INVESTIGATION AND DESIGN OF A STORAGE AND HANDLING SYSTEM FOR FUTURE COAL FIRED POWER STATIONS IN SOUTH AFRICA

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A project report submitted to the Faculty of Engineering, University of the Watwatersrand, Johannesburg for the degree of Master of Science in Engineering through course work and 4 months project.

JOHANNESBURG, NOVEMBER 1987

201026

STATEMENT OF ORIGINALITY

I hereby declare that the work presented in this report is my own, except where indicated otherwise, and that it has not previously been submitted for the purposes of obtaining credit for any other degree.

SIGNED: ....

DATED: ..2/11/87..................

ACKNOWLEDGEMENTS

Permission to submit this report for purposes of a higher degree was kindly granted by Escom senior management

I would like to thank Mel Berry and my supervisor Martin Bailey for their continual support and advice throughout the investigation.

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SYNOPSIS

An overall description of the storage needs of a modern coal fired power station in South Africa is given in the report

Alternative approaches to meeting these needs are explored and the costs, advantages and disadvantages are established

Finally recommendation as to which configuration best meets the requirements of a large coal fired power station is made.

CONTENTS

ANNEXURES

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1. INTRODUCTION

Escom is South Africa's largest electricity utility, generating and distributing 90% of the electricity requirements of South Africa or 60% of the electricity generated on the African continent.

The electricity is produced by 20 coal fired power stations, a nuclear station and 3 hydro stations and 3 gas turbine stations. Escom's new generation coal fired power stations are amongst the most technicaly advanced in the world and with a total generating capacity of above 3600 MW at a single site are some of the largest in the world. A 3600 MW power station provides employment for 2000 people, consumes 48 408 tons of coal, 120 Mega liters of water and produces 14 400 tons of ash per day. To support such a process many activities not directly related to the generation of electricity are required. An important one of these is the aquisition, storage and supply of the materials and spare parts needed to support the maintenance, administration and secondary process activities. Because of the "high tech" nature of most of the materials required and the location of the power stations far from the industrial centres, much of the required materials have to be stored at site. In 1984 Escom management become aware of several problems experienced with the storage facilities at the new generation power plants and realized that the design of the storage facilities had not kept pace with the development of the power plants. In order to overcome this, management commissioned an investigation to determine the actual storage requirements of a modern power plant and determine which storage system would best meet these requirements. (A broshure giving more detail on Escom and the role it plays in the S.A. economy is given in the appendices.)

1.1 Objectives of the investigation

The objectives of the investigation were thus to:

- determine when during the construction of a new power station, the stores facility should be built,
- establish how much storage capacity should be provided for each category of material and the method of storage,
- establish the zoning of the store,
- provide a design brief for new stores showing the necessary building configuration to meet the needs of the recommended materials handling and storage system.

2. STRUCTURE OF THE PROJECT

A standard systems design approach was used in the development of the requirement, design and selection of the storage system. The storage of the design were:-

- the definition of the system and boundaries,
- the identification of the required data and simplifying assumptions,
- gather and generate the required data,

- establish the operating characteristics, constraints and criteria of the system,
- develop a system description,
- identify the system components which meet the requirements of the system description.

The text of this report is structured in accordance with the stages of the project.

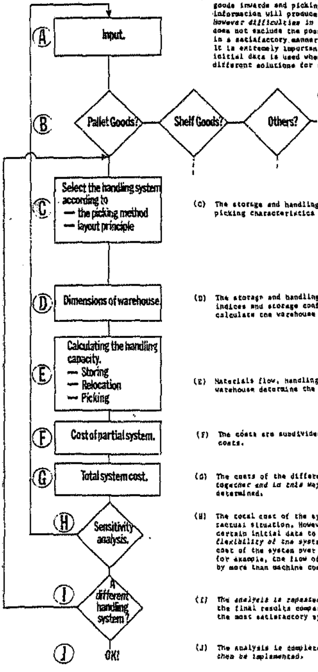
3. DEFINING THE SYSTEM AND BOUNDARIES

A materials handling system consists of two d[illegible] areas namely the physical aspects such as the facilities a[illegible]ment and the operational aspects such as processes and procedures. At the time of this investigation a major project with the aim of improving all aspects of Escom's materials management process was being initiated. As the stores operating pr[illegible]s and procedures would be developed during the major materials [illegible]nagement project, this investigation was limited to the physical aspects with one of the constraints being that the storage system selected must be compatible with several operating processes.

4. IDENTIFICATION OF DATA REQUIREMENTS

The data elements required and the analysis techni[illegible] [illegible]ed at each stage of the system design are shown in diagram 4.[illegible] [illegible] detailed listing of the specific data elements follows the diagram.

DIAGRAM 2.6 - STORES SYSTEM DEVELOPMENT



(A) Initial data has been restricted to *storage volume, flow of* goods inwards and picking intensity. Correct basic information will produce an accurate total evaluation. *However difficulties in* obtaining the correct initial data does not exclude the possibility of carrying out the analysis in a satisfactory manner. Informed estimations can be used. It is extremely important however, to ensure that the same initial data is used when making comparisons between different solutions for the system.

(B) Stores zones are determined by dividing the goods into storage classes e.g. pallet goods, small goods, crane handled goods, etc.
Separate zones are established for specific classes of good requiring special storage or handling e.g. hazardous materials, bulk liquids, etc.

(C) The storage and handling system is chosen according to the picking characteristics of each class of goods.

(D) The storage and handling system determines the utilisation indices and storage configurations which are used to calculate the warehouse dimensions.

(E) Materials flow, handling equipment data and size of warehouse determine the handling capacity.

(F) The costs are subdivided into storage costs and handling costs.

(G) The costs of the different categories of goods are added together *and in this way* the total cost of the system is determined.

(H) The total cost of the system *is calculated on the* basis of a factual situation. However the sensitivity analysis enables certain initial data to be varied to determine the *flexibility of the system* and to assess the change in the cost of the system over a fairly long period of time when, for example, the flow of materials is expected to increase by more than machine costs etc.

(I) The *analysis is repeated* for other handling systems - and the final results compared. This process is repeated until the most satisfactory system is established.

(J) The analysis is completed. Ideas and revised planning can *then be implemented.*

4.1 Space requirement data

- Volume of Goods Stored for each class of storage
- Stability of the stock volume
- Growth trends of the volume
- Utilisation Expected
  - Area
  - Height
  - Rack
  - Volume

  for each class of storage

4.2 Stock composition data

- Size and weight categories
- Material characteristics (inflammable, lon, fluid, etc.)
- No. of Product lines (NSNs) per class

4.3 Stock Movement and Picking data

- No. of Product lines held (NSNs)
- Amount of buffer stock
- Make up of orders (i.e. from which class of storage)
- Load size moved
- Orders per day
- Lines per order
- Receipts per day
- Lines per receipt
- Peak issues per hour
- Picks per man hour

4.4 Layout Data

- Unique storage zones required
- Service zones required
- Relationship study zones
- ABC analysis of movement for stock location within zones.

4.5 Cost Data

- Storage equipment
- Handling equipment
- Building
- Maintenance
- Labour

5. FINDINGS

Very little of the required data was readily available in a usable form and so most had to be generated using a variety of industrial engineering techniques. The techniques used are explained briefly below but for more detailed explanation references to text on the techniques are given where possible.

5.1 Measurement of the volume (m^3) of stock.

There was no way of using the data on the stock recording system to determine the volume of goods stored as none of the data recorded bore any relation to the physical size of the stock. The only way that the volume could be determined was by physical measurement.

The size of the store, and variety of items stored, made it impractical to measure each individual item. Three techniques were used to overcome this problem:

Where possible, for instance ... the block stacked areas or large item storage, the volume of goods was measured directly.

In racked or shelved areas the volume occupied by the shelving was measured and then sampling used to determine the rack volume utilisation.

In the remaining areas, the store was divided into suitable areas of a known size in which the average height of materials and area utilisation could be measured and used to calculate the stock volume.(3)(8)

The volumes measured at 4 representative stations is given in table 5.1

TABLE 5.1 VOLUME OF GOODS STORED PER STORES ZONE

	STATION 1 (~ 2 YRS.)	STATION 2 (4 YRS.)	STATION 3 (5 YRS.)	STATION 4 (8 YRS.)
HEAVY PLANT	284	1 717	2 024	1 538
LIGHT PLANT	809	1 104	1 186	870
GENERAL	16	199	160	367
OTHER COVERED	234	1 715	1 196	1 657
YARD	64	2 668	3 340	2 872
TOTALS:	1 407	7 403	7 906	7 304

<u>NOTE</u>: The age of each station (yrs of commercial services of set 1) is shown in brackets.

(<u>NOTE</u>: The figures given for the measured volumes include a 20% safety factor to accommodate inaccuracies in measuremnt, to ensure that peak volumes are catered for and cover any other uncertainties regarding volume. The figures should therefore be used as is, and not increased further by an additional safety factor).

5.2 Stability of stock volume

The stability of the stock volume was measured in 3 ways:

Firstly a 10% sample of stores items was taken and the number of days stock was established for each of these items. The number of days stock was then compared to inventory policy to establish where the measured volume lay on the demand quantity curve and how fast these stocks would be depleted. The results are shown in table 5.2.

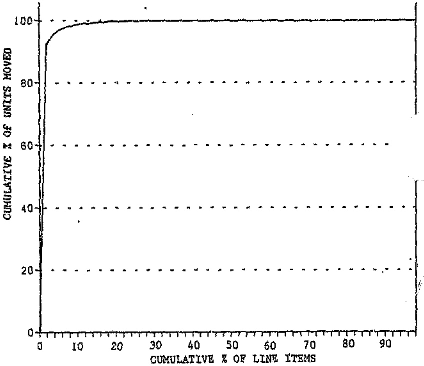
TABLE 5.2 MONTHS SUPPLY OF STOCK ON HAND

	NO STOCK	<3 MONTHS SUPPLY	3-6 MONTHS SUPPLY	6-12 MONTHS SUPPLY	>12 MONTHS SUPPLY
% OF TOTAL PRODUCT LINES (NSNS)	6,2 %	6,2%	5,7%	9,7%	72,2%

Secondly the volume of stock at one store was measured on two occasions 4 weeks apart to check whether there was any significant change in the stock holding between these two dates.

Thirdly a pareto analysis of movement against line items was carried out to establish what proportion of items were stagnant.(7) The results of this are shown in graph 5.2

GRAPH 5.2 PARETO ANALYSIS OF STOCK USAGE



This graph is extremely steep with only 2% of items responsible for 80% of the movement through the store. Its shape is typical of one found in process industries where large quantities of "insurance" spaces are kept.

5.3 Growth in stock

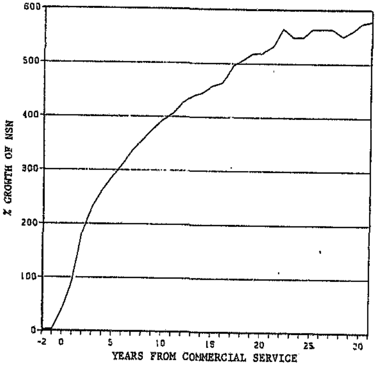
Since records were not kept of the physical volume of stock and there was no large age difference between the representative power stations, no direct projection of volume growth trends could be made. Instead a related index had to be found. Two indices which could possibly be used were identified as:

i) Growth in capital value of stock held.

ii) Number of NaNs (Line items)

It must be emphasised however, that these were only trend indicators and could not be used for accurate projection. It was also found that inflation had a varying effect on the capital value of stock held and so it was difficult to use as an indicator. Comparisons of the two indicators over short periods of time, where inflation effects were minimised, showed that the two indicators trends were very similar. The growth trend given by the growth of NSNs is given in graph 5.3

GRAPH 5.3 PLOT OF CUMULATIVE EFECT OF ANNUAL % GROWTH OF NUMBER OF NSNs ON A UNIT NUMBER AT OPENING OF STORE



5.4 Expected utilisation indicies

The expected utilisation indices were calculated for each type of storage and handling method, using equipment specifications and standards supplied by the manufacturers (Refer Annexure A1). The *indicies are given in table 5.4*

TABLE 5.4 EXPECTED UTILISATION FOR VARIOUS STORAGE AND HANDLING METHODS

TYPE OF STORE	AREA UTILISATION	HEIGHT UTILISATION	VOLUME UTILISATION
Heavy Equipment Requiring Crane	60%	* 42%	25%
Pallet Racked Area:			
Served by counterbalanced fork truck	36%	85%	31%
Served by reach truck	41%	95%	35%
Served by narrow aisle truck	50%	85%	43%
Block Stacked Area:			
Served by counterbalanced fork truck	63%	85%	54%
Served by reach truck	67%	85%	57%
Long Span Shelving (Hand Picked) ,600 x 2,75 units	43%	80%	34%
Steel Shelving			
,457 x ,914 std. units	41%	80%	33%
,380 x ,914 std. units	37%	80%	30%
,305 x ,914 std. units	34%	80%	27%

5.5 Utilisation indices achieved

The actual utilisation indices achieved were calculated using the volume of stock that had been measured and the total storage volume available. The available storage volume was obtained from actual measurements or drawings of the facility. The utilisation indicies achieved are given in table 5.5 and illustrated pictoraly below

TABLE 5.5 UTILISATION ACHIEVED

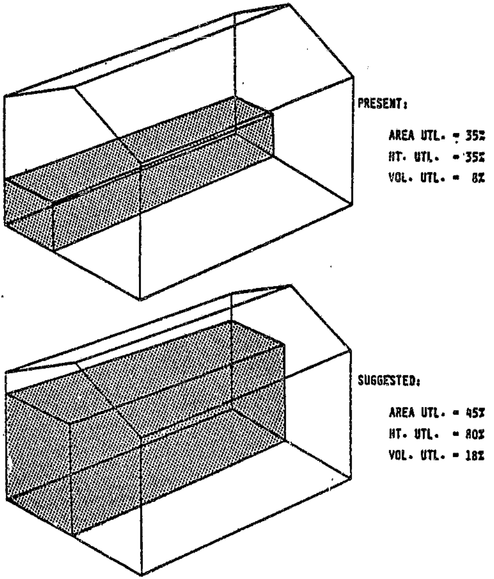
	STATION A			STATION B			STATION C		
	AREA UTL. INDEX	HEIGHT UTL. INDEX	VOLUME UTL. INDEX	AREA UTL. INDEX	HEIGHT UTL. INDEX	VOLUME UTL. INDEX	AREA UTL. INDEX	HEIGHT UTL. INDEX	VOLUME UTL. INDEX
Heavy plant	,57	,19	,11	,49	,27	,13	,70	,23	,16
Light plant	,25	,31	,05	,32	,36	,07	,47	,34	,16
General	,30	,82	,07	.31	,57	,05	,32	,49	,06
Other Covered	,40	,46	,12	,41	,50	,12	,46	,52	,19
Yard	,23	-	-	,25	-	-	,42	-	-

Where: Area Utl. = $\frac{\text{Area Covered By Stock}}{\text{Total Area (Incl. Aisles)}}$

Height Utl. = $\frac{\text{Storage Height}}{\text{Usable ht. of building}}$

Volume Utl. = $\frac{\text{Vol. of Racking}}{\text{Total Vol. of Building}}$ (Or Freestanding Stock)

PICTORAL 5.4 Illustration of the volume utilisation achieved against that expected.



5.6 Size and weight categories

Five representative size and weight categories were chosen and a well defined benchmark allocated to each. The stores items were then classified by determining which benchmark they were nearest to in terms of size or weight. This is generally referred to as a "Mag" or magnitude count. The results of the "Mag" count are given in table 5.6

TABLE 5.6 SIZE AND WEIGHT CATEGORIES

STORAGE METHOD	WEIGHT CATEGORY	SIZE BENCHMARK	PRESENT VOLUME	% OF NSNs
Floor	1 1/2 Ton	VW Beetle	1396	3,2
Heavy rack	50kg-1 1/2ton	Full pallet Office chair	952	3,7
Light rack	20Kg-50Kg	Office chair Waste bin	478	7,3
Long span shelf	20kg-50kg	Waste bin Coke can	370	11,3
Steel shelf	500g-20kg	Coke can Match box	500	52,6
Drawer or bin	500g	Match box	21	21,9

5.7 Material characterist

The material characteristics of the stock held were established by direct observation. It was found that certain materials held in a power station store have unfavourable storage properties such as acidity, corrisiveness, poisonous, perishability, fragility, exposure to heat, light or moisture, are awkward to handle, etc., but do not necessarily require storage in separate rooms. However, it is necessary to provide specialised storage for the following commodities:

TABLE 5.7(i) VOLUME OF GOODS FOR COMMODITIES REQUIRING SPECIALISED STORAGE

COMMODITY	PRESENT VOLUME $(M)^3$
Decanted oil	12
Gas	30
Paint	30
Steel	810

A very large proportion of materials require to protection and may be stored in the open. Refer table 5.7 (ii)

TABLE 5.7(ii) YARD STORAGE REQUIREMENTS

	PRESENT
Volume	3 340m^3
Area	8 800m^2

5.8 Number of product lines held

This figure was obtained from the stock status report. The monthly closing value for each one of three stores over a period of three years was found. The only figures which could be accertained for all 3 stations were the number of NSNs at ± 5 years. These are:

Station A 20 225

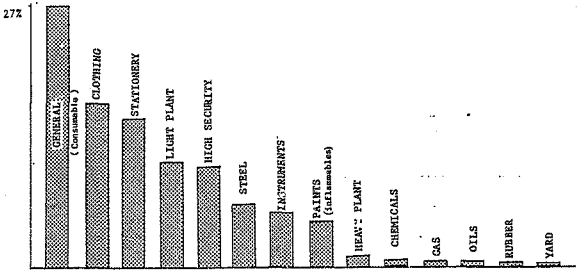
Station B 18 186

Station C 22 437

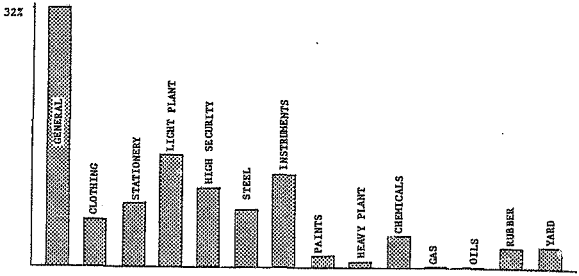
5.9 Make up of issues and receipt

A 10% random sample of 3 months issue documents was taken and analysed to determine the rate of issues from each storage zone. These findings are presented in graph 5.9(i). A similar exercise was done for the receipts and the results are shown in graph 5.9(ii).

