Mansoura Bulletin, Vol. 9, No.1, June 1984.

ENERGY CONSERVATION AND CUSTOMER/UTILITY ELECTRIC LOAD MANAGEMENT

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ABSTRACT:

Electric load management and energy conservation are major problems facing the electrical utilities. Three basic modes of energy conservation are identified: demand reduction, increased efficiency and substitution for scarce fuels. Direct and indirect load management objectives are: to reduce peak loads and have future growth in electrical loads in such a manner to cause more of it to fall off the system peak. In this paper an over view of proposed and implemented load management options for both the utility and consumers is presented.

INTRODUCTION:

Among the major problems facing the ministry of electricity and energy (MEE) in Egypt the fast rise in peak demand, the relatively low off-peak consumption patterns, the huge cost of utility expansion plans and the high cost and scarcity of fuels for peak loads generation plants.

It is known that generating capacity must be large enough to satisfy demand, besides providing for a substantial system reserve for reliability. The shape of an electric power system load curve varies daily, seasonally and from year to year according to the prevailing weather, the general pattern of life and commercial and industrial activities. The exact time of the annual system peak-load can also vary from year to year according to the coincidence of the constituent loads, although the shape of the sectorial load curves is more predictable.

Recently, emphasis has been placed on energy conservation plans which have as their major objective: reduced demand of total energy consumption without resulting in a detrimental effect upon the entire society and industriallization plans. The three basic modes of energy conservation have been identified as demand-reduction, increased efficiency (of conversion, transmission and distribution, and end-use), and substitution scarce fuels (natural gas and oil).

It is well known that utility generating capacity supplies loads through: base, intermediate and peak plants.

The base load plants essentially run all year long with annual cabacity factors of 70% or better. These are the hydraulic, nuclear and the more efficient fossil-fueled power plants. The annual capacity factors of the intermediate cycling plants, however, range between 70% and 15% depending on utilities specific load characteristics. This portion is supplied by the older, less efficient steam plants or more recently constructed highly,efficient combined cycle generation systems (Stag units).

The critical portion of the load is the remaining 15-25% of the system maximum power with gas turibnes as the most significant existing peaking systems. The primary disadvantages of the peaking generation are: usage of critical (scarcs) fuels, high fuel cost (three to four times that of the base load fuels), low thermal efficiency and high maintenance cost.

The two factors usually considered in the capital expenditure by power utilities are on the one hand the investment needed for the peaking plants and additionally for the peaking reserve, and on the other hand the amount of saving in capital investment achieved if the peak load could be reduced in emergencies, or in case of unpredicted demands, since the standby margins can then be kept smaller. These considerations suggest that effective managment of the load must be considered in planning expansions in power generation and transmission capabilities. A successful load control is expected to result in an effective utilization of energy resources coupled with a reduced need for critical expensive fuels, thus satisfying one of the major energy conservation measures.

Load Management:

Load management is a relatively new approach to adjust the demand for electricity (reshaping of utility's load curve) through actions with effected customers. Load management efforts concentrate on possible reduction of peak load and/or promotion of consumption in time of low demand (off-peak consumption). Fig.(1). Although the generation mix used by utilities (base load, intermediate cycling, and peak generation) has worked well historically, sharply increased fuel prices create a heavy penalty for the older less efficient equipment used on many systems to generate intermediate and peaking power. Thus an economic incentive exists in using base load; plants as a source of power now being generated by intermediate and peaking equipment. Direct and indirect methods to manage electric loads have been categorized: that the indirect methods involve customer inducements to shift demand away from system peak, leaving to the individual customer control over the extent to which his particular load at system peak is reduced. Direct methods, however went a smaller degree of load choice in the customer, reserving with the utility direct control over certain portions of its load. The customer, in this case, usually retains power to decide how much of his load, if any, will be subject to utility control.

All methods will ultimately influence the magnitude and timing of the customer loads. Customers supplied by electric utilities are grouped in what is known as the industrial, residential and commercial sectors.

The interesting coupling between load management and energy conservation originates from the fact that the reduction of peak loads decreases the amount of expensive peak capacity, and of course critical fuel consumption.

