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INDUSTRIAL LOAD CONTROL IN A LOCAL AUTHORITY WITH MIXED INDUSTRIAL AND DOMESTIC LOADS

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A project report submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 1985

DECLARATION

I declare that this project report is my own, unaided work.

It is being submitted for the degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination in any other University.

T. Grobler
SIGNATURE OF CANDIDATE

11 day of DECEMBER 1985

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ABSTRACT

The natural demand for electricity varies widely over a 24 hour period and seasonally. It is generally accepted that it is advantageous to flatten the demand curve.

The general approach is to implement load control in the case of residential loads. However, very little is done to control loads in the industrial sector.

This study looked at the possibility of controlling industrial loads supplied by Germiston Municipality. Major electricity consumers were studied.

The conclusion was that selective load management in the industrial sector is possible and cost-effective.

Criteria for a suitable load management system were examined, and a commercially available system was recommended.

On the national scale it was shown that load management is the most cost-effective way (within its limits) to meet increased electrical demand.

INTRODUCTION

The natural demand for electricity varies widely over a 24-hour period as well as during different seasons.

A certain maximum in demand occurs during the day or early evening and a deep and wide minimum during the night.

It is advantageous to modify the demand cycle to make it as flat as possible, as this will bring savings, by reducing the capital required for generation, transmission and distribution, increased utilisation of existing facilities and hence an increase in profitability.

A way to achieve a flatter demand curve is by reducing the demand during the peak period, by switching off non-essential loads during peak periods and reconnecting them when there is spare generating/transmitting capacity.

General black-outs of whole areas (which could otherwise occur if the demand exceed the capacity) can be avoided.

Germiston buys its electricity from Escom. A major component of the monthly electricity bill is proportional to the monthly maximum demand.

It is very common in South Africa and abroad to control domestic load, mainly water heaters. However, very little is done in the control of maximum demand in the industrial sector. Germiston is a local authority with residential and considerable industrial loads, and thus leads itself to investigation into industrial load control.

INDUSTRIAL LOAD CONTROL IN A LOCAL AUTHORITY

WITH MIXED INDUSTRIAL AND DOMESTIC LOADS

1. GERMISTON MUNICIPAL ELECTRICAL SYSTEM

1.1 System Description

City of Germiston buys electricity from Escom. Power is received via five input substations from Escom. The received Voltage at three of the five input points is 33 kV, one is 6,6 kV, and the remaining point is 11 kV this formerly being Elsburg Municipality which was taken over recently by Germiston.

the power is distributed throughout Elsburg at 11 kV. The primary distribution Voltage in Germiston is 33 kV. There are over 20 main 33/6,6 kV primary substations. From there the power is distributed to approximately one thousand substations where the supply is given to various consumers. The substations can be divided into four categories depending on consumer load.

(i) Large consumers from approximately 4-5 MVA. These consumers receive their supply at 33 kV, from which they transform and distribute power as required.

(ii) Consumers from approximately 1 000 KVA to 4 000 KVA. The supply is given at 6,6 kV via the main consumer's breaker and from there distributed and transformed as required by the individual consumers.

(iii) Consumers from approximately 200 KVA to 1 000 KVA. To these consumers the municipality provides power at 400 Volt via an individual substation with a municipal transformer.

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(iv) Consumers with load of approximately 200 KVA and less. These consumers are fed at 400 Volt from communal substations.

1.2 Different Consumers and Tariffs

Germiston has different tariffs for different consumers - see Appendix 2.

By the 21.05.85 there were 23 346 consumers on Tariff 1 A (Domestic consumers), 3 196 consumers on Tariff 2A (Commercial and Industrial consumers not exceeding 80 KVA), 15 consumers on special "off-peak" Tariff 21h00 to 07h00, and 835 consumers on T- (Commercial and Industrial consumers a .A).

From the 835 Commercial and Industrial consumers approximately 42 exceed 1 000 kW average maximum demand over one month and their total load before diversity exceed 75 000 kW.

There are approximately 114 non-residential consumers whose average maximum demand is between 200 and 1 000 kW and their total load before diversity is approximately 50 000 kW.

To estimate the domestic load at Germiston the following empirical formula is used which gives satisfactory results when compared with experience in Germiston.

$$Pc = Md\ K + (1-K)\ \frac{Md}{N} \qquad \text{[Formula 1]}$$

Pc = KW per consumer after diversity

Md = Max. demand of one consumer before diversity

K = 0.15 for small dwellings

K = 0.2 for large dwellings

N = number of individual consumers

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On the average in Germiston it was found K = 0.16

and Md = 13.2 kW

were realistic figures.

Using this formula the estimated domestic demand will be around 65 000 kW.

This can be summarised as follows :

Type of consumer	Number of consumers	Total consumer load before diversity (kW)	Diversity factor	Total load after diversity (kW)
Domestic including blocks of flats	23 346	396 000	See Formula 1	*65 000
Commercial or industrial using over 1 000 kW	42	75 000	*** 0,6	45 000
Commercial or industrial using between 200 kW and 1 000 kW	114	50 000	*** 0,6	30 000
Comerical or industrial using under 200 kW	679	**67 900	*** 0,6	40 740
TOTAL				180 740

* The figure of 23 346 domestic consumers include each block of flats as one consumer. Therefore this will give us approximately 30 000 individual households.

** Assumed load of 100 kW average per consumer.

*** 0,6 Diversity factor gained from experience in Germiston.

TABLE 1 - LOAD COMPOSITION IN GERMISTON

1.3 Load Cycle

The load cycle of Germiston during week days has a distinct fast rising peak around 09h00 in the morning. (See Appendix 1)

There is a distinct drop at 13h00 (lunch time).

A second peak occurs that is much lower than the one at 09h00 at 19h00 in the evening.

On Fridays a lot of industries have a shorter day and this can be distinctly seen as the load continues to drop from 13h00.

The same trend can be observed on Saturday when most of the commercial and industrial consumers shut down - the load drops from 12h00 (mid-day). The peak at 09h00 drops from over 190 MW to less than 140 MW, a difference of 50 MW. This can be attributed to part of the industries that closed on Saturdays. However there is a higher shopping activity. On Sunday 09h00 the demand drops to less than 115 MW, 85 MW attributted to commercial and industrial consumers. It must be remembered that certain industrial consumers operate 7 days a week, 24 hours a day.

Examination of the Graphs and the facts expressed in Table 1, shows that ⅔ of the load is industrial. The high sharp peak at nine o'clock in the morning can with reasonable confidence be identified as mainly contributed by the non-residential consumers. (Industrial and Commercial).

2. LOAD CONTROL

2.1 *Basic Techniques*

The basic techniques can be classified according to two criterions :

(a) One-way or two-way communication.

(b) Communication media :

1. Radio.
2. Signal superimposed on the 50 Hz power network by means of injection transformers.
3. Pilot or telephone cables.

Various communication media and transmission methods used, are :

1. Telephone
2. Radio
3. Pilot wire
4. Ripple]
5. Wave from distortion] Utilisation of existing power mains
6. Distribution line carrier]
7. Combination]

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Telephone

Telephone communication has severe limitations, like availability of lines and reliability.

Radio

Radio communication is used, usually for one way communication only. It has the advantage that it does not require costly injection equipment.

Pilot wire

Pilot wire - the use is very limited due to expense.

The concept of using the existing power lines as communication lines is very attractive as they are utility owned and controlled and are already in place.

When using electric power distribution network as a media the following should be considered :

(a) Signal attenuation

(b) Noise

(c) Bandwidth

(d) Injected power

(e) Interference

Electric power networks have higher attenuation the higher the frequency of the signal.

The combined characteristic of background and impulsive noise is frequency dependent, with higher noise amplitude at lower frequencies. (17)

The bandwidth : the wider the bandwidth the more noise and the poorer is signal to noise ratio at the receiver.

On the other hand the greater the information rate we want the wider the bandwidth is required.

The higher the injected power the better the signal to noise ratio at the receiver. The drawbacks are, cost and interference.

To create an efficient system we have to find a compromise between the above points.

Ripple

Ripple control systems have been widely used in Europe for nearly 40 years mainly controlling water heaters and night storage heating units. It is basically a one-way system with relative low frequency around 500 Hz high powered signal.

It requires high power injection equipment that is costly and can create interference problems.

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Distribution line carrier

Distribution line carrier systems can be unidirectional or bidirectional, which employ higher frequencies (around 40 kHz). Thus signals can be more easily separated or filtered out from the network. Bidirectional repeaters are usually used to amplify the strength of incoming and outgoing signals.

Being a two-way communcation system it can be used for the following :

1. Residential load control such as water heaters, air conditioners, etc.
2. Feeder control such as load monitoring, voltage regulation, etc.
3. metering including time of use metering, remote kWh and kW meter reading.

Waveform distortion

Waveform distortion can be used as a way in transmitting signals it can be done by introducing a voltage distortion or a short circuit as near as possible to the supply voltage zero-crossing point.

A number of individual cycles of the supply can be altered in a prescribed manner to form a recognisable code.

3. CONSUMERS WITH CONSUMPTION OVER 1 000 kW IN GERMISTON RESULTS OF SURVEY

A survey of non-residential consumers with maximum demand over 1 000 kW was conducted.

The aim of the survey was to establish the feasibility of controlling consumer's maximum demand during Germiston Municipality's peak demand period. These consumers were asked to identify the non-essential loads that can be switched off or reduced without affecting their production.

The results of the survey are enclosed in Appendix 3 and the summarised results are shown in Table 2.

It was emphasized to the consumers that this is a feasibility study and not a commitment on their side. The aim of the study was explained, and the response generally was very positive.

Approaching senior management yielded more positive results as they could appreciate the savings.

The consumers response could be devided into three groups.

1. Unwillingness to interfere with production, but no objection to switching off for a limited time, air conditioning and water heaters.
2. Consumers that could afford to switch off or reduce power used in production in addition to above.

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ELECTRICAL CONSUMERS>1000KW

NO	REF	NAME	KW USED	KW CONTROLLABLE
1	R63/347	HYPERAMA	2,500	900
10	HEN/1	POWER&PIPE.GALVANISERS	1,000	0
11	63/691	ACE PATTERN MAKERS	1,850	50
12	RK/1464	DUROPENTA	2,000	100
13	ROOKOP140/50	NAMPAK GLASS CONTAINERS	4,500	50
14	KAL/80/75	CONSOL PLASTICS	4,000	300
15	KAL/11/75	TRANSVAAL MALLEABLE FOUNDRY	2,400	250
16	W/277	POWER STEEL INV	1,200	30
17	W2/70	SANLAM INDUSTRIAL PROP		
18	W2/32	COCA COLA	1,200	50
19	KAL/13/27	NAMPAK LTD	1,200	30
2	AP/7	MALLEABLE CASTINGS	2,800	1,000
20	KAL/2/27	MOSER HARDCHROME	1,000	100
21	W1/257	MUSCO	2,000	200
22	W1/239	HIND BROS	1,000	500
23	W1/231	WJM PIPELINES	1,200	1,000
24	W1/238	AMASCO WADEVILLE	1,050	100
25	G57/688	NCP	8,000	650
26	G57/713	WOLTUBE	1,700	50
27	G3/3,809	GUESTRO	3,600	
28	G3/1185	STEEL WHEEL&AXLE	2,500	600
29	E108/RE150	RAND AIRPORT	1,000	
3	R63/75	MINESSOTTA MINING	1,400	60
30	G55/662	MONOWELD	1,300	200
31	G5/662	INSULPAN	750	40
32	G51/502	B.THMAS PILLEMER	1,900	300
33	G12/1290	ALBANY BAKERY	1,100	20
34	G4/1070	ILLHAN PLASTICS	1,150	0
35	HER4/94	KROST BROS	1,600	100
37	E90/205	NCI	1,200	100
38	R1519/20	WASTE MATTER	1,500	100
39	R63/130	AFRICAN GATE	1,300	100
4	R63/66	RECYCLING PLASTICS	1,700	50
40	R63/129	AFRICAN GATE2	1,200	50
41	R63/440	INTERPACK	820	130
42	R63/440	INTERPACK2	300	
43	R63/133	BUNDLE PLASTICS	2,000	80
5	TUN6	AMPAGLASS	1,250	20
6	TUN10	HEINEMANN	1,500	50
7	R63/PTN344	BROLLO2	3,500	
8	R63/PTN344	BROLLO1	2,500	600
9	R63/40	RIETFONTEIN GEN GALVANISERS	2,100	300
TOTAL:			77,870	8,260
COUNT: 42				

TABLE 2

SUMMARISED RESULTS OF SURVEY OF CONSUMERS DRAWING IN EXCESS OF 1 000 kW

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3. Consumers were prepared to re-schedule their production plans, but would prefer to know if there is a definite pattern of load periods, e.g. every day between certain hours.

