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Zoning Regulations and Greenhouse-Gas Management Policies in Building Sector

Are net-zero energy buildings possible? As we learn from existing experimental approaches, it is no longer technically unattainable. However, would it still be feasible if we set a target for all buildings to become net-zero in their energy use? Can this regulation be a socioeconomically fair, reasonable, and achievable goal? Considering a recent target set by the government, which aims to achieve net-zero energy of all buildings by 2025, there is a strong need to identify whether such a goal is practical, and if not, explore alternatives that may bring along other possibilities. Against this backdrop, this study aims to analyze the theoretical threshold of the reduction rate of greenhouse gases (GHG) of newly constructed buildings and revise building energy performance regulations and GHG emission performance standards by Use Area.

Goal for Strengthening New Building Energy Performance Regulations

	2012	2017	2020	2025
Residential buildings	Reduction of 30%	Reduction of 60%	–	Mandating net-zero energy
Non-residential buildings	Reduction of 15%	Reduction of 30%	Reduction of 60%	Mandating net-zero energy

Data: Ministry of Land, Infrastructure and Transport (2013); Government of Republic of Korea (2014); Ministry of Data, Industry and Energy (2014)

Chapter 2 reviews existing policies on green buildings and theoretical backgrounds that are relevant to this topic. Firstly, Section 1 reviews strategies of GHG reduction policies and limitations at the architectural level, and argues for the necessity of approaches at the urban planning-level. Section 2 suggests basic concepts and the current status of 'building energy performance regulations through land use regulations' including performance zoning. It also proposes a need for land use performance regulations based on GHG emissions of individual buildings. Lastly, in order to estimate GHG reduction performance of green buildings in general, Section 3 reviews existing literature and systems in five ways. The result suggests that the maximum GHG reduction rate could range between 50% and 80%, including the energy demand substitution effects of new and renewable energy generation.

Chapter 3 investigates land use systems and supporting systems for GHG reduction of the building sector in the developed world. Section 1 examines land use regulations and deregulation that target GHG reduction of the building sector and suggests future strategies for system improvement. Next, Section 2 reviews the low-carbon urban planning systems and guidelines of Japan for area-wide GHG management of the building sector. As the current GHG reduction goals are restricted to approaches at the architectural level in Korea, those at the urban planning-level are integral. Section 3 studies various supporting systems that promote green buildings and green urban planning through administrative or financial support. Lastly, Section 4 explores the essence of performance zoning that were adopted by the U.S. and Australia. The findings suggest that the introduction of performance zoning may play a significant role in the existing zoning system.

Chapter 4 explores building energy performance regulations and GHG emission performance standards by Use Area by analyzing theoretical thresholds of GHG reduction rates of newly constructed buildings. Firstly, Section 1 covers major methods and data used in this research. Section 2 examines energy consumption characteristics and their determinants by building use and level of zoning regulations by analyzing Building Energy Data (UNBE).

The Effect of the Level of Land Use Regulations on Energy Consumption Amount per Total Floor Area per Use of Building (Result of SUR Model Analysis)

Model type and main verification variables		Consumption amount per unit total area			Main results and implications
		Base	Air-conditioning	Heating	
Residential buildings	Floor area ratio	–	–	–	• From a morphological perspective, low and wide buildings have higher energy consumption compared to high and narrow buildings • Energy consumption decreases per total floor area as the site size increases
	Building-to-land ratio	+	+	+	
	Plottage	–	–	–	
Non-residential buildings	Floor area ratio	+	–	–	• Regarding the base consumption amount for non-residential buildings, a closer relation was found to the behavioral type and strength compared to the building form • The energy consumption per total floor area decreases as the site size increases
	Building-to-land ratio	+	+	+	
	Plottage	–	–	–	

Overall Analysis Table per Phase (Example: Residential building in an area size of 200m²)