This has the potential advantage of partially alleviating the uncertainties of dependence on unstable and expensive fuel resources in addition to the expected improvement in load factors. Many papers have reported an impact study of improved load factors on the power industry using computer programs. Moreover an off-peak growth in conumption increases the utilization of utilities equipment and spreads the demand more evenly across the day. This in effect reduces cost per unit of energy.

In the following; an overview and a discussion of the options available for managing loads are presented.

Load Management Options:

Electric utility load levelling can be divided in terms of what can be done at the customer end at the utility end. The main option is the use of energy storage systems at the utility end. At the customer end load levelling options can be divided according to the nature of the consumer sector (residential/commercial, or industrial). Fig.(2).

A. Energy Storage Systems:

Conceptually, the relatively efficient and economical baseload generation could be increased and the excess beyond the off-peak demand could be employed to charge the storage system. During the periods of peak demand, the stored energy would then reduce or replace the peaking generation plants. Fig.(3). In addition, the expanded base load generating capacity may replace part of the intermediate generation. Peak shaving is the term used when energy storage is utilised in the fashion just described. It should be expected, however that the overall system net outcome, with energy storage capacity, depends on the storage system efficiency. Tables (1, 2) show figures on cost and efficiency, in addition to relative merits of eightsuggested concepts of energy storage are listed.

Beside of the improved system load factor and power generation economics, energy storage capacities actually allow an increase of system peak capacity without new generation. This could solve or at least postpone capacity expansion problems facing some electric utilities. Deferring the need for new generation and network facilities results in the added advantage of reduced enviromental pollution. Besides, energy storage must meet utility type standards for: operating time, reliability, safety and enviromental compatibility of generating equipments.

Several candidate energy storage systems are: underground pumped hydro, compressed air storage, electric storage batteries, hydrogen, fuel cells, flywheels, superconducting magnetic storage and thermal energy storage.

B. Utilities Power Demand Control:

As stated earlier, one of the load management options available is to control the load curve allowing a more efficient system operation. Centralized network control, also termed ripple control, is accomplished when the ordinary electricity distribution network is used to transmit control signals.

Audio frequency impluses are superimposed on the network voltage at one or more central points and are transmitted throughout the controlled network. At selected convenient points in the network, these signals are received, evaluated and used for control purposes. This technique has been used successfully in Europe for years thus enabling the daily load curve to be influenced from a central point. Feasible fields of application of this technique result in as high utilization as possible of distribution equipment in using it to the control of direct or storage of heating, hot water storage, selected industrial and agricultural equipment, tariff-meters, maximum meters, street lighting, alarms or signalling, and power circuit breakers for emergency disconnection.

Ripple control enables utilities to switch on and off selected customers at fixed or variable times. This technique also permits the troughs in the load curve to be filled up and load peaks to be flattened out, enabling the utilities to raise the utilization factor and to improve the profitability of energy production and distribution.

The transmitting equipment includes units for central programming and coding of orders to be transmitted, for the control of the transmission cycle and remote control of transmitters, audio-frequency oscillator and coupling filters. Beside the major advantages of ripple control as a load controlling approach, it does offer the following: possibility of daily or weekly recurrents orders, not bound to rigid time programs, ease of change of programs at one centralized point, and not requiring periodic checking and adjusting as in the case of time switches.

C. Rate Structure:

Rate structure is in common use by electric utilities with large differences between peak and offpeak demand. Attractive off peak (promotional) rates are necessary to offset increased labor and equipment costs associated with peak operation. These promotional rates are offered in supplying naturally occuring, or scheduled, off-peak loads. Although the total electrical usage may be unchanged the total fuel consumed may be significantly reduced because production occurs with more efficient generating plants in addition to reduction, or delay, in future peaking capacity Fig.(4).

In recent years there has been growing concern that more account should be taken of the likely effect of prices and economic growth on future energy requirements.

If the prices assumed in forecasting future energy requirements are intended to guide consumers decisions correctly then these prices need to be equated to the marginal, or incremental cost of energy involved.

