Measuring Emergency Electrical Loads in Commercial Buildings

Terry Cousins, TLC Engineering Solutions (Pty) Ltd

Abstract

Many commercial buildings were built decades ago. The electrical facilities in these buildings often do not meet the requirements of modern loads. Provision of emergency power was often used for little more than emergency lighting. This paper will discuss the remote measurement of electrical loads at various points in low and high rise commercial buildings. The loads that are measured include chillers, heating, air handling, lighting and various office equipment such as computers and servers. The measurements are taken on the main and emergency distribution systems. The data is remotely collected from various sites to a data centre where it can be analysed. These measurements will assist utilities, consultants and facilities management personnel to design, plan and modify emergency and normal building supplies.

Commercial Buildings

In most cities there is a mixture of commercial buildings from those recently constructed to those that are decades old. The 50 story high Carlton Centre, located in downtown Johannesburg, is Africa’s tallest commercial building. This building with 72000m² of office space was completed in 1974 and at the time its electrical reticulation system represented the “state of the art”. This has become outdated and is being refurbished to meet the challenges of the new millennium. This situation is not uncommon all over the world.
The nature of electrical loads has also changed significantly over the years. Computers were located in centralized locations. Electric loads were continuous in nature and load profiles were more predictable as most companies only operated fixed hours “9 to 5”. Emergency power requirements were typically used for lighting and powering of equipment such as elevators.

Older buildings often have significant modifications made to their reticulation systems over time. Different standards of maintenance are applied when the ownership of the building changes. Documentation is often either not available or inaccurate as modifications are made without changes. The building knowledge is often known only to a few individuals and is lost when these people retire or move to other jobs.

Consequently building owners and managers are often unsure as to what normal and emergency capacity is available and how loads vary with time. This leads to uncertainty in operations and planning.

**Emergency Power**

Historically emergency power was usually provided for safety of personnel during a power failure. This included emergency lighting, ventilation and provision for evacuation using elevators. Many older buildings have no or very minimal emergency reticulation. In larger buildings the emergency supply was often centralized in a basement with a standby generator. Over time standby supplies and UPS equipment has been installed in various locations according to user requirements. This equipment is usually supplied by the tenants.

The modern business reality is a 24/7/365 operation. A loss of power is a significant loss of revenue

Critical loads can now include

- Computers, servers, workstations, printers etc
- Networking and communication
- Point-of-sale equipment
- Lighting
- HVAC
In order to plan, improve and provide for the modern tenant, it is essential to understand the nature of loads in buildings.

Building Monitoring Considerations

A program of instrumenting and monitoring loads can be used as a systematic way to determine the current state of the loads in a building. Monitoring systems can be used to profile loads by:

- Building type
- Tenant
- Time of day
- Day of week
- Season
- Other factors (e.g. ambient temperature)

Prior to implementing the monitoring program it is essential to determine the monitoring objectives. A monitoring program could be required for one or more of the following:

- New tenant requirements
- Documentation
- Refurbishment
- Energy consumption
- Potential for savings
- Planning & research

Once the objectives of the monitoring program have been determined, the monitoring plan can be devised based on these objectives. The ideal plan would include as much detail as possible by measuring as large as possible sample to provide a statistically valid result. The plan could require measurement of:

- Entire building
- Representative floor
- Specific office
- Particular load
- Some combination of the above

Depending on the monitoring objectives and size of the building, it will usually not be necessary to monitor every load. In some cases it is impractical to certain loads as there may be difficult to access the monitoring points. In such cases it is also possible to derive the value by measuring the feeder and the remaining loads and then determine the required value by summation. If there are a number of similar offices or tenants, a representative load profile can be determined by only monitoring one or a few of these.

Case Study: Low Rise Commercial Building

The following information is extracted from a monitoring study done on a 4 floor office building. The building houses a large electronic and print media company. The nature of its operation is 24/7. The incoming supply is shown below. The text in red indicates the monitoring points.
The client requested that the load profile of the entire building was measured. This comprises the main intake supply in the basement, two representative floors (operations) and the ground floor (catering, reception, security etc). Certain loads were identified as not important and excluded from the monitoring plan. The monitoring objective was to determine the load profile over a 12 month period. In addition the internal and external temperature was also measured. The incoming supply panel to the building was located in the basement. This is shown below.
A number of challenges relating to the site were identified as:

- No up-to-date documentation was available
- The building power could not be interrupted to install monitoring equipment due to the nature of the business operation
- Only the building maintenance electrician could be used to install the equipment.

