Seoul's Illumination Management Policy

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1. Background Information

1) The need of the policy

① Specialized Nightscape

'Urban Light Management Project', includes nightscape projects for bridges, cultural assets and facilities in order to provide attractions to tourists who visited Seoul during Seoul Olympic held in 1988. Seoul Metropolitan Government has made a sustained effort to manage lighting so as to create a beautiful and pleasant environment.

② Prevention of Light Pollution

Light pollution caused by excessively bright artificial lighting or night lights has emerged as a recent environmental issue for Seoul. Light pollution has caused lots of problems such as the deterioration of human biorhythms and destruction of the ecosystem. Experts are highlighting light pollution as one of the most rapidly expanding pollutions throughout the world.

Having recognized serious light pollution, Seoul Metropolitan Government has publicized the harmful effects of light pollution and been modifying the system since 2009. Seoul Metropolitan Government persuaded members of the National Assembly and pushed ahead with projects closely cooperating with the Ministry of Environment and made forty presentations on light pollution at public hearings, seminars and conferences by visiting local governments all over the country. Seoul Metropolitan Government enacted "Seoul Special City's Ordinance of Prevention of Light Pollution and Urban Lighting" in 2011 before the Korean Government established Act on the Prevention of Light Pollution by Artificial Lighting to protect citizens from light pollution resulting from excessive lighting and improve the quality of life. In a survey conducted by the Ministry of Environment in October 2010, 64.1 percent of respondents said that 'excessive artificial lighting may be considered environmental pollution' and 64.9 percent of respondents said that 'it is necessary to prepare laws and systems for controlling light

[1] Translation by ESL®

pollution'. Accordingly, the "Act on the Prevention of Light Pollution by Artificial Lighting' was enacted in 2012 to meet the desire for improvement in quality of life and to prevent traffic accidents, bad effects on the ecosystem caused by excessive light and the deterioration of the urban landscape created by messy advertisements.

"Criteria for Calculation of Acceptable Limit on Light Pollution Caused by Artificial Lighting and Amount of Damages" was established by the Korean Government in February 2014.

Accordingly, the Seoul Metropolitan Government prepared "Comprehensive Measures for 『Solving Light Pollution 』in Seoul " in February 2012. There were about 700 complaints of light pollution in Seoul in 2013 compared with 330 complaints in 2009 which suggests that it was necessary to prepare measures for preventing light pollution.

③ Electric Energy Saving

"Basic Plan on Energy Use Rationalization" (2008.12) made by the Korean Government aims to improve energy efficiency by 11.3% in 2020 compared with energy efficiency in 2007. As the need for energy saving has increased, the Ministry of Knowledge Economy established "Guideline on the Operation of Streetlight" and made public it in January 2012.

The main contents of "Guideline on the Operation of Streetlight" were related to 'switching on or off lights depending on the brightness in surroundings and adjusting brightness considering traffic' and 'installing integrated intelligent control systems and dimming systems'.

Seoul Metropolitan Government set up overall measure called 『One Less Nuclear Plant』in May 2012. One of the ten goals of 『One Less Nuclear Plant』is a "remarkable increase in smart lighting and supply of LED". Seoul Metropolitan Government plans to replace 7800 thousand lights with LEDs and create a smart lighting city by building an "IT based outdoor lights control system".

Seoul Metropolitan Government made "Mid and Long Term Plan on Improving LED Roadway Lighting" (2012) which aims to replace all roadway lights with LEDs passing through two stages.

Table 1. Mid and long term plan on replacing roadway lights with LEDs

Classification	Total	Stage 1(5 years)	Stage 2(5 years)	Remark
Period	10 years	2011-2015	2016-2020	
Goal	100%	50%	50%	
Quantity	177,180 lights	88,590 lights	88,590 lights	Lights that were already installed excluded
Necessary budget	139,5 billion won	86,4 billion won	53,1 billion won	

The above mentioned plans are closely related to electric energy saving. Replacing streetlights, security lights and signboards lights with LEDs made dimming possible which leads to electric energy saving.

Seoul Metropolitan Government devised a measure to save electric energy for lighting, prevent light pollution, reduce expenses required for public lights and provide improved convenience.2

2) Period during which the policy was implemented

The Act on the Prevention of Light Pollution by Artificial Lighting, which serves as the basis for a plan on preventing light pollution caused by artificial lighting, was enacted on February 1, 2012 to prevent light pollution arising from artificial lighting. The Act on the Prevention of Light Pollution by Artificial Lighting and Enforcement Decree of the same Act were then later implemented on February 2, 2013.

The purpose of the Act on the Prevention of Light Pollution by Artificial Lighting is to prevent harm to health or the environment caused by excessive emission of artificial lights and to provide a basis so that all people can live in a healthy and pleasant environment by managing artificial lights in an environmentally friendly way.

The Seoul Metropolitan Government enacted the「Ordinance of Prevention of Light Pollution and Management of Urban Lighting」on July 15,2010 and implemented it before establishing the Act on the Prevention of Light Pollution by Artificial Lighting. After enacting the Act on the Prevention of Light Pollution by Artificial Lighting in 2012, Seoul Metropolitan Government made a complete revision to the「Ordinance of Prevention of Light Pollution and Management of Urban Lighting」and enacted the「Ordinance of Prevention of Light Pollution and Creation of Good Lights」on July 17, 2014 . The Enforcement Rule of Ordinance of Prevention of Light Pollution was enacted on January 27, 2011 and ordinance of prevention of light pollution was revised on April 16, 2015

The Ministry of Environment determined matters required for standard for installation •management of lighting fixtures and made a public announcement on the matters. The Ministry of Environment established standards for installation •management of lights according to uses so that the standard can be used as a criteria to help prevent energy inefficiency and visual inconveniences arising from excessive light.

Standards for the installation •management of streetlights, security lights, lights for parks and lights for advertisements was established to present technical criteria for installation and maintenance.3

[2] 2014,『Smart Lighting City Seoul』a summary report on the construction feasibility study and establishment of basic plan

[3] 2015, Plan on preventing light pollution in Seoul

Table 2. Recommended standard for installation •management of lighting fixtures for preventing domestic light pollution

Notification	Implementation	Objective
Recommended standard for installation •management of lights for advertisements to prevent light pollution (Notification No. 2014-212 of the Ministry of Environment)	2014.11.28	To specify matters about efficient installation •management of lights for advertisements so that this standard can be used as criteria which help prevent energy inefficiency and visual inconvenience arising from excessive light
Recommended standard for installation •management of streetlights to prevent light pollution (Notification No. 2014-211 of the Ministry of Environment)	2014.11.28	To be used as a criteria that helps secure the safety of those who use roadways at night and prevent energy inefficiency and visual inconveniences arising from excessive light by installing and managing streetlights efficiently
Recommended standard for installation •management of security lights and lights for parks to prevent light pollution (Notification No. 2013-606 of the Ministry of Environment)	2013.12.31	To be used as a criteria that helps prevent energy inefficiency and visual inconveniences arising from excessive light by establishing standards for installation •management of security lights and lights for parks
Recommended standard for installation •management of decorative lights to prevent light pollution	Under way	To solve light pollution problems by presenting improvements according to types and applications of decorative lights and the limit in brightness considering surroundings

