



AALBORG UNIVERSITY
DENMARK

Aalborg Universitet

CLIMA 2016 - proceedings of the 12th REHVA World Congress

volume 8

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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

[Link to publication from Aalborg University](#)

Citation for published version (APA):
Heiselberg, P. K. (Ed.) (2016). *CLIMA 2016 - proceedings of the 12th REHVA World Congress: volume 8*. Department of Civil Engineering, Aalborg University.

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Constructing an effective maintenance plan for zero-energy apartment buildings

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Abstract

With global efforts to enforce various measures for energy reduction, South Korea plans to promote a zero-energy building mandate for all new buildings constructed after 2025. For this purpose, as of 2016, active research and construction work are underway to build an apartment complex with zero net energy consumption for 5 main types of energy use (cooling, heating, ventilation, hot water and lighting). As an inhabited residential complex, the apartment complex is expected to be available as rental housing for low-income families in the future. Constructing these zero-energy apartment buildings has the potential to save energy, however, it is still important for residents to recognize the proactive maintenance and management of the complex for zero energy consumption while residing in the complex. Aside from simple facility operations and malfunctions under facility management, there is a need for an efficient maintenance management plan for the people living in the apartment complex. The purpose of this study is to establish an efficient maintenance management plan for zero-energy apartment buildings. By deriving maintenance items that can be applied to domestic zero-energy houses through a comparative analysis of maintenance items from domestic and overseas green building standards and certification systems, we intend to develop the configurations of a maintenance management plan for zero-energy apartment buildings.

Keywords – maintenance;reducing energy;zero-energy apartment buildings

1. Background and objectives of the study

With a variety of measures implemented worldwide for energy reduction, the Korean government announced the 2030 energy and new industries diffusion strategy in November 2015.

The strategy includes a zero-energy building mandate for all new buildings constructed after 2025, and a plan for gradual expansion of large-scale CSS integrated businesses to reduce greenhouse gas emissions by more than 4 million tons per year from 2030.

To enforce the zero-energy building mandate for all new buildings after 2025 as part of the 2030 energy and new industries diffusion strategy, a national project has been carried out to build an apartment complex with zero net energy consumption for 5 main types of energy use (cooling, heating, ventilation, hot water and lighting). While there are a lot of experimental buildings to implement zero-energy apartment buildings in South Korea, this study makes the move to build a zero-energy apartment complex where people live.

Constructing zero-energy apartment buildings with zero net energy consumption for 5 main types of energy use is of great significance, however, it is still important for residents to recognize the proactive maintenance and management of the complex for zero energy consumption while residing in the complex not designed only for experimental use. For this purpose, aside from simple facility operations and malfunctions under facility management, there is a need for an efficient maintenance management plan for the people living in the apartment complex.

The present study is to propose a maintenance management plan for the efficient maintenance and management, and *residents'* awareness of the zero-energy apartment complex built for the first time in South Korea.

2. Methods

There have been few case studies showing examples of zero-energy apartment building in South Korea and other countries. To explore an efficient maintenance management plan for zero-energy apartment buildings, in this study we perform a comparative analysis of facility and resident maintenance items from domestic and overseas green building standards and certification systems, which can lead to derive major issues from oversea certification systems to provide an efficient maintenance management plan that can be applied to domestic zero-energy houses.

3. Zero-energy demonstration apartment complex

The zero-energy apartment complex as part of a national project is the first zero-energy housing built in South Korea. The complex consists of a total of 121 households in 3 different sizes (39 m², 49 m² or 50 m²) including four house types of detached single-unit housing, semi-detached dwellings, attached single-unit housing and attached multi-unit housing. Employing passive energy performance materials with external insulation methods, insulating doors and external blind windows and active energy performance materials such as solar, geothermal and biomass, the zero-energy apartment complex is currently under construction with the aim of zero net *consumption* for 5 main types of energy use (cooling, heating, ventilation, hot water and lighting) and is expected to be supplied to the public rental housing after completion.

