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Comparison & Verification of Program for Deducting Optimal Ratio of New Renewable Energy System

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Abstract

To fight weather anomaly affected by greenhouse gases due to rapid industrialization, the Korean government enforced the Act on the Promotion of the Development, Use and Dissemination of new renewable Energy since 2004, according to which 15% of the energy (as of 2015) that is expected to be used in a public building whose total floor area is at least 1,000 ㎡ should be provided with new renewable energy system when the building is constructed, reconstructed, or extended.

However, this act just presents an obligatory provision ratio of new renewable energy system and do not provide an optimal installation ratio of the system optimal to characteristics of energy use of building and demands of building users. In this context, the purpose of this study is to develop a program for deducting an optimal ratio of a new renewable energy system and to verify the program′s validity when compared to a simulation.

As for comparison and verification, the researcher compared the coefficient of determination values of factors related to economic, environmental and technical aspects to determine higher or lower correlation.

Keywords*: New &Renewable-energy, Economy Analysis, Technical Analysis, Environment Analysis, Optimize the ratio*

1. Introduction

1.1. Background and purpose

To fight severe environmental problems such as weather accidents and ozone layer destruction due to greenhouse gases, the Korean government enforced the Act on the Promotion of the Development, Use and Dissemination of new renewable Energy since 2004, according to which a new public building whose total floor area is at least 3,000 ㎡ should be applied by a new renewable energy system to the amount of 5% of the total construction expenses. Later the act was so revised that it was applied to construction, reconstruction and extension of a public building whose total floor area is at least 1,000 ㎡ and the expected amount of energy used (not the total construction expenses). However, the act just presents an obligatory provision ratio of new renewable energy system and do not provide an optimal installation ratio of the system optimal to characteristics and use of building and demands of building users. Thus, in case of lack of professional knowledge, it is difficult to select a new renewable energy system for a building and to deduce an optimal ratio of installing the system for complex application.

In this context, the researcher in this study developed a program for selecting a new renewable energy system and deducing an optimal ratio of installing during planning and designing a building (KRESS) and compared & verified reliability of the program for deducing an optimal ratio with which various systems are enabled to be

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combined and designed by selecting an appropriate source of new renewable energy and then calculating capacity of the system in the phase of initial designing.

1.2 Methods and scope

As a study of comparison and verification of a program for deducing an optimal ratio of a new renewable energy system, the methods and scope of this study are as follows.

The researcher compared and verified the validity of the developed program by using a developing tool (KRESS) and a simulation tool (Energy Plus) for selecting an optimal ratio of installing a new renewable energy system for public office buildings.

For comparison & verification of validity, the researcher assessed correlations of sub-items based on economic, environmental and technical aspects, a data that was used to compare and verify optimal application by evaluation priority for designing a new renewable energy system and optimal ratio of installing the system.

2. Overview of the developed program and buildings for comparison and verification

2.1 Overview of the developed program

The KRESS program developed in this study was developed by using of the MS-Excel VBA. As seen in the flow chart in Figure 1, the program can deduce an optimal ratio of installing a new renewable energy system on the expected amount of energy use of a building when considering solar power, solar collector, and heat pump, sources that can be easily applied to buildings among the 11 sources of new renewable energy designated domestically.

Fig 1. Develop program's Flow Chart & User Interface

When basic data such as building use and area are entered, the program calculates the energy consumption of the building based on the database, estimates the obligatory energy supply and the capacity of a new renewable energy system based on the calculation, and then presents application methods and optimal ratio of installing for evaluation items including economic, environmental and technical aspects based on evaluation priority of the energy.

2.2 Selection of buildings for comparison and verification

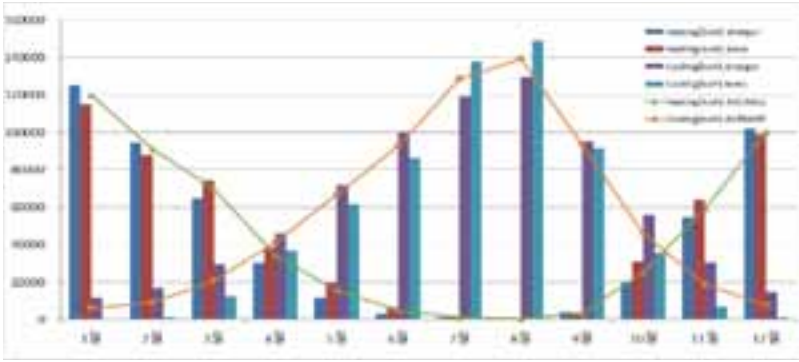
For verifying the validity of the developed program, the researcher performed a simulation analysis in which variables such as capacity of air conditioning and heating, number of occupants, and lighting equipment were applied by zone-based schedules based on weather data according to the current state of buildings (as seen in Table 1), by using the KRESS and the Energy Plus tools.

Table. 1 Overview of the subject building.

