Introduction

Beginning with fire, mankind has always exploited a variety of artificial light sources over the centuries. Using these light sources, we are able to do as we please any time and any place with or without sunlight. We can no longer imagine living without artificial lighting (hereafter “lighting”) especially since the time that electric lamps first became widely available.

Artificial light sources are inseparably tied to our lives, as lighting for various activities, heat sources for space heating and drying processes, information-processing media such as communication and copy machines, indicators for traffic signal lights and billboards, decorative illumination in scenic spots, and so on. The uses are innumerable.

But are these lights used in an efficient way? Light is a form of energy, and when a light source is turned on, commensurate power consumption always takes place. Since lighting is accomplished mainly by consuming fossil energy, it is imperative to employ efficient lighting.

Japan is obligated to reduce its greenhouse gas emissions with the entry into force of the Kyoto Protocol, but in reality, emissions have increased in comparison with the base year. New measures are required in addition to existing measures, especially for reducing the use of fossil energy. Lighting is a major source of power consumption in Japan, accounting for more than 10 percent of the gross generation. This is an area that requires energy conservation.

Outside Japan, policies banning the use of incandescent light bulbs, which are less efficient than fluorescent lamps, have been promoted as measures for reducing greenhouse gas emissions mainly in Europe and the United States. In Japan, lamp manufacturers have announced that they will stop producing general incandescent light bulbs by 2012 according to the intention of the Ministry of Economy, Trade and Industry. This will accelerate the process of replacing incandescent light bulbs with fluorescent lamps. Research laboratories of manufacturers and universities are developing light-emitting diodes (hereafter “LEDs”) for lighting, which are more efficient than fluorescent lamps. Given these circumstances, the Council for Science and Technology addressed high-efficiency lighting systems using new light sources in May 2008 as technologies required for reducing greenhouse gas emissions in its “Environment and Energy Technological Innovation Project”\(^1\).

This report, under the theme of energy-saving lighting methods, will cover the development of energy saving, highly efficient lighting fixtures, and the trends of the most advanced technologies for efficient lighting, which have rarely been examined so far.

Present Lighting Situation

2-1 Need for Efficient Lighting

Of a total generation of 988,900 GWh\(^2\) in FY2005 in Japan, 135,500 GWh,\(^3\) or 13.7% of generated electric energy, was consumed for lighting, as shown in Figure 1. Lighting is a relatively large part of our daily lives and lighting-related energy saving is easy for individuals to tackle. The effect of improvements in lighting will be significant because of a large amount of energy consumed for lighting.

While the use of mirrors and light-storage techniques to bring sunlight into buildings can contribute to saving energy, this report focuses on the efficiency of lighting using more efficient light sources.
of artificial lighting, which is defined in this report as illumination provided by light energy obtained from electric energy supplied to artificial light sources.

2-2 Prevalent Light Bulbs

As shown in Table 1, lamps can be roughly classified into three categories according to their light-emitting principles. Each lamp has advantages and disadvantages in its usage, and is used according to intended purposes. An index called “lamp and auxiliary efficacy” is widely used for comparing these lamps in terms of energy efficiency. The lamp and auxiliary efficacy (lm/W or lumens per watt) is the quotient of the total luminous flux (the total amount of light emitted by a light source in all directions, unit: lm or lumen) divided by the power consumption (unit: watt) of the lighting fixtures that mounts the lamp. As the lamp’s total luminous flux is greater, less electricity is consumed for maintaining the same brightness; thus the lamp is more efficient. Table 2 shows the representing lamp and auxiliary efficacy of typical lamps as of FY2005.

