Developing ESCo procedures for large telecommunication facilities using novel simulation techniques

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Abstract
Peak electricity demand in South Africa will exceed the available operational generation capacity in 2007. The state utility, Eskom, is addressing this challenge, inter alia, with the implementation of a national Demand-side Management (DSM) initiative. Studies in South Africa have shown that 20% of the total municipal energy is utilised in commercial buildings. Telecommunication companies own and operate a large portfolio of diverse buildings within the municipal boundaries. Energy Services Company (ESCO) analyses on these buildings showed huge savings as well as load reduction opportunities. ESCOs however face major problems in evaluating DSM projects on telecommunication facilities. To address these problems a new ESCO procedure for telecommunications facilities was developed and successfully implemented. It was proven that the new ESCO procedure is successful in solving the unique problems in performing ESCO analyses for telecommunications facilities.

Keywords: electricity demand, Energy Services Company, demand side management, commercial buildings, telecommunications facilities

1. Introduction

Electricity demand in South Africa is currently estimated as growing at approximately 1 000 MW per annum. The peak demand in 2005 was 34.8 GW, with the operational generation capacity in South Africa totalling at 37 GW (Gcabashe, 2003; DME, 2003). It is clear that (as shown in Figure 1 – De Kock, 2005), unless drastic steps would be taken before 2007, peak demand will exceed the supply capacity in high demand periods.

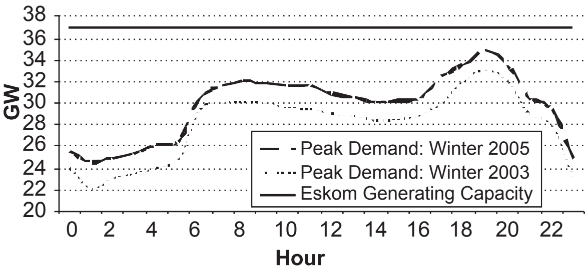

Figure 1: Electrical demand profile for South Africa

Various supply and demand technologies have been identified to address the growing demand of electricity in South Africa. Demand-side management (DSM) is a mechanism in which a utility or some other designated entity (Energy Service Company – ESCO) uses funds derived from the electrical system to modify patterns of electricity usage, including the timing and level of electricity demand (De Kock, 2005).

The prime objective of DSM is providing constant, efficient use of electricity by managing demand effectively. When DSM methods are successful, the demand is more consistent and electricity suppliers are better able to meet consumer requirements.

The influence of DSM in the reduction of peak growth is crucial to prevent or delay the installation of further generation capacity.

2. Energy usage in commercial buildings

International studies have shown that, on average, buildings account for one-third of the world's energy consumption (Janada, 1994; Drozdov et al, 1989).

In developed countries, 57% of all the electricity generated is utilised in commercial buildings. In developing countries, commercial buildings account for 38% (OECD, 1993) of total energy use. In South Africa, studies have shown that 20% of the total municipal energy is utilised in commercial buildings (Andersen, 1993) as shown in Figure 2.

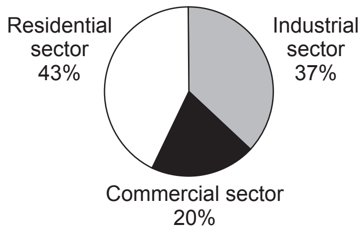

Figure 2: Energy consumption per sector in South African buildings

Studies done by TEMM International (Pty) Ltd. in South Africa have shown that in the commercial sector approximately 50% of energy is used for air conditioning (TEMM International, 1997). According to the South African Department of Minerals and Energy, this figure can be as high as 74% in summer for temperate climates (DME, 2001).

3. DSM opportunities in commercial buildings

Optimistic sources estimate savings as high as 70%, by improving design and management, as well as retrofit projects of existing commercial buildings. However, a more realistic figure seems to be 30% (Bevington, 1990; Mozzo, 1998). If a 30% penetration in the industry with a 30% saving per building could be realised in South Africa, it would result in a significant reduction in electricity demand (Botha, 2000).

Optimising building heating, ventilation, and air conditioning (HVAC) control provides the best return on investment, the easiest approach to promoting savings to building owners, and is also the easiest way to implement. Such retrofit studies would in most cases be of more value in older buildings than in new ones. However, one must remember that a building can be considered outdated even after 15 years of use (Spoormaker, 1995). Depending on the system, the maintenance history and implementation, newer buildings may also have potential for energy saving.

The HVAC system and energy efficiency in buildings means reduced electricity consumption, monetary savings for the owner and less greenhouse gases being released into the atmosphere. Although very important, energy saving measures must never compromise indoor air quality (IAQ). The reason is that IAQ has a direct effect on the health and productivity of the occupants (TEMM International, 1997; Woods, 1989). The cost associated with poor IAQ far outweighs savings due to reduced energy consumption (Sterling *et al,* 1997).

