Note that the BDCES groups the U-factor values based on three geographical zones in South Korea, including (1) central, (2) south and 3) Jeju Island. The central region includes Seoul, Incheon and other cities and provinces, while the southern region includes Busan, Gwangju and others.[9]

Table 2 Construction Design Criteria

	Items	Selected Contents
Mandatory Items	Insulation	This subsection provides region-specific U-factors for building envelope and thicknesses of insulating materials.
	Installation of Insulating Materials for Floor Heating	Insulating materials for floor heating must be installed between the floor slabs and hot water pipes (heating cable for electric heating).
	Dew Condensation Prevention and Sealing	Moisture-proof layers must be installed on the indoor side of insulating materials to ensure proper insulation performance. The joints between moisture-proof layers and insulating materials and the ends must follow the described provisions to prevent moisture permeation.
Recommended Items	Layout	Building orientation should face south or southeast to maximize natural lighting and heating. Longer distance between high-rise buildings is recommended in order to maximize sunshine exposure of lower floor units.
	Ground	The ceiling height should be as low as possible within the scope of the purpose and functions. The ratio of the building envelope to the building volume should be as small as possible.
	Insulation	This subsection recommends increasing the thermal resistance of the building envelope or reducing the window area to reduce heat loss from the walls, ceilings and floors. Multi-layered glass is recommended for sunrooms. A green roof is recommended for additional insulation and prevention of direct solar radiation exposure of the roof.

[8] U-value describes heat transmittance (watt/^{o}K m^{2}), while R-value describes thermal resistance (^{o}K m^{2}/watt).

[9] Additional provinces in the central region include: Gyeonggi-do, Gangwon-do (Excluding Gangreung, Donghae, Sokcho, Samcheok, Goseong, Yang-yang), Chungcheongbuk-do (excluding Young-dong), Chungcheongnam-do (CheonAhn) and Gyeongsangbuk-do (Cheongsong). The southern region also includes Daegu, Daejeon, Ulsan, Gangwon-do (Gangreung, Donghae, Sokcho, Samcheok, Goseong, Yang-yang), Chungcheongbuk-do (Young-dong), Chungcheongnam-do (excluding Cheonahn), Jeollabuk-do, Jeollanam-do, Gyeongsangbuk-do (excluding Cheongsong) and Gyeongsangnam-do.

	Sealing	This subsection recommends structuring the entrances to an apartment building and its residential units exposed to the outside air so as to shield the entrances from the wind.
	Natural Lighting	Natural lighting should be actively used, particularly in classrooms, public spaces and swimming pools.
	Ventilation	Exterior windows that can be manually opened should be installed in inhabited spaces in order to ensure effective ventilation even without electric ventilation devices.

Source: BDCES 2008

Table 3 Maximum Heat Transmission (U-factor) of Building Envelope Components by Region

Unit: $W/m^2 K$

Building Element			Overall Heat Transfer Value		
Wall	Exposed to the outside air		0.47	0.58	0.76
	Semi-exposed to the outside air		0.64	0.81	1.10
Ground Floor	Exposed To the outside air	Floor heating	0.35	0.41	0.47
		Other than floor heating	0.41	0.47	0.52
	Semi-exposed to the outside air	Floor heating	0.52	0.58	0.64
		Other than floor heating	0.58	0.64	0.76
Roofs over the Top Floor	Exposed to the outside air		0.29	0.35	0.41
	Semi-exposed to the outside air		0.41	0.52	0.58
Side Walls in Multi-family Housing			0.35	0.47	0.58
Middle Floor in Multi-family Units	Floor heating		0.51	0.81	0.81
	Other than floor heating		1.16	1.16	1.16
Windows and Doors	Exposed to the outside air		3.84	4.19	5.23
	Semi-exposed to the outside air		5.47	6.05	7.56

Source: BDCES 2008

2.3 Machinery Design Criteria

This section contains both mandatory and recommended items (Table 4).

The mandatory items require property owners and construction companies to meet the provided design specifications. This section also provides indicators for calculating heating/cooling capacity design such as average outside temperature and humidity by locale. It also requires that district heating connections and installed pumps comply with the relevant efficiency standards. Exterior pipes and ducts must be insulated in accordance with an MLTM standard.

The recommended requirements include using energy-efficient appliances and pumps, thermostats, and installations for solar energy, waste heat recovery and ventilation cooling.