These consumers required at least a day's notice.

Most consumers expressed willingness to co-operate, provided they will gain by way of tariff adjustment or discount.

Most thought that either a credit or discount related to the amount of load shed when requested was acceptable.

The summary of the survey is shown in Appendix 3.

The results of the survey are summarised in Table 2.

The following are typical examples taken from the above survey :

1. The largest consumer in Germiston is NCP using 8 000 kW (maximum) demand. As a by-product NCP produces heat that is utilised to generate electricity.

The load can be con[illegible]n 8 stages although at present only 3 stages are operatic

Stage 1 - 200 kW : [illegible] tower fans

Stage 2 - 200 kW : instrument compressors; this power can be transfered from municipal to NCP generator.

Stage 3 - Process compressors 200 kW;

The other 5 stages are not on line yet.

At the moment, 1,8 MW generating capacity is installed driven by steam that is a by-product. There is 250 kW spare generating capacity.

There is enough by-product steam available for another 1 000 kW generating plant.

As the steam is a by-product the self generating power is cheaper than that bought from Germiston Municipality.

At the moment NCP is not allowed to parallel their own generated power with the municipal network, therefore certain areas are fed seperately and have the facility of change-over from municipal to NCP power.

NCP are keen on having the possibility of paralleling their generators with the municipal power to achieve greater flexibility.

NCP is the only consumer that has generating capacity that is used not only for standby.

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2. Another typical example is Rietfontein General Galvanisers Ref. No. R63/40. This is an old consumer with a 2 100 kW average monthly maximum demand. As it is an old consumer no declaration of demand is recorded. (Declaration of dmenad was introduced only recently.)

Consumers that did not change their requirement were not required to submit declaration of demand.

The work is in 3 shifts.

There are 6 galvanising baths :

Bath No. 1	560 kW
Bath No. 2	550 kW
Bath No. 3	455 kW
Bath No. 4	---
Bath No. 5	425 kW
Bath No. 6	455 kW

The temperature of the baths is electronically controlled; the controller switches off the bath when the temperature reaches 460°C and switches on the bath when temperature drops to 435°C.

The minimum bath temperature allowed is 420°C.

There is no maximum demand controller.

The possibility exists of reducing the maximum demand and the units consumed by planning the work in such a way that low mass, but large volume items will be in the bath during the Germiston Municipality peak period.

By planning the production in this way maximum demand reduction of 300 kW can be achieved.

Rietfontein Galvanisers feel that irrespective of the economic situation they will be able to plan the production in such a way that for a number of hours a day their maximum demand will be reduced by approximately 300 kW.

Similarly consumers like Malleable Castings Ref. AP/7 indicated that by planning the production in co-ordination with Germiston Municipality, a maximum demand reduction of 800 kW can be achieved for several hours.

Similarly W J M Pipelines by planning production the maximum demand can be reduced up to 1 000 kW for a number of hours.

However, consumers like W J M Pipelines are very much dependent on the work load. At present load reduction is possible; however, it may not be necessary true in the future as dmeand for their products may rise, causing rise in production, hence electrical demand.

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3. A considerable number of consumers felt that they cannot reduce their maximum dmeand by switching off or reducing power used by production machines; the only power reduction possible, is by switching off air conditioning, space heaters, water heaters etc. in the offices.

   The important consumers in this category were Albany Bakery - declared load 1 600 kW and used 1 100 kW; Nampak Glass Containers, Ref. Rooikop 140/50 power used 4 500 kW and further increase in power consumption is planned; Illman Plastics - declared load 2 200 kW and future extensions planned.

4. Some consumers that indicated the ability to reduce the electrical demand during Germiston peak period, apart from switching off non-productive appliances like space and water heaters, are :

   HUBCO Ref. W1/257 -

   Reduction in consumption can be achieved by re-arranging production.

   BROLLO Ref. R63/PTN 344 -

   Switching off electricode boiler for 10 minutes every ½ hour and controlling galvanising plant.

   HYPERAMA Ref. R63/347 -

   Load reduction by controlling air conditioning ventilation and refrigeration.

   STEEL WHEEL AND AXLE Ref. R63/1185 and

   QUESTRO Ref. R63/3, 809 -

   Re-arranging production.

   THOMAS AND PILLENER Ref. GS1/502 -

   Reduction of consumption can be achieved by re-arranging production.

   Generally the approach of the consumers was positive. They were most co-operative and understanding. However, in big organisations one gets the impression that people in certain positions, for example production managers or engineering managers, are worried that the result of reducing electrical consumption at certain times will create more difficulties in the performance of their duties, be it difficulties in achieving planned production or the smooth running of the plant.

   Conversely when the person approached was in a position directly concerned with the profitability of the plant he was much more enthusiastic about any initiative that would save money.

   Two major consumers, a bakery (Albany Bakery) using 1 100 kW maximum demand and a glass container factory (Nampak Glass Containers) using 4 500 kW and further increase in electricity consumption is planned, indicated that the only power shedding that is possible are air conditioning, water and space heaters in the offices.

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It is interesting to compare results of the above survey with results of a similar survey done in Sweden (12). The price of electricity in Sweden is similar to S.A.

Bakeries in Sweden, according to (12) "By taking advantage of the thermal inertia of the ovens in a load priority system, and giving surrounding equipment low priority; the peak load could be reduced by approximately 30%".

Again in the glass manufacturing industry, where resistance heated glass meting furnaces are used, a possible load management application is to melt the glass during periods when the electricity price is low. The demand is much higher for melting than in a holding furnace. The ratio between melting and holding demand is approximately 4.

As highlighted in the above two examples it seems that management in S.A. is mot sufficiently motivated to reduce maximum demand and it is possible that further reduction of maximum demand is possible.

4. REVIEW OF LITERATURE ON THE SUBJECT OF LOAD CONTROL

Before looking further and deciding what should be done in the case of Germiston, it is usefull to review the approach elsewhere in the world on the same subject.

For quite some time load control in various countries was mainly implemented in the residential sector by switching off water heaters and space heaters.

The usual method of control is what is known as ripple control.

More recently a radio communication has been used for the same purpose.

Both methods are successful and achieved what was intended with reasonable reliability.

Some theoretical studies were done in the field of modeling, and prediction of overall residential electrical load shape (1) as well as studies of the shape of residential water heater load curves (4).

There are studies examining effective load management in general and examples were presented which include influence on the load curves resulting from modification to the water heaters (11).

In the recent times due to increasing cost of energy production (rising cost of fuel and cost of equipment) greater emphasis was put on load management by means of direct load control (DLC), time of day pricing, spot pricing and electrical thermal storage.

The relationship between the characteristics of utilities and direct load control (DLC) effectiveness was considered by (15) after studying various utility experiences with DLC.

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The utilities can be divided in two groups, winter peaking and summer peaking.

Most of the DLC was by controlling residential air conditioning, water heaters, space heaters and some interruptible/curtailable commercial customers.

The load shed by controlling the air conditioning is heavily dependant on the weather (15) and that of the water heaters dependant on the time of the day and to a lesser degree on the weather.

For example Pacific Gas Electric Co. achieved 32.4 MW load relief provided by the residential air conditioning program for a 98.3F° composite temperature and 72 MW for a 109.3F° composite temperature (15).

While American Electric Power Service Corporation (AEP) achieved on a 4.5 kW water heater a 0.85 - 0.71 kW load reduction/unit in winter and 0.55 - 0.35 kW load reduction in summer for a 4 hours defferal (15).

The cost benefits of such schemes depend heavily on customer incentives; conversely some programs actually showed a loss due to the excessively high cost of incentives (15).

Obviously very important factor in DLC is the shape of the load curve; a narrow short duration peak allows a high percentage of controllable load to be switched off.

Another utility which after experimenting with DLC came to the conclusion that DLC was not economically viable, was South Carolina Electric Gas Co. (15). The DLC experiment consisted of controlling air conditioners, water heaters and space heaters. The reasons for the negative results were mainly due to a flat load curve, (10/14 hrs summer peak), and about 15% of the demand was available from a pumped storage scheme that flattened the load curve even more.

The Detroit Edison had a radio controlled water heater sytem installed in 1968 (1st generation). Second generation load system control system was installed in the eighties. After it became apparent that the future load management systems could be expected to control additional types of loads and according to (2) the third generation of Load Management Equipment may be required in as little as five years after the installation of the second generation system, this generation of equipment will have to be expandable and should include optimizing routines to allow for interaction between many different load management strategies. This reference further states; "There are also many advantages to a two way system if cost and reliability considerations can be successfully addressed."

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Some innovative load management techniques discussed in (6) concentrate on commercial and industrial sectors, and utilize.

(a) use of Thermal Energy Cooling Storage in the Commercial Sector

(b) use of consumers' standby Generating capacity

(c) Industrial peak lopping load management

The results are interesting, however, load management discussed in (6) requires very active utility involvement and high incentives as well as high technical expertise which at present would be too revolutionary for Germiston.

(8) Describes results obtained from a two way load management experiment for large commercial and governmental customers supplied by the Potomac Electric Power Company. The two way communication was via a telephone system. The results of this experiment are described as encouraging and the system will be expanded in the future.

The future plans are to adopt different credit rates to participants who can shed load with short notice (5 minutes) as opposed to those who require longer notice (30 minutes).

5. LOAD CONTROL IN R.S.A.

As far as is known to the writer, the load control in South Africa is mainly restricted to the residential sector, i.e. the water heater.

The system is usually one way "ripple control" or radio transmitted signals.

There is voluntarily agreement between the various large consumers like the mines and Escom to reduce the electrical load when the frequency of the generated current drops. The frequency is monitored by a frequency relay installed in the main substation supplying the customer.

The system works as follows:

Frequency (Hz)	Signal to the consumer	Action required
49,5	Alarm	Warning
49,2	A	Shed level A
49,1	B	Shed level B
49,0	C	Shed level C

/15.....

