Comparing Lighting Energy Conservation Measures in the United States and Japan

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INTRODUCTION

When Edison invented the light bulb, he envisioned a technology that would not only provide better lighting quality than kerosene lamps, but also eliminate the health problems associated with combustion. A century later, these same issues still dominate the concerns of those in the lighting industry. Each generation of lighting technology brings about greater lighting quality to customers, but as scientists learn more about the health and environmental consequences of generating power with fossil fuel combustion, energy efficiency has become an important consideration for all energy-consuming products.

The United States (U.S.) and Japan consume 30% of the world's energy. In the U.S., lighting consumes 25% and 6% (EIA, 2001) of the energy used in commercial and residential buildings respectively. In Japan, lighting consumes 25% (JLA, 2002; TEPCO, 2003) and 16% (ANRE, 2000) of energy used in commercial and residential buildings respectively. Compact fluorescent lamps (CFLs) and electronic ballasts for fluorescent lamps have received the most attention over the past two decades due to their potential to save energy. In 2001, 53% of the ballasts sold in the U.S. were electronic compared to 36% in Japan (Nakamura, 2002). In the U.S., CFLs accounted for 3% of the total incandescent-lamp shipment compared to 10% in Japan (Navigant Consulting, Inc., 2002; Nakamura, 2002). This document explores some of the energy conservation programs related to electronic ballasts and CFLs implemented so far both in Japan and the U.S., and how these programs have contributed to the commercialization and adoption of these technologies. It also explores lessons that can be learned from the programs, and how this knowledge can be applied to encourage a faster adoption of superior lighting technologies in each of these countries. For this purpose, the authors conducted a literature review, interviewed experts in the U.S., and held a symposium and roundtable meeting with experts in Japan.

The U.S. and Japan have differences both in culture and energy supply mixes. Based on simple observation, one cultural difference related to lighting may be correlated color temperature (CCT). Lamps with higher CCT appear to be more popular in Japan than in the U.S. This in turn may affect consumers' acceptance of CFLs in both countries. Cultural differences such as this are subjective and too numerous to be mentioned here, but clear differences in the energy supply mix are indeed evident as seen in Table 1 (EIA, 2002a, 2002b).

Table 1. Energy Supply Mix Comparison Between the U.S. and Japan

	U.S.	Japan
Population (millions)	285 [2001]	127 [2001]
Total Electricity Generation (billion kWh)	3,854 [2002]	1,018 [1999]
Total Energy Consumption (quadrillion Btu)	97.1 [2001]	21.7 [1999]
Energy-Related Carbon Emissions (million metric tons of carbon)	1,540 [2001]	306.6 [1999]
Per Capita Energy Consumption (million Btu)	348.9 [2000]	171.6 [1999]
Per Capita Carbon Emissions (metrics tons of carbon)	5.7 [2000]	2.4 [1999]
GDP (trillion dollars)	10.5 [2002]	3.8 [2002]

Energy conservation can be encouraged by regulation, incentives, and/or awareness campaigns. Currently, national, state, and local programs both in the U.S. and Japan apply these measures to ensure and/or promote the use of energy-efficient lighting equipment among other energy-consuming products.

REGULATIONS

Table 2 summarizes some notable energy conservation regulations and standards related to lighting in both countries (IEIJ, 2002; Nakamura, 2002). This document focuses only on those programs that have affected directly the use of CFLs and electronic ballasts both in Japan and the U.S.