The popular belief in the past was that good IAQ and energy efficiency were in direct conflict (Mathews, 1996). A cost-effective way to improve the energy efficiency of an HVAC system, without compromising indoor comfort, is by implementing better control (American School & University, 1997). The most effective way to predict the impact of the system changes on the energy efficiency and indoor comfort is with the use of computer simulations (Lebrum, 1994).

Additional to the energy savings of building retrofits, there are various other improvements. For a lighting retrofit it could include improved light colour quality, and improved lighting levels. From HVAC improvements one may find reduced running hours, improved temperature control, faster equipment failure notification, more reliable preventative maintenance, additional safety and security and improved information on the system (Hotel and Motel Management, 1996). Some of these improvements will lead to additional savings over and above the energy cost reductions.

4. Energy usage in telecommunication buildings

With this investigation new ESCO procedures for large commercial telecommunication facilities were developed.

A typical facility may have any of the following energy end users:

- Switchgear – Supplies power to the building
- HVAC equipment – Ensures the correct environmental conditions
- Logistical equipment like computers, lights, elevators etc.
- Telecommunications equipment

Rabie (2000) mentions that of these end-users, the HVAC (Heating, Ventilation and Air Conditioning) system could represent up to 55% of the total building load. This is even higher than the 50% found in typical commercial buildings due to the constant heat load in telecommunication buildings.

Combined buildings are used for commercial purposes and also contain telecommunication systems. This scenario presents a problem to the HVAC system of the building since the equipment needs to operate at a much lower temperature than that which is comfortable for humans (20ºC ± 2ºC). Office areas are thus often cooled by standalone air conditioning systems where centralised HVAC plants are used for cooling equipment areas.

A common problem in many of the buildings, is that the equipment and building infrastructure is old. This leads to inefficiencies in the HVAC plants and creates a problem for the facility managers to maintain these buildings, and also ensure minimum energy usage.

5. Problems with ESCO implementations in commercial buildings

Most Energy Services Companies (ESCOs) do not have the skills, nor the tools, to conduct energy studies in buildings cost effectively. A study by Stein (1996) identified the common mistakes that are frequently repeated during energy efficiency projects. Some of these mistakes include the selection of inappropriate analysis tools, poor data collection, inadequate definition of baseline, inadequate reporting, inappropriate solutions and neglect of interaction between building systems (Stein, 1996).

Following is a list of problems ESCOs face implementing DSM projects in commercial buildings:

- Long time to perform ESCO analysis
- Low skills levels of personnel
- Lack of experience
- Lack of structured energy audit procedures
- Low availability of information and data capturing
- Lack of software tools to perform ESCO analysis
- Lack of simulation of proposed retrofits and savings opportunities
- No consequential reporting

It is clear from the above problems that an integrated ESCO procedure is needed that would enable the ESCO to accomplish a building energy audit and retrofit/saving study in the shortest possible time.

5. Novel ESCO procedure for telecommunication buildings

The general energy audit procedure can be described as follows:

- Identify the types and costs of energy use
- Understand how this energy is being used, and possibly wasted
- Identify and analyse alternatives such as improved operational techniques and/or new equipment that could reduce the energy costs
- Perform an economic analysis on the alternatives and determine which ones are cost effective for the business

When reading through this general procedure it makes a lot of sense and sounds simple. Why the need for a new integrated procedure for telecommunication facilities?

Maintenance of telecommunication facilities are often outsourced to facility managers, and usually include energy management. Even if the telecommunications company performs its own in-house energy management programme, they are still faced with a few unique problems in the telecommunications environment which add to the problems already mentioned in the previous section.

- Telecommunication companies have large portfolios of facilities and electricity is a large expense. To generate cost savings it means that energy management needs to be implemented on a large amount of different building types.
- Before energy management can be implemented an energy audit is required on these buildings that will identify the energy management opportunities. However, the only way to accurately predict the result and effectiveness of such measures is with the use of dynamic, integrated simulation software.
- The audit should provide the financial evaluation of the proposed energy savings opportunity and its potential DSM impact. The telecommunication company can then decide if DSM funding will be applied for, or if the project will be self-funded.
- The costs of these audits should be kept as low as possible to ensure projects are economically viable. Long audit times on a large scale will not be commercially viable.
- The potential savings opportunity should not have any negative impact on the operational conditions of the buildings. Many of the buildings are critical to the communications infrastructure and damage to equipment and loss of income can be incurred.
- The ideal scenario would be if the facility management company/personnel could perform these energy audits to save on audit costs. They already have a presence in the buildings, and know the detailed workings of the equipment in the building. The majority of maintenance personnel have good technical skills, but may lack the experience and tools to perform energy audits in the buildings, and evaluate energy savings opportunities. The new procedure should thus be simple enough and provide the necessary tools to perform the audit.

The new ESCO procedure was designed so that it provides an easy-to-use and effective toolkit for semi-skilled technicians to be able to conduct a building energy audit. It was proven that the user might have valuable practical experience, but has low qualification levels. The user must build the simulation model simply and intuitively. No intricate simulation, or mathematical options, should be set. All the standard retrofit and savings interventions must be very easy to set up and analyse. This will reduce the overhead cost of the project, as fewer personnel would be required for the audit.

