Obstacles and Opportunities in the Commercialization of the Solid State Electronic Fluorescent Lighting Ballast

October 1981

**Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830**

**Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute**

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

The views, opinions and conclusions contained in this report are those of the contractor and do not necessarily represent those of the United States Government or the United States Department of Energy.

PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
Under Contract DE-AC06-76RLO 1830

Printed in the United States of America
Available from
National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22151

Price: Printed Copy \$_____*; Microfiche \$3.00

*Pages	NTIS
	Selling Price
001-025	\$4.00
026-050	\$4.50
051-075	\$5.25
076-100	\$6.00
101-125	\$6.50
126-150	\$7.25
151-175	\$8.00
176-200	\$9.00
201-225	\$9.25
226-250	\$9.50
251-275	\$10.75
276-300	\$11.00

3 3679 00059 5795

OBSTACLES AND OPPORTUNITIES IN
THE COMMERCIALIZATION
OF THE SOLID STATE ELECTRONIC
FLUORESCENT LIGHTING BALLAST

Daniel R. Johnson
Alfred A. Marcus
Richard S. Campbell
Paul Sommers
Lisa Skumatz
Bonnie Berk
Phillip Petty
Catherine Eschbach

October 1981

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

PREFACE

The history behind the development of the solid state electronic fluorescent lighting ballast should be known to understand the perspective from which this report was written.

There is no way of knowing whether the lighting industry would have developed solid state ballasts (SSB) without the DOE program. Some characteristics of the fluorescent lighting industry suggest that it might have taken a long time. The industry is divided into lamp makers, ballast makers, and fixture makers. Presently, each group must make its products compatible with the other two because this product area is highly sensitive to cost. This, combined with the buyers' natural initial caution, makes the market vulnerable to imports from vertically and horizontally integrated foreign manufacturers, or to a much delayed adoption of this advanced technology. In most such industries, technological stagnation, created by the tyranny of standardization, would set in.

The DOE ballast program and the research efforts of Lawrence Berkeley Laboratory have succeeded in transferring this technological innovation to the private sector. An initial demonstration project has been completed at the headquarters of Pacific Gas and Electric and a second phase of installations in various facilities of Fortune 500 companies is under way. The first generation of manufacturing facilities has been established by the private sector partners in the program.

The questions arise, "When has the commercial success of the solid state ballast been established, and at what point should the government end its involvement in the development of the technology?" During this study, national policy relative to these questions has changed significantly, particularly on the point of government involvement.

Given the proposition that commercial success is not certain until it becomes clear that manufacturers of the SSB are established in an ongoing operation supported by revenues from the sale of the products, the government's position has shifted from continued support of the technology through that commercialization process, to support only for efforts to make the technology available for commercialization.

It is a well established fact, however, that many innovations require a period of extended support before they can stand on their own. If the innovation has certain public benefits associated with it which are high on the national list of priorities, then there are philosophical grounds for government to assist in that initial support, particularly if the mainstream private sector is unwilling to bear that burden. Further justification is provided if such a subsidization would accelerate the accrual of those benefits.

While these philosophical underpinnings have changed recently, this study was initiated under the general framework of accelerating the widespread adoption of the SSB, so that its energy conservation benefits might take effect as quickly and as much as possible. Given the philosophy of the present administration, this report should have gone no further than to acknowledge the accomplishments of the national lighting program. However, solid state ballasts are not yet accepted, and they still have some enormous technical and other hurdles to overcome before the nation can enjoy the conservation benefits they represent. This report, then is an attempt to identify and describe those hurdles, and to suggest some opportunities which would assist in that effort.

The perspective of the report could lead the casual reader to the conclusion that the odds against the future commercial success of the SSB are too great for there to be much hope for its success. The intent of this report is to expound upon the problems facing the SSB from the points of view of those who will ultimately affect its success or failure. Only by identifying and knowing these obstacles can solutions be generated to overcome them. It should be particularly noted that the SSB is only barely approaching the first generation product. And while it was not within the scope of this study to make technological forecasts, we believe that further technological and market development will result in drastic decreases in price to the consumer. For example, solid state incandescent dimmers are now sold for less than 1/10 the price at which they first were sold. In this regard, we have been extremely conservative.

EXECUTIVE SUMMARY

DOE's National Lighting Program has developed and successfully tested the technical and operating feasibility of the solid state ballast (SSB), and transferred the technology to the private sector.

The first generation of solid state electronic ballasts is now at its most critical phase of commercialization: market entry.

The recent change in presidential administrations has changed the emphasis that government had placed on commercialization and therefore rendered many possible recommendations for further government involvement politically infeasible.

The largest market for the ballasts is in 4-foot, 2-tube lighting fixtures manufactured for new construction:

- commercial establishments
 - office buildings
 - department stores
 - grocery stores
- public institutions
 - public schools
 - government buildings
- industrial establishments.

Several major obstacles are blocking rapid adoption of the SSB:

- high initial cost
- large cost premium/marginal payback
- undemonstrated reliability
- producing firms unknown in the lighting industry
- producing firms do not have established distribution systems.

The key influences of decisions to adopt the ballast are architects and engineers who specify building equipment.

The most important short-term actions are information dissemination programs to targeted audiences, particularly architect/engineers and corporate energy managers.

The action with the greatest overall impact would be to sponsor research and development to redesign traditional lighting fixtures with cheaper, lighter materials to take advantage of design flexibility offered by the SSB.

Some obstacles exist with redesigning the traditional lighting fixture:

- lack of integration in the industry, mandating component compatibility with other manufacturers' hardware
- fear of being associated with an unconventional technology that might fail

Two high-leverage opportunities would accelerate adoption:

- reducing initial cost through the financial incentives offered by the federal Schools and Hospitals Grants Program
- persuading electric utilities in the Pacific Northwest to promote the ballast as a part of their commercial conservation programs.

CONTENTS

PREFACE		iii
EXECUTIVE SUMMARY		v
1.0 INTRODUCTION		1.1
2.0 THE PRODUCT		2.1
2.1 PRODUCT ADVANTAGES		2.1
2.2 PRODUCT DISADVANTAGES		2.3
2.3 PAYBACK		2.4
2.4 COMPETING TECHNOLOGIES		2.12
2.5 FIRST GENERATION TECHNOLOGY		2.13
3.0 PRESENT TECHNOLOGY DELIVERY SYSTEM		3.1
3.1 BALLAST MANUFACTURERS		3.5
3.2 FLUORESCENT LIGHTING FIXTURE MANUFACTURERS		3.9
3.3 WHOLESALE DISTRIBUTORS		3.10
3.4 ELECTRICAL CONTRACTORS		3.11
4.0 THE MARKET		4.1
4.1 COMMERCIAL FIRMS		4.1
4.2 INDUSTRIAL ESTABLISHMENTS		4.4
4.3 PUBLIC INSTITUTIONS		4.8
4.3.1 Organizational Factors		4.9
4.3.2 Standard Operating Practices and Procedures		4.9
4.3.3 Channels of Communications		4.9
4.3.4 Federal General Services Administration		4.10
4.3.5 State General Service Administrations and Municipalities		4.10
4.3.6 Public School Systems		4.13

5.0	THE SPECIAL ROLE OF THE SPECIFYING COMMUNITY	5.1
5.1	RESPONSIBILITY FOR BALLAST SPECIFICATION	5.2
5.2	BALLAST CHOICE CRITERIA	5.3
5.3	LIFE-CYCLE COSTS VERSUS PURCHASE PRICE TRADEOFFS	5.4
5.4	INFORMATION FLOW ROUTES	5.5
5.5	OBSTACLES TO NEW TECHNOLOGY ACCEPTANCE	5.6
5.6	IN HOUSE SPECIFIERS	5.7
6.0	SPECIAL OPPORTUNITIES FOR COMMERCIALIZATION	6.1
6.1	PUBLIC UTILITY CONSERVATION PROGRAMS	6.1
6.2	TRADE AND PROFESSIONAL ASSOCIATIONS	6.3
6.3	TRADE AND PROFESSIONAL JOURNALS	6.4
6.4	AVENUES OF DIRECT ACCESS TO KEY INFLUENCES	6.5
6.4.1	Direct Mailing List	6.6
6.5	THE PCB ISSUE	6.6
6.6	DOE'S SCHOOLS AND HOSPITALS GRANTS PROGRAM	6.7
7.0	THE SYSTEMS APPROACH AND THE TECHNICAL MARKETING INTERFACE	7.1
8.0	RECOMMENDATIONS	8.1
	REFERENCES	R.1
	BIBLIOGRAPHY	Bib.1
	APPENDIX A - TRADE ORGANIZATIONS AND THEIR PUBLICATIONS	A.1
	APPENDIX B - TRADE AND PROFESSIONAL JOURNALS	B.1
	APPENDIX C - ETL TESTING LABORATORIES, INC. Letter Report No. 449151	C.1

1.0 INTRODUCTION

The DOE lighting program is based on applying solid state electronics to lighting. The Solid State Ballast Program is directed at improving the efficiency of fluorescent lights. To improve that efficiency, research contracts were let to three firms to develop better equipment. The resulting first-generation ballasts have been tested under industry standards for energy consumption, electronic interference, and failure rate. On all counts they have been successful, particularly in demonstrating to both buyers and suppliers in the lighting industry that solid state ballasts (SSB) are efficient and technically viable.

The principal methodology used to carry out this study was the open-ended telephone interview with decision makers associated with diverse public and private institutions that are influential in the commercialization process. Over 70 interviews were conducted. Because these interviews covered many disparate institutional settings, however, it should be noted that no single section of this report represents a statistically significant number of opinions. Each section is necessarily a subjective interpretation of the interplay of factors at work in the commercialization process.

The Department of Energy (DOE) contracted with Pacific Northwest Laboratory (PNL) to develop a commercialization study of solid state ballast, with emphasis on high-leverage opportunities for rapid dissemination of this technology into the marketplace. This study includes a description of product characteristics and their influence on the commercialization of the SSB, a description of the technology delivery system presently used by the ballast industry, an analysis of the market for SSB, and identification of some high-leverage opportunities to accelerate the commercialization process.

2.0 THE PRODUCT

This section describes the SSB's technical aspects that affect commercialization. The purpose of this section is not to draw fine technical distinctions, but to identify the technical matters affecting the marketability and to examine those effects. This examination and identification extends to the economics and technical aspects of the competitive environment into which the SSB is being introduced, since these will be the criterion by which the SSB will be evaluated by potential adopters. Comments on certain product characteristics like reliability, therefore, are not derived from the products' actual performance.

2.1 PRODUCT ADVANTAGES

The advantages of operating fluorescent lighting at high frequency have been known almost as long as fluorescent lighting itself. Prior to the growth of the solid state electronics industry and the accompanying miniaturization of circuitry, the concept was not feasible for large-scale applications like commercial and industrial buildings because it would have been necessary to install a centralized power system for lighting completely separate from the standard 60 Hz service for the building's other components.

Solid state circuitry, however, made possible the operation of individual fluorescent lighting fixtures at high frequency with conversion from 60Hz accomplished on a decentralized basis through the individual ballast. The electronic SSB, developed at Lawrence Berkeley Laboratories, first converts the 110 or 277 volt, 60 Hz line service to direct current, and then inverts it while increasing the frequency to about 30,000 Hz.

The SSB made possible many advantages that were not available with the traditional standard grade core coil ballast:

- 20-25% increase in efficiency over standard grade core coil ballast
- reduced heat loss
- reduced vulnerability to increased ambient temperature
- maintenance of high power factor throughout ballast life
- extended lamp life
- dimming capability without flicker

- extended ballast life
- lighter weight.

Increased efficiency is the major advantage to adopters and allows about a 25% savings on electricity bills for lighting. That increase also represents an advantage for utilities with shortages of generating capacity, particularly if the commercial lighting load is part of their peak demand. Reduced heat loss has two different applications: the ambient operating temperature within the fixture will be lower (an advantage because it extends the life of the fixture's components), and less heat will be produced in periods of air conditioning, thus placing less of a load on HVAC systems. Although this contribution's value to reduced HVAC loads has been debated from several perspectives, it can be used in promotional literature. That contribution is included in competing product literature and was mentioned by some architects who were interviewed.

The reduced vulnerability to increased ambient temperature essentially reduces the premium on the SSB which the end user must pay. Using standard core coil ballasts under increasing ambient temperatures requires the use of better grades of ballasts, which are progressively more expensive. Therefore, the differential between the cost of the SSB and the proper grade core coil ballast diminishes as the ambient temperature increases.

The maintenance of the increased power factor implies that the lighting system, which must produce a particular lighting level over an extended period of time, need not be overspecified. That is, manufacturer specifications need not be derated for nonrecoverable lighting losses over time, as does the standard core coil ballasts, whose power factor tends to deteriorate over time.

The effect of extending lamp life is obvious, although this advantage has not been adequately documented to date because of the small number of cumulative hours SSBs have been in operation, especially under real-life conditions. As yet, the extended ballast life has not been well documented either. The claim derives from the fact that numerous other solid state circuitry applications have increased the expected life of the components while maintaining exceptionally stable, trouble-free operation of electrical equipment.

The ability to incorporate dimming capability without flicker represents a major breakthrough over the standard core coil ballast. The lower frequency at

which the core coil ballast operates creates an unacceptable flicker when power input levels are reduced below a certain level. Because the increased frequency of the SSB eliminates this flicker, even further power reductions, and therefore energy and cost savings, above and beyond the inherent efficiency improvement are possible.

The SSB's lighter weight presents several advantages, the greatest of which warrants its own separate discussion and is presented in Section 5. Direct benefits because of this lighter weight accrue in terms of reduced shipping costs, which are a significant component of the price of a core coil ballast. Much greater manufacturing flexibility is also possible. SSB components can be manufactured in remote locations, even overseas, and then shipped to assembly plants near the point of distribution or sale.

2.2 PRODUCT DISADVANTAGES

Disadvantages of the SSB are relatively few and are presented in the context of the commercialization potential:

- unproven technology
- cost premium
- power usage metering interference
- radio frequency interference.

Because the SSB is a new technology, it faces the same acceptance problem as any new technology would, no matter how much of a comparative advantage it represents. Since the SSB has not been used widely under real operating conditions, potential adopters are uncertain about energy-savings claims, longevity, and especially about its long-term operation reliability. The mass production process for the SSB is not yet firmly established, leaving a serious credibility gap about quality control. Another doubt concerns warrantee service by the manufacturer for product failure, especially if the end users, suppliers, and specifiers have had no prior experience with that manufacturer.

Cost premium (i.e., the difference in price of the SSB and a standard core coil ballast that would otherwise have been purchased) is a major factor of resistance in and of itself. When coupled with the uncertainties mentioned above, the higher initial cost takes on greater proportions. The cost premium represents an investment purely in conservation. Even if the payback and

return on investment are attractive, the objections that this investment does not contribute to the firm's strategic business mission, to production of goods or services, or to maintaining the firm's market position, render it inferior to an investment that would contribute to those goals.

Concerns about radio frequency interference (RFI) were expressed by both potential end users and by actors in the technology delivery system. This phenomenon is attributable to the high frequency at which the SSB operates and is a potential cause of interference with communications and computer equipment. While the demonstration at the offices of Pacific Gas and Electric was conducted in relative proximity to computer equipment without harmful results, interference will remain a potential objection to adoption until the SSB has been applied in a wider variety of circumstances without interference with these other crucial systems. Although neither Lawrence Berkeley Laboratories nor Pacific Gas and Electric considers RFI a problem, marketers must deal with it as the SSB commercialization proceeds.