GRAPH 5.9(i) DISTRIBUTION OF ISSUES



GRAPH 5.9(ii) DISTRIBUTION OF RECEIPTS

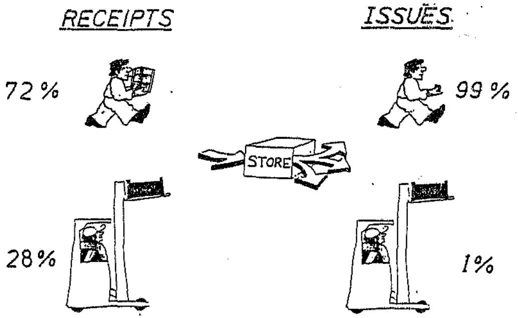


5.10 Load size moved (% bulk movement)

A 10% random sample of issue documents and a 20% random sample of receipt documents was taken for 3 months to determine what percentage of movements in the store were bulk and hence required mechanical handling. The findings are illustrated in the pictoral below.

PICTORAL 5.10

LOAD SIZE MOVED



5.11 Orders per day

A 10% random sample of the entries in the issue counter log book was taken for records covering a 3 to 5 year period, depending on the store, to establish the number of movements per day and the rate at which they increased over a period of time. A 10% random sample was then used to determine the number of line items picked for each order. A similar exercise was done for issues. The results obtained are given in table 5.11(i) table and table 5.11(ii).

TABLE 5.11(i) RATE OF STOCK MOVEMENT: *ISSUES*

	DUVHA	MATLA	KRIEL
NOVEMBER 1984 FIGURES			
Average orders/day	124	146	191
Peak orders/day	140	182	216
Average lines/order	2,20	1,86	2,40
Average picks/day	273	272	458
Peak picks/day	308	337	518
10 YEAR PROJECTION *			
Average orders/day	232		
Peak orders/day	262		
Average picks/day	499		
Peak picks/day	563		

* At 10 years of commercial service of 1st set.

TABLE 5.11(ii) RATE OF STOCK IMPROVEMENT: RECEIPTS

	DUVHA	MATLA	KRIEL
NOVEMBER 1984 FIGURES			
Average receipts/day	26	31	41
Average lines/receipt	1	1	1
10 YEAR PROJECTION *			
Average receipts/day	49		

* *At 10 years of commercial service of 1st set.*

5.12 Unique storage zones required

The number of unique zones required was determined from the size and weight analysis and the movements analysis which establish appropriate storage and handling methods. Safety requirements for hazardous stock were also carefully considered.[9] The storage zones required are thus:

- Very heavy equipment storage area (heavy plant).
- Heavy equipment (racked light plant).
- General storage (shelf & drawer).
- Steel storage (can be accommodated in very heavy and heavy storage areas).

- Gas store.
- Inflammable store.
- Oil decanting store (only required if decanting is done by stores personnel).
- Yard.

In addition to making provision for the actual storage of materials the building design must make provision for the administration and other supporting activities associated with the operation of the store. It was found that provision had to be made for the following areas in the design:

(i) Receiving:

- Truck loading/unloading area.
- Goods holding area (identification/quantity/ quality check).
- Receiving administration area.

(ii) Issuing:

- Issue counter area.
- Order make-up/assembly area.
- Issue administration area.

(iii) General service areas:

- Supervisors office.
- Admin. office.
- Recreation room/General office/Lecture room.

- *Archives room.*
- Kitchen.
- *Toilets.*
- Stairways.
- *Access control.*

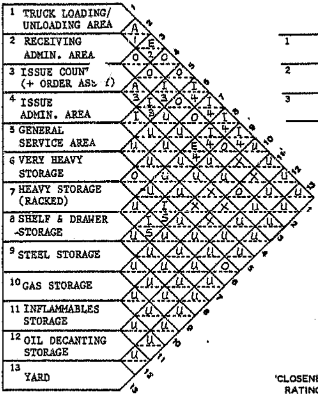
(iv) Equipment:

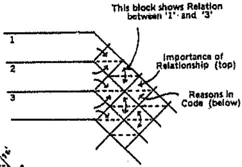
- Computer terminals.
- *Overhead crane.*
- Airconditioning unit.
- *Lifts where multilevel store.*

5.13 Relationship of stores zones

In order to determine the optimal placement of one stores zone W.R.T. another a standard relationship study[3] was carried out seperately by 3 people with good stores and handling experience. The summarised results of this exercise are given on the next pages.

CHART 5.13 RELATIONSHIP OF STORES ZONES





'CLOSENESS' RATING

Value	CLOSENESS
A	Absolutely necessary
E	Especially Important
I	Important
O	Ordinary closeness OK
U	Unimportant
X	Undesirable

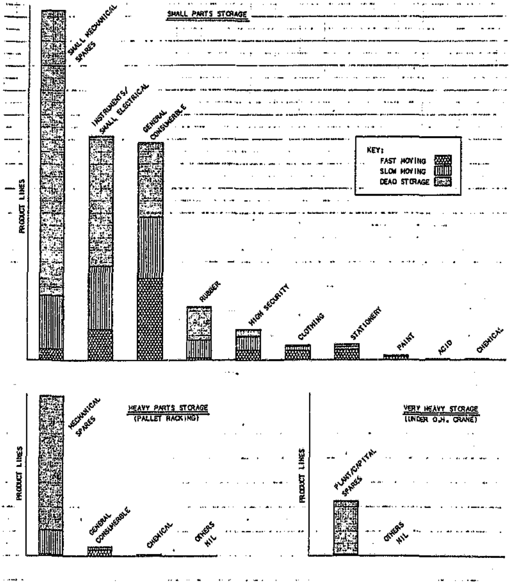
Reasons behind the 'Closeness' Value

Code	REASON
1	Records/terminal close at hand to confirm order & check data.
2	Adjacent issue and receiving preferred See 4.1.4c.
3	Minimise document flow.
4	Minimum materials handling.
5	Use of common equipment

5.14 ABC analysis of movement from each storage zone.

The intensity of material flow to and from each stores zone was determined by sampling the items listed on the "ABC analysis by usage quantity". From usage, description, category and each item was categorised according to rate of movement, type, storage and handling method. The results are show graphically on the following page.

GRAPH 5.14 STOCK MOVEMENT PER STORAGE ZONE



5.15 Cost data

Cost data for equipment was obtained from 11 different manufacturers and suppliers. The figures were budget figures and valid for the 2nd quarter of 1985. The building costs were calculated from the contract price of the Lethabo and Tutuka buildings. The *mezzanine cost* was calculated from the contract price of Kendal store's mezzanine. Maintenance costs of handling equipment were obtained from suppliers and users.

5.16 Storage equipment

Storage equipment costs per m^2 of building (i.e. including aisles) are shown below. These are approximate figures for comparison of storage system costs only, as in practice, there are wide differences between suppliers.

Shelving:

Steel shelving 2,2m ht	R170/m^2
Steel shelving 2,2m ht with dividers	R190/m^2
Steel shelving 2,2m ht with plastic bins	R230/m^2
Drawers 1m ht	R230/m^2
Long span shelving 2,5m ht	R110/m^2

Pallet racking:

6m ht 1,5ton/pair of beams	R105/m^2*
3,5m ht 1,5 ton/pair of beams	R 65/m^2*

Flooring:

Steel mezzanine (rack supported)	R120/m^2
Steel mezzanine (self supported)	R570/m^2
Concrete mezzanine	R295/m^2

5.17 Handling equipment

The costs of major items of materials handling equipment that may be appropriate for use in a power station store are given in Tables 5.17.2(i), 5.17.2(ii), 5,17.2(iii) and 5.17.2(iv).

NOTE: * Based on the racking/m^2 that can be accommodated in the store when using a reach truck at 41% area utilisation. Adjustments should be made where other materials handling equipment is used.

TABLE 5.17.2(*i*) *FORKLIFTS*

EQUIPMENT	*CAPACITY*	LIFT	STACKING AISLE	REACH	TRANSFER AISLE	ACCESS PALLETS BOTH SIDES WITHOUT TURNING	COST
<u>Counterbalanced</u>:(Electric)							
Hyster E20B	1000 kg	3,26 m	3,28 m	–	2,2 m	NO	R25 000 – R28 000
Clark EM15	1500 kg	3,3 m	3,40 m	–	2,2 m	NO	
Nissan CYB02L20U	2000 kg	3,3 m	3,56 m	–	2,2 m	NO	
<u>2 Way Reach</u>:							
Crown 1,0RR	1000 kg	6,1/6,8 m	2,65 m	,615 m	3,5 m	NO	R35 000 – R38 500†
TCM FRSB10 (FHM600)	1000 kg	6,0 m	2,60 m	,375 m	3,5 m	NO	
BT RT 1350E	1350 kg	6,3/7,0 m	2,55 m	,570 m	3,5 m	NO	R36 500 – R43 000†
Nissan JWHOIL 130	1350 kg	6,5 m	2,60 m	,580 m	3,5 m	NO	
Saxby 464 RX 14-60	1400 kg	7,6 m	2,60 m	,620 m	3,5 m	NO	
TCM FRSB 15 (FHM 600)	1500 kg	6,0 m	2,65 m	,530 m	3,5 m	NO	R40 000 – R55 000†
Crown 1.6 RR	1600 kg	6,1/6,8 m	2,65 m	,615 m	3,5 m	NO	
Atlet 160 U	1600 kg	6,1/6,7 m	2,57 m	,771 m	3,5 m	NO	
BT RT 1600E	1600 kg	6,3/7,0 m	2,55 m	,685 m	3,5 m	NO	
Nissan JWHROIL18U	1750 kg	6,5/7,1 m	2,70 m	,740 m	3,5 m	NO	
Atlet 200U	2000 kg	7,3 m	2,75 m	,633 m	3,5 m	NO	
<u>4 Way Reach</u>:							
Atlet 200UF	2000 kg	6,1 m	2,70 m	,660 m	3,5 m	NO	R65 000 – R72 000
BT FRT 2000	2000 kg	6,3 m	2,90 m	,560 m	3,5 m	NO	
<u>Swivel Reach</u>:							
Barlow Rotareach 1000	1000 kg	7,0 m	1,65 m*	1,30 m	4,0 m	YES	R90 000 – R107 000
Atlet URF 100	1000 kg	6,7 m	1,60 m*	1,30 m	4,0 m	YES	
BT TRT 1000E	1000 kg	7,0 m	1,70 m*	1,28 m	4,0 m	YES	
Cleco Mini Bison **	1000 kg	6,1 m	1,58 m*	1,14 m	4,0 m	YES	
BT TRT 1200E	1200 kg	7,0 m	1,75 m*	1,28 m	4,0 m	YES	
Barlow Rotareach 1500	1500 kg	6,0/7,0 m	1,65 m*	1,30 m	4,0 m	YES	
Star LS3	1500 kg	8,0 m	1,75 m*	1,03 m	4,0 m	YES	
Atlet URF 150	1500 kg	6,1 m	1,65 m*	1,20 m	4,0 m	YES	

Notes:
All equipment includes battery & charger.
† Includes side shift.
* With guide rails (R50/m not included in cost),
** Man up truck.

TABLE 5.17.2 (ii) VERY HEAVY PLANT HANDLING

OVERHEAD CRANES			
CAPACITY	SPAN		
	16m	24m	30m
40 Ton	R159 000	R190 000	R241 000
25 Ton	R113 000	R150 000	R191 000
16 Ton	R108 000	R115 000	R161 000
12 1/2 Ton	R 98 000	R105 000	R131 000
Double girder, 80m run typical			

AERO-CASTER SYSTEM

Capacity	Typical Size	Cost
30 Ton	1,8m x 1,1m	R10 500
16 Ton	1,2m x ,9m	R 8 000
7 1/2 Ton	,9m x ,8m	R 4 000

TABLE 5.17.2(iii) STORAGE / RETRIEVAL (S/R) MACHINES

S/R MACHINE:					
Capacity	Type	Load Carriage	Height	Aisle	Cost
300Kg	Small parts picking.	Rigid table.	9m	1,10m	R50 000
1 1/2 Ton	Heavy parts	Forks	9m	1,50m	R150 000

ADDITIONS:

Item	Cost
Conductor	R 95/m
Top & Bottom rail	R108/m
Erection	R7500

TABLE 5.17.2 (iv) FREE PATH ORDER PICKERS

FREE PATH MACHINE:					
Typical Equipment	Capacity	Load Carriage	Picking Ht. (Fork Ht.)	Aisle	Cost
BT OPT 1000	1 Ton	Pallet of bins on Forks.	9,0m (8,1m)	1,48m	R66 500*
Atlet UP	1 Ton	Pallet of bins on Forks.	10,5m (9,7m)	1,35m	R56 500*
373001 Atlet APC	1 Ton	Pallet of bins on Forks.	7,8m (7.0m)	1,30m	R41 000*

* Guide rail cost R50/m of aisle not included.

5.17.3 Buildings

Construction costs for the main stores building excluding service areas, (i.e. toilets, changerooms, stairways and mezzanine floors, etc.) were found to be as follows:

HFAVEY EQUIPMENT BAY ± R676/m^2
(11m High, excluding crane)

LIGHT EQUIPMENT BAY ± R630/m^2
(7,6m High)

This is based on the actual tender price for the Lethabo contract and includes the main construction, water supply, drainage, painting and other finishes, but excludes piling, springler system, air conditioning, lighting and compressed air.

5.17.4 Maintenance

Costs for maintenance of materials handling equipment were found to be as follows:

FORKTRUCKS ± R4500 per annum
(incl. Reach trucks)

SWIVELREACH TRUCKS ± 5000 per annum

FREE PATH ORDER PICKERS ± R4600
(250kg)

S/R MACHINES FOR SMALL PARTS ± R1200 per annum
PICKING (250kg)

S/R MACHINES FOR HEAVY PARTS ± R3000 per annum
PICKING (1 1/2 ton)

This data is based on information obtained from the University of the Witwatersrand Materials Handling Research Unit & equipment suppliers.

Annual maintenance costs for S/R machines were regarded as approximately 2% of the capital investment at a time when the capital value was not artificially inflated by the Rand/dollar exchange rate.

It was found however that a user operating a fairly old S/R installation, budgedted the following amounts:

R36/month per 400kg (small parts) machine

R67/month per 1 1/2 ton machine.

which equates to less than 1% of today's cost of equipment.

5.17.5 Labour

In view of the sensitive and confidential nature of specific labour rates and the fact that the final selection of the system would not be greatly influenced by this factor, it was considered non essential at this time to include these costs.

6. ESTABLISHMENT OF THE OPERATING CHARACTERISTICS, CONSTRAINTS AND CRITERIOR OF THE SYSTEM

6.1 System design input data

6.1.1 Storage volume

The measured volumes at the 3 representative stations of similar age, as given in table 5.1, are of the same order, despite the stations being constructed by different contractors and being located in different areas (i.e. close to a large industrial centre or from any town). The volume at station 4 is clearly less than would be expected as it is the older station but this can be atributed to the fact that it is a smaller station than the other 3 stations. This would indicate that the measured volumes could be used as a basis for design for stores of future stations. If the stations are to be larger than the current stations the volumes will have to be increased accordingly. Also although table 5.1. shows that there are considerable differences in the volumes of particular stores zones in the different stations, it was found that stock was located according to fairly vague classification. If the stock at the different stores had been classified and grouped according to the *same rules the volume in the various classes* would be similar. These reclassified volumes are shown in table 6.1.1 below.

TABLE 6.1.1(a) VOLUME OF GOODS PER STORES ZONE AFTER RECLASSIFICATION OF STOCK FOR A STATION OF APPROXIMATELY 5 YEARS OLD

MATERIAL CLASS	VOLUME OF GOODS (M^3)
Heavy Equipment (Plant)	1650
Light Equipment	1140
General (Consumable)	240
High security	25
Rubber	25
Paint and inflammables	30
Oil	110
Chemicals	175
Steel	810
Stationery	25
Instruments	80
Gas	30
Clothing	80
Yard	2975
TOTAL:	7595

The data given in paragraph 5.2. shows clearly that there are no large fluctuations in the volume of stock over short periods like those found in buffer stores. Thus the 20% safety factor built into the measured data should adequately cover any short term peak and no additional provision has to be made for buffer stock storage.

Although there were no short term fluctuations in the volume of stock, graph 5.3 shows that there is constant growth in the volume over much of the life of the power station. The growth is particularly pronounced in the early years and becomes less significant towards the end of the productive life of a power station being negliagible between 30 to 40 years after the 1st set commercial service. This growth in stock volume can be attributed to the fact that a modern power station can have up to 6 separate generating units or sets with the last set being completed up to 6 years after the completion of the first generating set. In addition to this, the continual upgrading of plant means that additional spares must be kept for the new types of plant installed.

For the design of the storage system it is important to realize that graph 5.3 can only be used as an indicator of how the volume requirements may increase and not as a means of determining the exact requirements at any stage in the life of a power station.

Thus it is important to recognise the uncertainty with regard to the volume of stock to be accommodated and design the storage system accordingly.

It is also important to realize that if the storage facility is built to accommodate the stock held after 30 years service, the facility would be grossly underutilized for most of its life.

To overcome these problems it was decided to design a storage facility which provided for easy modular expansion.

Since the volume of stock increased extremely rapidly over the first 10 years of service and since the data was collected from repres-.tative stations of up to 8 years of age, and thus could be accurately projected for 2 years, it was decided that the initial facility would be designed to accommodate the volume at 10 years service. This would mean that the facility would reach optimum utilization fairly rapidly and that the additional volume to be provided could be determined with a fair degree of certainty. Using the measured volumes given in table 6.1.1(a) and projecting them in accordance with the growth trend given in graph 5.3 the volumes of stock are as given in table 6.1.1(b).

TABLE 6.1.1(b) PROJECTED VOLUME OF STOCK PER STORE ZONE

STORAGE ZONE	VOLUME AT 10 YEARS
Floor	1745
Heavy rack	1190
Long span shelf	1060
Steel shelf	625
Drawer or bin	26
Decanted oil	15
Gas	38
Paint	38
Steel	1013
Yard	
Volume	$4175m^3$
Area	$10980m^2$

6.1.2 Rate of stock movement

The rate of stoci movement through the store is given *in paragraph* 5.11. The projected values for a station store 10 years old are reproduced below for convenience.

