Development of South Korea's National Integrated Building Energy Management System for Green Building Policies: Overview and Building Energy Statistics

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Abstract

The world has recently entered an era of post-2020 climate change regime for energy savings and greenhouse gas reduction. In response, the Ministry of Land, Infrastructure, and Transport has established a database titled "National Integrated Building Energy Management System" for the purpose of supporting and establishing policies in the building sector in South Korea. This large-scale information system is established by matching buildings' energy information—such as electricity, city gas, and district heating data—based on approximately 6.9 million buildings in South Korea. Using this database, building energy statistics for the nation are established by buildings' type, scale, area, structure, and number of use years. Furthermore, it is used for the nationwide green building portal called Green Together; by entering their addresses, building owners can compare their energy consumption to that of nearby buildings with similar conditions, and learn ways to reduce their energy consumption. From the non-existent of statistics on building energy and the unestablished policies for existing buildings, today the database makes it possible to establish green building policies from a macro perspective and inspect their effectiveness.

Introduction

Recently, every year has marked a steady increase in energy consumption, a quarter of which is attributed to the building sector, in South Korea. According to the first National Energy Master Plan, Korea's mean annual growth in energy demand has increased by approximately 2.1%, and by 2030, annual energy consumption in the building sector will grow by 1.5 times its consumption in 2006 (Cho and Kim, 2013). Since demand for amenities and convenience in buildings is greater in advanced countries, as are increases in building energy consumption, experts expect South Korea to experience a continuous increase in energy consumption by domestic buildings at a pace similar to that of advanced countries (You et al., 2012). The situation therefore calls for aggressive energy savings policies from the government and for the nation to compensate for steady increases in building energy consumption.

The detrimental effects of increased building energy consumption include elevated greenhouse gas (GHG) emissions. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), buildings' GHG emissions are caused mostly by energy consumption, and as Figure 1 shows, the building sector has greater potential for GHG mitigation than other sectors. In OECD countries, the potential to reduce GHG emissions in the building sector is twice as high as that for other sectors and at least 10 times greater than the potential for waste (Lee, 2016).

In McKinsey & Company(2010)'s analysis of the per unit cost of GHG abatement for each potential technical abatement measure, as shown in Figure 2, results showed

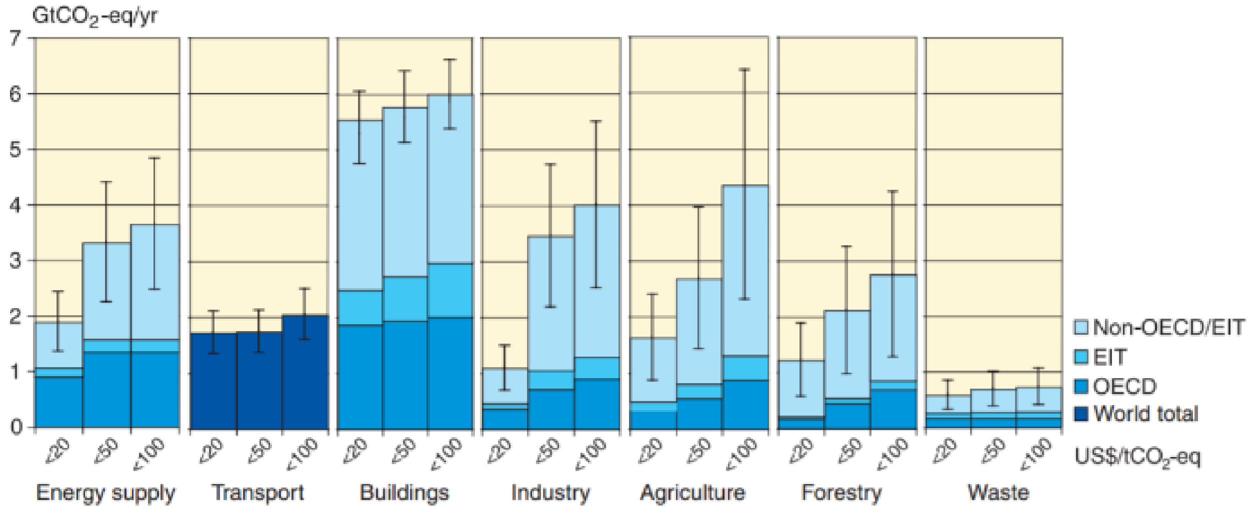

Figure 1: Estimated economic mitigation potential by sector and region using technologies and practices expected to be available in 2030. The potentials do not include non-technical options such as lifestyle changes (IPCC, 2007).