Another potential objection to SSB adoption is made by some utilities. They argue that because of the high frequency and the phase angle at which the SSB operates, standard metering equipment will not register the proper power usage. As was the case with RFI, neither Lawrence Berkeley Labs nor Pacific Gas and Electric considers this a problem. The implications of the potential objection, however, are twofold: utilities in some regions of the country may resist allowing their customers to install SSBs, and they may be reticent to promote SSBs as part of their conservation programs.

2.3 PAYBACK

The relation of the cost premium to payback and return on investment (ROI) is complicated. Not only will different calculation methods and assumptions produce different results, but presently nonquantifiable factors such as reduced maintenance and lower future capital costs attributable to longer ballast and bulb life should also be properly considered in the investment decision. However, consideration of these factors is impossible, since they are largely unknowns.

Besides these unknowns, methodological questions remain:

- Should future cash flows resulting from energy savings, etc., be discounted?
- Should inflation and projected power cost escalations be factored in?
- Should future cash flows be balanced against the full price of the SSB, or should the price differential between the SSB and the ballast that would otherwise have been purchased be used?
- Should installation costs be considered?
- Should the cost effects of life-cycle operating characteristics like maintenance of power factor be considered?

The point of raising these issues is that information on payback and return on investment may be both expensive and unreliable. Expense and unreliability are probably the reasons that most firms use a simple payback method to evaluate conservation investments (Schwartz 1981). Simple payback provides an easy method for comparing investments and treats competing technologies on a relatively equal basis. Within the constraints of simple payback, several issues merit consideration here.

Mr. Rudy Verderber of Lawrence Berkeley Laboratories correctly argues that the investment against which future cash flows must be measured is not the SSB's full price, but the cost premium paid for the SSB over the core coil ballast that otherwise would have been bought. A ballast must be purchased just to acquire the ability to use fluorescent lights; this investment is considered a capital cost and is not analyzed as an individual item in terms of ROI or payback. A conservation investment is made by purchasing a superior ballast that will yield energy savings compared to the energy that would have been used with a standard core coil ballast. These savings would accrue on the basis of the incremental or marginal investment in the SSB as compared to the core coil ballast. Therefore, return on investment and payback should be measured against that marginal investment, or cost premium. The SSB has two cost premium levels, depending on whether the replacement market, which generally involves small quantity orders, or the original equipment manufacturer (OEM) market, which generally involves large orders, is being considered. Since a larger absolute difference in prices exists at these two levels for the SSB

rather than for the core coil, the premium for the replacement market averages about \$20, while the premium for the OEM market averages about \$15. This difference is included in the payback analyses below.

In several of the interviews with both potential end users and actors in the technology delivery system the issue of comparison of energy savings was brought out. The first point in the issue was what types of hardware are being compared to yield what energy savings. Since generally four grades of standard core coil ballast exist, each of which has a different power input, the grade of ballast used in the comparison must be specified. This point carries over to the type of tube used in making the comparison. Unless the same type tube is used in both systems being compared, energy savings that might really be caused by a more efficient tube would be attributed instead to the ballast performance. The conditions under which the comparison is being made was the second point brought out. Laboratory bench testing will yield one set of results while tests carried out under actual operating conditions will yield another set of results. The third point is that much promotional literature uses comparisons based on American National Standards Institute (ANSI) standards for particular equipment types. Since these standards are based on average performance, which can vary by as much as 17% in actual practice (10% variance for lamp performance, and 7% variance for ballast performance) and still be considered within the standard, equipment will most likely vary on the downside of the standard.

Another point of great controversy centers around the savings attributable to decreased Heating Ventilation and Air Conditioning (HVAC) loads because of the SSB's reduced waste heat output. These questionable savings are not included in the payback analyses below for several reasons. First, different regions of the country will experience different effects of a reduced waste heat output. Savings will be much more significant in the south, where space cooling is predominant, than in the north, where space heating in winter will be required to deliver more Btus to compensate for the heat not contributed by the lighting system. These savings are excluded, however, primarily because any savings in HVAC operating costs are much more a function of the structural envelope, the actual HVAC equipment employed, and the space conditioning demands of the building occupants than they are of the lighting system's

effects on the structure's heat input. While HVAC energy usage is undoubtedly affected in many cases, the measurement of this effect is unreliable and difficult to document, thus making the effect highly variable. Promotional literature that bases significant proportions of reported energy savings on reduced HVAC loads should be viewed with appropriate circumspection.

These points were directed at two opposing implications, depending on the party making the point: that energy savings attributable to the SSB were either overstated or understated. In either case, if the SSB is adopted in a particular setting, the real energy savings will be a confusing issue. This confusion extends to conservation equipment in general and is one of the biggest concerns voiced by potential adopters of the SSB. Corporate energy managers are subjected to such a barrage of vendors, all making claims about their products, that sorting fact from fiction is very difficult. The clear recommendation was that the government could play a legitimate role in the area of disseminating information, debunking or verifying vendor's claims, by providing a testing service and publishing the results. Many people interviewed believed that credibility for such a service would be high, especially if the testing were done at the national laboratories or similar disinterested independent agencies.

The payback analysis presented here is a simple payback that does not discount future cash flows or account for either inflation or expected electricity cost escalation. This is in accordance with the most common evaluative method for lighting conservation technology and is based on test results and figures reported by Lawrence Berkeley Laboratories and which represent an average comparison to the core coil ballast, and on tests performed by ETL Testing Laboratories. These results include only savings attributable to superior SSB performance and do not include savings attributable to lighter HVAC loads, for the reasons mentioned above. Several scenarios are included to illustrate the variability of calculated paybacks based on different information. All paybacks denoted in years are based on the assumption of a 3,000 annual average operation of a lighting fixture.

Figure 1 is based on results reported by Rudy Verderber (1980) of Lawrence Berkeley Laboratory for average savings comparing the SSB to all categories of core coil ballast, including both 120 and 277 volt units. The figure represents

FIGURE 1. Simple Payback on \$20 Premium Based on 20% to 25% Energy Savings Over "Average" Core Coil Ballast

a range of 20% to 25% savings over a 100 watt input standard for comparison, with equivalent (normalized) light output, at the same temperature. The results indicate a payback of about 3 to 4 years on a \$20 premium in regions with high electricity costs, and a payback of 9 to 11 years in regions with low electricity costs.

Figure 2 is based on ETL Testing Laboratories' Letter Report #449151 and compares the performance of the SSB to ballast 1022 and 1024 (see Appendix C) in terms of input watts, regardless of light output. By comparing the SSB with two different core coil ballast types, a range of savings and paybacks is indicated. The cost premium used here, however, is an average of \$15 for the OEM market and does not reflect the difference in price of the 1022 and 1024 ballast. The results show a payback of 2 to 3 years in regions with high electricity costs, and 6 to 9 years for regions with low electricity costs. Figure 3 is based on the same input wattage differential, but uses a cost premium of \$20 for the replacement market. The result is a correspondingly longer payback of 3 to 5 years for high-cost regions and 8 to 12 years for low-cost regions.

FIGURE 2. Simple Payback on \$15 Premium Based on 17.9 to 26.9 Watts/Ballast Energy Savings (Light Output Not Normalized)

FIGURE 3. Simple Payback on \$20 Premium Based on 17.9 to 26.9 Watts/Ballast Energy Savings (Light Output Not Normalized)

Figures 4 and 5 are both calculated on a \$15 premium for the OEM market and represent the preferred method for calculating energy savings. They are based on the concept of lighting efficacy, or the amount of light produced per input watt of power. In the ETL report, on which the analysis is based, light output was measured in foot-candles. This measurement is adequate for the limited comparisons to be made here because the testing was performed in the same physical location. A better comparison would be made using lumens as the light output measure because lumens are more reflective of the amount of light being emitted, as opposed to the foot-candle, which measures an intensity of light at a certain distance from the luminaire.

The analysis assumes that a theoretical fixture would produce 210 foot-candles. This figure is actually an average of the 1022 ballast/Mainlighter CW lamp system and the EETech ballast/Mainlighter CW lamp system. A theoretical fixture that produces an average of 210 foot-candles is used to determine the amount of input power needed to yield a desired light output level. The theoretical average fixture is simply a convenient standard for desired light output. The inverse of efficacy is then taken to give a number whose units are watts/output light (in foot-candles for the purposes of this report). The denominator, foot-candles, is then standardized to 210, and the numerator is proportionately adjusted for each system being compared.

Using Mainlighter CW lamps, the results are a 0.086 watt/foot-candle savings for the SSB over the 1022 ballast and a 0.049 watt/foot-candle savings for the SSB over the 1028 ballast. This savings per foot-candle translates to a 17.27 watt/ballast and a 9.81 watt/ballast savings in the 210 foot-candle theoretical fixture. The payback on a \$15 premium is shown in Figure 4 to be 5 to 8 years in regions of low electricity cost, and at least 13 years in areas of high electricity cost. Figure 5 makes the same comparison, except the lower wattage lamp is used instead of the Mainlighter. The result is a payback of 4 to 7 years for high-cost areas, and at least 11 years in low-cost areas.

This analysis points out the variability in results of analyses performed using different assumptions and input parameters. The last method, basing the comparison on the inverse of lighting efficacy under similar conditions using the same equipment except for the ballast, is preferred because it appears to address the comparison issue in the terms most appropriate to building owners'

FIGURE 4. Simple Payback on \$15 Premium Based on 9.81 to 17.27 Watts/Ballast Energy Savings (Light Output Normalized Using Mainlighter Lamps)

FIGURE 5. Simple Payback on \$15 Premium Based on 10.79 to 19.79 Watts/Ballast Energy Savings (Light Output Normalized Using Low-Wattage Lamps)

and managers' needs, and it appears to do it fairly. When a building is designed, the lighting level necessary to perform the tasks in that building must be chosen. The most important consideration is obtaining that lighting level for the least cost in the long term.

Comparing ballast performance in terms of watts/lumen produced provides a basis on which to determine energy savings with one caveat. In the OEM market, because the actual comparison has been made on the basis of a theoretical fixture with a given light output, more light fixtures may have to be designed into the building when using the SSB to get the desired output light. This caveat is based on the illumination levels reported in the ETL report, which indicated that even though SSBs were more efficient, they produced a lower absolute illumination level per fixture.

In terms of commercialization efforts, this method for calculating payback may not be preferred. This method probably differs from the methods used by all manufacturers of lighting conservation equipment in their promotional literature because it projects a longer payback. Most promotional literature includes HVAC savings as well as other factors in payback analyses, and because it often depicts comparisons using combinations of different equipment, energy savings attributable to the technology being advertised may result partly from the other changes in equipment used in the comparison.

The payback cutoff figure most mentioned by potential end users who were interviewed was 2 years. While equipment with paybacks up to 5 years would be considered, equipment with a payback of less than 2 years would have a significantly greater chance for adoption. With these figures as a basis, the investment appears quite acceptable in some regions, marginal in some, and unacceptable in others.

2.4 COMPETING TECHNOLOGIES

A variety of technologies on the market compete directly with the SSB in that their function is to reduce the amount of energy used for illumination. Most technologies are based on some kind of sensing device, either a photocell that measures ambient daylight and adjusts the lighting level appropriately, or a motion-sensing device that switches the lights on and off according to occupancy. These two devices are competitors only because they may be perceived as

alternatives to the SSB. The SSB is compatible with both and can be used in combination with one or both to yield incremental savings.

A third competitor is the energy management system (EMS), which incorporates time-of-day controls on an entire lighting system. A direct comparison between the SSB and an EMS is difficult because lighting is generally only one component of an EMS system, and allocating costs paid for the system to lighting and other building components is also difficult. However, the SSB is also incompatible with energy management systems.

The most direct competitors of the SSB are devices that reduce the voltage to the lighting fixture and thus reduce the amount of power used by each fixture. Promotional literature for these devices claims that up to 70% of the lighting budget in a building can be saved, but much of this savings is attributable to the substitution of daylight, which reduces design overlighting, and HVAC system load reductions, none of which have been included in the SSB analysis. The retail price for the unit ranges from \$45 to \$55, which represents a much higher cost premium than for the SSB.

Traditional core coil ballasts that reduce the amount of power going to the fixture are also available to the OEM market. One type is a single-power level ballast that reduces both energy input and light output by about 30%. Another version reduces the power input in a stepped manner, supplying either 100% of a normal ballast's power, or, at the flick of a switch, reduces the power input and light output by nearly 50%. This ballast has an equivalent retail price of around \$26 and is purported by the manufacturer to exhibit no flicker problems.

2.5 FIRST GENERATION TECHNOLOGY

The objections to SSB adoption and the entire commercialization effort must be viewed in the context of a first generation technology. Imperfections and room for improvement are expected at this stage of development. The real question is whether the technology will be accepted to the degree that will allow it to progress smoothly into its second generation, at which point it will presumably be much more competitive with present lighting technologies.

One area of great expectation is in manufacturing efficiency and cost reduction. Many products have traveled through the learning curve in terms of their ability to be produced inexpensively. The most noted examples are in the area of solid state electronics. Figure 6 shows an array of target cost premiums required to yield a two-year payback, based on the evaluation method described above, and using watts saved per unit light output as the basis for calculation. Achieving low-cost premiums by reducing the cost of manufacturing would guarantee success for the SSB.

FIGURE 6. Target Cost Premium Required to Yield a Two-Year Payback

3.0 PRESENT TECHNOLOGY DELIVERY SYSTEM

Ballasts reach end users in two ways: as replacements for worn out ballasts in existing installations, or as components of new lighting fixtures. The former is generally termed the replacement market, and the latter is termed the OEM (original equipment manufacturers) market. These two paths through the supply chain, or technology delivery system, are depicted in Figures 7 and 8. Between 60% and 75% of the ballasts manufactured reach end users as installed components in new lighting fixtures, and 25% to 40% are replacement ballasts (Bureau of Census 1979a & 1979b).^(a) A warrantee and retail price structure for the four grades of standard core coil ballast and two types of SSB (manufactured by different firms) are given in Table 1.

TABLE 1. Warrantee and Retail Price Structure for Four Grades of Standard Core Coil Ballast and Two Types of SSB

<u>Grade</u>	<u>Warrantee</u>	<u>Price</u>
standard grade:	2 years	\$16.50
low temperature:	2 years	\$18.50
very low temperature:	2 years	\$19.00
energy efficient:	3 years	\$22.00

2 level core coil ^(a)	2 years	\$26.00
70% input core coil	2 years	\$20.00

solid state ballast #1 ^(b)	3 years	\$35.00
solid state ballast #2 ^(c)	1 year	\$105.00

(a) Described in Section 2.4, this ballast is sold only to OEM; retail price is included for comparison purposes only.

(b) This ballast is straight substitute for core coil (no dimming equipment).

(c) This ballast has photocells and a dimming system.

(a) Also based on interviews.

FIGURE 7. Technology Delivery System - OEM Market

FIGURE 8. Technology Delivery System - Ballast Replacement Market

While the figures for the core coil ballast may vary slightly from manufacturer to manufacturer, they are fairly standard in the industry. Warrantees may also vary both in written terms and quality of service, but the purpose of defining the term of the warrantee is to give an idea of the minimum reliability the SSB must be able to claim. In practice the implications of warrantees go beyond the written word or length of term. Manufacturers indicated that if a major problem occurred with product failure, preserving the manufacturer's reputation would take precedence over technicalities. The real effect of warranty and service, therefore, lies in the long-term perception of performance and reputation, rather than on a specific number of years.

