Better Lighting Saves Money

Pilot Project on Efficient Lighting at the National Autonomous University of Mexico (UNAM)

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Foreword

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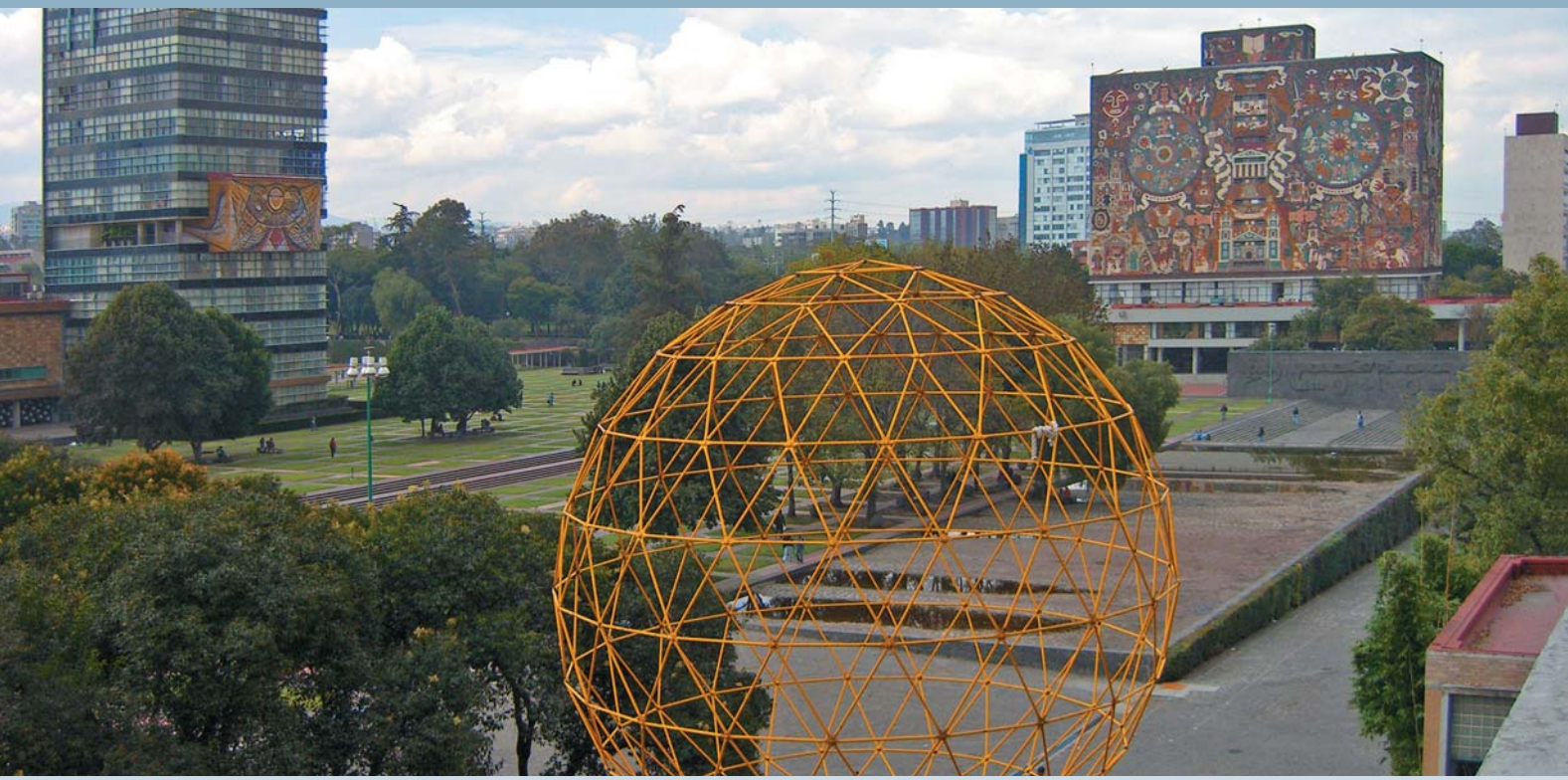
Ex-Director, UNAM Instituto de Ingeniería (Institute of Engineering)

