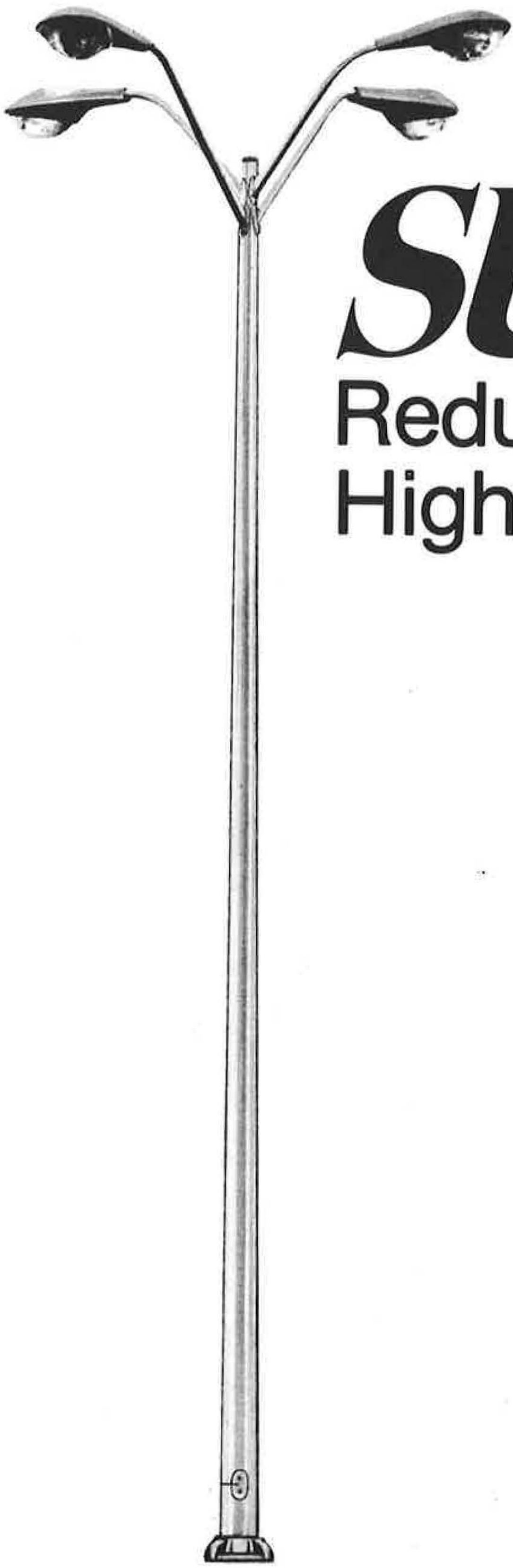

SUNUP

Reduces Cost of Highway Lighting

Ronald E. Stemmler and
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In his book, ***World Horizons,*** Cole D. Robinson relates this incident: When Benjamin Franklin wished to interest the people of Philadelphia in street lighting, he did not try to persuade them by just talking about it. He hung a beautiful lantern on a long bracket in front of his home. He kept the glass brightly polished, and he carefully lit the wick every evening at the approach of dusk. People walking about on the dark street saw Franklin's light a long way off and "came under the influence of its friendly glow." It seemed to be saying to everyone, "Come along my friend! Here is a safe place to walk. See that cobblestone sticking up? Don't stumble over it! Good-bye! I shall be here to help you again tomorrow night, if you should come this way." It was not long before Franklin's neighbors also began placing lights on brackets outside their homes. Soon the entire city realized the value of street lighting, and many followed his example with enthusiasm.

Since the early days of street lighting, there have been many changes in design and practice. Present practice is to mount lamps, usually with a mercury vapor illumination source, on towers often 12 to 18 m (40 to 60 ft) in height. Recently, sodium vapor lamps have been used, and tower heights are sometimes 30 m (100 ft). Regardless of the forms of the lighting source, the cost of electricity to operate them has always been a concern. In the past years, this concern has increased because of energy shortages. The investigation and analysis discussed in this

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article represent a tangible effort by the Ohio Department of Transportation to bring these high costs under control. This has come about primarily through use of a standardized contract and operating procedures contained in a manual called ***Strategy for Uniform Negotiation and Utilization of Power*** (SUNUP), prepared by the consulting firm of Ronald E. Stemmler and Associates (RESA). An additional benefit of this research is an estimated savings in energy costs of $250,000 per year.

The RESA research team uncovered several factors that were instrumental in improving the clarity of contracts as well as reducing the ultimate costs of the agreements. The department's effectiveness in operating its highway lighting system was rated by the use of a checklist (Figure 1), which is based on those factors that were found to be most critical in highway lighting operations.