In the OEM market ballasts are sold directly to lighting fixture manufacturers by sales representatives of the ballast manufacturer. Because of the quantity purchases in this market, and the ability therefore to plan ahead for long production runs, the price of a ballast to a fixture manufacturer can be discounted as much as 50% to 75% from retail. This information is difficult to document because of the differences in quantity buys from one fixture manufacturer to another and because of the closeness with which the information is held.

Lighting fixture manufacturers sell their finished product almost exclusively to the electrical wholesaler. For large construction jobs the fixtures themselves never reach the wholesaler, but are drop shipped to the job site. The title to the goods, however, always passes through the wholesaler, who sells it either to the contractor, or to the building owner, depending on the contractual arrangements between those two parties for the construction of the building.

In the replacement market ballasts are sold directly to wholesale houses by sales representatives employed by the ballast manufacturers in "home" areas where company offices that can support the efforts of a sales team exist. In areas where a company sales structure does not exist, manufacturers' representatives are used. The manufacturers' representatives never take title to ballasts that are sold, but act as independent agents carrying out the sales and service function on behalf of several manufacturers and several different product lines. The wholesaler then distributes the ballasts to either contractors or directly to end users' maintenance departments.

The remainder of this section describes the principal factors that affect the successful distribution of ballasts from the points of view of the various actors in the technology delivery system.

3.1 BALLAST MANUFACTURERS

Presently, two manufacturers of fluorescent lighting ballasts dominate the market: Universal Manufacturing, a subsidiary of Northwest Industries (a diversified holding company), and Advance Transformer, a subsidiary of North American Phillips (which is also a major manufacturer of lighting fixtures). General Electric and Jefferson Electric (a subsidiary of Litton Industries), must also be considered major manufacturers, but their market share of the fluorescent ballast industry (as opposed to high intensity discharge (HID) and other ballasts) are relatively small. Although market shares are not available from Bureau of Census Reports, and ballast manufacturers are not willing to divulge their own figures, various people interviewed and associated with the industry and industry related organizations suggested that the two major manufacturers (Universal and Advance) control almost 90% of the fluorescent lighting ballast market.

The four major manufacturers represent a classic example of oligopolistic competition in a mature industry. Profit margins are very small, product lines are near perfect substitutes from brand to brand, and prices are virtually equivalent for like products. In this situation, the only competitive weapons are the marketing efforts, short- and long-term, initiated by each manufacturer to build brand loyalty.

In the ballast industry these marketing efforts center on distribution, product warranties, and service. Simply put, the objective of distribution efforts is to ensure that ballasts are on the stock shelves, available for purchase, in every electrical wholesale supply house in the nation, and that deliveries to fixture manufacturers are on time. Warranty and service can be considered together, as two parts of an effort to reduce risk to contractors and purchasers.

The key executors of these marketing weapons are the sales and manufacturers' representatives. For the purposes of this report, these people will be

referred to as marketing representatives (MRs). Although the titles may vary from manufacturer to manufacturer, one important distinction exists between the sales' and the manufacturers' representatives (reps). The sales rep is employed directly by the manufacturer and serves only that manufacturer. The manufacturer employs sales reps in the geographic areas in which the organization is strong. In other areas, it uses manufacturers' reps, who are independent businessmen serving a variety of manufacturers and representing a variety of product lines. Their similarities, however, are that they both work on a commission basis, and their long-term success depends on providing the kinds of service described below. The MR is the intermediary who keeps tabs on wholesalers' inventories, implements reorders to insure effective distribution, and follows up on warrantee claims. His success is based not only on his mission to service the accounts in his territory, but also on the personal relationships he builds with actors along the supply chain. These actors come to trust and depend on him, and eventually to associate their perception of the manufacturer's image and reliability with the long-term impact his own personality and service record projects.

The MRs project themselves by providing business service. If a warrantee claim is made for a product failure, the MR is usually the key communicator and facilitator of a satisfactory settlement with the end user and the supplier intermediaries through whom the claim is made. As will be shown later, this service function is very important to suppliers of ballast hardware.

To understand the manner in which the MR builds loyalty through distribution, the diversity of the ballast product line and the nature of the demand for the ballast replacement market must be understood. Table 2 is a highly aggregated representation of the various ballast types on the market today, each of which operates a particular lighting fixture type. Because installed ballasts fail at unscheduled intervals and lighting is most often crucial to the business and productivity of the end user, electrical contractors or maintenance departments are asked to replace failures immediately. This situation requires ballast suppliers to maintain an inventory of all ballast types in the product line at the local level to avoid delays in replacing failed ballasts.

TABLE 2. Major Ballast Types^(a)

<u>Product Code</u>	<u>Ballast Type</u>
<u>Uncorrected power factor type:</u>	
36124 62	20 watt and less, switch start
36124 63	21 to 40 watt, switch start
36124 65	above 40 watt, switch start
36124 61	rapid start
36124 66	other than rapid and switch start
<u>Corrected power factor type:</u>	
36124 67	two-lamp 96T12 slimline and instant start
36124 68	other slimline and instant start
36124 71	two-lamp 40 watt rapid start
36124 72	800 to 1000 ma rapid start
36124 73	1500 ma rapid start
36124 74	other rapid start

(a) These ballast types represent generic categories within which many varieties exist.

The crucial role of the MR in this requirement is to assist the various suppliers operating between the end user purchaser and himself in maintaining a proper inventory of the product line, particularly as it affects the availability of any ballast type. Since perfect substitution exists among the various brands of ballasts, failure to make any ballast type available on demand will result in either brand-switching or replacement delays. The long-term absence of problems in obtaining the necessary ballast hardware plays a large role in building brand loyalty. The MR's ability to build business relationships that result in product availability is crucial to the manufacturer's commercial success.

The commercialization of an innovation like the SSB to an existing product line depends on either a capability to use the existing infrastructure to

employ sales and manufacturers representatives to introduce the product and integrate it into the product line, or a willingness and capability to compete in some way with the entrenched positions of present manufacturers through their MRs.

Each of the presently well-established firms in the industry has been considering the introduction of a SSB for at least as long as the DOE R&D program has been in existence. The fact that they have not introduced such a product is significant. Economics and reliability are the principal obstacles cited by manufacturers. In light of the above payback analyses, this point must be conceded, but one must also presume that general conservatism and the protection of the status quo are in the best interests of those presently engaged in manufacture. The competitiveness of the industry dictates, however, that if the SSB began to command some attention in the marketplace, all industry participants would be in a position to enter the SSB market. Whether this will happen will be known in the next year or so because EETech, one of the principal private collaborators with DOE in the development of the SSB, has officially launched its marketing campaign with a full-page advertisement in the May 11, 1981 edition of Energy User News.

If major ballast manufacturers do enter the SSB market with introductions of their own, the DOE program will have greatly achieved its objectives. The program will have forced an industry to orient its business towards conservation by working through a small "outsider" company, and competition will earnestly begin to identify and implement the least-cost manufacturing process and assure product quality and dependability. For national energy goals the greatest implication will be that SSBs will become available through all electrical wholesalers as a part of the established manufacturers' product lines, a feat which would take years to fully accomplish if left to a newcomer into the market. Obviously diffusion into the marketplace would accelerate, with more energy savings accruing faster.

Given their claims to date concerning the SSB, if major firms did not enter the marketplace, it would be a signal that they were so convinced of the nonviability of the product that they were willing to allow it to fail without their participation. The road to commercial success would be longer and more arduous, with less energy savings accruing.

A speculative matter that affects SSB's introduction into the marketplace through the existing manufacturers is the outright resistance of those manufacturers to incorporate the SSB into their product lines. Each manufacturer makes the consideration partially in the context of a zero sum game. For each SSB sale, one less traditional ballast will be sold, and the danger exists that the one less traditional ballast will be the manufacturer's own brand. On the other hand, the incentive exists to increase market share by getting users of the other manufacturers' traditional ballasts to adopt the innovation.

At least one manufacturer has strong motives to delay or prevent the introduction of the SSB. Sales from other product lines like light bulbs and fluorescent tubes provide high margins and significant cash flow to develop other parts of the corporation. Since the SSB is expected to significantly increase tube life, marketing of the SSB could reduce these cash flows in the medium and long term, representing a potential conflict of corporate objectives.

3.2 FLUORESCENT LIGHTING FIXTURE MANUFACTURERS

The Bureau of Census Reports MQ-36C (1976b) on fluorescent lighting ballasts and MA-36L (1979a) on electric lighting fixtures reveal that approximately 65% to 75% of ballasts manufactured each year are already installed in new fixtures when they reach end users. This figure is intended to represent only standard four-foot, two-tube fixtures and must be approximate due to the aggregation structure in the Bureau of Census reports. The figure does, however, agree with figures given by persons interviewed in the industry.

Each fixture manufacturer serves one or more market segments in terms of the quality of fixture produced. This segmentation ranges from less expensive fixtures which use lighter gauge steel and relatively cheaper components, including ballasts, for end users concerned with finishing a building for the least cost, to heavier more durable fixtures for industrial use where vibration from machinery dictates a sturdier design or inaccessibility dictates low-maintenance products. In the latter case, premium quality ballasts would be installed.

While the particular quality market the fixture manufacturer is targeting will certainly affect the type of ballast installed, the brand loyalty is a

function of other factors: end user specification, traditional supply agreements, or geographic convenience. None of the manufacturers contacted mentioned any differences in product quality or warrantee as reasons to purchase one brand of ballast over another. In terms of specification by the purchaser, fixture manufacturers felt that energy-efficient ballasts were increasing in demand (the improved core/coil type), but neither the manufacturers nor the customers were familiar enough with the SSB to even consider it as a real option.

To the fixture manufacturers, the ballast represents the fixture's most expensive component, which must be purchased as a fully completed component. All other parts of the fixture are either fabricated by the manufacturer from raw materials, or account for only a very small portion of the cost of the fixture. Because the ballast is the most expensive component, concern was expressed over installing a ballast with a large cost premium. No assurance could be provided that customers would perceive the benefits from the extra cost, and sales volume would therefore be jeopardized and market share would be lost to competitors selling less expensive fixtures with traditional core coil ballasts.

3.3 WHOLESALE DISTRIBUTORS

Wholesalers (also termed supply houses) are local distributors of electrical hardware, generally serving the equivalent of a metropolitan area. They handle both lighting fixtures and ballasts as part of a large diverse product line of all kinds of electrical hardware. Wholesalers usually compete with at least one other supply house in a service district and carry at least two ballast product lines. In some cases, however, the wholesaler is actually the ballast manufacturers "captive" representative for the region he serves and carries that brand of ballast exclusively.

Ballasts are low-margin items, and the wholesaler carries them for the convenience of the contractors and maintenance departments he serves. For this reason, product availability is a major concern to him, and as mentioned in Section 2.0, this is an area where he depends strongly on the service of the sales' or manufacturers' representative. For a wholesaler lack of availability would mean that a contractor would turn to a competitor to fill an order, which

might lead to that contractor ordering more than just a part of the ballast line from the competitor. Therefore the general problem of inventory control has a specific bearing on the loyalty of his customers. The wholesaler must keep a full line of ballasts in stock at all times so that they are available to his customers without delay.

The other major concern for the wholesaler is warrantee servicing. Claims can take a number of paths back to the manufacturer's representative, but often they are pushed up the supply chain, and therefore the wholesaler's reputation depends on the ballast manufacturer standing behind the product. Again, this is an area where the service of the sales or manufacturers' representative is crucial to the wholesaler's reputation. If the wholesaler is the captive sales representative, then his own ability to interface with the manufacturer and secure compensation for product failures is directly proportional to the trust his customers will in turn place in him when an equipment failure occurs. Without that trust his customers will turn to a manufacturer who will back his product, and another wholesaler who appears to be more responsive to their needs.

3.4 ELECTRICAL CONTRACTORS

The electrical contractor has the closest contact with the end user of anyone in the supply chain. He handles replacement situations as well as new construction. With replacement jobs the contractor has a great influence over what type of ballast is installed, since architects and engineers are generally not involved. The contractors interviewed are finding that an increasing demand exists for energy-efficient equipment. In one case the client (a large drug store chain) would accept nothing but the most efficient equipment, including lighting ballasts, although this attitude is not pervasive. In new construction situations the contractor has little influence over what type of equipment is used because it is specified by the architectural firm.

Perhaps the greatest consideration to a contractor is the ballast's warrantee, and the reputation of the manufacturer to honor it. In new construction the contractor is legally responsible for the proper functioning and operation of installed equipment for anywhere from one to two years after completion of the job, which may be months or even a year from the time when a lighting fixture was actually installed. Because of this responsibility, the contractor's

brand loyalty is established by a long-term perception of equipment reliability, and by how much responsibility for equipment failure he can shift to the equipment manufacturer.

Concern about availability of the product line also starts with the contractor. Many of his clients who do not have qualified electricians on their maintenance staff to call on him to perform ongoing service on their buildings on an as-needed basis. This might be an immediate need situation, especially in the case of lighting and ballast failures. The contractor must be able to secure the proper ballast on demand, or his client's lost time will damage their business relationship. If the supply house fails to have the proper ballast in stock, he will look either to a competing brand or to a competing supply house to meet his needs, thereby shifting the concern about availability one step up the supply chain. Eventually the concern with availability works its way to the manufacturer.

4.0 THE MARKET

The market for fluorescent lighting ballasts has been segmented into two categories: the replacement market and the OEM market for new construction. The replacement and retrofit markets represent sales of ballasts alone, while new construction represents ballasts installed in lighting fixtures at the fixture manufacturer's premises. Bureau of Census reports MQ-36C (1979b) on fluorescent lighting ballasts and MA-36L (1979a) on lighting fixtures indicate that 25% to 35% of the ballast market is in retrofit/replacement, and 65% to 75% is in fixtures sold for new construction, with a total volume of approximately 50 to 70 million ballasts per year, depending on the economy and the strength of the construction industry in any given year. In 1979, for example, about 67 million ballasts were shipped by manufacturers. Of this total in both new fixtures and replacement ballasts, approximately 50% were for four-foot, two-tube, rapid-start installations with corrected power factor. The greatest number of ballasts obviously are for the standard four-foot fixtures.

These two categories of sales, each with its own characteristics, can be further segmented by differentiating end users. For the purposes of this report, four end-user market segments were examined: large department store chains, large grocery store chains, office complexes, and restaurant chains. Open-ended telephone interviews with energy managers and persons in engineering departments were conducted to create a picture of the typical corporate decision structure through which a decision to adopt energy-efficient technical innovations like the SSB must pass. While each firm obviously had its own unique method of handling adoption decisions, enough similarity in the first three end-user types, grocery stores, department stores, and office complexes, existed to reveal a general pattern. Note that only very large firms were contacted in an attempt to identify and characterize high-leverage commercialization opportunities. This certainly affected the fact that enough similarity was discerned to draw some general conclusions, simply because the degree of specialization of corporate officers' functions in large firms was similar.

4.1 COMMERCIAL FIRMS

The first element common to these types of commercial firms was that almost every firm had a corporate energy manager whose sole or major responsi-

bility was to influence the reduction of energy use in the entire corporation. These energy managers' professional performance was evaluated on the basis of how much they were able to reduce consumption, but in all cases that energy manager had no line authority. The energy manager's position in the decision making structure is shown in Figure 9, along with the other parts of the firm with which he must interact to affect a purchase decision. His function was to gather, evaluate, and sift information about energy-saving techniques and technologies and to recommend adoption of the most effective ones to operating managers and engineering departments in the operating divisions. In this role the energy manager had open communications channels with corporate actors who would actually make the decisions to implement conservation measures. Interviews revealed that line managers were likely to listen to the energy manager because he provided a valuable service to them in terms of potential cost cutting.