Table 1: Electricity consumption for lighting in Japan

<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Major usage</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent &amp; halogen bulbs</td>
<td>Homes</td>
<td>Least expensive and convenient.</td>
</tr>
<tr>
<td></td>
<td>Commercial facilities</td>
<td>Can be directed freely.</td>
</tr>
<tr>
<td></td>
<td>Amusement facilities</td>
<td>Give us comfort.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Short lifespan. (1,000 to 2,000 hours)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low efficiency.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Produce a large amount of heat.</td>
</tr>
<tr>
<td>Fluorescent lamps</td>
<td>Homes</td>
<td>Long lifespan. (3,000 to 10,000 hours)</td>
</tr>
<tr>
<td></td>
<td>Offices</td>
<td>High efficiency.</td>
</tr>
<tr>
<td></td>
<td>Factories</td>
<td>Can produce many different colors of light.</td>
</tr>
<tr>
<td></td>
<td>Commercial facilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low tolerance for low temperatures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low tolerance for repeated on and off.</td>
</tr>
<tr>
<td>HID lamps</td>
<td>Sports facilities</td>
<td>Long lifespan. (6,000 to 12,000 hours)</td>
</tr>
<tr>
<td></td>
<td>Roads, tunnels</td>
<td>High efficiency.</td>
</tr>
<tr>
<td></td>
<td>Commercial facilities</td>
<td>Small and bright.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Expensive.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Take about 10 min. to glow.</td>
</tr>
</tbody>
</table>

The reference[4] was partly modified by STFC.
Figure 2 shows the quantity of lamps domestically shipped in FY2005. Approximately 500 million lamps were shipped in this fiscal year, of which fluorescent lamps accounted for the largest share followed by incandescent and halogen bulbs, and HID lamps (in this order). As shown in Table 2, energy can be saved simply by replacing incandescent bulbs with fluorescent lamps because of a significant difference in efficiency between these lamps; but unlike the countries where incandescent bulbs are more popular than fluorescent lamps, the proportion of fluorescent lamps to incandescent bulbs is about two to one in Japan. Since fluorescent lamps have already been widely used, efficient lighting alone won’t save much energy. More efficient lighting systems also need to be developed to achieve meaningful energy saving.

### Measures for Efficient Lighting Systems

The two measures explained below can be taken to increase efficiency in lighting systems.

1. **Improving the efficiency of lighting fixtures**

   The same amount of light can be emitted with less electricity consumption by improving the efficiency of lighting fixtures. The efficiency of lighting products has been continuously improved one after another by improving the lamp itself and lighting circuit, but the efficiency of existing products in both lamp and circuit will soon reach its maximum. Consequently, new light sources that have much higher efficiency (such as LEDs) than lighting fixtures using conventional lamps, are being exploited.
Improving the efficiency of lighting methods

By lighting a required area at a required level of brightness, efficient lighting can be achieved. This mainly applies to indoor lighting. This kind of approach has rarely been examined so far, but allows us to save energy regardless of the types of lighting fixtures used.

3-1 Existing Lighting Fixtures with Improved Efficiency

3-1-1 Incandescent and Halogen Bulbs

Incandescent light bulbs, developed in the 19th Century, have the longest history of the electric lights. Despite a high rate of loss as heat energy and inefficiency, these light bulbs are still widely used mainly in commercial facilities because of their warm color tone. In contrast, regular incandescent bulbs that can be replaced with fluorescent lamps will disappear before too long as lamp manufacturers decided to stop producing them by 2012.

Replacement with fluorescent lamps is difficult for special bulbs such as Krypton and halogen bulbs, which are characterized by their compactness and attractiveness as effective lighting with high color rendition. Production of these lamps will, therefore, be continued, but there is a desire for alternatives with enhanced color rendering properties comparable to special bulbs so that energy saving can also be achieved in this field, though the ratio of special bulbs to all lamps is small and contribution to overall energy saving is also small.

3-1-2 Fluorescent Lamps

As shown in Figure 2, fluorescent lamps account for over 60 percent of the total quantity of lamps shipped in the fiscal year. These lamps are the most popular lamps in Japan. When the fluorescent lamp was invented in the 20th Century, only straight tubes were immediately available, then circular tubes, and more recently, globe bulbs were developed. Now, suitably shaped fluorescent lamps are available depending on the place of use. Because of high efficiency and long lifespan, fluorescent light fixtures have become widely used in Japan. The turning point was the oil shock in the 1970s.