Shed level A is approximately 3,3%; Shed level B is approximately 6,6% and Shed level C usually represents 10% of consumers load.

Although there are no incentives or penalties, both parties, the consumer, and Escom benefit from the arrangement, as the consumer is aware that the result of a further drop in frequency will be selective power interruptions imposed by Escom.

A disadvantage of this arrangement is that if there is no frequency drop, there is no signal to the consumer to shed load even though it may be necessary for less efficient generators to be switched on in to the national grid to cope with the demand.

6. LOAD MANAGEMENT IN GERMISTON

> Most people learn from their experience.
> The clever ones learn from the experience of others.
>
> Ancient Proverb

From the studies of experiences in load control it is possible to formulate certain criteria for a successful DLC and to be aware of potential problems.

Obviously the higher and sharper the load peak, the more beneficial the load control scheme can be. The scheme should be cost effective. The cost of the system and the customer incentives should not exceed the benefits.

From the load curves of Germiston it can be seen that there is a sharp peak at 09h00 and a second lower peak at around 19h00.

As it was mentioned above, the morning peak can be attributed to the non-residential consumers and the evening peak to residential consumers.

Germiston does not have any generating or pump storage schemes, that could flatten the load curve.

From the above, based on experience of others (15) Germiston is a suitable candidate for the implementation of a load control scheme.

At present the possibility of installing a scheme controlling the water heaters is under investigation by Germiston.

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The price for a ripple control system that will be able to control 25 000 water heaters is as follows:

R1 200 000,00 for injection equipment and R85,00 for each relay (receiver), hence the price for 25 000 relays is R2 125 000,00. TOTAL PRICE excluding the installation of the 25 000 relays is:

Injection equipment	R1 200 000,00
25 000 relays at R85,00 each	R2 125 000,00
TOTAL excluding installation	R3 325 000,00
Installation	R 250 000,00
TOTAL	R3 575 000,00

The installation cost is based on one electrician and one assistant installing 25 units a day.

This will require 1 000 working days for the team of two at R250,00 per day including transport. Hence this cost should come to around an additonal R250 000,00.

The cost of a radio controlled scheme for 25 000 relays is roughly similar. The question is, how will a scheme such as the above reduce Germiston's maximum demand.

From a study performed by Germiston Electricity Department where 76 relays were installed it can be expected that the load shed will be approximately 1,2 kW/water heater i.e. a total of 36 000 kW. The above is true if all the water heaters are switched off at the same time.

It was also found that if a water heater is switched off, the diversified load decrease is between 1,5 kW and 0,4 kW depending on the time of the day (0,4 kW during night time). However, when the same water heaters are switched on (after 90 minutes or longer), the diversified load increase per water heater will be the full 3 kW.

Therefore it is not practical to switch all the water heaters on and off at the same time, thus the switching will have to be staggered. In this way, based on the experience of others (15) and in Germiston the reduction in maximum demand could be approximately 0,5 - 0,7 kW per water heater, equivalent to a reduction of 12 250 kW to 17 500 kW, on a total load of 75 000 kW (25 000 x 3 kW).

/17.....

the capital cost of the reduction in maximum demand is R204/kW, assuming the 17 500 kW maximum demand reduction and capital outlay of R3 575 000,00.

As the load peak in Germiston is due to industrial demand and as the residential load after diversity contributes to just over one third of the total maximum demand, (see Table 1), it makes sense to look at the industrial load. From Table 1 can be seen that 25% of maximum demand is used by 42 consumers of 1 000 kW maximum demand or more. (see Appendix 3).

The 42 consumers drawing over 1 000 kW each, indicated that they are able to shed 8 260 kW during the Germiston municipal peak. Of 42, 21 indicated that they could shed 100 kW or more each and the load shed would come to 7 630 kW. (see Table 3.)

Taking into account various difficulties such as diversity factor excessive optimism, etc., this figure can be reduced to 5 000 kW.

By controlling the 21 industrial consumers, the maximum demand shed will be equivalent to that shed by approximately 5 000 controlled water heaters at capital outlay of R1 020 000,00, assuming the same capital cost/kW shed as the ripple control.

Let us examine the most suitable way to encourage these industrial consumers to shed load during the Germiston Municipal peak. Here again experience of others may help.

Firstly it is useful to understand what one aims to achieve.

Germiston Municipality is interested in reducing its maximum demand as there is a maximum demand charge integrated over a period of one hour of approximately R10,00/kW.

On the other hand it is advantageous to sell the highest quantity of energy (kWh). At present the industrial consumers are charged on their maximum demand, integrated over a period of 30 minutes. (see Appendix No. 2). This encourages the consumers to flatten their individual load curves.

As a result many of the consumers recently installed maximum demand controllers, and a considerable number of consumers manage to reduce their peak and flatten their load curves. However, this does not always help Germiston Municipality, as the individual consumers peak does not necessary coincide with the municipal peak.

What would be much more helpful in the effort of reducing municipal maximum demand is to have a deep curtailment of controllable load during the peak time.

/18.....

There are different approaches to the whole subject of load management. One approach suggested is to have a free market system, whereby the consumer is charged according to the actual instantaneous price of energy at the time (12).

To implement this approach sophisticated communication and metering equipment is required.

NON RESIDENTIAL CONSUMERS

NO	REF	NAME	KW USED	KW CONTROLLABLE
1	R63/347	HYPERAMA	2,500	900
12	RK/1464	DUROPENTA	2,000	100
14	KAL/80/75	CONSOL PLASTICS	4,000	300
15	KAL/11/75	TRANSVAAL MALLEABLE FOUNDRY	2,400	250
2	AP/7	MALLEABLE CASTINGS	2,800	1,000
20	KAL/2/27	MOSER HARDCHROME	1,000	100
21	WI/257	HUBCO	2,000	200
22	WI/239	HIND BROS	1,000	500
23	WI/231	WJM PIPELINES	1,200	1,000
24	WI/230	ANASCO WADEVILLE	1,050	100
25	G57/589	NCP	8,000	650
28	G3/1185	STEEL WHEEL&AXLE	2,500	600
30	G55/862	MONOWELD	1,300	200
32	G51/502	B.THMAS PILLENER	1,900	300
35	HER4/94	KROST BROS	1,600	100
37	E90/285	MCI	1,200	100
38	R1519/20	WASTE MATTER	1,500	100
39	R63/130	AFRICAN GATE	1,300	100
41	R63/440	*INTERPACK*	*820*	*130*
8	R63/PTN344	BROLLOI	2,500	600
9	R63/40	RIETFONTEIN GEN GALVANISERS	2,100	300
TOTAL:			44,770	7,830
COUNT:	21			

TABLE 3

NON RESIDENTIAL CONSUMERS WITH CONTROLLABLE LOAD EXCEEDING 100 kW

/19.....

Ref. (10) discusses present and future prices and types of communication and metering equipment required for electricity spot pricing. With present technology it is definitely possible to implement and the cost of the equipment is not exorbitant especially if compared to the costs of electricity.

In future these options become even more attractive as the energy costs are rising whilst metering and communication equipment prices are dropping in real terms.

However, whilst spot pricing and some of the complicated schemes described in (10) which require many variables and short notice to consumers, the author feels that the ordinary industrial consumer without his own generating facilities, would only become confused and the information would not be utilised. Furthermore, if the intention is for the consumer to take an active part in load management, the acceptance by the consumer of the various schemes is important, otherwise the response will not be adequate and the objectives will not be achieved.

Ref. (14) summarises the findings of Electric Power Research Institute, (EPRI). Inter alia it is stated "Different customers have different preferences. Thus to better meets its customers' varying needs and preferences, a utility probably will need different programs for different customers segments".

Ref. (7) deals with the measurement of consumer preferences for load management and the trade-offs they are willing to make.

In summary:

(1) The double peaked load curve makes Germiston suitable for load management.

(2) From the composition of consumers and the survey conducted it is feasible to look at industrial consumers for load management.

(3) Any program must be acceptable to the consumers and as there are different categories of consumers different programs have to be developed.

(4) Due to advancement in methodology and technology, the load management techniques are in a state of constant change and development.

(5) The cost of capital equipment, running cost and therefore cost of energy will continue to rise. The cost of electronic equipment necessary for load management will decline in real terms.

/20.....

6.1 GUIDE LINES FOR LOAD MANAGEMENT SYSTEM IN GERMISTON

For Germiston load management one needs different prog.mms as there are different types of consumers and they have different needs.

The industrial consumer surveyed had different ways of operation in order to shed load. Some of them needed quite long notice to be able to re-schedule the planned production, others not.

Consumers should have the choice of participating in a load management scheme. A good incentive can be a suitable tariff, for example 3 price level (night tariff, normal, and super peak).

The time and period of the super peak should vary or even be deleted on certain days, as successful application will modify the load curve.

The Germiston load curve should be monitored constantly.

The participating consumers that will curtail the load during the super peak shoule have additional incentive similar to incentive suggested by (8) page 2324.

Or alternatively the credit to the consumer should be proportional to the difference between the maximum demand in kW - and average curtailed level in kW for that month.

Provided there is a maximum demand charge in the tariff structure, and the credit rate is less than maximum demand charge, this scheme will encourage individual consumers to maintain a flat load curve, and at the same time encourage deep curtailment during super peak curtailment period. The rate of credit/kW can be worked out in such a way that it will be attractive to the consumer and to the Germiston Council.

Based on the above guidelines it is clear that the system if implemented will have to have the facility of two-way communication or to have a large memory at the metering equipment that will store the monthly maximum demand and record all the curtailment and the maximum demand at preset times after curtailment signals are received.

However, the advanatage of a two-way system is that it is more flexible and other future strategies that may require the two-way communication feature are impiementable.

A two-way system, because of the feed back, can also detect problems and mulfunctioning and take steps to rectify them, thus it should have higher operational reliability.

/21.....

The communication medias for the two-way system that can be considered are pilot wires, telephone, or superimposed signal on the 50 Hz power network.

Pilot wires are expensive and future extension of the system may be difficult.

Telephone communication media can be considered, however, there are again problems as the telephone lines are not controlled by Germiston Municipality, therefore reliability and availibility of lines especially for extension of the system may become a problem.

The distribution line carrier system is a two-way system utilising the existing power lines. It has the feature and advantages mentioned above and these make it suitable for use when implementing a load managment system in Germiston.

It is flexible and expandable and thus can cater for different future strategies. It can also preform additional tasks like remote meter reading, and still can be used for one-way water heater control.

This study did not take into account many important aspects some of them specific to South Africa. To mention a few :

1. Successful implementation of load management introduces sophisticated and complicated components in to the system, that have to be maintained and operated by skilled personnel.

2. It is assumed that all the systems described work, but additional investigation and users reports would be desirable.

3. Political issues like boycots and back up availibility have to be considered.

7. THE BENEFITS OF LOAD MANAGEMENT ON A NATIONAL SCALE

Up until now, the load management was discussed form the Germiston Municipality point of view.

It would be interesting to look at load management from a more general point of view, on the National scale. Most of the information for this section is based on Ref. ('9).

Table 4, page 35 (9) shows the average annual increase in the amount of electricity sent out for consumption and by the Escom system in the Republic of South Africa for different periods of time.

The average annual percentage increase varies over the years but mostly is above 7% average, per year.

From table 3, page 35 (9) peak demand on integrated Escom system in the year 1982 was 15 532 MW and 7% of this more than 1 000 MW.