Table 3. Classification of artificial lighting to be managed

Classification	Legal basis	Target
Space lighting	Road under Article 2, Paragraph 1, Subparagraph 1 of「Road Act」	Streetlights
	Pedestrian walkway under Article 2, Paragraph 1 of「Pedestrian Safety and Convenience Enhancement Act」	Security lights
	Parks and greenbelts under Article 2, Paragraph 1 of「Act on Urban Parks, Greenbelts, Etc.」	Lights for parks
Decorative lighting	Article 2, Paragraph 1, Subparagraph 2 of Building Act. Article 3-5 of Enforcement Decree of the same Act. Seoul Metropolitan Government's Ordinance of Prevention of Light Pollution and Creation of Good Lights [schedule] facilities to be reviewed by Good Light Committee	Decorative lights
Lighting for advertisements	Article 4(Advertisement and Billboards subject to permission) of Enforcement Decree of the Outdoor Advertisements, etc. Control Act	Lights for advertisements

3) The Importance of the Policy

Remote surveillance and the control of lights are considered important in urban light policy because they can help save electric power and prevent light pollution by switching on or off lights and adjusting illumination as needed. Details of the surveillance and control of lights are as follows:

Table 4. Details of monitoring and controlling lights

Classification		Monitoring •control			Remark
		Switching on off lights	Dimming	Condition monitoring	
Lights for public use	streetlights	O	O	O	
	Security lights	O	O	O	Considering safety of citizens
	Lights for parks	O	O	O	
	Lights for tunnels	O	O	O	Lights are kept on around the clock
	Lights for underground roadways	O	O	O	Lights are kept on around the clock
	Landscape lighting	O	O	O	Special lights considering aesthetics
Lights for private use	Lights for signboards	O	O	×	Scheduled to be decided in the future

Conditions of all lights for public use are monitored, which means that functions such as dimming control are available. Considering the fact that a smart lighting system can be used for dozens of years, functions can be controlled depending on changes in circumstances.

It is reported that regulations for remote switching and dimming control of signboards for private use are being prepared. It is advisable to apply remote control to save electricity and prevent light pollution after relevant regulations are supplemented and lights are replaced with LEDs.

According to " review of plan to reduce the period required to construct 『smart lighting city Seoul』", policies on lights in cities require "replacing existing discharge lamps with LEDs and equipping dimming functions" because it is possible to monitor •control LEDs remotely.4

2. Policy Objectives

1) Establishment of basic plans for preventing light pollution

There are about 225,000 security lights all over Seoul. It is reported that there were a total of 3,141 light pollution related complaints in Seoul from 2009 to June 2013. There were 720 light pollution related complaints in Seoul in 2013 compared with 337 complaints in 2009 which shows that light pollution related complaints increased by 213%.

Lights for public use (streetlights, security lights, lights for landscape and so on) are required to be approved by the Seoul Metropolitan Government's "Light Pollution Review". 66.8% of signboards for private use have not been reported or approved. Messy advertising signboards spoil the beauty of the city and cause light pollution.

How to best control and manage light pollution caused by lights for public use or lights for private use in order to reduce light pollution should be considered in policies.5

① Proposal of the comprehensive basic direction for preventing light pollution

The Act on Prevention of Light Pollution by Artificial Lighting provides standards for managing light and therefore a plan on the prevention of light pollution should propose basic principles and directions for targets and the application of standards. "A plan on managing light environment' to be established by reflecting the basic direction for standards proposed in a plan on the prevention of light pollution proposes detailed guidelines for management.

② Preparation of measures for the prevention of light pollution by fields •stages

Measures are to be prepared for preventing light pollution and plans built on managing light pollution according to use and area based on legal management standards and provide a basis for Seoul Metropolitan Government's pushing ahead with policies on light pollution.

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3) 2014, 『smart lighting city Seoul』summary report on construction feasibility study and establishment of basic plan

[5] 2014, 『smart lighting city Seoul』summary report on construction feasibility study and establishment of basic plan

③ Preparation of measures for education •promotion of light pollution

Article 2 of the Enforcement Regulation of Act on Prevention of Light Pollution by Artificial Lighting provides that local governments should prepare measures for education and publication of light pollution so as to prevent light pollution. Accordingly, those in charge of light recognized the importance of light pollution and prepared manuals so that they can implement such policies. Having recognized that light pollution affects the health of citizens, the people in charge of light pollution made a plan concerning the increased publication of light pollution.6

2) Comprehensive plan for the prevention of light pollution

A plan for the prevention of light pollution is based on the Act on Prevention of Light Pollution enacted in February 2012 and has legal executive force on targets and standards determined by the Act on Prevention of Light Pollution and Enforcement Ordinance of the same Act.

The Act on Prevention of Light Pollution divided a plan on light into three stages; evaluation of present conditions, preparation of a basic plan and the preparation of a management plan. A plan for the prevention of light pollution is a basic plan that comes under stage 2. A plan for the prevention of light pollution aims to establish measures for preventing light pollution by reflecting standards for light emission according to use and area.

"Technical Service of Environmental Impact Assessment and Measurement • Survey of Light Pollution in Seoul" (hereinafter referred to as environmental impact assessment of light pollution) conducted in 2014 carried out a preliminary investigation for designating lighting environment management area in accordance with Article 16 of the Act on Prevention of Light Pollution.

Article 5 of the Enforcement Ordinance of Act on Prevention of Light Pollution provides that local governments should make plans for managing lights in an environmentally friendly way. A plan for managing the lighting environment should include goals and the basic direction of lighting management, management plans and a plan on technical •financial support .

Seoul Metropolitan Government established 「Ordinance of Prevention of Light Pollution and Creation of Good Lights」 in July 2014 and provided that a plan for the prevention of light pollution determined by the Enforcement Regulation of Act on Prevention of Light Pollution, urban lighting energy saving, carbon dioxide reduction, a plan on nightscape and preparation of guidelines for nightscape should be applied.7

「Enforcement Regulation of Act on Prevention of Light Pollution by Artificial Lighting」

Article 2(Planning on Prevention of Light Pollution by city •province)

② A plan on the prevention of light pollution by the city •province shall include.

[6] 2015, A plan on the prevention of light pollution in Seoul

[7] 2015, A plan on the prevention of light pollution in Seoul

1. Matters on present conditions of light pollution and prospects

2. Goals and the basic direction of the plan on the prevention of light pollution in the city •province

3. Measures for preventing light pollution by field •stage

4. Education •promotion of light pollution

5. A plan on taking measures for preventing light pollution in city•gun•gu (refer to autonomous district. The rest is the same as above)

6. Calculation of expenses required for implementing a plan on the prevention of light pollution by city•province and a plan on financing