Given the background of the telecommunication environment and the ESCO work in South Africa it can be stated that the primary requirements for a new ESCO procedure are that it should be simple, stable, and fast. The following software tools are introduced for specific use for ESCO analyses in telecommunication facilities:

Data gathering software
A large percentage of the building audit time is normally taken up by the gathering of data. It also requires various loggers, notepads, calculators, and the like. Typically, it is a very uncomfortable experience for the ESCO. By using a PDA for the data gathering only the required data is obtained, all the data is stored and the procedure is made more manageable for the ESCO. The captured data and equipment layout is exported to the simulation software.

Simulation model software
The simulation model software is stable, fast, and reasonably accurate. To achieve this, the mathematical models of all the HVAC components were simplified and verified in detail. A year-simulation is completed in less than three minutes on a regular personal computer (PC).

The software predicts the energy consumption and maximum demand figures of the last year within 15% of the actual figures. It must be noted that the user is more interested in the potential savings figure (a relative figure) than the total cost. Fluid conditions are only required on an hourly basis. The dynamics of the control of HVAC equipment on a short time scale is not needed.

Retrofit and saving intervention analysis software
The retrofit and savings analysis software uses the verified building simulation model, and allows the user to simulate retrofits and saving interventions on the building. This allows the auditor to establish what the potential savings will be, but also what the effect will be on the operating conditions of the building. These retrofits and interventions can now be evaluated without testing on-site, thus further reducing the time for the energy audit. It also means less risk for the telecommunication company since the retrofits and savings interventions have been verified through simulation.

Combinations of different retrofits and savings interventions can be simulated to evaluate the true effect of the combined option (it is not always just the sum of the different retrofits and savings interventions). This can only be done using an integrated building simulation model.

Financial analysis software
Since all these software modules are integrated, the simulated saving from the retrofits and saving interventions are automatically imported into this module and the financial analysis done. Calculations such as direct payback, discounted payback and net present value are calculated.

Report writing software
A template is generated to which all of the simulation and financial results are exported into a word processor format. This allows the ESCO to document the findings of the audit in much less time and in an understandable format.

The different steps and the logical flow of the new ESCO procedure are shown in Figure 3.

For telecommunication facilities a standard list of energy management opportunities was developed. The simulation and retrofit/ intervention savings software in the new ESCO procedure will be used to illustrate how simulation techniques can be used to evaluate energy management opportunities in the telecommunication environment. The list of the energy savings opportunities in tele-communication facilities has been compiled by practical investigation.

- Retrofitting the building envelope to improve efficiency
- Verification of municipal meter calibration and meter type (accuracy of meter)
- Tariff structure – Is the optimal tariff structure in use?
- Power factor correction – Opportunities for power factor correction?
- Lighting upgrade – Replace old inefficient lighting
- Lighting control – Prevent energy wastage when not required
- Optimal fan scheduling and control
- Changing temperature set points back to design conditions
- Temperature set point setback when cooling requirements change
- Economiser control – Ensure that already installed energy savings are working according to design
- Verify control system operation – Re-commission to design conditions
- Replacement of old redundant HVAC systems with new units
- Identifying inefficiency in the HVAC system
- Heating plant control

These and other energy savings opportunities have been applied in several case studies, of which one case study is described in the following section.

6. Case study
The new ESCO procedure was implemented on a large commercial building within the telecommunication environment.

The building forms part of a Head Office complex of buildings of a large communication service provider. The Head Office complex was chosen for this audit since the Head Office group of buildings has an annual electricity cost of more than R14-million per annum. The building was chosen because it represents a typical large commercial building in the telecommunications portfolio.