The installed capacity of Escom doubles approximately every eight years. This was necessary in order to meet the growing electrical demand.

/22.....

In order to maitain this growth the forecast for 1983 - 1987 capital expenditure is R21 787 million. It can also be seen that the hihgest growth of electricity sales was to bulk consumers (like municipalities) followed by sales to industries and mining.

By looking at Escom graphs and tables of maximum demand it can be seen that the Escom load pattern is very similar to the one for Germiston.

(1) The maximum demand usually occurs at 09h00.

(2) The maximum dmeand in winter is considerably higher than in summer.

(3) Similar demand patterns occur during the week days.

(4) A considerably lower demand curves on Saturdays and particularly on Sundays.

From the above is clear that reduction of Germiston's maximum demand will directly contribute to reduction in Escom's maximum demand as their maximum demands usually coincide.

Further it would be beneficial to Escom if their customers would be able to drop their electricity demand during National peak period and not to be over concerned with their individual maximum demands as long as their maximum demands do not coincide with Escom's

This strategy should be supported with suitable incentives (Tariffs, credit for curtailed maximum demand and for customers with Generating facilities spot pricing may be introduced.)

Unfortunately the load curves of other municipalities are not available to the author. However, the above is applicable generally to customers with any load curve.

This study and the investigation in water heater control revealed that Germiston municipality can reduce the maximum demand, by approximately 10%, if the load control schemes would be implemented successfully.

This means reduction of approximately 15 - 20 MW that can result in up to two million Rand per year in reduced maximum demand charges.

The capital cost of a suitable system would be approximately four million Rand. (See Appendix 4).

The subject of the running cost and incentives should not exceed 10% of the capital cost of the system.

Depending on the interest rates the payback period of such a system could be within two to three years, and can be financed by a local authority.

On the national scale, Escom's peak demand during 1982 was 15 532 MW. If a 5% reduction of the maximum demand is possible, as a result of implementation of load management schemes.

/23.....

The installed capacity can be reduced by a corresponding 750 MW of assigned rating.

The saving in capital expenditure can be considerable and can be estimated as follows :

From table 34, page 91 Ref. (9) the capital investment per MW of assigned rating varies between R1 061 000,00 to R1 790 200,00 for coal power stations. It can also be seen that the capital investment for pumped storage schemes are around R1 500 000,00 per MW of assigned rating.

Assuming the saving (conservatively) of one million Rand per MW of assigned rating, the capital saving would be 750 million Rand.

Another way of looking at the situation would be to consider which is a better investment for South Africa, an investment in new generating plant or investment in expenditure to optimise consumption by load management. The cost effeciency can be measured in Rands/MW.

The comparison between the two approaches in round figures is :

(1) Increase in installed generating capacity at a cost of over one million Rand per MW,

or

(2) Reduce maximum demand at a cost of 0,2 million Rand per MW.

8. CONCLUSIONS AND RECOMMENDATIONS

This study considered the load management as a tool to reduce maximum demand. it was shown that load management is an economical solution to reduce the maximum demand within certain limits.

Selective load management in the industry is possible and may be cost effective.

Suggestions for a suitable type of system and tariffs were made.

On the national scale, although figures for accurate estimates of load management benefits were not available, it was shown, based on conservative assumptions that considerable benefits can be achieved.

There are three ways to meet the increased electrical demand.

(1) To build new power stations.

(2) To flatten the load curve by building pumped storage schemes.

(3) To flatten the load curve by load management.

/24.....

The third is the most cost effective solution within its limits.

The load management schemes can be financed by the consumers such as municipalities, industry and mines.

However, the above consumers have to be guided, educated and motivated to make them aware of various possibilities open to them.

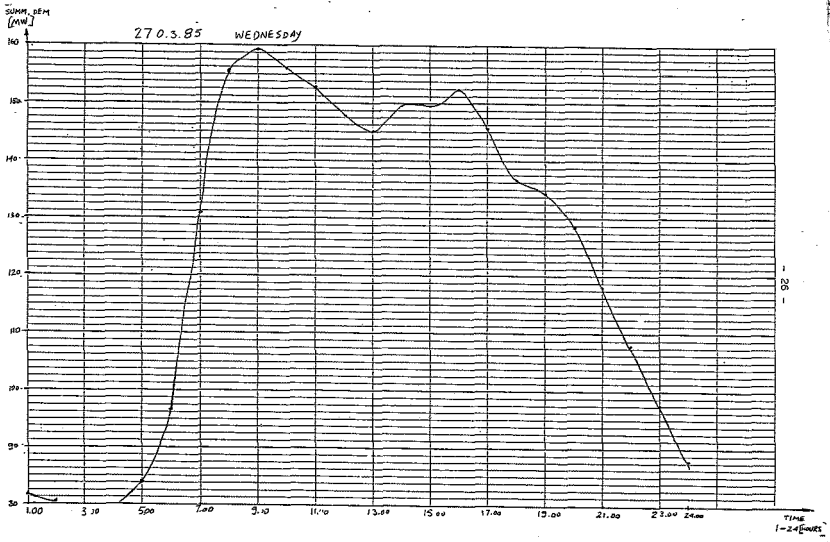
It is too much to expect from usually short staffed municipality, industrial company or mines to invest time and money in research and experiments in load management techniques.

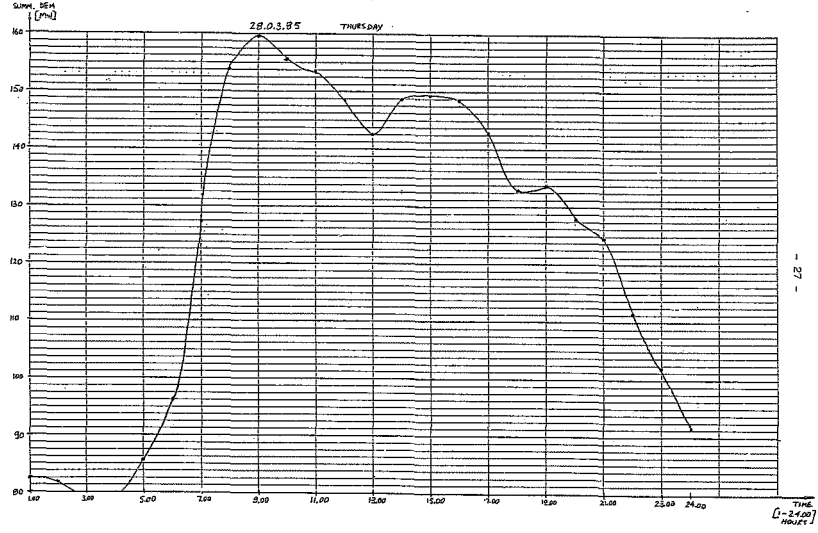
It is also inefficient if the same work is done unco-ordinated in various places.

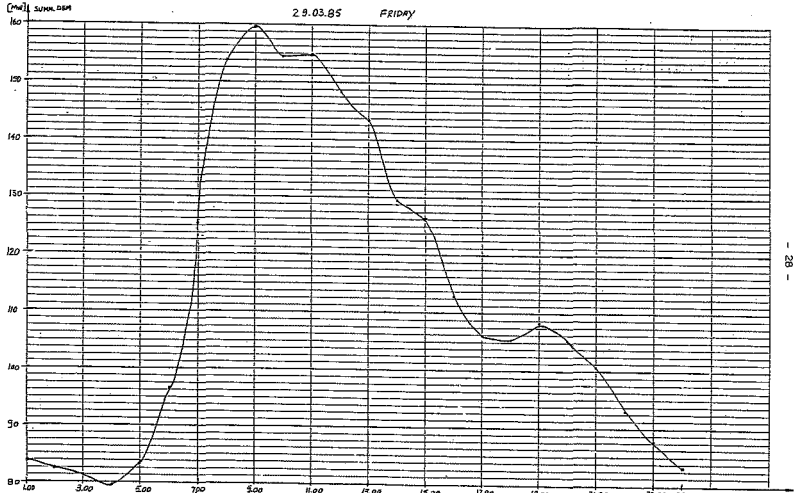
Escom or government bodies like SCIR should get involved in research co-ordination and to a certain extent financing of promising experiments in this field, as well as evaluate, educate and publish results from experiments in S.A. and abroad.

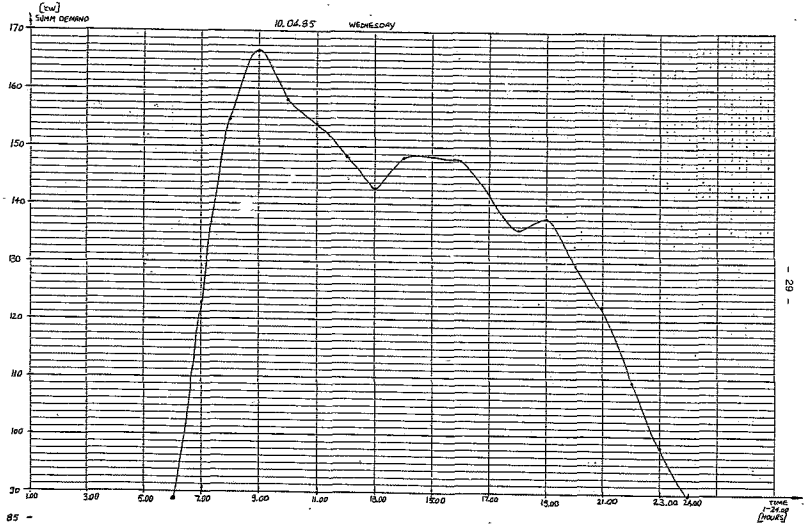
APPENDIX 1

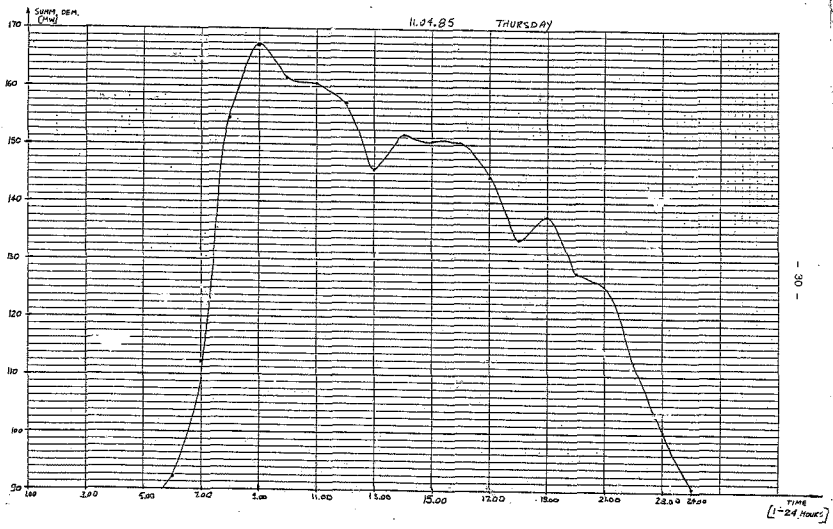
Combined typical load curves of Germiston Municipality