7. Matters required to prevent light pollution

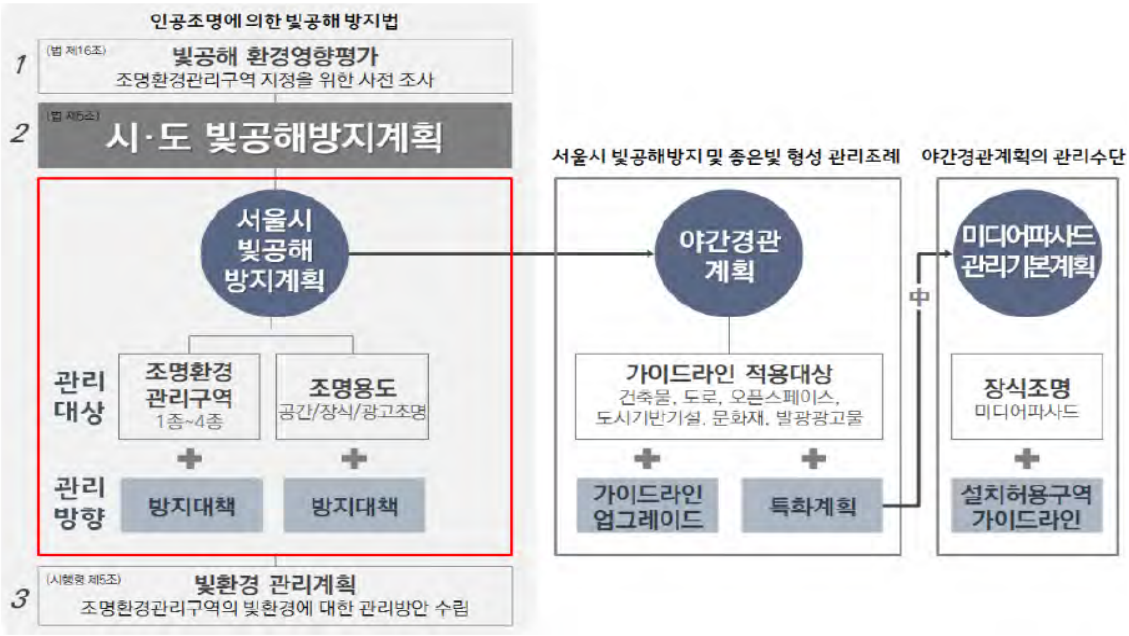


Figure 1. A plan on prevention of light pollution in Seoul

A plan on the prevention of light pollution was made based on the Act on Prevention of Light Pollution by Artificial Lighting and Ordinance of Prevention of Light Pollution. A plan on nightscape should be made as a part of a plan for the prevention of light pollution and guidelines on nightscape should be prepared so as to create good light. A plan on nightscape can include media façades as a part of specialization plan. It is advisable to make a basic plan on managing media façade lights as part of the plan on nightscape.

The Act on Prevention of Light Pollution by Artificial Lighting proposes standards for managing lights and targets. A plan on the prevention of light pollution is a ‘comprehensive plan’ for managing lights. A plan on the prevention of light pollution proposes principles and the

basic direction for the application of standards.8

Environmental impact assessments of light pollution were conducted in 2014 to better understand the present condition of targets and the result of the assessment has been used as the basis for the designation or cancellation of lighting environment areas. A plan on the prevention of light pollution proposes principles for the application of standards for legal management and secures the power of execution for the prevention of light pollution by considering the assessment of present condition of targets. It is necessary to make good use of a plan on the prevention of light pollution in various fields – such as urban planning, maintenance work and urban development. It is advisable that a plan on the prevention of light pollution should propose detailed guidelines according to lighting environment areas by applying principles suggested by a plan on the prevention of light pollution. This plan can be used as guidelines when making a plan on lighting environment areas.

Figure 2. Nature of a plan on the prevention of light pollution in Seoul

A plan on the prevention of light pollution shows a way to manage light pollution in order to prevent light pollution. It is advisable to create detailed guidelines that consider the characteristics of each region.9

3) Preparation of a plan on saving electric energy

Power usage in Seoul is 46.9 million MWh/year, which accounts for 10.3% of power usage all over the country. Power usage consumed by lights for public use (such as streetlights and

[8] 2016, A plan on management of light environment in Seoul

[9] 2015, A plan on prevention of light pollution

security lights) and signboards for private use is 1.1 million MWh/year, which accounts for 2.3 of the total power usage in Seoul and makes up 24% of the annual power produced by Kori Nuclear Power Plant 1. Streetlights and security lights are kept on with the same intensity of illumination until they switch off once they turn on regardless of traffic. It is advisable to adjust the intensity of illumination of streetlights and security lights in the middle of the night to save electricity.

It is reported that signboards for private use are on for 6.2 hours daily and for 1.3 hours during the daytime, which suggests that there is room for saving electricity by 20%.

The second goal of this policy is to work out a plan to save electricity and find ways to reduce power usage.

4) Relations with other policies

"A plan on the supply of LEDs to public organizations for 2013" prepared by the Ministry of Trade, Industry and Energy aims to improve energy efficiency of the public sector by replacing lights with LEDs by 2020. The authorities concerned support the replacement of lights with LEDs in accordance with regulations on the rationalization of energy use in public organizations and LED 20/60 supply plan. The relevant authorities offered "Guideline on Energy Saving through Efficient Management of Streetlights" for "energy saving by efficient management of streetlights" in 2012 and encouraged the introduction of integrated intelligent control systems or intelligent dimming systems.

Plans that Seoul Metropolitan Government worked out to save energy include "『One Less Nuclear Power Plant』" (2012.5), "Plan for supply of LED" (2013.2) and "Mid and long term plan on improvement of roadway lighting by replacement of lights with LED". A plan on the replacement of streetlights with LEDs is as follows.10

Table 5. A plan on the replacement of streetlights with LEDs in Seoul by year

Stage	Classification	Description					
Stage 1	Year	2011	2012	2013	2014	2015	Total
	Target lights	450		2,820	35,000	50,320	88,590
Stage 2	Year	2016	2017	2018	2019	2020	Total
	Target lights	18,000	18,000	18,000	18,000	16,590	88,590

Seoul Metropolitan Government made a complete revision to the ordinance of the prevention of light pollution in July 2014 so that it can better manage light pollution more comprehensively. Article 5 of the ordinance provides that matters on nightscape should be applied when making a

[10] 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

plan on the prevention of light pollution.

Seoul Metropolitan Government has endeavored to create beautiful and pleasant nightscapes. Seoul Metropolitan Government made basic plans concerning the nightscape in 2000 and carried out work to improve said areas in 2002 and 2009.

As people considered their quality of life and leisure activities more and more important, interest in nightscape increased. Accordingly, Seoul Metropolitan Government established departments that took responsibility for improving nightscapes, urban design and urban management as well as promoting tourism in order to enhance the quality of culture and citizens' lives.

However, as there are differences in values and standards of nightscapes between public organizations and private organizations and light pollution has increased, managing nightscapes in a systematic way has emerged as an area of major interest.

"Basic Plan on Nightscape in Seoul" was developed in accordance with 『Landscape Act』in 2008. 『Act on Prevention of Light Pollution by Artificial Lighting』 (here in after referred to as Act on Prevention of Light Pollution) was enacted in 2012 to reflect changes in the conditions. The basic plan on nightscapes developed in 2008 was required to be revised to meet the changing needs of citizens.

Seoul Metropolitan Government set basic goals and directions of nightscapes based on a survey of the present conditions of lights to reflect changes in circumstances.

A plan on the prevention of light pollution in Seoul proposed details on which the basic plan on nightscapes and media façade management based on 'Seoul's lights which urban attraction and various cultures keep in good harmony'. Seoul Metropolitan Government aimed to create nightscapes which can improve the beauty of Seoul and promote tourism and prevent light pollution. Seoul Metropolitan Government has endeavored to rethink the nightscapes of Seoul as attractions by developing a plan on the improvement of nightscapes.

3. Main Policy Contents

LEDs have led the emergence of industries whose production methods are completely different from those of existing industries and signify a rapid change of traditional industrial structures. Lots of lights have been replaced with LEDs with the help of advances in IT. Lighting has developed to an LED based digital lighting system, smart lighting and human centric lighting.11

Lighting for landscapes has shown the highest growth when examining the growth of LEDs in lighting markets all over the world. HID accounted for 80% of outdoor lighting in 2010 but it is expected that HID will make up less than 30% of outdoor lighting and LED will take up over 70% of outdoor lighting in 2020.

