WCB ENGINEERING BULLETIN

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The Institution of Certificated Mechanical and Electrical Engineers South Africa
Western Cape Branch (WCB)

JUNE 2022

MISSION STATEMENT: 1. To uphold the image and status of the Certificated Engineer. 2. To represent the Certificated Engineer at ECSA and other decision-making bodies concerning legislation, safety & health standards, the environment and the machinery regulations. 3. To promote continued education and training of its members and future engineers. 4. To promote fellowship in the engineering profession.

EDITORIAL

Welcome to the latest edition of the ICMEESA News Bulletin

So, South Africa finds itself undergoing extensive Loadshedding once again! This exacerbated by unlawful industrial action at ESKOM.

We have been speaking about lack of proper maintenance at the ESKOM coal fired power stations for a few years now. What has happened? Why is it that critical maintenance has not been caried out?
Then, to crown it all, some clever dick commits the act of sabotage!

What next? Never mind the inconvenience caused to members of the public. What is happening in our factories, mines and industrial areas? For those companies who do not have the means to purchase standby electricity by installing generator sets, it is a catastrophe.

Then of course we get to small businesses. How are they managing to survive?
I look after a small company who has a 12kVA generator set. While it keeps their essential services going, it also adds cost to the bottom line due to the extra diesel consumption (at ever increasing prices).

I am sure that all of our members and associates must be pulling their hair out!!

Anyway, on a lighter note – we present our quarterly news Bulletin as per norm.

Membership Fees:
I would like to thank all members who have paid their fees for 2022 thus far this year.
However, a number of payments have been received which do not have clear information on who has made the payment! – **while the invoice clearly states to please use the invoice number as a reference**!
This is not a good state of affairs as such a payment cannot be credited to whoever made the payment. So, **PLEASE** let us know should you be aware of your company making a payment and you suspect an incorrect reference has been used. THANK YOU!

We will be following up with members in the next month or two who have not as yet made the necessary payment.

In this Bulletin, we have the normal Questions and Answers for Factories and Mining GCC examinations. I also include a link to a copy of the Energize Magazine. If you want to subscribe to the magazine, follow links within the magazine. *energize*

The ECSA have re-introduced the E-Bulletin. To read the Bulletin – click the link below.
ECSA

Thank you to one of our members, Mr. John Davidson, for providing me with an article on the Steenbras Hydro Power Station in the Cape Town Metro. This article will be placed in two parts due to it's length.

Finally, we have held our Annual General Meeting on 28 June 2022 on a virtual platform. I would like to congratulate Mr. Micheil (Sias) Borman on his election as the Institution's Chairperson (President) for 2022/23. A report on the AGM is included in the Bulletin.

All members to kindly note that should they have a family member who is studying Electrical or Mechanical Engineering at a University or Technikon and has completed a first year successfully - ICMEESA has a single bursary available for 2023. Any interested person should forward an email to **info@icmeessa.org.za** with details of what they are busy studying.

Any contributions to future editions of this Bulletin from members would be welcome.

I trust that you will find the content of this news bulletin interesting enough to pass on to your colleagues and friends.

Chris Schnehage
chris@icmeewc.co.za

Dear members
It gives me great pleasure in reporting on the Institution's AGM held on 28 June 2022.

There were 26 members and guests present on the evening.

As AGMs go, this one was no different except for the fact that it was carried out on a virtual platform. Nothing like the real person to person meeting held in the past. Maybe with the COVID19 being mostly a thing of the past, we could do a combined event next AGM, so that members who cannot travel could also attend. (A challenge for next year!) From that aspect – the virtual platform is useful.

The Chairperson for 2021, Mr. Bernard Bryers presented his yearend report and then noted the Annual Report which will be put on the website. Note that all 2022 AGM matters will be on the Website under the ABOUT US/Corporate Governance tab.

Mr. Bryers then handed over the reins to Mr. Sias Borman. Sias was Senior Vice Chairman. Congratulations to Sias on accepting the challenge.

Sias Borman

The Board of Directors for 2022/2023 were confirmed as follows:

SURNAME	NAME	
Borman	Michiel Josias	Chairperson
Bosaletsi	Letuma Elia	
Bryers	Bernard	Immediate Past President/Chairperson
Buchanan	Ian David	
Clack	Gregory Lionel	
Clark	Brian Andrew	
Kloppers	Sarel Johannes	
Lambert	Henry Daniel	
Letsholo	Obed Nkweni	
Schnehage	Christopher William	
Singo	Edward	

After the official procedures were over, our guest speaker, Mr. Clive Rutter (President of ICMEESA 1983/4), presented a most interesting talk on "Maintenance Free Batteries – or are they?"
A copy of his presentation is on the website.