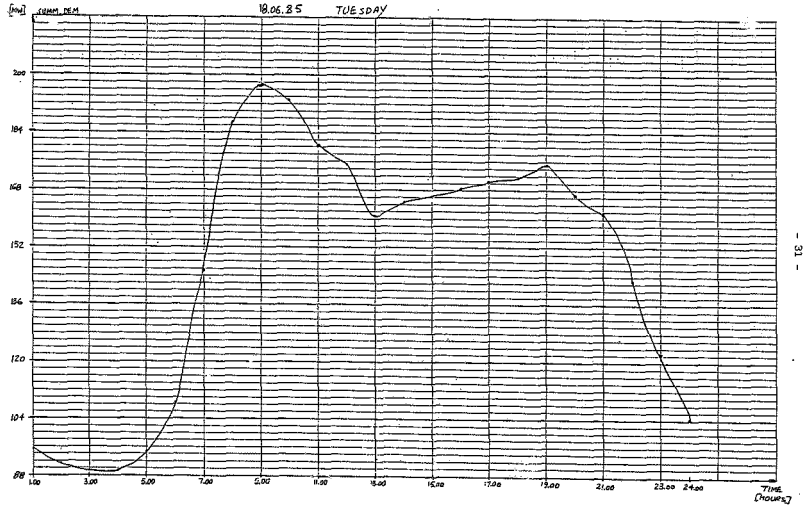

SUMM. DEM
[MW]
27.3.85
WEDNESDAY
160
150
140
130
120
110
100
90
80
1.00
3.30
5.00
7.00
9.30
11.40
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME
1-24 HOURS

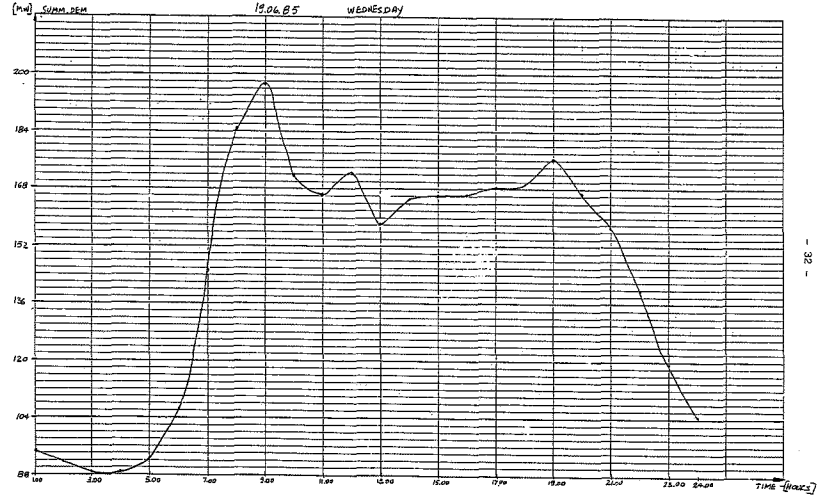

SUMM. DEM.
[g/m²]
28.03.85
THURSDAY
160
150
140
130
120
110
100
90
80
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME
[1-24.00]
HOURS

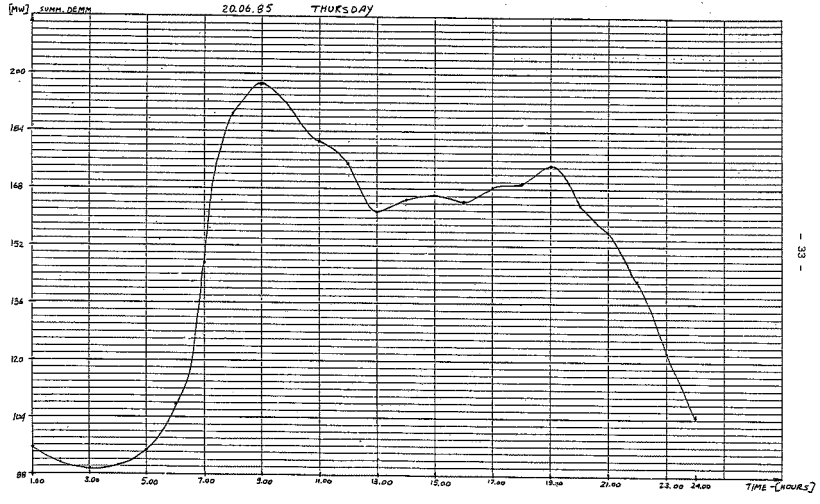

[mg/l] SUMM. DEN
29.03.85 FRIDAY
160
150
140
130
120
110
100
90
80
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME [HOURS]

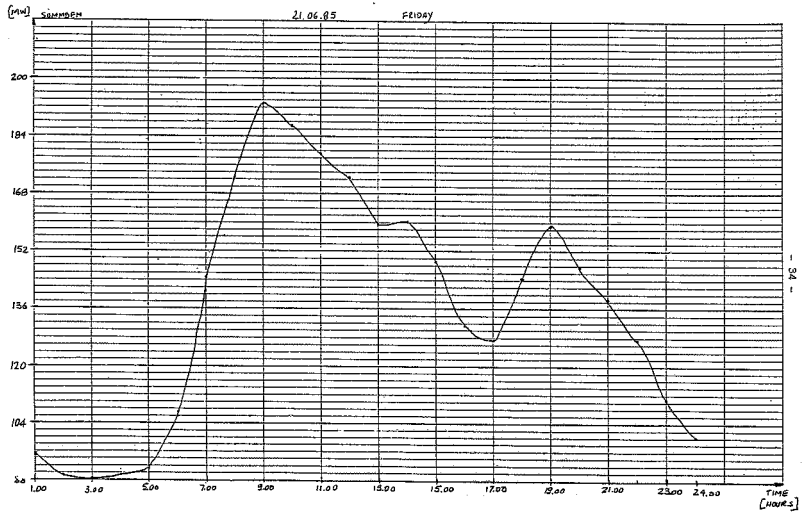

[kW]
SUM DEMAND
10.04.85
WEDNESDAY
170
160
150
140
130
120
110
100
90
85
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME
24.00
[hours]

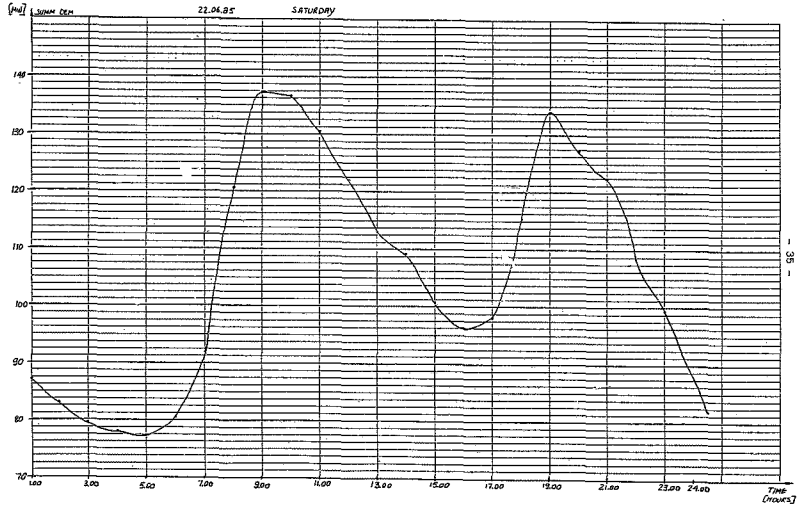

SUMS. DEM. (MW)
11.04.85
THURSDAY
170
160
150
140
130
120
110
100
90
1.00
2.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME [1-24 HOURS]

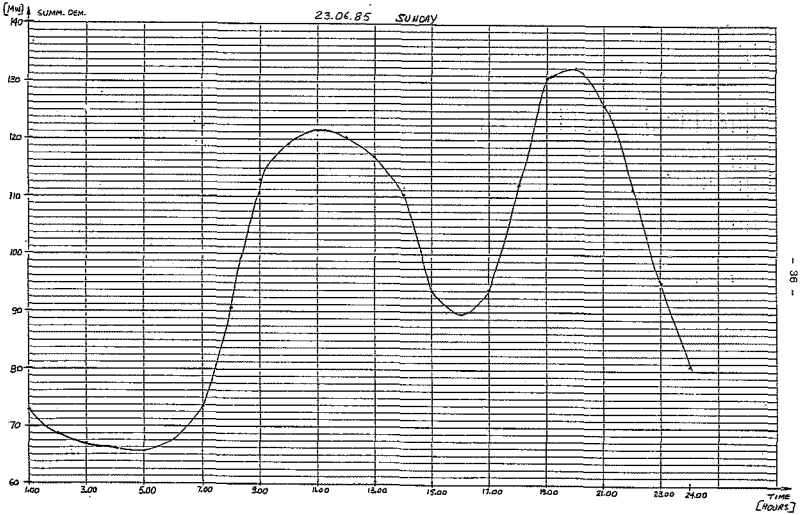

[mm]
SUMM. DEM.
18.06.85
TUESDAY
200
184
168
152
136
120
104
88
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME
[Hours]


[MW] SUMM. DEM
19.06.85
WEDNESDAY
200
184
168
152
136
120
104
88
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME [HOURS]


[MW] SUMM. DEMM
20.06.85 THURSDAY
200
184
168
152
134
120
104
88
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME [HOURS]


[MW]
SUMMER
21.06.85
FRIDAY
200
184
168
152
136
120
104
88
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME
[HOURS]
- 23 -


[mg] SUGAR CON
22.04.85
SATURDAY
140
130
120
110
100
90
80
70
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME [HOURS]


[MW] SUMM. DEM.
23.06.85 SUNDAY
140
130
120
110
100
90
80
70
60
1.00
3.00
5.00
7.00
9.00
11.00
13.00
15.00
17.00
19.00
21.00
23.00
24.00
TIME [HOURS]

APPENDIX 2

Germiston Municipality Electricity Tariffs

"SCHEDULE

TARIFF OF CHARGES

PART 1 : TARIFF

1. Basic Charge

(1) With effect from 1 July 1982 a basic charge of R60 per year shall be levied for each erf, stand, lot or other area, with or without improvements, which is or, in the opinion of the council can be connected to the supply main, whether electricity is consumed or not.

(2) The charge in terms of subitem (1) shall be payable by the owner of such erf, stand, lot or other area and shall be payable on the same date as the rate imposed for that year in terms of the Local Authorities Rating Ordinance, 1977.

2. Scale 1A : Domestic Supply

(1) (a) This scale shall be applicable to the following types of premises :

(i) Private dwelling-houses.

(ii) Homes run by charitable institutions.

(iii) Hostels.

(iv) Sport clubs situated on municipal property.

(b) Charges for the supply of electric energy for lighting, heating, cooking and motive power where used exclusively for domestic purposes, per kW.h : 2,18c.

(2) Scale 1B : Flats

This scale shall be applicable to flats and dwelling-units registered under the Sectional Titles Act, 1971 (Act 66 of 1971), irrespective of whether the electricity consumption is measured in bulk or not :

(a) Fixed charge, whether electricity is consumed or not, per flat, per month : R3.

(b) Per kW.h of electricity consumed : 2,18c.

3. Scales 2A, 2B and 2D : Commercial, Industrial and General

These scales shall be applicable to all premises or uses not specifically mentioned under any other scales and to the supply in bulk to a public body where the distribution is done by the consumer :

(1) Charges for the supply of electric energy through one meter, per month :

(a) Scale 2A

Per kW.h of electricity consumed : 5,5c.

This scale shall be applicable to a supply with a capacity not exceeding 80 kV.A.