[11] 2016, A plan on light environment management by Seoul

1) Examples of major projects for improving lighting in Seoul

Classification	Public facilities			Private facilities	
	Cultural assets (31)	Bridges on the Han River (27)	Public facilities (96)	Buildings (302)	Media façades (50)
Main facilities	Fortress Wall of Seoul Five palaces Myeong-dong Cathedral	Banpo Bridge Hangang Bridge Wonhyo Bridge	Seoul Namsan Tower, Sejong Center for the Performing Arts, Main office of Bank of Korea	Jongno Tower Samsung E office LG Gangnam Tower	Seoul Square, Sejong Center for the Performing Arts, Hanwha Galleria

※ The number of lights for landscapes: 506

① Project of improving security lights in Jongno, Seoul(2015)

It was reported that there were about eighty complaints every year caused by sleep disturbance resulting from security lights in Ewha Byeokwha Village, Jongno-gu. Authorities concerned carried out a project that replaced diffusion security lights with LEDs to improve lighting in Ewha Byeokwha Village.

After conducting the project, the lighting and beauty in the area improved considerably and light pollution such as light trespassing and glare reduced significantly by the installation of screens which blocked forward light and backlight efficiently.

② Project of improving security lights in Songpa-gu, Seoul (2013)

Seoul Metropolitan Government selected dark alleys, places which have lots of waste of electric power due to poor security lights, places which have excessive penetration of lights, places near elementary schools, middle schools and high schools or markets as targets.

6,382 high voltage sodium lamp security lights (100W) were replaced with cut off type LED security lights (50W). When analyzing the effects by selecting thirty buildings in which high voltage sodium lamp security lights were replaced with LED security lights, it was found that the amount of light which penetrated through windows reduced and brightness increased by over three times.

③ Project of improving security lights along Uicheon in Gangbuk-gu, Seoul (2012)

202 high voltage sodium lamps and metal halite lamps installed in a 3km long trail along Uicheon in Gangbuk-gu, Seoul (ssanghangyo~wolgyegyo 2) were replaced with LEDs which led to energy savings of up to 50 percent by means of a 3 stage control system (50 percent energy saving by four stage brightness control system). The waste of light pollution and energy

was reduced by preventing lighting from being diffused.

< 4 stage brightness control system >

Stage 1: 100% by 22 o'clock →stage 2: 75% after 22 o'clock →stage 3: 50% from o o'clock

	
LED security light 75W 100% (reduction of energy by over 70 percent compared with existing lights)	Dimming 50% (reduction of energy by over 50 percent compared with existing lights)

④ Project of improving lights for advertisements in Dobong-gu, Seoul (2014)

Dobong-gu has been replacing signboards to improve beauty since 2009 and completed the improvement of signboards installed in 88 shops located in a section from the intersection near Sophia Hotel to exit 1 and 4 of Ssangmun Station. The channel letter type that applies LEDs was used in replacing signboards. The replacement led to energy savings of over 75 percent.

2) Present condition of the operation of lights for public use

① Streetlight switching system – Namsan Mountain

Radio waves of 142MHz are used in switching streetlights in Seoul. Distribution box switches on or off switch after receiving the radio wave.

Relay stations have been installed in six places as radio waves which are emitted from streetlight control centers located in Namsan Mountain may be jammed by mountains or buildings.

It was not possible to check whether streetlights were in good condition and therefore each district has been installing remote monitoring systems starting in 2006 to observe and monitor the conditions of the streetlights. At present, 20 districts monitor 2,358 distribution boxes out of 6,840 distribution boxes all over Seoul. 7,611 streetlights are currently monitored.

② Security system switching system

Most security lights are installed on security light poles, electric light poles and building walls. Electric power is supplied from electric light poles installed by KEPCO (Korea Electric Power Corporation).12

Security lights are switched electronically. The reason for which each light is switched not by radio waves supplied but by the streetlight control center is to reduce costs. Installing radio receivers on each light costs a lot. The electronic switching system controls lights considering sunrises and sunsets occurring during the changes in seasons.

③ Tunnel • underground roadway switching system

Entrance connections, entrances, basic parts, exits and exit connections vary in the intensity of illumination of lights as well as varied use in tunnels or underground roadways so that drivers can drive more smoothly. For entrances and exits, the intensity of illumination is controlled by means of an outdoor sensor in a manner in which the intensity of illumination of the lights is switched partially.

④ Lights for parks switching system

Lights for parks are switched electronically, like security lights, in which radio waves are supplied via a streetlight control center located in Namsan Mountain. Lights for large parks are switched by a janitor's office.

⑤ Lights for landscape switching system

Lights for landscape are mainly used to highlight the beauty of objects. Most lights for landscapes are controlled by a lighting control system program. "Rules on implementation of ordinance of prevention of light pollution and lighting management in Seoul" provides that "lights for landscapes shall switch on 30 minutes from sunset and switch off at 23 o'clock".13

3) Examples of new technologies for improving lighting environment

① Sun visors controlling forward light •backward light suitable for streetlights (2013)

Sun visors controlling forward light •backward light suitable for streetlights was developed to solve the problem of light trespassing on agricultural land and residential areas.

Tin plates were attached to streetlights to protect drivers from light trespass arising from streetlights but this caused the overall lighting deteriorate as it blocked light.14

New sun visors that can be applied to streetlights which cause light pollution (light trespassing on agricultural land and residential areas) was developed as a part of a 'study of development and application of standard for installation •management of lighting fixtures'. Developed sun

[12] 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

[13] 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

[14] 2016, A plan on light environment management by Seoul

visors were designed to block light trespassing effectively while the quality of light was maintained. Performance of the sun visors was verified by measuring lighting and conducting simulations.

② Sun visor attaching to security light fixtures (2015)

The National Institute of Environmental Research developed sun visors attached to security light fixtures (4 types). The sun visor was designed to be attached to security light fixtures which cause the most light trespassing. Light trespassing could be reduced at a cost of 50 thousand won to 100 thousand won - 25-50 percent of the cost required to replace light fixtures.

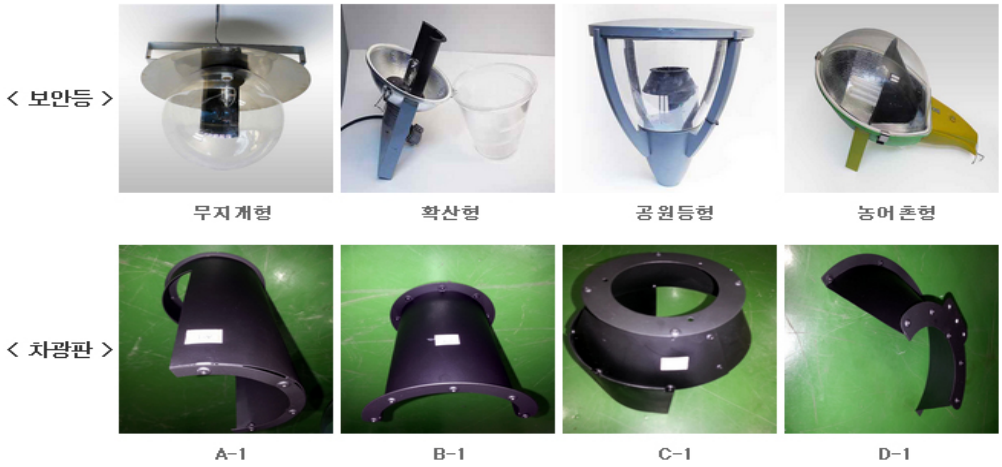


Figure 3. Sun visors attached to security light fixtures

The sun visor was designed in a manner that a plate shaped accessory is attached to security light fixtures so that light can be blocked. There are four types of sun visors.