This report includes a brief account of the current work at the National Autonomous University of Mexico (UNAM) in order to improve the lighting efficiency in its University City campus (Ciudad Universitaria), located in the south of Mexico City. The primary investigator of this project has been Büro Ö-quadrat, a German consultancy firm for economical and ecological studies and the UNEP/Wuppertal Institute Collaboration Centre on Sustainable Consumption and Production. The Mexican counterpart is Genertek S.A., a distinguished consultancy firm headed by Prof. Alex Ramírez, a lecturer in engineering of UNAM. The results herein reported were greatly facilitated by Dr. Carlos Gay-García, director of the Centre for Atmospheric Science (Centro de Ciencias de la Atmósfera) and Dr. Sergio M. Alcocer and Dr. Adalberto Noyola, who headed the Institute of Engineering during the course of the study. Both institutions belong to UNAM. As work was announced to start, the very valuable contributions of the School of Sciences and the School of Engineering of UNAM were added to the effort. In fact, as the reader of this report will realize, the combined effort to improve lighting efficiency and quality at UNAM is gaining momentum and will probably never stop.

The report may sometimes seem to be straightforward however it is extremely accurate in describing the present status of lighting practices at UNAM and of Mexico in general. In order to meet the electricity demand of perspective laboratories and new facilities, saving is proven to be the very best option. It is important to recognize that research and development in energy-saving lighting is in an early stage at UNAM and in Mexico. Therefore, it is very encouraging to see that a large part of the design and implementation of the new installations were performed by Mexican students and technicians, under the guidance of Prof. Ramírez of Genertek. Together with other university efforts of recent years, our university can become a model-campus of lighting and an energy-saving consultant itself. Thus taking a leading role in mitigating climate change while reducing CO_2 and toxic gas emissions.

As the finiteness of fossil fuels becomes an ever more important topic worldwide, it is very pleasant to realize that new research and development areas arise, not only to provide new economic and technological importance to university concerns, but also to improve the very basic enterprise of teaching. In fact, improved lighting should translate into better teaching results. And better lighting comfort does not only arise from better engineering or improved design; as the report describes, the physical nature of light, very much affected by the room decorations and fixtures, colours and materials, has a definite effect in learning. New areas of research in general comfort, teaching effectively and engineering practice also arise. Overall, this report is rich and welcome in providing new roadmaps for university development in very broad aspects.

1 The Project



The National Autonomous University of Mexico (UNAM) is the oldest and one of the most prestigious universities in the Americas.

UNAM is home to about 300,000 students, who together with their lecturers have access to no less than 130 different libraries.

UNAM's ensemble of buildings, sports facilities and open spaces were designated as a UNESCO World Heritage site in 2007.

Efficient Lighting – Spares State Coffers and the Climate

Lighting makes up a relatively large share of electricity consumption. Some 19 percent[1] of global demand for electricity is apportioned to the need for light. This figure is even higher in the retail and services sectors (34 percent)[2]. In schools and universities, lighting is often responsible for over half of the total electricity bill. The use of modern, efficient lighting technology can bring great savings in energy use and cut operational costs. This was the starting point for a unique pilot project carried out at the National Autonomous University of Mexico (UNAM).

Commissioned by the initiative "WISIONS of Sustainability", Büro Ö-quadrat and the UNEP Centre on Sustainable Production and Consumption (CSCP) devised a project which highlights how UNAM can benefit from an upgrade to more efficient lighting.

What makes the project unique is that it is based not only on theoretical calculations, but on experience gained with four separate modernisation programmes, which were designed and implemented in cooperation with Instituto de Ingeniería (Institute of Engineering) and Centro de Ciencias de la Atmósfera (Centre for Atmospheric Science).

Thanks to the excellent advanced planning and work performed by the Mexican engineering company Genertek S.A., significant savings and high returns on investment have been achieved.