Table 2. Energy Conservation Regulations and Standards in the U.S. and Japan

	U.S.	Japan
National Government Regulations	Energy Policy and Conservation Act (EPCA), 1975 National Appliance Energy Conservation Act Amendment, 1988 (Public Law 100-357) Energy Policy Act, 1992 (EPAct) • Federal Minimum Efficiency Standards • Energy Guide Label • Federal Building Requirements • Residential Codes • Commercial Codes	Law Concerning the Rational Use of Energy, 1979 (last amendment 1998) • Fundamental Policies, 1979 • Enforcement Ordinance, 1979 • Enforcement Regulation, 1979 • Evaluation Criteria (Notification No.191 for fluorescent lamps), 1998 • New Construction Code, 1999 (Criteria for clients for buildings) Evaluation Criteria for Manufacturers Regarding Improvement of the Performance
National Standards	ASHRAE/IES Standard 90.1, 1989 (last update 2001) • Area Method and Space-by-space Method • Specific Efficiency Standards	
Procurement Regulations	Federal Energy Management Program (FEMP), 1973 Executive Order 13123, 1999	Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities
State Energy Codes	California Title 24, 1975 (last update 2001)	Ordinance on Environmental Preservation to Secure the Health and Safety of Citizens of the Tokyo Metropolitan Area, 2001

NATIONAL GOVERNMENT REGULATIONS

The U.S. National Appliance Energy Conservation Act (NAECA), 1988, currently bans sales of lower-efficiency core-coil magnetic ballasts. By 2005 all new ballasts must be electronic although high-efficiency magnetic ballasts can still be purchased to replace previously installed ballasts. By 2010, magnetic ballasts will no longer be available, not even to be used as replacements. In other words, all ballasts will meet efficiency standards that thus far have only been achieved by electronic ballasts.

The survey results suggest that NAECA led to measurable reductions in lighting energy consumption. Because most electricity in the U.S. is generated by the combustion of fossil fuels, such decrease in consumption leads to environmental benefits in the form of reduced air emissions. The results also indicated that mandates tend to be more effective than voluntary programs when dealing with specific product regulations, although this particular legislation created fairly extensive administrative burdens. Survey opinions indicated that this program was

hampered because of the lack of input from diverse stakeholders, and although energy advocates and the U.S. Department of Energy (DOE) developed this initiative, the excluded parties caused many delays during implementation. It was also thought that the program was not well received by the industry and consumers, in part, because the government did not provide monetary incentives or assistance to facilitate adoption of the legislation. Finally, it was felt that while this initiative added to the manufacturing costs of lighting products, it resulted in efficient lighting technology that offset the increased product cost through energy savings.

The Japanese government has not implemented equivalent regulations. Roundtable participants suggested that Japan should require strict legislation that bans inefficient magnetic ballasts similar to NAECA for the further increase of energy efficiency. Note that before implementation, input from many stakeholders will be indispensable.

While lighting was not the primary objective of the U.S. Energy Policy Act (EPAct), 1992, this far-reaching energy legislation had considerable impact upon the lighting industry. This legislation mandated minimum efficacy criteria for lamps such as incandescent reflector and T-12 linear fluorescent, among others, as well as ballast efficacy factor (BEF) for electronic ballasts. Table 3 summarizes the minimum ballast efficacy factors for electronic ballasts (ECCJ, 2002).

Table 3. EPAct Efficacy Standards for Electronic Ballasts

Lamp type		Minimum BEF
1 lamp F40T12	120V	1.805
	277V	1.805
2 lamps F40T12	120V	1.060
	277V	1.050
2 lamps F96T12	120V	0.570
	277V	0.570
2 lamps F96T12HO	120V	0.390
	277V	0.390

EPAct prohibited manufacturing or importing lamps that do not meet the efficacy standards criteria and mandated that the lamp's lumen output, efficiency, and life are printed on the packaging. According to our survey, this labeling system made it much easier for consumers to compare products and select energy-efficient products. EPAct also established the testing procedures by which the information just mentioned was to be determined.

Since 1979, the Japanese government has utilized the Law Concerning the Rational Use of Energy, commonly referred to as the Energy Conservation Law. Much like EPAct in the U.S., this comprehensive law is designed to advance the effective use of energy through conservation measures for factory owners, builders, building owners, manufacturers, and users of machines and equipment. Although air conditioning and ventilation are the primary objectives of this energy legislation, it has had significant impact upon the Japanese lighting industry.