4. Comparative analysis of operation management plans from domestic and overseas green building certification systems

The Korean green building certification system first implemented in 2002 has gradually developed into the green standard for energy and environmental design. Both new and existing buildings belong to the certification target of the system, and can qualify for four levels of certification, depending on its assessment points based on the examination criteria: excellent(green level 1), good(green level 2), fair(green level 3), or *poor*(green level 4). A preliminary certificate is valid from the date of certification until use inspection or use approval is completed, and a standard certificate, once certified, is valid for five years from the date of certification.

Under the green standard for energy and environmental design, the assessment items aim to allocate points based on the potential of eco-friendliness across nine credit categories: land use and transportation, energy and environmental pollution, materials and resources, water cycle management, maintenance management, ecological environment, indoor environment, and housing performance sector. The assessment items in the category of the operation and maintenance of an apartment building is divided into ‘efficient building management’ and ‘efficient household management’.

The category of ‘efficient building management’ is comprised of details for the operation and maintenance of facilities to be installed as that of ‘efficient household management’ is configured with information about provision of user’s manual. The assessment details are mainly focused on the technical maintenance of facilities and equipment and the user's guide for apartment facilities.

Table 1 G-SEED maintenance management assessment items

Categories	Assessment Items	Issue
Efficient building management	Feasibility of Operation/maintenance documents and guidelines	<ul style="list-style-type: none"> - Detailed and stepwise instructions and checklists for the adjustment procedures of all major equipment and facilities with start, stop, emergency and normal operations - Detailed and stepwise instructions and checklists for major maintenance and repair work - Recommendations from manufacturers for major equipment and systems - Periodic preventive maintenance activity plans and forms based on maintenance and inspection cycle for filtering and cleaning - Manufacturer's performance specifications data and fault finding procedures

		<ul style="list-style-type: none"> - List of standard specifications for spare parts - Contact details for machinery and equipment installers, and maintenance personnel
Efficient household management?	Provision of user's manual	<ul style="list-style-type: none"> - Assessed on the basis of provision of user's maintenance manuals (documents or electronic documents) to residents ① Unit household floor plan including building structure (bearing wall / non-bearing wall) and pillar position ② Details for heating (cooling), hot water, and gas facilities ③ Details for water supply, drainage, and sanitation ④ Details for lighting and electrical facilities ⑤ Details for information communication equipment ⑥ Details for lifestyle etiquette and safety concerns about living in apartment buildings (extinguishing facility usage, evacuation routes, inter-household noise reduction measures, waste treatment, etc.) ※ User's manual shall include the following: <ul style="list-style-type: none"> - Inspection, failure detection and replacement methods, efficient operating methods, etc. - Periodic preventive maintenance based on maintenance and inspection cycle - Contact details for machinery and equipment installers, and maintenance personnel

In addition to the operation management plan of the domestic green building certification system described above, the following are other green building certification systems implemented earlier than the domestic system and used in some countries such as the UK, the USA, Japan, and Germany.

BREEAM is an environmental assessment method and rating system for new and existing buildings, first published by the British organization BRE (Building Research Establishment). Assessing the overall environmental quality of buildings, it is used as a tool for marketability review and assessment among owners, occupiers, designers and operators.

The 'Code for Sustainable Homes' as a BREEAM assessment tool has been mandatory for all new homes from May 2008. The code aims to protect the environment by providing guidelines on the construction of high-efficiency and high-performance homes built with higher sustainability performance. Code assessments are carried out in two phases, design stage and post construction stage, and uses an overall sustainability rating measured from 1 to 6.

The maintenance-related assessment items in the 'Code for Sustainable Homes' is divided into 'Energy Display Devices' from the category of 'Energy and Carbon Dioxide Emissions' and 'Home User Guide' from the category of 'Management'.

From the maintenance management items of the "Code for Sustainable Homes", it is known that the requirements are about providing diverse information on efficient housing operation management and facility maintenance such as devices for displaying energy consumption and cost, tips for energy saving, guidelines for various languages and Braille, and tips for purchasing high energy efficiency products.