TABLE 6.1.2 RATE OF STOCK MOVEMENT

10 YEAR PROJECTION *	
Average orders/day	232
Peak orders/day	262
Average picks	499
Peak picks/day	563
Average receipts/day	49

6.2 System sub areas

The sub areas that had to be considered in the design, along with this volume requirements are given in table 6.1.1(a). These areas, can however be grouped according to handling requirements. This regrouping is shown in table 6.2

TABLE 6.2 STORES ZONES GROUPED ACCORDING TO HANDLING METHOD

HANDLING REQUIREMENTS	COMMODITIES	STORAGE METHOD
General storage area:		
Man-handle	Very small Small Medium	Bin/Drawer Shelf/bin Long span
Palletised assistance	Heavy	Pallet racking
Heavy duty handling equipment	Very heavy	Floor
Specialised storage areas:		
Man-handle	Decanted oil	Long span
Man-handle	Gas	Floor
Man-handle	Paint	Long span
Man-handle Industrial truck Overhead crane	Steel	Heavy rack
Industrial truck	Yard	Floor

6.3 Storage and handling system chosen according to the picking characteristics.

There are two major groupings of order picking systems, namely:

- selective
- non-selective

Selective picking is used where a large number of slow moving lines are stored which move independtly of each other. It also facilitates a FIFO issue policy. This is the situation in power station stores, therefore we must use a selective picking method.

There are three types of selective order picking:

- Low-level: Used in warehouses with high turnover rate, high volume of goods in relation to storage capacity and a large number of lines per order.
- High-level: This is carried out in warehouses where there are a large number of articles and a relatively small requirement for a buffer stock.
- Station picking: Station picking is used when there is a relatively small number of articles and several similar orders can be picked at the same time.

In the 3 general sub areas of a power station store we have similar characteristics namely:

- an average of 2 lines per order;
- a turnover rate upwards of 1 year;
- an optimum space utilisation of 18%;

- a number of lines to capital value of stock ratio of 1/1000 i.e. (little buffer stock & large no of lines);
- orders which are mostly different and difficult to pick at the same time.

Thus these areas are ideally suited to high-level picking and we should attempt to use a materials handling method which facilitates selective, high-level picking.

In the specialized storage areas, there are very few line items per area. Thus these areas, are best suited to selective low level picking.

The handling methods for the various storage areas can thus be the following:-

6.3.1 Very heavy sub area (Heavy plant)

Materials handing equipment limitations restrict the type of picking of very heavy goods to low-level picking. With the system design in this section then, our aim must be to minimise the items stored in this area and maintain selective picking.

There are two materials handling methods capable of moving these items, namely:

- areo castors

- overhead crane

If selective picking is to be ensured then the floor area required if an overhead crane is to be used is nearly half that required for the areo c stors. The cost to provide the additional building area far exceeds the cost of the crane and so it is recommended that an overhead crane is used in this area.

6.3.2 Heavy sub area (Light plant)

In the heavy components section there are two types of handling equipment which allow high level storage. These are the various types of reach truck and the S/R machine. This equipment will allow storage ranging from 7m to above 20m. In order to decide which of these systems should be used a cost comparison must be carried out. This is done in section 6.4

6.3.3 Medium, small and very small sub area

For handling very small, small, and medium components there are three feasible handling techniques which provide for high-level picking. These are:

- Mezzanines
- S/P machines
- Fre path order pickers

A cost comparison has to be carried out in order to determine which of the three methods should be used. This is done in section 6.4

6.3.4 Specialised storage areas

i) Man-handleable areas
In these areas the picking system must be kept simple and the best aids are trolleys and hand pallet trucks which are operated at ground level.

ii) Steel storage area
The handling requirements for this group of stock are complex and if possible the area should be placed so that goods may be man-handled, handled by the industrial truck or the overhead crane.

iii) Yard area

The handling method best suited to this area is a heavy duty counterbalanced fork lift truck in the 5 to 7 ton range.

6.4 Warehouse dimensions, handling capacity and partial system costs

Refer Annexure A3 for detailed calculation of the following system costs.

6.4.1 Very heavy equipment bay (Heavy plant).

Dimensions:

- Width = 24m
- Length = 53m
- Height = 6,5m (To bottom of crane beam)

Costs:

- Handling equipment = R 190 000
  (40 ton crane)
- Building = R 859 872

  SUB SYSTEM COST = R1 049 872

44/...

6.4.2 Heavy equipment bay (Light plant)

i) Option 1 = Forklift truck
(Not high level picking.
Comparitive use only).

Dimensions:

- Width = 31m (Multiple of aisle + racking width.)
- Lenght = 53m
- Height = 5m (min clear headroom)

Costs:

- Storage equipment = R93 771
  (pallet racking 3,5m Ht).
- Handling equipment = R27 000
- (1,5 ton forklift)

- Building = R1 035 090
- NPV operating = 96 000
  SUB SYSTEM COST = R1 251 861

ii) Option 2: 2 way Reach truck

Dimensions:

- Width = 16m (multitiple of aisle + racking widht
- *Lenght* = 52*m*
- Height = 8m (min clear headroom)

Costs:

- Storage equipment = R 87 360 (pallet racking 6m Ht.)
- Handling equipment = R 43 000 (1,5 ton reach truck)
- Building = R 524 160
- NPV Operating = R111 000

SUB SYSTEM COST = R765 520

iii) Option 3: Swivel reach truck

Dimensions:

- Width = 13m (multitiple of aisle + racking width).
- Length = 46m
- Height = 9m (min clear headroom)

46/...

Costs

- Storage equipment = R 89 335
  (pallet racking to 7m Ht)
- Handling equipment = R106 900
  (1,5 ton swivel reach truck)
- Building = R376 740
- NPV Operating = R176 000
  SUB SYSTEM COST = R748 975

iv) Option 4: S/R machine

Dimensions:

- Width = 8,5m (multitiple of aisle + racking width)
- Length = 52m
- Heigth = 10m (min. clear headroom)

Costs:

- Storage equipment = R 90 556
- Handling equipment = R321 112
  (2 off 1 1/2 ton S/R machines)
- Building = R278 460
- NPV Operating = R 92 000
  SUB SYSTEM COST = R782 128

6.4.3 Bay for man-handled goods

i) Option 1: Manual handling on mezzanines

Dimensions:

- Width = 24m (Multitiple of aisle + racking width)
- Length = 52m
- Height = 7,6m (min. clear headroom)

Costs:

- Storage equipment = R 541 464
  (drawers, Shelves & Long span)
- Mezzanine floors = R 229 520
- Building = R 786 240
- NPV Operating = Negligible
  SUB SYSTEM COST = R1 627 224

ii) Option 2: Manual Handling on light duty
S/R machine

Dimensions:

- Width = 11m (Multitiple of aisle + racking width)
- Length = 71m
- Height = 10m (min. clear headroom)

Costs:

- Storage equipment (Drawers, shelves & long span)	=	R 541 464
- Handling equipment (3 off 300 kg S/R machines)	=	R 247 065
- Building	=	R 492 030
- NPV Operating	=	R 54 000
SUB SYSTEM COST	=	R1 334 559

iii) Option 3: Manual handling on a free path
order picking machine

Dimensions:

- Width = 23m (Multitiple on aisle + racking width)
- Length = 53m
- Height = 8m (min. clear headroom)

Costs:

- Storage equipment = R 541 464
  (Drawers, shelves & long span)
- Handling equipment = R 188 850
  (3 off high level order pickers)
- Cost of Building = R 767 970
- NPV Operating = R 125 000
  SUB SYSTEM COST = R1 623 284

6.4.4 *Specialized storage areas*

i) Decanted oil

Dimensions:

- Width = 4m (Multitiple of aisle + racking width)
- Length = 8m
- Height = 3m (min. clear headroom)

Costs:

- Storage equipment = R 3 520
- Building = R 20 160
  SUB SYSTEM COST = R 23 680

Costs:

- Storage equipment = R 541 464
  (Drawers, shelves & long span)
- Handling equipment = R 188 850
  (3 off high level order pickers)
- Cost of Building = R 767 970
- NPV Operating = R 125 000
  SUB SYSTEM COST = R1 623 284

6.4.4 Specialized storage areas

i) Decanted oil

Dimensions:

- Width = 4m (Multitiple of aisle + racking width)
- Length = 8m
- Height = 3m (min. clear headroom)

Costs:

- Storage equipment = R 3 520
- Building = R 20 160
  SUB SYSTEM COST = R 23 680

ii) Gas storage

For the storage of gas a covered wire cage should be provided:

- Width = ± 6m
- Length = ± 13m
- Height = ± 2,5m

Approximate cost:

- Structure = ± R5 500

iii) Paint: Manual picking - low level - long long span shelving.

Dimensions:

- Width = 6m (Multitiple of aisle + racking width)
- Length = 12m
- Heigth = 3m (min. clear headroom)

Costs:

-	Storage equipment	= R 7 920
-	Building	= R 45 360
	SUB SYSTEM COST	= R 53 280

iv) Steel storage

Complex handling & storage requirements

Dimensions:

- Width = 30m
- Length = 30m
- Height = 6m (min. clear headroom)

Costs:

- Storage equipment = R 99 000
- Handling equipment = Refer Annexure A3 d(iv)
- Building = R567 000

SUB SYSTEM COST = R666 000

v) Yard

No special facilities need be provided.

6.5 Capacity check

A storage and handling system must be able to cope with the peak throughput of the system. The peak movements for each area are given in table 6.5

TABLE 6.5 MOVEMENT PER STORES AREA

STORES AREA	PEAK PICKS PER MAN HOUR	PEAK RECEIPTS PER MAN HOUR
Very heavy	less than once per day	less than once per day.
Heavy	3	1
medium small very small	55	28
Decanted oil	1	1
Gas	1	Less than once per day.
Paint	4	1
Steel	2	2
Yard	Less than once per day	Less than once per day

..5.1 Very heavy storage

The movement in this area is very low and the overhead crane will easily cope with the throughput.

6.5.2 Heavy goods storage

The peak movement in this area is 4 movements per hour. (3 out and 1 in). An industrial lift truck can cope with 10 to 15 movements per hour. An S/R machine can cope with 30 movements per hour. Thus for all options only one machine is necessary. With only one S/R machine however, a transfer car is necessary to transfer this equipment between aisles. The transfer car is approximately half the price of an S/R machine but slows down the operation considerably and decreases the reliability of the system. In this particular application there is no great cost advantage in using only one machine and therefore it is recommended that 2 machines be installed.

6.5.3 Manually picked storage

For a manually picked mezzanine storage area of the dimensions given, each picker should be able to handle 27 movements per hour (this excludes the time taken to identify the item and establish its location code) thus a minimum of 3 runners would be required for this area to handle the peak of 83 movements per hour.

An S/R machine used in the power station store picking operation should handle 35 movements per hour thus 3 machines are required to cope with the peak throughput of 83 movements.

A free path order picker in the power station store picking operation should handle 30 picks per hour. *Thus 3 machines are required to handle the peak* throughput of 83 movements.

6.5.4 Specialized storage

The total peak movement from these areas is only 12 per hour thus one runner with the available equipment will easily cope with the peak throughput.

6.6 Total System Costs

In general it is desirable to choose the sub systems so as to minimnise the total system cost. In some cases though, non cost considerations could influence the decision and an option which is more expensive but which provides additional benefits could be used. This is especially true for cases where the difference in cost between systems is marginal.

6.6.1 Most economical system

STORE ZONE	EQUIPMENT	COST
Very Heavy	Overhead Crane/ Floor	R1 049 872
Heavy	Swivel reach/ 7m racking	R 748 975
Man-handled	S/R Machines/ 9m racking	R1 334 559

Specialized storage	Various methods	R 742 960

The total system cost will then be:

= R3 876 366

6.6.2 Most expensive system

STORE ZONE	EQUIPMENT	COST
Very Heavy	Overhead crane/ Floor	R1 049 872
Heavy	Forklift/ 3m racking	R1 251 861
Man-handled	Mezzanines/ 6,6 racking	R1 627 224
Specialized Storage	Various methods	R 742 960

The total system cost will then be:

= R4 671 917

6.6.3 Cost to provide the required volume using the present storage systems.

STORE ZONE	EQUIPMENT	COST
Very Heavy	Overhead crane/ Floot	R1 049 872
Heavy	Fork lift/ 3m racking	R1 251 861
Man-handled	Concrete mezz/ 2,2m racking sectionalized	R2 586 709
Specialized storage	Various methods	R 742 960

The total system cost will then be:

= R5 631 402

The difference between this and the most economical system is R1 755 036 or 31%.

GENERAL NOTES ON COSTING

1. Costs which remain constant regardless of the option chosen are not included in the costing. For example fire protection equipment which is generally dependent on the volume to be protected and not the configuration.
2. Only equipment which is readily available on the South African market has been considered. For example in Europe some small parts S/R machine systems are higher than 9m. This is considered non standard, and not readily available in S.A.
3. Labour costs have not been included in the operating costs since the choice of option does not necessarily reduce the number of employees as this remains largely dependent on the operating system.

6.7 Sensitivity analysis

The system costs were calculated for a specific case and all component costs were considered constant. However it has been pointed out that some of the data used in developing the system description was based on estimates. This applies especially to the projected volume of goods to be stored. Furthermore, component costs will fluctuate over a period of time. It is therefore necessary to establish how sensitive the total system cost is to these variables and over what range the chosen option remains the most economical.

6.7.1 Heavy parts storage

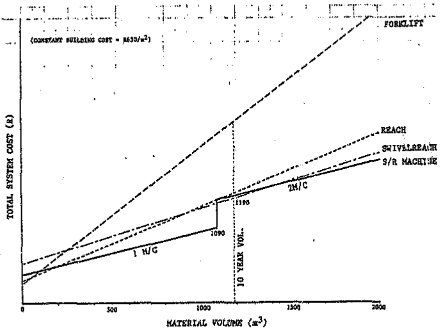
i) Sensitivity of option choice to the changes in volume of goods. (graph 6.7.1 (i).

The graph shows that the swivel reach truck is the cheapest option over a small range close to the projected volume of goods.

A change of 8% make the S/R machine option the most economical option.

However for volumes above the projected volume the cost difference between the 2 options is minimal and the decision as to which option should be used will have to be based on non cost considerations.

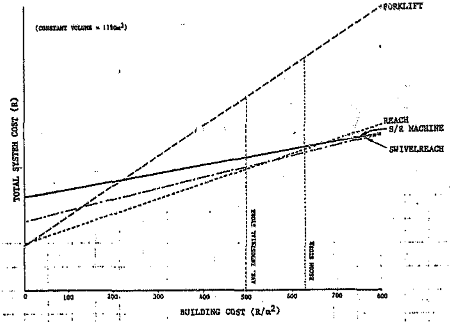
GRAPH 6.7.1 (i) SENSITIVITY TO CHANGES IN MATERIAL VOLUME (HEAVY PARTS)



ii) Sensitivity of option choice to changes in building cost (graph 6.7.1 (ii)

The graph shows that the option chosen is not very sensitive to changes in the construction cost per square metre of building. A change of 20% is required before an alternative option is more economical. The cost differences for all but the forklift option are minimal for most of the range.

GRAPH 6.7.1 (ii) SENSITIVITY TO CHANGES IN BUILDING COST (HEAVY PARTS)



iii) Sensitivity of option choice changes in exchange rate.

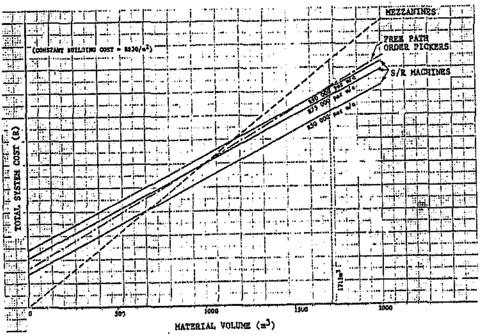
Since all the equipment is imported, any exchange rate fluctuations would affect all options in a similar way and thus not affect the choice. (NOTE: although some forklikft trucks are assembled in S.A. most of the components are imported).

6.7.2 Man-handled goods

i) Sensitivity of option choice to changes in volume of goods stored. (Graph 6.7.2 (ii).

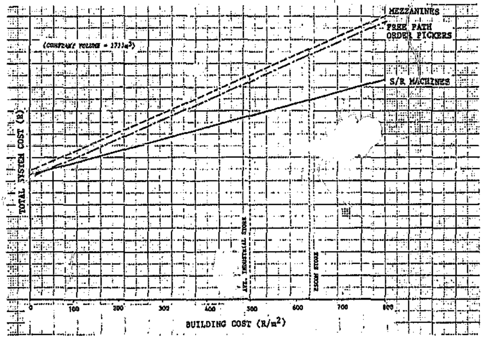
The graph shows that the S/R option is the cheapest over a broad range and the choice of option is not sensitive to fluctuations in volume to be stored. A change in volume of 61% must take place before an alternative option is more economical.

GRAPH 6.7.2 (i) SENSITIVITY TO CHANGES IN VOLUME (SMALL PARTS)



The graph shows that a change in the cost per square metre has virtually no effect on the option chosen. *A change of 94% in the cost per square* metre must occur before an alternative option is more economical.

GRAPH 6.7.2(ii) SENSITIVITY TO CHANGES IN *BUILDING COST (SMALL PARTS)*



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iii) Sensitivity of option choice to changes in exchange rates and cost of equipment. (Graph 6.7.2(ii).

All equipment costs given were established for the 2nd quarter of 1985 in order to facilitate comparison of alternative options.

In the period April 1985 to December 1986 the exhange rate has fluctuated widely. This fluctuation will affect the cost of imported goods more than locally produced items. It is therefore important to establish what affect an exchange rate fluctuation will have on the choice of option. The S/R machines and free path order pickers are imported machines and so their price will be affected by exchange rate fluctuations but since the mezzanine is locally produced, its price would not be affected.

On the graph 6.7.2(ii) three lines are shown for S/R machines at various prices. The line for the S/R machine costing R50 000 corresponds to the exchange rate at April 1985 (R-1,5918DM)). The line for the S/R machine costing R75 000 corresponds to the exchange rate at October 1985 (R=0,9979DM). The line for the S/R machine costing R90 000 corresponds to an exchange rate of (R=0,8316DM).

Only the line corresponding to the April cost of a free path order picker is shown on the graph since it is also an impor'ed machine subject to exchange rate fluctuations and will remain proportionally more expensive than the S/R machine. In all cases therefore, the free path machine can never become the chearer option.

From the graphs we see that even with the exchange rate fluctuations the cost of the S/R machine option is well below the mezzanine option at the projected volume and this volume needs to be reduced by 32% before the mezzanine option becomes cheaper.