Note that Persons who attended the AGM meeting will be able to claim 0.2 CPD point for attendance. The event number will be circulated to the attendees.

CWS

Plant Engineering: MINES mechanical question (June 2010 – Question 4)

QUESTION

A clear-water centrifugal pump installation in a gold plant has a negligible suction head. The pump delivers 220 m^3/h through a delivery pipe that is 30 m long, 156 mm in diameter and has a vertical lift of 26 m. The friction factor for the pipe, is 0,01.

Approximately midway along the length of the delivery pipe, a short pipe branches out from the delivery pipe. The branch pipe which is closed by means of a valve is at an elevation of 12 m above the centrifugal pump.

The valve is opened to a position where the discharge at the end of the delivery pipe is reduced to 135 m^3/h and 100 m^3/h of water flow through the branch pipe. At flow rates of 220 m^3/h and 235 m^3/h the pump efficiency is 78% and 77% respectively.

Determine the following:

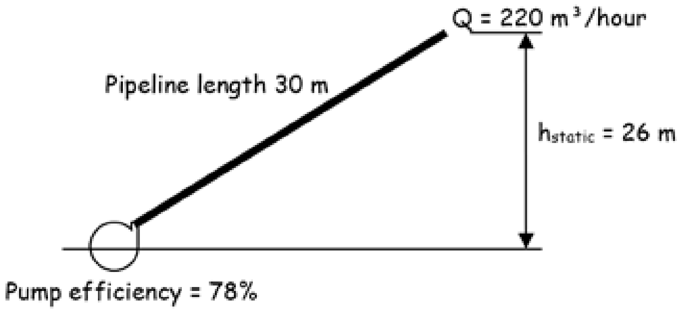
4.1 The power required to drive the pump while the valve in the branch pipe is fully closed (10)

4.2 The power required to drive the pump while the discharge from the branch pipe is 100 m^3/h. Assume that the loss in the branch pipe is negligible. (10)

[20]

Proposed Solution:

4.1 The power required to drive the pump while the valve in the branch pipe is fully closed



$$hf = \frac{4fLv^2}{2gd} = \frac{4fL(Q/A)^2}{2gd} = \frac{4fL[Q/(\pi d^2/4)]^2}{2gd}$$

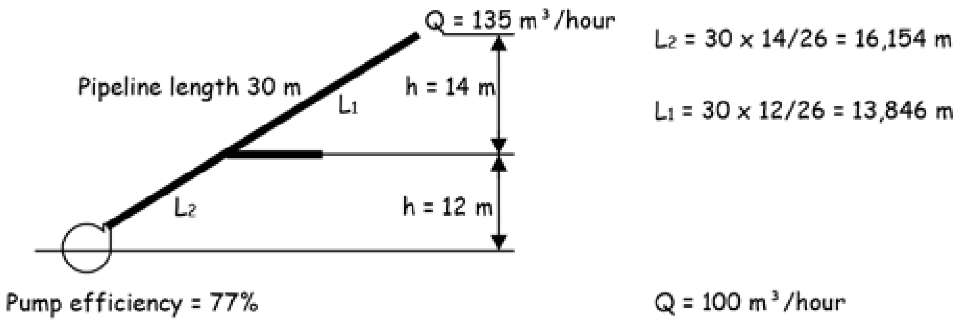
$$= \frac{4 \times 0{,}01 \times 30 \times [220/60^2\ (\pi \times 0{,}156^2/4]^2}{2 \times 9{,}81 \times 0{,}156} = 4{,}0079274 \text{ m}$$

H_{total} = hstatic + hf = 26 + 4,0079274 = 30,008 m

$$\text{Power input to pump} = \frac{\rho g H_{total} \times Q}{\text{Pump eff.}} = \frac{1 \times 9{,}81 \times 30{,}008 \times (220/60^2)}{0{,}78}$$

= **23,064 kW**

4.2 The power required to drive the pump while the discharge from the branch pipe is 100 m³/h. Assume that the loss in the branch pipe is negligible.