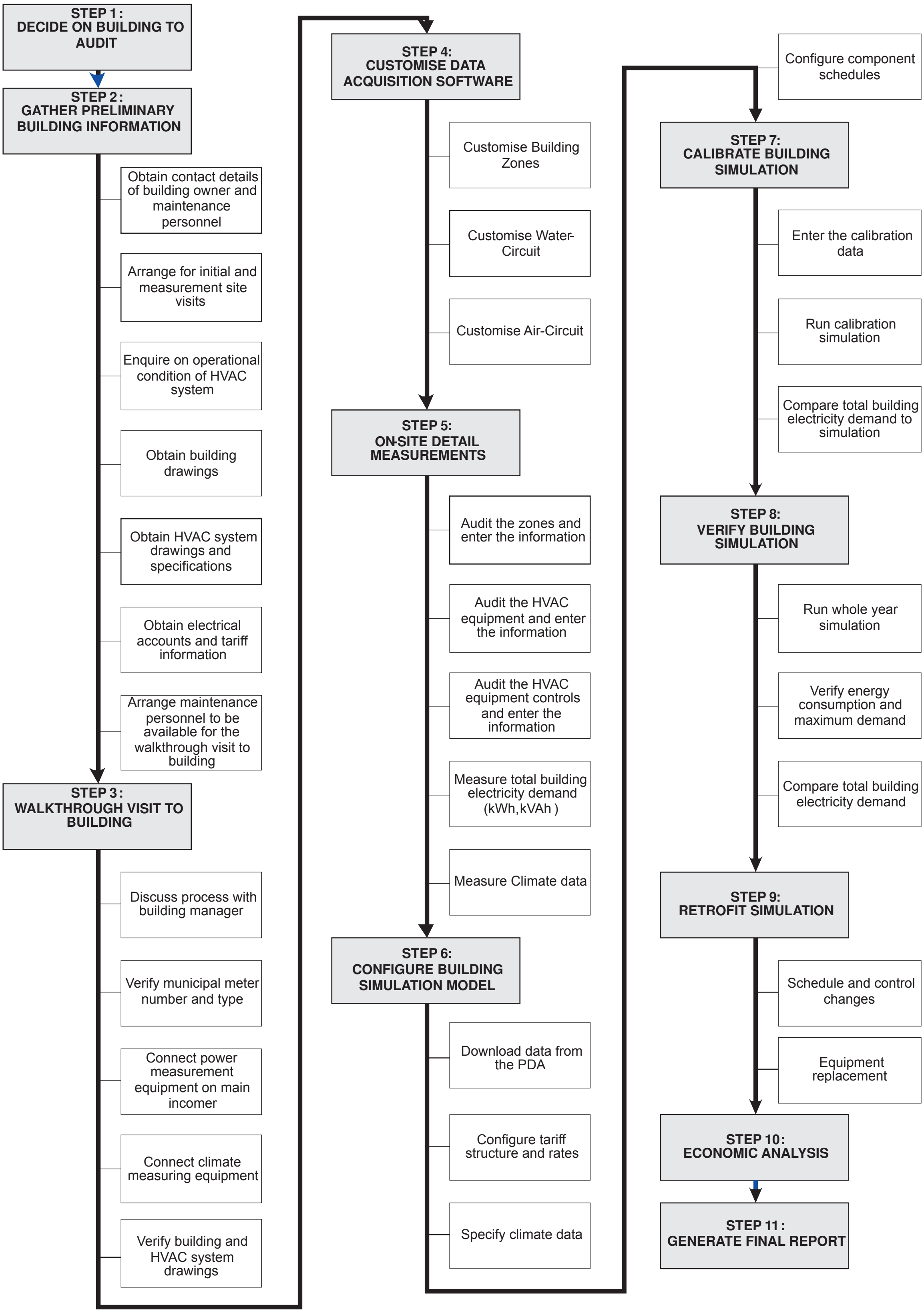

Figure 3: The new ESCO audit procedure for telecommunication facilities

6.1 Building information

The most important building and HVAC system information that was gathered are summarised in Table 1.

Table 1: Building description

Building description	Commercial building
Number of floors	27
Total floor area	24 000m^2
HVAC system	Multi-zone
Cooling plant	Watercooled, screw
Cooling capacity	4.530 KW
Heating plant	Electrical boiler
Heating capacity	0
Air distribution	Variable Air Volume Constant Air Volume
Control System	Building Management System

6.2 Building simulation model

The simulation program has a maximum of 12 zones that can be used in the simulation model. This forces the user to simplify the simulation model if the building has a more complex HVAC system.

The focus of the simulation was on the main Air Handling Units AHUs on the 15th and 27th floors. These units, together with the chilled plant, are the main energy consumers of the HVAC system. The other installed fans in the building are small compared to the main units, and the various fan coil units are additional load on the chilled plant. Therefore, the building was divided into seven zones. Figures 4 and 5 show schematic drawings of the simulation model – water-circuit and air-circuit.

6.3 Calibration building simulation model

The 'calibration' simulation ensures that the current status of the building will be simulated correctly, so that cost savings predictions are realistic. The model is considered calibrated when the predicted daily demand load is within 10% of the measured value – 80% of the time.

The calibration simulation compares the total building energy consumption over a weekday, Saturday and Sunday, to measured energy values. The total actual building energy consumption for these day types was measured during on-site detail measurements. One calibration climate input is used for the three simulated days. Figure 6 shows the simulation results for a typical weekday. This, and similar results for Saturdays and Sundays, prove that accurate results were obtained.

For all three day types, the simulated results were within the benchmark of 10% of measured values, for 80% of the time.

6.4 Verification building simulation model

The verification study is performed in order to verify the accuracy of the simulation model's energy consumption over a typical year. The verification simulation compares the simulated average seasonal energy consumption and maximum demand to the actual building data. The measured data was obtained from trended measurements on the building management system (BMS). The verification results are shown in Table 2.