Two marginal costs are usually used in this respect, the long and short run marginal costs. The LRMC of an increment of load is the difference between annual system costs with the load increment and annual system costs without the load increment, after time to reoptimize the system, where the load increment has been anticipated in advance, little time will be required for adjustment, but where load is unexpectedly imposed upon, or taken off, the system the incremental cost until the system has been reoptimized is known as short-run marginal cost SRMC. References have pointed out, however that the problem with pricing electricity according to marginal costs results in negative profits due to the fact that these costs are always below unit costs. Another problem is that if the rule of setting the price equal to marginal costs is not followed, attempts will be made by the firm to increase its output until size problems become unmanageable.

The use of diffrent types of tariffs in load management has been made possible through time switches and remotely actuated load control systems.

Time switches provide a simple control pattern on a rigidly fixed cycle giving the ON/OFF functions at the same time on every day of the year; These are usually used with what is known as time of day tariff. On the other hand, a remotely actuated load control system can use either a predetermined control pattern, and or operate in an irregular manner, unpredictable to the customers.

Diffrent types of tariffs have been suggested based on the following basic patterns.

- Variable predetermined pattern: varying with day of week, or season, according to an agreed-upon schedule.
- Variable weather dependent pattern: charging period of thermal storage may be varied according to outside temperature.
- Variable pattern according to supplyposition for space and water storage heaters where supply may be advanced or delayed from normal as required.
- Intermittent pattern according to, supply position: air conditioners, heat pumps, space and water heaters on normally unrestricted tariffs may be disconnected for short periods to reduce peak loads or relieve loading of particular circuits.

D. Other Options:

Many other forms of load management techniques have been reported. Voltage reduction has been frequently used when insufficient generating capacity serves peak period loads. Typically, implementation of this technique takes place of substation level by blocking the action of automatic voltage regulating equipments. The two major disadvantages are the inability to predict the amount of curtailed load, and the expected damage in various equipments (such as motors) since the procedure is not selective. Rotating curtailments have also been used to extreme circumstances of capacity deficiencies or fuel shortages.

Although effective in reducing peak requirements, the total energy consumed may remain unaffected for certain loads (such as water heaters), and could conceivably even increase. Critical loads and essential services (hospitals) are usually excluded from curtailment. Voluntary consumer cooperation has proven to be an effective technique, at least in the short term for energy conservation. The appeal of the method is that the consumer decides which usage is wasteful or necessary in meeting his own needs. Installation of energy or power monitors in residential, commercial and industrial establishments will be required to assist and encourage reductions in electrical energy usage.

Impacts Assessment:

Technology assessment is a class of policy studies which systematically examines the effects (impacts) on society that may occur when a technology is introduced, extended or modified with special emphasis on those consequences that are unintended, indirect or delayed. In the above several approaches for managing electric demand have been discussed but it is not known how individual users would respond to schemes with direct impacts on their lifestyle and/or economy. Some of the consumers, specially in the residential/commercial sectors, may prefer to pay higher price for the convenience of an instantaneous satisfaction of their complete demand, while other would agree to forego this convenience because of their desire to cooperate or to realize cost savings. With the adoption of new systems of tariffs consumers may be encouraged to store thermal energy and/or consider adding insulation that meets certain specifications. Impact assessment in this case should focus on the cost of material, labour, and energy involved in the manufacturing and installing of this insulation and the number of months or years required to recover the initial investment.

The impacts of load management on establishments with large industrial or commercial consumption need to be carefully evaluated since a resulting increase in the cost and services in addition to labor or economic inconveniences may tempt some industries to generate power on site rather than purchasing it from utilities.

CONCLUSIONS:

The advent of microelectronics and improved communications opens up a new approach for the electrical utilities in the key areas of credit and load management, with consequential economic benefits to the customer and investor alike.

Electricity demand is to be tailored to generation using the discussed managerial techniques and the new customer/utility aspects to cover credit management as excess plant provisioning is economically inefficient.

To make load management and energy conservation attractive to both users and utilities the flexibility and effects of new rate policies need to be considered.

Load management systems can impact electrical generation expansion plans, perform remote control functions, provide load research data and change the load shape to the utilities operational advantage.