$$\text{Friction head through first portion of pipe } hf_1 = \frac{4fLv^2}{2gd}$$

$$hf_1 = \frac{4 \times 0{,}01 \times 16{,}154 \times [135/60^2(\ \pi \times 0{,}156^2/4)]^2}{2 \times 9{,}81 \times 0{,}156} = 0{,}82473 \text{ m}$$

$$\text{Friction head through second portion of pipe } hf_2 = \frac{4fLv^2}{2gd}$$

$$hf_2 = \frac{4 \times 0{,}01 \times 13{,}846 \times [235/60^2(\ \pi \times 0{,}156^2/4)]^2}{2 \times 9{,}81 \times 0{,}156} = 2{,}110636 \text{ m}$$

$$P_{total} = P_1 + P_2 = \frac{\rho g H_{total} \times Q_1}{\text{Pump eff.}} + \frac{\rho g H_{total} \times Q_1}{\text{Pump eff.}} = \underline{1 \times 9{,}81 \times 30{,}008 \times (220/60^2)}$$

$$= \frac{1 \times 9{,}81 \times (14 + 0{,}812645) \times (135/60^2)}{0{,}77} + \frac{1 \times 9{,}81 \times (12 + 2{,}11063) \times (235/60^2)}{0{,}77}$$

$$= 7{,}0768 + 11{,}7352 = \mathbf{18{,}8121\ kW}$$

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A Legal Knowledge: MINES question

QUESTION (November 2021, Question 1):

You are the employer of a gold mine. The Mine Health and Safety Act requires you to staff the mine in such a way that you consider the health and safety of the employees. What must you do in terms of Section 7 of the Mine Health and Safety Act? [10]

Proposed answer

7. Employer to staff mine with due regard to health and safety (1) As far as reasonably practicable, every employer must-

   (a) ensure that every employee **complies with the requirements of this Act**;

   (b) institute the **measures necessary to secure, maintain and enhance health and safety;**

   (c) provide persons appointed under subsections (2) and (4) with the **means to comply with the requirements of this Act and with any instruction given by an inspector;**

   (d) **consider an employee's training and capabilities in respect of health and safety before assigning a task to that employee;** and

   (e) ensure that **work is performed under the general supervision of a person trained to understand the hazards associated with the work and who has the authority to ensure that the precautionary measures laid down by the employer are implemented.**

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Plant Engineering: FACTORIES electrical question (June 2017 – Question6)

QUESTION:

6.1 A three phase, 6 600 V feeder, supplies power exclusively to a pump station consisting of a number of pumps and motor units. When all the original pump and motor units operate simultaneously, the feeder carries a load of 1 000 kVA at a power factor of 0,8 lagging.

An additional 600 kVA synchronous motor is installed in the pump station to drive an extra pump. When run unloaded, this motor absorbs 60 kW. The pump to be powered by the synchronous motor requires 270 kW to drive it. When delivering 270 kW, the motor is 90% efficient.

Calculate, when all the original pumps are in operation and the synchronous motor is driving its pump, the

6.1.1 line current in the feeder; and (10)

6.1.2 power factor of the feeder at the pump station. (1)

6.2 Determine, when all the original pumps are in operation and the synchronous motor is uncoupled from its pump and run unloaded, the

6.2.1 line current in the feeder; and (8)

6.2.2 power factor of the feeder at the pump station. (1)

Suggested Answer:

The key to this solution lies in the fact that the synchronous motor acts as synchronous condenser and improves the power factor, thus effecting a change in the line current.

Considering the original condition with

Apparent Power, $S = \sqrt{3}.V.I \quad \therefore I_L = \dfrac{S}{\sqrt{3}\ V} = \dfrac{1000 \times 10^3}{\sqrt{3} \times 6600} = 87.5\ A$

This current lags the phase voltage by $\cos \varnothing = 0.8 \quad \therefore \varnothing_1 = 35.87°$

Input to synchronous motor $= \dfrac{\text{output}}{\eta} = \dfrac{270}{0.9} = 300\ kW$

The power factor of the synchronous machine is $= \dfrac{300}{600} = 0.5$ *leading*

From power factor $= \cos \varnothing = 0.5 \quad \therefore \varnothing_2 = 60°$ *leading*

The motor current $I_{m1} = \dfrac{S}{\sqrt{3}\ V} = \dfrac{600 \times 10^3}{\sqrt{3} \times 6600} = 52.5\ A$

Total reactive current, $I_{r1} = I_L \sin \varnothing_1 - I_{m1} \sin \varnothing_2 = 87.5 \sin (36.87°) - 52.5 \sin (60°)$

$= 7\ A$ *lagging*

Total active current, $I_{a1} = I_L \cos \varnothing_1 + I_{m1} \cos \varnothing_2 = 87.5 \cos (36.87°) - 52.5 \cos (60°)$

