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Industrial Innovations and Management toward More Efficient Usage of Electrical Energy

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INDUSTRIAL INNOVATIONS AND MANAGEMENT TOWARD MORE EFFICIENT USAGE OF ELECTRICAL ENERGY

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Abstract

This paper deals with some of the industrial accomplishments in alleviating energy supply and demand problems. A survey is presented on how electrical energy in America is generated, resources used and kilowatt usage for the years 1970 to and including 1974. Conservation of electrical energy is the main theme in which three primary areas of innovation and utilization of industrial equipment are discussed; induction, lighting, heating and air conditioning. An awareness of natural gas shortages and the trend toward an "electric economy" are reviewed. The real challenge to energy management is apparent in order to handle the greatest expansion in energy technology since the mid-1800's.

INTRODUCTION

It has been 18 months since the 1st UMR-MEC Conference. We saw charts and figures which were understood but the magnanimity of the numbers, sizes and shapes left us awed and concerned. It was informative and effective; the proceedings were a manmouth undertaking and the task was well done. We finally got a grasp or handle of what the overall energy situation is evolving to in this country. Questions were asked, statements were made, ideas of varying opinions were expressed and exchanged. We were told that there is no solution to our energy supply/demand problem for the next 25 years unless federal regulatory overbearance subsided and technical innovative forces were put into motion immediately, preferably in the same direction. (1)

Today I can report to you that such forces for technical innovation are in motion. From the commercial and industrial sectors of our society, the clamor of invention is moving outward in many technical areas. R & D energy expenditures by private enterprise are up to 15% this year. (2) A comprehensive marshalling of talents is beginning to produce the answers we need to have.

First to emerge on the energy market are the results of intensive work and efforts of TEM (Total Energy Management groups or teams) within industry aimed at conserving energy. The scope of this presentation is directed at the conservation of electrical energy. Voluntary energy conservation programs within industry are generating an energy usage philosophy which will eventually reach and effect every stratification of the American life/work style. Because of our base energy supply problems we are finding better ways to accomplish production goals at equal costs and expanding our energy developments with more efficient alternative possibilities.

A SURVEY OF ELECTRICAL ENERGY USAGE IN AMERICA

How do we presently use electrical energy in America? It has been reported that 80.1 million customers use electricity according to the following percentages of distribution:

88.6%	are residential
10.6%	are commercial
0.5%	are industrial
0.3%	are municipal
100.0%	

But the electric power required breaks down as:

32.6%	residential
23.1%	commercial
40.5%	industrial
3.8%	municipal
100.0%	(3)

In 1974 we went through 1.8717 trillion kilowatt hours and using the above percentages: 71 million customers (residential) used 0.610174 T-kw-hrs; 8.5 million customers (commercial) used 0.432363 T-kw-hrs; 0.4 million customers (industrial) used 0.758038 T-kw-hrs; 0.2 million customers (municipal) used 0.071125 T-kw-hrs

Expanding the above data with a little arithmetic, an approximate average use per customer can be determined so that in 1974 the: average residential customer used 8,594 kw-hrs; average commercial customer used 50,866.2 kw-hrs; average industrial customer used 1,895,095 kw-hrs; average municipal customer used 355,625 kw-hrs

The real challenge of a TEM group is to cut these non-residential values without the loss of production or jobs in an environment which is acceptable to the common good.

Figure 1 illustrates the electrical energy usage on a national scale.

There are two organizations in the U.S. which are monitoring the use of electricity. They are the FPC (Federal Power Commission) and the EEI (Edison Electric Institute in New York). U.S.A. Electricity Production (Trillion KW-HRS):

	FPC*	EEI**	
1970	1.531609	1.536400	
1971	1.613936	1.617100	
1972	1.747323	1.752200	
1973	1.856216	1.868800	
1974	1.864961	1.871700	(4)

*Total electric utility industry electricity production per FPC based on a 12 month year.

**1970-1974 output per EEI electric power survey committee based upon a 52 week year. "Yellow Sheets" published by EEI Statistical Section are released to the Wall Street Journal and appear every week.