Phase 1

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	1.40	1.48	1.55	1.63	1.70					
0.5~1.0	3.99	4.22	4.45	4.67	4.90	5.13	5.35	5.58	5.81	6.03
1.0~1.2	5.64	5.98	6.31	6.64	6.98	7.31	7.64	7.97	8.31	8.64
1.2~1.5	6.74	7.15	7.56	7.97	8.38	8.78	9.19	9.60	10.01	10.42
1.5~2.0	8.36	8.89	9.41	9.94	10.47	11.00	11.53	12.06	12.59	13.12
2.0~2.5	10.13	10.81	11.49	12.17	12.85	13.53	14.21	14.89	15.57	16.25
2.5~3.0	11.62	12.45	13.29	14.12	14.95	15.78	16.61	17.45	18.28	19.11
3.0~4.0	13.35	14.41	15.47	16.53	17.59	18.65	19.71	20.77	21.82	22.88
4.0~5.0	14.70	16.06	17.42	18.78	20.15	21.51	22.87	24.23	25.59	26.95
5.0~6.0	14.95	16.61	18.28	19.94	21.61	23.27	24.93	26.60	28.26	29.93
6.0~8.0	13.27	15.39	17.51	19.62	21.74	23.86	25.98	28.09	30.21	32.33
8.0~	13.84	14.90	15.95	18.04	20.46	22.88	25.30	27.72	30.14	32.56

Energy consumption amount (TOE/year)

–

Phase 2

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	0.76	0.80	0.84	0.89	0.93					
0.5~1.0	2.12	2.25	2.38	2.51	2.64	2.77	2.90	3.03	3.16	3.29
1.0~1.2	2.96	3.15	3.34	3.53	3.72	3.91	4.10	4.29	4.49	4.68
1.2~1.5	3.50	3.73	3.96	4.20	4.43	4.67	4.90	5.13	5.37	5.60
1.5~2.0	4.25	4.55	4.86	5.16	5.46	5.77	6.07	6.37	6.68	6.98
2.0~2.5	5.01	5.40	5.79	6.18	6.57	6.96	7.35	7.74	8.13	8.52
2.5~3.0	5.58	6.05	6.53	7.01	7.48	7.96	8.44	8.91	9.39	9.87
3.0~4.0	6.04	6.65	7.25	7.86	8.47	9.07	9.68	10.29	10.90	11.50
4.0~5.0	5.96	6.74	7.52	8.30	9.08	9.86	10.64	11.42	12.20	12.98
5.0~6.0	5.07	6.03	6.98	7.93	8.89	9.84	10.79	11.75	12.70	13.66
6.0~8.0	2.24	3.45	4.67	5.88	7.09	8.31	9.52	10.73	11.95	13.16
8.0~	2.10	2.26	2.42	3.50	4.89	6.28	7.67	9.05	10.44	11.83

Energy reduction capacity (TOE/year)

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	54.16	54.32	54.47	54.60	54.72					
0.5~1.0	53.18	53.40	53.60	53.78	53.94	54.09	54.23	54.35	54.47	54.58
1.0~1.2	52.43	52.70	52.94	53.16	53.36	53.54	53.70	53.85	53.99	54.12
1.2~1.5	51.86	52.17	52.44	52.69	52.92	53.12	53.31	53.48	53.63	53.78
1.5~2.0	50.87	51.26	51.60	51.90	52.17	52.42	52.64	52.85	53.04	53.21
2.0~2.5	49.51	50.00	50.43	50.82	51.16	51.47	51.75	52.00	52.24	52.45
2.5~3.0	47.97	48.59	49.14	49.62	50.05	50.43	50.77	51.08	51.37	51.63
3.0~4.0	45.24	46.13	46.89	47.56	48.15	48.67	49.13	49.55	49.92	50.26
4.0~5.0	40.53	41.96	43.16	44.18	45.07	45.84	46.53	47.13	47.67	48.16
5.0~6.0	33.93	36.27	38.19	39.78	41.13	42.29	43.29	44.17	44.94	45.63
6.0~8.0	16.86	22.43	26.65	29.96	32.62	34.81	36.65	38.20	39.54	40.71
8.0~	15.16	15.16	15.16	19.42	23.91	27.44	30.30	32.65	34.63	36.32