Despite this communication and flow of information, purchase decisions are made on a decentralized basis by line management, with participation by engineering departments on the corporate level, the operating division level, or both. The function of the engineering departments was to analyze the technical performance of the proposed technology, to examine its compatability with other systems already in place in the physical plant, and to estimate the technology's cost effectiveness. These were all considered to be potential problems by a significant portion of the engineers interviewed. One engineer remarked that it was his company's policy to wait until several years after a product was introduced to consider it for adoption, since the price was likely to fall significantly during that period. Reliability was the second major concern, with mention of radio frequency interference being made in only a few cases where the engineer was familiar with the SSB's technology.

A decision to purchase the SSB might necessarily be routed through the finance department as a capital allocation evaluation. In this case, the payback and return on investment would have to clear the corporate hurdle rates and compete with other projects for scarce funds. Competition with other projects is a major concern because other corporate objectives enter into the analysis. Firms are in the business of providing goods and services, not conservation. Therefore, investments that will increase market share in the firm's real business will most likely be considered before a long-term cost reduction program with a high initial capital investment (Yergin 1980).

FIGURE 9. End-Use Decision Structure - Commercial and Industrial Firms

Restaurant chains are similar to other commercial establishments contacted only in that they do have corporate energy managers who initiate conservation programs from the corporate level. The nature of the restaurant business, however, dictates that a much shorter payback period be used as a decision parameter. This generalization is made for chain restaurants and fast food chains whose business life-cycle averages somewhere around seven years, and whose major energy expenditures are made for cooking and for space conditioning rather than for lighting.

The short life-cycle for an individual restaurant forces an increased emphasis on capital expenditures with the least initial cost, especially in times of high inflation when the discount rate reduces the value of future cash flows. While this is true for corporate-owned individual restaurants, it is even more true for franchise operations where the franchise holder has a major input into the decisions about how his capital investment will be allocated. The corporation can influence the independent owner only to a certain degree. While it can recommend and persuade, the final decisions concerning capital outlays for the physical plant are viewed by the franchise holder in the context of minimizing initial investments to recover costs in the shortest period of time, thus making the concept of premium equipment like the SSB difficult to sell for the purposes of future cost reductions.

4.2 INDUSTRIAL ESTABLISHMENTS

Several industrial conservation priorities come before ballast replacement:

- changing incandescent bulbs to fluorescent tubes
- reducing wattage and delamping
- relying on light scheduling and computerized energy management systems
- using low-wattage, high-pressure sodium, and mercury tubes.

Ballasts ordinarily need to be replaced once every three to twelve years. Only then is some attention given to energy-saving alternatives. Also, new construction is often carried out with attention to ballast efficiency. However, rapidly growing industries (like the computer) often do not have the time to design new facilities to contain energy-saving devices, and they shy away from nonconventional products because of the added costs.

Features of industrial decision making include the following:

1. Empirical decision making. Companies often "try things out" and conduct studies before adopting new practices. They have what one energy manager called an "analytical style" in that they try to test suggested changes on a trial basis and scrutinize them carefully before actually adopting them.
2. Return on investment criteria. With new product introduction many companies rely on rapid payback and other return on investment criteria. Conservation measures often have to compete with other capital investment decisions. A 15% return on investment or an eight to nine month payback may be required. Given these criteria, SSBs have to demonstrate that they are competitive with other investments if they are to be adopted.

Companies are often conglomerates ("holding companies" of many separate divisions). Small energy groups (consisting of one or two engineers) at the corporate level often have to oversee the operations of numerous separate divisions and facilities. Responsibility for achieving energy savings rests with line management. The only central purchasing that exists in some companies is basic ordering agreements with large light manufacturers (such as G.E.) to purchase low-wattage fluorescent tubes.

One company contacted has a central energy committee that is composed of representatives from labor, management, and minorities and that makes suggestions and provides support for energy innovations. The committee is assisted by corporate engineering, which has to implement these decisions. Another company has central conservation goals, but gives line divisions the responsibility to implement these goals. The divisions may have energy committees or energy coordinators who have to achieve energy-saving goals at lowest cost and highest payback. A third company has an energy coordinating committee in each plant and a corporate-wide energy coordinating council. A fourth company also relies on a central conservation committee to coordinate activities. A fifth company relies on a "visitation program" from the central energy office to implement conservation goals. The central engineering group visits plants, makes recommendations, and provides technical assistance. A sixth company has

no central energy authority, but allows various corporate vice presidents to make energy-savings suggestions and have them approved by the President. Two other companies contacted have no central authority.

Generally, central energy authorities provide information and assistance to plant managers, but do not have the authority to do anything more than persuade them to adopt new practices. New facility construction is more frequently centralized in regard to energy purchasers than on-going operations. For new facilities companies often rely on outside actors like electrical contractors and architectural/engineering firms.

Industry energy managers often appear more eager and capable of obtaining new information than their government counterparts. One industry energy manager described his "broad and voracious appetite" for new ideas and approaches. He claimed that he is absolutely "inundated with unsolicited material" and that no shortage of information exists. Instead, redundancies are common. Trade journals, government documents, and energy publications such as Energy Users News and Energy Management are often relied on as sources of information. Other magazines mentioned were Plant Engineering, Building and Maintenance Management, and Plant Energy Management. Trade association meetings and trade association energy committees are also important sources for the exchange of information.

Some company officials are not as eager to seek out new sources of information, however. One described himself as "really not much of a reader" and another could not think of any publication he regularly scanned. These officials rely more on the initiative of plant engineers and managers, manufacturers, and vendors than on publications, trade associations and professional contacts. Some company officials take vendors more seriously and invite them to present information and to give demonstrations, but one official has a "crank file" where he puts ideas from vendors whom he considers un reputable.

Industrial energy managers used some of the following phrases and terms to describe barriers that prevent SSB adoption:

1. difficult to justify the change (savings have to be very great to remove existing ballasts)

2. may not be compatible with newly installed energy-saving tubes
3. too fancy
4. not visible
5. difficult to understand (in comparison to taking out bulbs and reducing wattage)
6. not suitable in all situations or applications
7. relatively low present electricity bill (for example, because of reduced utility rates for large users)
8. relatively low present electricity consumption for lighting
9. ballasts are infrequent to replace (maybe only once every ten years)
10. relatively high price of new ballasts (perhaps five to six times the price of conventional ballasts)
11. low priority item (alternative lighting conservation measures generally take preference)
12. still unproven reliability (for example, when used near heavy equipment)
13. no time to devote to ballast promotion within this company (use labor and capital to make product, not to change lighting)
14. chronic problem of implementation (difficulty of selling new ideas to plant managers)
15. low payback or insufficient return on investment.

Many industrial energy managers expressed the opinion that they are not seeking government assistance and have no desire to work with the government. Specific subsidies or monetary incentives are not needed to induce change in their behavior. Most believed that federal involvement in company conservation programs should be minimal. Some recalled, however, that state programs have been helpful. In California, for example, a company energy manager remembered that the utility (Pacific Gas and Electric) was willing to pay half the purchase price of low-wattage fluorescent tubes; and in New York an energy manager recalled effective energy lighting efficiency regulations.

Managers oppose government subsidies, but indicated that they seek and appreciate receiving additional information about government research. Their impression is that government labs "generally do good work," and they expressed the opinion that the proper role of government is to illustrate the kinds of things that are possible through demonstration projects. Another opinion is that the government should also use the products it promotes. In addition, some support the idea that the government should require central purchasing agreements for energy-efficient equipment.

A different view of the role of government was provided by an energy manager who argued for government requirements like building energy performance standards. Such requirements, he maintained, prod industry and "muscle companies" into energy savings. However, this manager was opposed to government and utility sponsored audits of company activities, which he felt should be carried out by private entrepreneurs. This manager emphasized the role of private contractors and consultants as transmitters of new technologies developed by the government to industry. Overall, however, the feeling among industrial energy managers was that government action by itself does not induce change.

4.3 PUBLIC INSTITUTIONS

In this section, the results of interviews with officials in several generic types of public institutions are presented. Public institutions generally differ with private ones in that their goals, and therefore their decision making procedures, are less objective and often less explicit. The best support for the SSB's commercialization would be for the federal government to initiate a policy encouraging the SSB adoption as a lighting conservation measure. When this report was being written, the General Services Administration (GSA) was in the process of setting standards for SSB's so that they may be included on its supply schedule. The purpose of this section, however, is not to describe what could be, but to examine public agencies as they operate today, to describe the kinds of decision processes that are at work, and to identify obstacles and opportunities to the SSB acceptance as part of a general conservation effort.

The literature on organizational process discusses some of the inherently conservative features of large-scale organizations. This literature, as it relates to the adoption potential of the SSB, will be reviewed briefly.

4.3.1 Organizational Factors

The Carnegie-Mellon School of Firm Behavior argues that organizations experience a variety of pressures stemming from the existence of different coalitions of interest with different goals (Cyert and March 1963). Both private and public bureaucracies have been found to be responsible to various constituencies. Wilson (1980), for example, holds that the "tasks an agency performs, the constitutional framework in which it is imbedded," and "preferences and attitudes of citizens and legislatures" are critical determinants of government agency behavior. Wilson (1980, pp. 357-394) also notes that decisionmaking is influenced by coalitions of diverse participants, namely career bureaucrats, political appointees, agency professionals, public activists, and corporate managers, all having different motives and all interacting within complex institutional settings.

4.3.2 Standard Operating Practices and Procedures

When organizations take action, they tend to act according to standard operating procedures (SOPs) and to invoke one of a limited number of programs or routines (Allison 1971). While SOPs are by definition well suited to routine problems, they are ill-equipped to deal with unusual situations like innovations. The almost universal response by actors in the supply chain to the question "Why do you do business with this particular supplier?" was puzzled hesitation which eventually evolved to, "That's the way it's always been," or "We are geographically close to them and we know them." The only variation on this theme was an expression of confidence in the MR. Generally, organizational behavior evolves slowly over time as existing SOP's are incrementally modified to meet the requirements of new situations.

4.3.3 Channels of Communications

On a day-to-day basis, organizations monitor the environment by focusing on only a few incoming variables. Business decision making, according to Mintzberg, Raisinghani and Theoret (1976, pp. 246-275), therefore, is based on

imperfect information: "The organization rarely begins with full understanding of the decision situation it faces or the need to find a solution and only has a vague idea of what that solution might be or how it will be evaluated when it is developed. Organizational change is often slow because of the need to coordinate the behavior of diverse participants, the need to overcome standard operating procedures, and the need to act on the basis of limited information.

4.3.4 Federal General Services Administration

A thorough study of the purchasing function of the Federal General Services Administration (GSA) has been done under separate cover by Peter Benenson of Lawrence Berkeley Laboratories and so will not be repeated here. The following is a summary of obstacles to implementing lighting energy conservation measures from that report (Benenson and Nides 1979, p. iii):

...equipment installed in new construction and major retrofits is provided by contractors whose equipment selection is based on the lowest initial cost that meets the minimum specifications: federal laws require that specifications be written broadly enough to permit three or more vendors to bid; proprietary equipment cannot be exclusively specified and its procurement is extremely difficult for both Navy and GSA personnel; economic and regulatory incentives for energy conservation are minimal; lighting equipment for normal maintenance and operations is obtained through federal supply schedules, admission to which is time-consuming and involves extensive paperwork; UL approval and certified performance results must be obtained; reliable information about energy conservation equipment often does not reach government employees; and evaluation and performance procedures vary regionally. Recommendations are presented for prospective suppliers of energy efficient products which suggest expedient approaches for implementing these products in federal office buildings."

4.3.5 State General Service Administrations and Municipalities

Procurement officials from a random sample of 17 states throughout the country were interviewed. In 11 states the use of energy-efficient ballasts was mentioned. Use of ballasts was limited, however, even in states that indicated knowledge of them. They were generally used only to replace worn-out ballasts in state buildings where it was possible to do so. Numerous obstacles blocked more wide-scale adoption of energy-efficient ballasts [including elaborate formulas involving cost efficiency and life-cycle savings, institutional issues, and lack of comparative advantage (perceived)].

Almost uniformly, state purchasing agents do not consider a change in ballasts a preferred conservation measure. The idea is considered, if at all, only after low-wattage bulbs and energy-efficient fluorescent tubes have been introduced. Ballasts involve uncertain replacement costs and the bother of converting to a new system--disadvantages that are not encountered in introducing other conservation measures.

In state governments purchasing is sometimes handled by individual agencies that buy new material as they see fit. A central purchasing agent who can police orders for energy-efficient ballasts may not exist. In nine states this institutional issue blocks the more wide-scale use of energy-efficient ballasts. The state purchasing agent does not have a mandate to insure that energy-efficient ballasts are ordered. Alternatively, if he does have such a wide-ranging mandate, he may not know of the existence of newer technologies.

Various elaborate formulas involving cost efficiency and life-cycle savings were necessary to indicate that ballasts were needed. Eight of the states in the sample used some type of formula in deciding whether to install ballasts or to use other energy-saving devices. Massachusetts, for example, based its formula on price and the number of watts used; that is, the least cost for the most light, taking into account the life of the lamp, lumen output, etc. One buyer said that the energy-efficient ballasts were listed at twice the price of the old style ballasts and he doubted that the savings compensated for the higher price.

State officials mentioned the lack of an aggressive marketing campaign for ballasts ("No one has ever come to see me") and the fact that energy-efficient ballasts are not generally available. One city government has an aggressive campaign to obtain information on various energy-saving technologies, but that city is an exception. Other city governments rely on "salesmen who come around periodically" or on vendors for their information. One official obtains information from a university extension service. Others mentioned journals such as the National Institute of Governmental Purchasing Journal and The National Institute of Governmental Technology Journal as sources of information.

Uncertain replacement costs and the bother of converting to a new system are frequently mentioned by state officials as barriers to the adoption of the SSBs. Under various formulas involving cost efficiency and life-cycle

savings used by states, energy-efficient ballasts have to save considerable energy to compensate for their high price. Finally, state officials mentioned that new ballasts have to be available in many categories suitable for different types of use if they are to be adopted widely. Many city officials felt that energy-efficient ballasts are not cost-efficient. They might be in "a hundred years," but "right now, they're not."

State procurement officials suggested the following steps that can be taken by the federal government to increase the use of ballasts:

- government testing, specifications on equipment, and guidelines
- a rating system for energy efficiency that would facilitate the ordering decision
- a requirement that central contracting agreements be made with manufacturers to provide only the lowest cost and most energy-efficient lighting equipment.

Cities are like states in that purchasing is decentralized. City-wide standards for the purchase of energy-efficient equipment rarely exist. Most cities, for example, have no specific lighting standards. Each building is handled individually. If a central office exists, a gap between program plans and actual implementation may occur.

In one city a central office sends information to departments, which have to be persuaded by the office's suggestions because that office has no formal authority. In another city mandatory use requirements are being considered, but they have yet to be approved by the proper political officials. In a third city a committee composed of engineers and interested citizens has been studying central purchase agreements. In a fourth, an energy office is working on a comprehensive energy plan that is being designed by a large, city-wide committee. Overall, however, organizational arrangements to carry out a conversion to energy-efficient ballasts are not in place in either state or city governments.

Cities rely on a "standard bidding process." They have bid lists with the names of local distributors and give orders to the lowest bidder. One city has an oral bid process with calls being made to three vendors from whom bids are solicited. Most bid lists, however, are longer and include twenty vendors or more.

