

Energy Efficient Lighting

THE PILOT RETROFIT AT ERICSSON TELECOM AB'S FACTORY

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Abstract

The efficient lighting project at Ericsson Telecom AB in Visby, Sweden focuses on the general lighting in one of the main assembly halls. The hall covers 6 300 m² of the plant's total area of 32 000 m². The new lighting system at Ericsson Telecom AB is one of many projects in Uppdrag 2000, a wide ranging scheme for the efficient use of energy, run by The Swedish State Power Board - Vattenfall. The low-energy lighting project at Ericsson Telecom AB has been made possible through a co-operation between Ericsson Telecom AB, Gotlands Energiverk AB (GEAB), Svensk Energiutveckling (SEU) and Vattenfall Östsverige.

Previous Lighting

The previous general lighting in the assembly hall consisted of 564 fluorescent tube fittings from the early 1960's. A major part of these fittings (545) were equipped with 2 x 58 W tubes and the remaining 19 with 3 x 58 W tubes. These old fittings used slightly more than 333 MWh and the power demand was 76 kW.

New Bright Light

Several advantages are gained by replacing the 564 old fittings with 446 new ones, each of them equipped with 2 x 50 W fluorescent tubes. The consumption of energy is reduced by an estimated 183 MWh (excluding the store room) and the power demand is decreased by about 26 kW. As a comparison, a conventional, lighting system would have reduced the consumption of energy by 68 MWh. The new fittings are equipped with reflectors and anti-dazzling screens, which give a better light - bright, but not dazzling. The fittings also have a high-frequency device to control the light. In combination with a light modulator and an amplifier, they form a constant-illuminance system. This means that there is no need for the lights to be switched on full capacity on a sunny day. The system is constructed to give a constant general light of 300 lux in the assembly hall. The high-frequency device obtains an instantaneous ignition and the flickering of the fluorescent tubes is hence eliminated. The experience of the lighting retrofit is considered very attractive by the staff.

Economic Analysis

The total investment in the new lighting system at Ericsson Telecom AB is around 988 000 SEK. According to our calculations, the new bright light at the plant will cut the annual electricity bill and maintenance costs by roughly 68 000 SEK (1989 prices). The new low-energy lighting system has an estimated pay-off time of 14 years.

*The new energy-efficient lighting system at Ericsson Telecom AB
- more light with less energy.*

INTRODUCTION

Ericsson Telecom AB in Visby is one of several companies included in "Uppdrag 2000", Vattenfall's (the Swedish State PowerBoard) wide ranging scheme for the efficient use of energy. The joint venture at Ericsson's started with an energy analysis, performed by Vattenfall Östverige and the local energy board, Gotlands Energiverk AB (GEAB).

"Uppdrag 2000"

Vattenfall has previously been able to act on an expansive electricity market, where an increase in demand has been met by an expansion in production at a relatively low cost. Today we have a new and different situation and The Swedish State Power Board has the ambition to limit and postpone the expensive construction of new power plants. "Uppdrag 2000's" objective is to improve the efficiency of energy use. It is looking at the potential for energy savings and better energy management in industry, private and public buildings and in single-family houses.

"Uppdrag 2000" will also give valuable experience and knowledge about the use of energy and alternative and complements to electricity which can be of value to the customer. The objective is also to find an optimal balance between further expansion of electricity production resources and measures taken at the customer end in order to reduce the increase of energy demand. "Uppdrag 2000" works closely with the customers in demonstration projects, such as Ericsson Telecom AB, to gain in-depth knowledge of various ways of saving electricity. The scheme intends to obtain a sufficiently large and reliable information base to enable an estimate of the whole country's conservation potential. "Uppdrag 2000" runs from 1986 to 1991.

The Company

Ericsson is in many ways synonymous with telephones and other telecommunication equipment. The company has worked hard not to become rigid and hold on to old technology. It has chosen to expand and develop its business and today it is an international company and the world-leader in many areas of telecommunications.