Energy reduction rate (%)

Phase 3

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	0.29	0.87	1.45	2.03	2.61					
0.5~1.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
1.0~1.2	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
1.2~1.5	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
1.5~2.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
2.0~2.5	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
2.5~3.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
3.0~4.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
4.0~5.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
5.0~6.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
6.0~8.0	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50
8.0~	0.29	0.87	1.45	2.03	2.61	3.19	3.76	4.34	4.92	5.50

Solar energy production capacity (TOE/year)

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	20.69	58.90	93.38	124.65	153.14					
0.5~1.0	7.25	20.59	32.57	43.38	53.19	62.13	70.32	77.83	84.77	91.18
1.0~1.2	5.13	14.53	22.95	30.52	37.36	43.59	49.27	54.47	59.26	63.69
1.2~1.5	4.30	12.15	19.15	25.44	31.12	36.26	40.95	45.24	49.18	52.81
1.5~2.0	3.47	9.78	15.38	20.38	24.88	28.95	32.64	36.01	39.10	41.93
2.0~2.5	2.86	8.04	12.60	16.66	20.28	23.54	26.49	29.17	31.61	33.85
2.5~3.0	2.49	6.98	10.90	14.36	17.43	20.18	22.66	24.90	26.93	28.79
3.0~4.0	2.17	6.03	9.36	12.26	14.82	17.08	19.10	20.92	22.56	24.04
4.0~5.0	1.97	5.41	8.31	10.79	12.94	14.81	16.46	17.93	19.24	20.41
5.0~6.0	1.94	5.23	7.92	10.16	12.06	13.69	15.10	16.33	17.42	18.39
6.0~8.0	2.18	5.65	8.27	10.33	11.99	13.35	14.49	15.46	16.29	17.02
8.0~	2.09	5.83	9.08	11.24	12.74	13.92	14.88	15.67	16.33	16.90

Solar energy substitution rate (%)

Phase 4

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	74.86	113.22	147.85	179.25	207.88					
0.5~1.0	60.43	73.99	86.17	97.16	107.13	116.22	124.54	132.19	139.24	145.75
1.0~1.2	57.56	67.23	75.89	83.68	90.72	97.12	102.97	108.33	113.26	117.80
1.2~1.5	56.15	64.32	71.60	78.14	84.04	89.39	94.26	98.72	102.82	106.59
1.5~2.0	54.34	61.03	66.97	72.28	77.06	81.37	85.29	88.86	92.13	95.14
2.0~2.5	52.37	58.04	63.04	67.48	71.44	75.01	78.24	81.17	83.85	86.30
2.5~3.0	50.46	55.57	60.03	63.98	67.48	70.61	73.43	75.98	78.30	80.42
3.0~4.0	47.41	52.15	56.25	59.82	62.96	65.75	68.23	70.47	72.48	74.31
4.0~5.0	42.50	47.36	51.47	54.97	58.00	60.65	62.99	65.06	66.91	68.57
5.0~6.0	35.87	41.50	46.11	49.95	53.19	55.98	58.39	60.50	62.36	64.01
6.0~8.0	19.05	28.08	34.92	40.29	44.61	48.16	51.14	53.66	55.84	57.72
8.0~	17.25	20.99	24.24	30.66	36.64	41.36	45.18	48.32	50.97	53.22