In response to a question about the federal government, a city official held that DOE provides "no help," "no money," and is "generally not interested in conservation." Generally, none of the city officials are aware of government programs available to implement energy-efficient measures promoted by DOE.

4.3.6 Public School Systems

The Federal Schools and Hospitals Grants Program is a major factor in the school officials' awareness of their energy situations and potential conservation measures. The program has created a large incentive for them to specifically identify conservation programs that they can use to apply for federal funds for implementation. Because of the increased awareness, all the school systems contacted were aware that the grants existed and were generally aware of what measures could be implemented in their schools. According to the Pennsylvania State Energy Office, which administers the federal grants program for that state, lighting conservation measures consisted almost entirely of relamping and behavioral programs to reduce the amount of hours lights are burning. There was no awareness of the SSB.

The decision structure for public school systems is depicted in Figure 10. Generally, the school principal initiates efforts to identify opportunities and begins to pursue implementation strategies. He almost always delegates responsibility for action beyond the initial stages to his assistant or his financial officer and the maintenance supervisor. Because of a lack of energy or engineering expertise, the Federal Grants Program imposed the requirement that an outside consultant be contracted to advise the school district on the various potential conservation projects and their cost and benefit advantages. This requirement must be fulfilled before the school could even be considered for funding.

To get SSBs on the potential list of conservation measures, the energy consultants for each school district must be contacted, since their analyses are a prerequisite to application for federal assistance. This outside actor complicates any strategy for inducing school districts to adopt the SSB as part of their conservation efforts because the school district selects the consultant of its choice, making it more difficult to identify the influencing parties.

FIGURE 10. End-User Decision Structure - Public Schools

Because of the capital and labor intensity of an SSB retrofit project, additional institutional constraints impede its adoption. Major capital outlays by school districts necessarily require school board approval, thus introducing a political process. The board is highly likely to require a bond issue, which means that the political process would be open to the entire community for approval. The planning and implementation necessary for these constituencies to be advocates of conservation measures like SSB both complicate and lengthen the process necessary for adoption. Also, the nature of the institution of public schools does not lend itself to primary concern for the physical plant. While operating budgets are matters not likely to be glossed over, concern with paybacks and financial investment decisions generally take a back seat to concerns about the curriculum, staffing, and other issues that relate to the educational process itself.

5.0 THE SPECIAL ROLE OF THE SPECIFYING COMMUNITY

Architectural engineering firms play the key role in the buying decision for lighting ballasts. They choose or oversee the choice of fixtures to be placed in both new construction and remodeling. To understand the ballast market, the firms' operation and the incentives and procedures involved in their lighting fixture decisions must be understood.

The architectural field is made up of firms ranging from small, single architect operations to large firms employing more than 900 persons. The largest number of firms (77%) are small businesses employing 1-9 architects. Medium-sized firms employing 10-99 architects make up 22% of the field, while large firms employing 100 or more represent only 1% (American Institute of Architects 1980). As a percent of 1972 business volume, however, the share represented by medium-sized firms is large (48%), while the share contributed by the small firms is small (38%), considering the absolute number of firms. Large firms contribute 14% to business volume, as shown in Table 3.

In the interviews stratification in the field was reflected in several ways. Large firms tend to have their own in-house lighting engineering departments, in contrast to medium and small firms in which work not done by the architects is subcontracted to engineering consulting firms. The type of work, and therefore the type of lighting installed, differs between large and small firms. Large firms are more likely to custom design lighting fixtures to specifically meet clients' needs. Concerns with first costs rather than life-cycle costs of fixtures installed are more likely to be primary in small firms,

TABLE 3. Field of Architects and Engineering Firms Surveyed
(Bureau of Census 1972)

<u>Firm Size</u>	<u>Employees</u>	<u>Percent of Firms</u>	<u>Percent Business Volume</u>
Small	1 - 9	77%	38%
Medium	10 - 99	22%	48%
Large	100+	1%	14%

concerns shared by their clients. Finally, information acquisition differs between small and large firms. The sections below deal with these points in more detail.

Four main areas were covered in the interviews with architectural firms: 1) who specifies lighting fixtures and to what detail, 2) on what criteria a ballast brand/type is chosen, 3) whether life-cycle costs or first costs are considered, and 4) the means by which firms learn about new products and the obstacles that might block acceptance.

5.1 RESPONSIBILITY FOR BALLAST SPECIFICATION

Information from large firms shows that from 15% to 100% of the lighting specification is done by the architects or in-house engineering specialists, although one large firm with several locations sent lighting work to the home office. The large firms often employ a completely separate electrical engineering department with which the architects can freely consult on contracts. The share of work not done by the architects or lighting/electrical engineers employed by the firm is subcontracted to electrical or lighting engineering consultants. The firms generally work with several firms with whom they have a close relationship and working history rather than seek out competitive bids. A fairly high percentage of contracts are not designed by the participating architect because much of this work involves designing special purpose lighting fixtures to accommodate specific needs of the client. In these cases, the architect often does not have enough specialized knowledge to put together compatible fixtures to fit the requirements of the contract, and the expertise of an electrical engineer becomes necessary.

In large firms, great portions of the specifications are taken from previous work, often leaving only 20% to 30% of the job to be newly created. This repetitious detail is commonly stored on computers, from which specification data can be manipulated to fit the current job. Standard lighting systems are obvious candidates for the computer. This represents an additional barrier in that SSB's must get specified on several jobs before they reach the degree of acceptance to be included in some standard format.

An "open" specification is one in which a product is specified along with the names of three or four preferred suppliers, and in which the words "or

approved equal" appear. This is a legal requirement on most public work. In private work, however, the trend is toward a "closed" specification because of the time and cost involved in checking and approving the alternatives. Public work also uses a "performance" specification, in which no supplier is mentioned, only the performance standard for the desired product.

The medium-sized firms report specifying lighting fixtures in 10 to 100% contracts. Several firms employ one or a few engineers, but more often engineering consulting firms are used. The percent of work contracted out varies directly with the type of work being done for the client; residential work is generally done in-house, while public and commercial work is frequently contracted out. As in large firms, work that requires standard fixtures is designed by the architects, while specialty work is performed by lighting design engineers, with the lighting engineers often participating in client/architect meetings.

The architects at small firms specify between 75 to 100% of lighting fixtures in the buildings they design because of the high percent of residential work done by these firms. In most cases, architects merely specify standard incandescent fixtures for these residences, so ballast specification is unnecessary. However, even when fluorescent fixtures are used, the complete fixture and not its component parts is usually stipulated by the architect in charge. The type of work done by small firms seldom requires specialized lighting packages, so the architects can order standard fixtures and the services of skilled lighting engineers are unnecessary.

5.2 BALLAST CHOICE CRITERIA

The relative importance of ballast attributes as viewed by architects and engineers varies directly with client needs. The features named most often by representatives of large firms include reliability, low noise level, low cost, energy efficiency, and low temperature. One firm stressed the importance of a ballast/fixture combination that can be easily installed and requires little maintenance. Another expressed interest in the heating/cooling load impact of the ballast. All are concerned with maintaining the good reputation of the architectural firm; therefore, primary concerns also included the ballast's warranty and manufacturer reputation.

Medium-sized firms share many of the concerns of the larger firms, with energy efficiency, low cost, low noise level, and local availability among the major concerns. One firm (specializing in library work) finds that ballasts that can be installed remotely have an advantage in reducing noise in sensitive areas, and that ballasts allowing careful control over illumination intensity are also desirable.

Ballast attributes that concern small firms are more limited. Although cost, energy efficiency, and noise are all factors, small firms rate knowing the ballast salesman as one of the primary factors determining their choice of a ballast type. However, the type of work done by small firms is of a different nature than that done by larger firms. Generally, small firms deal with standard fixtures for which many substitutes exist, and choice among competing ballast brands seems to be made on the basis of salesman familiarity.

5.3 LIFE-CYCLE COSTS VERSUS PURCHASE PRICE TRADEOFFS

Virtually all the large firms have fairly established policies concerning recommendations to the client considering life-cycle costs as opposed to initial costs in the lighting decision. Some firms appear to be strong advocates of energy-efficient ballasts. Beyond merely urging clients to consider life-cycle costs of more efficient ballasts, one firm pointed out the building in which it has its offices was designed to require no separate heating system; it uses heat from lights and employees to warm the building. Another large firm has been interested enough in energy efficiency to carry out several informal in-house studies of conservation alternatives and payback periods, which it uses in its recommendations to clients. Other firms are not so vigorous in their recommendations to clients, but all the large firms reported that they provide payback information so clients can make an informed choice. However, some clients are on tight budgets and first costs must be the overriding concern. Several firms pointed out an interesting distinction between two types of large job clients. They find clients for one-owner monumental work (that is, clients who will occupy their own office building or factory) are much more concerned with life-cycle costs and energy efficiency than the speculator/developer clients who plan to sell the building after completion.

Architects at medium-sized firms seem somewhat less likely to have a set policy concerning recommendations about life-cycle costs of lighting fixtures. One firm gives clients a choice among three ballast brands (all of which the firm says are energy-efficient). Another firm discusses the life-cycle versus first-cost issue with the client, but makes no recommendations. Several others routinely specify ballasts with lower life-cycle costs. Architects at one firm have found that roughly half of their clients choose ballasts with low initial cost, while the other half (mostly the telephone company, universities, and city government) favor energy-efficient ballasts.

In small firms first costs seem to be the most important concern for the client, and most firms make no other recommendations. One firm noticed some trend toward life-cycle cost considerations, especially in buildings to be occupied by the client, but generally, in the housing market and especially in the speculative/developer housing market, first costs are the overriding consideration.

5.4 INFORMATION FLOW ROUTES

Information gathering by large firms has typically taken several paths. Manufacturers very often solicit the largest firms through mailings or visits by salesmen. Most large firms contain full technical libraries, which carry subscriptions to the major architectural and engineering journals, and gather information on products and developments from articles and advertisements. Employee participation in professional associations and organizations provides two paths by which such information is passed: presentations and word-of-mouth. The Sweet's Catalog is also used by most large firms to get an idea of the types of products available (the state-of-the-art). Any of these information paths can feasibly be used to provide information about SSBs and can be expected to reach a fairly wide and interested audience.

Generally, medium-sized firms obtain new product information through mailings and advertisements in trade journals, visits by salesmen, attendance at some professional conferences, and the Sweet's Catalog. The owner of one medium-sized firm reports that she obtains information by directly telephoning contacts at the major manufacturers and asking what new products are available.

Small firms receive product information through a few main channels: contact with salesmen, advertisements in trade journals, limited mailings from manufacturers, and local manufacturing catalogues. The Sweet's file generally is not used because many of the firms are too small to receive the publication.

5.5 OBSTACLES TO NEW TECHNOLOGY ACCEPTANCE

In spite of the general interest in energy efficiency, interviews indicated that several obstacles block the application of SSBs in actual construction. The biggest obstacle appears to be the unwillingness of any firm to risk its reputation by being the first to install a new technology. Very clear resistance was expressed.

Further, getting an idea accepted by architects may not be enough. One architect claimed that a new technology may take fifteen years to break through to general use in new buildings. Electricians in construction are conservative in equipment installation, believing that lawsuits are less likely if problems occur with state-of-the-art equipment. Therefore, these contractors are hesitant to experiment with innovations, and considerable delays result in the application of new technologies.

Architects' reluctance to deal with unfamiliar firms (that is, other than the main manufacturers) is another obstacle. However, even if the product is introduced by a major manufacturer, one architect confessed that if only one company sold the item, he would assume that lack of competition meant that the product was overpriced and he probably would not use it.

Beyond these obstacles, however, the architects and engineers from these firms provided information that could be used to present the new product in the best possible light and give it a better chance of integration into the market. No matter which channel of communication is used, to be most useful to architects and engineers, the following information should be included:

- cost
- energy use
- guarantee
- noise level

- compatibility with standard fixtures
- availability (under what brand names)
- restrike time
- testing information
- heating/cooling load
- advantages over existing equipment
- suggested applications
- size
- wattage capacity
- remote mounting possibilities
- names or addresses for further information (contact person or trouble-shooter)

5.6 IN HOUSE SPECIFIERS

Many large corporations that handle changes to existing buildings and new construction have their own "captive architect" departments. Often these corporate architects commission most of the design work to outside consultants, but some handle all the work themselves.

When work is done in-house, specification requirements by the corporation may be detailed enough to preclude all but one type of ballast, or it may be general enough to allow for brand competition. In that case, the corporate purchasing department might become involved to seek out the best deal within the specification parameters.

If the lighting design part of the architectural service is contracted to an outside firm, the guidelines set by the corporation still may or may not leave room for ballast type or brand preference. In all cases, however, the bidding process for equipment suppliers may be a closed bid, with only those firms with which the corporation has done business in the past being asked to participate. This is of major consequence to a small firm whose name is not yet established in the ballast industry.

6.0 SPECIAL OPPORTUNITIES FOR COMMERCIALIZATION

Part of the purpose of this study was to identify high-leverage opportunities to accelerate SSB commercialization. During interviews with ballast industry officials and persons with firms that are potential adopters of the SSB, various situations, some of them representing direct outlets for sales and others representing information dissemination channels, were identified.

6.1 PUBLIC UTILITY CONSERVATION PROGRAMS

Utility company conservation programs were investigated through telephone interviews with at least two utilities in each region of the country. The purpose was to identify which regions and which utilities were engaged in conservation efforts that might assist the SSB commercialization efforts. While most utilities contacted had some kind of conservation program, most were aimed at the residential sector and were not particularly suited for promoting energy-efficient equipment to commercial or industrial establishments.

In one region of the country, however, utilities are developing very active conservation programs that could prove to be a vehicle for encouraging early SSB adoption. In the Pacific Northwest demand for electric power is approaching the limits of available supplies, and new supply options are severely constrained by environmental and economic considerations. Consequently, Pacific Northwest utilities regard investments in conservation almost as equivalent to investments in new supplies. This attitude is particularly true if the utility can match conservation measures against the problem areas of its load management. If, for example, commercial lighting is part of peak demand, as it is in many areas where irrigation uses daytime base load in the summer, the incentive to promote measures like the SSB is greatly enhanced.

Given the constraints, conservation investments may be the only short-term option. Consequently, the area's utilities couple their energy audit programs with the offer of information on economically feasible conservation investments, interest-free or deferred payment loans, and assistance in preparing bid packages for contractors or actual negotiation with contractors on behalf of building owners. Regulatory commissions are aiding the utilities in

this strategy by approving zero interest and/or deferred payment loan programs, whereby the utility makes loans to consumers to carry out approved conservation projects. Some commissions allow loan funds to be included in the utility's rate base, thereby giving the utility an additional incentive to promote conservation.

The Northwest's utilities are presently the only ones offering any financial assistance for conservation efforts. However, some initial program requirements must be met. The utilities must be supplied with prototypes of the technology so that they can test it to demonstrate to themselves that the technology is reliable, cost effective, and properly adapted to conditions in the service area (this applies mainly to items like heat pumps whose operating characteristics must be optimized to local climate patterns). Several utilities are presently promoting use of electric heat pumps, including add-on heat pumps for water heaters, and water heater insulation jackets, which they have tested and modified to suit local conditions. In addition, the utilities with conservation departments have engineering staffs to analyze customers' buildings and recommend economically attractive changes in lighting and heating systems. Ballast changes are not yet standard features of such utility programs. Changes to energy-efficient light tubes are often recommended, however, and as energy-efficient ballasts become more widely known, they may be included in utility programs if they meet the economic efficiency criteria used by the utilities. A similar pattern of testing and active recommendation is to be expected for the next generation of conservation technologies.