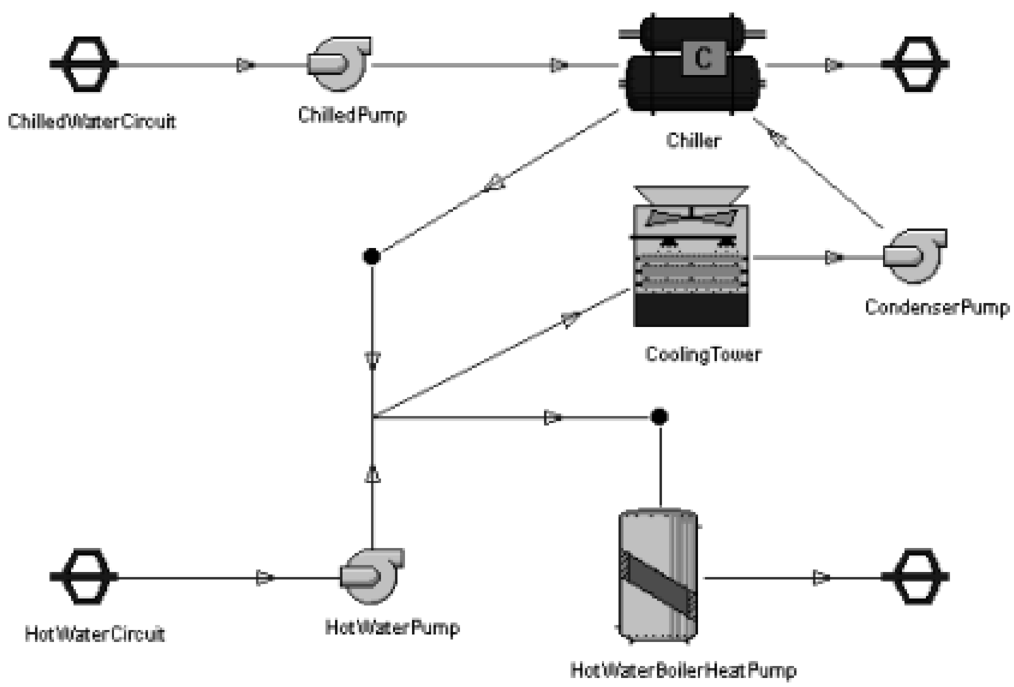

Figure 4: Simulation model: water-circuit

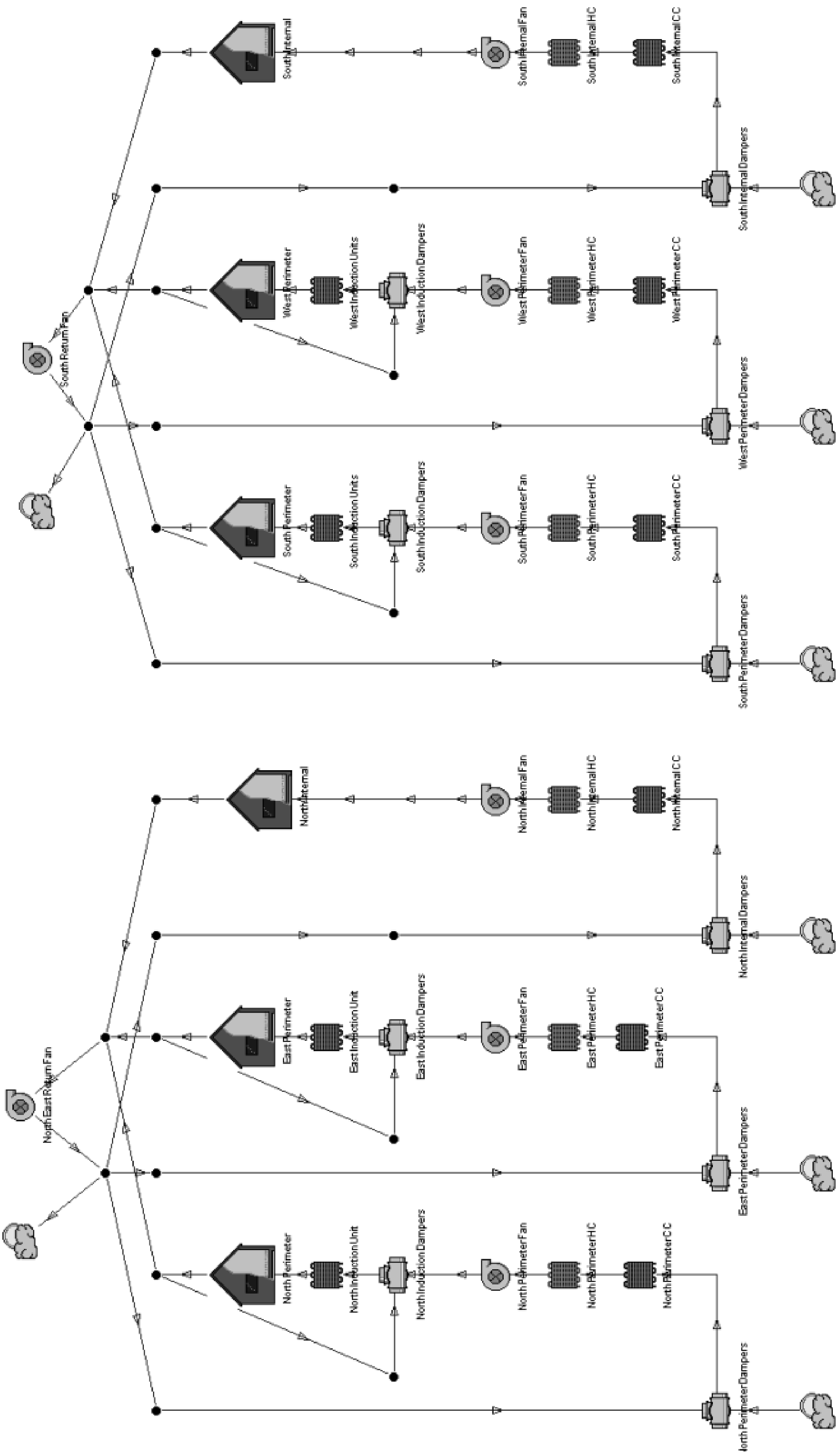

Figure 5: Simulation model: air-circuit

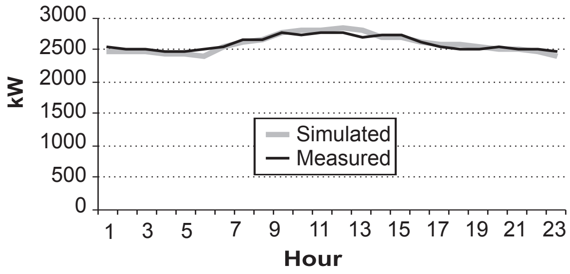

Figure 6: Weekday calibration simulation results

Table 2: Verification study outputs

	Summer	*Winter*
Total seasonal energy consumption (MWh)		
Simulated	14 150	5 870
Measured	14 353	6 010
Error (%)	1	2
Average season maximum demand (kW)		
Simulated	2 632	2 254
Measured	2 560	2234
Error (%)	3	1

It can be seen that the annual simulated values are very close to the actual measured values. This can be expected due to the good calibration results obtained in the previous step. This shows that the simulation model, weather and other seasonal data used in the simulations are accurate enough to proceed with the retrofit and saving intervention analysis.

6.5 Retrofit and saving intervention simulations

To determine the largest energy users in the building, an end-user energy cost breakdown is simulated and shown in Table 3.

Table 3: Building energy cost breakdown

Description	*Energy (MWh)*	*Cost (R)*	*R/kWh*	*% of total*
HVAC system	8 170	1 612 464	0.12	46
Lights	7 288	1 438 463	0.12	41
Other	2 391	471 996	0.12	13
Total	17 850	3 522 923	0.12	100

Since the biggest savings opportunity exists on the HVAC system, the contribution of the different HVAC components is also calculated and shown in Table 4. The highest energy consumers will have the biggest potential for energy cost savings. If the contribution of each energy user had to be measured this would have been a very lengthy process. Because of the accurate building simulation model the end-user contribution could be simulated.

Table 4: HVAC system energy cost breakdown

Description	*Energy (MWh)*	*Cost (R)*	*R/kWh*	*% of total*
Cooling	4 143	817 717	0.1201	51
Heating	0	0	0.1201	0
Ventilation	2 143	423 029	0.1201	26
Pumping	1 883	371 719	0.1201	23
Total	8 170	1 612 464	0.1201	100

From the tables it is obvious that the HVAC and lighting systems are the biggest consumers, and thus present the biggest opportunity for savings. The different retrofit and saving interventions are described in more detail below.