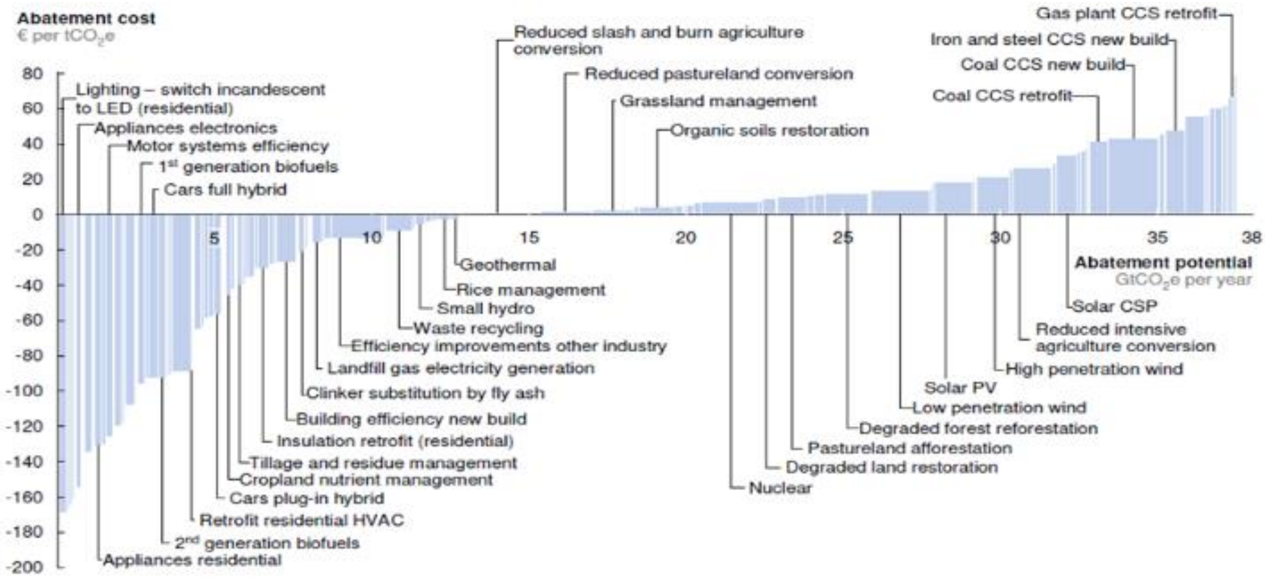

Figure 2: Global GHG abatement cost curve beyond BAU-2030 (McKinsey & Company, 2010)

low negative (-) abatement costs of technologies applicable in the building sector. As such, the sector has higher GHG mitigation potential than others and a lower GHG abatement cost. Consequently, many countries enforce GHG mitigation policies that focus on the building sector (Lee, 2016).

The world has recently entered an era of post-2020 climate change regime for energy savings and GHG mitigation. Many countries have either established, are currently running, or are developing diverse policies for energy savings and GHG emissions mitigation. In particular, the building sector manufactures various types of structures whose GHG emissions vary greatly, which poses difficulties when establishing and implementing related policies. In response, to support and establish policies in the South Korean building sector, the Ministry of Land, Infrastructure, and Transport has established the National Integrated Building Energy Management System (NIBEMS) database. This study examines the construction status and a statistical analysis of the NIBEMS database, and discusses future directions in policymaking using the database.

Background of the NIBEMS

Established based on the ***Support Act creating green buildings***, the NIBEMS database contains the energy administration's information on energy consumption and building information, called "building ledger." The large-scale information system was established by matching buildings' energy information—such as electricity, city gas, and district heating data—based on the information of approximately 6.9 million buildings in South Korea. The energy information refers to the monthly energy usage data in actual building units. This is meaningful because (1) the data were from the actual demand aspect, and not the supply aspect; and (2) the data were established based on the buildings across the entire country, and not based on buildings in local community units. It should be noted that using the database allows unit-building-based management as well as building management in the macro perspective. Depending on whether the goal is to facilitate policymaking and its support, share information, manage data and their usage, or improve building performance, database users can generate services that, in turn, facilitate the nationally integrated management of census data about all buildings in South Korea, as well as their uses, for both policymaking and statistical analysis. Figure 3 shows the service diagram of the NIBEMS database (Park and Jeong, 2015).

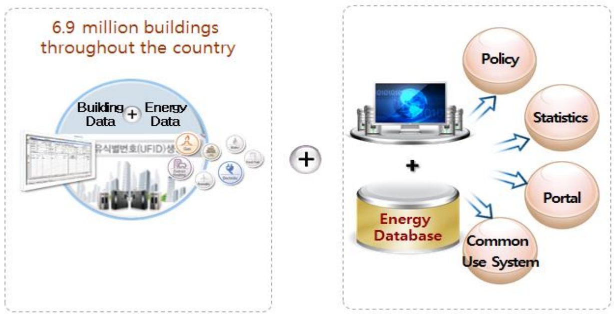

Figure 3: Service diagram of the NIBEMS database (Park & Jeong, 2015)

Data collection ranges and establishment process

As shown in Figure 4, the NIBEMS database was first established beginning with Seoul in 2011 and was expanded to the capital region and surrounding areas in 2012, to five metropolitan cities in 2013, and to cities and provinces throughout the country in 2014. Ultimately completed in September 2015, the database now contains 9.2 TB of data from 87 energy supply organizations, 57 million consumer charges, 3.4 billion cases of energy consumption data, and 22 million cases from building ledger matching, from all across the nation.