A detailed examination of where the loads could be measured was undertaken. Power measurement requires both voltage and current monitoring. The line voltage could be monitored at a number of points. These included the busbars, panel meter, building metering and unused circuit breakers. Panel meters and circuit breakers were used in this case.

Current measurement options are usually limited to using existing current transformers (CT’s) where possible and providing clamp-on or split-core CT’s. Split core CT’s were used as these provided high accuracy with a low size profile. Installation did prove to be a challenge as the CT’s had to measure load on multiple conductors per phase. This is shown below.
Clamp-On Current Transformer Installation Location

The monitoring equipment was installed at the top of the switchgear panel. A GSM link was used to remotely transmit the data back to a central database. This location provided adequate signal strength without the need for an external antenna. The installed monitoring system is shown below.

Monitoring System Installation

The building floor supply consists of an emergency feeder, a supply for the lights and one for the plugs. There is a distribution panel on the north and south side of each floor. The floor distribution supply is shown below.
Electrical Supply to Floor Loads

The emergency and normal supply panels are shown below.

Installation access was difficult as the conductors required for load measurement were stiff and cable-tied together.

Data Acquisition System
The data acquisition system used for building monitoring was able to provide the following:

- Measure multiple voltage and current inputs (up to 32 channels)
- Calculate apparent power (kVA), active power (kW), power factor (pf), energy (kWh) and maximum demand (MD) from the phase current and voltage
- Measure single and three phase circuits. (Resist the temptation to measure only 1 phase as representative of a 3 phase load. There is often severe unbalance between phases.)
- Save readings at a selectable interval (usually 5 or 10 minutes)
- Better than 2% accuracy. (Accuracy does not need to be metering class – 5% is usually adequate)
- Data capacity for a minimum of 12 months of readings. This is non-volatile hard drive storage
- Local flat panel display and keyboard. This is used to configure the equipment on site. (Since the equipment is closed it does not necessarily need a local display. Configuration could alternatively be performed using a PDA or laptop)
- The equipment is mounted in a lockable enclosure to prevent tampering
- A backup power supply is provided for up to 3 hours to ride through during power outages. The power supply is connected to the emergency supply which is only out of service until the standby generator switches in.
- Remote data transmission using GSM/GPRS back to a central database

The data collected by the unit can also be manually retrieved using a memory stick or disk. It is recommended that where access is difficult, data should be transmitted to a collection point using a local area network (LAN) or a wireless technology such as GSM/GPRS, CDMA or WiFi. Remote data collection can also be used where data is required real-time or near real-time. There could however be cost restrictions where there are several monitoring points in the building. The data from each system could be centralized before the data is sent to the central data storage unit.

The data flow from system installed in the example building is shown below.

![Measurement and Data Flow from Building Monitoring System](image-url)

Data received from the monitoring system is stored in a database. The database is able to store data from the remote systems indefinitely. The database should ideally be based on an open standard where possible. MS Excel, MS Access and SQL are all commonly used for data storage. The
reliability and integrity of the data was a critical requirement of the system. An example of an MS Excel database table is shown below.

### Example Database Data from Building Monitoring System

**Results**

Results from the monitoring system are available in a graphical form. This includes waveforms, trends and disturbances. In addition summary statistics of mean, maximum, minimum values is provided. Common data can be used for different stakeholders – building management, maintenance, consultants etc. Consultants will normally require a more comprehensive data set. Some example building data are shown below.
Data analysis was performed at fixed intervals during the measurement period. Analysis tools are able to select channels and dates of interest and perform cumulative measurements. Data is displayed in a simple format as shown above. Data can also be exported from the database for further analysis.

The conclusions drawn from the measurement are based on measurement objectives. This was to determine if the supply is able to meet current and future needs, what the diversity of the supply is to accommodate additional loads and what the potential is for increased capacity.

Conclusion
Emergency and normal electrical loads in commercial buildings can be measured reliably and cost effectively using remote monitoring equipment. These measurements will assist utilities, consultants and facilities management personnel to design, plan and modify emergency and normal building supplies.

References:

http://www.amethyst.co.za/JhbLandmarks/


Eskom Demand-Side Management (DSM) Programme. Case Study: Carlton Centre, Johannesburg