At the plant in Visby, electronic components for the computerized communication system AXE are produced and assembled. The 750 employees also test printed circuit cards. The plant was built in stages during the period 1961-1975.

THE ENERGY AUDIT

The study of the energy flow at the plant has been limited to one assembly hall, covering 6 300 m² or 20% of the plant's total (heated) area of 32 000 m². Facts and figures here mentioned only concern this particular assembly hall, unless otherwise stated. The energy analysis was undertaken in order to obtain an energy balance.

The assembly hall is heated by district heating distributed through a system of radiators and warm air. Excess heat from processes e.g. soldered wires, heat testing of circuit cards, lighting and people also contributes to the heating of the assembly hall.

The general lighting previously consisted of old fluorescent tube fittings with two and three tubes in each fitting. (See also section "previous lighting".) The hall also has a number of additional local lighting fittings.

The energy consumption in the assembly hall is an estimated 1 365 MWh electricity and 1 300 MWh district heating, adding to about 19% of the plant's total energy use.

Measurements were made at 15 points. The data were collected during four weeks with a computer logger and momentarily by hand. After the analysis of data, the assembly hall's energy balance was determined.

ACTION

After having carefully considered all proposed energy saving suggestions together with Ericsson Telecom AB, it was decided that changing the general lighting in the assembly hall would be the best start.

The new general lighting system had the following criteria: tube fittings with 2 x 50W tubes, reflectors, anti-dazzling screens and a high-frequency device for lighting adjustments forming a constant-illuminance system together with a light modulator and an amplifier. It was further decided that the new lighting system should give an average general light of 300 lux, which is recommended by The National Energy Administration, Ljuskultur, Mekanförbundet, Verkstadsföreningen and Uppdrag 2000¹.

PREVIOUS LIGHTING

The previous lighting in the assembly hall consisted of 564 fluorescent tube fittings from the early 1960's with no reflectors. A major part of these (545) were equipped with 2 x 58W tubes and the remaining 19 with 3 x 58W tubes. Another 74 slightly more modern fittings had 2 x 58W tubes. All the fluorescent tube fittings were made by Sievert. The general lighting fittings were assembled on a wire, 4.5 metres above the floor. They were evenly spread across the assembly hall and ignition of the lights was divided into 10 sections.

Additional local lights consisting of 300 tube and bulb fittings was situated at almost every workstation. They varied in design and manufacture and were switched on by hand by the person working.

In the assembly hall, there are skylight windows allowing a considerable amount of daylight into the hall.

Total area of skylight windows: about 1 200 m² = 16% of the floor area

Total area of ordinary windows: about 160 m² = 2% of the floor area

Table 1: Measured power demand in the assembly hall, including driving device losses, before the retrofit

Additional lighting:	13.0 kW
General lighting:	75.7 kW
Specific lighting:	12.0 W/m ² (6 300 m ²)
Total lighting:	88.7 kW

The above results for the installed power demand were obtained first with all the lights switched on and then with only the general lighting switched on. The measured results respond to power factor cos j=1. The horizontal illuminance (1 metre above the floor) was measured when it was dark outside and with only the general lighting switched on. The illuminance in the assembly hall varied between 400 and 575 lux and in the warehouse between 180 and 325 lux. The operating time was 4 400 hours per annum and the use of energy was 333 MWh.

Table 2: Operating costs per annum

	kSEK
Power demand cost (229.5 SEK/kW x 75.7kW)	17
Energy cost (333 MWh x 240 kr/MWh)	80
Maintenance cost (tubes & replacement, incl. labour)	5
Total annual operating cost (1989)	132

NEW BRIGHT LIGHT

The new general lighting system in the assembly hall consists of tube fittings with high frequency ballasts to ensure constant illuminance in combination with incoming daylight. The fittings have been symmetrically assembled on to existing wires. The company wanted to use these existing wires at 4.5 metres above the floor because of transportation and high vertical workstations (assembly stands). The consequence of this was that the desired average illuminance of 300 lux was exceeded by 110 lux at the design stage. However, with the constant illuminance system this is no longer a problem and the desired illuminance of 300 lux is now obtained.