Table 1: Current Statistics of Information Systems for Energy and GHG (KICT, 2016)

System	NGMS (National GHGs Management System)	KESIS (Korea Energy Statistics Information System)	K-apt (Apartment Management Information System)
Purpose	Managing national statistical data about GHGs	Establishing and supporting energy policy	Providing information for nationwide sharing of information about management fees and energy consumption of multi-residential buildings
Operating entity	Ministry of Environment	Ministry of Trade, Industry and Energy	Ministry of Land, Infrastructure, and Transport
Primary functions and content	■ Establishing international standard GHG statistics and a document preparation system ■ Integrating management system under the target management system for the management and distribution of preparing agencies' work statements, agency inquiry requests and verification, implementation plans, performance records, and monitoring plans ■ Facilitating the perusal and management of resources of official representatives (e.g., at offices of general administration, administration, management, and delegated agencies) dependent on authorized access	■ Investigating energy consumption information on a national scale ■ Collecting information from energy supply and demand statistics and energy censuses ■ Developing a main index of energy industry structures and production activities ■ Establishing clear ranges for energy industries ■ Providing statistics and financial indices for energy production, supply and demand ■ Establishing and supporting energy policies	■ Supporting decision making by comparing multi-residential buildings ■ Improving transparency in management by publicly announcing management fees for shared areas ■ Spurring the nation's voluntary energy savings ■ Strengthening the quality and prolonging the life of housing by managing maintenance history ■ Ensuring transparency in bidding processes by announcing bidding results
Website homepage			
Limitations	■ Targeted buildings include only those within the building sector and do not reflect the total number of buildings. ■ Only statistical data for GHGs limited to the management office under the target management system are included.	■ Only national-scale energy statistics can be investigated. ■ Detailed information system for the building sector is not established.	■ Only multi-residential buildings are targeted. ■ Information on other types of buildings cannot be investigated.

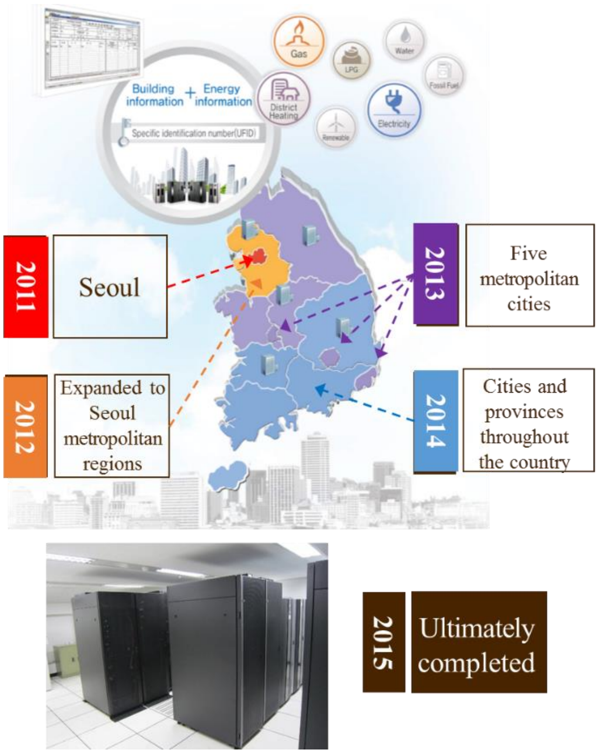

Figure 4: Data collection ranges and establishment process

Established based on monthly energy usage data in actual building units in all buildings in South Korea, data are highly effective and reliable for energy consumption calculation and estimation (Park and Jeong, 2015).

Differentiating current energy and GHG statistical data

The government has established and operated a statistical data system for energy and GHG pertinent to their potential use and purpose, with divisions led by the following departments:

- National integrated management system for GHG
- National integrated information system for energy statistics
- Information management system for residential buildings

The details are shown in Table 1 (KICT, 2016).

Unlike the aforementioned statistical systems, the NIBEMS database provides data for demand using the collected data of the actual energy use per building unit, allowing for the management of energy consumption at both the building and unit level (KICT, 2016).

NBEIMS: Establishment process and characteristics

The NIBEMS database was established by matching energy information from the Energy Administration and building information from building ledgers provided by the National Building Administration System. Its establishment processes include four stages: data gathering, standardization, data matching, and data warehouse/data mart construction (Jeong, 2015), as shown in Figure 5 (KAB, 2015).

Because the NIBEMS database contains a combination of energy and building information, energy information can be provided for each building by type, scale, area, structure, and number of used years. As such, various aspects of energy information and support services can be provided by establishing a statistical building energy database on a national scale, including the following main functions and support systems:

- A building energy information system,
- An energy consumption certification system,
- Support of the goal management support system, and etc.