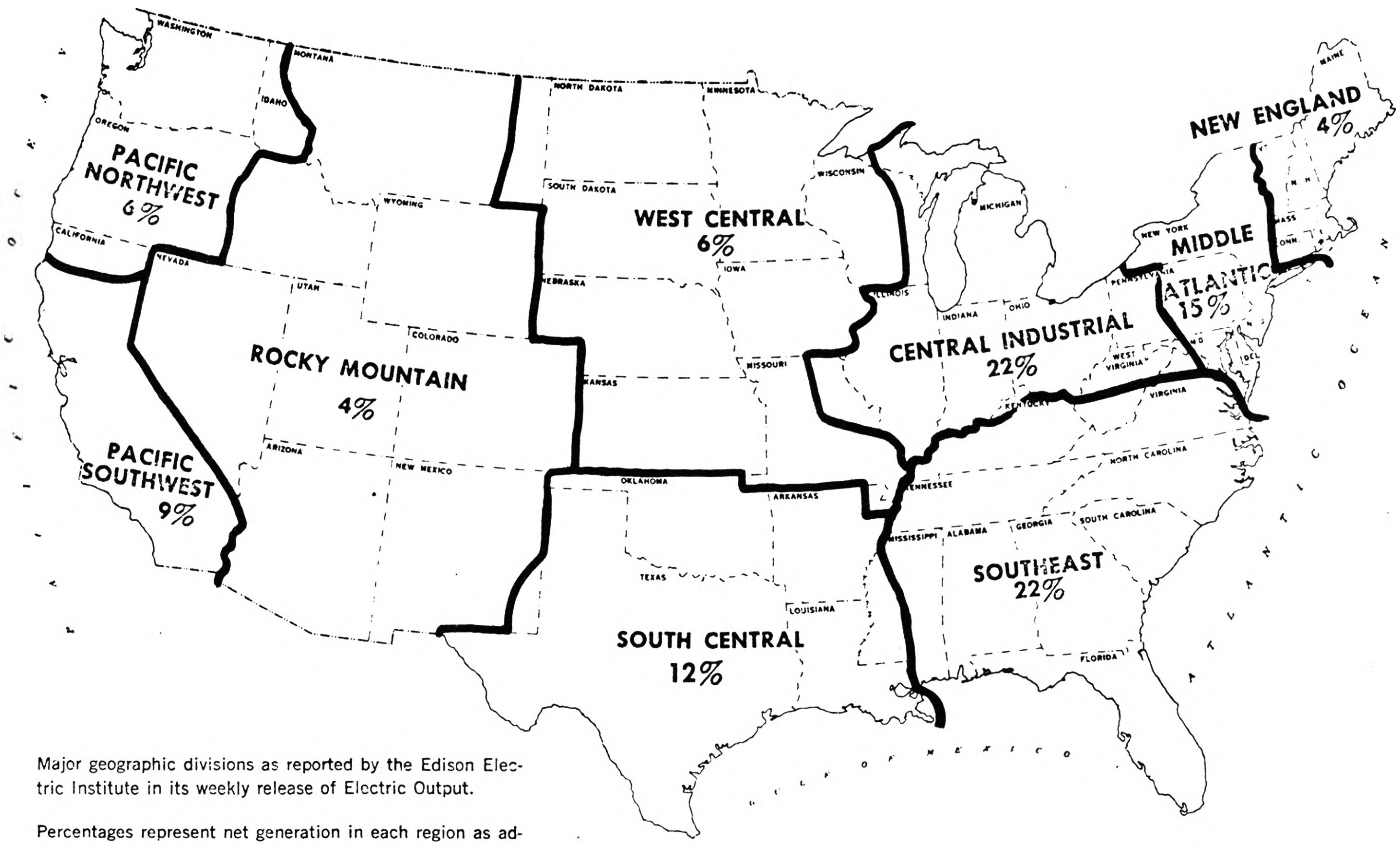
Electricity, as we presently know it, is a source-dependent form of energy. Most of it is a by-product of torque, time and temperature within a power plant/distribution system. When discussing the aspects of an electric economy, we should keep in mind that movements of inter-related energy forms will always be based upon availability of supply and cost of supply. Thus, all fossil fuels and petrochemicals are resource-dependent; a simple deduction all too often overlooked by forecasters.