$= 96.25\ A$ *in phase with voltage*

A6.1.1 Total line current, $I_L = \sqrt{I_{R1}^2 + I_{a1}^2}$

$= \sqrt{96.25^2 + 7^2}$

$= \mathbf{96.5\ A}$

A6.1.2 New power factor, $pF_1 = \dfrac{I_{a1}}{I_L} = \dfrac{96.25}{96.5}$

$=$ ***0.9974, say 1 (unity)***

Unloaded power consumption is given as 60 kW and from power factor $= \frac{p}{s}$

therefore pF of unloaded motor $= \frac{60}{600}$

$= 0.1$ representing a leading angle of $\cos^{-1} 0.1 = 84.26°$

The motor current $I_{m1} = \frac{S}{\sqrt{3}\,V} = \frac{600 \times 10^3}{\sqrt{3} \times 6600} = 52.5$ A (as before but now at 84.26°)

Total reactive current, $I_{r2} = I_L \sin Ø_1 - I_{m1} \sin Ø_3$

$= 87.5 \sin(36.87°) - 52.5 \sin(84.26°)$

$= 0.26$ *A lagging*

Total active current, $I_{a2} = I_L \cos Ø_1 + I_{m1} \cos Ø_3$

$= 87.5 \cos(36.87°) - 52.5 \cos(60°)$

$= 75.25$ *A in phase with voltage*

A6.2.1 Total line current, $I_{L2} = \sqrt{I_{R2}^2 + I_{a2}^2}$

$= \sqrt{75.25^2 + 0.26^2}$

$= \mathbf{75.5\ A}$

A6.2.2 New power factor, $pF_2 = \frac{I_{a1}}{I_L}$

$= \frac{75.25}{75.5}$

$= 0.9967$, ***say* 1 *(unity)***

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A Legal Knowledge: FACTORIES question (November 2021 - Question 1)

1.1 Define the following terms given in the Occupational Health and Safety Act:

1.1.1 Major incident (1)
1.1.2 Listed work (1)
1.1.3 Organism (1)
1.1.4 Regulation (1)

1.2 The chief inspector has in writing directed you, as an employer, to prepare a written policy concerning the protection of the health and safety of your employees at work, including a description of your organization and the arrangements for carrying out and reviewing that policy. The chief inspector also published guidelines concerning the contents of the policy.

What are the guidelines published by the chief inspector? (1)

1.3 The Minister has by notice in the Gazette declared certain activities at your workplace, under the conditions or circumstances specified in the notice, to be listed work. Subject to the arrangements prescribed, after consultation with the health and safety committee established for that workplace, you have to take three specific steps.

Name TWO of these steps. (2)

1.4 You manufacture refrigeration equipment and there are 140 persons employed in the factory. You also have 30 persons who do installation, maintenance and repairs on premises where the refrigeration equipment is installed. In your offices there are 29 persons employed but you also have 28 administrative employees who do sales, advertising and consulting services in the field.

1.4.1 How will you determine how many health and safety representatives you have to designate?(1)
1.4.2 How many health and safety representatives do you have to designate for the factory? (1)
1.4.3 How many health and safety representatives do you have to designate for the offices? (1)

[10]

Suggested answer:

1.1.1 "major incident" means an occurrence of catastrophic proportions, resulting from the use of plant or machinery, or from activities at a workplace
1.1.2 "listed work" means any work declared to be listed work under section II
1.1.3 "organism" means any biological entity which is capable of causing illness to persons
1.1.4 "regulation" means a regulation made under section 43

1.2
S7 OHSAS 18001: Occupational Health and Safety Management Systems – Specification
OHSAS 18002: Occupational Health and Safety Management Systems – Guidelines for the implementation of OHSAS 18001.

1.3

12 a) identify the hazards and evaluate the risks associated with such work constituting a hazard to the health of such employees, and the steps that need to be taken to comply with the provisions of this Act;
b) as far as is reasonably practicable, prevent the exposure of such employees to the hazards concerned or, where prevention is not reasonably practicable, minimize such exposure; and
c) having regard to the nature of the risks associated with such work and the level of exposure of such employees to the hazards, carry out an occupational hygiene programme and biological monitoring, and subject such employees to medical surveillance.

1.4.1 17(5) The employees performing work at a workplace other than that where they ordinarily report for duty, shall be **deemed to be working at the workplace** where they so report for duty
1.4.2 Four
1.4.2 One

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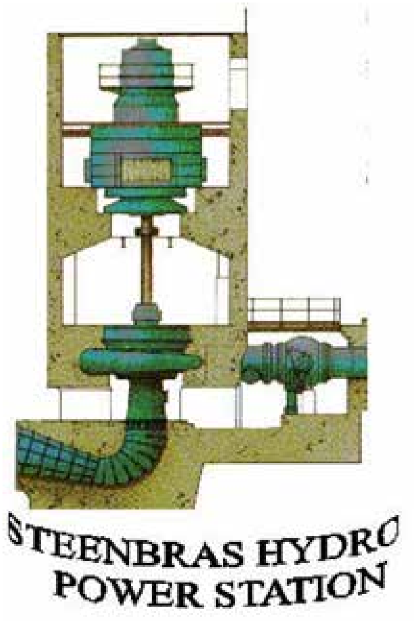
The following is **Part 1** of an article that was updated in 2002, and therefore some factors have changed since then.