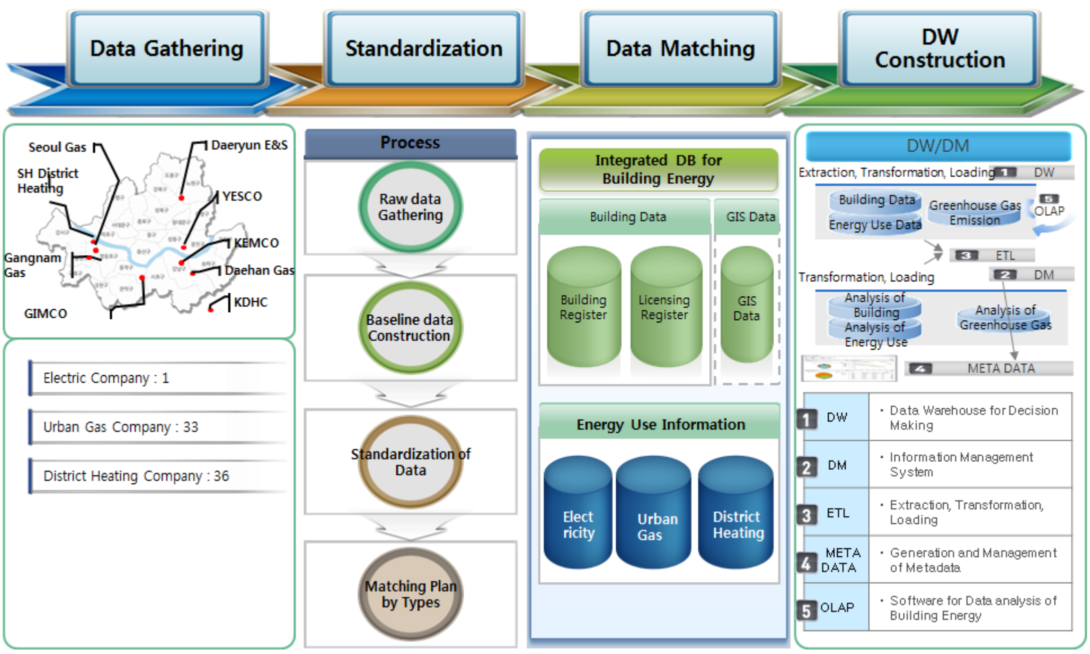

Figure 5: Establishment processes of the NIBEMS database (KAB, 2015)

Introduction of the Green Together portal

The NIBEMS database is used for the nationwide green building portal called Green Together. By entering their addresses, building owners can compare their energy consumption to that of nearby buildings with similar conditions, and learn ways to reduce their energy consumption that are appropriate for their energy level.

The system can also encourage voluntary participation in information sharing between the government and private sector—that is, between the general public and policymakers, building administrators, and building owners—and the frequent use of diverse services at will. Figure 6 shows the homepage of the Green Together website (www.greentogether.go.kr).

Figure 6: Homepage of the Green together website (www.greentogether.go.kr)

Meanwhile, NIBEMS services building energy information to two targets, as shown in Table 2.

Table 2: Building energy information services of NIBEMS

Division	Information offer	Target
Energy consumption information (www.greentogether.go.kr)	Comparison of energy consumption information in home and neighbours	The public
Building energy performance certification system (www.greentogether.go.kr)	Building energy performance certification management	
Opening of energy information system (www.open.greentogether.go.kr)	Opening of energy information	
Administrative support (www.stat.greentogether.go.kr)	Energy statistics and condition inquiry	Policy-maker

Statistical analysis of basic data using the NIBEMS database

The NIBEMS database furnishes information about buildings in terms of type, scale, area, structure, number of years used, and energy consumption. With that information, the database allows analyses of building energy consumption that can assess its status from a macro perspective. For one, buildings' energy consumption was analysed in terms of building use (residential and office), size, and region.

Current status of buildings' energy consumption in terms of building use, size, and region

Figure 7 shows energy consumption per building in terms of use, size, and region, differentiated by colors. Darker colors indicate a greater amount of energy consumption. Here, region refers to the administrative district of South Korea, as shown in Table 3.

Energy consumption was highest in the capital region and surrounding areas (i.e., SU, IC, and GG), where the greatest number of buildings appear in the greatest density. By region, the highest energy consumption was in US, a city with an area of 10,000 m^2 that includes many industrial buildings. Other regions either comparable in size or larger that have many industrial buildings also show relatively greater energy consumption. Figure 7 presents the distribution of energy consumption per building. Although industrial buildings are known to consume considerable energy, US's energy consumption far exceeds that of any other region due to the types of intensive industry it hosts: oil refining, chemical manufacture, and heavy industry. Such basic data can aid the establishment of both national and local energy savings and GHG reduction policies.

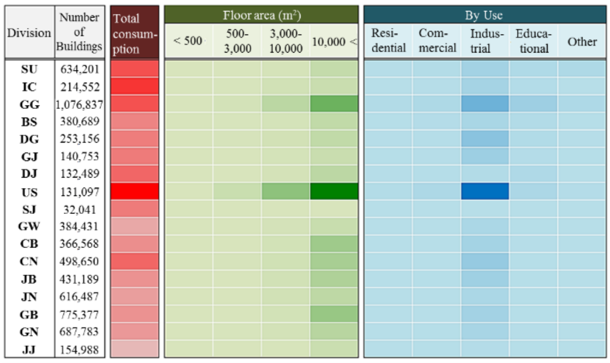

Figure 7: Residential buildings' energy consumption for each building analysed in terms of building use, size, and region (TOE/building · yr)