7. RECOMMENDATIONS

It is recommended that the storage facilities at future coal fired power stations in South Africa be designed according to the following principles:-

i) The most cost effective system option (Refer 6.6) be chosen except where substancial reasons against arise at the time of system selection.

ii) Power Station stores systems be developed according to the specifications laid down in section 6.4 using a "systems approach" to new disigns.

iii) The power station storage and handling system be provided as per section 6.4 comprising:

- 3 of S/R machines to 9m (Small parts picking)
- Swivel reach truck to 8m (Heavy parts handling)

- Overhead crane (Very heavy parts handling)
- Separate zones for specialized storage only where necessary.

iv) The final stores facility, rather than several temporary buildings, should be provided at ± 2 years before first set commissioning.

v) The power station store be designed on a modular basis where the first module accommodates 10 years growth and the second module the remaining growth until decommissioning.

vi) The actual stock growth be monitored during the first 10 years of a power station's life in order to accurately project the storage requirements up to decommissioning.

vii) The projected growth rate (5.3) and stock volumes (6.1.1 a) be used initially as a basis to determine the size of future power station stores.

viii) "Open steel" rack supported mezzanines be used in future stores in preference to structural mezzanines.

ix) Internal walls to a store are to be avoided in future designs, i.e. don't provide unnecessary storage cells.

x) All future stores are designed to suit the chosen equipment and requirements of the store.

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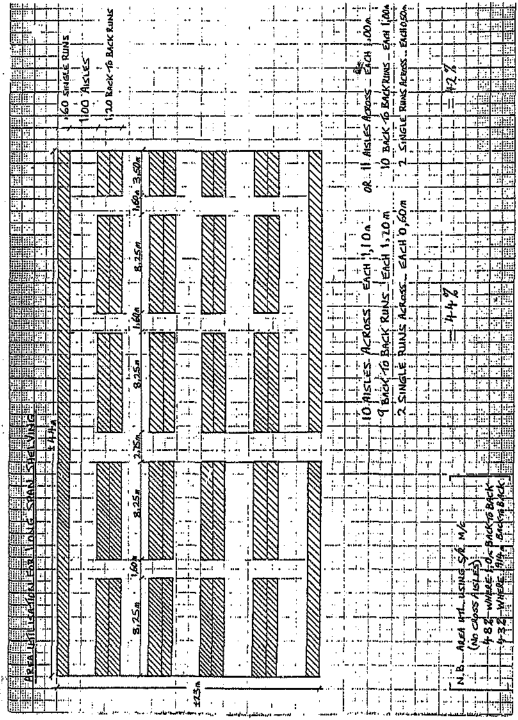
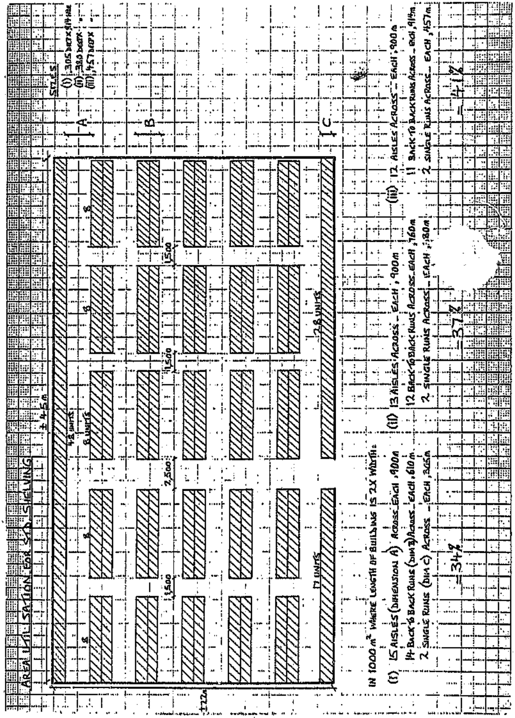
ANNEXURE A1

DETERMINATION OF EXPECTED AREA UTILISATION

(a) Long Span Shelving



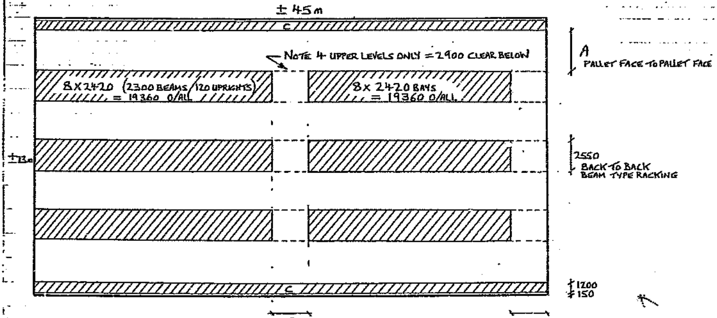
(b) Standard Shelving



ANNEXURE A1

(c) Pallet Racking

AREA UTILISATION FOR
BULK/PALLET LOADS OF HEAVY PARTS



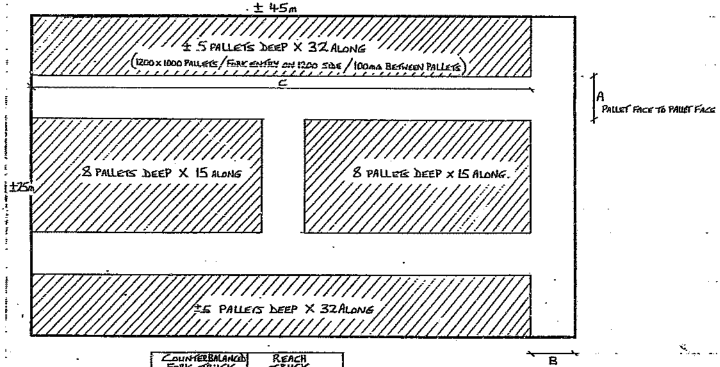
	COUNTERBALANCED FORK TRUCK	REACH. TRUCK	SWIVEL REACH TRUCK.	S/R MACHINE
LENGTH OF BACK TO BACK RACKS.	16 BAYS X 2420	16 BAYS X 2420	16 BAYS X 2420	18 BAYS X 2420
CROSS AISLES 'B' X 2	4400	7000	3000	–
BUILDING LENGTH.	43 120	45 720	46 720	43 560
LENGTH OF RACK AGAINST EA. WALL 'C'.	17 BAYS X 2420 + 1 BAY X 1920	18 BAYS X 2420 + 1 BAY X 2120	18 BAYS X 2420 + 1 BAY X 3020	18 BAYS X 2420
STACKING AISLES 'A' X 4	14 000	10 400	6800	6000
RACKS ACROSS.	(3x2550)+(2x1350)	(3x2550)+(2x1350)	(3x2550)+(2x1350)	(3x2550)+(2x1350)
BUILDING WIDTH.	24 350	20 750	17 150	16 350
UTILISATION *	39%	44%	53%	63%

* USE 3% LESS IN CALC'S.

ANNEXURE A1

(d) Block Stacking

AREA UTILISATION FOR BLOCK STACKING



	COUNTERBALANCED FORK TRUCK	REACH TRUCK
PALLETS ALONG 'C'	33 X 1300mm	32 X 1300mm
CROSS AISLE 'B'	4400	7000
BUILDING LENGTH	45100	45100
STACKING AISLES 'A' X 2	7000	5200
PALLETS ACROSS	17 X 1100mm	18 X 1100mm
BUILDING WIDTH	25700	25000
AREA UTILISATION *	66%	70%

* USE 3% LESS IN CALCULATIONS.

ANNEXURE A2

ABC ANALYSIS BY MOVEMENT

ESTIMATED STORAGE REQUIREMENTS (10 YEARS COMMERCIAL SERVICE)

(a) Small Parts Storage

		FAST MOVING			SLOW MOVING			VERY SLOW MOVING		
		BINS OR DRAWERS	SHELVES	LONG SPAN	BINS OR DRAWERS	SHELVES	LONG SPAN	BINS OR DRAWERS	SHELVES	LONG SPAN
GENERAL CONSUMABLE	Items	380	751	300	358	743	138	633	743	138
	Items/opening	10	0,67	0,67	10	0,67	0,67	10	0,67	0,67
	No. openings *	38	1122	453	36	1110	206	63	1110	206
	Rack volume (m^3)	2,7	111,1	237,4	1,7	109,9	99,1	3,0	109,9	99,1
GENERAL BULK	Items	-	-	36	-	-	28	-	-	-
	Items/opening			0,26			0,26			
	No. openings			141			109			
	Rack volume (m^3)			166,7			131,3			
SMALL MECHANICAL SPARES	Items	48	144	48	124	688	303	1650	3576	550
	Items/opening	10	0,60	0,60	10	0,60	0,60	10	0,60	0,60
	No. openings	5	241	81	12	1134	508	165	5907	924
	Rack volume (m^3)	0,2	23,9	30,7	0,6	114,2	244,3	7,8	592,8	443,4
INSTRUMENTS/ SMALL ELECTRICAL	Items	477	149	3	646	578	69	1513	956	193
	Items/opening	12	1,30	1,50	12	1,30	1,30	12	1,30	1,3
	No. openings	40	115	2	54	446	53	126	723	149
	Rack volume (m^3)	1,7	11,4	1,1	2,3	44,2	5,6	5,3	71,6	71,7
CLOTHING	Items	4	52	143	-	83	-	-	28	
	Items/opening	10	0,67	0,67		0,67			0,67	
	No. openings	1	77	213		123			41	
	Rack volume (m^3)	-	7,6	102,1		12,2			4,1	
RUBBER	Items	18	18	18	151	138	69	412	275	-
	Items/opening	10	1,50	4,5	10	1,58	6,6	10	1,62	
	No. openings	2	12	4	15	87	8	41	170	
	Rack volume (m^3)	0,1	1,2	3,2	0,7	8,6	10,1	1,9	16,8	
PAINT	Items	-	8	69	-	-	14	-	-	-
	Items/opening		58	0,58			0,58			
	No. openings		14	118			24			
	Rack volume (m^3)		1,4	56,8			11,3			
INFLAMMABLE	Items	-	1	4	-	-	1	-	-	-
	Items/opening		1	0,37			0,50			
	No. openings		2	7			2			
	Rack volume (m^3)		0,2	3,3			0,8			
ACID	Items	-	1	4	-	14	-	-	-	-
	Items/opening		1	0,37		0,60				
	No. openings		2	7		23				
	Rack volume (m^3)		0,2	3,2		2,3				
STATIONERY	Items	44	135	39	41	14	-	-	55	-
	Items/opening	10	0,75	0,75	10	0,75			0,75	
	No. openings	5	181	52	4	19			74	
	Rack volume (m^3)	0,2	17,9	25,0	0,2	1,9			7,3	
HIGH SECURITY	Items	88	89	21	220	55	-	165	-	-
	Items/opening	10	0,61	0,61	10	0,60		10		
	No. openings	9	145	34	22	91		17		
	Rack volume (m^3)	0,4	14,4	16,4	1,0	9,0		0,8		
CHEMICAL	Items	-	-	3	-	-	14	-	-	-
	Items/opening			2			2			
	No. openings			7			30			
	Rack volume (m^3)			7,8			36,0			

TOTAL SMALL PARTS STORAGE

DRAWER OPENINGS = 674 OFF (± 31 m^3)
SHELF OPENINGS = 13 069 OFF (± 1072m^3)
LONG SPAN OPENINGS= 3 336 OFF (± 1818m^3)

OVERALL LIF , ITEMS= 18 651 OFF

* Typical opening sizes:

	H	W	D
DRAWERS-	90 X	1000 X	450
	150 X	1000 X	450
SHELVES-	300 X	1000 X	330
LONG SPAN -	400 X	2000 X	500
	600 X	2000 X	1000

944015

ABC ANALYSIS BY MOVEMENT

(b) Heavy Storage on Pallet Racking:

ESTIMATED STORAGE REQUIREMENTS (CONT'D)
(10 YEARS COMMERCIAL SERVICE)

		FAST MOVING		SLOW MOVING		VERY SLOW MOVING	
		WOODEN DECKING	PALLETS	WOODEN DECKING	PALLETS	WOODEN DECKING	PALLETS
GENERAL CONSUMABLE	Items	39	39	35	34		
	Items/opening	5,9	2,3	5,8	2,3		
	No. openings *	10	26	6	15		
	Rack volume (m^3)	20	50	12	29		
GENERAL BULK	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
MECHANICAL SPARES	Items	5	39	83	398	803	1942
	Items/opening	1	2,8	1,9	3,8	3,2	3,2
	No. openings	5	14	44	106	248	808
	Rack volume (m^3)	10	26	83	203	474	1161
INSTRUMENTS/ SMALL ELECTRICAL	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
CLOTHING	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
RUBBER	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
PAINT	Items	-	1	-	-	-	-
	Items/opening		2				
	No. openings		0,5				
	Rack volume (m^3)	-	1	-	-	-	-
INFLAMMABLE	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
ACID	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
STATIONERY	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
HIGH SECURITY	Items	-	-	-	-	-	-
	Items/opening						
	No. openings						
	Rack volume (m^3)	-	-	-	-	-	-
CHEMICAL	Items	-	17	-	-	-	-
	Items/opening		0,36				
	No. openings		47				
	Rack volume (m^3)	-	90	-	-	-	-

TOTAL PALLET RACKING

DECKED BEAMS = 313 OFF PAIRS ($\pm$ 599 m^3)
PALLET BEAMS = 817 OFF PAIRS ($\pm$ 1560 m^3)
OVERALL LINE ITEMS= 3475 OFF

* Typical rack opening (2 pallet positions) = 630 X 2375X 1200 (H W D)
Pallets 1000 X 1200 with fork entry on 1000 side.

944015

(c) Very Heavy Storage Under [illegible]

ESTIMATED STORAGE REQUIREMENTS [illegible]
(10 [illegible] AS COMMERCIAL SERVICE)

		FAST MOVING	SLOW MOVING	VERY SLOW MOVING
GENERAL CONSUMABLE	Item Volume (m^3)	- -	- -	- -
GENERAL BULK	Item Volume (m^3)	- -	- -	- -
PLANT/CAPITAL SPARES	Item Volume (m^3)	8 13	- -	1108 1732
INSTRUMENTS/ SMALL ELECTRICAL	Item Volume (m^3)	- -	- -	- -
CLOTHING	Item Volume (m^3)	- -	- -	- -
RUBBER	Item Volume (m^3)	- -	- -	- -
PAINT	Item Volume (m^3)	- -	- -	- -
INFLAMMABLE	Item Volume (m^3)	- -	- -	- -
ACID	Item Volume (m^3)	- -	- -	- -
STATIONERY	Item Volume (m^3)	- -	- -	- -
HIGH SECURITY	Item Volume (m^3)	- -	- -	- -
CHEMICAL	Item Volume (m^3)	- -	- -	- -

TOTAL HEAVY STORAGE

OVERALL LINE ITEMS = 1116 OFF (1745m^3)

944013

CALCULATION OF WAREHOUSE DIMENSIONS, HANDLING CAPACITY AND INITIAL INVESTMENT COSTS.

(a) Very heavy equipment bay (Heavy plant).

Volume to be stored = $1745m^3$

Area utilisation index = 0,6
Storage height = 2,3m

Floor area required = $\frac{1745}{0,6 \times 2,3}$

= $1\ 264m^2$

If 24m span crane is used the run would be 53m.

Sub system building dimensions:

For an overhead crane area, a 2 to 1 length to width ratio is usually considered economical.

Width = 24m
Length = 53m
Height = 6,5m (To bottom of crane beam)

The sub system cost would then be:

- cost of handling equipment

40t crane = R190 000

- cost of building

$1\ 272m^2$ @ $R676/m^2$ = R859 872

SUB SYSTEM COST = R1 049 872

(b) Heavy equipment bay (Light plant)

(i) Option 1: Forklift truck (Not high level picking comparitive use only).

- volume of goods = $1190m^3$
- storage height = 4m
- area utilisation = 36%
- rack volume utilisation = 50%

Rack volume required = $2\ 380m^3$

Floor area required = $\frac{2380}{0,36 \times 4}$

= $1\ 653m^2$

Sub system building dimensions:

For a forklift truck the width of one aisle plus racking is 6050mm.

Thus the width should be approximately a multiple of this.

5 aisles = 30,25m ∴ use 31m wide.

Width = 31m
Length = 53m
Height = 5m min clear headroom

The sub system cost would be:

- cost of storage equipment

  $1643m^2 \times R65/m^2 \times \left(\frac{0,36}{0,41*}\right) = R93\ 771$

- cost of handling equipment

  1,5 ton fork lift = R27 000

- cost of building

  $1\ 643m^2$ @ $R630/m^2$ = R1 035 090

SUB SYSTEM COST = R1 155 861

(ii) Option 2: 2 way reach truck

- volume of goods = $1190m^3$
- storage height = 7m
- area utilisation = 41%
- Rack volume utilisation = 50%

Rack volume required = $2\ 380m^3$

Floor area required $= \frac{2380}{0,41 \times 7}$

$= 829m^2$

Sub system building dimensions:

The width of one aisle plus racking for a 2-way reach truck is 5150mm. Thus the width of the building should be approximately a multiple of this.

3 aisles = 15,45m ∴ use 16m.

Width = 16m
Length = 52m
Height = 8m min clear headroom.

*See note at 5.14.1

The sub system costs would be:

- cost of storage equipment

  $832m^2$ @ $R105/m^2$ = R87 360

- cost of handling equipment

  1,5t 2 way reach truck = R43 000

- cost of building

  $832m^2$ @ $R630/m^2$ = R524 160

SUB SYSTEM COST = R654 520

(iii) Option 3 Swivel reach truck

- volume of goods = $1190m^3$
- storage height = 8m
- area utilisation = 50%
- rack volume utilisation = 50%

Rack volume required = 2 $380m^3$

Floor area required = $\frac{2380}{0,5 \times 8}$

= $595m^2$

Sub system building dimensions:

The width of one aisle plus racking for a swivel reach truck is 4250mm.

(NOTE: At this width guide rails at the base of the racks are required). Thus the width of the building should be approximately a multiple of this.

3 aisles = 12,75m ∴ use 13m

width = 13m
length = 46m
height = 9m min clear headroom

The sub system cost would be:

- cost of storage equipment

$598m^2 \times R105/m^2 \times \left(\frac{0,50}{0,41}\ *\right) \times \left(\frac{7}{6}\ †\right) = R89\ 335$

- cost of handling equipment

1,5t swivel reach truck = R100 000

guide rails, 138m @ R50/m = R6 900

*See note at 5.14.1

† cost adjustment for rac ht

- cost of building

$598m^2$ @ $R630/m^2$ = R376 740

SUB SYSTEM COST = R572 975

(iv) Option 4: S/R machine

- volume of goods = $1190m^3$
- storage height = 9m
- area utilisation = 60%
- rack volume utilisation = 50%

Rack volume required = 2 380

$$\text{Floor area required} = \frac{2380}{0,6 \text{x} 9}$$

$$= 441m^2$$

Sub system building dimensions:

The width of one aisle plus racking for a $1^1/2$ ton S/R machine is 4050mm. Thus the width of the building should be approximately equal to a multiple of this.