Utilities traditionally have been in the business of selling electric power, not conservation. Only very recently has the idea arisen that selling conservation may be in the best interests of a utility facing the steeply rising marginal costs of new energy supplies. Organizational arrangements reflect this change in economic realities. In the Pacific Northwest several utilities have separate conservation departments whose job is to sell energy conservation practices to residential and commercial customers. In most utilities in other regions of the country, however, conservation is the job of the marketing department. A mixture of these two roles reflects utility company uncertainty as to whether marketing conservation technologies are really in the best interests of an energy supply company.

Utilities receive information about new energy conserving technologies from various sources, including trade and professional journals, government publications, and laboratory reports. Edison Electric Institute (EEI) is a major source of literature that is distributed to utility customers. EEI literature includes a National Energy Watch program in which many utilities participate. Customers with energy-efficient homes (well insulated, energy-efficient lighting systems, etc.) can have their homes certified under this program. The certification presumably confers status on recipients, or real market value to homeowners intending to sell their homes.

Except in the Pacific Northwest, which faces unusually large differences between current average and marginal energy supply costs, conservation practices are of uncertain economic value in the perception of most electric utility companies. Little incentive exists to resolve the organizational issues that impede conservation programs for utility customers. Other than in the Northwest, utilities may not market energy-efficient ballasts aggressively. Even in the Northwest, ballast changes must compete with a number of other promising technologies. For example, insulation of older buildings is probably going to be the major priority of conservation-minded utilities for some time due to the enormous possible energy savings. Technical questions such as those raised by industrial respondents will also present barriers to utilities who do get interested in ballasts.

6.2 TRADE AND PROFESSIONAL ASSOCIATIONS

Most trade associations and professional societies are comprised of a significant portion of the technical people and other special interest segments of the population who will have direct impact on the acceptance or failure of this new technology in the near term. They represent a vast information dissemination network. Virtually all of these associations and societies have some mechanism in place with which to inform, educate, and stimulate professional development for their members.

These organizations present a high-leverage opportunity to provide information to an interested group through conventions, trade shows, and periodicals that serve these organizations. Many of these organizations contain a highly

selective population with a significant degree of homogeneity, at least along some clearly defined parameters. Identifying those trade and professional organizations whose memberships include persons who will impact the acceptance and use of SSB was the first task undertaken by this study.

After those organizations were identified, the next step was to identify the organizations that were actually interested in energy conservation technologies, especially the commercial industrial sector's consumption of electricity for illumination. Telephone interviews were conducted to assess the relative importance that was attached to energy conservation in general, and lighting energy requirements in particular.

The trade and professional organizations that were identified are listed in Appendix A. Included in this listing is relevant information on the mission of the organization, a contact person and the telephone number, membership size, and publications that are produced by the association. This information can be used to initiate a large-scale information dissemination campaign, targeted to the special interests and level of expertise of the groups being addressed. Included are associations and societies that represent manufacturers, distributors, electrical engineers, architects and the specifying community, and potential end users.

6.3 TRADE AND PROFESSIONAL JOURNALS

This section reports information on several periodicals that serve target audiences in the architectural and engineering fields. The information is the result of a series of telephone interviews conducted to provide the basis for a more extensive assessment of the interest in the SSB.

Interviews were conducted with representatives from the publications staffs of various prominent professional organizations in the architectural and engineering fields to gain an insight into the importance of energy conservation to these societies. The interviews indicated that a large and growing interest exists in the generic topic of energy conservation in buildings. The interest in energy-efficient design, though pervasive, was evidenced in varying intensities.

The staffs of the periodicals with larger audiences expressed an interest in articles that would discuss the SSB's important features. The energy conservation potential of this technology was congruent with their policies of disseminating information on the latest developments in the field of energy efficiency in building design.

Table 4 summarizes Appendix B, which describes periodicals for which information was received. A subjective evaluation of the level of interest in the SSB and more detailed information is found in the appendix.

TABLE 4. Trade and Professional Journals and Publications

<u>Publication</u>	<u>Circulation</u>	<u>Field/Market Served</u>	<u>Editorial Pages for Energy as % of Total</u>	<u>Level of Interest in SSB</u>
<u>Progressive Architecture</u>	73,550	A/E ^(a)	8.9%	Inter-mediate
<u>AIA Journal</u>	40,000	A/E		Inter-mediate
<u>Construction Specifier</u>	14,310	A/E & Spec. Writers		High
<u>Lighting Design & Application</u>	11,070	Lighting Eng.		High
<u>Industrial Engineer</u>	25,725	Productivity Eng.	3.9%	Low

(a) Architects/Engineers

6.4 AVENUES OF DIRECT ACCESS TO KEY INFLUENCES

The Sweet's Catalogue, published by McGraw Hill, Inc., is widely accepted as the foremost reference for specifiers of building equipment. It purports to reach over 90% of the designing, specifying and purchasing power for products in the general building market (Table 5):

TABLE 5. Sweet's Catalogue

<u>Types of Offices</u>	<u>Annual File Distribution</u>
Architectural Offices	9,500
Architectural/Engineering Offices	2,800
Consulting Engineering Offices	300
Building Design Engineering Offices	700
General Contracting Offices	6,600
Owner Design Departments	400
Owner Planning Departments	400
Government Offices	600
Schools, Libraries, Others	<u>1,700</u>
Total	23,000

The Sweet's Catalogue has been used previously by DOE programs to create greater awareness of the advantages and capabilities of state-of-the-art technology, with the caveat that no particular vendor or manufacturer be singled out as a supplier of the technology. The market development branch of the solar technology division has used the catalogue to promote use of solar technologies. The opportunity exists to do the same for the SSB, with the message reaching precisely the audience most crucial to the commercial viability of the technology.

6.4.1 Direct Mailing List

A mailing list that includes energy managers for each of the Fortune 1000 firms, as well as other purchasers of energy-related products, is available from Energy Engineering Magazine. The total list numbers 40,000 and includes subscribers to Energy Engineering Magazine. Such a list can be used to distribute SSB promotional literature and technical information.

6.5 THE PCB ISSUE

Interviews with potential end users in the food processing industry revealed that all ballasts manufactured prior to 1978 contained PCBs, a highly toxic substance. At that time regulations were adopted by the Environmental

Protection Agency to prevent the manufacture of ballasts with PCBs. The problem of the ballasts still in place and containing PCBs still remained, however. The matter is still in the courts, but the point is that the food industry, including processors, wholesalers, and retailers, are sensitive to any potential criticism that might be directed at them and that regards the presence of PCBs in their facilities.

If the courts decide that all food facilities must be retrofitted with ballasts that contain no PCBs, a great opportunity will exist to offer the SSB as a conservation alternative, simply because of the sheer volume of ballasts that will necessarily be purchased. Even if the courts do not rule on the matter, the fact that the industry is sensitive to the issue presents another lever in convincing them to retrofit their facilities.

The other area that has the potential to become extremely sensitive to this issue is the public school system. Even though the matter has not surfaced to capture public attention, it may do so at some time in the future, presenting the opportunity for the manufacturers of the SSB to exploit the situation.

6.6 DOE'S SCHOOLS AND HOSPITALS GRANTS PROGRAM

Although the Schools and Hospitals Grants Program's funding level is being severely reduced by the Reagan administration, it still represents an opportunity to reduce the barrier of high initial cost to the adopter of the SSB. The program is administered by the DOE regional offices through the state energy offices. Applicants must have completed an energy audit by a qualified consulting company and must have carried out all low- and no-cost conservation options before they can qualify for grant monies. After that, they are required to submit applications describing the proposed conservation projects, which are evaluated on a predetermined formula according to the project's simple payback, its annual cost savings, its annual energy savings, and a weighting factor for the normal number of degree days over the national average. Based on the applications' evaluations scores, the proposals are numerically ranked, and funds are allocated until they run out.

A major objection by school administrators to this program and the way it works is the amount of preparation and paperwork necessary to reach the

application stage. At that point, there is no guarantee of monies to carry out the proposed activities. Other institutional barriers are mentioned in Section 3.3.3.

7.0 THE SYSTEMS APPROACH AND THE TECHNICAL MARKETING INTERFACE

High initial cost is the primary and most imposing obstacle to commercialization. While the learning curve and subsequent improvements in production methodology may yield manufacturing cost reductions in the middle and long term, the most critical period in the product life cycle is directly after commercial introduction, precisely the period into which the SSB has just entered. The question now is whether development of the technology been sufficient to satisfy a need in the marketplace.

Certainly in terms of the original objectives of the lighting division, the development of the electronics and design of the ballast itself must be considered a major advancement in conservation technology. Two product characteristics that have resulted from this work and that could significantly improve the product's comparative advantage, however, have not been exploited.

The ability to scale down the solid state circuitry from the core coil ballast greatly enhances flexibility in the ballast's design. The SSB could be produced in a variety of sizes and shapes, even colors, with no increase in the manufacturing cost. The first SSBs to be introduced are the same shape and size as the traditional ballasts to make the SSB compatible with all equipment in the OEM and the replacement market, since all fixtures manufactured to date for the general commercial/industrial market are standard design.

The decrease in the SSB's weight compared to the core coil ballast, however, results in the lighting fixture's enhanced design flexibility. The size and shape of the fixture is still limited by the standard tube design, with which it must also be compatible, although the materials used in fixture manufacture no longer need to be able to support what once was by far the heaviest component of the system. Cheaper, less durable materials than sheet steel could be used, eliminating some or all of the cost premium on the SSB component of a new fluorescent lighting fixture. Shipping costs in the fixture industry could also be reduced.

The comparative advantage of a lighting system could be significantly enhanced by vertically integrating the advantages of the SSB's possible improved technology. Obstacles to commercial success would exist, however. A building owner using a new and unique lighting design would have no alternative to

switch back to a core coil ballast without replacing the entire fixture. This obstacle, however, has not prevented other technologies using solid state electronics from being commercially successful. Automobiles, for example, now carry assemblies for several functions that must be replaced in whole. Other potential obstacles would be the same, or variations of obstacles the SSB now faces, as an unproven product. With innovative design, a potential adopter's risk would be limited to the questions of performance and reliability, and greater payback and return on investment incentives could be demonstrated.

Other up-front costs involve the brokering of the technology to the next stratum of vertical integration. The design of a new lighting fixture would be senseless without the intention of actual production. The costs of selling the idea to the fixture industry need to cover the broker's efforts to secure a commitment to at least consider tooling up for a production line. These costs, plus the development costs for the prototype design, the costs of installing manufacturing capacity, and marketing expenses comprise the total brokerage cost to gain the comparative advantages made available by another level of integration.

Thus far, the greatest obstacle to such a process is expressed by architects who are unwilling to risk the good reputation of their names by associating with an unknown product that might fail. This attitude is based on conservatism and a lack of knowledge and conviction about the potential of the SSB and its manufacturers.

Because the obstacles confronting the integration of further advancements of this technology are of an institutional nature involving the coordination of separate industries, or segments of an industry, and since these obstacles appear to be too risky to expect the private sector to develop the idea on their own, the government has a legitimate role to play in assisting the effort. If potential design candidates and candidate materials, the cost implications of the design candidates for manufacturing costs, both capital and operating, and the resulting enhancement in the product's attractiveness were known in advance, they would be much more likely to receive consideration from the private sector.

8.0 RECOMMENDATIONS

Political feasibility is a major constraint to implementing measures that would certainly improve the prospects for achieving programmatic goals and objectives. The change in administrations during the course of this study has dictated that many of the recommendations that would have been made under a Carter regime be re-examined in light of the difference in philosophy and approach of the Reagan team. In short, the plan under Mr. Carter was to place increased emphasis on the commercialization efforts to better prepare a program or product for the marketplace demands and exigencies. This emphasis had two underlying justifications: 1) no energy savings would accrue from any R&D results if they were not adapted to the competitive arena, and 2) if they were not entirely attractive to the marketplace, the private sector would take much longer to promote them than if some of the roadblocks were removed by a governmental commercialization effort. The difference in the Reagan approach is based on the principle that if an idea is worth its salt, the voracious appetite of the private sector to address market needs would be sufficient to develop and introduce the idea. This approach is a retrenchment to the more traditional position that government should limit its involvement to basic research, and that technology transfer would take place at the initiation of industry.

Because of these political changes, the following recommendations are presented in order of decreasing political feasibility. The first recommendations are actions that would significantly enhance the chances for commercial success and are probably politically feasible. Subsequent recommendations are actions that would enhance marketability, but that are now marginal in terms of political feasibility. The entire range is included because of the origin and orientation of this study towards the small firm without an entrenched market position.

1. A second phase of the SSB R&D should be initiated and directed at designing a complete lighting system, including fixture, ballast, and tubes, which is lighter in weight and includes less expensive capital inputs into the fixture component. This design improvement would

offset the SSB's cost premium and would be a major step towards advancing the technology to the second generation.

The objective of a new R&D phase would be to reduce both the energy intensity factor in the manufacturing of fluorescent lighting fixtures and the transportation energy component of fixture distribution. The effort could be justified because it would be a generically different area of R&D from the work on the ballast, and because the opportunity to conduct such R&D was not available until the SSB opened up the possibility for greater design flexibility. The obvious advantage of such an endeavor is that the cost of the entire lighting system could be reduced, thus eliminating the major objection about the SSB's high initial cost for the OEM market.

2. The SSB's benefits and availability to the specifying community should be publicized through presentations to trade association conventions and/or through promotional releases to their journals. This process has already begun through the efforts of Rudy Verderber at Lawrence Berkeley Laboratories, but certainly it is not complete. It represents a relatively low-cost effort with potentially high returns, although the measurement of those returns is difficult. Because the SSB was developed through a government research program, an article would be more appropriate than a publicity release from a private concern. This opportunity to disseminate information is particularly good now, since the R&D program for the SSB is virtually at a close. It is also a strategic time for the commercial viability of the product, since it was only recently made commercially available. While the manufacturer is responsible for promoting the product, no energy will be conserved until the SSB replaces less efficient core coil ballasts in the marketplace. In terms of affecting real energy savings, an effort to increase the appropriate audience's awareness of the technology and the success of the federal R&D effort is completely justified.
3. A series of meetings should be conducted with Northwest utility officials to develop the promotion of the SSB as an energy-saving

technology through their commercial and industrial conservation programs. One possible approach to this effort would be to enlist the Bonneville Power Administration as a coordinating agency for all applicable conservation measures resulting from federal R&D programs. An educational seminar along with prototypes of equipment should be supplied so that the utilities could conduct their own evaluations of the technologies with the assistance of the expertise of those who developed them.

4. Use of Federal Schools and Hospitals Grants Program to overcome the obstacle of initial cost should be encouraged by publicizing the energy savings potential to school administrators and their energy consultants. The first step in this process would be to make the federal administrators aware of the technology and the results of the testing and demonstration programs. This awareness could enhance the SSB's acceptability as a conservation measure worthy of funding and facilitate the dissemination of SSB information through the regional offices and state energy agencies to the administrators who are actively pursuing conservation efforts.
5. A direct mail campaign should be conducted to energy managers to develop awareness of the existence of the SSB technology and its benefits and to provide a channel for them to get information on manufacturers, prices, etc. This is a highly selective communication effort to reach those persons who are in a position to directly influence the adoption of conservation technologies. The mailing could inform energy managers about technologies emerging from all R&D efforts in appropriate areas and could use the federal energy hotline as a referral service for more detailed information on the technology's availability.
6. An advertisement that describes the SSB technology and its benefits and provides a channel for architects and engineers to get information on manufacturers, prices, etc. should be placed in the Sweet's catalogue for architects and engineers. This effort would reach the most influential group of actors (and the most serious bottleneck) affecting the commercial success of the SSB.