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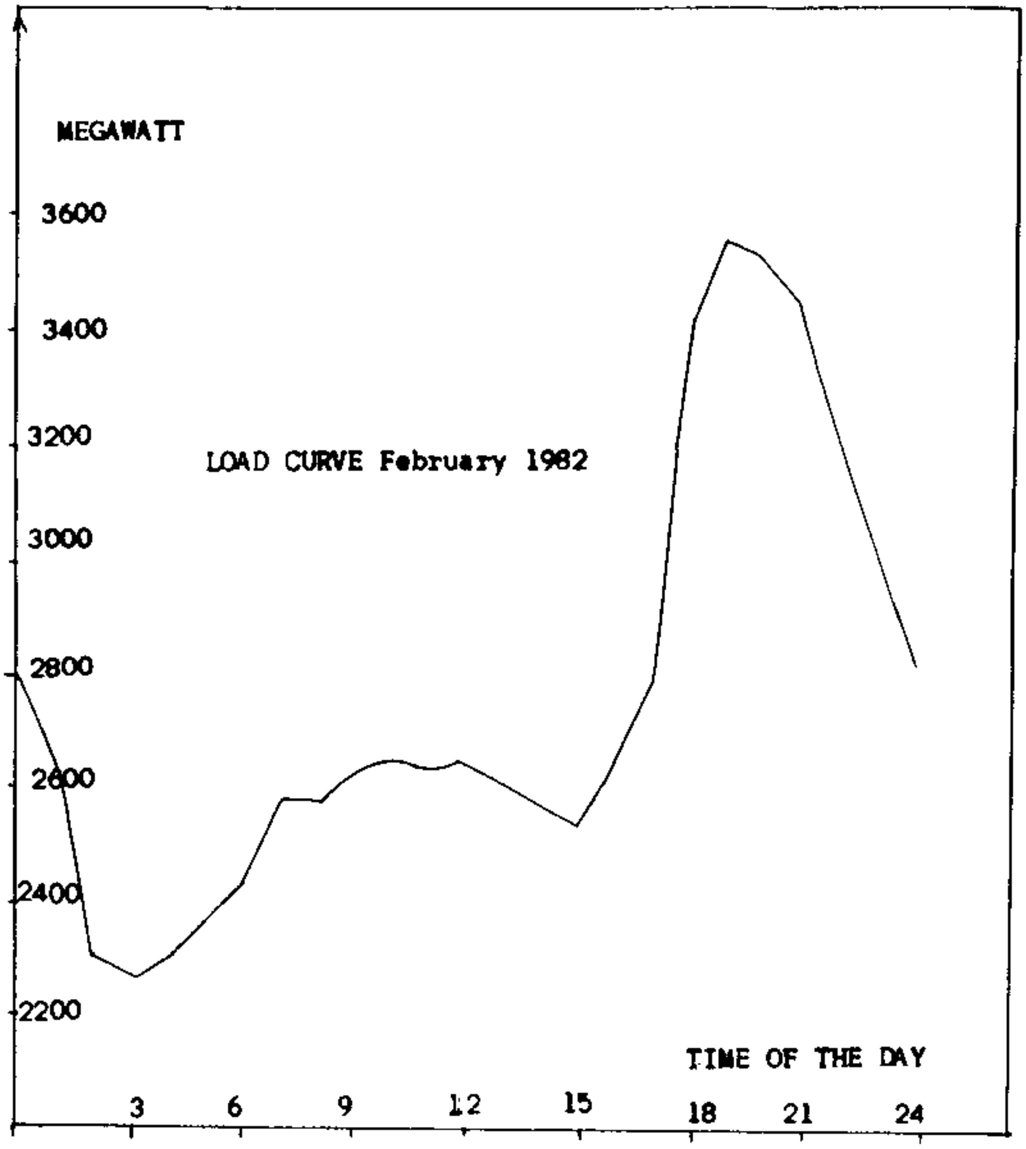

Fig.(1) Egyptian Unified Grid Load Curve Feb. 1982.
Load increase from 2600 MW to 3600 MW in 4 HRS.
(Very distorted load curve). (Ref. Al-Tabalawi).