Efficiency technologies have been actively developed for fluorescent lamps. Both lamps and lighting circuits, including ballasts, have been improved, and inverter-type ballasts and inverter-specific Hf fluorescent lamps (fluorescent lamps driven exclusively by a high frequency), which can reduce losses that do not contribute to light emission, have led to considerable improvement in efficiency.

Fluorescent lamps, which were developed to replace conventional regular incandescent bulbs, are globe bulb-type fluorescent lamps. These lamps are provided with a built-in lighting circuit or ballast and can be screwed into a conventional socket for incandescent bulbs. Globe bulbs have a luminous efficiency that is four times higher than that of incandescent bulbs, reducing power consumption to 1/4 of the conventional bulbs when providing the same amount of light. This means that the energy-saving effects would be significant if incandescent bulbs were simply replaced by fluorescent lamps. As the cost of producing fluorescent lamps has been

![Figure3: Changes in mean efficacy of fluorescent lamps](source: Reference[1])
considerably reduced, introduction of these lamps can be accelerated in a short period.

Figure 3 shows changes in the mean efficacy of fluorescent lamps. The efficiency of each lamp has increased every year, and the efficiency of straight and circular lamps is particularly significant as inverter-type Hf fluorescent lamps have been disseminated.

Fluorescent lamps are the most popular lighting fixtures in Japan at present, but mercury contained in the tube is difficult to process after the lamps are discarded. There are companies that collect mercury from discarded fluorescent lamps, but only a fraction of lamps are brought to these companies, and many municipalities still collect and dispose of them in landfills as non-burnable garbage. The efforts to improve fluorescent lamps have reduced the amount of mercury; for example, fluorescent lamps manufactured in 2007 contain less than 10 mg of mercury compared with those manufactured in 1980 containing 100 mg of mercury, but still a certain time is required to achieve zero mercury. Establishment of a collection system is a big issue to be solved.

3-1-3 HID (High Intensity Discharge) Lamps

High-pressure mercury lamps, metal halide lamps and high-pressure sodium lamps are generically called high intensity discharge lamps. These lamps are highly efficient, suitable for illuminating a wide area continuously for a certain period time, and widely used in factories, gymnasiums and roads.

Metal halide lamps were developed for the purpose of increasing the efficiency and color-rendering properties of mercury lamps used often for large-scale outside lighting. Replacing mercury lamps with metal halide lamps has been gradually promoted, but the proportion of HID lamps to all lamps is still small. The lamps also have the same mercury-treatment problem at the time of disposal.

3-2 Energy Saving Effects of Higher Efficiency Alternatives

The Japan Electric Lamp Manufacturers Association (JELMA) has recommended four energy-saving measures through which existing lamps are to be replaced with more efficient alternatives. As a result, the power consumption can be reduced by a maximum of 12,740 GWh. According to the estimation by the JELMA, power consumption in 2010 will be 138,000 GWh if none of these measures are taken. In contrast, if all of measures (a) to (d) are implemented, a large reduction equivalent to 9.2% of all power consumption can be achieved.

(a) Replace regular incandescent bulbs with highly efficient fluorescent lamps (assuming that half of bulbs can be replaced).
(b) Replace halogen bulbs with more efficient lamps (assuming that half of lamps can be replaced, and the proportion of conventional lamps to alternatives is 1 to 1).
(c) Replace all 40W straight fluorescent tubes, which are most widely used among all fluorescent lamps, with Hf fluorescent lamps.
(d) Replace all mercury lamps with metal halide lamps.