REFERENCES

- Allison, G. J. 1971. Essence of Decision: Explaining the Cuban Missile Crisis. Little, Brown, and Co., Waltham, Massachusetts.
- American Institute of Architects. 1980. AIA Firm Survey. American Institute of Architects.
- Benenson, P. and J. Nides. 1979. Lighting Energy Conservation in Federal Office Buildings: Implementation Procedures and Obstacles. EEB-L-79-02, Lawrence Berkeley Laboratories, Berkeley, California.
- Bureau of Census. 1972. "1972 Census of Service Industries series on Engineering Architectural and Surveying Services." Bureau of Census, Washington, D.C.
- Bureau of Census. 1979a. "Electric Lighting Fixtures." MA-36L(79)-1, Bureau of Census, Washington, D.C.
- Bureau of Census. 1979b. "Fluorescent Lamp Ballasts." MQ-36C(79)-5, Bureau of Census, Washington, D.C.
- Cyert, R. and J. March. 1963. A Behavioral Theory of the Firm. Prentice-Hall, Englewood Cliffs, New Jersey.
- Mintzberg, H., D. Raisinghani and A. Theoret. 1976. "The Structure of Unstructured Decision Processes." Administration Science Quarterly (21):246-275.
- Schwartz, R. 1981. "More Efficient Lamps Offer Quick Return." Energy Users News. 6(6):1.
- Verderber, R. R. 1980. "Electronic Ballast Improves Efficiency." Electrical Consultant. 60(6):22-26.
- Wilson, J. Q. (ed.) 1980. The Politics of Regulation. Basic Books, New York, New York.
- Yergin, D. Sunday, October 12, 1980. Conservation Editorial. Wall Street Journal.

BIBLIOGRAPHY

Benenson, P. and J. Nides. 1979. "Lighting Energy Conservation in Federal Office Buildings: Implementation Procedures and Obstacles." LBID-063, EEB-L-79-02, Lawrence Berkeley Laboratory, University of California, Berkeley, California.

Iota Engineering. 1977. "Phase I Report on Energy Efficient Electronic Ballasts for a Two-40Watt Fluorescent Lamp System." Prepared for Lawrence Berkeley Laboratory, University of California, by Iota Engineering, Inc., Tucson, Arizona.

Pacific Gas & Electric Company. 1980. "Evaluation of High Frequency Electronic Fluorescent Lamp Ballasts." Report 500-79.59, Pacific Gas and Electric Company, Department of Engineering Research, San Francisco, California.

Stevens Lumioptics Corporation. 1978. "Phase I Final Report Subcontract No. 2019702 'Energy Efficient Fluorescent Ballasts'." LBL-7852, UC-95a, EEB-L-78-04, L-13, prepared for Lawrence Berkeley Laboratory by Stevens Lumioptics Corporation, San Ramon, California.

Verderber, R. R. 1980. "Electronic Ballast Improves Efficiency." Electrical Consultant. 60(6).

Verderber, R. R. 1980. "The 'Real' Energy Savings with Electronic Ballasts." LBL-10707, EEB-L-80-01, L32, Lawrence Berkeley Laboratory, University of California, Berkeley, California.

Verderber, R. R. and O. Morse. 1980. "On-Site Demonstration Procedure for Solid-State Fluorescent Ballast." LBL-11619, L-37, EEB-L-80-07, Lawrence Berkeley Laboratory, University of California, Berkeley, California.

U.S. Department of Commerce. 1979. Electric Lighting Fixtures. MA-36L(79)-1, U.S. Department of Commerce, Bureau of the Census, Washington, D.C.

U.S. Department of Commerce. 1979. Fluorescent Lamp Ballasts. MQ-36C(79)-5, U.S. Department of Commerce, Bureau of the Census, Washington, D.C.

APPENDIX A

TRADE ORGANIZATIONS AND THEIR PUBLICATIONS

APPENDIX A

TRADE ORGANIZATIONS AND THEIR PUBLICATIONS

AMERICAN ASSOCIATION OF COST ENGINEERS

308 Monongahela Building
Morgantown, West Virginia 26505

Exec. Director: Kenneth K. Humphreys
(304) 296-8444
Membership: 4,000
Staff: 6-10
Annual Budget: \$100-250,000

Publications:

Cost Engineering	bimonthly/adv.
Cost Engineers Notebook	irregular
Directory	annual
Transactions	annual

Annual Meetings: June or July

A professional society of individuals interested in the solution of problems of estimating, cost control and profitability

AMERICAN CONSULTING ENGINEERS COUNCIL

Suite 802
1015 15th St. N.W.
Washington, D.C. 20005

Exec. Director: Larry N. Spiller
(202) 347-7474
Membership: 3,500
Staff: 25-30
Annual Budget: \$1-2,000,000

Publications:

Directory	annual
International Directory	biannual
Last Word	weekly

Semiannual Meetings Spring/Fall

Supports the American Consulting Engineers PAC

AMERICAN ELECTRONICS ASSOCIATION

2600 El Camino Real
Palo Alto, CA 94306

Pres: E. E. Ferrey, CAE
(415) 327-9300
Membership: 1,200-1,300 companies
Staff: 35-40
Annual Budget: \$2-5,000,000

The largest trade association serving the electronic and information technology industries. Supports the American Electronics Association Electro PAC.

AMERICAN HOME LIGHTING INSTITUTE
230 North Michigan Avenue
Chicago, IL 60601

Director: Arnold W. Rodin
(312) 236-3816
Membership: 500-550
Staff: 6-10
Annual Budget: \$250-500,000

Publications:

Light Rays	bimonthly
Transportation Notes	quarterly

Annual Meetings	Fall
-----------------	------

Membership is manufacturers and distributors of lamps, fixtures and their component parts.

AMERICAN INSTITUTE OF ARCHITECTS
1735 New York Avenue N.W.
Washington, D.C. 20006

Exec. VP: David O. Meeker, Jr.
(202) 785-7300
Membership: 26,000 licensed architects
Staff: 140-150
Annual Budget: \$2-5,000,000

Publications:

AIA Journal	monthly/adv.
Memo	biweekly

Annual Meetings	Spring
-----------------	--------

Promotes the standards of architecture and the interest of the architectural professional; the umbrella organization of the U.S. architectural profession.

AMERICAN INSTITUTE OF BUILDING DESIGN

#138, 2730 Arden Way
Sacramento, CA 95825

Exec. Director: Ms. Diana Partos
(916) 483-2423
Membership: 500-600
Staff: 2-5
Annual Budget: \$25-50,000

Publications:

Newsletter	quarterly/adv.
Professional Designer	monthly/adv.

AMERICAN INSTITUTE OF CONSTRUCTORS

1140 N.W. 63rd Street
Oklahoma City, OK 73116

Exec. Director: Glenn A. Dowdy
(405) 843-5531
Membership: 1,800-1,900
Staff: 2-5
Annual Budget: \$100-250,000

Publications:

The Professional Constructor semiannually

Annual Meetings January

Serves as the qualifying body for individuals in the construction profession. Founded the American Council for Construction Education, the recognized accredited agency for colleges and universities grants four-year degrees in construction.

AMERICAN INSTITUTE FOR DESIGN AND DRAFTING

3119 Price Rd
Bartlesville, OK 74003

Exec. VP: Norman N. Freling
(918) 333-1053
Membership: 2,600
Staff: 2-5
Annual Budget: \$100-250,000

Publications:

Design and Drafting News monthly

Annual Meeting April

Seeks to promote improved quality and efficiency in the drafting profession and industry.

AMERICAN INSTITUTE OF INDUSTRIAL ENGINEERS

25 Technology Park
Atlanta, GA 30092

Exec. Director: David L. Belden, P.E.
(404) 449-0460

Membership: 32,000

Staff: 35-40

Annual Budget: \$2-5,000,000

Publications:

AIIE Transactions	quarterly
The Engineering Economist	quarterly
Industrial Engineering	monthly/adv.

Annual Meetings	May
-----------------	-----

ASSOCIATED INDEPENDENT ELECTRICAL CONTRACTORS OF AMERICA

Suite 201
1201 North Watson Road
Arlington, TX 76011

Exec. Director: John M. Portwood
(817) 640-8121

Membership: 550-600 companies

Annual Budget: \$250-500,000

Publications:

Independent Electrical Contractor Magazine	bimonthly
News Circuit Newsletter	biweekly

Annual Meetings	Fall
-----------------	------

ASSOCIATION OF CONSULTING MANAGEMENT ENGINEERS, INC.

230 Park Avenue
New York, New York 10017

Exec. VP: Joseph J. Brady
(212) 679-9693

Membership: 50-60 companies

Staff: 2-5

Annual Budget: \$100-250,000

Members are domestic and international management consulting firms.

ASSOCIATION OF ENERGY ENGINEERS, INC.

Suite 340
4025 Pleasantdale Road
Atlanta, GA 30340

Exec. Director: Albert Thumann, P.E.
(404)447-5083
Membership: 2,000
Staff: 2-5
Annual Budget: \$50-100,000

Publications:

Energy Engineering	bimonthly/adv.
Energy Management Magazine	monthly

Annual Meetings	Fall
-----------------	------

Licensed professional engineers, architects and consultants with experience in the conservation and development of energy sources. Concerned with energy conservation, new energy sources, solar and wind power engineering.

CERTIFIED BALLAST MANUFACTURERS ASSOCIATION

2120 Keith Bldg.
Cleveland, OH 44115

Secretary-Treasurer: M. R. Davies
(216) 241-0711
Membership: 6-10 fluorescent lamp ballast manufacturers
Staff: 2-5
Annual Budget: \$10-25,000

Publication:

CBM News	quarterly
----------	-----------

Coordinates lobbying efforts and disseminates information on the ballast market developments.

CONSTRUCTION SPECIFICATIONS INSTITUTE

1150 Seventeenth Street N.W.
Washington, D.C. 20036

Editor: Donald Day
(202) 833-2160
Membership: N/A
Staff: N/A

Publications:

Constructions Specifier monthly/adv.

Produces the magazine of construction practices and technology.

ELECTRIC POWER RESEARCH INSTITUTE

P.O. Box 10412
Palo Alto, CA 94303

President: Floyd Culler, Jr.
(415) 855-2000
Membership: 5-600 Electric Utilities

Publications:

EPRI Journal monthly

Researches electrical energy and development.

ELECTRICAL-ELECTRONICS MATERIAL DISTRIBUTORS ASSOCIATION

RFD # 1
Sheffield ME 01257

Exec. VP: Walter E. Hugger
(413) 229-2867
Membership: 50 individuals 20-30 companies
Staff: 1
Annual Budget: \$10-25,000

Annual Meetings Spring

Affiliated with the National Association of Wholesaler-Distributors.

ELECTRICAL EQUIPMENT REPRESENTATIVES ASSOCIATION

1308 Pennsylvania
Kansas City, MO 64105

Exec. Director: John S. McDermott
(816) 221-0918
Membership: 90-100 Companies
Staff: 1
Annual Budget: \$25-50,000

Publications:

EERA Directory annual

ELECTRICAL INDUSTRY STUDY BOARD

Suite 3614
One East Wacker Dr
Chicago, IL 60601

Exec. Director: Michael P. Fallon
(312) 467-6574
Membership: 4,500-5,000 Companies
Staff: 2-5
Annual Budget: \$500,000-1,000,000

Publications:
Conduit quarterly
Annual Meetings October

Does research on marketing methods, manufacturing technologies, new products and tools for the electrical contracting industry.

ELECTRICITY CONSUMERS RESOURCE COUNCIL

Suite 314
1225 Connecticut Avenue N.W.
Washington, D.C. 20036

Exec. Director: Jay B. Kennedy
(202) 466-3066
Membership: 15 companies
Staff: 2-5

Publication:
Elcon Report irregular

Members are industrial electricity consumers who support the examination of electricity regulatory practices with the purpose of minimizing generation and distribution costs.

ENGINEERING FOUNDATION

345 East 47th Street
New York, New York 10017

Exec. Director: John A. Zecca
(212) 644-7828
Membership:
Staff:
Annual Budget: \$2-5,000,000

Semiannual Meetings Spring and Fall

Includes five major engineering societies (including Institute of Electrical and Electronic Engineers), as a department of United Engineering Trustees. Supports engineering research. Not a membership organization.

FEDERAL CONSTRUCTION COUNCIL

c/o National Academy of Sciences
2102 Constitution Avenue N.W.
Washington, D.C. 20418

Exec. Secretary: Henry A. Borger
(202) 398-6497

Membership: 9 agencies

Staff: 6-10

Annual Budget: \$100,000-250,000

Publications:

General Newsletter	bimonthly
Transactions of the FCC	annual

Members are professional employees of federal agencies and participants on the Board to the National Academy of Sciences. Encourages cooperation among federal construction agencies.

ILLUMINATING ENGINEERING SOCIETY

345 East 47th Street
New York, New York 10017

Exec. VP: Frank M. Coda

(212) 644-7913

Membership: 10,000-11,000

Staff: 20-25

Annual Budget: \$500,000-1,000,000

Publications:

IES Lighting Handbook	every five years
Journal of the Illuminating Engineering Society	quarterly
Lighting and Design Application	monthly/adv.

Annual Meetings

Summer

Sponsors the Illuminating Research Institute.

INSTITUTE OF BUSINESS NON-RESIDENTIAL DESIGNERS

Suite 2705
1350 Avenue of the Americas
New York, New York 10019

Exec. Director: Ted Materna
Membership: 850-900
Staff: 2-5
Annual Budget: \$100-250,000

Publications
News Bulletin monthly

Nonresidential interior designers and allied manufacturers of related products.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.
345 East 47th Street
New York, New York 10017

Exec. Director: Eric Herz
(212) 644-7900
Membership: 190,000
Staff: 275-300
Annual Budget: \$5,000,000

Publications:
Proceedings monthly
Spectrum monthly/adv
35 monthly transactions journals

International professional organization.

INTERNATIONAL ASSOCIATION OF LIGHTING MAINTENANCE CONTRACTORS
Tower Suite 507, 301 Maple Avenue
West Vienna, VA 22180

Exec. Director: Robert C. LaGasse, CAE
(703) 938-3339
Membership: 200 companies
Staff: 2-5
Annual Budget: \$50,000-100,000

Publications:
Main Lighter seven per year/adv

Includes companies that clean, repair and maintain commercial and industrial lighting fixtures.

INTERPROFESSIONAL COUNCIL ON ENVIRONMENTAL DESIGN
c/o AICP, 1776 Massachusetts Avenue N.W.
Washington, D.C. 20036

Secretary: Israel Stollman
(202) 872-0611
Membership: 6 societies
Staff: 1
Annual Budget: \$10,000

Members include: AIA, American Consulting Engineers Council, American Institute of Certified Planners, American Society of Consulting Planners, American Society of Landscape Architects, the American Society of Civil Engineers, and the National Society of Professional Engineers. Monitors federal legislation affecting the quality of life.

NATIONAL ASSOCIATION OF ELECTRICAL DISTRIBUTORS
600 Summer Street
Stamford, CT 06901

Exec. Director: Arthur Hooper
(203) 327-1290
Membership: 1,900
Staff: 30
Annual Budget: \$1-2,000,000

Publications:
The Electrical Distributor monthly/adv

Association of Jobbers and Wholesalers.