Area (㎡)	Construction area	2,929.27
	Total floor area	10,320.48
	Parking area	1,533.98
Thermal perfusion (W/㎡.K)	Exterior wall	0.47
	Windows	2.7
Internal heating value (W/㎡)	Person	0.15
	lighting	20
	Electrical equipment	22
direction	East	

According to the results of the simulation (see Table 2), the total energy requirement was 2,806,648 kWh by the KRESS and 3,232,935 kWh by the Energy Plus, with the deviation of 13.2%. In the Energy Plus, changes in daily air conditioning & heating and amount of electricity used were applied because of application of local weather data, while the KRESS uniformly calculated amount demanded based on the unit equation presented by legislation. This is the reason that the energy requirement deduced by the KRESS was less than that by the Energy Plus, requiring further examination Tables, figures, equations, and lists

Table. 2 Estimated energy consumption of the subject building



End Uses Energy	KRESS	Energy plus	measuring efficiency
Heating	464,623 (kwh)	538,793 (kwh)	13.8 %
Cooling	514,935 (kwh)	619,694 (kwh)	16.9 %
Hot water	132,893 (kwh)	154,227 (kwh)	13.8 %
Electronic Equipment	1,694,197 (kwh)	1,920,224 (kwh)	11.8 %
Total End Uses	2,806,648 (kwh)	3,232,935 (kwh)	13.2 %

3. Comparison & verification and optimal ratio of new renewable energy system

3.1 Comparison & verification of new renewable energy system

For comparison & verification of new renewable energy system, the researcher classified methods of application of [C01～66] (see Figure 2) so that at least 671.157kWh of new renewable energy could be produced when the ratio of obligatory installation was 12 % based on the Act (as of 2014), investigating the reliability of the developed program via comparison & verification of correlations based on the KRESS and the Energy Plus. For comparison & verification of correlations, higher or lower correlation was determined via comparing the coefficient of determination (R^2) values of the factors of economic, environmental and technical aspects of the KRESS and the Energy Plus.

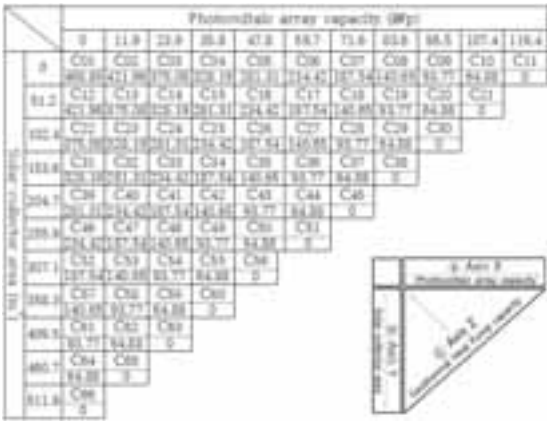


Fig 2. Categories of application plans of a new and renewable energy system

As for the correlations of economic aspects by the KRESS and the Energy Plus, among the sub-items of the economic aspects (see Figure 3), the R^2 value of initial investment costs used for installing and applying a new renewable energy system was 1.0 [Eic], that of maintenance and management cost used for maintaining and managing the system for certain period was 1.0 [Emrc], and that of energy cost that could be reduced by the system was 0.92 [Eec]. As for the correlations of technical aspects (see Figure 4), the R^2 value of supply reliability for safe supply of energy was 0.97 [Tesr] and that of energy efficiency as a rate of energy production on initial investment cost was 0.95 [Tee]. For the correlations of environmental aspects (see Figure 5), the R^2 value of CO2 emission for reducing greenhouse gases was 0.81 [Ecey].

As for correlations based on economic and technical aspects, the R^2 values were consistent as the entered values of the main items in the KRESS and the Energy Plus. However, the environmental aspects showed deviations in the correlation R^2 due to difference in the total energy demands between the KRESS and the Energy Plus.