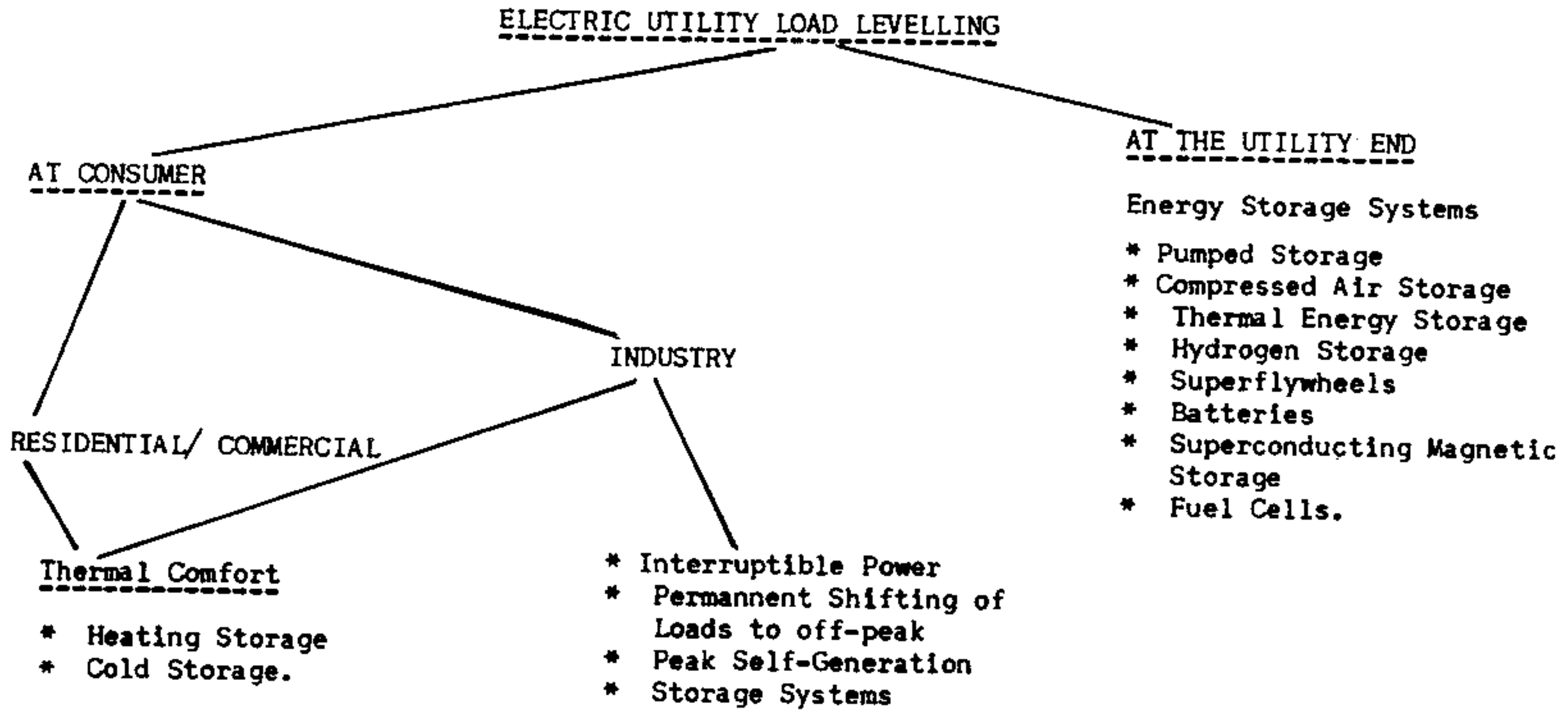
ELECTRIC UTILITY LOAD LEVELLING
AT CONSUMER
AT THE UTILITY END
Energy Storage Systems
* Pumped Storage
* Compressed Air Storage
* Thermal Energy Storage
* Hydrogen Storage
* Superflywheels
* Batteries
* Superconducting Magnetic Storage
* Fuel Cells.
INDUSTRY
RESIDENTIAL/ COMMERCIAL
Thermal Comfort
* Heating Storage
* Cold Storage.
* Interruptible Power
* Permannent Shifting of Loads to off-peak
* Peak Self-Generation
* Storage Systems

FIGURE (2).