2 aisles = 8,1m ∴ use 8,5m

width = 8,5
length = 52m
height = 10m min clear headroom.

The sub system costs would be:

- cost of storage equipment

$$442m^2 \text{ x } R105/m^2 \text{ x}\left(\frac{0,6}{0,41}*\right)\text{x}\left(\frac{8}{6}\dagger\right) = R90\ 556$$

- cost of handling equipment

2 off 1,5 ton S/R machines = R300 000

104m support rail @ R203/m = R21 112

- cost of building

$442m^2$ @ $R630/m^2$ = R278 460

SUB SYSTEM COST = R690 128

*See note at 5.14.1

† cost adjustment for rack ht.

(c) *Bay for* man handled goods

(i) Option 1: Manual handling on mezzanines.

The type of mezzanine used has a major impact on the cost of the system. The most economical type of mezzanine, from both the material cost point of view and space utilisation is the rack supported mezzanine. Thus only this system will be considered.

- volume of goods = 1 711m^3(Long span + shelves + drawers)
- *storage height = 6,6m*
- area utilisation = 41%
- rack volume utilisation = 50% (shelves)
- rack volume utilisation = 75% (drawers)

Rack volume required

For very small components the rack volume utilisation acheived when drawers are used is 3 times better than the rack volume utilisation achieved when steel shelves are used. The cost of *drawers is twice that of shelving for the same rack volume.* However since only $^1/3$ of the rack volume is required if drawers are used, the drawer system is the most economical. A rack volume utilisation of 75% can be achieved if drawers are used.

Rack volume required:

shelves = $\frac{1685m^3}{0,5}$ (long span + std. steel)

= 3 370m^3

drawers = $\frac{26m^3}{0,75}$ = 35m^3

Total = 3 405m^3

Ground floor area required (with 2 levels of mezzanine above i.e. 3 x 2,2m high tiers of racking) = $\frac{3\ 405}{0,41x6,6}$

= *1 258*m^2

Sub system building dimensions:

The width of one aisle plus racking for a small parts pick area is 2m. Thus the building width should be approximately equal to a multiple of this.

12 aisles = 24m

width = 24m
length = 52m
height = 7,6m min clear headroom

The sub system cost would be

- cost of storage equipment

long span shelving = 78m^2 x 3 levels x R110/m^2 = R258 390

steel shelving = 462m^2 x 3 levels x R190/m^2 = R263 340

drawers = 13m^2 x 3 levels x R506/m^2 = R19 734

- cost of mezzanine

2 levels x 1248 m^2 x R120/m^2 = R299 520

- cost of building

  1248m^2 @ R630/m^2 = R786 240

  SUB SYSTEM COST = R1 627 224

(ii) Option 2. Manual handling on light duty S/R machine.

- Volume of goods = 1 711m^3 (Long span + shelves + drawers)
- storage height = 9m
- area utilisation = 48%
- rack volume utilisation = 50% (shelves
- rack volume utilisation = 75% (drawers)

Rack volume required = 3 405m^3

Floor area required = $\frac{3405}{0,48x9}$

= 788m^2

Sub system building dimensions

The width of one aisle for an S/R machine of this type plus the width of racking is 2100mm. Thus the building width should be approximately a multiple of this.

5 aisles = 10,5m ∴ use 11m

Width = 11m
length = 71m
height = 10m min clear headroom

The sub system costs would be

- cost of storage equipment
  (see option 1 for calculation)

  = R541 464

- cost of handling equipment

3 off 300kg S/R machines = R150 000

355m rail & conductor @ R203/m = R72 065

Transfer car = R25 000

- cost of building

$781m^2$ @ $R630/m^2$ = R492 030

SUB SYSTEM COST = R1 280 559

(iii) Option 3. Manual handling of a free path order picking machine

- volume of goods = 1 $711m^3$
- storage height = 7m
- area utilisation = 40%
- rack volume utilisation = 50% (shelves)
- rack volume utilisation = 75% (drawers)

Rack volume required = 3 $405m^2$

Floor area required $= \frac{3\,405}{0{,}4 \times 7}$

$= 1\ 216m^2$

Sub system building dimensions

The width of one aisle plus racking for a free path order picker is 2500mm. Thus the building width should be approximately a multiple of this.

9 aisles = 22,5m ∴ use 23m

width = 23m
length = 53m
height = 8m min clear headroom

The sub system costs would be:

- cost of storage equipment

(see option 1 for calculation) = R541 464

- cost of handling equipment

3 off highlevel order pickers = R165 000

477m of guide rail @ R50/m = R23 850

- cost of building

1 $219m^2$ @ $R630/m^2$ = R767 970

SUB SYSTEM COST = R1 498 284

(d) Specialized storage areas

(i) Decanted oil. Manual picking - low level - drum racking and long span shelving.

- volume of goods stored = $15m^3$
- storage height = 2,2m
- area utilisation = 43%
- rack volume utilisation = 50%

Rack volume required = $30m^3$

Floor area required = $\frac{30}{0,43x2,2}$

= $32m^2$

Sub system building dimensions

The width of one aisle plus racking is 2 000mm. Thus the building width should be approximately a multiple of this. (For this type of picking, Kallywist [7] suggests that the length to width ratio should be 1:1 to 2:1 as a rule of thumb).

2 aisles = 4m

width = 4m
length = 8m
height = 3m min clear headroom

The sub system cost would be.

- cost of storage equipment

  $32m^2$ x R110/m^2 = R3 520

- cost of building

  $32m^2$ @ R630/m^2 = R20 160

SUB SYSTEM COST = R23 680

(ii) Gas storage: Manual picking -low level - on ground storage.

For the storage of gas a covered wire cage should be provided. The cost of this is minimal and will not be included in the total system cost. A cage of approximately $76m^2$ should be provided well away from the main stores building.

(iii) Paint : Manual picking-lowlevel-long span shelving.

- volume of goods stored = $38m^3$
- storage height = 2,5m
- area utilisation = 43%
- rack volume utilisation= 50%

Rack volume required = $76m^3$

Floor area required = $\frac{76}{0,43x2,5}$

= $71m^2$

Sub system building dimensions.

The width of one aisle plus racking for manually picked long span shelving is 2 000 mm. Thus the building width should be a multiple of this.

3 aisles = 6m

width = 6m
length = 12m
height = 3m min clear headroom

The sub system cost would be:

- cost of storage equipment

$72m^2$ x R110/m^2 = R7 920

- cost of building

$72m^2$ @ R630 = R45 360

SUB SYSTEM COST = R 53 280

(iv) Steel storage. Complex handling and storage requirements.

- volume of goods stored = 1 $013m^3$
- storage height = 2,5m
- area utilisation = 60%*
- rack volume utilisation = 0,75*

* (It was found that with a good layout in this section of the store, good area and rack volume utilisation figures were easily obtained at the 3 representative stores.)

Rack volume required = 1 $351m^3$

$$\text{Floor area required} = \frac{1351}{0,60 \times 2,5}$$

$$= 901m^2$$

Sub system building dimensions

Since the major portion of stock in this area is boiler tubing and this tubing is generally in lengths of 8 to 10m the best layout for this area is a block of racking 10m deep either side of a 10m wide gangway.

width = 30m
length = 30m
height = 6m min clear headroom

The sub system costs would be

- cost of storage equipment

A range of storage equipment will have to be used but the cost of long span shelving will be used as an average figure for costing purposes.

$900m^2$ x R110/m^2 = R99 000

- cost of handling equipment

The steel store should, if possible, be placed in an extension of the heavy plant bay and close to the light plant bay so that the goods can be handled by the overhead crane and the industrial truck serving the light plant bay. If this is not possible a small (3 ton) overhead crane would have to be provided over the plate storage in the steel store. The cost of a small crane would vary greatly with changes in span and run but generally is very low (one to two thousand rand) in comparison with other handling equipment in this report and since it does not affect decision making it is felt that an estimated cost is not necessary.

- cost of building

  $900m^2 \times R630/m^2 = R567\ 000$

SUB SYSTEM COST = R666 000

(v) Yard

Volume of goods to be stored = $4\ 175m^3$

area required = $10\ 980m^2$

In general no special facilities need be provided for yard storage. However this is dependent on the soil and drainage characteristics of the specific store site and the requirements will have to be established for each store.

OPERATING COSTS

erating cost comparison of alternative options.

Only costs which differ significantly depending on which option is used will be considered. The real cost of capital was considered to be 5% in accordance with the "Economic parameters" memo dd 17.10.85. (Escom Internal).

(a) Heavy plant storage

A 10 year life is used for the industrial lift trucks and a 30 year life for the S/R machines.

(i) Forklift truck

NPV of maintenance cost over 30 years
= R69 000

NPV of replacement cost over 30 years
assuming a 10 year life (i.e. 2 replacements)
= R27 000

NPV of operating costs are thus
= R96 000

(ii) Reach truck

NPV of maintenance cost over 30 years
= R69 000

NPV of replacement cost over 30 years
assuming a 10 year life
= R42 000

NPV of operating costs are thus

= R111 000

(iii) Swivel reach

NPV of maintenance cost over 30 years
= R77 000

NPV of replacement cost over 30 years
assuming a 10 year life
= R99 000

NPV of operating costs are thus
= R176 000

(iv) S/R machine

NPV of maintenance costs over 30 years
= R92 000

No replacement cost since has a life of 30 years.

NPV of operating costs are thus
= R92 000

(b) Manhandled goods

(i) Mezzanine

The maintenance cost associated with mezzanines is negligible.

There will be no need for replacement within a 30 year period.

(ii) S/R machine

NPV of the maintenance cost over a period of 30 years.

= R54 000

No replacement of equipment will be necessary in the 30 year life.

NPV of operating costs = R54 000

(iii) Free path order picker

NPV of the maintenance cost over a period of 30 years

= R71 000

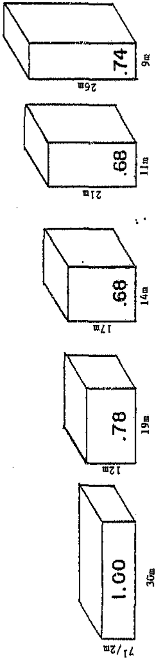
NPV of replacement costs assuming a life of 10 years.

= R54 000

NPV of operating costs = R125 000

ANNEXURE A5

COST PER CUBIC METRE FACTOR



The cost per cubic metre of building reduces with the increase in height up to ± 20m.

ANNEXURE A6

ADVANTAGES & DISADVANTAGES OF S/R MACHINES

(a) Advantages:

(i) Make better use of existing space eliminating need for additional space or new building.

(ii) Keep cost of new building construction to a minimum.

(iii) More efficient use of manpower increases productivity.

(iv) Cut time needed for supervision.

(v) Reduce or eliminate damage to material stored.

(vi) Reduce the amount of present material handling.

(vii) Cut maintenance costs of system compared to conventional equipment.

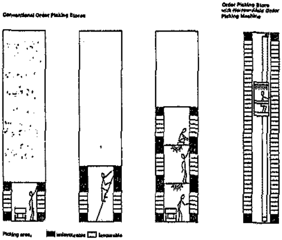
(viii) Reduced pilferage

(ix) More efficient handling of material to and from storage area.

(x) More effective inspection of material.

(xi) Reduced customer waiting time.

(xii) Smoother operation.



Conventional order picking stores have goods located either over a wide area on a single storey or on a number of mezzanine floors.

In most cases, the pedestrian picker has long distances to cover on foot and steps to climb. Other factors which reduce efficiency include the difficulty of working in confined positions requiring stooping or stretching, or on unsteady ladders.

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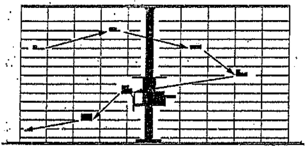
ANNEXURE A6



Order picking cycle on the "man to the goods" principle

Far greater operational efficiency can be achieved by using S/R order picking machines. In the shortest time the stores person is transported by the machine to any required compartment by simultaneous horizontal and vertical movement of the cabin.

The S/R machine facilitates fast multi-line order assembly or retrieval of several orders on one cycle.

However picking one single line order per cycle is still 75% faster than the present manual pick method.

(b) Disadvantages:

(i) Some inflexibility.

(ii) Fairly accurate racking required.

(iii) Aisle bound machines.

(iv) Limited local supply.

(v) Demands proper locality coding.

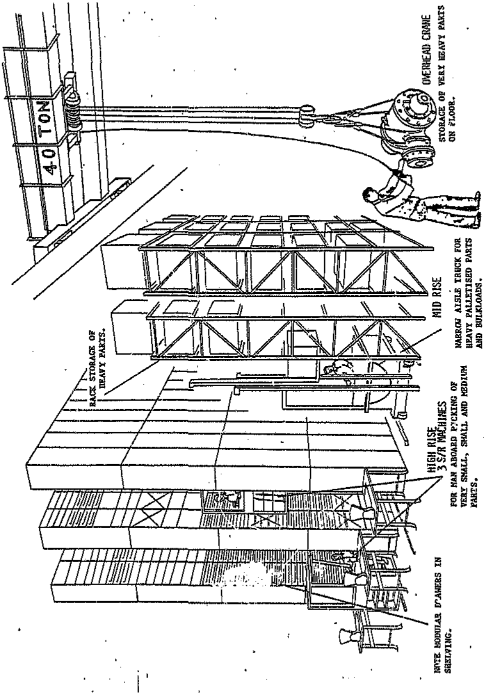
ANNEXURE A6

ADVANTAGES & DISADVANTAGES OF VARIOUS HANDLING SYSTEMS

	TYPICAL SPEED	MAN-POWER	SUITED TO SHORT OR LONG DISTANCES	TYPE PART	NO. OF LINE ITEMS SUITED	TYPICAL CAPITAL COST	AISLE BOUND	MAX PICKING HEIGHT	TYPICAL LOAD	GENERALLY ABLE TO COMPUTERISE	FLEXIBILITY	MOVEMENT CAPACITY (moves in & out per hour)
HEAVY PARTS:												
1) REACH TRUCK	1m/s to 2m/s	Low	Short to medium	Palletised	Small	R43 000	No	7m	1 ton/ 1 1/2 ton	No	Excellent	10 to 15
2) SWIVELREACH	1m/s to 2m/s	Low	Short to medium	Palletised	Medium/ Large	R100 000	No	9m	1 ton	No	Excellent	15
3) S/R MACHINE LARGE	2m/s to 4m/s	Low	All	Palletised	Large	R180 000	Yes	40m	1 ton	Yes	Medium to Good	30
SMALL PARTS:												
1) MAN WITH BASKET	1m/s	Large	Short	Small	Medium	R5	No	2,5m	5 kg	No	Excellent	25
2) MAN WITH HAND TROLLEY	0,5m/s	Large	Short	Small/ Medium	Medium	R100	No	2,5m	100kg	No	Very Good	25
3) POWER TRUCK (Low level picker)	1,5m/s	Medium	Medium	Small to fairly large	Medium to high	R25 000	No	3,5m	750kg	No	Good	30
4) FREE PATH ORDER PICKER	2m/s	Low	Medium	Small	Medium to high	R65 000	No	7m	1 ton	No	Good	25
5) S/R MACHINE (Small)	3m/s to 4m/s	Low	All	Small	Medium to high	R75 000	Yes	12m	300kg	Yes	Medium to Good	35

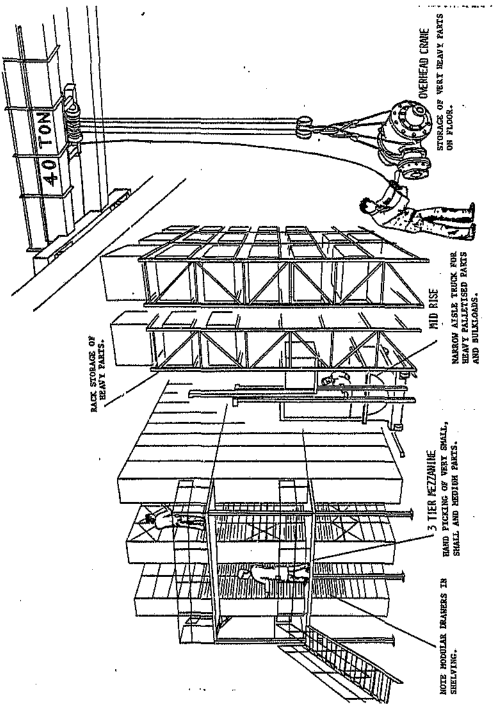
ANNEXURE A7

SCHEMATIC OF RECOMMENDED SYSTEM



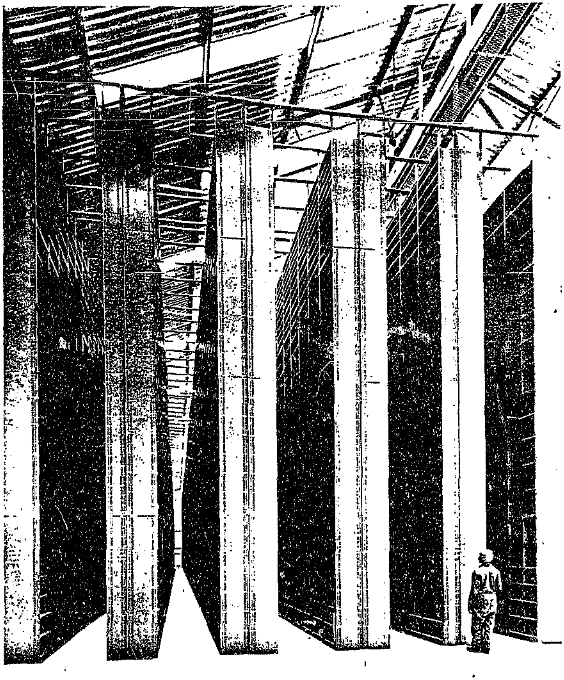
ANNEXURE A8

SCHEMATIC OF ALTERNATIVE MANUAL SYSTEM

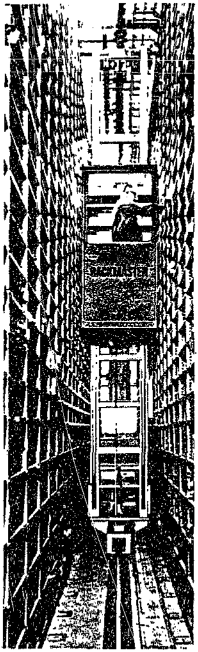


TYPICAL HIGH RISE INSTALLATIONS

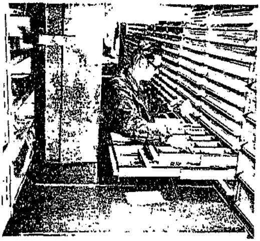
Installation at Iscor showing high rise shelving/drawer system for small parts storage.