Master plan pinpoints huge cost-saving potential

Based on the experience gained with the four model lighting modernisation projects, the results were extrapolated to produce a master plan for the entire university campus. The outcome was extremely impressive: in return for an initial investment of just US$ 3 million, and by reinvesting the savings resulting from lower electricity costs over the next seven years, UNAM would save approximately US$ 68 million in electricity and operating costs for the entire lifecycle of the investment[3]. This constitutes huge savings from which everyone would benefit:

- The Mexican government benefits because the cost-saving measures significantly reduce electricity and maintenance costs at UNAM.
- The energy utility Luz y Fuerza benefits because lower electricity consumption eases the university's power distribution network, doing away with the need for expensive infrastructural improvements.
- Mexican society benefits because less electricity is generated, making more oil available for export or other purposes.
- Both the environment and the climate benefit from lower emissions of pollutants and greenhouse gases.
- Finally, students, lecturers and university staff benefit from better lighting and flikker-free light. Saving electricity enhances user comfort at UNAM.

[1] IEA, 2006: Light's Labour's Lost. Policies for Energy-Efficient Lighting, p.177
[2] Op. cit., p. 178
[3] Based on the lifecycle of the new lighting system (20 years) and a constant electricity price of US$ 0.16/kWh

Hidden potential worth millions

Electricity consumption at the university amounts to 70,000 MWh per year[4]. Because most buildings are neither heated nor air conditioned, lighting is the greatest eater of electricity.

A well-planned upgrade of the existing lighting system could result in overall savings of 60 percent and cut UNAM's electricity consumption by about a quarter. The university's lighting system thus harbours great savings potential.

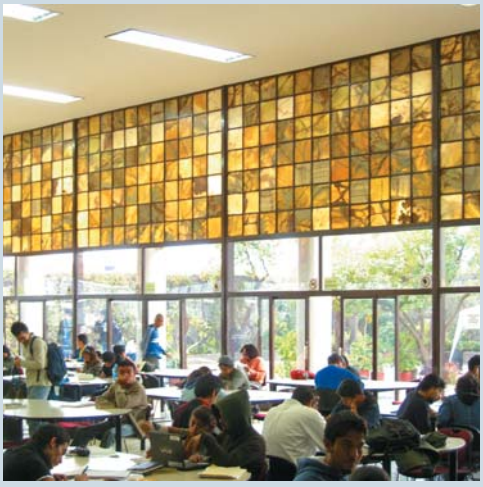
High returns from modern technology

The lighting in many UNAM buildings is over thirty years old. Out-dated T12 tubes (38 mm diameter) are used, which give off somewhere between 15 and 20 percent less light than subsequent T8 technology (26 mm diameter).

Replacing the T12 tubes not with T8 but with even more efficient T5 tubes (16 mm diameter) would allow a whole technology to be jumped, whereby better results can be achieved.

Using high-efficiency tubes, electronic ballasts and lighting controls could allow energy savings of up to 90 percent along with higher returns on investment.

[4] Exact details of electricity consumption cannot be provided because it is difficult to calculate the volume for some buildings whose electricity is supplied from decentralised sources.



Better light, greater comfort

Many lights are in poor condition and only give off between 50 to 70 percent of the light they originally provided. Lighting quality is equally poor in some places. Upgrading the entire lighting system would make the campus far more comfortable to work in.

Intelligent controls minimise need for artificial light

In many parts of the UNAM campus, lights remain switched on even when daylight is sufficient. And lights are frequently left on when rooms are not in use.

With intelligent lighting controls, the use of artificial lighting can be made dependent on the amount of incident daylight available and thus cutting electricity consumption significantly.
Presence detectors are another cost-saving aid: if a room is not being used, the lights are automatically switched off after a short period of time.
As will be shown later, this project involves an extremely cost-effective investment which will in no way undermine the user comfort.