The developed sun visor was designed to block light trespassing arising from backward light. The sun visor allows forward light to be kept while backward light is lowered by 60%. It was found that the intensity of the vertical illumination in residential areas was reduced to 1.1~7.1lx from 8.9~17.9lx.

③ Light fixture realizing rotationally symmetrical luminous intensity distribution by prism (2015)

This technology, which can be applied to bollard shaped and post top shaped LED fixtures, was designed to prevent glare by applying a ring shaped prism to the outside of light sources while the performance of the fixture is maintained.

The prism was applied by optics of the existing light fixture controlled light by the simple repetition of patterns while Clear Guide technology reduces glare by dispersing light by means of a ring-shaped light guide. This technology provides style options depending on the light distribution of light fixture.15

[15] 2016, A plan on light environment management by Seoul

4. Policy Effects

1) Economic effects

① Using lighting for tourism

Some districts in Korea make good use of lighting to attract tourists and vitalize the local economy. At the Busan Port Festival held in Busan, an LED waterboard and media façade lighting were used which provided various attractions. Four hundred thousand people visited the Port Festival held in Busan in 2015. The festival has played an important role in vitalizing the economy of Busan and improving its overall image.

② Energy saving by LED technology

LEDs have made a great contribution to saving energy as they consume less power compared with other light sources. LEDs make it possible to create various advertising designs. They can be installed in narrow spaces in which it is not easy to place neon or fluorescent lamps. LEDs are expected to help reduce greenhouse gas emissions and power consumption as they are highly efficient in saving energy.

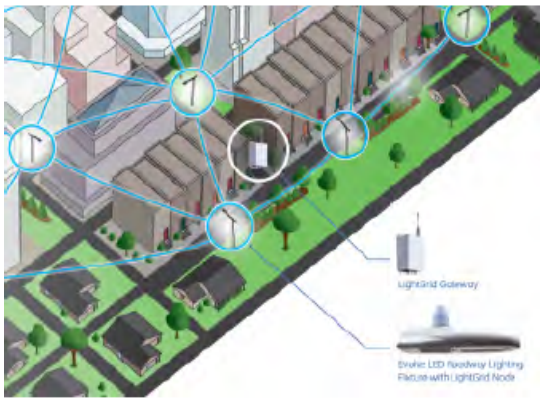


Figure 4. LED wireless lighting system block diagram

Figure 5. System network block diagram

2) Environmental effects

① Effect in terms of humanities

At night, there are bright places such as shopping areas and entertainment districts as well as quieter places, for example residential areas. It is desirable for lights to be in good harmony with their surroundings.

However, 『beauty of night』 is disappearing because there are excessive lights from cars, signboards and other sources.

Projects that aim for recovering 『beauty of night』have been implemented.

② Effects in terms of human engineering

There have been a total of 3,141 complaints about light pollution in Seoul from 2009 to June 2013. Out of the 3,141 complaints, 2,918 which accounted for 92.9% resulted from sleep disturbance or excessive brightness by artificial lighting. Sleep disturbance makes it difficult for citizens to live a healthy life and is likely to cause cancer.

Smart lighting monitoring • control system can minimize effects on the human body by turning off or dimming lights which are likely to cause light pollution.16

3) Additional effects

①Improvement in quality of life

Lighting control reduces sleep disturbance resulting from artificial lighting that accounts for 80 percent of complaints by dimming unnecessary lighting which leads to the improvement of quality of life.

Lighting control makes contributions to the improvement of the safety of citizens because it can detect faults and take actions to remedy these and adjust the intensity of illumination as needed.

② Contributions to industry such as job creation

Jobs to be created are done so by dividing costs (such as material costs and construction costs) required for the implementation of 『smart lighting city Seoul』by unit wage.

Table 6. Calculation of job creation effects by the project of「smart lighting city Seoul」

classification	Necessary cost (million won)	Average unit wage (won/day)	Necessary workers (won/day)	Necessary workers (year/person)
Material cost	38,761	184,486	210,103	785
Construction cost	24,708	184,486	133,929	500
Cost of design and supervision	5,203	205,518	25,317	95
Maintenance cost/year	4,203	184,486	22,782	85
total	72,875	758,976	392,131	1,465

This project can create 1,465 jobs. 85 maintenance related jobs will be kept as long as the

[16] 2015, A plan on prevention of light pollution in Seoul

system operates. The lighting control industry is expected to grow rapidly with the standardization of the lighting related system, advancement of technology and mass production.17

5. Challenges

1) Absence of relevant regulations and standards

Before the Act on Prevention of Light Pollution by Artificial Lighting was established, light pollution was controlled based on「Road Act」, 「Landscape Act」and 「Outdoor Advertisements Etc. Control Act」. The Act on Prevention of Light Pollution by Artificial Lighting was enacted in 2012 to regulate and manage light the pollution systematically and was implemented in 2013.

Seoul Metropolitan Government managed nightscapes based on 'basic plan on nightscape in Seoul (2000 and 2008) but it was unsatisfactory because it was more concerned with the creation of good light than the management of good light.

Seoul Metropolitan Government enacted an ordinance of light pollution in 2010 for the first time in Korea but the ordinance was limited in managing light pollution and did not provide the means to manage the light pollution systematically.

When assessing the impact of light pollution on the environment, it was found that lighting of 41 percent exceeded acceptable light emission levels; lighting for space accounted for 68%, decorative lighting 70%, and lighting for advertisements 30%.

In Seoul, advertisements have been installed in a disorderly manner. When NASA photographed 19 cities around the world, it showed that the lighting in Seoul was immoderate.

It seems that the supply of LEDs has been responsible for such disorderly building decoration. Lights in the center of cities are abused and wasted due to the absence of proper awareness of lighting.

Table 7. Present condition of outdoor lighting

(unit :place/light)

classification	total	Lights for space			Lights for advertisements	Lights for decoration
		streetlights	Security lights	Lights for parks		
quantity	1,320,048	234,663	226,849	34,119	800,000	24,417

[17] 2014, 『Smart lighting city Seoul』 summary report on construction feasibility study and establishment of basic plan

Table 8. Complaints of light pollution (all over Seoul)

classification	total	2015	2014	2013	2012	2011	Prior to 2010
Number of complaints	6,686	1,216	1,571	778	857	706	1,558

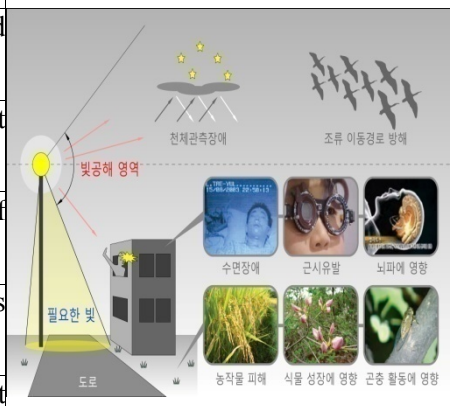
2) Lack of awareness of light pollution

Light pollution has a bad effect on the lives of citizens but most people are unaware of the 'Act on Prevention of Light Pollution by Artificial Lighting' and consider light pollution a waste of energy.

It is necessary to have various channels from which everyone can assess information easily so that people can be provided with information on light pollution.

Table 9. Types of effects of light pollution

classification	Types of damage	Conceptual diagram of light pollution
Effects on the human body	Changes in biorhythm, insomnia, cancer	
Effects on the ecosystem	Decline in the breeding of animals and growth of plants	
Astronomical observations	Two thirds of world population cannot see stars	
Energy efficiency	Waste of energy, excessive emission of carbon dioxide	
Negligent accidents	Poor traffic environments – such as glare	
Urban nightscapes	People do not feel comfortable at night due to excessive light. Identity of night is lost	



3) Unsatisfactory measures for maintenance

It is expected that citizens' interest in light pollution and complaints of light pollution will increase after the Act on Prevention of Light Pollution by Artificial Lighting' is implemented. Some districts may have difficulty in handling complaints concerning light pollution due to a lack of departments in charge of light pollution.