(b) Scale 2B

The council shall, at the written request of the consumer and subject to the conditions of Part 2 of this tariff, where the consumer receives a supply under Scale 2A and has installed a separate circuit for the purpose, install a special meter for measuring the supply of electricity for commercial cooking, water heating and refrigeration purposes, and the charge for such supply as measured by such meter

shall be as follows :

Per kW.h : 4,8c.

(c) Scale 2D

The minimum period for which metering for the demand tariff prescribed in terms of this scale shall be installed, shall be 12 months. The tariff prescribed in terms of this scale will normally suit consumers whose monthly consumption is fairly regular and whose demand exceeds 40 kW.

(i) Service charge per meter, per month : R25.

(ii) Demand charge per kW of the maximum demand registered over any consecutive 30 minutes during the month : R7.

(iii) A unit charge per kW.h of electricity supplied during the month which shall be the same as the unit charge paid by the council from time to time for the purchase of electricity in bulk.

(iv) The aggregate for the month of the service charge, the demand and the unit charge aforesaid shall be subject to a discount calculated at the rate of 10 per cent upon the amount, if any, by which the said aggregate exceeds R3 000.

(v) Subject to a minimum charge of R30 per month, the net amount calculated in terms of subparagraph (iv) shall be subject to a general discount or surcharge allowed to or levied on the council for the purchase of electricity in bulk.

(vi) The maximum kilowatt demand figure used in the calculation of the charges payable in terms of sub-paragraph (ii) shall be one of the following, whichever is the highest :

(aa) The actual demand recorded, or

(bb) from a date 6 months after the date of connection or the date on which a larger connection for an increased supply is provided, 70 per cent of the maximum kilowatt demand requirement declared by the consumer when applying for a connection or an increased supply.

(vii) Six months' formal notice of intention to reduce the supply shall be given to the engineer in writing by the consumer : Provided that for the purpose of calculating the demand charge payable in terms of sub-paragraphs (ii) and (vi), no such reduction of the consumer's declared maximum kilowatt demand requirement shall be taken into account during the first 18 months after the date of providing the connection or a larger connection for an increased supply.

(2) *Rules applicable to Scale 2D*

(a) Where a consumer's electrical installation is tested by the council, and the kW demand is found to be less than 80% of the kV.A demand, the council shall be entitled to give the consumer written notice to improve his power factor to not less than 80% within six months, failing which the council shall replace the kW demand meter with a kV.A-demand meter and the charges under Scale 2D shall then apply to kV.A-demand instead of to kW-demand.

(b) In the case of consumers supplied through transformers, if metering is carried out on the low voltage side of the transformer a surcharge of 2,5% on the kW.h registered, and 2,5% on the maximum demand recorded, shall be made.

4. Scale 3 : Special 'Off-Peak' Tariff

The Council shall, at the written request of the consumer and subject to the conditions of Part 2 of this tariff, install a special meter for measuring the supply of electricity, from 21h00 to 07h00, subject to the following :

(a) that the consumer receives a supply under Scale 2D; or

(b) that the consumer has installed a separate circuit for the purpose, and such circuit takes the supply only from 21h00 to 07h00.

The charge for the supply as measured by such meter shall be as follows :

Per kW.h : 1,3c.

5. Scale 4 : Itinerant Consumers

Electricity shall be supplied to circusses, merry-go-rounds, amusement parks, persons carrying on construction works and other casual consumers at the following rates :

(1) For the first 300 kW.h per meter consumed during any month, per kW.h : 15,5c.

(2) For all additional kW.h consumed during the month, per kW.h : 5,5c.

6. Scale 5 : Lighting of Telephone Booths

Electricity shall be supplied to the telephone department for the lighting of telephone booths within the municipality at a flat rate

of R6-00 per booth, per annum.

7. Surcharge

In addition to the charges provided for in terms of scales 1A, 1B, 2A, 2B, 2D, 3, 4 and 5, a surcharge shall be payable as follows :

(1) In respect of scales 1A, 1B, 2A, 2B, 3, 4 and 5 : 30%

(2) In respect of scale 2D : 10%

(3) (a) Whenever, after 1 March 1981, Escom changes the general discount or surcharge in its bulk supply tariff, the surcharge levied in terms of subitem (1) shall be adjusted in accordance with the following formula :

New surcharge -

$$\left[\left(1 + \frac{T}{100}\right) \times \left(1 + \frac{0,45V}{100}\right) - 1\right] \times 100\%$$

Where -

the new surcharge is calculated to the nearest third decimal;

T is the percentage surcharge levied in accordance with subitem (1) immediately preceding the adjustment in Escom's bulk supply tariff; and

V is the percentage increase or decrease in the bulk purchase price of electricity due to the adjustment in the general discount or surcharge in Escom's bulk supply tariff. (In the case of a decrease in purchase price, V is taken as negative.)

(b) Consumption over the period between meter readings immediately preceding and immediately succeeding the date on which the adjustment in the surcharge comes into operation shall be deemed to have taken place evenly.

8. *Adjustment of kW.h-charge*

(1) When the kW.h-charge incorporated in the Electricity Supply Commission's bulk supply tariff to the council is increased or decreased, the kW.h-charge payable in terms of scales 1A, 1B, 2A, 2B, 3 and 4 shall be increased or decreased with P cent per kW.h. P is calculated to the nearest third decimal as follows :

$$P = 1{,}027 \times E \left[\frac{1 + \frac{S}{100}}{1 + \frac{C}{100}} \right]$$

Where –

E is the increase or decrease in Escom's kW.h-charge;

S is the general discount or surcharge in Escom's bulk supply tariff (if a general discount is applicable, the value of S is taken as negative);

C is the surcharge payable in terms of item 7.

For the purpose of determining P for the first time the original kW.h-charge shall be taken as 0,9663c per kW.h.

(2) Consumption over the period between meter readings immediately preceding and succeeding the date on which the increase or decrease in the kW.h-charge for electricity purchased in bulk by the council comes into operation, shall be deemed to have taken place evenly.

9. Calculation of Monthly Charges

The monthly account under each of the scales in this tariff shall be calculated to the nearest cent.

10. *Definitions*

For the purpose of this tariff, unless the context otherwise indicates - 'kW.h' means a consumption of electrical energy as measured by the council's kilowatt-hour meters, and calculated at the rate of 1 000 watts electrical energy consumed each hour. All calculations shall be to the nearest kW.h

'kW' means kilowatt;

'kV.A' means kilovolt-ampéres

PART 2 : GENERAL

1. *Standard Connections*

(1) The Council shall provide the following standard connections :

(a) single-phase supply at low voltage, limited to 60 ampéres.

(b) three-phase supply at low voltage.

(c) three-phase supply at high voltage.
(6 600, 11 000 or 33 000 volts).

(2) Where the connected load of an installation exceeds 40 kV.A, the engineer may determine that the supply shall be at a voltage of 6 600 volts or 11 000 volts.

(3) Where the connected load of an installation exceeds 3 000 kV.A, the engineer may determine that the supply shall be at a voltage of 33 000 volts.

(4) All permanent service connections shall be provided by means of underground cables.

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'kW.h' means a consumption of electrical energy as measured by the council's kilowatt-hour meters, and calculated at the rate of 1 000 watts electrical energy consumed each hour. All calculations shall be to the nearest kW.h

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APPENDIX 3

Results of survey of consumers with demands exceeding 1 000 kW

REF: R63/133
NAME: GUNDLE PLASTICS
KW DECLARED: 3200 KW USED: 2000 KW CONTROLLABLE: 00
NOTES: MISC

REF: R63/440
'TERPACK2
'): 472 KW USED: 300 KW CONTROLLABLE:

REF: R63/440
NAME: INTERPACK
KW DECLARED: 1279 KW USED: 820 KW CONTROLLABLE: 130
NOTES: KW CONTROLLED FOR BOTH ACCOUNTS
MAINLY AIR CONDITIONING
DISCUSSED WITH :MR BUCHART AND MR MANN
SENIOR MANAGEMENT

REF: R63/129
NAME: AFRICAN GATE2
KW DECLARED: KW USED: 1200 KW CONTROLLABLE: 50
NOTES: NOT CERTAIN DEPENDS ON LABOUR
AND TRADE UNIONS -OVER TIME WORK
DISCUSSED WITH MR MCWILLIAMS-PLANT
ENGINEER

REF: R63/130
NAME: AFRICAN GATE
KW DECLARED: N KW USED: 1300 KW CONTROLLABLE: 100
NOTES: SEE NOTE AFRICAN GATE2

REF: R1519/20
NAME: WASTE MATTER
KW DECLARED: 1600 KW USED: 1600 KW CONTROLLABLE: 100
NOTES: M15C
DISCUSSED WITH DR MINSHELL-MANAGER

REF: E90/205

NAME: MCI
KW DECLARED: 1200 KW USED: 1200 KW CONTROLLABLE: 100
NOTES: 100KW CAN BE DROPPED FOR 2TO3
HOURS BY PLANNING PRODUCTION
DISCUSSED WITH:MR R KATZ PLANT ENGINEER

REF: NER4/94

NAME: KROST BROS
KW DECLARED: 1600 KW USED: 1500 KW CONTROLLABLE: 100
NOTES: 100KW CAN BE DROPPED BY PLANNING
THE PRODUCTION AND CONTROLLING THE
GALVANISING AND ELECTROPLATING SECTIONS.
DISCUSSED WITH MR W DEVILLIERS

REF: G4/1070

NAME: ILLMAN PLASTICS
KW DECLARED: 2200 KW USED: 1150 KW CONTROLLABLE: 0
NOTES: NEW CONSUMER

REF: 612/1290

NAME: ALBANY BAKERY
KW DECLARED: 1600 KW USED: 1100 KW CONTROLLABLE: 20
NOTES: CONTROLLABLE LOAD:
OFFICE AIR CONDITIONING,SPACE AND WATER
HEATERS.
DISCUSSED WITH MR SPINDLER-ENG MANAGER

REF: 651/502

NAME: B.THMAS PILLENER
KW DECLARED: 1900 KW USED: 1900 KW CONTROLLABLE: 300
NOTES: 300KW CAN BE DROPPED BY CAREFULLY
PLANNING PRODUCTION
DISCUSSED WITH MR JULIAN PLANT ENG.

REF: 65/662

NAME: INSULPAN
KW DECLARED: 1050 KW USED: 750 KW CONTROLLABLE: 40
NOTES: CONTROLLABLE LOAD CONSISTS OF:
AIR CONDITIONING, SPACE AND WATER HEATER
CUTTING MACHINES, LIGHTING.
DISCUSSED WITH:MR H JACOBS-PLANT ENG

REF: 655/662

NAME: MONOWELD
KW DECLARED: 1500 KW USED: 1300 KW CONTROLLABLE: 200
NOTES: BY CONTROLLING ZINC BATHS 200KW
CAN BE SHED.
DISCUSSED WITH:MR VAN WYK PRODUCTION
MANAGER.

REF: E108/RE150

NAME: RAND AIRPORT
KW DECLARED: N KW USED: 1000 KW CONTROLLABLE:
NOTES: NOT DISCUSSED

REF: 63/1|85
NAME: STEEL WHEEL&AXLE
KW DECLARED: 2800 KW USED: 2500 KW CONTROLLABLE: 600
NOTES: THE CONCUMER IN PROCESS OF
INSTALLING MAX DEMAND CONTROLLER
ACCORDING TO THEIR STUDIES THEY SHOULD
BE ABLE TO SHED UP TO 600KW,COMBINED
WITH GUESTRO.
DISCUSSED WITH MR CORNEW-ENGINEERING
MANAGER.