Verification of tariff structure and metering

The building group is currently on a standard two-part tariff. This means that the user is billed for total kWh used during the month, the maximum demand recorded and service charges. There are no time-of-use periods and thus energy is charged at a flat rate.

The building simulation model was used to simulate the electricity costs should the building be changed to the time-of-use tariff. The study showed a 3% increase in the electricity costs should the tariff be changed. It would thus not be advisable to change the building to a time-of-use tariff structure.

Power factor correction

The current power factor of the building is approximately 0.8. This is a low power factor but the municipal meter measures several buildings of which this is only one of the buildings. At this municipal supply point the power factor is 0.94, and thus rather good.

Verify temperature set points

In commercial buildings the zone temperature set points are seldom out-of-range, or something that cannot be changed much. The buildings tenants complain on a daily basis about too warm or too cold conditions, and the optimum set point that suits everybody is difficult to find. It can be stated that the set points in commercial buildings are self regulatory due to the human comfort element.

Verify control system operation

During the investigations, several problems were found with the HVAC control system. These problems were immediately rectified, which meant better IAQ and lowered power consumption. Since these problems were corrected as part of the normal responsibility of the maintenance company, these changes were not quantified as separate interventions.

Fan scheduling at night

For this intervention the ventilation fans were turned off at night when the building is unoccupied. The assumption was made that these times are from 18:00 to 04:00. The working hours of the occupants of the building are from 07:00 to 16:00. It was therefore assumed that turning the fans off at 18:00 would be safe. Also, turning the fans on at 04:00 should have the zones at the correct temperature when the occupants arrive. The scheduling times used are shown in Table 5.

