REPORT ON THE

ENERGY SAVING STRATEGIES

FOR THE

MINERALIA BUILDING

OFFICES OF

THE DEPARTMENT OF MINERAL AND ENERGY AFFAIRS

VISAGIE STREET, PRETORIA

As part of the

CaBEERE Project

funded by

DANIDA (DANCED)

executed by
COWI A/S of Denmark

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EXECUTIVE SUMMARY of the ENERGY AUDIT on the MINERALIA BUILDING

An Energy Audit was done on the Mineralia Building, cnr. Of Andries and Visagie Streets during August 2002. The energy audit forms part of the CaBEERE Project aiming at building capacity energy efficiency and renewable energy. The CaBEERE Project is funded by DANIDA (DANCED). The DME is renting about 57% of the office space in the building. They occupy Floors 3 to 9 of Block A, B and C, Floor 6 of Block D, E and F and Floor 8 of Block F.
Electricity consumption is measured per Block (25 meters) that is read by the owner on a monthly basis.
Offices have surface mounted fluorescent type light fittings and console type air conditioning units. Offices and windows are facing north or south. The north and south walls are of a lightweight construction.

Building Performance:

No	Description	Before	After	Low Value	High Value
1.1	Total energy consumption per year	1 612 225 kWhr	1 221 360 kWhr		
1.2	Average MD per month	466 kVA	412 kVA		
1.3	Building net office rented area	10 434 m²	10 434 m²		
1.4	Annual cost of energy	R 455 742	R 379 325		
1.5	Specific maximum demand per month	45 VA/m²	40 VA/m²	45	120
1.6	Specific energy consumption	155 kWhr/m²	118 kWhr/m²	140	500
1.7	Specific annual energy cost	R 44 / m²	R 37 / m²	R 25	R 80
1.8	Annual energy cost per unit	R 0.28 / kWhr	R 0.31 / kWhr	R 0.20	R 0.40
1.9	Energy / person (440) / year	3 664 kWhr	2 753 kWhr		
1.10	Energy / person / year/hr (8 hrs)	458 kWhr	344 kWhr		
1.11	Energy per person per month	305 kWhr	232 kWhr		
1.12	Specific energy consumption of lights	33 kWhr/m²	27 kWhr/m²		
1.13	Specific energy consumption of AC	70 kWhr/m²	64 kWhr/m²		
1.14	Rented area per person	30 m²			
1.15	Office area per person	24 m²		10 m²	16 m²
1.16	Net estimated annual saving	16%	**R 76 417**		

Notes:
1. Rented area = 13 185 m²
2. Net office area = 10 434 m²
3. Number of people = 440
4. Working hours per day = 8 hrs
5. Also see **Addendum 1** for the Audit Report

Recommendations:

1. That automatic time clock control is provided on the existing lights:
   Annual saving =R15 604 Cost=R37 500 Payback = 2.4 years

2. That automatic time clock control is provided for the air conditioning installation:
   Annual saving =R27 025 Cost =R62 500 Payback = 2.31 years

3. That maximum demand control is provided on some of the AC-console units:
   Annual saving =R32 001 Cost =R100 000 Payback = 3.12 years

Future Options:

1. That film be considered for the north facing windows.
2. That insulation be considered for the spandrel panel of each window module.

BONESA Report:
If the BONESA Report is implemented, the payback period on the automatic time clock control on the lights will increase:
Annual saving =R 7 726 Cost =R37 500 Payback = 4.85 years

1. INTRODUCTION

The investigation is based on the specification that was issued by the DME.
The building is a rented property by the DME who occupies about 57% of the lettable office space. Therefore the energy cost for diverse services is not for their account.
The building has 9 floors and comprises two phases, known as Phase 1 and Phase 2.
The air-conditioning for the offices comprises console type AC-units, although a number of wall-mounted splits were also added in due course.
Office lights are of the fluorescent type and lights in passages, stairs and toilets are of the incandescent type.
Energy consuming office equipment is mainly computers.