Table 4 Machinery Design Criteria

	Items	Selected Contents
Mandatory Items	Outside Air Conditions	This subsection provides benchmark values regarding outside air temperature and humidity for calculating heating/cooling system capacity by region.
	Heat Supply and Transmission Facilities	Central heating systems, pumps for floor heating water, and insulation materials for pipelines and ducts must comply with the corresponding efficiency standards.
Recommended Items	Indoor Temperature	This subsection provides the indoor design temperature and humidity for calculating the capacity of a heating/cooling system by building function. (The recommended design temperature is 20 °C for heating and 28 °C for cooling.)
	Heat Supply Facilities	Heat supply facilities should be energy efficient. Heat recovery facilities should be installed to collect the waste heat. Heating and cooling systems that use off-peak electricity or natural gas should be used. Advanced cooling systems such as district cooling, micro-cogeneration cooling and renewable energy cooling systems are recommended.
	Air Conditioning Facilities	Economizers utilizing cool outside air are recommended when they are cost-effective.
	Water Distribution Facilities	Water supply and circulating pumps as well as booster pumps should have controls allowing for variable speeds. High-efficiency fans should be used.
	Ventilation & Control Facilities	This subsection recommends recovering waste heat. A separate thermostat should be installed in each room or heating zone in an apartment.
	Sanitation Facilities	The service water tank should be designed to hold water at 55 °C or less; water temperature can be raised by booster heaters as needed. Energy consumption facilities should have automatic or network integrated controls.

Source: BDCES 2008

2.4 Electric Facility Design Criteria

The mandatory requirements of the electric facility portion of the code include the use of efficient transformers, motors, and lighting. The recommended items involve induction motors, demand controllers for peak load conditions, energy efficient elevators and high intensity discharge (HID) lamps for outdoor spaces (Table 5).

Table 5 Electric Facility Design Criteria

	Items	Selected Contents
Mandatory Items	Electric power supply	The subsection mandates installing energy efficient transformers and transformer monitors.
	Power equipment	The main line voltage drop must comply with the Korea Electric Association's indoor wiring regulations.
	Lighting equipment	This subsection mandates installing energy efficient lighting systems with fluorescent lamps and motion sensors for entrances. Sun-lit areas must have a selective shut-off capability.
Recommended Items	Electric power supply	This subsection recommends the configuration of controllers on banks of transformers, demand controllers for peak times and individual electricity consumption meters for each dwelling unit.
	Power equipment	This subsection recommends installing energy-efficient induction motors and an energy-efficient system for the control of elevator motors.
	Lighting equipment	This subsection recommends using light emitting diode (LED) lamps for exit lamps and programmable high intensity discharge (HID) lamps for outdoor lighting. Incandescents are not to be used, except for emergency lights.
	Control equipment	This subsection recommends installing group operation controls for elevators and automatic controls for indoor lighting equipment.
	Standby energy loss	This subsection recommends using products certified for low standby power consumption.

Source: BDCES 2008

2.5 Renewable Energy Facility Design Criteria

This section was added in the revisions to the original 2001 code. The installation of renewable technologies is not mandatory. However, installing these systems according to the standard would provide opportunities for obtaining a higher score in the energy-saving worksheet. Renewable energy facilities include solar thermal heaters, solar photovoltaic cells, geothermal heat-pumps and wind turbines (Table 6).

Table 6 Renewable Energy Facility Design Criteria

	Items	Selected Contents
Mandatory Items	Solar thermal heaters (for water or space heating)	The heater must be appropriately installed in consideration of installation area, heating demand, and desired temperature.
	Solar photovoltaic cells	The cells must be installed in sun-lit areas, preferably facing south, at an angle maximizing solar insolation[10].
	Geothermal heat pumps	Appropriate heat pumps must be selected in consideration of the building type, geologic characteristics, available space and cost effectiveness.
	Wind turbines	Appropriate wind turbines must be selected in consideration of available space, wind direction and speed, economic and energy efficiency, and reliability.
	Installation and maintenance	Installed systems must not negatively affect the structural integrity of the building.
Recommended Items	Solar thermal heaters (for water or space heating)	Recommended items include: active demand control to maximize daytime consumption and reduce heat storage capacity; installation angle set according to seasonal demand; installation of an integrated control system between the solar heating and auxiliary heat source.
	Geothermal heat-pumps	Grouting is recommended to minimize pore space between heat exchangers and underground, using high heat conductivity materials. Accurate estimate of loop size in consideration of capacity is recommended.
	Wind turbines	Installation locations with consistent wind direction and speed are recommended. Safeguard measure against destruction by typhoon is recommended.