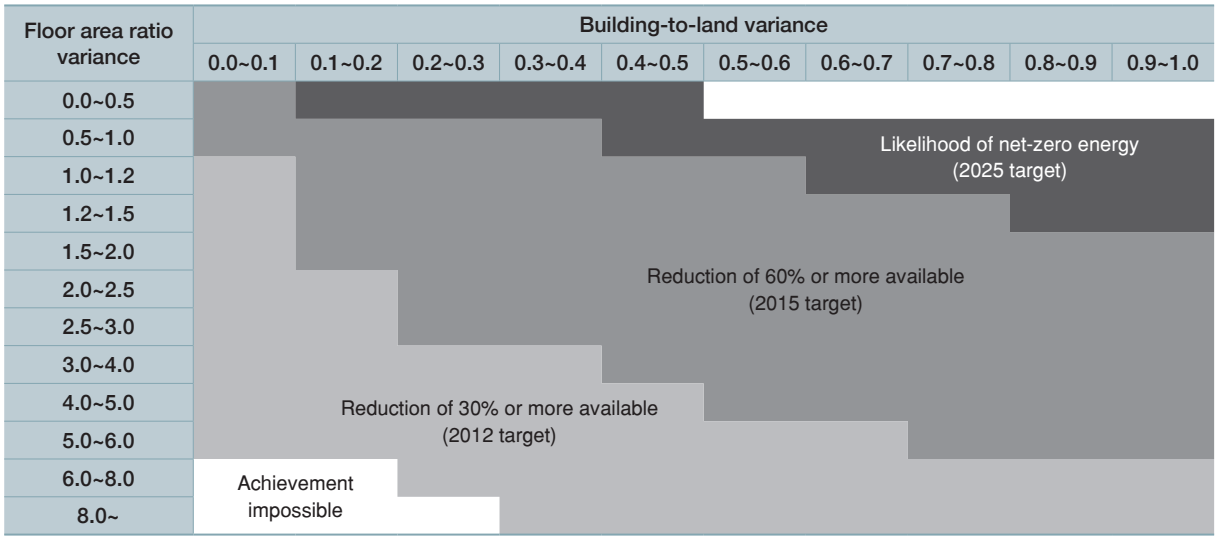
Total energy reduction rate (%)

용적률 급간	건폐율 급간									
	0.0~0.1	0.1~0.2	0.2~0.3	0.3~0.4	0.4~0.5	0.5~0.6	0.6~0.7	0.7~0.8	0.8~0.9	0.9~1.0
0.0~0.5	7.04	-3.90	-14.84	-25.78	-36.71					
0.5~1.0	10.53	7.32	4.10	0.89	-2.33	-5.55	-8.76	-11.98	-15.19	-18.41
1.0~1.2	10.69	8.90	6.92	4.93	2.94	0.96	-1.03	-3.02	-5.01	-6.99
1.2~1.5	10.95	9.45	7.95	6.45	4.95	3.45	1.95	0.45	-1.04	-2.54
1.5~2.0	10.90	9.89	8.88	7.87	6.87	5.86	4.85	3.84	2.83	1.82
2.0~2.5	10.72	10.08	9.44	8.80	8.15	7.51	6.87	6.23	5.59	4.95
2.5~3.0	10.47	10.06	9.65	9.25	8.84	8.43	8.03	7.62	7.21	6.80
3.0~4.0	10.03	9.85	9.67	9.49	9.31	9.12	8.94	8.76	8.58	8.40
4.0~5.0	9.39	9.39	9.40	9.40	9.40	9.40	9.41	9.41	9.41	9.41
5.0~6.0	8.72	8.84	8.96	9.07	9.19	9.31	9.43	9.55	9.67	9.79
6.0~8.0	7.67	7.91	8.14	8.37	8.60	8.83	9.07	9.30	9.53	9.76
8.0~	7.16	7.36	7.55	7.82	8.10	8.39	8.67	8.95	9.24	9.52