The law sets voluntary targets that building clients have to strive to achieve and has identified energy efficiency guidelines for buildings and equipment including lamp-ballast systems. It has also identified efficacy criteria for eleven electric appliance categories, the most pertinent to this

discussion being fluorescent lamp luminaries. Table 4 shows the current criteria for luminaire efficacy of twelve fluorescent lamp/ballast systems (ECCJ, 1999a).

Table 4. Law Concerning the Rational Use of Energy Criteria for Fluorescent Lamp Luminaires

	Category	Efficiency (lm/W)
1	Luminaires that use linear type-110 rapid-start fluorescent lamps	79
2	Luminaires that use linear type-40 high-frequency lighting only fluorescent lamps	86.5
3	Luminaires that use linear type-40 rapid-start fluorescent lamps	71
4	Luminaires that use linear type-40 fluorescent lamps with starters	60.5
5	Luminaires, with electronic ballasts and starters, that use linear type-20 fluorescent	77
6	Luminaires with magnetic ballasts and starters that use linear type-20 fluorescent lamps	49
7	Luminaires in which the sum of the numerical values denoting classification by size for circular fluorescent lamps in use is more than 72	81
8	Luminaires in which the sum of the numerical values denoting classification by size for circular fluorescent lamps in use is more than 62 but 72 or less	82
9	Luminaires, with the electronic ballasts, in which the sum of the numerical values denoting classification by size for circular fluorescent lamps in use is 62 or less	75.5
10	Luminaires, with the magnetic ballasts, in which the sum of the numerical values denoting classification by size for circular fluorescent lamps in use is 62 or less	59
11	Table lamps that use compact single-capped fluorescent lamps	62.5
12	Task lamps that use linear fluorescent lamps	61.5

"Classification by size" refers to the classification by size specified in Attached Table 1 in the Japanese Industrial Standard C7601. It represents nominal lamp wattages.

The most recent amendments to the Japan's Energy Conservation Law were made in 1999. These amendments established a method called the Top Runner Method to determine and update the efficacy criteria. The Top Runner Method has spurred manufacturers to compete with each other in their efforts to improve luminaire efficacy. This method also identifies and updates the target for luminaire efficacy, which all luminaire manufacturers must strive to achieve within a certain period of time. The luminaire efficacy target is based primarily on the most energy-efficient luminaire within a group. The schedule to achieve the goal is determined based on expectations of technology advancements and typical product development cycles. The gauge of whether a manufacturer has achieved the target is the average efficacy of all its products against the target luminaire efficacy. If a manufacturer does not meet the established criteria, the manufacturer's name is posted publicly and the government may order the manufacturer to increase its efforts towards achieving the goal. This law also mandates that product efficacy be printed in catalogs or on products so that consumers are able to select products with the highest energy efficiency. In conjunction with this effort, a voluntary labeling system, the Energy Conservation Labeling Program, implemented in 2000, has assisted consumers to identify lighting products that meet the criteria.

Unfortunately, efficacy targets such as the ones shown in Table 4 are voluntary targets. In other words, luminaires that do not meet the criteria can still be sold in Japan. Attendees at the roundtable meeting in Japan suggested that, to increase the impact of the law, stricter penalties

for disobeying it might be needed. If, for instance, the law banned the use of magnetic ballasts, Japan could further reduce energy consumption.

Even though, at first glance, regulatory actions in Japan appear to be similar to those in the U.S., they are actually milder. Nonetheless, this legislation is the prime reason why Japan has maintained the world's highest energy efficiency levels for more than two decades (ECCJ, 1999b). In general, the Japanese conservation policy, which encourages voluntary efforts and increases energy conservation awareness, seems to have been more effective than mandating requirements thus far. Mandatory performance-based regulations, however, could lead to further reductions in energy consumption.

PROCUREMENT REGULATIONS

The Executive Order 13123, 1999, is part of the EPAct. It mandates that the "Federal Government, as the Nation's largest energy consumer, shall significantly improve its energy management in order to save taxpayer dollars and reduce emissions that contribute to air pollution and global climate change." The order requires energy consumption reductions of 30% by 2005, and a 35% reduction by 2010 in all federal buildings. As part of the mandate, ENERGY STAR products must be used when life cycle costs warrants it. Agencies were directed to try to meet ENERGY STAR building criteria by 2002.