Source: BDCES 2008

2.6 Energy-Saving Worksheet Criteria

The energy-saving worksheets include "General Items," "Mandatory Items" and a "Performance Index Review". All buildings must submit an energy-saving worksheet that has a total point value no less than 60. In order to be approved for construction, the building must not only satisfy all of the mandatory requirements, but also adopt some of the "recommended" items according to the property owner's preferences. The review process is based on blueprints and supplemental data provided by the construction company. In designing the point system, two key criteria the Korean government considered were the energy saving potential and the ease of market adoption. For example, an energy efficient but expensive technology will receive more points in the system to encourage its adoption (Lee 2006).

[10] Insolation means the amount of sunlight that shines on each square meter.

2.7 Relaxed Zoning Restrictions on Building Size

A new addition to the BDCES, this section describes the incentive system to encourage property owners to exceed the 60 point minimum requirement in the energy saving worksheet or to obtain energy certificates which is to explained in clause 3.1. The local zoning restrictions on height and floorspace of buildings are relaxed for buildings exceeding 70 points. Specifically, buildings that achieve 70-80 points or 3rd grade certificates get a 2% relaxation in these requirements; 80-90 points or 2nd grade certificates get a 4% relaxation, and 90-100 points or 1st grade certificates get a 6% relaxation.

For example, a building with 85 points or 2nd grade certificates in a zone where the height restriction is 100 meters and the restriction on floorspace is 1,000 square meters can be 103 meters tall and have 1,010 square meters of floorspace. This type of incentive could be very effective in high-density cities like Seoul or Busan, where most of the buildings are built at the maximum size restrictions.

To qualify for the relaxation in zoning requirements, the property owner and construction company should submit a separate application with the energy-saving worksheet when applying for a building permit. However, it is also possible to apply retroactively after the building permit is issued. The reviewing official in the local government should only approve the application if it meets the explicit design and implementation conditions in actual construction. If a property owner fails to implement any one of the items in the application, the local government can reject approval, and order the building to be built to the original zoning regulation.

3 Other Developments

Besides the mandatory building energy standard, the BDCES, South Korea has also promoted an array of voluntary programs to improve building energy efficiency.

3.1 Energy Efficiency Labeling Program for Buildings

Newly built or renovated dwellings with more than 18 households are classified into three grades depending on the application of energy-saving features and equipment. A building which surpasses a certain performance standard is provided with a Certificate of Building Energy Efficiency, which makes the building eligible for low-interest rate construction loans. The Korean government has progressively expanded the energy efficiency labeling program by targeting office buildings in 2004 - 2010 (Y. Lee and S. Kim 2008).

3.2 Green Building Certification Program

The Green Building Certification Program applies environmental lifecycle assessment to the buildings sector, including production of materials, design, construction, maintenance and building demolition. The program aims to improve environmental performance, reduce energy use and the related GHG emissions (Y. Lee and S. Kim 2008).

The certification audits cover existing buildings, including multi-unit dwellings, residential and commercial complexes, public and private commercial buildings and remodeled buildings. The program can also issue a certification if the construction contractor chooses to undergo an audit from the initial design stage. The system has four grades and certification is valid for five years, with the possibility of a five-year extension. After ten years, the regulation requires a new audit for renewal (Hong, Chiang et al. 2007).

3.3 Financial Incentives

KEMCO is planning to provide financial support to energy-efficient activities including cogeneration, energy savings and the use of renewable energy (Table 7).

Table 7 KEMCO's Financial Support for Rational Energy Use in Buildings (under Notification No. 2002-239)

Project Classification		Areas	Incentives (Financial Support)
Project with Energy-Saving Facilities	Energy-Saving Project	▪ Cogeneration ▪ Energy-Saving Facilities	▪ Loan for facility construction (100% of the construction costs, with annual interest of 5.25%) / 8-year grace period and loan payable in 7 years, and ▪ Up to US$10.6 million[11] for each project owner
		▪ Voluntary Agreement	▪ Loan for facility construction (100% of the construction costs with annual interest of 4.00%) / Up to US$10.6 million for each construction site / 8 year grace period and loan payable in 7 years, and ▪ Up to US$21.1 million for each project owner / Review energy-saving performance in last 5 years and energy-saving plan for upcoming 5 years
	Energy Saving Company (ESCO) Project	▪ Various	▪ Loan for facility construction (100% of the construction costs with annual interest of 4.00%) / 5 year grace period and loan payable in 5 years, and ▪ Up to US$10.6 million for each investor
	Demand Forecasting Project	▪ Demand Controlling Facilities ▪ Thermal Storage	▪ Loan for facility construction (100% of the construction costs with annual interest of 4.00%) / 3 year grace period and loan payable in 5 years, and ▪ Up to US$21.1 million for each building
	Energy-Saving House Promotion Project	▪ Project Promoting Energy Efficiency Labeling	▪ Loan for facility construction (100% of the construction costs with annual interest of 4.00%) / 2 year grace period and loan payable in 2 years, and ▪ Up to US$15.8 million for each construction

[11] One won was $1.056 * 10^{-3}$ US dollar on June 30, 2006 (www.oanda.com/convert/classic).