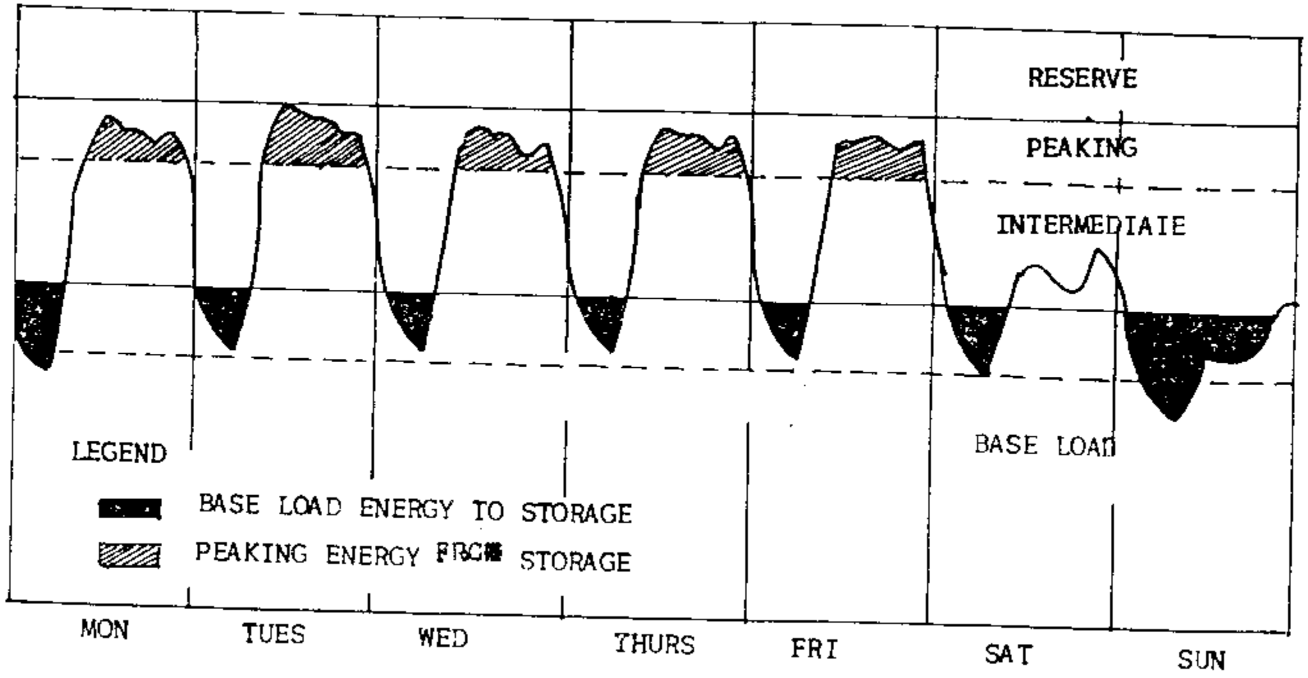

FIGURE (3) ENERGY STORAGE IN GENERATION MIX.