<table>
<thead>
<tr>
<th></th>
<th>Without measures</th>
<th>With measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent &amp; Halogen</td>
<td>140,000</td>
<td>120,000</td>
</tr>
<tr>
<td>HID lamp</td>
<td>120,000</td>
<td>100,000</td>
</tr>
<tr>
<td>Fluorescent lamp</td>
<td>100,000</td>
<td>80,000</td>
</tr>
<tr>
<td>Reduction of 12,740 GWh (9.2%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 4: Energy-saving effects of replacing lamps with more efficient alternatives

Prepared by the STFC based on Reference
The efficiency of light bulbs, including fluorescent lamps, has steadily been improved, and will be continuously improved by lamp manufacturers. However, efficiency improvements have a limit. It is unrealistic to expect a significant improvement, for example, to 200 lm/W, which is twice the present level. Consequently, alternative new light sources have been exploited.

3-3 Development of Lighting Fixtures Using New Light Sources

3-3-1 Development of LED Lighting Fixtures

LEDs are a semiconductor. They emit light when electric current passes through them. They are expected to be a next generation light source possibly having a luminous efficiency of 200 lm/W (as a light source, not a lighting fixture), which is considered difficult to achieve with traditional light sources. Since light is emitted from the semiconductor component itself, LEDs contain few deteriorating parts and have longer lifespans than traditional light sources. LED chips (semiconductors without circuits) with a luminous efficiency of 150 lm/W have already been achieved. In reality, however, the efficiency sharply drops when the semiconductor is assembled into a fixture. Enhanced lamp efficacy is the present issue. Losses in conversion from AC to DC power (LEDs require direct current to operate) and heat from peripheral devices (reduction due to heat) are said to be potential causes for the drop in efficiency.

LED lamps emit pale blue light, which is not suitable as an alternative to incandescent bulbs or fluorescent lamps. The development of a product that can emit light similar to the one emitted from incandescent bulbs is desired. Decreases in color temperatures are detrimental to efficiency. Further increases in efficiency are considered urgent necessities to replace existing products.

Figure 5 shows the projected improvements in the lamp and auxiliary efficacy of LED lighting fixtures presented by NPO, the Japan LED Association. The products emitting warm white light (incandescent color) are intended to replace incandescent bulbs and fluorescent lamps. Their luminous efficiency has already exceeded incandescent bulbs to a considerable extent, but is about the same level with fluorescent lamps. The efficiency of warm white light emitting LED lighting fixtures is expected to be improved every year, and may exceed fluorescent lamps within a couple of years. It is also expected to overtake metal halide lamps, a typical HID lamps, and currently most efficient fluorescent lamp, Hr tubes around 2015.

In order to show the possible effects of introducing LED light fixtures quantitatively, the projected maximum values based on the assumptions of (a) to (c) are listed in Figure 6.

(a) Required scale of lighting

The required scale of overall lighting is fixed. The total amount of luminous flux (the sum of the amount of light emitted by a lighting fixture) in 2010, estimated by the Japan Electric Lamp Manufacturers Association, is assumed to be the required amount of luminous flux in each fiscal year. The power consumption in 2010 is the result of “With measures” in Figure 4.

(b) Efficiency of LED lighting fixtures

The efficiency is based on the technology roadmap in Figure 5, prepared by NPO, the Japan LED
Association. The value in 2020 is also used for the efficiency in 2050, which is excluded from estimation.

(c) Progress of replacing existing lighting fixtures with LEDs

It is presumed that LEDs will replace all incandescent and halogen light bulbs by 2015, while gradually replacing other lamps. All existing lamps will be replaced with LEDs in 2050. This is, in short, a presumption for estimating the maximum effects. Figure 6 shows the estimated effects of introducing LEDs based on the above assumptions. There is a large possibility of halving the present power consumption. As indicated above, LEDs are a markedly effective technology for saving energy through lighting, but there are also a number of technical issues to be solved for the dissemination of LEDs in the future.