To meet these goals, DOE's **Federal Energy Management Program** (FEMP) created the SAVEnergy program in 1995. For each project, the program generates an action plan in which an audit identifies sources of energy consumption, and then evaluates alternative plans for conservation. After implementation, the results are tracked. This tracking allows for easy sharing of information, and helps the agency to determine the most cost effective means of saving energy in future projects. Between 1985 and 1997, federal investment was about $2 billion, and saved about $16.7 billion in energy costs. The program also chartered criteria for ballasts and fluorescent lamp luminaires. Tables 5 and 6 provide a summary of minimum BEFs for electronic ballasts and efficacy recommendations for CFLs respectively, which are updated every year (EERE, 2003).

Table 5. Minimum BEFs for Electronic Ballasts

Lamp	Lamp Type	Number of Lamps	BEF	
			Recommended BEF	Best Available BEF in the Market
Four-Foot and U-Tube Lamps	T8, 32W	1	2.54 or higher	3.00
		2	1.44 or higher	1.54
		3	0.93 or higher	1.06
		4	0.73 or higher	0.79
	T12, 34W	1	2.64 or higher	3.05
		2	1.41 or higher	1.53
		3	0.93 or higher	0.95
Eight-Foot Lamps	T8, 59W	2	0.80 or higher	0.81
	T12, 60W	2	0.80 or higher	0.80

Table 6. Efficacy Recommendations for CFLs

	To Replace Incandescent Bulb Rated at (W)	Necessary Light Output (lm)	Typical CFL Replacement Wattage (W)	Recommended CFL Efficacy (lm/W)
Bare lamps	40	495 or more	11 - 14 watts	45 or more
	60	900 or more	15 - 19 watts	60 or more
	75	1200 or more	20 - 25 watts	60 or more
	100	1750 or more	≥29 watts	60 or more
Reflector type lamps	50	550 or more	17 - 19 watts	33 or more
	60	675 or more	20 - 21 watts	40 or more
	75	875 or more	≥22 watts	40 or more

The authors' survey results suggest that the procurement regulations within EPAct led to reductions in lighting energy consumption, as it established minimum lumens emitted per watt consumed for various lamps. The measure appears to have been quite successful. The recommended CFL efficacies in Table 6 and EPAct's mandatory labeling program appear to have increased consumers' recognition of compact fluorescent lamps, while the criteria for BEFs for electronic ballasts from FEMP have greatly increased the use of high performance electronic ballasts in federal government buildings.

The U.S. interviewees felt that one advantage of the EPAct procurement regulations was that EPAct did not require any monetary incentives from the government to encourage implementation. However, considerable administration was needed to insure compliance with the program. In addition, the initiative was formed by energy advocates and DOE with little input from consumers or industry until the policy was announced. At this point industries fought against the regulation. It is unclear how much consumer groups and other organizations welcomed EPAct.

STATE ENERGY CODES

ASHRAE/IESNA 90.1 is a national consensus standard developed jointly by the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) and the Illuminating Engineering Society of North America (IESNA). The standard sets minimum requirements to promote the principles of effective, energy-conserving design for buildings and building systems (Schwedler, 2001). While some states in the U.S. have adopted ASHRAE/IESNA 90.1 and others have chosen to create stricter lighting energy efficiency standards than federal law mandates, California has been a leader in incorporating lighting provisions in its state code. This is particularly true of Title 24, arguably the most progressive code in the country with respect to energy conservation.

Title 24 was established as the result of a legislative mandate to reduce energy consumption in the state of California. There is flexibility in the regulation so that local governments are able to create additional standards that are more stringent than the energy standards allowed under Title 24. The standards are updated periodically. According to California Energy Commission (CEC), the next update Title 24 is expected to be adopted by the Commission by July 1, 2003, and go into effect in 2005.