TYPICAL HIGH RISE INSTALLATIONS



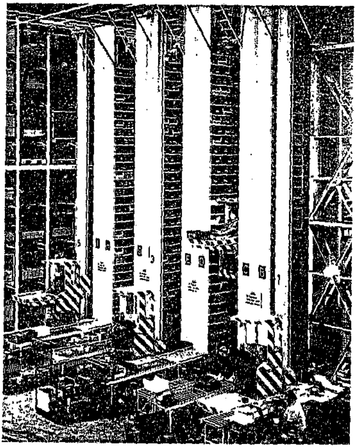
Small mechanical spares storage.



ANNEXURE A9

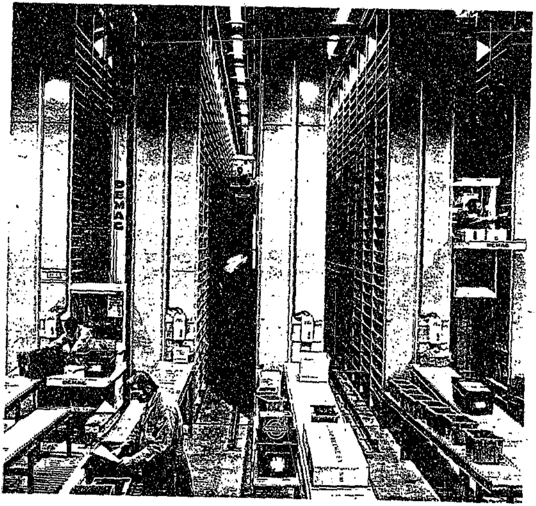
TYPICAL HIGH RISE INSTALLATIONS

Order picker in main store, Demag, Boksburg.



Installation in engineering industry similar to Demag's own facilities at Boksburg.

TYPICAL HIGH RISE INSTALLATIONS



Order picking of motor vehicle parts, Volvo.

TYPICAL HIGH RISE INSTALLATIONS

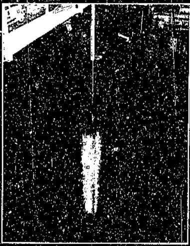
Installation in electrical engineering industry (Europe).
Storing small components in tote bins.

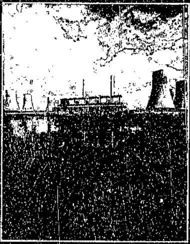
The requested parts are taken out of the storage compartment by hand, packed in order-picking boxes and weighed on the S/R-machine itself on a platform with an integral weighing device

Making the most of available resources

In South Africa, electricity is generated mainly by coal-fired power stations. Hydro- and nuclear power stations contribute additional power. There are insufficient water resources in this country to make large hydroelectric schemes possible. Available water supplies are more effectively used for irrigation and for town and city requirements.

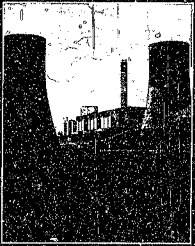
Nuclear power is particularly advantageous in coastal areas where seawater may be used to conserve scarce supplies of fresh inland water. It will be increasingly adopted as coal resources are exhausted, towards the middle of the next century.





Die benutting van beskikbare hulpbronne

In Suid-Afrika word elektrisiteit hoofsaaklik deur steenkoolkragstasies ontwikkel. Hidro- en kernkragstasies verskaf bykomende krag. Daar is te min water in hierdie land om groot hidro-elektriese skemas moontlik te maak. Die beskikbare water word meer effektief vir besproeling en die behoeftes van dorpe en stede gebruik. Kernkrag is veral in kusgebiede voordelig waar seewater gebruik kan word om die skaars vars water van die binneland te bewaar. Dit sal toenemend gebruik word soos steenkoolreserwes uitgeput raak teen die middel van die volgende eeu.



Protection and restoration of the environment are priority issues in Escom's policy

Die beskerming en herstel van die omgewing is prioriteite in Evkom se beleid

Environmental impact control programmes prevent the destruction of plant and animal life and guarantee almost total restoration of natural surroundings on completion of construction work.

Close cooperation with communities affected by Escom construction projects ensures that adequate provision is made to cater for the needs both of the local populace and the incoming construction workers and employees.

Permanent anti-pollution measures in power stations limit water and air pollution.

Programme om invloed op die omgewing te beheer verhoed dat die plante- en dierelewe vernietig word, en waarborg bykans algehele herstel van die natuurlike omgewing ná voltooiing van konstruksiewerk.

Noue samewerking met gemeenskappe wat deur Evkom se konstruksieprojekte geraak word, verseker dat voldoende voorsorg getref word om in die behoeftes van die plaaslike bevolking sowel as die inkomende konstruksiewerkers en werknemers te voorsien.

Permanente teenbesoedelingsmaatreëls in kragstasies beperk water- en lugbesoedeling.

Electricity is the driving power behind our modern industrial society. It is both the starting point and the road for progress

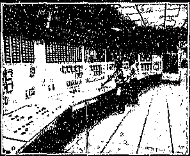
Elektrisiteit is die dryfkrag agter ons moderne nywerheidsgemeenskap. Dit is die beginpunt sowel as die weg na vooruitgang

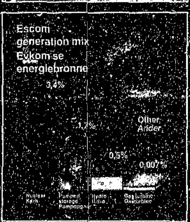
There must be a consistent, high quality supply of electricity to guarantee economic and technological development. Escom, the national electricity utility of South Africa, and one of the top ten utilities in the world provides electricity not only for the needs of the whole of South Africa but exports to Bophuthatswana, Ciskei, Lesotho, Moçambique, Namibia, Swaziland, Transkei, Venda and Zimbabwe.

Escom is internationally acclaimed for its achievements in:

- *high-voltage and extra-high-voltage transmission at high altitudes*
- *lightning research*
- *developing variable speed drives at power stations*
- *static compensation*
- *dry-cooling technology.*

Escom is in the forefront of power generation technology. Many of its engineering achievements in this field have pioneered progress in the Western world. Research and development benefit from the exchange of information with foreign research institutes.





Daar moet 'n egalige toevoer van elektrisiteit van hoë gehalte wees om ekonomiese en tegnologiese ontwikkeling te waarborg. Evkom, die nasionale nutsmaatskappy in Suid-Afrika en een van die eerste tien in die wêreld, verskaf elektrisiteit nie net om in die behoeftes van Suid-Afrika te voorsien nie, maar voer energie uit na Bophuthatswana, Ciskei, Lesotho, Mosambiek, Namibië, Swaziland, Transkei, Venda en Zimbabwe.

Evkom word internasionaal geloof vir sy prestasies op die gebied van:

- *hoëspanning- en ekstrahoëspanningtransmissie in gebiede hoog bo seespieël*
- *weerlignavorsing*
- *die ontwikkeling van wisselspoedaandrywing by kragstasies*
- *statiese kompensasie*
- *droogkoeltegnologie.*

Evkom is aan die spits van die tegnologie van kragontwikkeling. Baie van sy prestasies op die gebied van die ingenieurswese was baanbrekerswerk in die Weste se vooruitgang. Navorsing en ontwikkeling trek voordeel uit die uitruil van inligting met buitelandse navorsingsinstansies.

Every facet of our way of life is touched by Escom's role in producing electricity

Elke faset van ons leefwyse word deur Evkom se rol in die ontwikkeling van elektrisiteit geraak

Escom's activity over almost 70 years gives it the necessary experience to provide for the country's energy needs. Escom has adapted its objectives and methods to the changing requirements of Southern Africa's development.

Professionalism and customer awareness are keys that are enabling Escom to meet its customers' needs without placing an undue financial burden on them.

Escom is an equal op[illegible] organisation – [illegible] people as its most valuable resource and encourages them to develop to their fullest potential.

"**I** believe that good businesses are created, built by peo[illegible] with a vision of where the[illegible] want to be and the energy to [illegible] through. We have remoulded [illegible] to meet the challenges of South Africa today with this principle in mind."

John Maree - Chairman

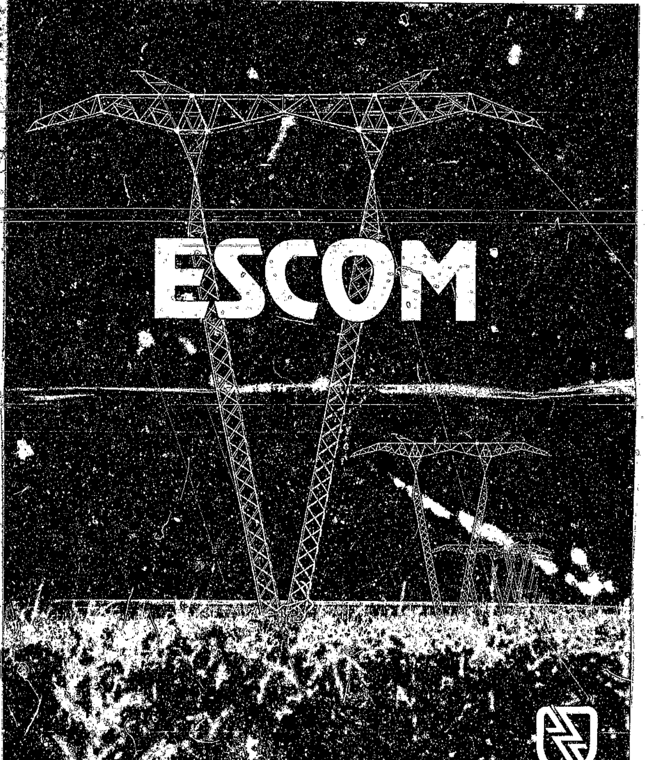
Evkom se bedrywighede oor bykans 70 jaar gee aan hom die ervaring om in die land se kragbehoeftes te voorsien. Evkom het sy doelwitte en metodes by die veranderende behoeftes van Suidelike Afrika se ontwikkeling aangepas.

Professionalisme en klantbewustheid is sleutels wat Evkom in staat stel om in sy klante se behoeftes te voorsien sonder om 'n onredelike finansiële las op hulle te plaas.

Evkom werk baie nou saam met verskaffers en kontrakteurs om die beste diens aan die land te lewer. Evkom is 'n gelykegeleenthede-organisasie – hy aanvaar sy mense as sy kosbaarste hulpbron en moedig hulle aan om hul potensiaal ten volle te ontwikkel.

"**E**k glo dat goeie sake-ondernemings deur mense met 'n visie van waar hulle wil wees geskep en gebou word, en wat die energie en dryfkrag het om dit deur te voer. Met hierdie beginsel in gedagte het ons Evkom omvorm om vandag se uitdagings in Suid-Afrika die hoof te bied."

[illegible] Maree - Voorsitter


ESCOM
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Changing face of power

Escom is emerging from its remodelling process with a new personality

South Africa's national power utility, Escom, has undergone a radical restructuring since 1985 which has changed the character of the organisation. Increasingly, the company's focus is on its customers (with intense concern given to holding down tariff rises), on developing its personnel and on its broader responsibilities to the community.

Today, Escom is being run as a meritocracy rather than a bureaucracy, and it measures its success in business terms. Nevertheless, the supply of electricity is not seen exclusively as a business, with the objective of making profits, but as a vehicle to create prosperity and to raise living standards in SA as a whole.

Though it operates under an Act of Parliament, Escom is not a state-owned corporation but an independent, self-financing, non-profit undertaking whose purpose is to supply the nation's electricity needs in the most cost-effective way — subject to resource constraints and the national interest.

The Management Board of Escom is answerable to and appointed by the Electricity Council. This is a non-executive body appointed by the Minister of Economic Affairs and Technology which is responsible for policy, the setting of objectives, planning and control. The Council comprises representatives of major electricity consumers and key government departments, all chosen for their specialist knowledge.

"Escom receives no money from the state," says chairman John Maree. "We have to operate efficiently for the good of the country. We take the strong view that if we do our job badly it will affect the economy adversely. If we do it well, it can assist the South African mining and manufacturing industries to maintain their competitiveness."

Thus the prime mission of Escom is "to satisfy the electricity needs of customers in the most cost-effective way, subject to resource constraints and the national interest." But there is a broader mission to use the organisation's expertise, capacity and resources to benefit the whole southern African region, without regard to political boundaries. Escom sees electricity as a way of achieving social and economic development.

The organisational structure of Escom has been changed at two levels. As already mentioned, the control system at the top has been changed so that it is highly responsive to consumer needs. The Council and the Management Board operate in close harmony and have a sound relationship.

At a lower level, management control has been decentralised with the establishment of 52 strategic business units, each with its own support system and area of control. This has had an immediate impact on management efficiency and innovation, and has enhanced the quality of communication throughout the organisation.

Maree: raising efficiency levels

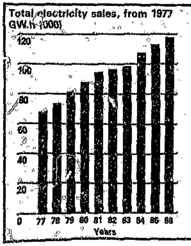
Another factor improving communication has been the flattening of the reporting structure. The previous middle level has been disbanded, and now the lines of communication from the lowest levels of the organisation to top management have been considerably shortened.

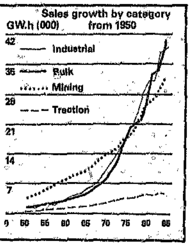
Good communications are aided further by a new performance management system at the top levels which entails joint objective-setting and goal setting for the year ahead, with regular reviews. Individual performance has improved, and the demand is coming from the organisation to implement the system at lower levels.

"A system which forces the superior and his subordinates to communicate will accelerate this culture change," says Maree.

Making fundamental cultural changes to so large an organisation cannot be accomplished overnight. It takes time for the new philosophies to permeate through all levels. Initial plans to reduce the size of the head office structure are now going to take longer than originally envisaged. This required that some head office functions would be devolved on to the shoulders of the SBUs, and will have to wait until the units a ready to take on additional functions.

However, a heartening development is that for the first time the top manage-





ment teams of the three main line functions — generation, distribution and engineering — are devising strategies and programmes and holding seminars to look at how they can entrench the new culture and get the message across to people of other language groups. Language problems, culture problems and perception problems tend to intensify as one moves to lower levels in an organisation.

Although Escom is the sole supplier of electricity to most of SA, it is nevertheless keenly responsive to market forces. "The total thrust of the management team and the council is to do their job effectively so that the organisation can supply power as cheaply as possible," says Maree. "There are people on our council who represent the consumer or the major consumer bodies, and they watch our costs and tariffs keenly."

While the members of the council are state appointees, they operate independently, and they don't refer their decisions back to the state. Their constituencies are the consumer bodies they represent, whereas the constituency of state corporations is the government.

Escom can supply all the needs that SA may have for the foreseeable future. "Electricity is not going to be a limiting factor in our growth," says Maree. "We have good generating capacity, with new and very efficient power stations coming on stream. Our main transmission facilities are good. Our national network is in good condition. We can supply bulk power to anybody who wants it."

Because Escom has had such immense growth in recent years (unlike the rest of the world) it has been expanding its generating capacity very rapidly. Power stations under construction at the moment will increase capacity by 60%. The result is that its generating facilities are extremely modern. "It is state of the art," says Maree. "For this century I would say that our facilities are as modern as any in the western world. We are achieving 78% availability, which is higher than the world standard of 77%. A station like Matla runs at 90%."

And while growth has slowed considerably in the last three years, it is expected to continue at its current 4%-5% a year, a not-insignificant rate by world standards, with a lead time of 6-7 years in the construction of conventional power stations, and 10 years for a nuclear station, the corporation will have to start committing new plant in 1990-91.

The urban township electrification programme now being planned will not have a dramatic impact on demand growth, particularly in the early stages. The whole programme for the first 60 townships will require a third of the power of a single big power station. But in 20 or 30 years' time, when the ripple effects of electrification (development of home industries, increased use of appliances) have made themselves felt, the impact could be significant.

The programmes designed to improve internal efficiency have only just got off the ground, but their success has been clearly demonstrated.

"When we instituted the Managers Awards and Chairman's Awards to recognise achievement, in many areas there was an initial scepticism," says Maree. "But we told each strategic business unit to identify the achievements in its organisation, and we have discovered that there are unsung people doing exceptional work within the organisation. Each SBU made its own awards, and the best of these came through to a head office function for recognition at the top. There was tremendous enthusiasm and a great deal of pride on the part of those recognised.

"We set Escom on a new road to become an efficient professionally managed organisation where people progress by merit. I think we have come a long way down that road. There is still a long way to go, but the caravan is moving."

People power

Escom today is an equal opportunity employer, committed to advancement purely on merit regardless of the sex or colour of the individual. With 57 000 people on its payroll, its policies are bound to have a major impact.

The corporation has proceeded cautiously, negotiating with the trade unions involved, and has established parity for 12 000 employees in the course of the past year.

Because of established practice and vested interests on the one side, and trade union pressures on the other, however, achieving this is a lot more complex than would appear at first sight.

"The first issue is to establish parity of remuneration and of conditions of service," says Dr George Lindeque, general manager (human resources). "Parity of conditions was the easier part. Escom has an open pension fund, and all race groups can apply for the same housing assistance. As far as salaries and wages are concerned, you have to identify those individuals who qualify for parity.

"There [illegible] discrimination between professionals, but there do tend to be differences between non-professional categories of staff, and these have to be corrected." Thus if an employee has proved his competence at a job, regardless of his qualifications, he can acquire salary parity with a white person doing the same job. Achieving equality of opportunity is not a passive operation, Lindeque notes. "It has to be developed. We have to unfreeze the organisation," he says. "We will not be satisfied to establish tokenism. On the other hand, we don't have an affirmative action programme, and we don't want to create facades. We want to be come a meritocracy. We have to balance and manage our equal opportunity programme."

It is a low profile programme which

Power station workers: no bars on advancement

aims to avoid trampling on susceptibilities or heightening emotions. It seeks to strike a reasonable balance between black expectations and entrenched minority rights.

"But the burning issues are not only toilet facilities or recreation rooms," says Lindeque. "They are opening up career paths and establishing equity between the haves and have-nots in our organisation."

In tandem with this, Escom must actively pursue its education and training programme to ensure that people have the opportunity the achieve the qualifications and skills necessary to allow advancement. Career development is the responsibility of the employee himself, but Escom has the responsibility to provide the development and training resources.

The employee, in consultation with hi superior, can choose what skills he needs for his advancement and then work towards achieving them. All these programmes are "line-driven" — line managers must see that their personnel are being developed. The approach to training and development is holistic or systematic, in that each ... supports the others.