Table 3: Data on the new lighting system.

Number of tube fittings:	446
Manufacturer:	Taiba
Type:	116B-258-6
Reflector:	high finish, electrically oxidated, pure aluminium and wide radiating
Anti-glare screen:	aluminium
Tubes:	two 50W, argon gas (Philips)
Drive device:	high-frequency device (Philips) to control the constant-illuminance system, 28 - 45KHz.
Loss of power per tube fitting:	11W
Total capacity per tube fitting:	111W
Installed power demand:	49.5 kW
Specific lighting:	7.8 W/m ² (6 300 m ²)

ELECTRICITY SUPPLY

In the electrical interlock board room there is a main central unit which is supplied by a 0,4 kV switch gear unit. Main cables run from the main central unit to all the eight cubicles situated in the assembly hall. In every cubicle there is a central unit and single-phase cables run from here to tube fittings in every work module in the assembly hall. There are 40 modules in total, but only 31 are included in the new general lighting system. Every work module covers 200 m² and has 15 tube fittings, except where there are offices and similar units within the module.

OPERATING THE LIGHTING SYSTEM

The on and off functions of the lighting system are divided into two main functions. The first operates the lights at staff and transportation passages and along the outer wall. There is no subordinate timefunction. The lights are operated manually through switches placed by the assembly hall's entrance and exit. The second main function operates the lights for the work modules and is controlled both manually and through a timer. The timer is operated through a computer unit. The maximum rating is between 06.00 - 24.00.

In conjunction with the time control there are switches to control four lighting sections at the main entrance of the assembly hall. Each section includes up to ten work modules, which offers a possibility to switch off the light in the sections where no one is working, e.g. in the evenings.

In addition, every work module has its own light switch used by the staff working in the particular module. The purpose of this switch is that the light should be switched off when no one is working in the module. One of the work modules has two attendance transmitters, assembled behind the circuit closer. This is to achieve an automatic on/off lighting function. One running time meter has been installed in this module for later evaluation. Another module with only an ordinary lightswitch, also has the running time meter installed.

Constant-Illuminance System

In order to combine the new general lighting with incoming daylight, a constant-illuminance system manufactured by Philips has been installed. The system consists of one high frequency device (HF device) of adjustable design, one light relay and one amplifier. The constant-illuminance system operates as follows:

The light relay (a photocell), the amplifier and the high frequency devices work in a closed circuit. Depending on the amount of daylight and the adjusted sensitivity the light relay responds to, the voltage (A) between the relay and the amplifier, can vary between 0 - 12 V. The control voltage (B) from amplifier to HF device varies between 1V (45 kHz and 10% illuminance) and 10V (28 kHz and 100% illuminance). The circuit is constructed to be steady if the light relay voltage (A) is, for instance, 6V.

When (A) is less than 6V, the control voltage will increase (B), which brings the fittings to produce more light and the voltage increases (A). When (A) is more than 6V, the control voltage (B) will decrease, which diminishes the light from the fittings and the voltage (A) is hence reduced. Conclusion: the control voltage (B)

controls the illuminance given by the tube fittings, as an effect of the amount of light reaching the light relay, which responds accordingly and gives the voltage 6V. The obtained illuminance, in this case 300 lux, depends on the adjustments made on the light relay.

It is very important that the light relay is correctly located to get a well functioning system. It should be placed where it can register the incoming daylight as well as the light from the "dimmed" fittings, the so called measurement area. An appropriate assembly level in this case is levelled with the fittings themselves. It should also be placed so that the measurement area is not affected by direct sunlight, additional located lights, temporary changes in the interior design etc. It should not be possible to switch off the light in the measurement area alone. The measurement area is representative of the incoming daylight in the rest of the hall. In this particular project it was one of the assumptions that the daylight spread evenly in the assembly hall.