Table 3: Administrative district of South Korea

Provinces ("do" in Korean)	Cities("si" in Korean)
Gyeonggi-do (GG)	Seoul-si (SU)
Gangwon-do (GW)	Busan-si (BS)
Chungcheongbuk-do (CB)	Incheon-si (IC)
Chungcheongnam-do (CN)	Daegu-si (DG)
Jeollabuk-do (JB)	Daejeon-si (DJ)
Jeollanam-do (JN)	Gwangju-si (GJ)
Gyeongsangbuk-do (GB)	Ulsan-si (US)
Gyeongsangnam-do (GN)	Sejong-si (SJ)
Jeju-do (JJ)	

Figure 8 shows building energy consumption per unit area according to building use, size, and region. Building energy consumption per unit area was greater in US and CN—where industrial buildings' energy consumption and energy consumption in various areas 500 m^2 - 10,000 m^2 were greater than in the capital region and surrounding areas.

Division	Total floor area (m^2)	Total consum-ption	Floor area (m^2)				By Use				
			< 500	500-3,000	3,000-10,000	10,000 <	Resi-dential	Com-mercial	Indus-trial	Educa-tional	Other
SU	589,044,566										
IC	199,436,596										
GG	1,103,994,463										
BS	231,655,499										
DG	164,245,291										
GJ	103,452,397										
DJ	114,606,939										
US	95,766,573										
SJ	19,168,078										
GW	136,982,964										
CB	210,732,136										
CN	175,595,563										
JB	187,826,878										
JN	156,085,465										
GB	259,315,688										
GN	274,620,867										
JJ	45,122,126										

Figure 8: Building energy consumption per unit area according to building use, size, and region (TOE/ m^2.yr)

Lastly, building energy consumption per unit and person, as shown in Figure 9, was analysed for each region. Total energy consumption was greater in GG and SU, which have larger populations and more units. However, building energy consumption per unit and person was higher in US, which has a smaller population and fewer units; CN showed similar results. By contrast, SJ demonstrated relatively high building energy consumption per unit and person. As a newly planned city, SJ presumably has diverse factors affecting energy consumption, including the relocation of government offices, construction activities related to the development of national research complexes, and the migration of the neighbouring population.

Division	Total popula-tion	Total number of units	Total consum-ption	Energy consump-tion per person	Energy consump-tion per unit
SU	10,103,233	4,194,176			
IC	2,902,608	1,136,280			
GG	12,357,830	4,786,718			
BS	3,519,401	1,421,648			
DG	2,493,264	970,618			
GJ	1,475,884	573,043			
DJ	1,531,809	592,508			
US	1,166,377	442,250			
SJ	156,125	62,807			
GW	1,544,442	673,978			
CB	1,578,933	656,321			
CN	2,062,273	871,459			
JB	1,871,560	774,562			
JN	1,905,780	823,667			
GB	2,700,794	1,153,559			
GN	3,350,257	1,343,984			
JJ	607,346	246,516			

Figure 9: Building energy consumption per unit and person for each region (December 2014)

Energy consumption in comparison: Residential and office buildings

For each region, a residential building complex with at least 500 units was selected, and the buildings' energy consumptions were compared. A total of 5,782 complexes were selected with approved in 2015. All complexes were divided into six area-based sections (Table 4).

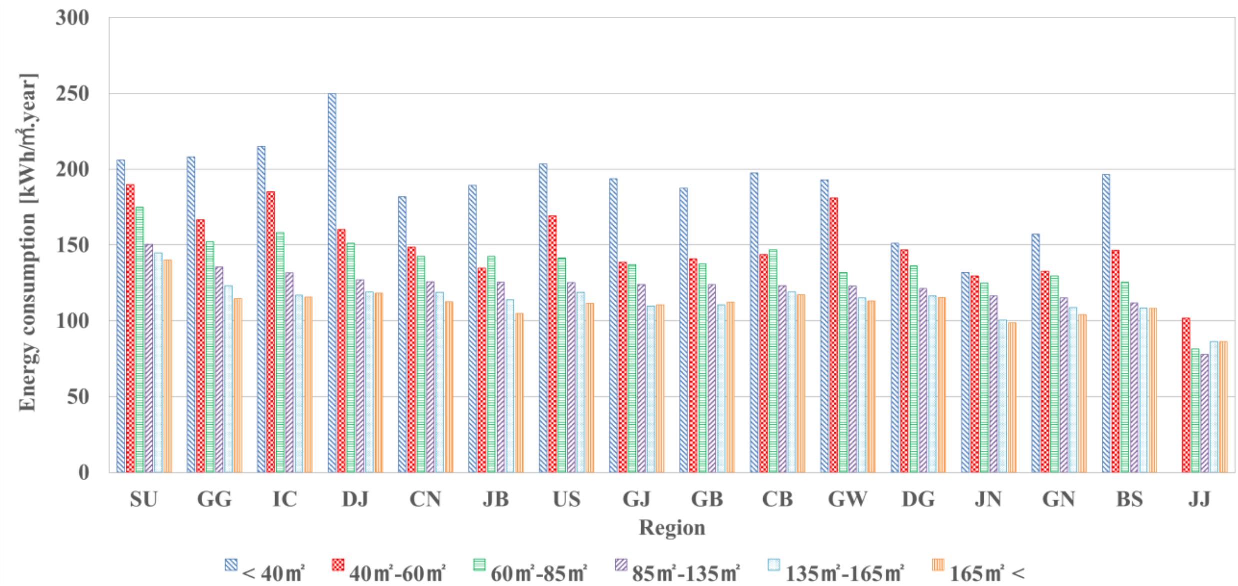

Figure 10: Residential buildings' energy consumption by region and area (kWh/ m^2· yr)