2. CONCLUSIONS

The following conclusions can be made from the investigation:

- The overall energy consumption of the rented area by the DME is low.
- Therefore energy savings will only be marginal.
- Energy savings by replacing office lights as per the BONESA report, will be a good option.
- It shall be considered to mount the new light fittings below the soffit of the slab.
- Time clock control for the lights shall be considered.
- Time clock control for the air conditioning installation shall be considered.
- Providing a heat reflecting film on the north facing windows will be a good option, but the payback period is long.
- Providing an insulating panel on the spandrel of the window, will be a good option, but the payback period is long.
- Providing additional roof insulation for Floor-9 will be good option, but the payback period is long.
- Fluorescent tubes shall be replaced with new tubes.
- Power Factor Correction is not an option for the Tenant.
- A combined single electricity meter for all the rented floors does not indicate any significant savings.

3. METHODOLOGY

The methodology of the investigation was briefly as follows:

- Drawings of the building were obtained.
- The power distribution network of the building was investigated.
- The main power supply of the building was logged for a period of one week.
- The power supply of lights, plugs and air conditioning on each of the 25 floor distribution boards was logged for a period of one day each.
- Measurements of typical lighting lux levels were taken.
- Windows and wall panels were inspected.
- The performance of a typical console AC-unit was measured.

4. SURVEY OF THE BUILDING

The survey of the building comprised the following:

- A walk-thru was done in the beginning and was followed up with more visits as required.
- Energy consuming equipment mainly comprises lights, plug points and AC-units.
- The profile of power consumption for lights, plugs and air conditioning was determined by means of logging the power supply of each commodity on the floor distribution board.
- History data of accounts from the City Council was obtained to determine the load profile of the building over a year cycle. See **Addendum 3** for the calculated year profile for the building, based on the account data.
- Phase 2 of the building has an Enermax-type electricity meter with a profile memory. This is very useful information. See the graphs in **Addendum 11**.
- It became clear that the time of the year during which our survey was conducted, is actually the period of lowest energy consumption.
- See the inventory list in **Addendum 4** for the number of light fittings, computers and AC-units.

5. SELECTION OF PRIORITY AREAS

Based on the calculations as shown in the addendums, the selection of priority areas is as follows:

- The major energy consumer in the building is the air conditioning installation. Therefore the biggest potential for savings will be with this installation. However, the real performance of the air conditioning installation can only be investigated in summer. In August the majority of AC-units were off and in general will be off.
- Although most of the AC-units are being switched off after-hours, our recordings do indicate saving potential with automatic time clock control on the central power supply to the AC-units on each floor distribution board.
- The same applies for the light installation. Although the discipline in the building for switching off lights is good, our recordings still show potential with automatic time clock control on the central power supply to the lights on each floor distribution board.
- The replacement of office lights with new fluorescent light fittings will save energy as per the report of BONESA and will not be repeated in this report. If the light fittings will not be replaced, it is strongly recommended to replace all existing tubes. See **Addendum 13** for lux level measuring results.
- If the office lights are not replaced as part of the BONESA project, then at least the incandescent lights in the passages, stairs and toilets shall be replaced. See **Addendum 14** for the details.
- The wall panels below the windows are poorly insulated. It only consists of a 5mm wooden panel on the inside and a steel panel on the outside. Additional insulation on the inside is strongly recommended, although the payback period is long.
- The glass façade of the building forms a large percentage of the overall wall, 70%. Therefore measures to reduce heat gain and heat loss through glass will have a substantial influence on the conditions in the offices, specially on the north side. However, the payback period is long.

6. ANALYSIS OF SAVING POSSIBILITIES

The best saving possibilities are the following:

- Lights:
  - Switching of lights with central time clock control to assure lights have been switched off after-hours.
  - Providing individual switches per office to switch off lights when the office is not occupied.
  - Replace old tubes with new tubes to improve lighting levels **or**
  - Replace light fittings as per the Bonesa Report.
- Air conditioning:
  - Switching of air conditioning with central time clock control to assure AC-units has been switched off after-hours.
  - Provide load control on the AC-console units on the south side of the building to allow only 50% of compressors to run simultaneously.

7. PROPOSED ACTION PLAN

We recommend that a tender document be compiled to call for tenders for the supply, installation and commissioning of the following:

- Time clock control on the lights.
- Time clock control on the air conditioning.
- Maximum Demand Control on some AC-console units.

Future options to consider:

- Consider providing film on the north facing windows in due course.
- Consider providing insulation on the spandrel panel of each window module.
- Replace incandescent lights with fluorescent lights, if not done by Bonisa.