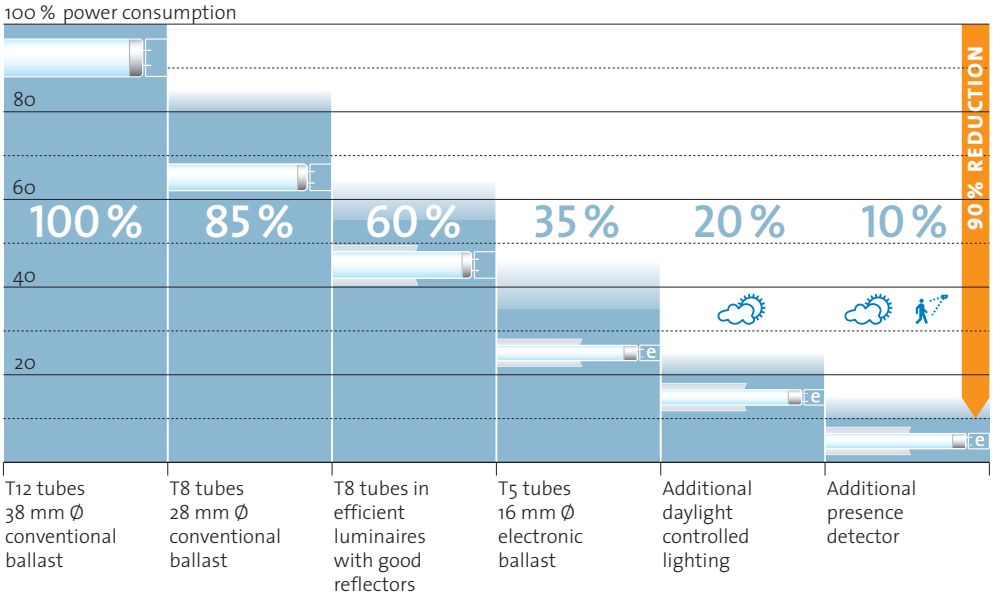
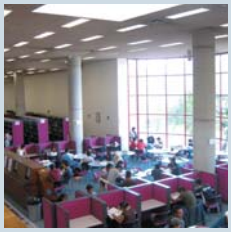


Fig. 1.1: Optimised lighting upgrade: Use of efficient technology can cut electricity consumption by as much as 90%

2 New Lighting: Four Model Areas

2.1 Classroom

2.2 Library



2.3 Foyer

2.4 Workshop

Four specific areas are used to illustrate how a well-planned lighting upgrade can cut costs and enhance the quality of lighting in the buildings. The four typical upgrade scenarios are as follows:

- Classroom, laboratory
- Library
- Foyer
- Workshop, laboratory

Based on the findings of the retrofit examples and those of further analyses, a master plan was developed to replace the lighting in UNAM campus buildings (see chapter 3).

2.1 Classroom, Laboratory

Pre-upgrade situation
The laboratories at the Institute of Engineering were built several decades ago and have shed roofing to provide glare-free daylight (see pictures beside and below).

The current lighting is in need of replacement and is no longer in keeping with energy-efficient technology. A tour of the laboratories also showed that:

- Artificial light is not adjusted according to incident daylight.
- Presence detectors have not been installed. The lights stay on even when a laboratory is not in use. This is partly because the light switch is situated in one particular laboratory at the other end of the building.

Package of measures
Following a detailed plan, high-efficiency luminaires including T5 technology with dimmable, electronic ballasts were installed.

These changes provide the amount of light needed relative to incident daylight. The more incident daylight is available, the less artificial light is produced. Once the required light level is reached, the room is lighted exclusively using natural daylight.

The new lights were also wired to presence detectors, so that they are only switched on when the laboratory is in use.

Outcome

- These measures have reduced electricity consumption in the laboratory by 72 percent.
- The annual savings amount to 4,500 kWh.
- The payback period is 5.4 years.
- Better visual comfort and uniformity of the lighting level.

Shed roofing on the laboratories of the Faculty of Engineering

Before: Laboratory with daylight and artificial light

After: Laboratory with new daylight-controlled lighting

	Pre-Upgrade	Post-Upgrade
Lighting	2 x 32 Watt (T8)	1 x 28 Watt (T5)
Ballasts	Conventional	Dimmable, electronic
System power	60 Watt	33 Watt (max)
Luminaire efficiency	40%	75%
Daylight control	No	Yes
Illuminance level (Ø)	374 Lux	438 Lux
Electricity saved	**–**	**72 %**

2.2 Library

The Rivero Borrell library

Pre-upgrade situation

UNAM has around 130 libraries of varying sizes. The Rivero Borrell library selected for the model project is representative of all other libraries on the campus. The lighting systems in the libraries of UNAM are in use for many hours throughout the year. So these areas are of particular interest for a modernisation program. The existing twin-tube lights were each equipped with two T8 tubes and an electronic ballast, but the luminaire was inefficient.