It is necessary, therefore, to prepare measures to deal with complaints arising from light trespassing and light pollution in residential areas.

4) Relaxation of acceptable light emission levels

Major advanced countries and international organizations have implemented systems for a long time and divided areas into four separate categories.

It is necessary to strengthen relaxed levels considering the real condition of domestic light environments. It is also necessary to designate zones to consider light environments in downtown areas that change day by day due to the development of light sources and manage such light pollution efficiently.

6. Solutions

1) Designation of lighting environment management areas

① Article 9 of the Act on Prevention of Light Pollution by Artificial Lighting (Designation of lighting environment management area)

Prepared measures to solve light pollution and the top three problems of inconvenience by designating and managing areas or zones that light pollution has occurred or is likely to occur.

② Establishment of the foundation for effective management of light pollution by securing effectiveness of laws

Analyze types of damage from light pollution and the occurrence of light pollution so as to apply the intensity of illumination appropriately considering the living environment of citizens such as green areas, residential areas and commercial areas.

Table 10. Types of damage from light pollution

(unit: cases)

classification	sum	Disturbed sleep	Inconvenience	Glare	others
total	3,560	3,045	397	99	19
Year of 2015	1,216	1,074	75	62	5
Year of 2014	1,571	1,424	136	4	7
Year of 2013	773	547	186	33	7

Table 11. Types of occurrence of light pollution

(unit :case)

classification	sum	Lighting for space	Lighting for advertisements	Electronic display	Decorative lighting	others
total	3,560	2,905	420	43	92	60
Year of 2015	1,216	928	173	33	39	43
Year of 2014	1,571	1,392	123	5	39	12
Year of 2013	773	585	124	5	14	5

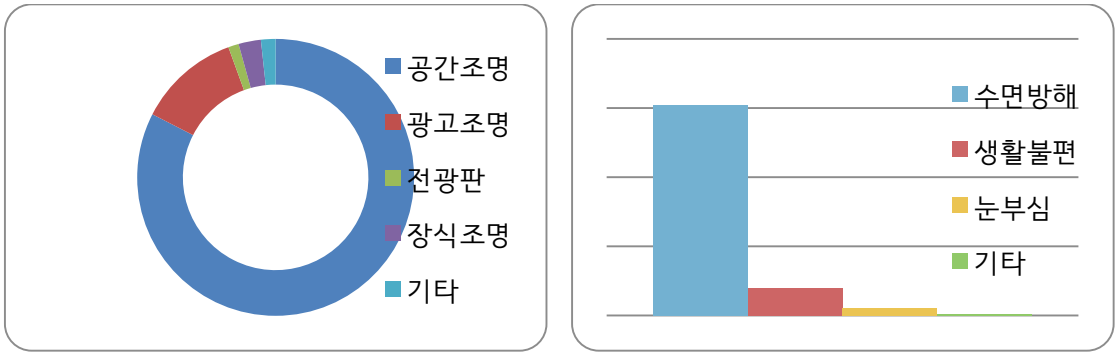


Figure 6. Types of occurrence of light pollution

③Enactment of the ordinance of the prevention of light pollution in Seoul (2010.07) and revision (2014.07)

Seoul Metropolitan government designated lighting environment management areas (class 1 ~ class 6) in 2010 and prepared standards for the installation of lights according to use and provided administrative guidance should violations occur.

Seoul Metropolitan government has operated the Good Light Committee and Award for Good Light and lighting support system to encourage citizens to take part in the prevention of light pollution and reviewed a plan on the classification of lighting environment management areas and standards for detailed designation and boundaries according to classes.

Seoul Metropolitan government held a public hearing to publicize light pollution and encourage citizens to participate in activities to reduce light pollution and to take the opinions of lighting environment management areas (plan) from citizens and those concerned.

Figure 7. The public hearing

④ Environment impact assessment of light pollution (2013.08.28 ~ 2014.03.25)

The environment impact assessment of light pollution aims to promote environmentally friendly and sustainable development as well as a healthy and pleasant life by predicting and assessing the impact on the environment when planning a project that is likely to have noticeable effects.

The environment impact assessment conducted by the Seoul Metropolitan Government showed that 41 percent exceeded acceptable light emission levels and suggests that it is urgent to designate and manage lighting environment management areas.

Table 12. Measurement and analysis of light environments according to use of lighting

Types of lighting	Places measured	Number of lights measured	Number of lights exceeding acceptable level	Percent of exceeding acceptable light emission level(%)
Lighting for space (streetlights, security lights, lights for parks)	114	1,494	911	60.9
Lighting for advertisements (advertising signboards, electronic displays)	97	5,049	884	29.0
Decorative lighting (lights for landscapes)	85	287	209	72.8

The light pollution prevention project was carried out first targeting lighting for spaces in a way that citizens could feel the reduction of light pollution.

Lights for advertisements need continued management as there are so many lights for advertisement installed. The management of large electronic displays has been strengthened because it requires light pollution management for drivers and pedestrians.

Lights for decoration cause less light pollution compared to other lights because they are small in number and turn off after 11 o'clock in the evening. Policies that aim to encourage voluntary improvement and reduce light pollution by managers has been implemented.

⑤ Designation of lighting environment management areas by stage (2015.05.07)

Before the designation of lighting environment management areas by stage, opinions of residents, heads of district and city councils were taken (members of five councils including Dobong-gu council stated opinions) by providing notice of lighting environment management areas (plan)('15.2.16~3.16) and the Good Light Committee reviewed the designation.

Opinion polls of the designation of lighting environment management areas showed that both citizens and shop owners consented to the designation of lighting environment management areas. Discussion meetings showed that all heads of the interested parties agreed with the designation of lighting environment management areas.

Lighting environment management areas were designed by stage. Green areas, residential areas and commercial areas that came under stage 1 were announced first and industrial areas that fell under stage 2 were announced by establishing detailed acceptable light emission levels considering use of land.

Setting the goals and direction of light pollution management	Setting direction of Seoul's light policy (mayor policy no.30, 2012.02.07)
↓	
Environmental impact assessment of light pollution	(Article 9 Paragraph 3 of law) (2013.08.28~2014.03.25)
↓	
Development of the designation of lighting environment management area plans	(Article 4 Paragraph 1 of enforcement regulation) (mayor policy no. 374, 2014.12.26)
↓	
Public notice to 25 districts about intent	(Article 4 Paragraph 2 of enforcement regulation) (2015.02.16~2015.03.06)

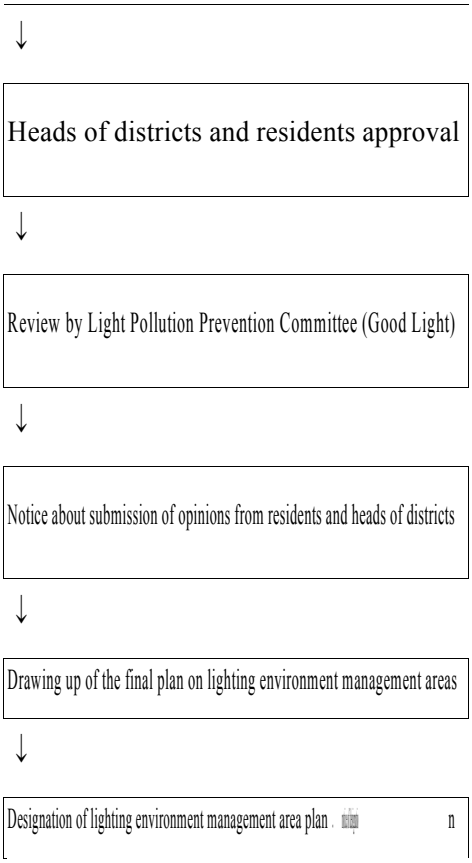


Figure 8. Procedures for designation of lighting environment management areas

Artificial lighting was determined as a target of the designation based on Article 9 of the Act on Prevention of Light Pollution by Artificial Lighting (Article 2 of enforcement decree of the same act).