The standards are detailed and thorough in scope. For instance, there are different requirements for buildings depending on their intended purpose. The standards prescribe, among other things, minimum efficacies, minimum number of lighting controls to be installed in rooms of various sizes, maximum lighting power densities, which vary depending on the planned usage of the various spaces in the building, and the maximum amount of power the lighting of a building can consume for a given area

According to the CEC standards have saved about $20 billion dollars to date (CEC, 2002). Title 24 has resulted in significant reductions in energy consumption and environmental benefits. It is also estimated the standards will save $57 billion by 2011 (CEC, 2002).

The interviews found that one of the major reasons for Title 24's success was the input of a wide variety of stakeholders during the decision making process. This input helped ensure a final decision which was acceptable to most of the parties involved in the discussions, reducing the litigation that typically follows passage of environmental laws in the U.S. The agreements reached through this process resulted in dramatic reductions in energy demand, ultimately allowing the state to avoid the need to build new power plants for most of the 1990s. The interviews also indicated that similar results would likely be achievable if other states or countries adopted measures similar to Title 24, provided that they had an infrastructure that was conducive to effective enforcement of the laws. Enforcement is probably necessary, as energy efficiency programs have been most successful when they include both incentives and regulations. To achieve success similar to Title 24, states and/or countries must incur the additional administrative burdens associated with such program. Depending on the location, these burdens may not be extravagant, since existing building codes already require governmental administration, and Title 24 rules are only triggered by new construction or significant renovation.

One of experts interviewed believed that title 24 helped foster widespread adoption of many of the lighting industry's most successful energy saving technologies of the past two decades, such as T-8 lamps, occupancy sensors, and electronic ballasts. It is also felt that the shift in technologies made the plan popular with innovators, and the energy savings fostered an acceptance by most other groups.

Japan has a state building code in Tokyo: Ordinance on Environmental Preservation to Secure the Health and Safety of Citizens of the Tokyo Metropolitan Area. However, the enforcement of the code is not as strong as California's Title 24. The Tokyo code holds up voluntary targets that building clients are supposed to achieve, but the government has not made these targets mandatory yet (Nakamura, 2002). Japan may not necessarily need state codes. Nevertheless, roundtable members agreed that bringing the functionality of California's Title 24 into the central government codes and regulations could further increase energy conservation.

INCENTIVES

Although regulation can be an invaluable tool for advancing energy-efficient lighting technologies, the experts indicated that better results are achieved when regulations are combined with incentives. Thus, while regulations are essential to ensure minimum compliance, appropriate incentives can inspire entities to go far beyond the bare minimum. Often, incentives lead to innovative solutions that are even more effective than those prescribed in regulations. Table 7 compares incentive measures in the U.S. and Japan (IEIJ, 2002; Nakamura, 2002). This paper focuses on rebates and tax incentives.

Table 7. Incentives for Energy-Efficient Lighting Technologies in the U.S. and Japan

	U.S.	Japan
Rebate	• Rebates from electric utilities	• None
Tax Incentives	• None	• Tax system concerning the promotion of restructuring the relation between supply and demand of energy
Electricity Price	• Deregulation of electricity market • Demand side management (lower price for off-peak)	• Three-step pricing—electricity price increases as the consumption increases.
Product Development	• Research and development (R&D) and demonstration funds for new lighting technologies	• R&D and demonstration funds for new lighting technologies
Others	• Direct install • New construction assistance • Catalogs	• Funds for buildings equipped with energy-efficient technologies

REBATES

In the U.S., many rebate programs have worked well in the regulated utility market and spurred consumers to purchase electronic ballasts. Electric utilities offer customer refunds for the purchase of energy-efficient lighting products. If a rebate program is implemented along regulatory actions for new construction, it usually functions well, although timing is important. For instance, because electronic ballast incentives were synchronized well with NAECA and EPAct, most of them were successful. However, several states have begun deregulating electricity prices causing rebate programs to become less influential and more difficult to implement.