Package of measures

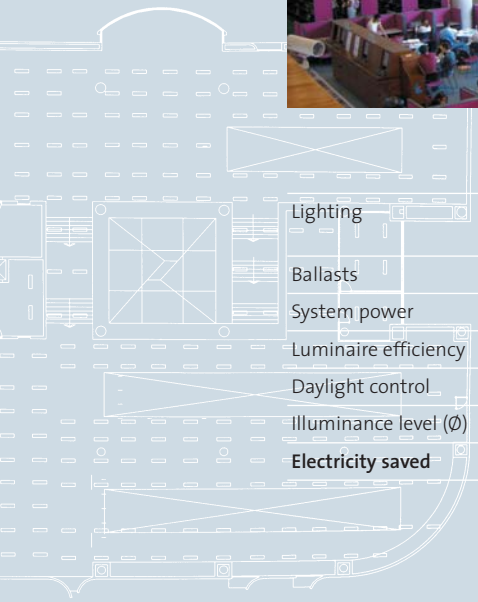
The existing lights were replaced by high-efficiency models (86 percent efficient)[5]. Light is now provided by one T5 tube with high luminous efficiency and a maximum power consumption of 62 Watt. The amount of light given off is controlled by a daylight sensor. When incident daylight is strong, artificial light is reduced or switched off. At dusk and during the darker hours, the light sensor indicates that more artificial light is needed.

[5] The power consumption of the old lighting systems, which depend on the age of the lamps and the ballasts, was measured by the laboratory of Genertek S.A.

Outcome

- If the new lighting system is in full use it consumes the same amount of electricity as the old system. However, the new lighting system provide much better light at reading tables.
- The new lighting system effects significant savings on maintenance because the lights and their components have a longer lifecycle than the old ones.
- With the new daylight control, the light tubes have shorter running time, it is subject to less wear and tear and the maintenance intervals are longer. As the ceilings are approximately 7 metres high, scaffolding is needed for maintenance work, which makes every replacement of light tubes and ballasts an expensive undertaking.
- Despite significantly higher level and better lighting quality during the early mornings and late evenings, electricity consumption is reduced by more than 50 percent.
- The payback period is 12.3 years.
- Keeping the illumination quality unchanged whould have led to electricity savings over 75 percent.

The library before retrofiting the lighting system. Artificial light is added to daylight.



	Pre-Upgrade	Post-Upgrade
Lighting	2 x 32 Watt (T8)	1 x 54 Watt (T5 High Output)
Ballasts	Electronic	Dimmable, electronic
System power	60 Watt	62 Watt (max)
Luminaire efficiency	40%	86%
Daylight control	No	Yes
Illuminance level (Ø)	293 Lux	479 Lux
Electricity saved	**–**	**59 %**

2.3 Foyer

Pre-upgrade situation
Foyers are also one of the typical elements in the UNAM buildings included in the pilot project. They are particularly well-suited for the purpose because incident daylight can often be used and existing artificial lighting is usually too strong and is left switched on for prolonged periods.

The Centro de Ciencias de la Atmósfera foyer is open day and night, including weekends, because staff often work on experiments that are conducted overnight and throughout the weekend.

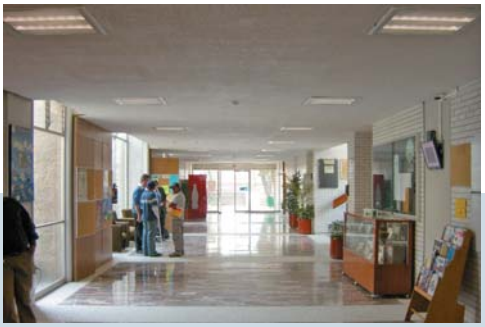
Prior to the upgrade, 36 lights (each with four tubes) were left on during the day, although the foyer is flooded with daylight from the side. At night, a single row of lights with 18 old, inefficient tubes was left permanently switched on.

Package of measures
During the upgrade, 36 lights were replaced by 18 high-efficiency lights. The new lights were fitted with dimmable electronic ballasts and a lighting control system made by lighting specialist Leviton.

Now, only as much artificial light is used as is needed. At night, the vast majority of lights (with the exception of those in the reception area) are only switched on when someone enters the foyer and the movement detector activates them.