Table 4: *Division of Sections by area*

Classification	Area (m^2)
Section 1	Smaller than 40
Section 2	40 – 60
Section 3	60 – 85
Section 4	85 – 135
Section 5	135 – 165
Section 6	Greater than 165

Results of a comparison of building energy consumption by region and area appear in Figure 10. In all regions, building energy consumption decreased as the area increased from small (i.e., Section 1) to large (i.e., Section 6). At the same time, energy consumption was high in smaller areas such as Section 1, Section 2, and Section 3. In the regions of DJ, JB, CB, and BS, the energy consumption of Section 1 was particularly higher than that of other sections. By contrast, energy consumption in DG, GN, JN, and JJ did not differ much between sections.

For a comparison of office buildings' energy consumption, among buildings with a gross floor area of at least 3,000 m^2 for each region, per the building ledger, 6,417 buildings approved in 2013 were selected. Figure 11 shows their distribution.

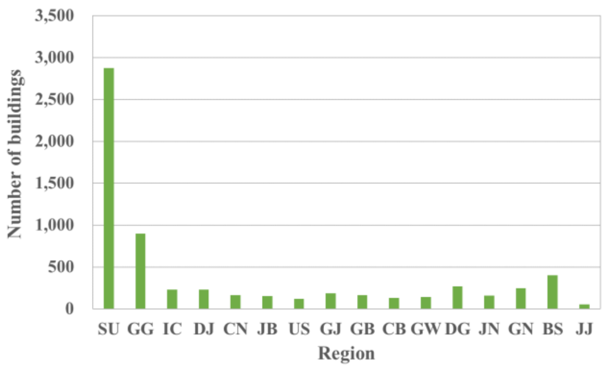

Figure 11: Nationwide distribution of office buildings with floor area of 3,000 m^2 or greater

More than half of all office buildings were in SU and GG. Except Busan, the other regions showed an even distribution. Figure 12 shows the distribution of office buildings in energy consumption for each region and by area.

Office buildings' energy consumption was greatest in SU, whereas other regions, including GG, showed similar levels of energy consumption. By contrast, excluding a few regions (i.e., IC, US, CN, GW, and JN), energy consumption increased along with area. Interestingly, the opposite was the case in residential buildings.

Progress in policies and services using the database

From the non-existence of established policies for existing buildings, today, the database makes it possible to establish green building policies from a macro perspective and inspect their effectiveness. Using the information on energy consumption and the building information provided by the database, the government has established and is implementing policies related to diverse processes of green building creation, including:

- Building energy conservation plans
- Building energy efficiency ratings certification
- Green standard for energy and environment design
- Building energy performance certification system

In the future, measures to improve and activate current policies will be prepared and used in establishing mid- to long-term roadmaps related to green building creation (Kwak, et al., 2016). In addition, it will be possible to establish a policy for energy saving and greenhouse gas mitigation efforts by extracting the buildings of large energy consumption and greenhouse gas emissions.

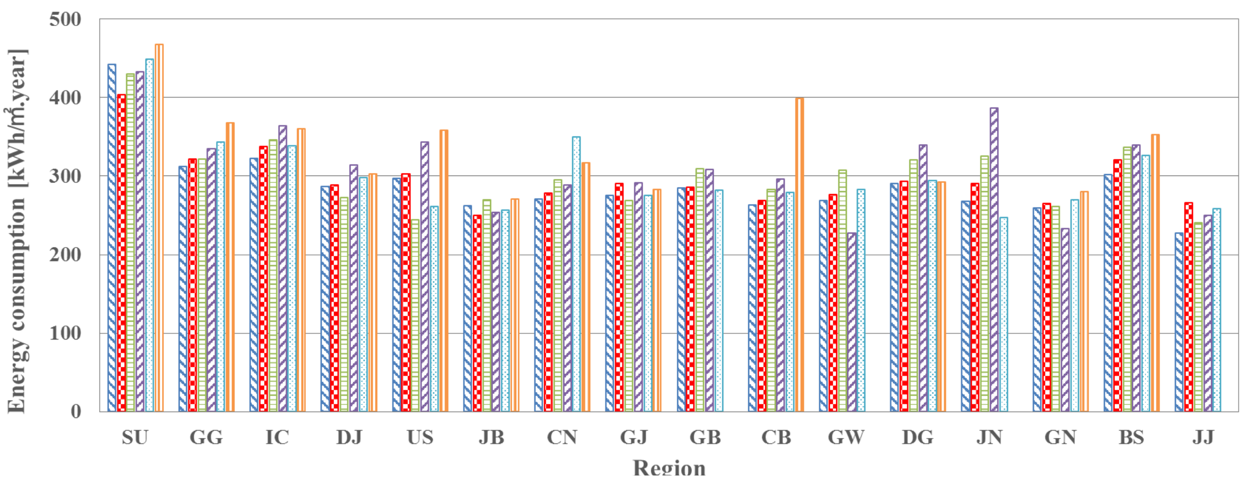

Figure 12: Distribution of office buildings with a gross floor area of at least 3,000 m^2 in energy consumption by region (kWh/㎡.yr)