The article was provided to me by Mr. John Davidson, Senior Member, ICMEESA.



2002 Edition

CITY OF CAPE TOWN: TRADING SERVICES: ELECTRICITY DIRECTORATE

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INTRODUCTION

The first hydroelectric power station in South Africa, with a capacity of 300 kilowatts, was installed in 1895 by the Cape Town City Council at Molteno reservoir in Oranjezicht situated on the lower slopes of Table Mountain. Another first for the City was Steenbras, being the first hydroeleytric pumped-storage scheme on the continent of Africa.

Apart from its economic advantages, the Steenbras pumped-storage scheme also affords an increased measure of security of supply to the City since, unlike thermal power stations, hydroelectric pumped-storage installations, can be brought into operation and up to full load within a matter of minutes.

The underlying principle of pumped-storage is now well established, the economic advantages having been first realised and exploited in the late nineteenth century. In recent years there has been a considerable upsurge of interest in pumped-storage with the result that today there are hundreds of major installations around the world. ESKOM has built two of their own considerably larger pumped-storage stations in South Africa, subsequent to the inauguration of Steenbras.

Because of the varying demand for electricity during any given day, there is a high demand during the mornings and late afternoons with a surplus of generating capacity available in the valley or low demand periods at night. In a pumped-storage scheme, surplus generating capacity is employed to utilize relatively low cost off-peak electricity to pump water from a lower to an upper storage reservoir. During periods of peak demand in the day, this same water is released back to the lower reservoir thereby generating relatively low cost electricity as in a conventional hydroelectric power station.

ELECTRICITY GENERATION IN CAPE TOWN

HISTORICAL BACKGROUND

The early history of electricity supply in Cape Town began in 1879, when Cape Town was visited by the Scientia Studiosa Company. The idea of employing electricity for lighting purposes in Cape Town was first proposed by Mr. John Gamble, the then Colonial Hydraulic Engineer, who suggested that water turbine driven generators could make use of the power in the water flowing down into the City's main service reservoir from a reservoir to be built on Table Mountain. It was not until 1895 that this idea of lighting the City by electricity was finally brought to fruition with the establishment of the Cape Town Electricity Undertaking and the inauguration of its first power station on the banks of the Molteno Reservoir.

Because of the steadily increasing demand for electricity, it was found necessary in 1898 to increase not only the generating capacity of the Molteno power station, but also to convert the Dorp Street substation into a power station by the installation of further generating plant. The third power station was built in Dock Road and was known as the Central Electric Light Works. It was commissioned in 1904 with an initial coal-fired steam generating capacity of 1 850 kW. This capacity was progressively increased over the years to its ultimate capacity of 28 000 kW by 1927.

The next phase was the construction of another coal fired power station, with an initial capacity of 120 000 kW, adjacent to the Dock Road power station. In 1952, this new power station, known as the Table Bay power station, was increased to its ultimate design limit of 200 000 kW.

After considering a number of alternative sites the City's fifth power station was constructed in Athlone and the first stage, with an initial capacity of 90 000 kW, was commissioned in 1961. The capacity of the Athlone power station was increased to its ultimate capacity of 180 000 kW in 1967. To improve the security of supply to the City's consumers and to meet short peaks and other emergencies, a 40 000 kW gas turbine plant was installed at this power station in 1973.

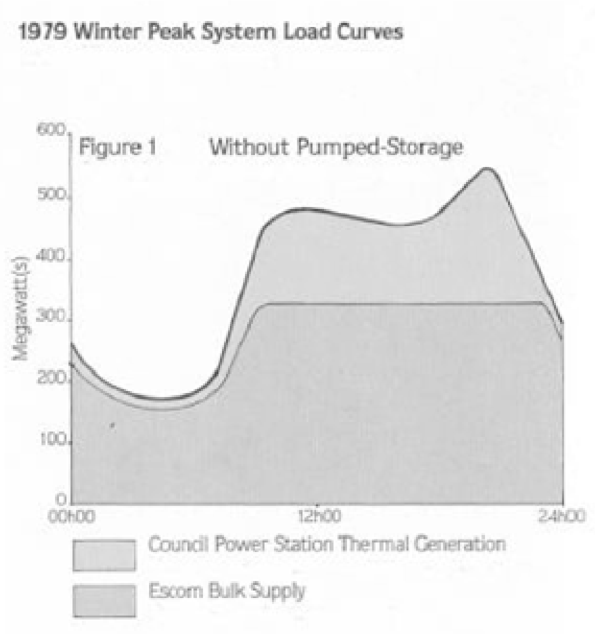

Figure 1

The original intention was to extend the capacity of the Athlone power station by building yet another coal-fired power station on an adjacent site. After detailed investigation, however, it was resolved to meet the City's future power requirements by taking a bulk supply. A long term agreement was accordingly entered into with ESKOM in 1974