LEED is another green building certification system, developed in 2000 by the USGBC (US Green Building Council). The LEED certification system, unlike other certification systems, was developed in all sectors related to the building industry, such as manufacturers, environmental organizations, building owners, equipment companies, state governments, research institutions, professional associations, and universities. LEED certification goes through the public process by undergoing a review process by the general public.

The LEED certification system offers four certification levels - Certified, Silver, Gold and Platinum -- that correspond to the number of credits accrued in five target categories: LEED for bd+c, LEED for id+c, LEED for bo+m, LEED for homes, and LEED for ND.

The assessment items corresponding to the category of operation and maintenance management of the LEED bd+c, the most commonly evaluated, can be classified into building-level energy metering, enhanced commissioning, and advanced energy metering. The requirements for the building-level energy metering are about ensuring that an integrated sub meters is used to provide a building energy level meter, and that the data of energy consumption and demand is shared with the USGBC at intervals of at least one month for five years. The United States operates a commissioning system delegated to experts for the maintenance of buildings at the post construction stage. Also, recertification is required every year to review the operation and budget planning

of buildings constantly by making use of feedback effectively from users and certification authorities.

The operation and maintenance items of the LEED for Homes as a housing assessment tool include Energy Metering, Education of Homeowner, Tenant, and Building Manager of EA Prerequisite.

The requirements for the LEED for Homes are ensuring operation and maintenance training for residents, managers and owners, and mandatory practice with all equipment installed for efficient housing use.

Japan has established a building assessment system named the Comprehensive Assessment System of Building Environmental Efficiency (CASBEE) based on the GBtool(Green Building Assessment Tool). It is composed of four assessment tools corresponding to the building life cycle: Pre-design, New Construction, Existing Building and Renovation. Assessment for the Existing Building involves the building specifications and performance assessment at the time of evaluation. Assessment for buildings is made based on the CASBEE for home by dividing the space of the target building into interior and exterior space. Assessment items for interior space involves the issues of ‘environmental quality and performance of user friendly buildings’ while assessment items for exterior space are about ‘reducing environmental burdens by user friendly buildings’. The assessment items corresponding to the operation management of the certification system is largely divided into the categories of maintenance repair and maintenance management. Assessment items for maintenance repair cover the ease of maintenance considering the convenience of replacement, and a maintenance repair system comprising of periodic inspection, repair and recovery. Assessment items for maintenance management are ensuring proposal of housing management schemes for the maintenance planning and support, and energy management control for reducing energy consumption. In Japan, building data should be kept for at least one year for follow-up assessment.

Table 2 CASBEE for HOME maintenance management assessment items

Categories		Issue
Maintenance repair	Ease of maintenance	- Maintenance of drainage pipes, water pipes and gas pipeline and assessment of the ease of electrical wiring in consideration of the convenience of replacement
	Maintenance repair systems	- Periodic inspection, repair, recovery and replacement - Manuals or periodicals for information, consultation service - Basic building information and inspection history for follow-up inspections
Maintenance management	Proposal of housing management	- Assessment of maintenance planning and support system - Compliance with conservation planning of

	schemes	certification standards for Long-term quality - Reference to My Home maintenance guidelines supervised by Housing Finance Agency and inspection record
	Energy management control	- Energy control and management for reducing energy consumption - Use of devices to display electricity, gas and water (energy consumption, energy costs, etc.) - Use of devices to display energy consumption, installed on the end of outlets and gas valves - Distribution panel having a function of cutting off a branch circuit depending on the use conditions of power consumption devices - HEMS application

The DGNB Certification System was developed in collaboration with the German federal transportation, the Architecture and Urban Development Agency and the German Sustainable Building Council (DGNB) in 2009. The system, not just a tool for assessing buildings, covers a comprehensive review of ecological, economic, socio-cultural and functional perspectives, technologies and processes in the course of planning to assess the level of buildings. Unlike other existing certification systems that evaluate highly the environmental aspects, it is based on several criteria including environmental quality, economic quality, socio-cultural and functional quality, technical quality, process quality and land quality along with three keywords of ecological, economic and social impacts. Assessment of new buildings focuses on the wellbeing and comfort of users, awarding high credits on the items of noise protection, variability improvement and indoor air quality. Low maintenance cost, maintenance of buildings, and quality of buildings are also regarded as important for the assessment. The assessment items related to the operation and maintenance correspond to the life cycle impact assessment of environmental quality, the cleaning and maintenance planning of technical quality, and documents for the facility management of process quality.

