HISTORIC

The first engineering prototype was implemented on a PC board without any enclosure. The units were hand assembled and laboratory tested before installation. Twelve units were installed in Hamilton in an unoccupied office which had two full windows located East and South on the 7th floor, with no adjacent building shadowing the office. This was an ideal condition.

The results of the test, which lasted from April to November, showed exceptional success, with as much as 70% power savings in a given day. On the average, with a lighting cycle between 7am to 7pm, and only a direct photosensor feedback for day light saving we averaged 50% savings over one week. However we noticed that the 8Watts steps in the dimming process remained detectable and we proceeded to a redesign to accommodate less than 4 Watts level changes.

The second batch of engineering prototype units working in 4 Watts increments were assembled by hand and this time in an aluminum enclosure. Extensive laboratory tests showed that we were running into component heating too close to critical. We redesigned the unit to better dissipate the heat, and 50 units were built by an outside contractor. These units came back and were thoroughly tested, and we found still too much component stress. A further modification of each unit followed and only components which had failed were replaced, but most components, already stressed were retained.

Two units underwent a switching cycle extensive test program. We performed the following cycle: - switch power ON, full demand for 20secs - dim to 40% power for 20 secs - dim to 80% power for 20secs - turn OFF for 20 secs 60,000 cycles were done with 2 of the units following the above cycles, and one reference fixture was simply switched without using our controller. The tubes are guaranteed for 1000 switchings. After 3000 switchings, the reference tubes failed. It took 27,000 switching for the controlled tubes to degrade up to failure with the units we controlled. After going through two sets of tubes, we terminated the testing since the controller unit showed no aging nor deterioration.

In a parallel test we had one unit which cycled continuously from 80% power demand and 40% demand within 40 secs, and then was software switched OFF for 20 secs. We had again a reference fixture fully on at the same time. After 60,000 cyclings the controlled tubes were still looking like new, while the reference tubes already showed graying at the end electrodes, which meant they were aging fast.

We proceeded then to test every unit and put them through an 800 cycle switching and dimming cycle.

Before installing these units in the field, it was decided to add a bypass relay to our controller unit, so that if any malfunction occurs, full light can be restored instantly to the area and does not adversely affect the office. Unfortunately, due to the mechanical bouncing of contacts at power on, several units were damaged when the relay contacts welded through arcing. We resolved this by energizing the relays on a separate circuit, therefore preventing relay bouncing and arcing. This bypass relay is not planned to be implemented in further installations. Since we removed this mechanical bypass arcing, not one single unit failed in the last 7 months of operation, despite of the fact that some units had previously been seriously stressed (we had anticipated a 20% failure rate).

FIELD TEST: Feb-Sep 2002

The field test was planned in a fully populated office building in Toronto. The area controlled represents 1/4 of a 20,000sqft floor on the 2nd floor of the building. One side has a full window with blinds and faces West. The sun appears only around 2pm. The other side is facing North and has windows, but they are obscured by a tall office building, hence very little light comes in. The ceiling is a low ceiling and there are tall partitions. This is possibly the worst case since 20ft deep in the area there is not much daylight saving available. Furthermore, because the afternoon sun is already low on the horizon, the workers close the blinds because of the reflections and glare on their computer monitors. The area contains 2 full circuits of fixtures (24 total) which can be controlled with our dimmer unit. One circuit, 2 rows near the West window, have a photosensor feedback from the area within 15 feet from the window. The other circuit, deep in the floor, has no daylight saving feedback. A third reduced circuit (4 fixtures) has also our dimmer installed, but it is not controlled, it acts as one of the reference sources. The mirror image of the floor has been rewired (North-East corner) to give a reference total power.

There is one photosensor monitoring the outside light level (between the blinds and the outside). The latter provides us with the outside daylight profile. The power is independently monitored by Toronto Hydro. Each circuit is monitored with current/voltage/power recordings continuously. We provide the recording of the daylight level via our external sensor. Toronto Hydro accesses their data logger remotely and analyze the results independently from us.

The office is a typical insurance company office, with clerical staff. The building lighting control switches the lights on at 6am and switches them off at 9pm after the cleaning staff has left.

We have installed a simple PC to run the light dimming manager for our controlled units. We have programmed in a profile which is the following:

- 6am to 8am: dim to 50% power
- 8am to 9am: dim to 70% power
- 9am-5pm (normal working hours) dim to 80% power
- 5pm-9pm (cleaning staff): dim to 50%

Furthermore, since some office workers stay after 5pm, or calls in after 9pm, we have installed a simple button that is an override button, that causes the light to come up to 70% power level (called a “boost”). After one hour the controller resumes the original setting (unless boost is reactivated).

After 2 months of operation, we have introduced a daylight savings management based on a single outside sensor by predicting the levels needed in each of the area. This would not be as efficient as the direct zone feedback for the zone directly near the window, but it compensates on the whole floor with a much cheaper and simpler controller.