Saving Energy

If the operating time remains at 4 400 hours per annum, the energy saving will amount to approx. 183 MWh. The use of energy will be 150 MWh with the new lighting system compared to previously 333 MWh. However, this is only the estimated figures and only after a running period of 1 - 3 years can a reliable result be obtained.

Table 4: The calculated energy consumption of 150 MWh is based on the following data.

Energy used with HF device without constant-illuminance system	218 MWh
Reduced energy consumption with constant-illuminance system (31%)	68 MWh
Annual energy consumption	150 MWh

The reduced energy consumption calculation (68 MWh) is based on a combination of using the daylight throughout the year and reducing the new average measurement of illuminance from 486 lux to 300 lux.

Table 5: Annual Operating Costs

	kSEK	
	New system	Previous
Power demand cost (229,5 SEK/kW x 49,5 kW)	11	17
Energy cost (150 MWh x 240 SEK/MWh)	36	80
Maintenance cost (tubes and replacements incl. labour)	17	35
Total annual operating cost (1989)	64	132

The annual savings with the new lighting system is about 68 kSEK compared to the old system.

Initial Expenses

The total investment in the new lighting system at Ericsson Telecom AB is 988 000 SEK. It includes the costs shown in table 6.

Table 6: Total investment.

	kSEK
In accordance to the made offer	905
Additional orders	83
Total initial expense	988

Table 7: Investment costs – specific costs.

	Investment kSEK	Demand MWh	Reduction MWh	Reduction SEK/kWh
Previous lighting	–	333	–	–
Conventional lighting	683	286	47	14.53
HF-device	794	218	64	1.73
HF-devicewith dimmer	988	150	72	2.69

The pilot plant is financed by Ericsson, GEAB and Svensk Energiutveckling (SEU).

OBSERVATIONS

Several problems occurred on this journey towards an entirely new lighting system in the assembly hall. The time table for instance could not be kept, the reason being faulty reflectors. The faulty reflectors were wide-radiant and had dents on the top part, damaged in the production. This was not discovered until the assembling of the reflectors was in its final stage.

When checking the illuminance with the correct wide-radiant reflectors, it was also discovered that the expected minimum of 70 % levelness between the highest and the lowest illuminance measure, simply could not be held. When looking at the manufacturer's information sheet, it was clear that the manufacturer must have made an error.

After changing the faulty reflectors to new medium-radiant reflectors in four tube fittings, the illuminance was checked again and the 70% limit was kept. All the faulty reflectors were changed as well as the fitting sides and anti-glare screens.

At the same time, the light relay (photocell) was fitted, which would form part of the constant-illuminance system. This work was delayed due to change of staff at the supplier Philips Ljus AB. This has taught us that it takes a fair amount of interest and involvement even from the supplier when new technology is purchased. The large amount of faulty high-frequency devices added to the delay.

CONCLUSIONS

The lighting retrofit at Ericsson Telecom AB's plant in Visby is the first of its kind in Sweden. The high-frequency device together with the constant-illuminance system has meant an entirely new lighting technology to contractors as well as purchaser.

The new lighting system has undoubtedly several advantages compared to the old one. Above all is the non-flickering light appreciated by the staff. However, a decline in the rate of absence due to illness has not been established yet since the time has been too short to evaluate the long-term influence of the new lighting-system. An increase in productivity is difficult to verify as well, since work in the factory has not been on full capacity after the time of the retrofit.

The difficulties in adjusting the constant-illuminance system and in particular the optimal placing of the light relay (photocell) appears to be solved in the end.

We have made an important experience: it is most important to assess the incoming daylight and its interaction with the electrical lighting system's performance.

REFERENCES AND NOTES

- [1] 300 lux is recommended to the manufacturing industry in the booklet "Låt inte belysningen stå och läcka energi" 1988.
- [2] Abbreviations: kSEK = thousand Swedish kronor
- [3] Currency: 1SEK = 7.47 ECU (September 1991)