INTRODUCTION OF PUMPED STORAGE

Since then, most of the electricity to the City of Cape Town licensed area of supply has come from ESKOM. Peak power was relatively expensive while its off-peak power was correspondingly cheaper. The City thus found it to be economically viable to construct a pumped-storage installation of 180 000 kW to significantly reduce its dependence for peak power from ESKOM. The City's Athlone coal fired power station's significance has reduced since 1979 (currently <90 MW capacity), but is still used today to reduce peak power requirements from the bulk supplier, this despite the adverse operating conditions such peaking duty imposes on such old thermal plant.

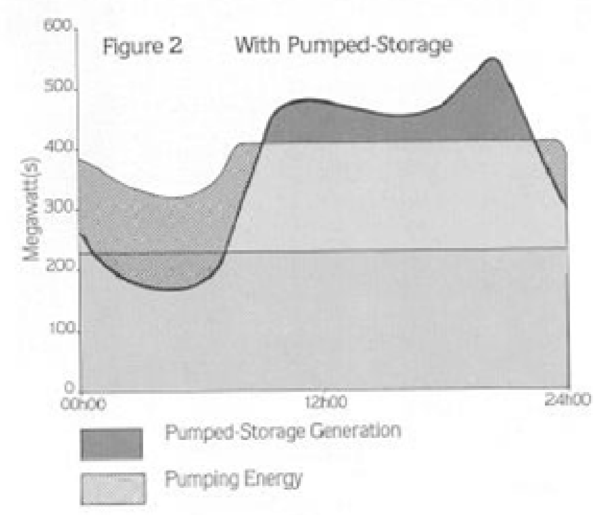

Figure 1. Illustrates the typical daily load curve for Cape Town twenty two years ago without Steenbras, the daily peak demand requirements being met by the Council thermal stations and the bulk, base load from ESKOM. Figure 2 Illustrates the effect of introducing pumped storage that would allow for optimisation of this bulk supply from ESKOM to a virtually constant daily supply. Figure 3 illustrates actual data of the system on 4 July 2001. The Steenbras pumping rate at almost 200 MW overnight until 06:30 and restarting at 22:00 is included in the shaded portions overlapping the bulk supply energy at the base of the graph.