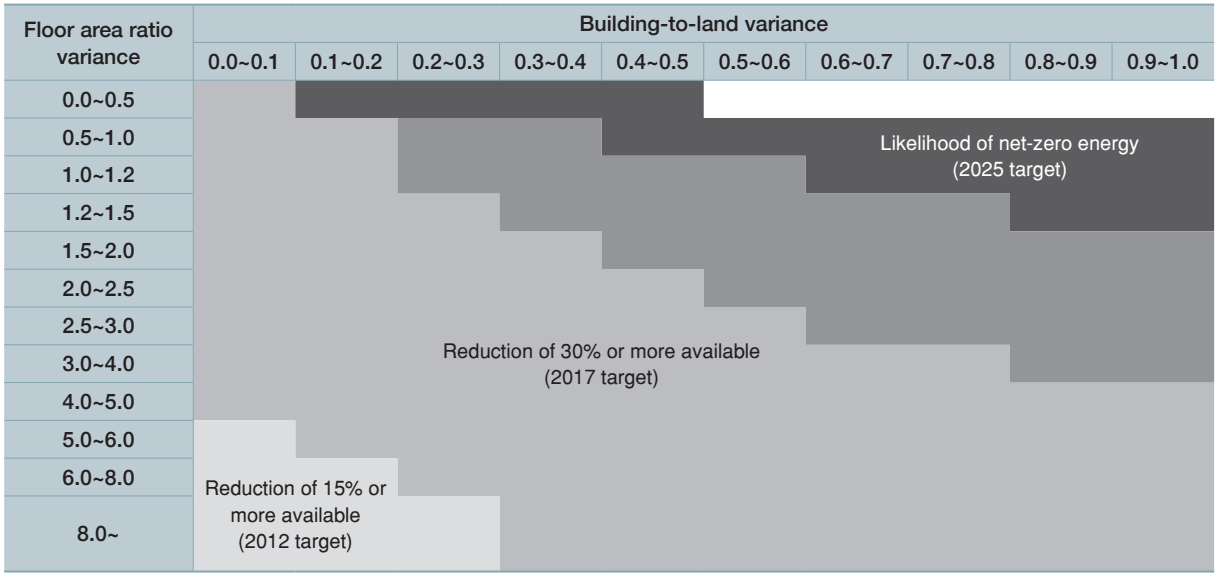
Minimum consumption amount per unit total area (kgOE/m²)

Based on the findings from Section 2, Section 3 analyzes theoretical thresholds of GHG reduction rates of newly constructed buildings by building use and level of zoning regulations.

Likelihood of Achieving Goal of Strengthening Energy Performance per Variance between Floor Area Ratio and Building-to-Land Ratio for Residential Buildings

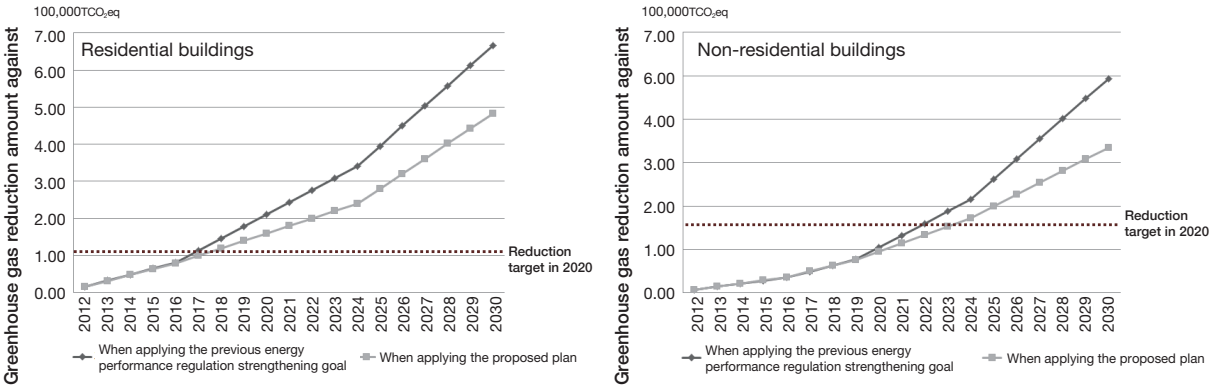


Likelihood of Achieving Goal of Strengthening Energy Performance per Variance between Floor Area Ratio and Building-to-Land Ratio for Non-residential Buildings



The results suggest that it is impossible to achieve the net-zero energy goals in all Use Areas except for class 1 exclusive residential area.