		Certification (Program for Building Efficiency)	site (Under US$31.7 million for each project owner)
Project with Alternative Energy Source		▪ Solar Energy Facilities ▪ Alternative Energy Facilities	▪ Facility construction cost on loan (100% of the facility construction cost with annual interest of 4.00%) / 3 year grace period and loan payable in 5 years, and ▪ Up to US$15.8 million for each project owner

Source: Lee, 2006

3.4 Energy Audit Program

KEMCO conducts energy audits for residential and commercial buildings at the request of the building owners. As part of the audit, KEMCO identifies and recommends energy-saving measures. As noted above, low-interest loans are available to finance the improvements. Between 1980 and 2001, KEMCO performed only 377 energy audits. KEMCO inspected a total of 2,096 businesses and buildings between 2002 and 2004, a period covered by a national Three-Year Plan for Energy Auditing (Hong, Chiang et al. 2007).

In 2007, the government mandated that energy audits be conducted every five years for buildings in which annual energy use is over 2 ktoe. Certified energy efficient buildings can be exempted from this requirement (IEA 2006).

3.5 Voluntary Agreements for Existing Buildings

Voluntary agreements have been a major component in South Korea's energy efficiency strategy since the South Korean industrial sector first began using such agreements in 1998. In a voluntary agreement covering an industrial sector, companies sets their own energy conservation targets, propose implementation methods and execute the plan. The government provides direct financial support or tax incentives to support the agreement (IEA 2006).

The voluntary agreement for buildings targets buildings with annual energy consumption over 2 ktoe. In order to enroll in the program, a building owner needs to submit an action plan to reduce energy use and related emissions. A 5% reduction target is recommended over five years. The government provides low-interest loans, tax incentives, technical support and public recognition to participating buildings (Hong, Chiang et al. 2007).

3.6 Renewable Energy in Buildings

In 2003, the South Korean government set two targets for market penetration of new and renewable energy: 3% of total primary energy supply in 2006 and 5% in 2011. To achieve these targets, the government passed the Second Basic Plan for New and Renewable Energy Technology Development and Dissemination (IEA 2006). Under this plan, the government is implementing two programs to promote renewable energy use in buildings as outlined below.

- **The 100,000 photovoltaic houses project.** In order to promote the use of solar power in buildings, the South Korean government is supporting the construction of 100,000 homes that rely on solar photovoltaic power for some of their power needs. To meet this goal, the government provided US$59.6 million[12] in subsidies to 332 projects between 2001 and 2004 with an estimated 837 kW capacity (IEA 2006).

- **Public-sector buildings.** The South Korean government passed legislation in 2002 requiring that all newly built public buildings (including central and local government buildings) with over 3,000 square meters of floor space allocate at least 5% of their construction costs to new and renewable energy facilities. In 2004, the government provided US$4.3 million[13] to ten model businesses (IEA 2006).

4 Conclusions

South Korea preferred a simple structure for the design of the BDCES in order to ease its implementation. The BDCES is a prescriptive building energy standard. It contains three main sections: "Construction Design," "Machinery Design," and "Electric Facility Design." Each section outlines both mandatory and recommended items. All new property owners must submit an energy-saving worksheet that has a total point value no less than 60. In order to be approved for occupancy, the building must not only satisfy all of the mandatory requirements, but also adopt some of the recommended items according to the property owner's preferences. The standard also provides incentives for exceeding the 60 point minimum by relaxing zoning requirements on height and size.

Besides the mandatory building energy standard, the BDCES, and Energy Audit Program, South Korea has also promoted an array of voluntary programs to improve building energy efficiency, including Energy Efficiency Labeling Program for Buildings, Green Building Certification Program, Financial Incentives, and Voluntary Agreements for Existing Buildings.

[12] Based on the average exchange rate in that period.
[13] One won was $8.69*10^{-4}$ US dollar on June 30, 2004 (www.oanda.com/convert/classic).