There are several frequently cited problems with rebate programs. One of the most common complaints is that these programs are unpredictable. In some states, rebates are seen as “on again – off again.” Such actions create confusion among customers and alienate those who do not receive the expected rebates, ultimately reducing the effectiveness of these programs. In addition, if customers believe that the rebates will be reintroduced at a later date, customers may refrain from investing in energy-efficient technologies, the opposite of the programs’ intentions. Also, if rebates are merely subsidies for more expensive technologies, they may not create a sustainable market transformation, but rather a temporary benefit that will last only as long as the government’s funding.

TAX INCENTIVES

Japan has taken more centralized means to implement incentives than the U.S., namely tax incentives. Between 1998 and 2000, energy-efficient lighting products such as fluorescent lamp luminaires with electronic ballasts were subject to the tax incentives. It is unknown how well tax incentives have worked with respect to lighting. Currently, the tax incentive covers only high-end integrated lighting systems equipped with electronic ballasts, photosensors, and dimming controls.

AWARENESS MEASURES

Table 8 summarizes awareness measures in the U.S. and Japan (IEIJ, 2002; Nakamura, 2002). Both countries attempt to enlighten consumers on purchasing energy-efficient products by various means, each playing a unique and important role. Among the many measures, this study focuses on a few labeling systems and testing programs.

Table 8. Awareness in the U.S. and Japan

	U.S.	Japan
Labeling and Testing	Green Lights Program, EPA ENERGY STAR Program, DOE, EPA National Lighting Product Information Program	Energy Conservation Performance Catalog Energy Conservation Labeling, Japan Industry Standards (JIS) C 9901-2000 Energy Conscious Building Mark, Institute for Building Environment and Energy Conservation
Others	National Council on Qualifications for the Lighting Professions (NCQLP) Public Service Announcements: *Change a light, change the world* and *Socket Boy* Training Centers Publications	Qualifications for the Lighting Professions—Experts and Consultants Public Service Announcements Green Purchasing Network (GPN) Training Centers Publications

VOLUNTARY LABELING

The ENERGY STAR® program began in 1992, as a voluntary labeling program designed by the U.S. Environmental Protection Agency (EPA) to help consumers identify energy-efficient products and reduce greenhouse gas emissions. In 1996 DOE partnered with EPA to further promote the ENERGY STAR label (Figure 1). The ideology behind this program is that labeling allows consumers to make more informed decisions about the products that they purchase. Because ENERGY STAR products must conform to specific quality and energy efficiency guidelines, consumers seeing the ENERGY STAR label would know that they were purchasing a good product that is energy efficient.

Figure 1. ENERGY STAR Label

A typical use of an ENERGY STAR lighting product in a residence is the replacement of a 100-watt incandescent lamp with a 24-watt CFL. Using an ENERGY STAR CFL with a life of about 10,000 hours instead of an incandescent lamp (700-1000 hours) will save the typical U.S. customer around $75 in electricity charges, which more than offsets the additional $10 that the ENERGY STAR lamp costs compared to a standard lamp. One of the interviewees estimates that if each household used ENERGY STAR lighting in only one room, CO_2 emissions could be reduced by 1 trillion tons each year. Although the performance of CFLs has been dramatically improved recently, CFLs still have issues such as their non-instantaneous start when turned on and lower color rendering index than incandescent lamps. CFLs might have disappointed consumers who were attracted by ENERGY STAR labels at the early stages of the program. To better inform consumers about the starting time and color appearance of CFLs, new quality metrics should be established and shown along with efficacy standards.

A recent and notable ENERGY STAR campaign was the *Change a Light, Change the World* program. This program lasted from October to December of 2001 and was a nationwide promotion for energy-efficient lighting. The promotion coordinated national and local programs designed to raise awareness and reduce barriers to use ENERGY STAR certified lighting. The program increased sales of ENERGY STAR lighting by as much as 300%. In Japan, lamp and luminaire manufacturers frequently conduct such promotions, as well as TV spots informing consumers about how much energy and money they can save when using electronic ballasts and CFLs.