Table 5: Fan scheduling times

Weekday	*Saturday*	*Sunday*
00:00-04:59: OFF	00:00-05:59: OFF	00:00–23:59: OFF
05:00-17:59: ON	06:00-13:59: ON	
18:00-23:59: OFF	14:00-23:59: OFF	

The simulation program showed that all zones were on set point temperature in the morning at the start of office hours. The simulation also showed that the temperatures in some of the zones become high during the night when the fans were switched off. Figure 7 gives the simulation temperature output for a summer weekday (worst case scenario).

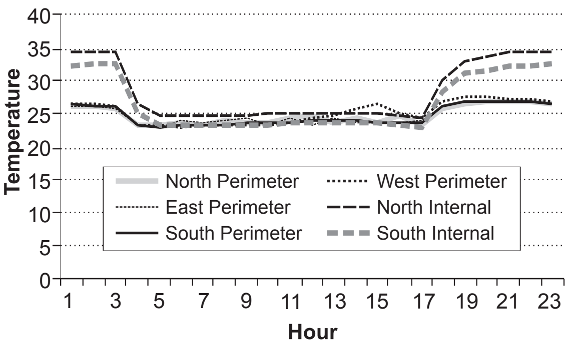

Figure 7: Fan scheduling at night – Simulated zone temperatures

The total seasonal reduction of the building due to the fan scheduling at night is shown in Table 6. It is interesting to note that this intervention will have no effect on the Maximum Demand (MD) of the building, since the MD always occurs during the day when the building is occupied and, therefore, maximum energy usage.

Table 6: Results – fan scheduling at night

	Reduction				
	Total summer season		*Total winter season*		*Annual*
kWh	1 522 106	11%	278 809	19%	9%
MD	0	0%	0	0%	0%

During the day the fans were turned off for similar times as for the previous intervention, but the assumption was made that on Saturdays the fans could be turned on again at 05:00 and switched off at 14:00. On Sundays, the fans were turned off for the whole day. The total seasonal reduction due to the fan scheduling at night and on weekends is shown in Table 7.

Table 7: Results – Fan scheduling at night and weekends

	Reduction				
	Total summer season		*Total winter season*		*Annual*
kWh	2 009 650	14%	399 875	7%	12%
MD	0	0%	0	0%	0%

This and the previous intervention will be subject to approval from the building owner. The off-periods of the fans can easily be changed and re-simulated should the building owner not agree with the time periods.

Economiser enthalpy control

The building is currently operating economisers with temperature control logic. However, the study showed that many of the dampers appeared to be out of order. Economisers operating on enthalpy control could save more energy, because it also takes into account the latent heat of the air. For this intervention, the economisers were simulated on enthalpy control. The total seasonal reduction due to the economiser enthalpy control is shown in Table 8.

Table 8: Results – economiser enthalpy control

	Reduction				
	Total summer season		*Total winter season*		*Annual*
kWh	94 063	1%	50	0%	0.5%
MD	794	4%	0	0%	3%

It can be seen that the majority of savings will be achieved in the summer since the cooling load is more than in winter months.

Installation of evaporative coolers

Evaporative coolers cool the air by evaporating water into the air. The advantage of this is that it uses very little energy, and removes some of the cooling load from the chillers. Figure 10 shows the temperature of the zones predicted by the simulation program with the installation of evaporative coolers.

It can be seen that the zone temperatures are kept between at 23°C and 25°C as required. The

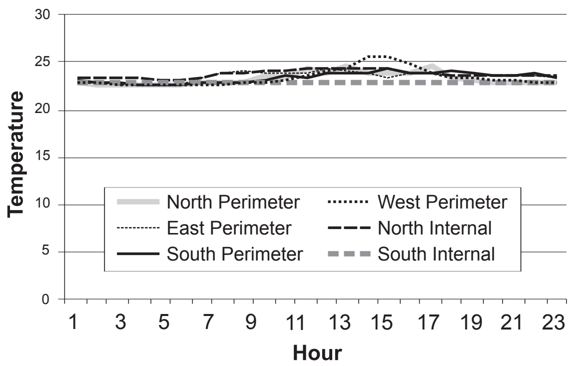

Figure 10: Installation of evaporative coolers: Simulated zone temperatures

total seasonal reduction due to the evaporative coolers is shown in Table 9.

Table 9: Results – installation of evaporative cooler

	Reduction				
	Total summer season		Total winter season		Annual
kWh	793 106	6%	266 437	5%	5%
MD	1 127	5%	835.64	9%	7%

Scheduling of lights at night
For this intervention, the lights are switched off at night, for the same period as for the fan scheduling. This intervention does not assess the influence of energy efficient lighting, but uses the current lighting system in the building. The total seasonal reduction due to the scheduling of lights at night is shown in Table 10.