PRELIMINARY RESULT

The savings ranged from 30% to 40% on a daily basis. The low 30% savings were due to the fact that workers were calling in after 7pm and sometimes stayed till midnight. This was only the case about 4 times per month. The average savings over one week were 35% in the period monitored.

The feedback from the office occupants was overwhelming. Most workers did not notice that we were dimming the lights, and did not feel hindered. Several workers noticed the dimming but welcomed it because the light delivered was much mellower and was not harsh to the eye. One worker even said that she looks into the dimmed lights to relax her eyes. Another worker stated that since we installed the dimmer control she does not suffer from migraines. No one complained about having to use the “boost” button at off times, they readily accepted this method.

LESSONS LEARNED

1- The location chosen was a worst case scenario. If one looks at the illumination plots it shows clearly that when the sun would shine in and therefore cause heavy dimming, the blinds would be closed, and disable the daylight saving. The combined use of blinds and the northern shadowing effect of the adjacent building contribute to this worst case scenario. This suggests that blinds have to be modified in order to be partially closed only to prevent glare, but should still let light shine on the ceiling. This also suggests that more savings can be obtained by simply planning the position of the work cells and the orientation of the computer screens, avoiding glare.

2- The gains resulting from the single outside illumination feedback were the dominant savings. This “predictive” lighting management based on outside illumination is simple and versatile, yet sufficient for excellent efficiency.

3- The manual override permits to set the lighting management to very low values when no one is on the floor, and yet allows people arriving on the floor to have decent lighting.

4- The local zone photosensor seems to be less productive in this environment. The cost of the photosensor unit combined with the difficult choice of location, set up and adjustment, requiring very skilled personnel to install, outweighs by far the extra savings obtained by the simple lighting level management. Furthermore this control is very sensitive to the blind operations as well as sometimes by the furniture displaced or someone standing in the path of the sensor.

5- The main gains come from the efficiency of the dimming profile. At the moment we have only implemented 10% level adjustments. We think that implementing 5% level adjustments will bring an extra few per cent gains because of the finer control profile.

PROJECTIONS

1- The light management should be a system approach, where the dimmer unit is the hardware controlled by an intelligent controller that has a dimming profile programmed and a simple outside illumination feedback.

2- The control lines are separate from the power circuits. Therefore zones can be re-configured without changing the power wiring. We can also use software switching, augmenting the flexibility of the system. For instance we can define more zones than circuits, and hence when the building management program switches a circuit on (large zone), the soft switching can curtail the lighting in a much smaller worker zone, hence realizing considerable savings.

3- The use of overrides could be also localized to zones. At the moment the whole area is affected at once (24 fixtures). If the zones were reduced, only say 6 fixtures could be overridden, and again considerable savings realized. We could replace the hardwired switches to infra red emitters (similar to TV controllers) to limit control wiring.

4- Extend the user communication by using a LAN with a gateway input replacing telephone activation of requests. A user would order the light on at a certain time directly with an interactive web program before leaving home, or using Palm like wireless web access. The whole controller could replace the existing building management unit and provide much more flexibility and user friendly interface.

SUMMARY

1- Power savings through daily scheduling of dimming levels at no loss of convenience for users can guarantee better than 25% power savings.

2- Better use of daylight saving where possible, using a global control based on outside illumination can bring 35% to 40% savings.

3- If blind operations and window orientation is used as well as efficient furniture organization is achieved to avoid glare, we can expect savings as large as 50%.

4- If 24 hour operation is needed, savings as high as 70% can be achieved.

5- With the deregulated market, the time of billing is crucial. The cost increases at bright sunny days in the Summer due to heavy air conditioning demands. This is the time where daylight savings can be best achieved, hence savings occur at high KWh cost intervals. Hence when dollar savings are considered, the savings are even larger.

6- Dimming causes less heat generated, hence there is less need for air conditioning, adding to the dollar savings mentioned in (5).

7- The decrease in demand due to lighting during these peak periods in the Summer, as well as the reduced demand in the early evenings when there is peak demand, help the power utilities. The need for less installed capacity means less investment required for the power utilities.

8- The user benefit from the savings directly since in the deregulated market the cost of KWh varies with the time of day, hence dimming decreases the demand at these critical times. For instance you may save only 35% power, but the cost of that power may be many multiples of the base power you are comparing it to. For example in Summer 2002, there were periods in the middle of the afternoon where the rates plummeted at 70c /KWh versus the 4c /KWh at normal off times.

9- The tube life is definitely extended.

10- Due to the ballast being better balanced and generating less heat, its lifetime is also considerably extended.

10- Comfort to user:

- quality of light: no flicker; no glare; soothing to the eye; migraine and epileptic seizure improvement; less fatigue; less stress;
- controllability: manual override can tune to user comfort; internet access with friendly user interface;

11- Ancillary (hidden benefits)

* Environmental: tube life extended saves discarding polluting material; in retrofits no need to dispose of toxic products such as old tubes, ballasts and fixtures, they can be reused.
* Less peak power capacity hence less power plant pollution
* commercially viable payback: from 1 to 4 years depending upon installation.