List of Acronyms

APP	Asia-Pacific Partnership on Clean Development and Climate
BAI	Bureau of Audit and Inspection of Korea
BDCES	Building Design Criteria for Energy Saving
BEF	Ballast efficiency factor
ESCO	Energy service company
GDP	Gross domestic product
GHG	Greenhouse gas
HID	High intensity discharge
IEA	International Energy Agency
KEMCO	Korean Energy Management Corporation
KICT	Korea Institute of Construction Technologies
KOLAS	Korea Laboratory Accreditation Scheme
KRW	Korean won (currency of South Korea)
ktoe	Thousand tons of oil equivalent
LED	Light-emitting diode
MKE	Ministry of Knowledge Economy
MLTM	Ministry of Land, Transport and Maritime Affairs
MOCIE	Ministry of Commerce, Industry and Energy
Mtoe	Million tons of oil equivalent
OECD	Organisation for Economic Co-operation and Development
ppm	Parts per million
REUA	Rational Energy Utilization Act
UMD	University of Maryland (College Park)
VA	Voluntary agreement

References

1. Ahn, M.-C. (1998). "The Energy Conservation Programme of the Republic of Korea." Compendium on Energy Conservation Legislation in Countries of the Asia and Pacific Region. Retrieved September, 2008, from http://www.unescap.org/esd/energy/publications/compend/ceccpart2chapter3.htm#2%20Energy (Accessed).
2. EIA (2008). "South Korea Energy Profile." Retrieved May, 2008, from http://www.eia.doe.gov/emeu/cabs/South_Korea/Background.html.
3. EIA (2008). "World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels." Retrieved January, 2009, from www.eia.doe.gov/emeu/international/carbondioxide.html (Accessed).
4. Hong, W., M. S. Chiang, et al. (2007). Building Energy Efficiency: Why Green Buildings Are Key to Asia's Future. Hong Kong, Asia Business Council.
5. IEA (2006). "Energy Policies of IEA Countries: The Republic of Korea." Retrieved September, 2008, from http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1921 (Accessed).
6. IEA (2007). Energy Balances of OECD Countries (2007 edition), OECD, Paris.
7. IMF (2008). "World Economic Outlook Database." Nominal GDP list of countries. Data for the year of 2007. Retrieved January, 2009.
8. IMF (2008). "World Economic Outlook Databases." Retrieved January, 2009, from www.imf.org/external/ns/cs.aspx?id=2 (Accessed).
9. Lee, S.-E. (2006). Energy Efficiency Building Standards in Korea. Seoul, Korean Institute of Construction Technology.
10. Y. Lee and S. Kim (2008). "Trends in the Korean building Ventilation Market and Drivers for Change." Retrieved January, 2009, from http://www.aivc.org/medias/pdf/Free_VIPs/VIP26_Korea.pdf (Accessed).

Useful Websites

1. Korea Energy Management Corporation (KEMCO), www.kemco.or.kr/
2. Korea National Statistics Office, www.nso.go.kr/eng2006/emain/index.html
3. Ministry of Land, Transportation, and Maritime Affair, http://test.mltm.go.kr/EngHome/index.jsp

The Asia-Pacific Partnership on Clean Development and Climate

The Asia-Pacific Partnership on Clean Development and Climate is an innovative new effort to accelerate the development and deployment of clean energy technologies.

Partner Countries

APP partners Australia, Canada, China, India, Japan, Republic of Korea, and the United States have agreed to work together and with private sector partners to meet goals for energy security, national air pollution reduction, and climate change in ways that promote sustainable economic growth and poverty reduction. The Partnership will focus on expanding investment and trade in cleaner energy technologies, goods and services in key market sectors. The Partners have approved eight public-private sector task forces covering:

- Aluminum
- Buildings and Appliances
- Cement
- Cleaner Use of Fossil Energy
- Coal Mining
- Power Generation and Transmission
- Renewable Energy and Distributed Generation
- Steel

The seven partner countries collectively account for more than half of the world's economy, population and energy use, and they produce about 65 percent of the world's coal, 62 percent of the world's cement, 52 percent of world's aluminum, and more than 60 percent of the world's steel.

Buildings and Appliances Task Force

Reducing our use of energy for buildings and appliances decreases the demand for primary energy and is a key means to deliver better economic performance, increase energy security and reduce greenhouse gas and air pollutant emissions. Partner countries have recognized for some time the importance of cooperating on energy efficiency for buildings and appliances, and have already taken a range of bilateral and other collaborative actions in this area. As the Partners represent a majority of the world’s manufacturing capacity for a diverse range of appliances, we have the potential to drive significant regional and global improvements in energy efficiency in this sector. The Partners will demonstrate technologies, enhance and exchange skills relating to energy efficiency auditing, share experiences and policies on best practices with regard to standards and codes, as well as labeling schemes for buildings, building materials and appliances.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