<Lights subject to outdoor artificial lighting management>

l i g h t i n g f o r s p a c e : s t r e e t l i g h t s , s e c u r i t y l i g h t s , l i g h t s f o r p a r k s

advertisements: permissible outdoor advertisements (electronic displays, protruding signboards, signboards

1 0 m o r m o r e i n w i d t h)

decorative lighting: lights installed on 5-story or higher building or those whose total floor area is

2,000㎡or more, lodging facilities, amusement facilities, bridges

Lighting environment management areas were designated for green areas, residential areas and commercial areas on July 30, 2015 (enforcement date: 2015.08.10(Mon)). Lighting environment management areas were classified into four classes considering the use of land.

Table 13, Designation of lighting environment management areas

lighting environment management areas	designation	area (㎢)
total		605.59
Class 1	Green areas for conservation, Natural green areas (national parks, urban nature parks, ecological and scenery conservation areas, wildlife reserves, cemetery parks)	110.40
Class 2	Productive green areas, natural green areas (areas that do not come under class 1)	124.20
Class 3	Residential areas (exclusive residential areas, general residential areas, semi-residential areas)	325.70
Class 4	Semi-industrial areas	19.99
	Commercial areas	25.30

Table 14. Acceptable light emission levels by class (Article 6, Paragraph 1 of enforcement regulations of the same act)

target	Criteria for measurement	Reference value	Lighting environment management area				
			class1	class2	class3	class4 semi industrial industrial area	Commercial area
Lights for space, Electric advertisements	①illuminance (lux)	Maximum value	Less than 10			Less than 15	Less than 25
advertisements	②brightness of surface (cd/㎡)	Maximum value	Less than 50	Less than 400	Less than 800	Less than 900	Less than 1,000
Electric advertisements	③brightness of surface (cd/㎡)	Mean value (around 24 o'clock	400/ Less than 50	800/ Less than 400	1000/ Less than 800	1250/ Less than 900	1500/ Less than 1000
Decorative lighting	④brightness of surface (cd/㎡)	Mean value	Less than 5		Less than 15	Less than 20	Less than 30
		Maximum value	Less than 20	Less than 60	Less than 180	Less than 240	Less than 300

※ Lighting fixtures installed before the designation of lighting environment management areas have a grace period of 5 years

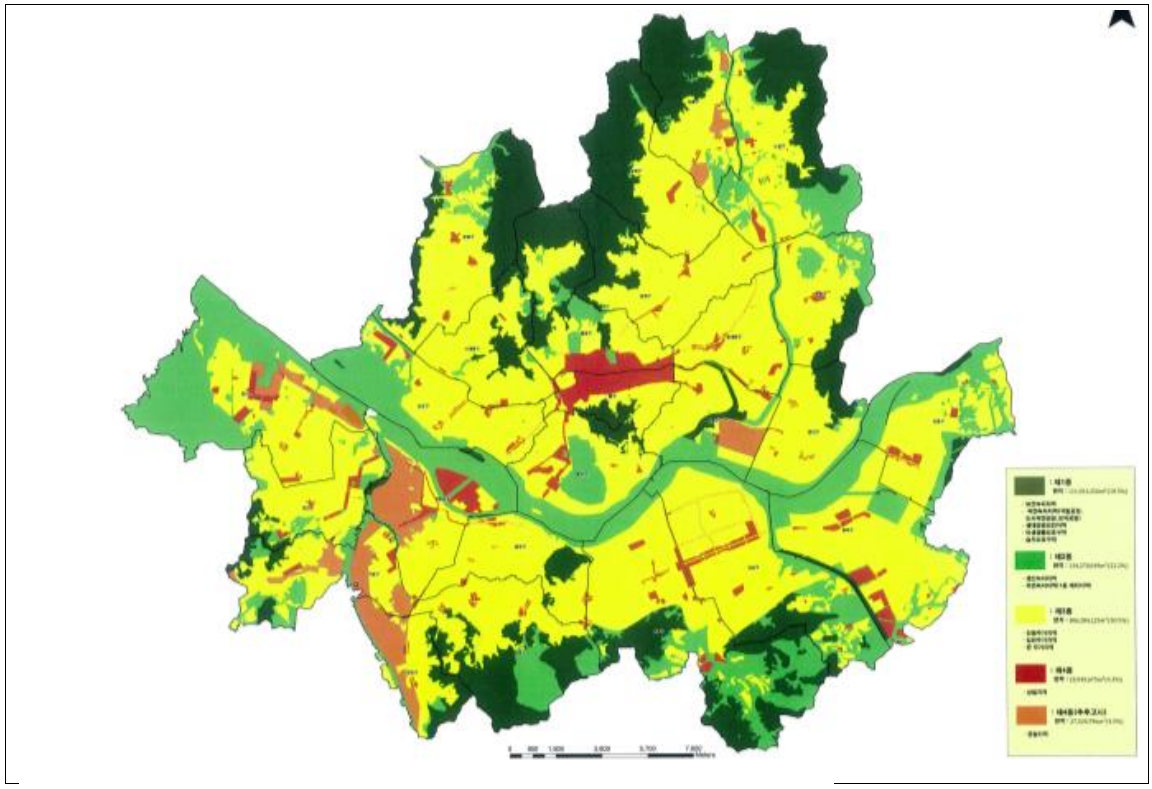


Figure 9. Map of the designation of lighting environment management areas

The qualitative effect of the designation of lighting environment management areas includes the removal of light pollution, improved safety of citizens walking, energy saving and the protection of the ecosystem. Quantitative effects of the designation of lighting environment management areas is the reduction of electric energy; yearly savings of electric power are 409,630 MWh (40,261(security lights) + 45,799 (streetlights) + 4,207 (lights for parks) + 315,056 (lights for advertisements) + 4,307 (lights for decoration)) which amounts to a yearly ton of oil equivalent of 94,215 TOE. Table 15 below shows the expected effect by area.

Table 15. Expected effect by area

Areas		Before designation	After designation
Value of Seoul	Identity	Unplanned • disorderly light (my lighting)	Light of consideration for citizens and moderation (our lighting)
	Beauty	Confusing and poor	Globalization of Seoul's brand value (Lighting Urban Community International held in Seoul in 2016)
	Tourism	Tourists were concentrated into commercial areas	Tourists were distributed evenly all over Seoul (Han River, Namsan Mountain, central area etc.)
Life quality of citizens	Safety of citizens	Unsatisfactory walking environments	Improved women's safety in residential areas
	Sleep disturbance	Excessive lights disturbed sleep	Relieved sleep disturbance by removing unnecessary lights
	Road safety	Glare may cause negligent accidents	Improved safety of drivers and pedestrians
	Complaints	over 700 complaints annually	Complaints are expected to be reduced gradually
Protection of ecosystem	Astronomical observation	Two thirds of the world population cannot see stars	Citizens can see stars even in the center of the city
	Plant growth	Bad effects on plant growth such as over growth	Smooth plant growth, ecofriendly green areas
Energy saving	Electric power saving	Waste of electric energy	Energy reduced by 30 ~ 70 percent
	Reduction of Co2	Excessive emission of Co2	Emission of CO2 reduced by 50%

2) Drawing up a plan on the prevention of light pollution considering characteristics of light environment

It is advisable to draw up a plan on the prevention of light pollution which considers the characteristics of the light environment, use of lighting, types of lighting and lighting environment management areas.