Corresponding energy forms to produce the electricity are as follows: (%)

	OIL	COAL	NG	NUCLEAR	HYDRO
1970	12.7	45.6	22.4	1.4	15.9
1971	14.8	42.6	23.9	2.3	16.4
1972	16.9	42.2	22.1	3.1	15.7
1973	18.4	43.5	18.6	4.5	15.0
1974	17.6	44.1	16.9	6.0	15.4

Source: U.S. Bureau of Mines (5)

The generation and maintenance of our electricity depends upon another source of energy, usually coal, to produce the BTU's



Major geographic divisions as reported by the Edison Electric Institute in its weekly release of Electric Output.

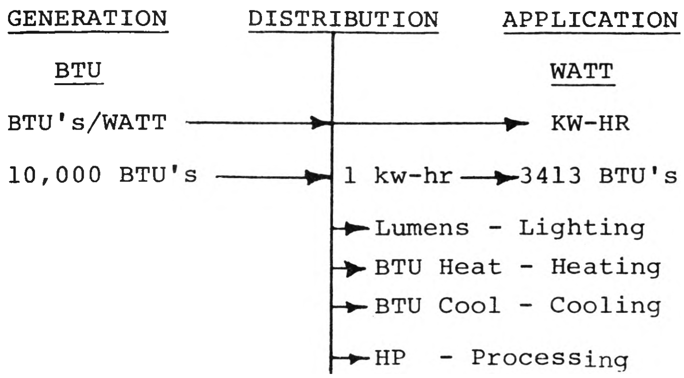
Percentages represent net generation in each region as adjusted for net imports.

January 1, 1973

FIGURE 1

to generate the steam, that turns the turbine, that motors the generator that produces the electricity on a continuous basis.

POWER PATTERN OF ELECTRICITY



With the present day technology, the overall efficiency is between 30% and 40% depending upon hardware and policy so that to have this single kilowatt hour in workable form it requires:

0.8 lbs. of coal

or

0.00175 barrels of oil (6)

or

10.5 cu. ft. of natural gas

or

1.25×10^{-5} gm. E. Uranium (7)

Advancements are being made in various generation areas with heat recovery cycling techniques, fuel combination, and new hardware to improve these overall efficiency values, thus reducing the number of BTU's required per watt. But we are talking about time and a great deal of capital investments to make all the necessary physical changes. In the meantime, these base energy resources are not as plentiful as we first thought nor are the sources secure at stable prices.

To parallel these efforts, alternate sources and development work are on the way. This we can see in much of the work which is being presented to us this week.

This also brings us right back to where we were --- conservation; conservation for two reasons: Economics and Time.

ECONOMICS

From the standpoint of economics, the power you save may be your own. Not only is the industrial rate in cost per kilowatt hour going up but the demand rates and fuel adjustment costs are going up as well.

Cost of base kilowatt hour
Cost per kilowatt on demand
Cost for fuel adjustment
Local taxes

All of which contribute to the overall price per kilowatt hour which we will be paying. Peak power penalties, fuel adjustment charges and taxes are compelling business leaders to look in the direction of on-premise energy systems as a competitive hedge against incrementing utility costs. If such energy systems use fossil fuels as a basis of prime movement, the competitive hedge will not be realized in most cases. And for this reason, the cost of power is no longer considered a fixed cost item.

From June 1973 to December 1974, a survey of 24 utilities was conducted and electric rates paid by industrial and large commercial customers rose an average 63.1%. (8)

TIME

By reducing the load on the feeder system with careful conservative measures on a consistent schedule, the demand is more easily met at the point of generation, thus reducing the amount of capitalization required to meet and maintain the demand. This in effect will buy needed time in order for the production technology to catch up with the application technology; the improved systems of greater efficiency to come on stream.

In the beginning stages, electrical energy conservation within the home or office or industry are not the result of procuring expensive modifications or hardware, but rather a well-planned system or survey of many small alterations which are compatible with work/life sytle patterns, schedules and safety guidelines.