Discussion of the data quality

The existing database matching 2012-2014 average rate is 85.6%, as shown in Table 5. Here, the cause of non-matching data was analyzed and classified into 11 types as shown in Table 6. The highest non-matching type was absence of architecture information(# 2) with a ratio of 58.2%. To ensure the ease of new database matching and the accuracy of the existing database matching, address standardization and building properties system are needed between building information and energy information (Kim et al. 2016).

Table 5: Analysis of current situation of effective and inconsistent data (Kim et al. 2016)

Classification	2012	2013	2014
Effective data	30,884	31,422	31,211
Inconsistent data	4,418	5,171	6,222
Total	35,301	36,593	37,433

In addition, the system construction is required to include information on other energy sources like petroleum energy that has high proportion of non-urban areas and small residential areas and renewable energy that has high potential in development and utilization (Kim et al. 2016).

Table 6: Missing type of inconsistent data and distribution percentage (Kim et al. 2016)

Classifica-tion	Non-matching type	Rate (%)
Absence of energy or architecture Information	# 1. Absence of energy information	2.8
	# 2. Absence of architecture information	58.2
	# 3. Number of lot	2.1
Inconsistent information	# 4. Number of lot-floor	3.8
	# 5. Number of lot-building's name	2.8
	# 6. Absence of energy information	15.4
	# 7. Absence of architecture information	5.4
Changing architecture information	# 8. Change of use (remodeling)	4.6
	# 9. Tear down, destruction, absence of architecture Information	0.3
	# 10. District unit	1.9
Other missing data	# 11. etc	2.7

Future work

Green building related support systems by region

Figure 13 shows energy consumption and GHG emissions for Gangnam-gu, Seoul. With the support of the database, building energy-savings and GHG-reduction policies can be established and implemented for each region, tailored