REF: 63/3,009
NAME: GUESTRO
KW DECLARED: 4200 KW USED: 3500 KW CONTROLLABLE:
NOTES: ONE ACCOUNT WITHSTEEL WHEEL&AXLE

REF: 657/713
NAME: WOLTUBE
KW DECLARED: 2000 KW USED: 1700 KW CONTROLLABLE: 50
NOTES: 50KW LOAD DROPP BY SWITCHING OFF
24-3KW AIRCONDITIONERS
DISCUSSED WITH: MRT KRUGER PLANT ENG

REF: 657/689
NAME: NCP
KW DECLARED: 3400 KW USED: 8000 KW CONTROLLABLE: 650
NOTES: CONTROLLABLE LOAD:
1)200KW COOLING TOWERS FANS CAN BE
SWITCHED OFF FOR 15MINUTES EVERY 30 MIN
2)200KW INSTRUMENT COMPRESSORS CAN BE
TRANSFERED FROM MUNICIPAL TO NCP POWER
3)200KW PROCESS COMPRESSORS CAN BE.
SWITCHED OFF FOR 15 MIN EVERY 30 MINUTES
4)250KW SPARE GENERATING CAPACITY
TOTAL=200+15/30+200+200+15/30+250=650KW
DISCUSSED WITH:MR MOLLER CHIEF ENG AND
MR WALLAS ELECTRICAL ENG

REF: W1/230
NAME: AMASCO WADEVILLE
KW DECLARED: N KW USED: 1050 KW CONTROLLABLE: 100
NOTES: LOAD SHED BY PRODUCTION PLANNING
AND SWITCHING OFF NON ESENTIAL LOADS
DISCUSSED WITH:MR VAN STRATEN-PLANT ENG

REF: W1/231

NAME: WJM PIPELINES
KW DECLARED: 3000 KW USED: 1200 KW CONTROLLABLE: 1000
NOTES: NEW CONSUMER AT THE TIME OF
SURVEY PLANT WAS NOT ON FUL PRODUCTION .
INDUCTION HEATERS CAN BE USED DURING
NON PEAK HOURS, PRODUCTION PLANNED
ACCORDINGLY IF THERE WILL BE AN
INCENTIVE
DISCUSSED WITH:MR A BAUER-PLANT ENGINEER

REF: W1/239

NAME: HIND BROS
KW DECLARED: 1000 KW USED: 1000 KW CONTROLLABLE: 500
NOTES: WITH SUITABLE INCENTIVE THE TEA
BREAK CAN BE MOOVED TO 8.00 TO 9.30
DURING THE REST OF THE TIME NO LOAD CAN
BE SHED. THIS IS NOT ACOMITTMENT
DISCUSSED WITH MR LORENDOS PLANT ENG.

REF: W1/257

NAME: HUSCO
KW DECLARED: 2000 KW USED: 2000 KW CONTROLLABLE: 200
NOTES: LOAD CONSISTS OF:
2*150KW HEATERS FOR STEEL FORGING
5*200KW HEATERS FOR STEEL FORGING
2*300KW HEATERS
SPOT WELDERS: 2*600KJA
2*400KVA
COMPRESSORS
LOAD CAN BE SHED BY CONTROLLING THE
ABOVE LOAD
DISCUSSED WITH:MR MATHEWS-MANAGING
DIRECTOR

REF: KAL/2/27

NAME: MOSER HARDCHROME
KW DECLARED: NOT DECLARED KW USED: 1000 KW CONTROLLABLE: 100
NOTES: LOAD CONSISTS OF:
27 ELECTRO PLATING TANKS,
100KW CAN BE SHED BY PREPLANNING PRODUC-
TION,POSSIBLE CERTAIN MODIFICATIONS TO
THE TANKS WILL HAVE TO BE DONE.
DISCUSSED WITH MR WORREL-PRODUCTION
MANAGER

REF: KAL/13/27

NAME: NAMPAK LTD
KW DECLARED: N KW USED: 1200 KW CONTROLLABLE: 30
NOTES: N

REF: W2/32

NAME: COCA COLA
KW DECLARED: 1800 KW USED: 1200 KW CONTROLLABLE: 50
NOTES: 50KW CAN BE SHED BY CONTROLLING
COLD ROOM, AIR CONDITIONING, VENTILATION
ETC.
DISCUSSED WITH:MR COETZE-ENGINEER

REF: W2/70

NAME: SANLAM INDUSTRIAL PROP
KW DECLARED: 1120 KW USED: N KW CONTROLLABLE:
NOTES: NEW

REF: W/277

NAME: POWER STEEL INV
KW DECLARED: 1200 KW USED: 1200 KW CONTROLLABLE: 30
NOTES: LOAD CONTROLLABLE:
AIR CONDITIONING AND HEATERS IN THE
OFFICES.
INFORMATION SUPPLIED BY:
MRS C.M. VISAGIE-DIRECTOR

REF: KAL/11/75

NAME: TRANSVAAL MALLEABLE FOUNDRY
KW DECLARED: N KW USED: 2400 KW CONTROLLABLE: 250
NOTES: LOAD CAN BE SHED BY PRODUCTION
PLANNING.
DISCUSSED WITH MR VAN ZYL--PROJECT MA-
NAGER

REF: KAL/80/75

NAME: CONSOL PLASTICS
KW DECLARED: 4000 KW USED: 1000 KW CONTROLLABLE: 300
NOTES: LOAD CAN BE SHED BY CONTROLLING
AIRCONDITIONING, SPACE AND WATER HEATERS
ETC
DISCUSSED WITH MR RAYNAL-CONSULTANT

REF: ROOKOP140/50

NAME: NAMPAK GLASS CONTAINERS
KW DECLARED: 3600 KW USED: 4500 KW CONTROLLABLE: 50
NOTES: CONTROLLABLE LOAD:
AIR CONDITIONING, SPACE AND WATER
HEATERS IN THE OFFICES.
DISCUSSED WITH:MR LOTZ-CHIEF ENGINEER

REF: RK/1464

NAME: DUROPENTA
KW DECLARED: 1800 KW USED: 2000 KW CONTROLLABLE: 100
NOTES: 100KW CAN BE DROPPED BY SWITCHING
OFF 300KW FACTORY AIR CONDITIONING FOR
15 EVRY 30 MINUTES LEAVING THE FANS ON
IN ADDITION OFFICES HAVE INDIVIDUAL
AIR CONDITIONING UNITS
DISCUSSED WITH MR HARDY PLANT ENGINEER.

REF: 63/691
NAME: ACE PATTERN MAKERS
KW DECLARED: N KW USED: 1850 KW CONTROLLABLE: 50
NOTES: KW USED=1500+350,TWO ACCOUNTS

REF: HEN/1
NAME: POWER&PIPE GALVANISERS
KW DECLARED: N KW USED: 1000 KW CONTROLLABLE: 0
NOTES: MAIN ACTIVITY GALVANISING
NO VARIATION OF MATERIAL GALVA-
-NISED, THE TEMPERATURE CANNOT BE LOWE-
-RED AS IT IS AT IT'S LOWEST LIMIT
DISCUSSED WITH MR COPE-MANAGING DIRECTOR

REF: RG3/40
NAME: RIETFONTEIN GEN GALVANISERS
KW DECLARED: N KW USED: 2100 KW CONTROLLABLE: 300
NOTES: MAIN ACTIVITY:GALVANISING
LOAD CONSISTS OF:BATH NO1:550KW
BATH NO2:550KW
BATH NO3:455KW
BATH NO4:-----
BATH NO5:425KW
BATH NO6:455KW
LOAD CAN BE SHED BY PLANNING THE PRODUC-
-TION.(LOW MASS HIGH VOLUME ITEMS-LESS
POWER USED)
INFORMATION RECEIVED FROM:
1)MR RICHARDSON GENERAL MANAGER
2)MR BARNETT MANAGING DIRECTOR

REF: RG3/PTN344
NAME: BROLLO1
KW DECLARED: N KW USED: 2500 KW CONTROLLABLE: 600
NOTES: SEE BROLLO2

REF: RG3/PTN344
NAME: BROLLO2
KW DECLARED: 3500 KW USED: 3500 KW CONTROLLABLE:
NOTES: 600KW OF LOAD CAN BE DROPPED BY
SWITCHING OFF 930KW ELECTRODE BOILER FOR
10MIN EVERY 30MINUTE AND CONTROLLING
GALVANISING PLANT.
DISCUSSED WITH MR SENDIN-ENGINEERING MA-
NAGER AND MR GOODWEEN-CONSULTANT

REF: TUNI0
NAME: HEINEMANN
KW DECLARED: 1500 KW USED: 1500 KW CONTROLLABLE: 50
NOTES: OFFICE AIRCONDITIONING

REF: TUN8
NAME: ANPAGLASS
KW DECLARED: 1600 KW USED: 1250 KW CONTROLLABLE: 20
NOTES: 12 AIRCONDITIONERS/SPACE HEATERS
DISCUSSED WITH MR SADA NAIDOO-PLANNER

REF: R63/66
NAME: RECYCLING PLASTICS
KW DECLARED: 1700 KW USED: 1700 KW CONTROLLABLE: 50
NOTES: MISC
DISCUSSED WITH:CC MINSHELL-MANAGING
DIRECTOR

REF: R63/75
NAME: MINESSOTTA MINING
KW DECLARED: 1800 KW USED: 1400 KW CONTROLLABLE: 60
NOTES: CONTROLLABLE LOAD CONSISTS OF:
ADMIN AIRCONDITIONERS-70KW
COLD ROOM -70KW
TAPE MODULE- CHILLING-60KW
HEATING- 40KW
TRAINING CENTRE AIRCONDITIONING-20KW
SERVICE BUILDING CHILLERS-100KW
PRODUCTION AIRCONDITIONING 40KW
DISCUSSED WITH:MR HUTCHINSON SEN PROJECT
ENG

REF: AP/7
NAME: MALLEABLE CASTINGS
KW DECLARED: 3300 KW USED: 2800 KW CONTROLLABLE: 1000
NOTES: LOAD CONSISTS OF:
1)MELTING FURNACES 2*1MW
2*0.5MW
2)ANNEALING FURNACES 3*0.4MW
3)AUX PLANT AND OFFICES 0.8MW
IT IS POSSIBLE TO MELT OUTSIDE GERMISTON
MUNICIPALITY PEAK HOUR AND BY DOING THIS
TO SHED DURING PEAK HOUR AT LEAST 1MW.
DISCUSSED WITH MR HATFIELD-MANAGING DI-
RECTOR AND MR TALMAGE-PLANT ENGINEER.

REF: R63/347
NAME: HYPERAMA
KW DECLARED: 2500 KW USED: 2500 KW CONTROLLABLE: 900
NOTES: TYPE OF ACTIVITY:
LARGE SUPERMARKET,
INSTALLED LOAD 4187.50KW TOTAL,CONSISTS
OF:AIR CONDITIONING:2100.45KW
REFRIGERATION:640KW.
HEATING:300.55KW
MOTORS VARIOUS:163.875KW
LIGHTING:453KW
STAND BY GENERATOR:-512KW
DISCUSSED WITH:MR DEKONING-MAINT ENG

APPENDIX 4

Manufacturer's description and cost estimate of the Distribution Line Carrier System

APPENDIX 4

MANUFACTURER'S DESCRIPTION AND COST ESTIMATE
OF THE DISTRIBUTION LINE CARRIER SYSTEM

The typical commercially available system is shown in Fig. 1. The system can perform one-way or two-way load management.