Table 10: Results – light scheduling at night

	Reduction				
	Total summer season		Total winter season		Annual
kWh	2 713 714	19%	904 263	15%	18%
MD	0	0%	0	0%	0%

It is important to note that this intervention will have no effect on the MD used by the building, since the MD always occurs during the day when the building is occupied. It is important to note that since the building model is an integrated simulation model, the effect on other building systems is also calculated. Heating load in the zones was reduced by scheduling the lights and the savings will include kWh savings due to the reduced load on the HVAC system.

Lights scheduling nights and weekends
For this intervention, the lights are switched off for the same time during weekdays, Saturdays and Sundays as for the fan scheduling intervention. This intervention also does *not* assess the influence of energy efficient lighting, but uses the current lighting system in the building. The total seasonal reduction due to the scheduling of lights at night and weekends is shown in Table 11.

Table 11: Results – Light scheduling night and weekends

	Reduction				
	Total summer season		Total winter season		Annual
kWh	3 619 758	26%	1 257 285	21%	24%
MD	0	0%	0	0%	0%

Combined retrofits and savings interventions
The combination of all the retrofits and savings interventions mentioned above, will obviously provide the biggest saving. The integrated simulation results of the combined savings are in Table 12.

Table 12: Results – combined retrofits and savings interventions

	Reduction				
	Total summer season		Total winter season		Annual
kWh	4 574 097	32%	1 657 493	28%	31%
MD	1008	5%	734	8%	6%

The relative savings are impressive but do not say much until converted into monetary value, and compared to the implementation costs. The financial analysis will be discussed in the next section.

6.6 Financial analysis

Numerous retrofit and savings interventions were investigated through simulation. In the previous section, the kWh and demand reduction percentages were calculated. The combined percentage reduction in kWh and demand does not directly relate to the total percentage cost savings. The actual percentage cost savings is shown in Table 13.

The cost calculations are based on an active energy cost of 12.01c/kWh, and MD of R51.51.

The only user inputs required for the financial analysis is the project cost. It is assumed that the scheduling of the equipment will have zero capital input, as an existing maintenance contract on the BMS will be able to implement these retrofits and interventions. For practical purposes, it was assumed that capital costs would be covered by a loan with an interest rate of 12% per annum.

It can be seen that the combined retrofits and interventions will have a 21% reduction in annual electricity costs. The financial analysis is shown in Table 15.

Table 13: Electrical cost saving

Description	*Simulated annual cost (R)*	*Annual cost savings (R)*	*% savings*
Base-year	3 956 038	-	-
Economiser Enthalpy control	3 903 903	52 135	1%
Fan schedule night	3 762 713	193 325	5%
Fan schedule night & weekend	3 692 258	263 780	7%
Light schedule night	3 536 268	419 770	11%
Light schedule night & weekend	3 371 383	584 655	15%
Evaporative cooler	3 727 703	228 335	6%
Combined	3 117 916	838 121	21%

In Table 12, the annual kWh reduction for the combined retrofits and savings interventions were shown. The DSM effect of the combined retrofits and savings interventions is calculated in Table 14.

Table 14: DSM effect on building energy and demand

Total summer season reduction (kWh)	*Total winter season reduction (kWh)*	*Annual reduction (kWh)*	*Daily average kW reduction*
4 574 097	1 657494	6 231 590	721 kW

7. Conclusion

The new procedure was applied to several case studies, in order to verify that the objectives have been achieved. It was shown that the new ESCO procedure fully addresses the specific requirements of telecommunication facilities. Some of the specific outcomes of the application of the new procedure on several case studies were the following:

- The procedure was proven to be feasible for a large and diverse portfolio of buildings.
- The audit times for performing an energy audit and building simulation was reduced dramatically.
- The improved data capturing procedure ensures that only relevant data is recorded.
- Different configurations of HVAC systems found in telecommunication facilities were successfully simulated.
- The simplified simulation building model was proven to be accurate.
- Retrofits and savings intervention simulations were performed on the building model to evaluate savings opportunities.
- DSM potential was simulated to evaluate the possibility of DSM programme funding.
- Lower qualified personnel could be used to perform the data capturing, simulation and savings analysis.

It was proven through implementation that the new ESCO procedure is successful in solving the unique problems experienced in performing ESCO analyses for tele-communications facilities.

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Table 15: Financial analysis

Description	*Savings*	*Project cost*	*Direct payback period (months)*	*Discounted payback period (months)*	*Loan rate (%/year)*	*Net present value (R)*
Year 3						
Economiser Enthalpy control	52 135	14 500	3.3	4	12	110 719.47
Fan schedule night	193 325	0	0.0	0	12	464 334.03
Fan schedule night & weekend	263 780	0	0.0	0	12	633 555.05
Light schedule night	419 770	0	0.0	0	12	1 008 216.71
Light schedule night & weekend	584 655	0	0.0	0	12	1 404 242.66
Evaporative cooler	228 335	600 000	31.5	38	12	-51 577.86
Combined	**838 121**	**614 500**	**8.8**	**10**	**12**	**1 398 525.22**

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