In-house measurements to be taken by the Department:

- Introduce stricter rules for shutting down computers after-hours
- Introduce stricter rules for switching off lights wherever possible.

8. BUILDING DESCRIPTION

8.1 General:

The building is situated on the corner of Visagie and Andries Streets and is a rented property by the DME. The building is just over 20 years old and was typically designed for cell offices with a passage in the middle, such that the building would be suitable for console type air conditioning.
The building was designed in two phases, although eventually it was built as one phase. Each phase has three blocks, therefore the blocks are called A, B and C for Phase 1 and D, E and F for Phase 2. Each block has a row of offices on the north side and a row of offices on the south side. The east and west ends have no windows.
The building is built in a H-shape with the lift lobbies, toilets, tea kitchens and stores in the joining passages between the offices on the north and south sides.

8.2 Floors and Roofs:

The floors are a concrete coffer type slab and the offices have no ceilings. The coffer slab is the ceiling and is generally painted white, although in some places it is painted a sand colour.

The roof has no visible additional insulation and therefore consist of the concrete coffer slab with a cement screed (to slope towards the drains) and a grey colour waterproofing.

8.3 Windows:

The windows have aluminium frames with single clear glass. The windows are mounted between the concrete columns that are 6.15m apart. Of the six windows panels between columns, three are openable with a sliding action upwards.
The floor to ceiling height is 2 500mm of which 150mm is the power skirting, 650mm is the spandrel panel and 1 700mm is the window height.
The % glass on the north and south sides is therefore high, ± 68%.
Each window has an overhang of 950mm at the top of the window. The overhang is a concrete slab between the concrete columns. The width of the concrete column between windows is 300mm.

8.4 Spandrel Panel:

The bottom section of the north and south façade of 650mm high is a steel panel in a steel frame to support the AC-console units.
Between each set of concrete columns there are therefore six steel panels of which the outer two panels do not have louvers for AC-console units. The other four panels have a steel louver on the outside. Where these panels do not house an AC-console unit, it has a typical spandrel panel of steel on the outside and 5mm plywood on the inside.

9. PROJECT DESCRIPTION

9.1 Electricity Meters:

The Council has a conventional type of electricity meter on the outside that measures the total power consumption of Phase 1 and 2. The site is on a maximum demand tariff.
Phase 2 of the complex has a separate Enermax meter with a useful memory for account data and power consumption profiles. See **Addendum 11**.
Each block has its own electricity meter for energy consumption and maximum demand.
The floors of Block B do not have a maximum demand meter.

9.2 Power Supply Distribution:

The 11kV main power supply terminates in the high tension (HT) room of Phase 1. From there it splits to the transformers of Phase 1 (2 off 1000 kVA) and the HT-room of Phase 2 with 2 off transformers (800 kVA each).

Transformer 1 of Phase 1 supplies the auditorium, lifts and Floors 2, 4, 6 and 8 of Block A. The DB of Floor 2 supplies Floor 3 of Block A etc.

Transformer 2 of Phase 1 supplies Floors 1, 2, 3, 4, 5, 6, 7, 8 and 9 of Block C and Floors 1, 4 and 7 of Block B. The DB of Floor 1 in Block B supplies Floor 2 and 3 of Block B etc.

Power supply in Phase 2 to the floors of the DME is as follows:

Floor 6 of Phase 2:	-	Block D is fed from transformer 1.
	-	Block E is fed from transformer 2.
	-	Block F is fed from transformer 2.
Floor 8 of Phase 2:	-	Block F is fed from transformer 2.

9.3 Measuring:

Loggers were fitted on the power supply of transformers 1 and 2 of Phase 1. See **Addendum 10**. Some day-profiles are also shown.

The power supply profiles of Phase 2 were obtained from the existing Enermax meter. See **Addendum 11**. Nearly a full year's data was captured on this meter of Phase 2. A graph is shown for each month of the year, as well as a typical day for each month. The profiles of Phase 2 can be considered as a good reflection of the typical profile of the whole complex.

Each distribution board (DB) on the floors that are rented by the DME, were logged for a period of 24 hours to obtain a power consumption profile on lights, plugs and air conditioning. There is a total of 25 DB's. See **Addendum 9** for the graph information.