As can be seen, the difference is in the Load Management Terminal (LMT). LMT-1 is a one-way terminal, and LMT-2 is a two-way terminal.

The supplier's detailed description of the system and individual components is available in Ref(16). The supplier indicated during discussions that a one-way system necessary for water heater control will be similar in price to the ripple control system.

This system will include all the components except the two-way Load Management Terminals that can be added as required.

The price of LMT-2 is approximately R1 000,00. As only 21 industrial consumers will be controlled, it means that an additional R21 000,00 is required. The rest of the system cost is assumed to be identical to the ripple control system, namely R3 575 000,00.

It might be necessary to allow for an additional number of repeaters at an estimated additional cost of R50 000,00 for the equipment and R50 000,00 for installation.

A further estimated cost for future expansion in the number of controlled industrial consumers, additional software and contingencies is R300 000,00.

In summary, the costs will be as follows :

One-way basic system	R3 575 000,00
Additional LMT-2 (Two-way Load Management Terminals)	R 25 000,00
Additional Repeaters	R 50 000,00
Additional installation cost	R 50 000,00
Fund for expansion, additional software and contingencies	R 300 000,00
TOTAL	R4 000 000,00

Westinghouse

AUTOMATED DISTRIBUTION SYSTEM

Typical System — One Line Diagram

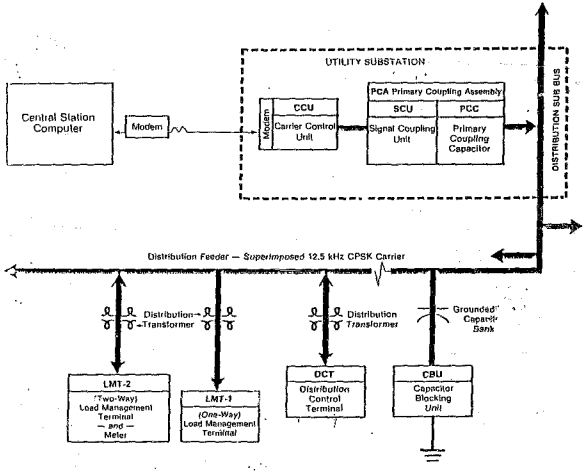


FIGURE 1

Westinghouse Electric Corporation
Electronics, Measurement and
Control Business Unit
Raleigh, NC 27611

Product Bulletin
42-600

Page 1

September, 1983
New Information
Mailed to: E, D, C/2040/DB

EMETCON™
AUTOMATED DISTRIBUTION SYSTEM

System Description

Description
The EMETCON System provides electric utilities with reliable one-way and/or two-way distribution line carrier communications for performing:

- Load control,
- Feeder automation, and
- Metering and operation functions.

Load Control
Load control for reducing system peaks can be performed remotely using either one-way or two-way terminals. With these terminals a utility can control the operation of deferrable customer loads such as:

- Hot water heaters,
- Air conditioners/heat pumps
- Resistance heaters,
- Swimming pool pumps, and
- Irrigation pumps.

Loads can be shed in time intervals of 7.5, 15, 30, or 60 minutes, and automatically restored over a random period of up to four minutes. An optional cold load pick-up is available.

Feeder Automation
Feeder automation, utilizing two-way communications to control and monitor the equipment on distribution feeders or buses, can help most utilities maximize system efficiency and reduce operating costs. It enables utilities to perform tasks such as:

- Distribution substation and feeder load balancing and monitoring,
- Capacitor bank switching,
- Substation transformer monitoring,
- Sectionalizing, and
- Voltage regulator control and monitoring.

Metering and Operations Functions
Metering and operations functions, which are performed with two-way terminals, include:

- Load survey,
- Service connect/disconnect,
- Time-of-use metering,
- Tamper indication, and
- Remote kWh and kW meter reading.

The two-way remote terminals used for metering and operation functions are also capable of performing the load control functions performed by one-way terminals.

Communications
The EMETCON system has been designed to utilize multiple communications media. Distribution line carrier, the primary communication medium of the EMETCON system, is used for communications between the substation equipment and remote line and terminal equipment. Telephone or microwave channels are commonly used for communications between the Central Station computer and the substation equipment.

Distribution line carrier was chosen as the primary medium for the EMETCON system because it offers many advantages over other communications media. These advantages include:

- It is utility owned and controlled,
- It allows communication with all points on the distribution system,
- It provides both one-way and two-way communications,
- It provides sufficient communications speed for full system implementation,
- It uses communication lines that are already in place,
- It provides for group and unique addresses.

The EMETCON system with its advanced signaling techniques, enables two-way communications even during service interruptions.

General Description
The EMETCON system components can be easily divided into four basic groups:

- Central Station
- Substation equipment
- Line equipment
- Terminal equipment.

The Central Station includes the processor responsible for initiating commands, storing the retrieved information, and processing reports for the users. It is the brain of the system and, in general, is responsible for overseeing system operation.

The Central Station sends its messages over a dedicated telephone line or microwave channel to the substation equipment.

At the substation, the equipment receives the messages, checks them for transmission errors, and then converts them to the carrier frequency. The distribution line carrier signal is coupled to the distribution bus and then sent to the remote terminals.

A variety of EMETCON terminals are available for control and data collection functions. The one-way terminals receive and execute control commands that may not need verification. The two-way terminals, in addition to executing one-way commands, are also capable of returning metering and status information such as load survey, service connect/disconnect, time-of-use metering, tamper indication, and remote meter reading.

System Benefits
The EMETCON system offers utilities the opportunity to:

- Shave peaks,
- Conserve energy,
- Reduce system operating costs,
- Decrease outage time,
- Increase distribution line efficiency (VAR control),
- Increase utilization of existing facilities,
- Improve load factor.

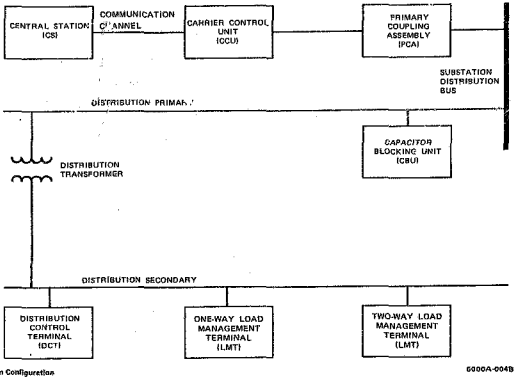
Because the EMETCON system provides exceptional flexibility to the utility, the economic results of any combination of benefits listed above would be sufficient to cover the expenses to install and operate the system.

System Configuration
As discussed in the General Description section, the EMETCON system equipment is configured within four basic groups:

Central Station
The Central Station includes the computer hardware and operating software to initiate the control commands and to collect metering and operational data from the remote terminals. A variety of reporting formats are available to the user.

Substation Equipment
At the substation, the Carrier Control Unit (CCU) receives the signals from the Central Station, translates the commands to carrier frequency, and sends the commands to the terminal equipment over the distribution line. The CCU also receives requested data from the remote terminals, checks for transmission errors, and forwards the data back to the Central Station.

Signals from the CCU are coupled to the distribution bus by the Primary Coupling Assembly (PCA). Returning signals are retrieved by the PCA for processing in the CCU.



System Configuration

6000A-004B

Line Equipment
All carrier-based systems utilize Capacitor Blocking Units to prevent the desired carrier signals from being shunted to ground. These CBU's may be installed either in the neutral or line connections of the grounded wye capacitor banks.

The optional carrier signal Repeater may be applied to enhance signal-to-noise ratios for improved communications. The Repeater may be added in the field as a simple, economical solution to exceptionally high noise environments.

Terminal Equipment
The terminal equipment, located on the secondary side of the distribution transformer, consists of both one-way and two-way terminals. These intelligent, microcomputer-based terminals perform the major work of the system. The one-way terminals will control up to two loads where verification is unnecessary, while the two-way terminals provide load status feedback and perform the operations functions listed previously.

Hardware
Detailed product bulletins, each including sections on product description, applications, features, and specifications, follow this document as part of the Product Bulletin 42-600 series.

Training and Technical Assistance
A variety of basic and advanced training courses are available for operation, installation and maintenance of the EMETCON system and the system components. Technical assistance by EMETCON engineers and technicians during installation and start-up is available as well as telephone support service.

Westinghouse Electric Corporation
Electronics, Measurement and
Control Business Unit
Raleigh, NC 27611

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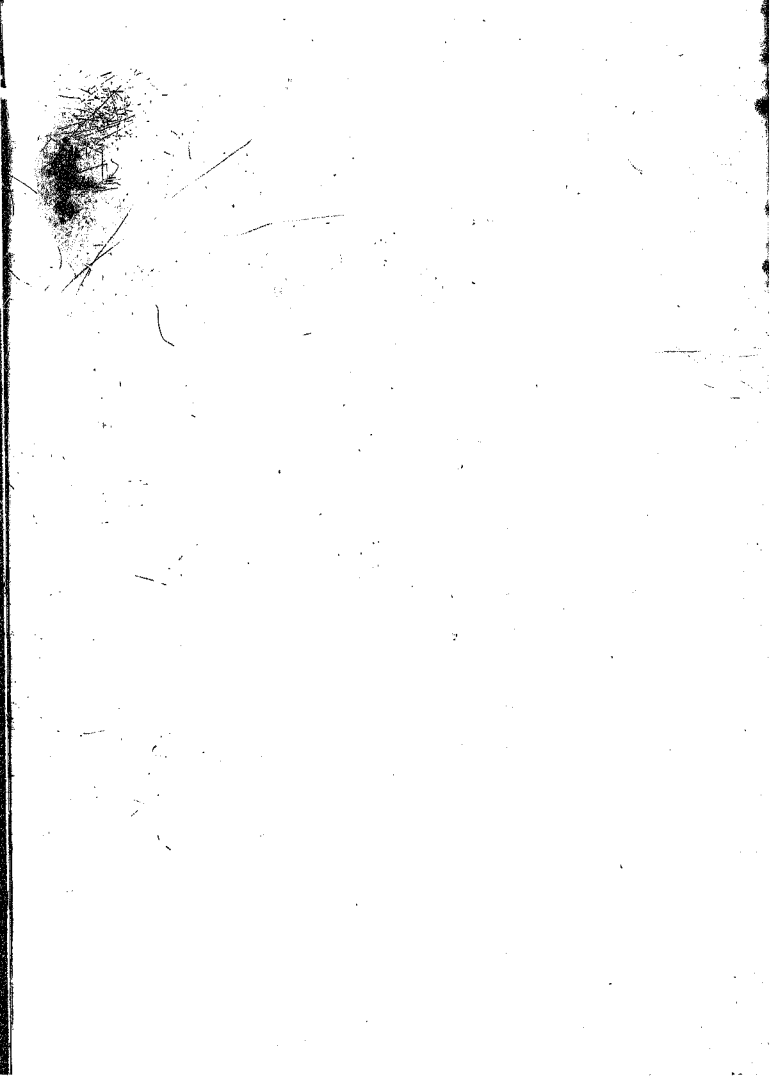
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