The ultimate indicator of progress from efforts in conserving electrical energy is the familiar kilowatt meter, and with the aid of a stopwatch and a simple formula, many interesting and revealing studies can be conducted on the effect of various

$$\frac{\left(\frac{3600}{t}\right) \times K_h}{1000} = \text{kw-hr usage for (t) at observed load}$$

whereby: t = seconds required for a single revolution of the meter rotor

K_h = factor of the meter

pieces of cycling equipment in relationship to total load characteristics. In industry, 6 to 8% of the electrical energy can be saved by the mere simple reduction of nonproductive lighting and equipment usage. An additional 3 to 18% savings have been realized with power factor corrections and periodic power auditing of load distribution centers. With proper management and enthusiasm, electrical energy conservation is beginning in earnest with the American industries and is yielding the largest percent of savings change with the least amount of capital required, in the shortest length of time. The lessons on how to do it are about to come forward. Soon to be available from the Electric Power Research Institute in Palo Alto, California is a needed handbook entitled, "Handbook of Electricity Conservation Technology", which will present the state of the art of technology and procedures for electrical energy conservation by users. It will not have all the answers, but it will perhaps for the first time, allow a company or industry to draft its own program to handle its internal energy requirements in a more efficient manner. Specific hardware markets are developing which offer consistent and unique innovations toward solving the multi-faceted energy conservation dilemma which we find ourselves groping with.

There are three primary areas of innovation and utilization of industrial equipment for electrical energy conservation.

1. Induction Equipment
2. Lighting Equipment
3. Heating and A/C Equipment

INDUCTIVE EQUIPMENT

a. Gains in electronics have produced low cost solid state relay control systems which offer several benefits to the user. The control side of using industrial equipment has long been an area in need of updating. AC loads of up to 45 amps can now be controlled more efficiency with less mechanical effort, thus less energy.

b. Brushless DC motor drive systems are now available because of innovations of magnetic solid state switches, thus improving the conversion efficiencies of the total drive system.

c. Load monitoring and shedding. Motor control centers can now be monitored with an array of advanced equipment which generate to large computer type of programmable load controllers and phase balance simulators.

LIGHTING EQUIPMENT

To develop a practical light source from electricity which can provide the most lumens per watt at the least cost is the continuing goal of people involved in this particular energy conservation market. At present, the HPS (High Pressure Sodium) light and ballast system provide this result.

LAMP	WATTS	LUMENS PER WATT
Incandescent	150	19
Fluorescent	40	78

LAMP	WATTS	LUMENS PER WATT	
Mercury Vapor	100	42	
	175	49	
	250	48	
	400	56	
Metal Halide	175	86	
	400	100	
High Pressure Na	100	95	
	150	107	
	250	120	
	400	125	(9)

The HPS can be easily adapted to the office as well as these outside lighting needs with normal outlet voltages. The relative high initial cost of the HPS is quickly offset by the advantages of having fewer fixtures per area, the longevity of the HPS bulb and the power savings of 8 to 10% over past systems.

HEATING AND AIR CONDITIONING

In process heating, the predecessor of the "heat pump" is the temperature amplifier. (10)

Target heating for forced air heating systems is being considered by microwave, dielectric and induction. Steam can also be produced from water using microwave target heating and a less expensive system with induction target heating technique. (11)

Compressor stages via turbine compressor is coming forth as an efficient step forward in air conditioning equipment. This is coupled with the developments of more efficient electric drive systems.

WORKING WITHOUT NATURAL GAS

This is a 66 bed, acute care hospital located in Callaway County. It is the Callaway County Memorial Hospital. Their supply of natural gas is not guaranteed for this winter, forcing its administration to consider converting back to fuel oil for heating purposes. Two other hospitals in adjoining counties have had to make the transition. These energy tradeoffs are more expensive and less efficient, throwing dependency upon an energy base which we are supposed to be getting away from on a national scale. The Natural Gas shortage is real and the FPC priority level system has reached hospitals in several regions of Missouri. Consequently, the "electric economy" is here whether we are ready for it or not. You either go all electric or you don't build; there simply is no present alternative.

Under construction is this 28,000 sq. ft. manufacturing area with an all electric 1800A service. Here evaluations will be conducted on conservation techniques and equipment. Here electrical energy will be in the center of Total Energy Management and the EUI (Energy Use Index) will be used to formulate a power philosophy of practical adaptation.