Accordingly, Section 4 suggests a regulation level that is practically reachable by building use and Use Area. It also provides test results on GHG reduction impacts. Simulations reveal that the revised regulations, developed in this study, are applicable enough to achieve national GHG goals for the residential building sector, while less so for the commercial building sector. We conclude that an off-site approach is also essential to achieve the national GHG goals, which include new and renewable energy generation and sharing of unused energy.



Simulation Result of Greenhouse Gas Reduction Effect of the Proposed (Plan) for Energy Performance Regulations for New Buildings

Overall Proposal (Plan) for Performance Regulations for New Buildings per Building Use – Use Area

Classification		Basic unit for energy consumption at existing buildings*(kgOE/m²/year)		Energy reduction target (%)**		Permissible energy consumption amount for new buildings (kgOE/m² /year)	
		Residential buildings	Non-residential buildings	Residential buildings	Non-residential buildings	Residential buildings	Non-residential buildings
Previous regulation target	2012	Permissible energy consumption amount for new buildings (kgOE/m²/year)		30	15	No standard	
	2015			60	30		
	2020			-	60		
	2025			Net-zero energy	Net-zero energy		
Proposed plan	Class 1 exclusive residential area	20.11	26.81	100	100	0.00	0.00
	Class 1 general residential area	25.44	33.43	90	85	2.54	5.01
	Class 2 general residential area	27.43	31.73	80	70	5.49	9.52
	Class 3 general residential area	26.77	33.67	70	55	8.03	15.15
	Quasi-residential area	26.13	28.66	75	60	6.53	11.46
	General commercial area	22.14	35.91	60	50	8.86	17.96

* This means the average value of buildings completed of construction before January 1, 2012, which plays the role of the standard building in this analysis.

** The energy reduction target means the value including the energy consumption substitution rate through production of new and renewable energy.

Data (existing regulation target): Ministry of Land, Infrastructure and Transport (2013), Government of the Republic of Korea (2014), and Ministry of Trade, Industry and Energy (2014)

Lastly, Section 5 establishes a GHG emission performance standard by Use Area as a longer policy alternative. The performance standards for each Use Area range from 15 to 220kg CO_2-eq/m^2/year. Simulations reveal that 66% of total GHG emissions can be reduced by 2020 solely through this performance standard.

Performance Standard for Greenhouse Gas Emissions per Use Area

Classification of use area	Current density control (based on floor area ratio)	Variance of floor area ratio pertaining to the maximum permissible standard	Amount of greenhouse gas emissions per site area pursuant to the change of the building-to-land ratio in the pertaining variance (kgCO_2eq/m²/year)		Performance standard of greenhouse gas emissions per unit site area per use area		
			Residential buildings	Non-residential buildings	Residential buildings	Non-residential buildings	Single standard
Class 1 exclusive residential area	~100%	50~100%	–3.26~16.02	–1.00~20.44	15	20	20
Class 1 general residential area	~150%	120~150%	9.81~30.00	14.16~39.25	30	40	40
Class 2 general residential area	~200%	150~200%	21.16~38.76	27.91~51.85	40	50	50
Class 3 general residenital area	~250%	200~250%	37.59~49.07	49.67~67.68	50	60	60
Quasi-residential area	~250%	200~250%	34.72~49.07	45.17~67.68	50	60	60
General commercial area	~800%	600~800%	111.74~128.24	213.24~222.12	130	220	220

Chapter 5 summarizes implications for future GHG management policy, as follows. Firstly, the government should revise building energy performance regulations for newly constructed buildings. Second, the government should adopt the GHG emission performance as a new instrument in zoning regulation. Finally, to efficiently manage the two systems suggested above, various supporting systems need to be established as a long-term goal, including incentive systems for successful reduction of GHG, penalties (such as enforcement fines) for failure to achieve their goals, and a GHG emission trading system.

Key words : Greenhouse Gases (GHG), Building Energy, Green Building, Zoning Regulations

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