The energy-saving effects that were discussed heretofore focused only on efficiency, but the dissemination of LEDs is not possible if it is not economically viable. Reducing the product cost is therefore a large issue. The present price of LED lighting fixtures is four to five times the price of fluorescent lamps. Though the initial investment is high compared with bulb-type fluorescent lamps, the price of high efficiency LEDs has already been set to a level allowing the initial investment to be paid off in five to six years\(^6\). Reduced product cost is desirable in order to maximize the advantages of introduction.

To replace the existing products, the performance of LEDs should be at least equivalent to that of these products, not to speak of efficiency. Since the warm light of incandescent and halogen lamps is a preferred color of light, LEDs with the incandescent color are being developed as in the case of fluorescent lamps. While it is under development now, the quality of light and variety of products must be provided for the satisfaction of consumers.

Because the history of LEDs as commercial products is short, standards have not yet been established. Standards are necessary since more manufacturers are expected to break into the market with increased demand for LEDs.

3-3-2 Development of OELD Lighting Fixtures

OLED lighting fixtures are developed as a next generation light source of LEDs. Advantageous features of OLED include\(^9\) the following:

- A light-emitting plane is formed with light-emitting compounds deposited on the surface of a substrate. The very thin light emitting plane allows the entire fixture to be thin. The fixture can also be bent flexibly if flexible materials are used for the substrate.
- A luminous efficiency of 200 lm/W is theoretically attainable according to calculation. Light of any color can be emitted by combining various light-emitting compounds.

As listed above, the features of OLED are quite different from those of other light sources, including LEDs. In addition to the replacement of conventional lighting fixtures, it can be used in totally different
applications, for example, for toothbrushes, dental mirrors, magnifying lenses and bags, and other items on which lights could not be installed so far.

At present, the lamp and auxiliary efficacy of OLED is 20 lm/W, which is almost the same as that of incandescent bulbs, and the lifespan is 3,000 hours, which is less than half the lifespan of fluorescent lamps. Because of these figures, it remains in the trial phase. However, a roadmap for catching up with LEDs was drawn up concerning the lamp and auxiliary efficacy of OLED, as shown in Figure 7. Commercialization of OLED as a lighting fixture is promoted along with the extension of the lifetime of elements. If the efficiency and lifespan of OLED bear comparison with those of LEDs, OLED will be used more widely because of its property that light of any color can be emitted.

3-4 Efficient Lighting Methods
3-4-1 Changes in Power Consumption in Lighting

As explained in 3-2, the efficiency of lighting fixtures has been largely improved. This section will verify that the improved efficiency contributes to saving energy based on data accumulated so far.

Figure 8 shows changes in the total power consumption and luminous efficiency of lamps summarized by the Japan Electric Lamp Manufacturers Association. The power consumption from 1990 to 2010 was nearly uniform in a range between 130,000 and 140,000 GWh, while the mean luminous efficiency (a weighted average of all lamps used in Japan) has increased every year during this
3.4.2 Task-Ambient Lighting

Task-ambient lighting refers to a lighting arrangement in which local task lights are installed separately from ambient lights. While the traditional lighting arrangement provides uniform and direct lighting to keep the entire office bright, day and night, this approach provides higher light levels for the task areas only, for example, on desks that are fixed work areas. Ceiling lights function as ambient lights for creating a good ambient atmosphere, and task lights ensure the brightness of the desk area for work. Table 3 lists schematic diagrams of task-ambient lighting.

This approach saves energy for lighting. Reduced power supply to ceiling lights will reduce heat radiated from these lights, and increase space-cooling efficiency. There is a report\(^{[10]}\) of 30-percent decreases in power consumption through the introduction of task-ambient lighting, and additional 15-percent decreases in power consumption for air-conditioning as a result of reduced radiation of heat from lighting facilities. In this manner, a secondary effect can be expected by improving efficiency in lighting methods. In the schematic diagrams in Table 3, workers are able to adjust the brightness of task lights only by turning them on and off. A system in which ambient lights can be adjusted invariably is being developed\(^{[11]}\) at a university research laboratory for information-processing study from the perspective that every one has a favorite brightness level. This method aims to increase the amenity of workers in offices and improve work efficiency in a similar manner as distributed multiple lighting, which is explained in the next paragraph. Additional increases in efficiency by 20 percent were observed in experiments, making a maximum of 50-percent decrease in power consumption. Task-ambient lighting is an efficient lighting method with the potential for a great energy-saving effect.