Lighting environment management areas were designated as four classes considering use, present condition of land use, order of the Ministry of Environment, environmental impact assessment of light pollution, opinions from residents and autonomous districts and a review. A plan on the prevention of light pollution according to lighting environment management areas that considered characteristics of areas in Seoul was therefore then proposed. The plan which aimed to improve existing lighting fixtures and maintenance and to prevent light pollution was prepared.

3) Proposal of action plans on the sustainable and systematical prevention of light pollution

The manual of light pollution was prepared and distributed so that those concerned can better manage light pollution in a sustainable and systematical way and owners, designers and constructors of lighting fixtures can observe regulations on light pollution.

It is advisable to publicize the dangers of light pollution so that people will participate in activities which aim to reduce light pollution and its damaging effects.

4) Strengthening management systems by implementing technology to reduce light pollution

The light pollution management system was established by setting objective standards for light pollution reviews and implementing technology to reduce light pollution. The management system aimed at reducing light pollution was prepared to improve the safety and life quality of citizens by conducting demonstration projects.

Seoul's light policy aims at lights free of pollution, energy saving, participation of citizens and good light under the vision of "creating night which citizens feel comfortable". The basic goal and direction of the plan on the prevention of light pollution are "Seoul, city of attractive light in which citizens feel comfortable".18

① A plan on the selection of smart lighting that uses the internet and its subsequent implementation (one complex)

It is possible to control the intensity of illumination via a two-way communication between the central system and lighting by constructing an integrated system that connects lighting for public use and lighting for private use (ex. Lights for advertisements). It is possible to provide information on streetlights, CCTV, WiFi, fine dust, traffic and tourism.

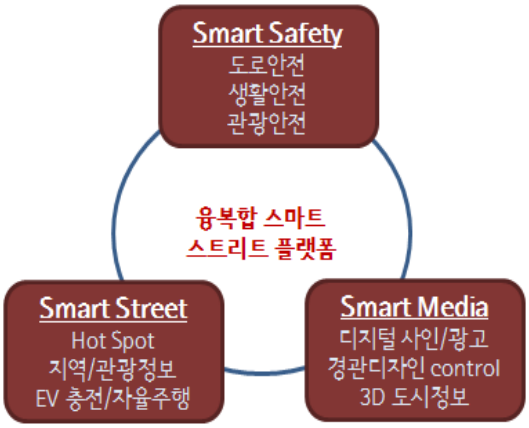


Figure 10. Convergence smart street platform

Efforts to find ways to control the intensity of illumination, color and brightness according to

[18] 2015, A plan on prevention of light pollution in Seoul

the movement of objects, space, season, time and weather and make it possible to provide information on CCTV · lighting for landscape · WiFi · fine dust, traffic and tourism have been made.

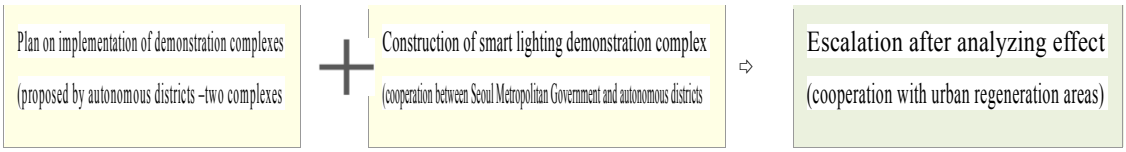


Figure 11. Action plan on the smart lighting city

② Construction of the smart lighting demonstration complex

It is advisable to carry out this project with the cooperation of Seoul Metropolitan Government and autonomous districts and organize consultative groups consisting of residents (consultative groups: decision making/city.district: support for projects).

③Expansion by stage after analyzing the effects of demonstration project

Analyze effects in terms of safety of the citizens (improvement in the intensity of illumination), reduction of light pollution, energy saving and convenience.

5) Construction of a smart lighting demonstration complex free of light pollution

Seoul Metropolitan Government pushed ahead with a project of constructing a smart lighting demonstration complex free of light pollution in 2016 with a view to making a contribution to creating good light and improving citizens' negative awareness of acceptable light emission levels by building exemplary demonstration complexes. One autonomous district was selected out of the 25 districts in Seoul.

The smart lighting system adjusts the intensity of illumination according to traffic to save energy on lights for public use (streetlights, security lights, lights for parks) and lights for private use (lights for advertisements) around Tongilro in Seodaemun-gu(Muakjae Station~Hongje Station).

The demonstration project cost about 2 billion won and maximizes its effects by keeping pace with existing projects of improving signboards. The project will play the role of test bed for smart lighting systems by converging various advanced technologies (installation of beacons and public wi-fi) in the demonstration complex. The demonstration complex will be constructed in 2017 and then demonstration complex projects will be expanded.

Table 16. Target of improvement of lights for advertisements in demonstration complexes

Section		Number of buildings	Number of businesses	Number of signboards
Hongeun Intersection~Hongje three way intersection(780m)		58	383	1,149
Hongje three way intersection ~exit no. 3 of Muakjae Station(520m)		47	217	423
Total	Hongeun Intersection ~ exit no. 3 of Muakjae Station	105	600	1,572

Table 17. Target of improvement of lights for public use in demonstration complexes

Types	Target of improvement
Streetlights	A total of 252 lights (underground roadway CDM 250W 116 lights, lights for waling 70W 136 lights)
Security lights	A total of 175 lights(12 sodium lights, 29 metal lights, CDM 93 lights, LED 41 lights)

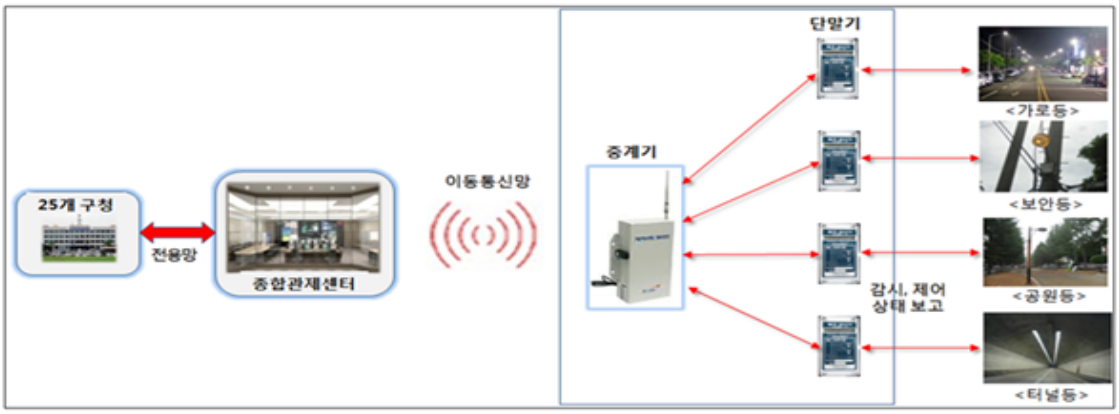


Figure 12. Diagram of smart lighting system