THE PRESS

There simply isn't time here to discuss the problems which the press is having in this struggle to present the facts. The rate at which events are moving on a numerical scale makes it difficult to evaluate before the variables move. There simply is no other source of contemporary information available to go by. I believe the following slides best depict the problems.

THE ADVENT OF ANOTHER INDUSTRIAL REVOLUTION?

What I have presented here today is but a small portion of the overall efforts and results in innovations concerning electrical energy conservation. The social and economic conditions are ripe, the need is definite and the potential is present --- for the greatest expansion in energy technology since the mid-1800's.

In conclusion, unless efforts are unified, technical goals moving in the same direction, and incentives of freedom and accomplishment are present, then all other social problems and causes accompanying the real physical shortages of base resources and capital (and indirectly, food supplies) will be secondary to this one --- securing independent base energy alternatives and know-how for the future generations to come. The worst mistake that we can make here today is to assume that our federal government is going to solve this problem with its present machinery. The ERDA (Energy Research and Development Administration) inspite of 90 or so committees and sub-committees which regulate it, is a bright spot in the confidence flap which exists between a government and its people. The very least that we can do is to begin, first by encouraging our youth to participate and get involved in the many fronts which make up our energy dilemma.

Where we are headed with these energy systems and technology, I simply do not know --- I do know that we are most certainly on our way.

REFERENCES

RE: 1 "Today's Energy Sources - Their Projected Life", presented at 1st UMR-MEC Conference by Dr. John McKetta, Department of Chemical Engineering, University of Texas, Austin.

RE: 2 St. Louis Post-Dispatch, September 2, 1975, p. 7B.

RE: 3, 4 and 5 (See 1st acknowledgement).

RE: 6 Taken from a conversion table prepared by General Electric Corporation (LB4 back cover).

RE: 7 The Ubiquitous Atom, G. and L. Spruch. Taken from a conversion of 2000 lbs. of uranium = 3 million tons of coal or 12 million barrels of oil of potential fuel value.

RE: 8 Wall Street Journal, May 14, 1975, p. 11.

RE: 9 Taken from literature provided by Guth Lighting, a Division of Sola Basic.

RE: 10 "The Templifier for Process Heat", Westinghouse Corporation, report #PSP 5/30/75, R. L. Dunning.

RE: 11 Studies by Central Electric Company.

ACKNOWLEDGEMENTS

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35mm SLIDES

1. Kilowatt meter and stop watch
2. Optrol, Inc., Solid state relays DC control of AC loads to 45A
3. Optrol, Inc. Test Board
4. Siemens Corporation Brushless DC Motors

5. Pacific Technology, Inc., Model 410 Power Demand Monitor and limiter
6. Pacific Technology, Inc., Model 410 Power Demand on line
7. Pacific Technology, Inc., Model 410 Power Demand on line
8. Pacific Technology, Inc., Proportional Load Control Systems
9. Pacific Technology, Inc., Programmable Load Control Systems
10. Pacific Technology, Inc., Model 414 Power Demand Controller
11. Pacific Technology, Inc., Incremental Load Control System
12. Pacific Technology, Inc., Load Simulator and Proportional Controller with power factor monitor
13. Pacific Technology, Inc., Automatic Load Control System
14. Reduced diameter of stator with PMs
15. General Electric Supply HPS Intersection
16. General Electric Supply Lighted Factors with HPS
17. General Electric Supply Office Interior HPS
18. General Electric Supply Lighted Swimming Pool HPS
19. General Electric Supply Auditorium HPS
20. Central Electric Company, Lake Wappapello, Mo. HPS System
21. Central Electric Company, Lake Wappapello, Mo. HPS System
22. Central Electric Company, Callaway Memorial Hospital
23. Central Electric Company, South Plant, All Electric Service
24. Central Electric Company, South Plant, All Electric Service
25. Central Electric Company, Our Energy Crisis and the Press
26. Cartoon - Cat and Mice
27. Cartoon - Our Knight in Shining Armor
28. Cartoon - President Ford and Congress on Energy Police Compromise
29. Cartoon - Democratic Energy Policy
30. Rural America 1914 - "Electricity on the Farm for 14¢ per week"