NATIONAL ASSOCIATION OF ENVIRONMENTAL PROFESSIONALS
Suite 805
1901 North Moore Street
Arlington, VA 22209

Exec. Secretary: Ms. Penny Harrison
(703) 522-2727
Membership: 600-650
Staff: 2-5
Annual Budget: \$25,000-50,000

Publications:
Newsletter monthly

Individuals involved in environmental planning.

SOCIETY OF AMERICAN REGISTERED ARCHITECTS
2011 West Pershing Road
Chicago, IL 60609

President: Richard Shields
(312) 247-1700
Membership: 900-1,000
Staff: 1
Annual Budget: \$50,000-100,000

Publications:
Practicing Architect quarterly/adv

Annual Meetings Fall

Splinter group of AIA, preferring architects remaining involved in the designing process to the exclusion of the role of contractors.

TECHNICAL MARKETING SOCIETY OF AMERICA
Box 91113
Los Angeles, CA 90009

Exec. Director: Mark R. Johnson
(213) 649-2426
Membership: 3,000
Staff: 2-5
Annual Budget: \$100,000-250,000

Publications:
Areospace Market Outlook bimonthly
Newsletter bimonthly
Selected Readings bimonthly
Seminar Proceedings annual

Engineers interested in marketing technical products and data.

TECHNOLOGY TRANSFER SOCIETY
NIAC-USC Denny Res. Bldg.
Los Angeles, CA 90007

Secretary: Sy Gottlieb
(213) 741-2371
Membership: 200
Staff: 2-5
Annual Budget: \$10,000-25,000

Publications:
Journal of Technology Transfer Semiannually
Newsletter quarterly

Annual Meetings June

Concerned with the transfer of technology among disciplines such as science, engineering, management, education, and information science.

APPENDIX B

TRADE AND PROFESSIONAL JOURNALS

APPENDIX B

TRADE AND PROFESSIONAL JOURNALS

The business-related publications for which extensive information has been gathered on circulation, field market served, business and occupational analysis of readership, and editorial content of past issues have been audited by one of two organizations:

Business Publications Audit of Circulation, Inc.
360 Park Avenue South
New York, New York 10010

Audit Bureau of Circulation
900 North Meacham Road
Schaumburg, Illinois 60195

The information reproduced in this appendix was taken from Publisher's Statements or from Media Comparability Council's Media Data Form. This information was designed to be used in conjunction with Standard Rate and Data Service (SRDS) information, Publisher's Rate Cards, Circulation Audits and other available information characterizing the readership of the publication or their perception of the validity of the information contained in it. Additional information describing advertising rates, editorial policies, and author's guidelines is available on file.

Five periodicals were reviewed:

AIA Journal
Progressive Architecture
The Construction Specifier
Lighting Design and Application
Industrial Engineer

Additional information on several other periodicals is on order from BPA. The periodicals of interest are listed in the last section of this appendix.

Additional information is available from Standard Rates and Data Service, and The Aires Directory. Both list trade publications and give statistical analyses of each.

American Institute of Architects
1735 New York Avenue N..W.
Washington, D.C. 20006
(202) 626-7485

AIA JOURNAL

Field Served:

The AIA Journal (official publication of the AIA) serves the architecturally designed construction market. The AIA journal is a restricted circulation periodical. To receive the periodical recipients must be registered architects and architectural employees, including a limited number of corporate members (not registered architects).

Circulation:

Average nonqualified	9,000
Average qualified	<u>31,500</u>
	40,000

Business/Occupational Breakdown of Qualified Circulation

For Issue of May 1980:

	total copies	% of total
Registered Architects.....	29,588	83.4%
Architectural Employees.....	5,887	16.6%

Information taken from BPA Publisher's Statement, June 1980.

PROGRESSIVE ARCHITECTURE

Reinhold Publishing
600 Summer Street
Stamford, CT 06904
(203) 348-7531

Field Served:

Progressive Architecture's reader audience includes persons from all functions within the architectural design field and persons who have design and specifying responsibilities. This periodical is not a limited circulation publication; however, it does serve a highly specialized group of professionals in architecture and engineering firms throughout the nation.

Circulation:

1979 average paid circulation (last 6 months)..... 71,949

Circulation to Field Served Analyzed by Business/Industry Classification:

<u>Business Class</u>	<u>Circulation</u>
Architectural, A/E Firms	37,855
Architectural Designers	865
Designers other than above	6,739
Consulting Engineers Firms	3,214
Contractors & Builders	4,234
Government	3,792
Commercial, Industrial & Institutional	4,602
Building Materials & Equipment Mfg.	782
Universities etc.	9,163
Misc.	<u>2,304</u>
Total.	73,550

Editorial Content

Special Reports: Topical Analysis

	<u>Number of Pages</u>	<u>% of total</u>
P/A Awards	47	
Energy Conscious Design	79	
Monumentality	31	
Interior Design	61	
Preservation & Remodeling	31	

Beyond Modernism	<u>41</u>	
	290	33.6%
Architectural Design	327	37.8%
Interior Design	113	13.1%
Planning/Urban Design	34	3.9%
Technical	89	10.3%
Products/Literature	54	6.3%

Information taken from ABC Media Comparability Council's Media Data Form for 1980.

THE CONSTRUCTION SPECIFIER

The Construction Specifications Institute
1150 Seventeenth Street N.W.
Suite 300
Washington, D.C. 20036
(202) 833-2160

Field Served:

The Construction Specifier serves individuals involved with construction specifications in architectural and engineering firms and architectural departments of industrial, governmental, institutional and other organizations in the architectural market. The circulation list is limited to individual specification writers, architects, consultants and engineers, draftspeople, contractor's consultants, contractors, producers and/or distributors of construction materials, equipment or supplies. A limited number of persons like students and educators in allied fields are also included.

Circulation:

As of the June 1980 issue there were 13,705 recipients.

Business/Occupational Breakdown of Qualified Circulation for May 1980:

<u>Classification by Occupation</u>	<u>No. of issues</u>	<u>% of total</u>
Architects/Engineers/Spec. writers	7,877	55 %
Contractors	1,711	12 %

Draftspeople	83	0.6%
Distributors/Mfg firms	3,281	22.9%
Exec. officers of Professional groups	221	1.6%
Educators/Students/Insurance Counselors	<u>1,137</u>	7.9%
	14,310	

Information taken from BPA Publisher's Statement, June 1980.

LIGHTING DESIGN AND APPLICATION

Illuminating Engineering Society of North America
 345 East 47th Street
 New York, New York 10017
 (212)

Field Served:

Lighting Design and Application contains information and articles on the latest lighting techniques and products including commercial, industrial, and residential application.

Circulation:

As of June 30, 1980, total average paid circulation was 11,071.

Business/Occupational Analysis of Circulation for the May 1980 Issue:

<u>Classification by Business</u>	<u>Total Subscriptions</u>
A/E firms, Interior & Lighting Design firms	3,558
Commercial Industrial Users	588
Electric Utilities	887
Distributors & Wholesalers	1,578
Electrical Contracting firms	633
Medical Personnel & Educators	479
Engineers.	1,714
Misc..	<u>1,860</u>
B.5	Total . . . 11,297

Information taken from Lighting Design and Application, June 1980.

INDUSTRIAL ENGINEERING

25 Technology Park/Atlanta
Norcross, GA 30092
(404) 449-0460

Field Served:

Industrial Engineer is a publication of the American Institute of Industrial Engineers, Inc. and is a limited circulation periodical. To qualify for membership in AIIE and receive a paid subscription of this periodical, an individual must be trained through academic and/or working experience to apply industrial engineering concepts and knowledge to the problems they face as managers or engineers in manufacturing, service industries, or government. Activity in the field of Industrial Engineering typically draws upon specialized knowledge and skills in mathematics, physical and social sciences, together with the principles and methods of engineering analysis and design to specify, predict, and evaluate results of the system's organization. Ninety percent of the membership holds a minimum of a B.S. degree.

Circulation:

As of 1979 total circulation was 25,725 (last six months' average).

Functional/Occupational Analysis of Subscribers for the May 1980 Issue:

<u>Job Function</u>	<u>Recipients</u>	<u>% of Total</u>
General Management	2,757	7.4%
Functional Managers/Dept. Heads	4,843	13.1%
Supervisors of Technical or Professional Personnel	4,730	12.8%
Engineers, Analysts	5,284	14.3%
Educators	877	2.4%
Consultants	1,370	3.7%
Others	<u>14,022</u>	
Total	37,000	

Analysis of Editorial Pages by Major Subjects Covered in 1979:

<u>Subjects Covered</u>	<u>Number of Pages</u>	<u>% Of Total</u>
Facilities Layout Design	20	3.2
Material Handling, Storage	61	9.5
Personnel: Productivity/ Training, etc.	132	20.2
Computer Information Mgmt Systems	59	9.1
Office of the Future	6	1.0
Forecasting and Planning Methods	33	5.1
Cost Reduction and Productivity	77	11.8
Energy Management and Conservation	25	3.9
Coverage of Institute Activities	105	16.1
Maintenance	15	2.3
New Products & Literature	81	12.4
Miscellaneous	<u>122</u>	18.7
	653	

Information taken from BPA Media Comparability Council's Media Data Form 1980.

The following group of periodicals was identified from the Directory To The BPA Buyer's Guide and Market Comparability Programs, June 1980. This listing includes periodicals viewed as potentially valuable for the Solid State Ballast Information Dissemination Program. The titles are listed by topic or line of business. The publisher's statements are on order at minimal cost.

<u>ID #</u>	<u>Business</u>	<u>Title</u>
164	Architecture	* <u>AIA Journal</u> <u>Architectural Design Cost and Data</u> <u>Architectural Record</u>
206	Building Construction	<u>Building Design and Construction</u>
209	Building Management	<u>Building Operation and Management</u> <u>Buildings - The Construction and Bldg</u> <u>Mgmt Journal</u>

257	Consulting Engineers	<u>Consulting Engineer</u> <u>Electrical Consultant</u> <u>Specifying Engineer</u>
311	Electrical Goods-Wholesale	<u>The Electrical Distributor</u>
320	Electronics	<u>EDN</u> <u>Electronics Engineers Master</u> <u>Electronic Component News</u> <u>Electronic Design</u> <u>Electronic Engineering</u> <u>Electronic Engineering Times</u> <u>Electronic Products Magazine</u> <u>IEEE Communications Spectrum</u> <u>Micro Electronic Manufacturing and</u> <u>Testing</u>
497	Lamps & Lighting Retailers	<u>Home Lighting & Accessories</u>
655	Manufacturing/Industries, Equipment, Products & Systems	<u>Industrial Equipment News</u> <u>Industrial Product Bulletin</u> <u>New Equipment Digest</u>
Awaiting assignment to a market classification:		<u>*The Construction Specifier</u> <u>Electrical Energy Management</u> <u>Energy International</u> <u>Energy Management</u>

REFERENCES - APPENDIX B

Audit Bureau of Circulations. 1980. Business Publication Publisher's Statement. Audit of Lighting Design and Application by Audit Bureau of Circulations. Available from Lighting Design and Application, New York, New York.

Audit Bureau of Circulations. 1980. Media Data Form. Audit of Progressive Architect by Audit Bureau of Circulations. Available from Progressive Architect, Stanford, Connecticut.

Business Publications Audit. 1980. Media Data Form. Audit of Industrial Engineering by Business Publications Audit. Available from Industrial Engineering, Norcross, Georgia.

Business Publications Audit. 1980. Publisher's Statement. Audit of AIA Journal by Business Publications Audit. Available from AIA Journal, Washington, D.C.

Business Publications Audit. 1980. Publisher's Statement. Audit of The Construction Specifier by Business Publications Audit. Available from The Construction Specifier, Washington, D.C.

APPENDIX C

ETL TESTING LABORATORIES, INC.
Letter Report No. 449151

ETL Testing Laboratories, Inc.

Formerly Electrical Testing Laboratories, Inc.

Industrial Park Cortland, New York 13045 Telephone 607-753-6711 TWX 510 252 0792

Testing Inspection Certification

Acoustical • Air Conditioning & Refrigeration • Chemical • Electrical • Mechanical • Photometric

Letter Report No. 449151

April 29, 1980

Order No. 17257L

Mr. Tom Kohler
EETech, Div. of Beatrice Foods
2735 Brundage Road
Baldwinsville, NY

Dear Mr. Kohler:

We have completed the illumination measurements produced by the dual lamp "Visionair" Luminaire which you supplied with different ballasts. The results are tabulated below:

<u>Ballast</u>	<u>Lamp</u>	<u>Bulb Wall Temperature</u>	<u>System Input Watts</u>	<u>Illumination Footcandles</u>	<u>Footcandles Per Watt</u>
1022	Mainlighter CW	115.7	93.2	220	2.37
	Wattmiser II	105.8	82.5	212	2.57
	Wattmiser WW	106.9	82.4	209	2.53
1024	Mainlighter CW	113.8	84	229	2.73
	Wattmiser II	104.7	72.9	207	2.83
1028	Mainlighter CW	113.8	84.2	219	2.60
	Wattmiser II	105.7	74.3	214	2.88
	Wattmiser WW	106.8	75.0	211	2.82
EETECH 4/22-3	Mainlighter CW	110.9	66.3	198	2.98
	Wattmiser II	104.9	59	202	3.43
	Wattmiser WW	104.7	58.5	195	3.34

(All measurements were performed with the luminaire operated at 120 volts A.C.)

Report No. 449151

2.

The illumination measurements were made in a room having nominal reflectances of 80% ceiling, 50% wall and 30% floor having dimensions of 15 feet long x 14 feet wide at a mounting height of 6-1/2 feet.

This work was authorized by your Purchase Order Number 0483.

Yours truly,

P. R. Smester, Manager
Photometric Laboratory

PRS/mm

DISTRIBUTION

No. of
Copies

No. of
Copies

OFFSITE

A. A. Churm
DOE Patent Division
9800 S. Cass Avenue
Argonne, IL 60439

27 DOE Technical Information
Center

12 Gene De LaTorre
Conservation and Renewable
Energy Division
U.S. Department of Energy
Room 1H050
Forrestal Building
1000 Independence S.W.
Washington, DC 20585

John Cuttica
Conservation and Renewable
Energy Division
U.S. Department of Energy
Room 6H065
Forrestal Building
1000 Independence S.W.
Washington, DC 20585

Kerry Stroup
30 Broadstreet E.
34th Floor
Columbus, OH 43215

Dr. James C. Fletcher
Energy Resources Program
1140 Benedum Hall
University of Pittsburgh
Pittsburgh, PA 15261

Dr. James T. Cobb
Energy Resources Program
1140 Benedum Hall
University of Pittsburgh
Pittsburgh, PA 15261

3 Rudy Verderber
University of California
Berkeley, CA 94720

James Jewell
Pacific Gas & Electric
77 Beale Street
San Francisco, CA 94106

Thomas V. Bonoma
Graduate School of Business
Marketing Department
Harvard University
Cambridge, MA 02138

Mitt Nathanson
Universal Manufacturing
200 Robin Road
Paramus, NJ 07652

ONSITE

DOE Richland Operations

H. E. Ransom

36 Pacific Northwest Laboratory

R. S. Campbell (6)
D. E. Deonigi
D. R. Johnson (24)
V. L. Lee
P. N. Petty
L. A. Skumatz
L. D. Williams
T. L. Willke
Publishing Coordination (2)
Technical Information (5)

14 Human Affairs Research Centers

C. Eschbach
A.A. Marcus (12)
P Sommers