Table 3 Comparison of maintenance assessment items from various green building certification systems

Operation Type	Management Items	South Korea G-SEED	UK BREEAM	USA LEED	Japan CASBEE	Germany DGNB
POE execution for housing one year after occup	Follow-up Assessment		○			

ancy						
Measurement and evaluation of energy consumption			○	○		○
Trial operation for a certain period after building completion	Trial operation			○		
Stepwise management guidelines for major facilities	Facility Management	○	○	○	○	○
Periodic preventive maintenance for filters, cleaning and maintenance cycle		○	○	○	○	○
Data recording of energy consumption and demand	Energy Data Management and Control		○	○		○
Energy control and management for reducing energy consumption					○	
Regular training of building managers	Education		○	○		
Sharing of energy use data			○	○	○	○
Residents' information education for efficient use			○	○	○	○

From the table above, it is found that the certification system of South Korea focuses on the facility management such as stepwise management guidelines for major facilities and periodic preventive maintenance for filters, cleaning and maintenance cycle.

In contrast, overseas certification systems manage a wide range of items such as housing performance evaluation after occupancy, trial operation for a certain period after building completion, and data recording of energy consumption and demand. The systems also suggest regular training of building managers and residents for the efficient use of houses, and energy control and management for reducing energy consumption.

As a result, for the domestic certification system, it is recommended to include additional items such as housing performance evaluation after occupancy, data recording of energy consumption and demand, and regular training in addition to facility management.

5. Development of an operation and management manual configuration system for the zero-energy demonstration complex

Based on the issues on the assessment items for the operation and maintenance of the domestic green building certification systems and the implications of overseas assessment items, an operation and management manual configuration system for the zero-energy demonstration complex was developed as follows:



Figure 1 Operation management manual configuration system for domestic zero-energy apartment buildings

First, the assessment items of the operation and maintenance management for apartment buildings are largely classified into operation management, maintenance management and living management. The operation management covers administrative work such as office management, financial management and human resources management. In the category of the maintenance management, a new configuration is constructed by adding energy management and renewable energy facility management for the zero-energy housing management to building facility management, safety management, repair and maintenance, landscape management and cleaning and sanitation. The living management, taking into account the current era characterized by

the emphasis on community activation, includes assessment after occupancy and education and PR for the zero-energy housing management in addition to community living management and community activation.

The energy management for the zero-energy housing management in the category of the maintenance management consists of trial operation, data management and control, energy performance assessment, and housing performance assessment. In the assessment after occupancy of the category of the living management, new assessment items are added for regular residents' satisfaction survey. Finally, the living management includes education for efficient energy management and PR items for the promotion of zero-energy housing.

6. Conclusions

In this study, we developed the operation management manual configuration system of an operation and maintenance management plan for the zero-energy apartment building built for the first time in South Korea by deriving maintenance items that can be applied to domestic zero-energy buildings through a comparative analysis of case studies from developed countries that have been at the forefront of low energy building development to implement green building certification systems earlier than South Korea.

In the operation management manual configuration system, we further supplemented insufficient portion of the management items in the domestic certification systems with energy management, facility management, assessment after occupancy, and education and PR for the efficient management of zero-energy housing. Since the zero-energy apartment complex is designed for living space where people live, not only for experimental use, there is a need to explore various plans for the diffusion of zero-energy housing through continuous monitoring and residents assessment.

Acknowledgment

This research was supported by a grant(#13AUDP-B067603-01) from Architecture & Urban Development Research Program funded by Ministry of Land, Infrastructure and Transport of Korean government.

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