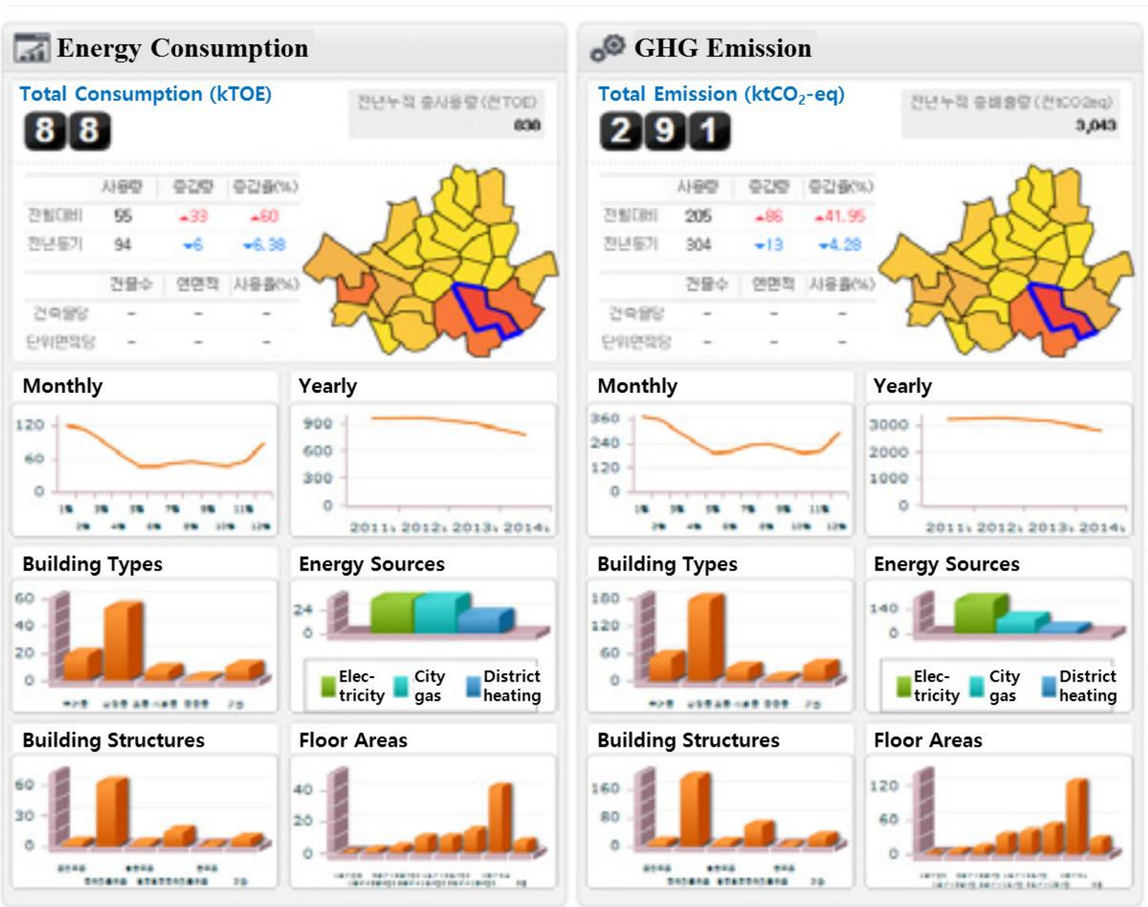

Figure 13: Example of energy consumption and GHG emissions of Gangnam-gu, Seoul (KAB, 2015)

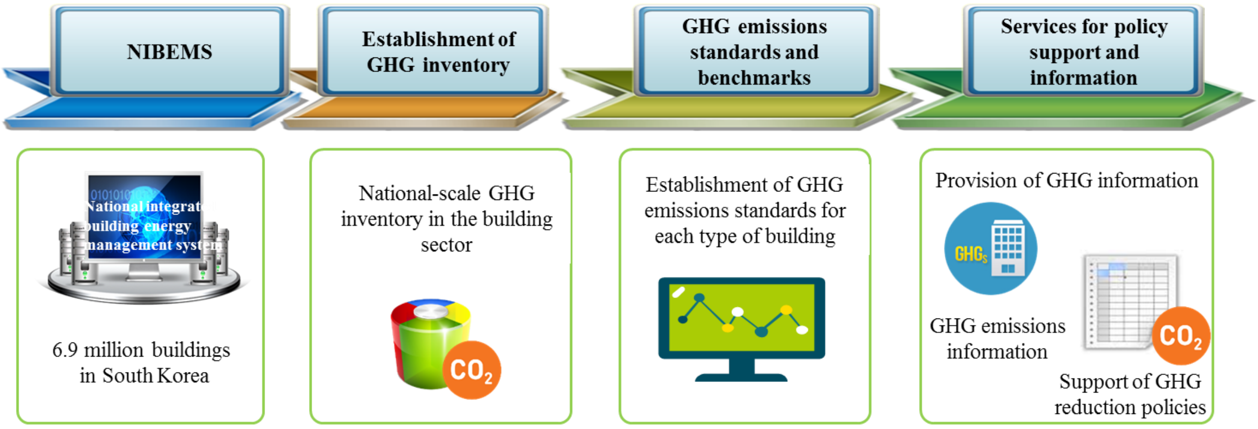

Figure 14: Strategies to link with the current systems (KICT, 2016)

with consideration to such regional characteristics as climate and city conditions. Furthermore, by providing in common the modules and platforms needed for all regions, an effective local database-use system can be established, through which effects in national budget savings can be expected (KAB, 2015).

Developing technologies for national SMART GHG management in building sector

To manage GHG emissions in the building sector, investigate their current status, and analyse their characteristics, a national-scale public GHG integrated information management system and its analysis technology need to be developed. This platform technology is for an integrated approach and public big data management in consideration of the correlation between national energy consumption and GHGs (KICT, 2016). Figure 14 shows the system's development process, and the details are described as follows:

(1) Development of an integrated management technology system for GHG emissions in the building sector based on information on buildings and their energy consumption linked to the NIBEMS

(2) Establishment of a GHG inventory for the building sector and provision of information on the status and characteristics of GHG emissions in the building sector

(3) Development of for GHG emissions by establishing GHG emission standards for each type of building and developing modification factors in consideration of influence factors for GHG emissions

(4) Provision of services for the nation and government supporting GHG-reduction policies for the building sector

Services provided include the following (Shin et al., 2016):

- Support for policy enforcement related to the implementation of an emissions trading scheme (ETS), the establishment of reduction goals and inspection of their implementation, etc.
- Establishment of a GHG inventory in a bottom-up approach and the monitoring of GHG emissions by region, building characteristics, and energy sources
- Comparison of GHG emissions in similar uses
- Analysis correlation by data characteristics

Conclusion

The NIBEMS database was established by the government to support the building sector and establish sound policies. This study examined the construction status and a basic statistical analysis of the NIBEMS database, and introduced overall utilization methods using the database. Although this database may not solve all problems at hand, it is expected to play a vital role in policymaking and support for energy savings and GHG reduction in the building sector from a macro perspective in both national and regional scales. According to IPCC (2007), an incomplete and unreliable information system is one of the most daunting barriers in the implementation and application of buildings' GHG-reduction technologies. As such, the existence of a national database, established on the data of buildings across the entire country, matters greatly. In the future, advanced NIBEMS and its related studies will be able to develop green building technologies and policies that can be used internationally as well as domestically.

Acknowledgement

This study was supported by the National Research Foundation of Korea (NRF-2017R1C1B5018390); and the Ministry of Land, Infrastructure, and Transport for Urban Architecture, R&D Projects (17AUDP-B079104-04).

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