The programmes are under the general guidance of a special training task force. Among its responsibilities is to ensure that the training is done to suit the requirements of the organisation, and to move towards the ideal of a meritocracy.

In all, Escom supports 2 000 learners — 800 apprentices, 500 learner technicians, 375 graduates in training, and 600 bursars at any one time at various universities. With 10 000 applications a year for 100 bursaries, the standard of those selected is high.

Last year's priority at Escom the decentralisation of management, has given way this year to the next phase, which will focus on manpower development.

The core of this programme is a performance management system (PMS) which puts Escom at the cutting edge of management thinking internationally, says Louis van der Merwe, manager responsible for management performance and development.

The central principle of the process is that of shared responsibility for the individual's performance and development, with a system of goal-setting which focuses on outputs ... for excellence and indic... h employee makes a "cont... with his team leader, specifying his contribution to the agreed over-riding objective of the team. The setting of team and individual goals is negotiated in a participative process, but the "contracts" are in written form and are formally reviewed every three months.

Having agreed them, each individual's responsibility is to establish what competencies (knowledge and skills identified by means of a special diagnostic procedure) are needed to deliver the required results.

Escom's obligation, on the other hand, is to provide the support and training which will enable the individual to acquire the competencies. It gives the individual a menu of learning opportunities from which to choose. Fundamentally, though, the individual accepts responsibility for his own development.

"The process is a flexible one," says Van der Merwe. "The contracts can be renegotiated if its objectives turn out to be unrealistic. But once a contract has been agreed upon, individuals are expected to perform." Salary increments depend on performance, and act as signals acknowledging achievement. These signals will vary according to whether the individual met his targets, exceeded them, came close or fell badly short. And exceptionally poor performance could lead to dismissal.

What makes the PMS work? Strong leadership from the top has been a critical element in the success of the new approach. Where the system has failed overseas, it has been because this element was lacking, says Van der Merwe. Implementation of the PMS started with the 150 top managers in the organisation. This year, the system is being cascaded down to the next layer of 1 500 middle managers.

Another factor in its success has been the close link with remuneration. Very few performance systems elsewhere have been linked to pay as directly. Equally important is the participative process. "A superior does not hand down objectives to his subordinates but negotiates them," says Van der Merwe. "In this way a shared vision is created for the future of the organisation. We create a picture that people can strive for. As you get into this process you find a new psychology taking hold. Like a top athlete is taught to do, people begin to see themselves winning."

Spreading the light

Electricity in the home is still a dream for most of SA's blacks, an estimated 20m-22m of whom are without it despite progress in electrifying major townships like Soweto.

Escom believes that the fastest, most cost-effective way of improving the quality of life in SA is to extend the use of electricity to the homes of all its people.

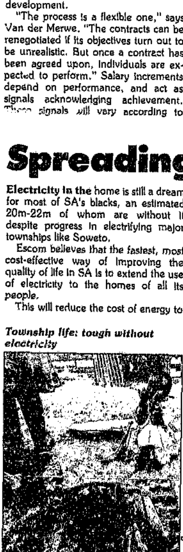
This will reduce the cost of energy to the average black family. The dominant source of fuel at present (particularly in rural areas) is wood, which is consumed at a rate of 12m-14m tons a year, denuding woodlands, destroying tree cover and polluting the atmosphere. This is followed in importance by coal, dung (in rural areas), paraffin, candles and gas.

But the alternative fuels are expensive. Paraffin costs nine times as much as electricity, candles four times as much and coal twice as much. In addition to reducing energy costs, a switch to electricity enhances the earning potential of a black family. It makes possible the development of home industries, and improves study conditions for students used to reading by the inadequate light of a candle.

The convenience of a hot bath at the turn of a tap will be a new experience for most blacks. More important though are the health advantages derived from reduced pollution, proper sewage disposal (which requires electrical pumps), improved hygiene and the easy ability to boil drinking water.

"Not only does electrification improve

Township life: tough without electricity



the quality of life immeasurably for black members of our society, but it offers the opportunity for increased employment opportunities through the development of home or local industries," says chief executive Ian McRae. "Once you go down that road you start to create other growth potential for the electricity supply industry and for appliance sales. Increased use of electric sewing machines and power tools in turn spins off into sales of textiles, building materials and the like."

So while Escom sees a social responsibility element in this programme, it also sees it as a means of stimulating economic growth. "Urbanisation is a fact of life in SA," says McRae. "We will not stop the movement of people into towns and cities, so we must learn to manage it."

The major obstacle preventing this transformation is the cost of reticulation and installation, which works out at about R2 400 per stand using conventional Western standards. But Escom has devised ways of reducing these costs by half, to R1 160 per stand, using appropriate technology rather than the excessively high standards of Western technology now enforced.

Present practice, for example, favours underground cabling, miniature substations and individual house metering. While these practices might be appropriate to SA's sophisticated First World component, they impose constraints in the form of costs, planning and resources for both construction and maintenance. Urban and rural areas can be rapidly and relatively cheaply electrified using aerial conductors, pole-mounted transformers and prepaid metering systems.

Methods of wiring homes should also be reassessed. The conventional method costs thousands of rands. But a single connection box could be provided to each home, allowing the use of a single light fitting and a plug outlet, at costs between R150 and R300.

This may not be up to the standard of a fully electrified home in a sophisticated suburb, but it is cheap and quick to install and would be a tremendous step forward for people at present locked into the use of primitive heating and lighting. Surveys have found that the top power priority among blacks is lighting, followed by cooking and then heating.

In pursuit of these objectives, Escom has launched a plan to bring electricity to 60 black townships, home to 3m people, for R348m — compared to the

McRae: powerful vision

estimated R700m that would normally be needed.

Before it can get off the ground, however, local authorities must discard unnecessary regulations and r[illegible] and accept the need for s[illegible] plementation of the proposal.

The scheme also requires [illegible] ment — and money — from gov[illegible] ment, local authorities, RSCs, development aid agencies and foundations. Not even overseas financing has been ruled out, though it obviously will not be readily available. Finally, the users themselves will ultimately have to make a contribution. Escom plans to act as the catalyst for and driving force behind the scheme.

The initial response to the township electrification programme has been positive, and McRae is confident the money needed will be forthcoming. "I believe that if you have a clear goal the money will come," he says. But it is important that the intermediaries — the municipalities, local authorities or regional services councils — which retail electricity to the public, do not charge too much for that service.

Escom is prepared to assist local authorities with the planning and implementation of the schemes, training of staff and providing guidance on maintenance. But this would be an interim arrangement, and Escom would intend eventually to disengage from such activities.

Escom has sufficient generation capacity already to cope with the increased demands of this programme, which would require 1 000MW of capacity — a third of the capacity of a standard power station. Minimal additional infrastructure and manpower would be required.

Much of the inspiration for the proposal came from Escom's Alexandra project, where it is involved with the local authority in upgrading one of the Reef's most notorious black townships. Asked by Alexandra administrator Steve Burger to come up with a plan to electrify Alexandra, Escom decided that providing electricity to shanties was not the answer. What was needed was a complete refurbishment of the dilapidated township.

To date, contracts involving a third of the R90m allocated by government for the project have been placed, but by the time the job is complete, Alexandra will have been extensively renewed. Under a 1980 redevelopment plan which failed because it required wholesale flattening and rebuilding of much of Alexandra and resettlement of its people, the cost would have been R276m.

Escom chief executive Ian McRae believes the Alexandra project can be completed in three years.

Though a lot has been learned from [illegible] project, no two townships are alike, and it is probably impossible to transplant the model to another township. But when a number of similar projects have been completed, Escom will have a body of knowledge and experience sufficient to meet most township problems it is likely to encounter.

Escom believes in principle that electrification should not be undertaken without an upgrading programme. "It makes no sense to electrify a squatter home," says McRae. "It is far better to upgrade the dwelling and then electrify. But we believe it is necessary to accept that the squatter is there because he wants to be there — perhaps because it is convenient, or close to work."

In parallel with the urban electrification project, which has top priority, Escom is looking at electrification in rural areas and has already committed itself to a programme in KwaZulu. More than 2 000 applications have been received for electrification in KwaZulu. The supply of electricity to Ulundi, for example, could transform the potential for small industry in the town. Investigations are also being conducted concerning Kangwane and Lebowa.

In the long term — by the end of the century — Escom hopes to be providing electricity to between two-thirds and 75% of the black population, which by then will be 35 million. But McRae hopes to have made significant inroads into major urban and rural communities by the mid-Nineties.

Managing the funds

Financial liability management has become a critical factor in the way Escom operates as a business enterprise. Debt servicing, both within SA and abroad, accounts for 50% of total Escom costs, and it thus represents the biggest opportunity for increased business efficiency.

Escom is not a passive player in achieving this, according to Larry Harper who, as general manager (finance), is behind the corporation's new dynamic approach. "You don't simply pass on to the customer the effects of market changes," he says "We try and minimise the impact of adverse effects in the markets."

Escom has a major borrowing requirement which it has reduced by cutting expenditure and generating revenue at levels that are adequate to meet costs and allow the maintenance of internal funding at about 30% of total funding.

Clearly, as a business enterprise, Escom cannot finance everything from borrowings. Because it is such a large borrower, it can never totally isolate itself from the impact of rising interest rates or a deteriorating exchange rate, but the objective is to develop financial instruments that satisfy the requirements of Escom and the electricity customer as well as the wishes of investors.

Among examples of this 'financial engineering':

- Interest rate swops. Long-term (three-year) money is swopped into shorter dated interest rates while still having the money available for the three-year period.
- Escom has adopted a much more active approach to foreign exchange management. The previous policy of covering all forex transactions irrespective of the outlook or the cost of cover has given way to a more flexible style. The corporation is still risk-averse, and will always fix its costs if it can do so at a reasonable price.

But sometimes the cost of doing this looks too high in relation to the potential benefits, so on a managed and selective basis Escom is now prepared to take a stance in the market and possibly leave some foreign exchange commitments uncovered.

"We will take a view on the market, but we won't bet everything on this," says Harper. "The portion of our exposure that we are prepared to manage in this way is about $500m. We get views on which currencies are over-valued and which under-valued. We want to denominate our liabilities in over-valued currencies which are then expected to decline."

Escom's foreign exchange exposure amounts to roughly $10bn, a large portion of which is covered with the Reserve Bank.

Harper: not a passive player

- Interest rate caps. This involves taking out an insurance policy against interest rates rising above a given level. Escom's objective is not to save a fortune but to reduce the cost of debt by a fraction of 1%. "If we reduced the cost of our total debt by a tenth of 1% we would save R20m a year," says Harper. "Our objective is to save that tenth. Hopefully it will grow until we are saving the whole 1%, which will be worth R200m a year to us."
- Interest rate futures. It is possible to hedge against an increase in rates by buying a future. The relatively small cost of buying a futures contract gives protection against higher rates.

Escom's Treasury Department, which is managing a liability portfolio of R20bn and a foreign currency exposure of the same size, is probably the single biggest corporate operation of its kind in the country — bigger, indeed, than that of many banks.

Another important financial activity revolves around determination of electricity tariffs. Escom is constantly doing projections of inflation rates, interest rates and costs, always with the question in mind: how can we minimise tariff increases?

Escom had hoped to contain tariff increases over three years to 12%, 10% and 10%, starting in 1986. This, however, was dependent on the inflation rate holding below 15%. It now looks as if it will not be possible to meet the third leg of this undertaking in 1988.

Although interest rates have come down, and costs have been contained (Escom expects to end the year R200m inside its budget), this year has seen an acceleration in the inflation rate combined with reduced revenue because electricity sales have been below expectations. Additionally, interest rates are expected to start rising in 1989.

Another factor is that Escom's inflation rate tends to be higher than the national rate because of exposure to for example, mine wage increases. The foreign exchange rate has also been a negative factor in the past, with 20%-30% of Escom's costs currency-related.

The alternative to raising tariffs is to reduce internal financing (currently accounting for 30% of capital expenditure), but this would require increased levels of borrowing and would provide only a short-term advantage.

Supply & demand

SA has for four decades been one of the fastest growing electricity markets anywhere. Today it has a well developed infrastructure of 27 power stations with a total installed capacity of 28 000 megawatts and 170 000 km of transmission lines.

But the beginning of the Eighties ushered in a dramatic change for Escom, during which the growth rate flagged markedly in response to deteriorating economic conditions. Now, instead of a projected 7% a year, Escom is planning for long-term demand growth of 5%.

This has brought about some important changes in the corporation's approach. Firstly, it has slowed down its power station development programme. Indeed, for some years it will have spare capacity as a result of the programme which was set in motion in the early part of the decade

Five major power stations requiring

Workers at Matimba: dry cooling breakthrough

an eventual investment of about R18bn, are currently under construction or on order. Together, they will increase Escom's capacity by about 18 000 MW — a 64% increase on present capacity.

The slowdown of future expansion plans has, in turn, made it possible to reduce future borrowings. These peaked in 1987 and will progressively decline in the years ahead. In any event, they have been subject to constraints because of the debt standstill imposed in 1985. Foreign loans are no longer available as they once were, except to a limited extent in export credits.

This means greater dependence on the domestic capital market for funding, and also greater dependence on internal financing (by way of electricity tariffs). Despite the latter, however, severe cost-cutting has enabled Escom to commit itself to rate increases of only 12% last year and 10% this year — well below the rate of inflation.

The increased amount of spare capacity in the system, while not welcome, has allowed Escom to operate more efficiently — running the newer stations at near full capacity while reducing operations at the older, less efficient stations. This, in turn, has reduced coal consumption per unit of electricity sent out and eliminated winter power reductions and interruptions due to overloading.

Despite the capacity excess, Escom has launched a campaign to promote more efficient and cost-effective uses of electricity. Its former orientation towards supply-side management (focusing solely on the efficiency of supply) has now been complemented by demand-side management.

This is being done in recognition of two needs. Firstly, to ensure that customers feel Escom has their interests at heart; and secondly, to reduce future capital requirements.

The belief is that more efficient use of power could lower the long-term demand growth rate by half a percentage point without negatively affecting the economy. This could save hundreds of millions of rands. This saving, it is hoped, will be accomplished by such measures as ironing out peaks and valleys in demand by means of variable tariffs, educating consumers in the efficient use of electricity, encouraging the construction of energy-efficient buildings, and encouraging manufacturers to produce more energy-effective domestic appliances.

SA still has low electricity prices — lower than Canada, despite its abundant cheap hydro-power, and about half the price in Britain. But the price rose faster than in most other western countries last year, and this has created a perception of high prices.

Technically, the corporation is a world leader in coal-fired power station operation and design. The 4 000 MW Matimba power station, now nearing completion, will be the world's largest direct dry-cooled station, while Kendal (4 100 MW), also under construction, will be the world's largest indirect dry-cooled station. Although dry-cooled stations are thermally less efficient than evaporation-cooled stations, the shortage of water in certain areas of the country makes it necessary to take this option.

Another technical advance has been in the use of low-grade coal. The 3 700 MW Lethabo station, with three of its eventual six generating sets already in operation, is burning the lowest grade bituminous coal ever used in such a large power station. It is capable of using coal with an energy content as low as 16 MJ/kg, and has a reactivity of combustion 30% lower than the norm for low-grade coal in Europe or the United States.

Coal-fired stations account for 86% of Escom's installed capacity, nuclear for under 7%, pumped-storage for 3,6%, hydro-electric for less than 2%, and [illegible] for 1,4%. Although nuclear capacity will be increased during the next century, the scope for increasing other types is limited and coal will remain the dominant fuel for decades.

REGIONAL DREAMS

Despite the obvious political obstacles, the dream of a southern African power network stretching as far north as Zambia is a potent one for Escom executives.

"Although the political portents do not look that favourable, we believe the fundamental advantages of such a network are so attractive for southern Africa that it should be pursued," says chief executive Ian McRae. "The political problems are greater than ever. But there is an interdependence in the region which cannot be gainsaid."

A southern African grid would allow other nations to export some of the abundant power potential within their borders to SA, and thus develop the resources for the benefit of the region as a whole. In most cases, these countries do not have the internal demand to justify the huge capital cost of such schemes.

The Cahora Bassa scheme was designed to achieve this objective, though political turbulence within Mozambique has prevented it achieving its potential. But Escom has not lost hope that the Cahora Bassa scheme will become a productive part of its grid as originally envisioned.

The corporation has working arrangements with six of the nations of the region already, and is hoping to extend that to another two or three of the Southern African Development Coordination Committee countries.

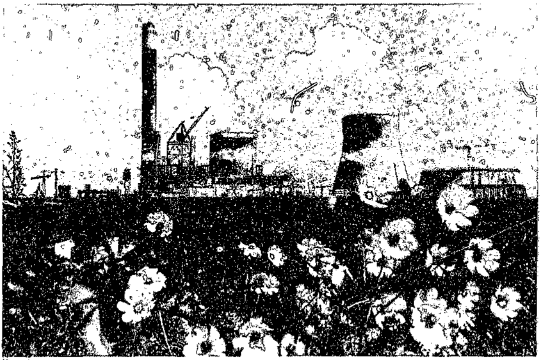
"We are already cooperating extensively with other nations in the region," says McRae. "We have had a get-together with them, and have talked about sharing our knowledge and capabilities, and have identified some opportunities and common problems. We will be starting to move into the area of strategic planning, and ultimately the interconnection of power distribution systems."

Databank

FACTS AND FIGURES ON ENERGY-RELATED TOPICS

NUMBER DB/GP/6 JULY 1986

ESCOM'S POWER STATION PROJECTS



Kendal

FORECASTING THE NEED

Escom's objective is to supply reliable and cost-effective supplies of electricity when and where it is required, subject to the resources available and the national intero·t. In order to accomplish this, Escom must forecast the country's need for electricity up to twenty years ahead of time so that it can pl·n and construct the power stations required to generate this powe·. It takes nearly nine years to complete construction of the first turbo-generator set of a power station and a further five years before an entire 3 600 MW coal-fired station is in operation.

ESCOM THE POWER BEHIND TOMORROW

Databank is an information service provided by Escom's Communication Department, P.O. Box 1091, Johannesburg 2000. Tel (011) 800-3487

Escom presently has six power station construction projects at different stages of development. Of the five 3 600 MW coal-fired power stations, three, Kendal [1], Matimba [2] and Majuba are dry-cooled, [3] Kendal by the indirect and Matimba and Majuba by the direct dry-cooling technique. The sixth project, Palmiet, [4] is a pumped storage scheme [5] which Escom is developing in cooperation with the Department of Water Affairs.

PALMIET

Palmiet is the second pumped storage scheme Escom has undertaken in conjunction with the Department of Water Affairs. The first, the 1 000 MW Drakensberg scheme, was completed in 1982. Palmiet's first unit will be taken into commercial operation in November 1987 and the second in March 1988 to generate a total of 400 MW. Power generated here will be fed into the national transmission network at the Bacchus substation near Worcester.