The Interstate highway illumination operation in Ohio costs $1 million annually for electric energy purchased from several power companies in the state. Costs for operating the Interstate lighting system would have doubled in fiscal year 1975 had the power agreements being negotiated at that time been consummated. With limited operating funds available to the Ohio Department of Transportation, those increases in operating costs needed to be forestalled. The department, therefore, sought alternative operating policies based on appropriate data and information for effective managerial decisions.

At the time the study began, rate negotiations were

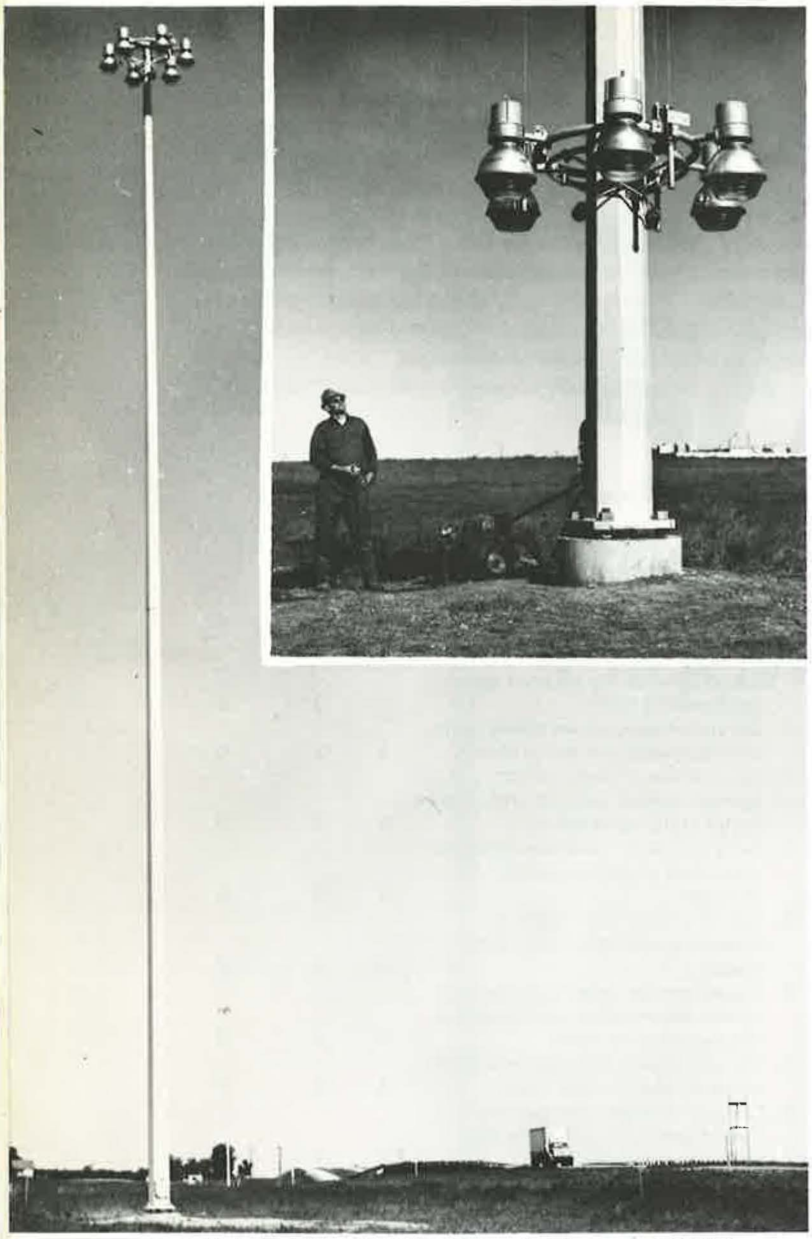
Figure 1 Transportation agency strategy checklist.

Circle the score that closely represents your agency (state, city, etc.).