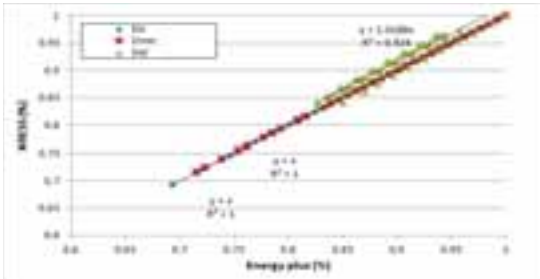


Fig 3. Comparison and testing of correlations according to economy

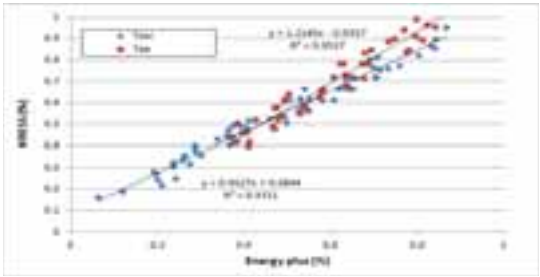


Fig 4. Comparison and testing of correlations according to technicality

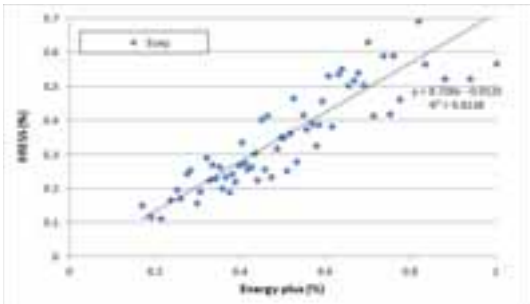


Fig 5. Comparison and testing of correlations according to environmentality

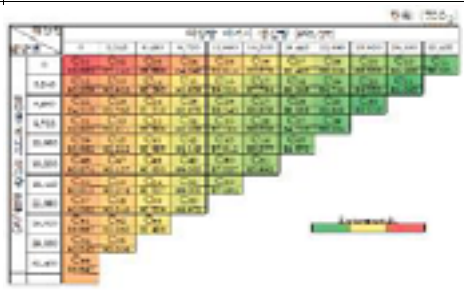
3.2 Optimal ratio of installing a new renewable energy system

Via analysis of economic, environmental and technical aspects per each alternative [$C_{01\sim66}$], an optimal ratio of installment was analyzed (see Table 3).

As for an optimal system based on the economic aspects of a building, C_{11} : PV (100%) was assessed as an optimal system both by the KRESS and the Energy Plus. For an optimal system based on technical aspects, the KRESS assessed only C_{11} : PV (100%) as optimal one, while the Energy Plus assessed C_{11} : PV (100%) and C_{21} : PV (90%)+SC(10%) as optimal ones. For an optimal system based on environmental aspects, both the KRESS and the Energy Plus assessed C_{21} : PV (90%)+SC(10%) as an optimal system. As for an optimal ratio of installment based on complexity, the KRESS assessed C_{11} : PV (100%) as an optimal system, while the Energy Plus assessed a (complex) C_{21} : PV (90%)+SC(10%) as an optimal system reflecting characteristics of building use and zone-based energy use schedule. As mentioned above, in the simulation of subject building for comparison and verification by the KRESS and the Energy Plus, a system was assessed as an optimal one as the PV was more applied in a single or complex system. For the subject building, thus, at least 90% of PV in a system may be most efficient ratio for a new renewable energy system.

Table. 3 Optimal installation percentage of multiple applications of new renewable energy by the programs

[unit:%]

	KRESS	Energy plus
Optimal installation percentage		
The Economy Analysis	C_{11}	C_{11}
	PV (100%)	PV (100%)
The technical Analysis	C_{11}	C_{11}, C_{21}
	PV (100%)	PV (100%), PV (90%) +SC (10%)
The Environment Analysis	C_{21}	C_{21}
	PV (90%) +SC (10%)	PV (90%) +SC (10%)
The Optimize Analysis	C_{11}	C_{21}
	PV (100%)	PV (90%) +SC (10%)

*[SC]:Solar Collector ,[PV]:Photo Voltaic, [GH]:Ground Heat`

4. Conclusion

As a study of comparison and verification of a program for deducing an optimal ratio of a new renewable energy system, the results of this study are as follows.

1) The researcher investigated verification of the developed program by calculating the total amount of energy use using the KRESS and the Energy Plus; the amount simulated by the Energy Plus was 13.2% higher than that by the KRESS because the former reflected characteristics of energy consumption based on building use, energy production based on surrounding weather, and requirements by users.

2) The R^2 values of economic and technical aspects by application methods [$C_{01\sim66}$] in the KRESS and the Energy Plus were 0.97 and 0.96, respectively, indicating that the deviation of coefficient of determination in the A Study of Optimal Design Techniques for the Application of Renewable Energy Combination Systems in School Facilities correlation was slight because the main items entered for the two simulations were consistent. The R2 value based on the environmental aspects was relatively lower, or 0.81, due to the difference in total energy requirement between the KRESS and the Energy Plus. However, the overall R^2 value was 0.91, indicating a favorable correlation.

3) As for an optimal sy stem of new renewable energy assessed by analysis of technical & environmental aspects per each alternative [$C_{01\sim66}$] for the subject building, both the KRESS and the Energy Plus assessed a system in which PV was more applied among the new renewable energy sources as an optimal one. For application methods of a new renewable energy system appropriate for the subject building, C_{11} : PV (100%) (A single system) and C_{21} : PV (90%)+SC(10%) (A complex system) may be optimal ones.

In developing a program for deducing an optimal ratio of a new renewable energy system for public buildings, selecting an appropriate energy source and calculating energy capacity & combining various systems, the comparison & verification of the results by the KRESS and the Energy Plus simulations was determined to be favorable. Improvements in reliability are required through further verification of various variables and consistent supplementation.

Acknowledgement

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