To determine a year profile of the building, the account data since 1999 was obtained from the Council. See **Addendum 2**.

9.4 Lights:

The building has ±1000 fluorescent type double tube 1 500mm long light fittings, mainly in the offices and ±200 incandescent type light fittings mainly in the passages, toilets and staircases.

The light fittings in the offices are mounted inside the coffers of the concrete slab on a typical pattern. With the office partitions not in typical positions, this sometimes causes light fittings to be too close to partitions.

The office light fittings are grouped together in zones per floor (number of circuit breakers) as follows:

Block A= 5,	Block B= 2	Block C= 6 (zones per floor)
Block D= 3,	Block E= 3	Block F= 3 (zones per floor)

The lights in the passages are on a separate circuit.

For savings on switching lights with time clock control, see **Addendum 7.1**.

The lights on the floors of Phase 1 can be switched in North and South Zones to enable switching of lights on the north side by means of day-night switches. For savings on this option, see **Addendum 7.2**.

When lights will be replaced as part of the project of Bonesa, the payback on the light control options will increase. It can be assumed that the power consumption of the new lights will be ±60% of the present light power consumption. The calculated payback periods will increase likewise. Therefore only the payback of the option as per **Addendum 7.1** will remain feasible.

The experiment with the light fittings where it was lowered out of the coffer slab and where the tubes were replaced with new tubes, proofed to be worthwhile. See **Addendum 13** for measuring results.

If light fittings would not be replaced as per of the Bonesa project, it will be advisable to at least replace all the incandescent light fittings in the passages, toilets and staircases. See **Addendum 14** for details.

The option of individual switches per light fitting was not investigated in full detail. The cost per light fitting will be ± R100 and the calculated payback will depend on the chosen diversity of lights that will be switched by personnel during office hours. With a saving of 2 hours per working day per year, the payback will be ± 20 years.

9.5 Air Conditioning Installation:

The rented area has 434 AC-units of which 325 are AC-console units (originally fitted) and 109 are mid-wall AC-split units.

Some of the AC-console units were checked for its performance and there were no indication that the units cannot perform due to its age. See **Addendum 12** for test results. It can be seen that the 9 000 and 16 000 Btu unit performed well in the cooling mode, but that the 12 000 Btu unit did not provide any cooling, although there was current drawn by the compressor. This indicates a waste of energy with no cooling being provided, due to bad maintenance.

The units are already more then 20 years old and vibration is a problem on some of the units. The air conditioning installation is the major energy consumer in the building. See **Addendum 5** for details.

The building has 3 models of AC-consoles units, a 9 000 Btu, 12 000 Btu and a 16 000 Btu unit. These units originally may have been positioned according to a specific partition layout and office sizes, but may not necessarily be relevant today. All three models have the same size heater bank, that is 3 kW heating capacity.

Maintenance on these units remains of the utmost importance and some of the personnel reported that no maintenance was noticed during the last 2 years. The DME should insist on proper maintenance on these units.

Two options are considered to reduce the cost of energy on this installation:

9.5.1 Time Clock Control:
With time-clock control on the AC-units, it will assure that the units will always be off after-hours. Our measurements indicated that AC-units remain switched on during nighttime due to the human factor. Time clock control will eliminate this. See **Addendum 6** for details.

9.5.2 Load Control:
With reference to the calculated heat load of the offices, it can be seen that a typical south office with one AC-console unit will have about double the cooling capacity from one unit. Therefore the running of the compressors of the units on the south side can be controlled such that only half of the compressors are running at any given time. A specially designed controller can be fitted in each AC-console unit on the south side to allow the compressor to run for 7½ minutes and to be off for 7½ minutes. By controlling 50% of the units in the one time zone and 50% of the units in the other time zone, the maximum demand of the power consumption of the compressors on that floor will be reduced by half.
One disadvantage of this approach is that the units in these positions will have to remain there and shall not be relocated to the north side during maintenance.
See **Addendum 6** for more details.