Overcoming the unwillingness of consumers to trade high initial costs for long-term energy savings has proven to be one of the major challenges facing the ENERGY STAR program. The national program has focused primarily on educational programs, raising awareness of the long-term savings that energy-efficient products can provide. In addition, the program provides a highly visible certification indicating the product is energy-efficient. Overall, the interview experts felt that the ENERGY STAR program has been quite well received by the industry and consumers and has helped encourage the development and purchase energy-efficient products. Part of its effectiveness is due to its voluntary nature. Another reason the program has worked so well is that it has created an “all-win” opportunity for government, manufacturers, and customers. ENERGY STAR’s lighting programs have certainly provided significant environmental improvements, with one estimate indicating a reduction in carbon emissions of 700,000 metric tons in 2001.

Ultimately, the program can be transferable to other countries, but obviously needs to be modified to reflect local interests and values. Developed nations could easily implement similar programs, and labeling of exports may help savvy companies in developing nations adopt more efficient lighting technologies.

In Japan there is also an ENERGY STAR program for office appliances such as computers, displays, copy machines, and printers, but it does not cover lighting products. For electric appliances including fluorescent lamp luminaires, the government chartered an industry standard in 2000, the Method of Calculation and Representation of Energy Efficiency Standard (JIS, 2000). The JIS publication includes a voluntary labeling program called Energy Conservation Labeling. The Energy Conservation label indicates if an appliance achieves the goal specified by

the Energy Conservation Law mentioned earlier. Figure 2 shows the two logos from Energy Conservation Labeling. If an electric appliance meets the voluntary target determined by the Top Runner Method, the appliance receives a green label; otherwise, the product receives an orange label. For fluorescent lamp luminaires, a logo is posted in manufacturers' catalogs along with information about the luminaire's efficacy, the percentage of the luminaire efficacy against the voluntary target, and when the manufacturer is scheduled to achieve the voluntary target.

Figure 2. Energy Conservation Labels in Japan

The Energy Conservation Center of Japan (ECCJ) updates its website to show manufacturers' and retailers' use of the Energy Conservation labels. The most recent ECCJ update reported that Energy Conservation Labels appeared in all luminaire manufacturers' catalogs. It is also reported that about 35% of people recognized the labels and 76% of the consumers said that the labels were useful when they looked for energy-efficient appliances (ECCJ, 2003). However, it is unknown how manufacturers welcome the Energy Conservation Labeling program.

PRODUCT PERFORMANCE TESTING AND PUBLICATIONS

The National Lighting Product Information Program (NLPIP), established by the Lighting Research Center (LRC) in 1990, helps lighting professionals, contractors, designers, building managers, homeowners, and other consumers to find and effectively use efficient, quality products that meet their lighting needs. Sponsored by government agencies, public benefit organizations, and electric utilities, NLPIP disseminates objective manufacturer-specific information on energy-efficient lighting products (LRC, 2003).

The environmental benefits of this program are mostly indirect. By spreading accurate information about the performance of various lighting products, consumers are able to purchase more efficient products. Originally, manufacturers viewed the program skeptically, but eventually stakeholders accepted and praised the program, when they realized it helped users identify and value quality products. More than 15,000 people access the online data each year. There is an electronic ballast database on NLPIP's website to present comprehensive information on performance characteristics. Lighting specifiers can search energy-efficient and high performance ballasts through the website. This program has intensively conducted evaluations of CFL performance as well.

Because the program requires an independent laboratory that can objectively test products, it may not be easy to duplicate in many situations or in places where the appropriate equipment is not readily available. On the positive side, the program requires relatively limited administration.

The ECCJ has published and updated the Energy Conservation Performance Catalog of electric appliances, including fluorescent lamp luminaries, to assist consumers to select energy-efficient

appliances. The Energy Conservation Performance Catalog program collects luminaire efficacy data from manufacturer catalogs, ranks all luminaires by efficacy, and updates the top 25 luminaires for rooms of various sizes every six months. For each of the top 25 luminaires, the catalogs also show lamp and ballast types, dimensions, and estimated energy consumption and electricity prices throughout a year.