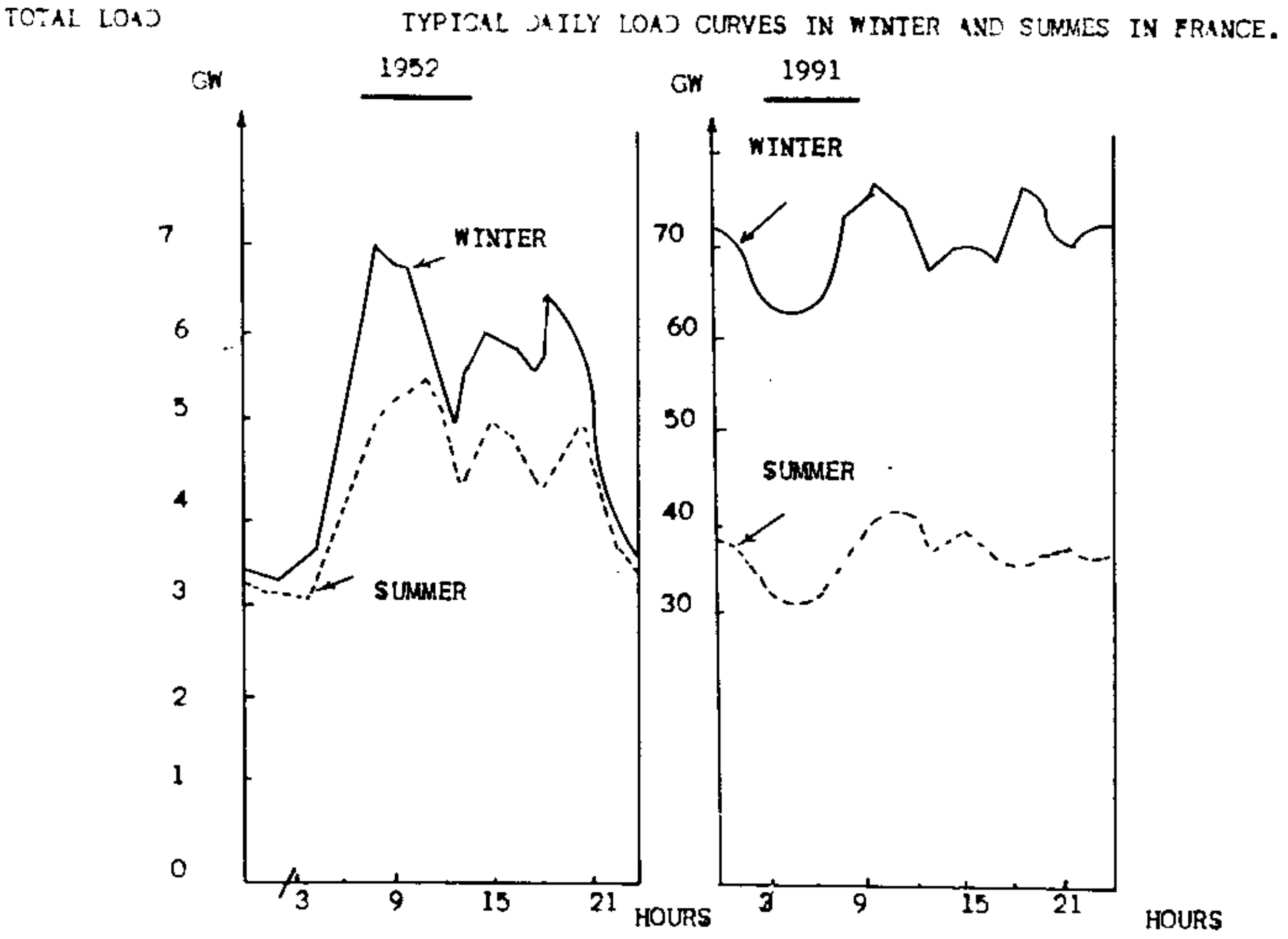

Fig. (4): Effect of load management and differential pricing of electricity on winter and summer load curve in France.

TABLE 1 CHARACTERISTICS OF VARLOUS GENERATING AND STORAGE SYSTEMS

		PROBABLE MINIMUM ECONOMIC SIZE (MWh)	APPROXIMATE CAPITAL COst ($/KW)	POTENTIAL EFFICIENCY%	LIKELY ENERGY/ UNIT VOLUME KWh/m^3)	EXPECTED LIEE (years)
1.	Underground Pumped Hydro	10.000	200	65	2	50
2.	Compressed Air Storage	200	230	45	4	20
3.	Batteries	10	150	75	250	20
4.	Hydrogen Storage	10	300	50		30
5.	Superconducting Magnets	10,000	700	85	20	30
6.	Superflywheel	10	400	85	35	30
7.	Combustion Turbine	50 MW	120	24		20
8.	Steam Cycle Plant	500 MW	350	37		30

TABLE 2 RELATIVE MERITS OF STORAGE CONCEPTS (0 to 3 WITH 3 THE HIGHEST)

CRITERIA	UNDERGROUND PUMPED HYDRO	COMPRESSED AIR STORAGE	BATTERIES	HYDROGEN STORAGE	SUPER CONDUCTING MAGNETS	SUPER-FLYWHEELS
Economic Feasibility	3	3	3	1	0	2
Environmental Compatibility	1	1	3	3	3	3
Impact on Material Resources	3	3	2	2	1	3
Siting Flexibility	1	1	3	2	2	3
Operating Availability	3	1	3	3	1	2
Constrution Lead Time	1	1	3	2	2	2
Safety	3	2	2	2	2	2
Power System Compatibility	2	2	3	3	2	2
Impact on Fuel Resources	2	1	3	2	3	3