	Yes	Unsure Possibly	No
1. Do you have an electric utilities specialist presently on your agency headquarters staff?	5	3	0
2. Do you presently have power utility contracts with 2 or less utilities?	5	2	0
3. Do you have a single, uniform, agency-initiated contract that is used for all utility agreements?	5	2	0
4. Are your utility contracts formally negotiated at agency-owned facilities	3	2	0
5. Are all of your rates based on metered usage rather than flat usage?	4	2	0
6. Is your energy usage from multiple meters accumulated and billed at a volume/discount level?	7	4	0
7. Are you eligible for a separate tariff based on your volume usage?	4	2	0
8. Do your contracts separate the maintenance portion of the rates from the energy portion?	3	1	0
9. Do you currently have an operation preventive maintenance program?	2	1	0
10. Do you exclusively use agency work forces for maintenance activities?	2	1	0
11. Do you keep at least 75% of your highway lighting in operation at all times?	4	2	0
12. Do you keep at most 95% of your highway lighting in operation at all times?	6	3	0

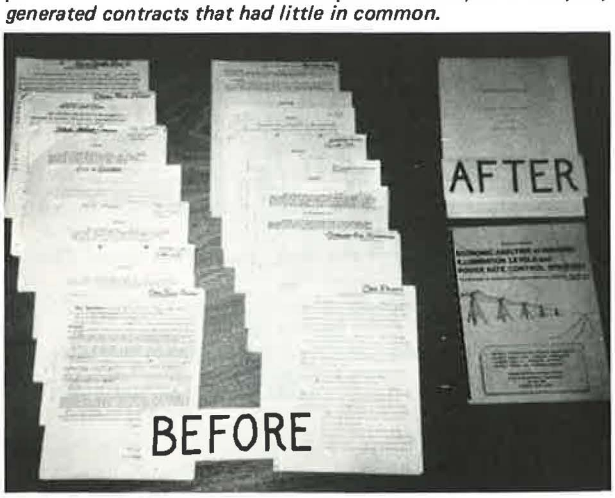
Add your circled scores for TOTAL SCORE

TOTAL SCORE	PROGNOSIS OF YOUR AGENCY STRATEGY
45-50 points	Excellent strategy, your program obviously needs no improvement.
38-44 points	Good strategy, your program could possibly be improved.
25-37 points	Average strategy, your program could definitely be improved.
0-24 points	Weak strategy, your program definitely needs improvement.



High mast lighting reduces normal maintenance requirements since they are high above the road oil and dust pollutants.

A single, agency-generated, standardized contract for negotiating power rates with electric utilities replaces a multiple of company-generated contracts that had little in common.



possible, but sufficient data were not available to define existing rates, trends, and comparisons. Decreased levels of illumination were also considered. However, the costs were not available. Furthermore, the enforcement by the Federal Highway Administration of the standards of the American Association of State Highway and Transportation Officials and the American National Standards Institute constrained many such alternatives. A final complexity was added to the problem by the fact that a number of power companies refused to offer minor maintenance services that the department had to perform at additional cost.

Facing increasing electrical rates, unsettled contracts, and departmental budget limitations, the Ohio Department of Transportation asked RESA to review, examine, and analyze the entire process of purchasing electrical energy and to recommend ways to ensure necessary levels of illumination at costs ultimately beneficial to Ohio's taxpayers.

Summary of the Research

The research was undertaken in three phases: analysis of energy rate structure and trends, analysis of alternative illumination levels, and development of strategies for negotiation and operation.

ANALYSIS OF ENERGY RATE STRUCTURES AND TRENDS

In phase 1, a detailed analysis was made of the six electric utilities that sold energy to the state as a basis for predicting cost increases. The major cost sources and their trends were identified, and an extensive and detailed investigation of the following component costs of power production was conducted.

Component	Percentage of Cost
Fuel	41
Operation	17
Taxes	12
Purchased Power	11
Depreciation	11
Maintenance	8

Fuel represents 41 percent of operating expenses. To understand the impact of this major cost component, especially as experienced by the consumer, we investigated the fuel adjustment procedure that is used by utility companies to account for fuel adjustment clauses that are subject to regulation by the state public utilities commission.

The following information illustrates how fuel costs and fuel adjustments are calculated for a specific company. All adjustment factors are based on the same formula, but the numbers vary.

1. **Fuel base and fuel adjustment factor.** Rates are based on a fuel cost of 39.9¢/million Btu. When fuel costs change, prices per kWh are changed by 0.00096 ¢/kWh for

each change in fuel cost of a full 0.1¢/million Btu. This fuel adjustment factor or translator was established in 1973, when the power plants used 9,695 Btu to produce each kWh; it was calculated as follows for each change in cost of 0.1¢/million Btu:

$$\frac{0.1¢/\text{million Btu}}{1{,}000{,}000 \text{ Btu}} \times \frac{9{,}695 \text{ Btu}}{\text{kWh}} = 0.0009695¢/\text{kWh}$$

Fuel adjustment factor = 0.00096¢/kWh (rounded)