3.4.3 Distributed Multiple Lighting

Distributed multiple lighting is a lighting arrangement in which a multiple number of low-watt light fixtures are distributed and separately used depending on the purpose. A typical house has a set of circular fluorescent lamps in the ceiling of the living room and another set of lighting near the dining table. In the left photo of Figure 9, for example, two sets of lamps in the room illuminate at a total of 92 watts. The suitable brightness of lighting fundamentally depends on the activity, number of people in the room, time zones (evening or midnight), purpose (reading a

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**Table 3: Schematic diagrams of task-ambient lighting**

<table>
<thead>
<tr>
<th>Mode</th>
<th>TAL (1)</th>
<th>TAL (2)</th>
<th>TAL (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task lighting</td>
<td>Task lights</td>
<td>Task lights</td>
<td>Task lights</td>
</tr>
<tr>
<td>Ambient lighting</td>
<td>Overall lighting</td>
<td>Upper lights</td>
<td>Combined TAL (1) and TAL (2)</td>
</tr>
</tbody>
</table>

![Schematic diagrams of task-ambient lighting](image)

* TAL (Task and Ambient Lighting)

Source: Reference\(^{[12]}\)
book or chatting) and so on, but it is difficult to adjust brightness with the traditional lighting arrangement. It is said that staying in a bright room at night may result in a disruption of the genuine rhythm of daily lives, and affects the quality of sleep.

The lighting of a household with elderly people tends to be unnecessarily bright, but brightness is required only in the area of work. Illuminating the entire room is not always essential.

In distributed multiple lighting, a multiple number of lights are provided in a room, and used separately depending on the area and time of activity in the room to improve the lighting efficiency. In the right photo of Figure 9, six 12W fluorescent lamps are installed, and even when all lights are turned on, the sum of wattage is 72 watts. The principle of improvement is that total wattage does not exceed that of original one-lamp-per-room arrangement.

This method has been developed to make the living space comfortable by adjusting brightness, and is now expected to save energy too.

3-4-4 Introduction of Human Detection Sensor and Light Control System

Human detection sensors are used for turning on and off designated lights to get rid of wasted electricity caused by forgotten lights. Applications are expanded to the entrance light of a house and the light for emergency staircases in offices. The sensors are becoming familiar to us.

The light control system automatically adjusts the intensity of indoor lights when the sunlight has reached the room. Several systems have already been put into the market. They are useful in that too bright lights can be controlled. This system has been employed in only a limited number of buildings.

4 Future Issues on Diffusion of Efficient Lighting

4-1 Development and Promotion of Highly Efficient Lighting Fixtures for Diffusion

The long-term goal is to improve the efficiency of all lighting fixtures; and in the short term, the prime task is to replace inefficient incandescent and halogen bulbs immediately. For this purpose, compact fluorescent bulbs and other alternatives to incandescent and halogen bulbs are to be developed. Diffusion and promotion of alternatives in a country where preference for incandescent bulbs is stronger than in Japan will contribute to global energy saving. LEDs and OLED were presented in 3-3 as highly efficient alternatives to conventional lighting fixtures. LEDs in particular can be the next generation lighting fixtures, and are likely to be available for saving a large amount of energy when the efficiency indicated in the technology roadmap is achieved.

4-2 Collection and Publication of Data

Efficient lighting is one achievable energy-saving effort in households, but there is only a limited amount of published data on power consumption for lighting. Continuous surveys on power consumption in households are necessary for increasing the awareness of citizens and keeping them informed.