9.6 Reducing the Heat Load of the Building:

The heat load of the building can be reduced by means of the following measures:

9.6.1 Provide heat-reflecting film on the windows on the north side.
The solar heat gain through the glass on the north side during the winter months is enormous, to such an extent that the calculated cooling load for the summer and winter on a typical north office is the same. Several options can be considered, for example double glazing, reducing the glass area and external shading. The window frames are not suitable for double-glazing and reducing the glass area will be difficult with the sliding windows. Partial shading is already provided by the overhangs and external louvers will therefore restrict visibility unnecessarily.
We are of the opinion that a heat reflecting film will be a good option for this application. See **Addendum 8** for more details.

9.6.2 Provide insulation on the spandrel panel:
The panel below the window is only a sheet metal section with 5mm plywood on the inside. Especially during the spring, winter and autumn seasons, direct sun will warm these panels. Insulation on the inside will reduce this heat gain. See **Addendum 8** for more details.

9.6.3 Provide roof insulation:
The heat gain on the top floors, Floor 9, can be reduced by providing additional insulation. Providing insulation on the inside will be difficult due to the coffer slab with no ceiling. Therefore insulation will have to on the outside. This will be an expensive exercise and paybacks will even be longer than the other options and therefore be unrealistic.

9.7 Power Factor Correction:

The building shows potential for power factor correction, as can be seen mainly from the power consumption profiles of Phase 2. See **Addendum 11**. The estimated saving in maximum demand for the building is 75 kVA.
The savings benefits of such an installation will be applicable to the owner of the building and not the DME as a tenant on some of the floors.
The power factor of the building will be the worst during summer when the AC-units are running on cooling.

9.8 Combined Metering for the DME-Floors:

One option would be to investigate the benefits of one electricity meter for all 25 DB's of the DME, compared to the 25 individual meters at present.
Our comparison of the meter readings on the 25 DME meters with the building totals do not indicate any substantial savings in this regard.
See **Addendum 2** for account data.

9.9 Equipment:

As can be seen from our measurements, the load on the plugs after-hours is minimal and it will also be impractical to switch this power supply off because of computers that have to be properly shut down.
It is therefore important that all computers be set for optimum energy savings mode with reference to the screen and the hard disc. Further it is advisable to shut down computers after-hours. We understand that this is the policy in the DME.
When Photostat machines are hired or leased, it is important to make sure that the machines include the latest power saving features.
The only other major power consumer on the floors is the hot water urns in the tea kitchens. It is important that all urns shall be switched off after-hours. Our recordings indicated that it was the case.
No central hot water equipment was found in the rented area of the DME.

9.10 Office Space:

As can be seen from the audit report, the available space per person is 24 m². This is a very low density and the potential should be there to reduce this area per person without necessarily increasing the energy consumption in the same proportion. The equipment power consumption may increase, but the AC and light power consumption should remain the same.
If more office space is required in future, space planning by a professional may be worthwhile.

9.11 BONESA Report

If the replacement of lights will be done according to the report of Bonesa (See Addendum 15), the feasibility of the automatic time clock control on the lights will change as shown in Addendum 7.3. The payback period will increase from the original 2.4 years to 4.85 years.

Therefore the implementation of the automatic light control will have to be carefully considered. It remains the safest way of assuring that lights are off after-hours, but the payback period is relatively long. See **Addendum 7.3** for details.

Addendum 1
AUDIT REPORT

Addendum 2

ACCOUNT DATA

- **annual consumption history**
- **graph of history data**
- **monthly data**

Addendum 3

Year Profile for Loads

- **Total**
- **Lights**
- **Plugs**
- **AC**

Addendum 4

Inventory List of Equipment

Addendum 5

Energy Saving Potential For switching:
-Lights
-Plugs
-AC

Addendum 6

Savings with Time Clock Control on AC

Addendum 7

Savings with Time Clock Control On Lights

7.1 Lights as one Zone per Floor
7.2 Lights as two Zones per Floor
7.3 Lights with Bonesa Report

Addendum 8

Options with Cooling Load Reductions

Addendum 9

Graphs of Load Profiles On DB's

Addendum 10

Graph of Load Profile
On Phase-1: TXF-1
On Phase-1: TXF-2
(Block A, B and C)

Addendum 11

Graphs of Load Profiles On Phase-2 (Block D, E and F)

Addendum 12

Performance of AC-consoles

Addendum 13

Performance of Lights

Addendum 14

Incandescent Lights Payback

Addendum 15

BONESA Report