Despite the excellent distillation of information, independent third parties do not verify the validity of manufacturers' original data. If the Energy Conservation Performance Catalog had third-party testing data along with catalog data from manufacturers, consumers could easily confirm the reliability of the data. The Energy Conservation Performance Catalog literally focuses on energy efficiency, or luminaire efficacy, which may mislead consumers, as the roundtable attendees pointed out. For instance, although a bare lamp controlled by an electronic ballast might have the highest luminaire efficacy, the bare lamp may not provide a comfortable visual environment. Customers should be able to select and use energy-efficient luminaires without sacrificing satisfaction. Lamp life is another important aspect for understanding the lifetime cost of a product. Therefore, it is important to provide other comprehensive evaluations including life and quality indexes for color rendering, luminous intensity distribution, and so on.

DISCUSSION AND CONCLUSIONS

Based on our surveys, interviews, and roundtable meeting, this section discusses what actions the U.S. and Japan can undertake in the near future to increase the spread of energy-efficient lighting technologies.

Regulations

While both countries' regulations may appear similar, they are fundamentally different from each other. The U.S. regulations carry mandatory targets that manufacturers and building clients must achieve. Japanese regulations carry voluntary targets that manufacturers and building clients must strive to achieve.

In Japan, the Energy Conservation Law has covered luminaire system efficacy for different types of luminaires including CFL table lamps. High electricity prices initially raised consumer awareness in Japan, and the Energy Conservation Law has maintained this high awareness for twenty years. Since consumer awareness seems to have reached a plateau, mandatory performance-based criteria will be needed to further increase energy efficiency of lighting products, especially of electronic ballasts.

In the U.S., the Federal Minimum Efficiency Standards and the Federal Energy Management Program have already covered goals to be achieved by manufacturers who make CFLs and electronic ballasts. For electronic ballasts, these regulations appear to have been effective. However, for CFLs, the regulations do not appear to have been as successful. As discussed previously, CFLs have much higher efficacies than incandescent lamps but still have starting and color rendering issues. It is still unknown how fast CFL starting must be to satisfy consumers. The color rendering index of CFLs do not exceed those of incandescent lamps. However, color appearance of objects illuminated by CFLs is not always poor. People seem to prefer a CFL to an incandescent lamp if the color appearance is acceptable, yet there is no color appearance metric

currently standardized in the U.S. To better understand CFL performance, additional metrics to evaluate CFLs' starting speed and color appearance tolerances should be developed. Then, a recommendation of the indexes should be presented along with mandatory efficacy standards so that consumers can appropriately select CFLs.

Incentives

In the U.S., many utility companies have implemented rebate programs for CFLs and electronic ballasts. If well managed, such rebate programs worked well for both technologies. Some manufacturers, however, have been dissatisfied with sporadic rebates. Recent moves towards deregulation of the U.S. electricity market make implementation of rebate programs more difficult.

This study did not identify recent incentive efforts for electronic ballasts and CFLs in Japan. Incentives for these technologies may not work well there, as voluntary actions have proven to be successful. However, since consumers are aware of the need for energy conservation measures, they may be eager to adopt new energy-efficient technologies. Incentive packages should be implemented to foster new technologies such as LEDs, which could become applicable for general lighting in the future. Even without incentive programs, the sales of CFLs might continue to increase in Japan, as long as the improvement of CFLs continues. Japanese consumers and specifiers who prefer higher CCTs have the option of replacing incandescent lamps with CFLs of higher CCT (i.e., 5000K and 6500K) to create a more preferable lighting environment. This may be a reason why CFLs are more popular in Japan than in the U.S.

Awareness

Consumer awareness appears to be lower in the U.S. than in Japan, thus awareness measures must become increasingly more important in the U.S. Decision makers should also take advantage of lower electricity prices while seeking more positive stimulation packages such as the *Change a Light, Change the World* campaign and other demonstration programs to increase the adoption of energy-efficient lighting technologies.

One of the important findings of this study is that Japanese consumers require third party evaluations of lighting products so that they can more appropriately choose energy-efficient products such as electronic ballasts and CFLs. An independent testing program such as the U.S.'s NLPIP may be a good model for a similar program in Japan.

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