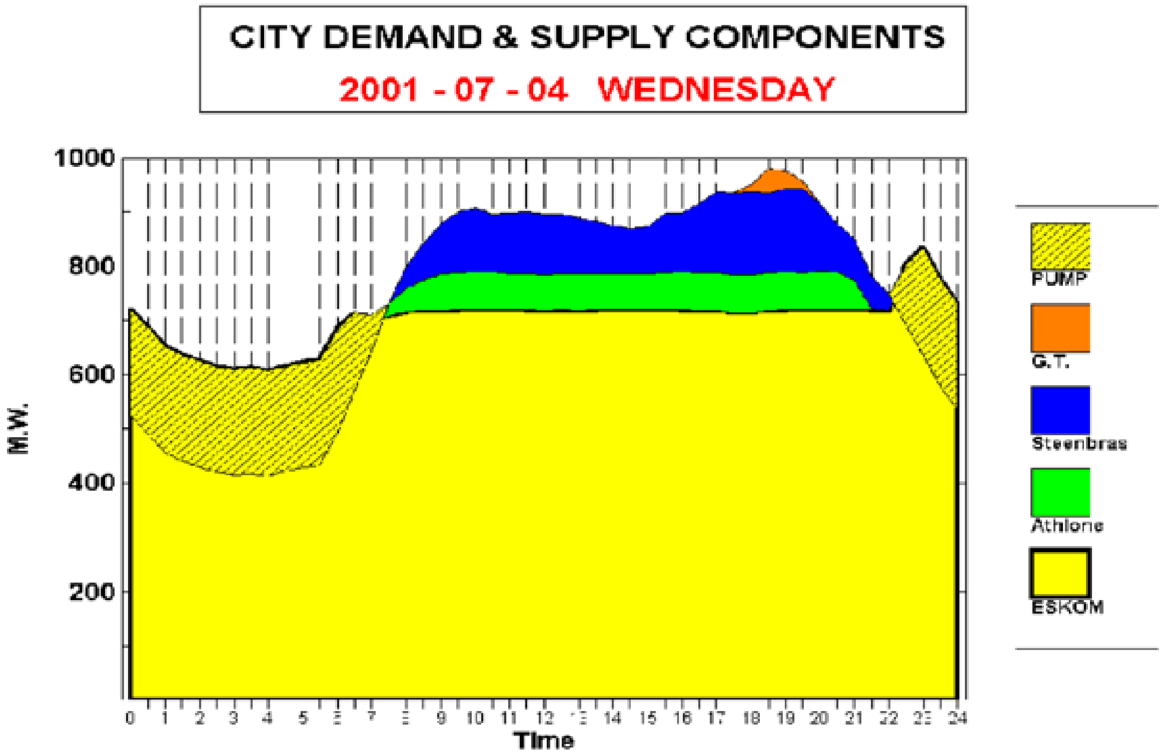

Figure 3: Recent Winter System Load Curves

Thus principle of the advantages of pumped storage operation has been illustrated where the flattening of the ESKOM demand profile is clearly shown. Note in the Figures 1, 2. & 3, how the system load has grown from less than 600 MW 22 years ago, to almost 1 000 MW now evident.

THE STEENBRAS PROJECT

The introduction of pumped-storage to Cape Town was first considered by Mr. C G Downie, the then City Electrical Engineer, who in 1952 suggested to the University of Cape Town that this subject might be considered as a thesis for a BSc degree. Following on this suggestion, a thesis was submitted which proposed the use of existing reservoirs on Table Mountain as an upper water supply source, with a power station of 50 000 kW capacity situated to the south of the mountain in Orange Kloof.

During 1958, investigations were initiated jointly by the City Electrical Engineer and City Engineer into the feasibility of a pumped-storage installation on Table Mountain, in conjunction with a water supply augmentation scheme. The scheme envisaged a new upper reservoir in Disa Gorge or Echo Valley and a lower reservoir in Orange Kloof. This proposal was subsequently followed up by the Council's consulting engineers but, as Table Mountain was a proclaimed national monument, its implementation proved difficult at the time and the proposal was dropped.

In 1963 the subject of pumped storage was again revived and the possibility of employing either the existing Steenbras dam or Wemmershoek dam as a site for a pumped-storage scheme was considered. However, with Athlone power station being under-utilized at the time, this proposal was not deemed economically viable.
In 1969 the Council's consulting engineers recommended that a 180 000 kW pumped-storage scheme be considered on Paarl mountain after other schemes using fresh water at Steenbras and sea water at Chapman's Peak and Witsands had also been investigated and abandoned as being uneconomic. Because of planning and amenity difficulties, the Paarl site was also dropped.

About this time the City Electrical Engineer and City Engineer had joint discussions on the possibility of combining a pumped-storage installation with a water supply scheme employing a second dam upstream of the then existing Steenbras dam. Following on these discussions, the Council resolved to construct this second dam to augment the City's water supply. It then became logical to combine this new dam with a pumped-storage scheme.

Exploratory drilling on site was commenced in 1971. After the invitation of tenders for the main items of plant and a further economic reappraisal of the scheme, the approval of all authorities was ultimately obtained. Steenbras pumped-storage scheme became a reality with the issue of the first contract acceptance letters in March 1975. Soon afterwards the civil engineering contractors moved onto site. The Steenbras pumped-storage installation is located 50 km from Cape Town on the lower slopes of the Hottentots-Holland mountain range near Gordon's Bay.

ECONOMIC CONSIDERATIONS

The final original cost of the Steenbras pumped-storage scheme, including the overhead line connecting the power station to the City's transmission system at Mitchell's Plain, was estimated at around R65 million at the time. This was equivalent to an installed cost of R361 per kilowatt.

The economic justification for this large capital investment by the City was based on the escaping of correspondingly high ESKOM demand charges, then about R57 per kW per annum. Because of inflationary trends, the annual value of the ESKOM demand charges that were escaped with the generating capacity of Steenbras, increased steadily year-by-year in step with the inevitable increases in ESKOM:s tariff. By originally making conservative assumptions in respect of the rate of escalation in ESKOM's tariff and the interest rate, it was calculated that the cumulative present value of the annual savings in ESKOM demand charges, less all operating costs of the pumped-storage scheme, would equal the full capital outlay on the scheme within a decade of commissioning the station.

The dual tariff structure applied in the Cape Town Electricity Undertaking then, is still in use today namely, ESKOM's Nightsave tariff. A charge is levied for energy consumed in cents/kWh and the charge levied for maximum demand (as attained in any given calendar month in R/kW). These were 7,26 cents/kWh and R46,17/kW respectively for 2001 excluding various surcharges and discounts.