TUTUKA

Tutuka's [6] first set was put into commercial operation in May 1985 and its final set is due to be commissioned in June 1990. Situated near Standerton in the eastern Transvaal, it will be the first power station to feed energy into Escom's new 765 kV extra-high-voltage system which will be erected over the next ten years. Tutuka uses a dry ashing technique which will save approximately 2 million litres of water per day when all six of its sets are operative.

LETHABO

Lethabo[7] is located in the northern Orange Free State about 8 km south of Vereeniging. Its proximity to the heart of the Vaal Triangle enables Lethabo to feed energy into Escom's local 275 kV transmission network. The first set came into operation in December 1985 and the last is scheduled for completion in December 1990.

Special techniques of piling had to be developed in the construction of the power station to overcome the problems caused by the expansive characteristics of the "heaving soils" prevalent in this area. The coal used at Lethabo has a particularly high ash content (28-42%) and this has necessitated the development of a special type of boiler to burn the poor quality coal. Both Escom and the contractor were involved in the design of the boiler.

DRY-COOLING AND MATIMBA

With the construction of Kendal, Matimba and Majuba, Escom is pioneering development in the field of dry-cooling technology. Matimba will be the first direct dry-cooled power station in the world and until Majuba is completed, also the largest. The first set is due to be taken into commercial operation in February 1987 and the last in September 1991. The choice of dry-cooled technology for Matimba was heavily influenced by the shortage of water in the area. Dry-cooled systems consume approximately 0,5 to 0,8 litres/kW.h compared to the 2,5 litres/kW.h required by wet-cooled systems. Matimba has no cooling towers since all cooling is performed by forced draught fans. Power generated at Matimba will be transformed to 400 kV for distribution via the national grid.

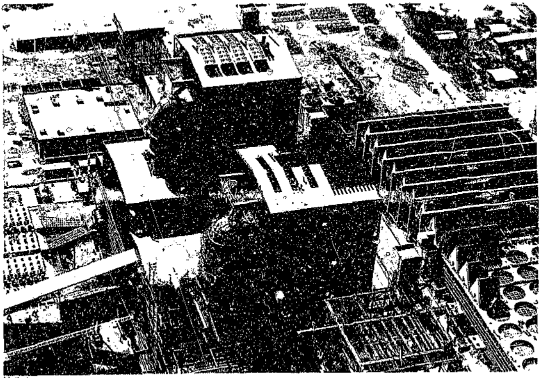
1 See Technical brochure/Kendal/985
2 See Technical brochure/Matimba/985
3 See What is dry-cooling and how does it work? DB/E2/1
4 See Technical brochure/Palmiet/985
5 See Pumped storage and water transfer DB/E2/8
6 See Technical brochure/Tutuka/985
7 See Technical brochure/Lethabo/1185

ESCOM **THE POWER BEHIND TOMORROW**

KENDAL

Kendal power station uses the indirect dry-cooling method. Construction began in 1982 and the first set will be completed in June 1988. The last set will go into commercial operation in September 1994. The power station's output will be fed into the national grid at 400 kV. Kendal's cooling towers at a height of 165 m and base diameter of 165 m are the largest in the world. To support this structure, special "X"-shaped cross columns were used in its construction for which the contractor had to develop special construction techniques.

Majuba's first set will be completed only in September 1991 and the last in 1996. These dates reflect the unfavourable economic climate and consequent decrease in estimated demand for electricity which caused Escom to defer the construction of Majuba's sets.



Matimba

References
Keywords: power station
Author. Communication Department/HV
Source: Databank 1225H
Reference No. DB/GP/8
Date: July 1986
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Verwysingsno.: DB/AP/8

ESCOM'S POWER STATION PROJECTS

Station (location)	Majuba (Volksrust)	Kendal (Witbank)	Matimba (Ellisras)	Lethabo (Vereeniging)	Tutuka (Standerton)	Palmiet (Grabouw)
Installed capacity	—	—	—	1 x 618	2 x 609	—
Total installed MW	3942	4116	3990	3708	3654	400
Total sent-out MW	3690	3780	3690	3558	3510	400
Completion date	September 1996	September 1994	September 1991	December 1990	September 1989	March 1988
Main Contractors	Boilers Steinmüller Turbine-generators GEC Turbine Generators Direct dry cooling GEA Air-cooled systems Contracts for other plant such as coal-handling, ash-handling, water-treatment, auxiliary civil engineering and building works, precipitators, electrical power and control instrumentation will be awarded during the latter part of 1987 and early 1988.	Boilers Combustion Engineering International Turbo-generators Kraftwerk Union AG Main civil works Gilis-Mason Construction Chimneys Karrena Africa Generator transformers ASEA Electric SA Cabling (construction) Industrial Electrical Cabling (permanent) Kilpatrick Terrace earthworks Gilis-Mason Construction Main instrumentation Brown Boveri SA Coal-handling stockyard PHB Weserhütte Terrace Not yet awarded Water treatment plant Aquazur Reunert Indirect dry cooling D B Thermal Sewage plant (mechanical) Prentec Station services building LTA Civil Engineering (North) CW pumps Sulzer Bros Condensers Kraftwerk Union AG Tube mills Kennedy von Saun Corporation Low pressure services Tilaco Contracting Raw water reservoir Gilis-Mason Construction Coal stockyard civil works Gilis-Mason Construction	Earthworks LTA Construction Civil engineering CONCOR Industrial Steelwork (subcontractor) GENREC Boilers SIEVA Turbine-generators MAN (Germany)/ Alsthom (France) Generator-transformers ASEA Electric Chimney 1 and 2 CONCOR Construction Main station cabling Industrial Electrical Unit control and instrumentation Siemens Fire protection system CIW Coal handling on terrace LTA MITEC Coal stockyard conveyor Bateman Engineering Ash conveyor system Babcock Moxey Dust conditioning plant Babcock Claudius Auxiliary cooling system Hanson Sobelco Sewage plant Aquazur Reunert Electrostatic precipitators Simon Carves Africa Water treatment plant Simon Carves Africa Direct dry-cooling system GEA Air-cooled systems	Earthworks Murray & Roberts Roads & raw water reservoir Peter Faber Civil engineering Gilis-Mason Construction Piling Frankipile South Africa Steelwork Dorbyl Structural Engineering Boilers Babcock Engineering Precipitators Brandt Contracting Turbine-generators IMS/MAN/Alsthom Generator-transformers ASEA Electric Cooling towers D B Thermal Circulating water pumps APE Africa Chimneys Tilegrin Joint Venture Buildings Gilis-Mason Construction Cabling and switchgear Siemens Instrumentation and control Siemens AG Siemens Process computers Siemens AG Siemens Low-pressure services Group Five Projects Fire control system Group Five Projects Coal conveyors Babcock Moxey Fly ash conditioners Babcock Claudius Peters Ash Conveyors Mechanplan Coal stockyard conveyors Babcock Moxey Stockyard stacker-reclaimers Strachan & Henshaw Ash dump machinery Koch Water treatment plant Foster Wheeler Energy Coal and ash civil works LTA Construction	Earthworks Gilis-Mason Civil Engineering Airfield and roads Fowler Construction Civil engineering CMGM Natal Coastal Steelwork Dorbyl Structural Engineering Boilers L&C Steinmüller (Africa) Precipitators Lurgi Turbines GEC Turbine Generators Generator-transformers ASEA Electric Cooling towers GEA Aircooled Systems Cooling water pumps Sulzer Bros Chimneys Karrena Africa Buildings (administration, workshops, stores) Wilson-Holmes Cabling and switchgear Hubert Davies Construction Instrumentation and control Siemens Process computers Siemens Low-pressure services Tilaco Projects Fire control system Mather & Platt Coal and ash conveyors Bateman Engineering Coal stockyard conveyors and equipment Coalequip Stockyard stacker-reclaimers Strachan & Henshaw Rail link to stockyard civils Peter Bayly Construction Ash dump machinery PWH Weserhütte Water treatment plant Foster Wheeler Energy Coal silos & civil works CMGM Glyboton & Montaslobou	Exploratory excavation Department of Water Affairs Preliminary civil work Savage & Lovemore Main civil work Palmiet Civil Contractors Rockview and Kogelberg Dams Department of Water Affairs **Mechanical engineering** Pump-turbines, governors and spherical valves JM Voith GmbH West Germany Penstock steel linings Sorefame Africa Gates and screens John Thompson Africa Machine hall crane Mannesmann Demag Low-pressure service pipework To be awarded **Electrical engineering** Generator-motors Fuji Electric Co. Japan Transformers ASEA Electric Load switches and reversing isolators Brown Boveri Control room equipment To be awarded **Major Consultants** Civil Consulting Engineers SVE (consortium of companies consisting of Ninham Shand, van Niekerk, Klein & Edwards, Electrowatt.) Environmental Consultants Ecokonsult Incorporated

ESCOM THE POWER BEHIND TOMORROW

ESCOM IN BRIEF '86

HIGHLIGHTS FROM THE
1986 ANNUAL REPORT

An excellent organisation maintains superior performance reflected in sound management, tight financial control, constant innovation and exceptional customer service. Escom is committed to meeting this challenge.

ESCOM EVKOM

Copies of the 1986 Annual Report, as well as Escom's Statistical Yearbook, may be obtained from the Communication Manager, Escom, PO Box 1091, Johannesburg 2000. These publications are also available in Afrikaans.

PROFILE OF ESCOM

Escom is the national electricity utility of South Africa. It ranks among the largest and technically most advanced utilities in the world. It has an installed capacity of more than 28 000 MW, operates 27 power stations and uses more than 172 000 km of high-voltage transmission lines.

It supplies more than 90% of the electricity used in South Africa and this represents nearly 60% of the electricity generated on the African continent. It serves the whole of South Africa and exports electricity to Bophuthatswana, Botswana, Ciskei, Lesotho, Mozambique, SWA/Namibia, Swaziland, Transkei, Venda and Zimbabwe.

Escom was established in 1923 as the Electricity Supply Commission. In 1985, the Electricity Amendment Act replaced the Commission with a body corporate known as Escom, which has a control and management structure consisting of the Electricity Council and the Management Board.

Electricity Council and Management Board

The Electricity Council is a non-executive body. Its members, appointed by the Minister of Economic Affairs and Technology, are drawn from organisations representing major electricity consumers and key Government and State departments. Members are appointed for their specialist knowledge and skills. The Council is responsible for policy, setting of objectives, planning and control. It also appoints the Management Board.

The Management Board, which is composed of the Senior General Manager (chairman), the Assistant Senior General Manager and seven general managers, is the executive body responsible for the day-to-day running of Escom, subject to the directives of the Electricity Council.

Mission

Escom's mission is to satisfy the electricity needs of customers in the most cost-effective way, subject to resource constraints and the national interest.

Strategy

The strategy adopted by the organisation is to develop Escom as a business that maximises the value of its products and services for the benefit of South Africa.

Escom's structure is based on a high degree of decentralisation and customer orientation.

The organisation is divided into six functional groups, each headed by a general manager. There are two main line functions, Generation and Distribution. These are supported by a further line function, Engineering, and three head-office service functions – Finance and Data Processing, Human Resources and Services. The General Manager (Generation) is assisted by a second general manager who is in charge of Operations.

Philosophy

Escom strives to provide customers with electricity and services of the greatest possible value, measured in terms of quality and price. It maintains good relations with customers through constant liaison and evaluation of their requirements, as well as the quality of service they receive.

The interdependence of Escom with its suppliers of goods, services and finance is recognised, and a healthy, long-term business relationship with them is pursued.

Escom is an equal-opportunity employer where remuneration and advancement are based on performance and market considerations, regardless of race, creed or sex. Employees are provided with an environment in which they can develop their full potential through education, training, work experience, problem solving and innovation.

Accounting policy

Escom uses a fund accounting convention at present. However, pending an amendment to the Electricity Act expected during 1987, it will in future report on its financial activities and position in conventional business accounting terms.

Under the fund accounting convention, there is no share capital. Capital expenditure is financed from borrowings and own funds, as prescribed by the Electricity Act. Fixed assets are not depreciated but, instead, the debt used to finance them is amortised.

Borrowings are obtained by raising loans and issuing bonds in local and overseas capital markets, through local money-market operations and through trade finance arranged in conjunction

PROFILE OF ESCOM

continued

with suppliers of capital equipment. Internally generated funds, obtained from tariff income as prescribed by the Electricity Act, is the other source of finance available to Escom.

There are at present three internal funds: the Capital Development Fund, the Reserve Fund and the Redemption Fund.

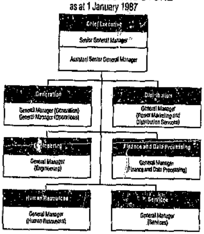
The Capital Development Fund finances capital expansion and the replacement of assets taken out of service. The Reserve Fund is for upgrading plant, exceptional repairs or emergencies. It is also used, to a limited extent, for self-insurance, thereby reducing expenditure on insurance premiums. The Redemption Fund provides for the redemption of local loans on a sinking-fund basis.

There is a secondary market in Escom's locally registered stock, which is actively traded on the Johannesburg Stock Exchange and by Escom itself. Escom is able to buy and sell such stock on behalf of its various Funds and, although a buyer of last resort, aims to be a net seller of its own stock. Proceeds from sales are reinvested by Escom, on behalf of its Funds, in new Escom stock issues.

Under the proposed system the practice of investing internal funds in Escom's own loan stock issues and the associated accounting mechanism for raising internal interest charges is to be abolished. Fixed assets in commercial operation will be depreciated. Costs, including depreciation charges, transfers which may been made to accumulated reserves and any appropriations which have been made from past accumulations, will be reported.

ORGANISATION STRUCTURE

as at 1 January 1987



ESCOM AT A GLANCE

	1986	Change 1985–86 %	Average yearly increase 1981–86 %
Financial			
Revenue (R million)	5 845	26,4	22,2
Charges against revenue (R million)	5 645	23,1	20,5
Net expenditure on fixed assets (R million)	3 770	–20,7	14,1
Fixed assets at 31 December (R million)	27 633	15,3	22,2
Average price per kW.h sold (cents)	4,98	20,0	16,9
Average cost per kW.h sold (cents)	4,81	17,9	15,3
Average coal cost per ton (Rand)	14,87	12,2	8,9
Electricity sold by Escom (mill. kW.h)	117 353	4,5	4,6
Operating statistics			
Total electricity sent out by Escom (mill. kW.h)	126 766	3,5	4,8
Electricity available for distribution (mill. kW.h)	123 748	3,8	4,4
Coal burnt in Escom power stations (Mt)	58,9	–1,0	1,8
Water consumed in Escom power stations (Mℓ)	262 372	–4,8	2,2
Peak demand on integrated Escom system (MW)	18 278 (20/6/86)	2,4	4,5
Escom plant in service at 31 December			
Installed capacity (MW)	28 086	9,2	7,0
Assigned sent-out rating (MW)	26 682	9,5	7,0
Transmission lines:			
765 kV	427	—	—
533 kV (DC) (km)	1 030	—	—
400–220 kV (km)	18 012	3,0	3,7
165 kV and below (km)	163 103	7,4	7,8
Staff employed at 31 December	60 800	–7,9	3,1

R1,00 = US$ 0,4570 on 31 December 1986

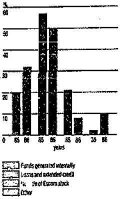
SUMMARISED BALANCE SHEET
as at 31 December 1986

(All figures in Rand millions)	1986	1985
Fixed assets	27 633	23 969
Non-current assets	6 339	5 749
Current assets	1 692	1 427
	35 664	31 145
Financed by		
Loans and extended credit	19 348	18 153
Current liabilities	3 302	2 321
Total net debt	22 650	20 474
Statutory funds	9 373	7 948
Reserves	3 641	2 723
	35 664	31 145

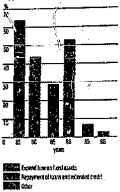
SUMMARISED INCOME STATEMENT
for the year ended 31 December 1986

(All figures in Rand millions)	1986	1985
Electricity sold	5 845	4 625
Operating expenditure	2 465	2 144
Operating income	3 380	2 481
Loan charges	3 060	2 303
Contribution to Reserve Fund	120	150
Net income	200	28
Accumulated deficit at beginning of the year	(487)	(420)
	(287)	(392)
Prior year adjustment	—	(95)
Accumulated deficit at end of the year	(287)	(487)

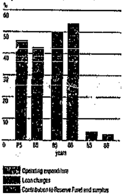
Source of funds



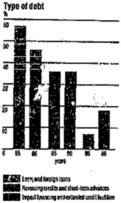
Application of funds



Expenditure as a % of costs



Type of debt

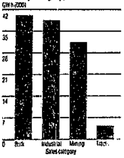


STATEMENT OF SOURCE & APPLICATION OF FUNDS

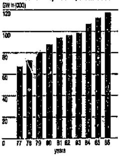
for the year ended 31 December 1986

(All figures in Rand millions)	1986	1985
Source of Funds		
Funds generated internally	2 782	1 437
Proceeds of external finance	5 841	5 763
Increase in net current liabilities	716	256
Deferred expenditure	113	(150)
Other	21	14
Total Source of Funds	8 673	7 400
Application of Funds		
Repayment of loans and extended credit	4 626	2 177
Fixed assets, net	3 778	4 757
Expenditure to secure future fuel supplies	169	357
Increase in housing loans to employees	50	56
Reserve Fund expenditure	49	53
Total application of funds	8 673	7 400

Sales by category, 1986



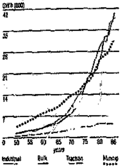
Total electricity sales, from 1977



Printed by The Standard Press

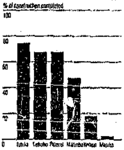
Sales growth by category, from 1950

GWh (000)



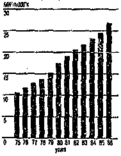
Power stations under construction

% of construction completed



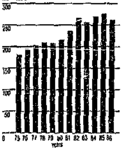
Sent-out capacity

MW in 000's



Water consumption

ML in 000's



ESCOM IN BRIEF '86

HIGHLIGHTS FROM THE
1986 ANNUAL REPORT

An excellent organisation maintains superior performance reflected in sound management, tight financial control, constant innovation and exceptional customer service. Escom is committed to meeting this challenge.

ESCOM EVKOM

Copies of the 1986 Annual Report, as well as Escom's Statistical Yearbook, may be obtained from the Communication Manager, Escom, PO Box 1091, Johannesburg 2000. These publications are also available in Afrikaans.