4-3 Establishment of Legislation

4-3-1 Revised Act on the Rational Use of Energy

The Act on the Rational Use of Energy was enacted as an energy-conservation law. The act has been in
operation for nearly 30 years, since its establishment in 1979, and largely contributed to saving energy in Japan. Provisions for lighting facilities are included in the act, but only applicable to specific buildings that have a total floor space of more than 2,000 m². The scope should be expanded to other existing buildings to increase energy-saving effects.

Qualification systems for persons in charge of energy management are also provided to promote energy conservation. Qualified persons for lighting are also required to exclusively improve lighting efficiency in the future.

4-3-2 Subsidies

Energy-saving technologies have been developed for lighting, including LED lighting fixtures and highly efficient lighting methods. Cost reductions are also discussed. A high initial cost may be inevitable. Subsidies are also necessary in the lighting industry to encourage the use of high-efficiency lighting fixtures to disseminate new technologies, as in the precedent for introducing energy-saving technologies.

Efficient lighting methods are studied mainly at research organizations of universities. To establish the technologies developed in laboratories, demonstration experiments are indispensable for a certain period in a building of a suitable scale. Financial aid at the experimental stage, not at the introduction stage for the completed technologies, is necessary and effective for promoting efficiency-improvement studies for lighting methods.

4-3-3 Review of Standards

Required illuminance in office lighting design is specified to 500 lux[8]. This illuminance should be maintained even if lamps have deteriorated. The initial illuminance of lights is, therefore, set to 700 lux at the time of installation, but this may be an excessive margin of safety ratio surpassing as much as 40 percent of the originally required illuminance.

The illuminance standards[14] were established in 1979. The current computer-based work was not assumed at that time. Required illuminance should be reviewed to make necessary amendments to the standards for adjusting to the present energy-saving requirements.

4-4 Fostering Lighting Engineers

Efficient lighting methods, such as task-ambient lighting and distributed multiple lighting, need to be understood and employed by the client when building facilities are designed. This in turn requires engineers who are familiar with these efficient lighting methods to support the design of facilities.

Lighting engineers should be educated in an integrated manner, and qualified in a qualification system. The Illuminating Engineering Institute of Japan has set an independent training program for engineers, and gives appellations such as lighting consultant and lighting engineer to those who pass the exams. They are, however, less well known to the public. In order to allow lighting engineers to become engaged in design more actively, the authority of engineers should be strengthened. As explained in 4-3-1, legal arrangements, such as national qualification of lighting engineers, are required.

A system of qualifying architects and other appellations in relation to buildings has already been established. Adding lighting engineers to the present qualification system may allow design engineers to obtain lighting technologies.

4-5 Maintaining Japan’s Technological Competitiveness in Lighting

Energy conservation in lighting has been achieved in Japan through the use of efficient lighting fixtures. Efforts of lamp manufacturers for technological innovations, including inverter-driven fluorescent lamps, are the major contributing factor. The technologies in Japan take a leading role in the industry for developing new light sources such as LEDs and OLED.

As shown above, Japan is good at developing highly value-added items, but development and production technologies should be continuously refined. Appealing our technological capabilities to the world is also required.

5 Conclusion

Energy consumption is an indispensable part of our modern lives, and this report looks at ways to consume less energy through lighting. As required technologies for the efficient use of efficient instruments are common to all energy equipment and systems, energy conservation should be considered not in one particular case but in every case by understanding the present situation; and it should be carried out under
the most optimum conditions. The need for energy-saving efforts never ends, even when some targets are achieved, but should be continued towards the “zero waste” goal.

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References

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Having engaged in the management of oil-refining facilities, operation of oil-stockpiling bases, and development of new businesses, etc. in an oil company, he is now interested in science, technology and policies for achieving a low-carbon society in the environment and energy fields, and engaged in researches in these fields.

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