2. Calculation of monthly fuel cost. The fuel consumed during each month is priced at the weighted average cost of the fuel inventory at the beginning of the month and fuel receipts during the month. For January 1975, this was

1,740,011 tons of coal consumed at $21.41/ton = month and fuel receipts during the month. For January 1975, this was

1,740,011 tons of coal
consumed at $21.41/ton = $37,254,993
1,528,157 gal of oil
consumed at $0.3246/gal = 495,977
Total = $37,750,970

3. Calculation of heat produced. The fuel is tested before burning to determine its heat content (Btu/lb or Btu/gal), and the monthly heat total is calculated. For January 1975, this was

1,740,011 tons of coal
x 10,821 Btu/lb
x 2,000 lb/ton = 37,658,246,000,000
1,528,157 gal of oil
x 137,022 Btu/gal = 209,391,000,000
Total Btu = 37,867,637,000,000

4. Calculation of average cost per million Btu. For January 1975, this was

$37,750,970 ÷ 37,867,637,000,000 Btu =
99.6¢/million Btu

5. Determination of monthly fuel adjustment amount. The monthly fuel adjustment amount was calculated for January 1975, as follows:

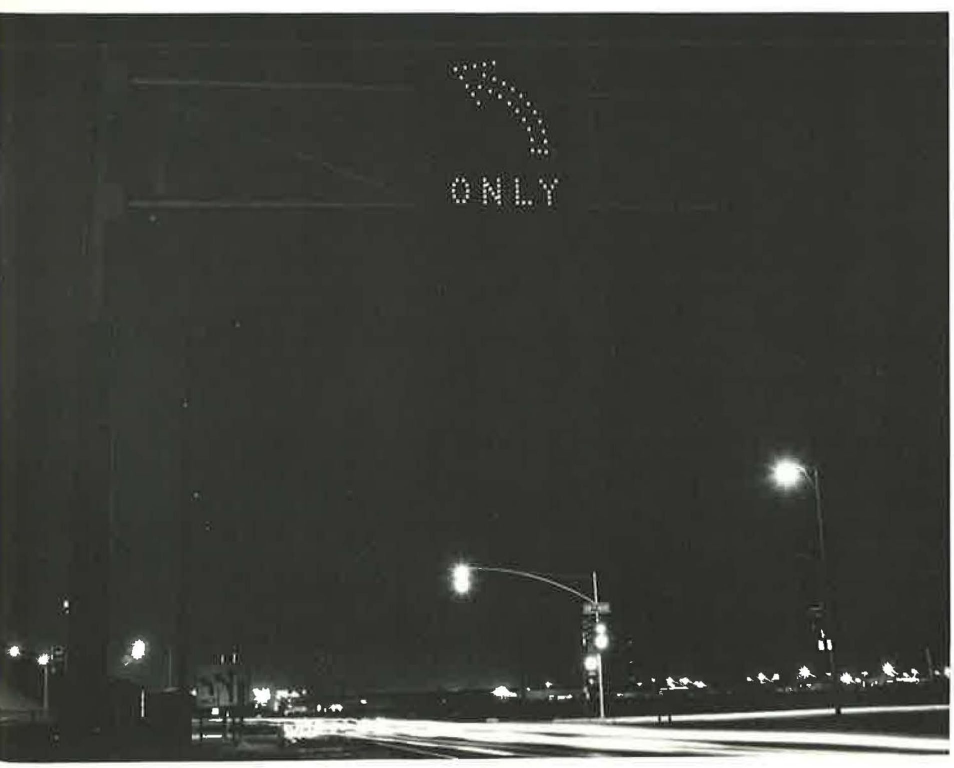
Number of 0.1¢/million Btu increments above base cost = (99.6¢ - 39.9) x 10 = 597 increments
597 x $0.0000096/kWh = $9.9957312/kWh fuel adjustment

This analysis provided a forecast of future changes in cost components that was compared to the rates being offered by the power companies for the next biennium. This comparison identified the justifiable rate increases and clarified those cases in which the utility company appeared to be requesting unfair rates. It also provided a statistical means to forecast what the utility companies could be expected to ask in future rate negotiations.

ANALYSIS OF ALTERNATIVE ILLUMINATION LEVELS

Phase 2 involved determining feasible options for changing the levels of lighting on highways (feasible was defined as being within legal requirements set forth by state or federal agencies). Various alternatives, such as turning off every other light and changing the wattage of luminaires, were evaluated according to ANSI standards. The results of this analysis indicated that, if the Ohio Department of Transportation met federal highway lighting standards, no combination of turning off lights was acceptable. Lower wattage bulbs could be used, as long as the lumen output was not lowered significantly.