In addition to its economic advantages, the Steenbras pumped-storage scheme has always been considered to offer certain security of supply benefits. The lower dam when empty, has a reserve capacity sufficient to accommodate twelve and a half hours of potential generation at full output to meet demand for power in an emergency. Again with recent developments in the Electricity Supply Industry, quality of supply is becoming important with the introduction of NRS047 and NRS048. Local generation is a significant tool to be used in a quality of supply situation. However local generation is considered an expensive option if used for improved quality of supply only. Pumped storage has the disadvantage of having to purchase electricity as its primary source of energy where it can only return 70 to 80% of that energy to the system.

Since 1995 the National Electricity Regulator has required returns from generating stations in order to licence them. The economic performance of Steenbras is depicted on the following chart under the Nightsave tariff. The lower performance during 1997 and 2000, were due to a three and one month station outage respectively, to attend to the main penstock waterway lining.

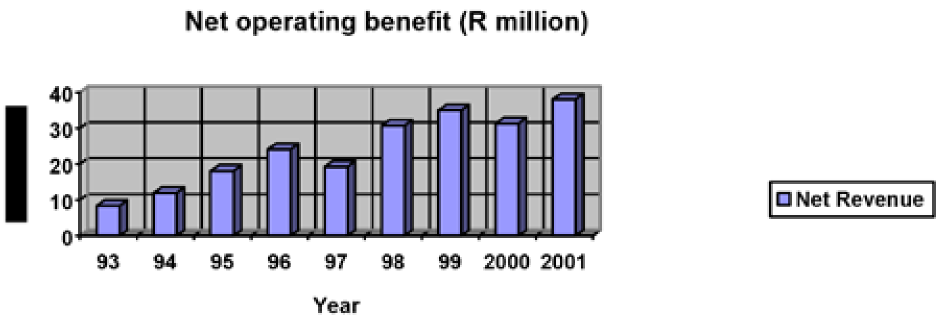

Figure 4: These figures represent the "avoided" bulk charges under the Nightsave Tariff

There are strong indications that this will all change in the very near future with the introduction of more cost reflective tariffs on ESKOM's current structure and a move towards the wholesale electricity pricing structure or WEPS and the prospect of an open competitive power pool within South Africa. Nightsave is far from cost reflective and subsidises other tariffs. However these topics are beyond the scope of this document. Suffice it to say, that such developments will present significant challenges to the economic operation of Steenbras. Studies are being made of the most advantageous tariff structure to adopt in the interim. For example, the use of the Megaflex tariff which is based on time of use of electrical energy. It is anticipated that this may significantly alter the daily operating cycle of Steenbras. This has to be offset by the careful choice of when and how to generate versus the pumping or purchasing time. Figure 4a depicts the anticipated generation and supply versus demand mix, for the Cape Town Electricity Undertaking.

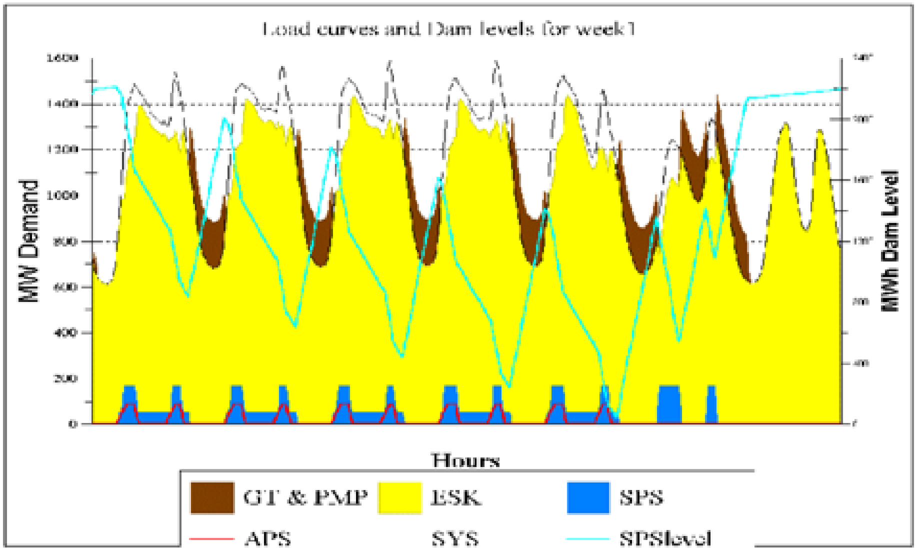

Figure 4a: Anticipated load curve for one week indicating the different loading of Cape Town generation.

TO BE CONTINUED....