One of the more attractive alternatives investigated was turning off all highway lighting during the summer months. Within the period from early May to early August, the normal burn period for highway lighting falls well outside the time of peak traffic volume. In addition, during this



Mercury vapor lighting reduces operation costs of energy significantly below those of incandescents, and high-pressure sodium lighting reduces construction costs below those of mercury vapor lighting because of wider spacing.

season, there are generally fewer days of inclement weather. Table 1 gives the total monthly hours of burn time for highway lights based on number of days, available hours of daylight, and average percentage of clear days. The average monthly time was based on twelve 30-day months. Therefore, values in Table 1 based on actual days per month are 5 hours too high. Each value has been adjusted to correspond to the average. Burn time for an average summer month = 1,567.0/5 = 313 - 5 = 308 hours. Burn time for an average winter month = 2,602/7 = 372 - 5 = 367 hours.

Other policies for reducing lighting were investigated, such as turning off all lights from midnight to 6:00 a.m., the period of lowest traffic volume. However, this would have required special timing equipment at each power delivery point. In addition, this practice would have resulted in lights being turned off during the worst weather seasons, when lighting provides the greatest psychological and safety benefit to the motorist. Further considerations in reducing the levels of illumination included the tacit responsibility of the department to the stranded motorist in high crime areas and the use of attrition in allowing the number of functioning units to decrease.

One alternative for improving illumination levels was to replace low efficiency luminaires (incandescents) with high efficiency units (mercury vapor or high pressure sodium) and with high-mast lighting. Recommendations for making these replacements were made for specific installations within the state.

DEVELOPMENT OF STRATEGIES FOR NEGOTIATION AND OPERATION

Phase 3 was concerned with providing a logical basis for managerial decisions with regard to contract negotiations and to operation of the Interstate highway lighting system. The analysis of cost components and levels of illumination provided input to this phase, which in effect involved carrying out procedures in the SUNUP manual. The manual contains a standard contract with explanatory notes, a methodology for planning negotiating strategy, and instructions for keeping the manual up to date. The standard contract, a departure from past department policy, consolidated and standardized necessary clauses so that, instead of a completely different contract for each utility company, the same basic contract could be drawn up for any one of them.

The SUNUP manual, and particularly the standardized contract, had far-reaching effects on the negotiating policy of the Ohio Department of Transportation. These policy changes were ultimately realized in energy conservation and cost savings for Ohio's taxpayers.

Conclusions

The research results were put to use almost as soon as they were produced. By means of joint department and RESA seminars, implementation was accomplished on a stepwise basis throughout the entire research project. The standardized contract and procedures contained in the SUNUP manual were applied immediately in negotiations between the department and those utility companies that had pending contracts. Decisions on maintenance by contract or by state crews were clarified by the contract, which separated the costs of energy from the cost of maintenance. Policy statements concerning types of lighting as well as allowable levels of illumination were established on the basis of research results. Full implementation of the recommendations was estimated to have a potential savings of $250,000 per year, or approximately a 16 percent reduction in cost.

Acknowledgments

For their help and contributions to this study, we wish to thank Donald Scheck and Lawrence Grey of Ohio University; Tom Major, Ed Smith, Bob McMillen, and Bill Breda of the Ohio Department of Transportation; and John Murphy, Mary Ann McClure, Roxanne Scheck, and Walter Hobocienski of RESA. We also wish to thank the Ohio Department of Transportation and FHWA for their sponsorship of the research project. The authors are responsible for the facts and the accuracy of the data presented.

Table 1

Month	Days/Month	Clear Day Burn Time	Cloudy Day Burn Time	Percentage of Clear Days	Clear Day Burn Hours/Month	Cloudy Day Burn Hours/Month	Total Hours/Month
January	31	12.90	14.10	37	148.0	275.5	423.5
February	28	11.97	13.17	42	141.0	214.0	355.0
March	31	11.03	12.23	44	150.5	212.5	363.0
April	30	10.08	11.28	52	157.0	162.5	319.5
May	31	9.13	10.33	58	164.0	134.5	298.5
June	30	8.18	9.38	62	152.0	107.9	259.0
July	31	8.78	9.98	64	174.0	111.5	285.5
August	31	9.72	10.92	64	193.9	122.0	315.9
September	30	10.65	11.85	63	201.5	131.5	333.0
October	31	11.58	12.78	58	208.0	166.5	374.5
November	30	12.52	13.72	28	143.5	255.0	398.5
December	31	13.49	14.67	30	125.5	318.5	444.0