Outcome
- These measures cut the amount of electricity needed to light the foyer by more than 90 percent.
- Annual electricity savings amount to 21,000 kWh.
- The modernisation costs will pay for themselves in 1.3 years.
- These changes are not limited to the institute foyer. In fact, the UNAM campus has many similar foyers, all with energy saving potential of over 90 percent.

Centro de Ciencias de la Atmósfera



The institute foyer (Centro de Ciencias de la Atmósfera) pre and post modernisation

	Pre-Upgrade	Post-Upgrade
Lighting	4 x 20 Watt (T12)	2 x 14 Watt (T5)
Ballasts	Conventional	Dimmable, electronic
System power	96 Watt	33 Watt (max)
Luminaire efficiency	35%	84%
Daylight control	No	Yes
Illuminance level (Ø)	123 Lux	180 Lux
Electricity saved	**–**	**> 90%**

2.4 Workshop, Laboratory

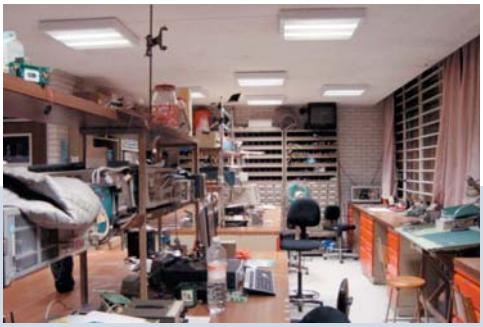
Pre-upgrade situation
UNAM has numerous workshops and laboratories. The standard of lighting in the laboratory of Centro de Ciencias de la Atmósfera, which was studied in the model project, was especially poor. The task at hand was not only to save money but to significantly improve the quality of lighting in the building.

The poor lighting in the workshop stemmed from the fact that the lights had previously been fitted with 300 Watt lightbulbs. When new bulbs were purchased, the old ones had gradually been replaced with 100 and 150 Watt bulbs. This meant that the built-in reflectors could no longer fulfil their function. The 100 Watt lightbulbs are significantly shorter in length, causing the focal point to shift considerably in relation to the reflector (see picture on the left). The result was extremely poor lighting.

Package of measures
The upgrade was completed without the need for a lighting control system because it was assumed that the laboratory's few users could switch the lights on and off as required.

Outcome
- The modernisation measures resulted in a significantly better standard of lighting, with an increase of illuminance level from an average 50 Lux to 206 Lux.
- Energy savings of approximately 70 percent were achieved.
- The payback period is 5.9 years.

Old lights in the laboratory at the Centro de "Ciencias de la Atmósfera", with 100 Watt lightbulbs and reflectors



New lighting in the Centro de "Ciencias de la Atmósfera"

	Pre-Upgrade	Post-Upgrade
Lighting	Lightbulbs	2 x 14 Watt (T5)
Ballasts	–	Dimmable, electronic
System power	100 / 150 Watt	33 Watt
Lamp	100 / 150 Watt	2 x 14 Watt
Illuminance level (∅)	50 Lux	206 Lux
Electricity saved	**–**	**65-75%**

2.5 Economic aspects

When planning this type of lighting system, the first thing that must be done is to determine how much light is required.
Of the four sample rooms, the lighting in the library and the workshop/laboratory at the Institute for Atmospheric Research was far from adequate.

In both cases, a lighting system was planned which provides significantly better lighting quality. The situation was particularly poor in the laboratory at Centro de Cienias de la Atmósfera. Lighting was installed which was four-times as strong as that of the pre-upgrade lighting system.

Even so, there was still potential for huge energy savings because the laboratory had been equipped with light bulbs. If the new lighting had been installed with the same light output as the old system, then the more efficient lighting would have achieved a 94 percent cut in electricity consumption.

In implementing the project, all costs were identified and compared with the savings achieved. The viability of the modernisation measures is shown as a simple capital payback period. However, no interest is calculated against the capital investment and no price increase is taken into account for electricity supply. The payback period for the capital investment was between 1.3 years (entrance/foyer at Centro de Cienias de la Atmósfera) and just over 12 years (Rivero Borrell library). The extremely short payback period for the Centro de Cienias de la Atmósfera foyer is due to the very long running time of the pre-upgrade lighting system.

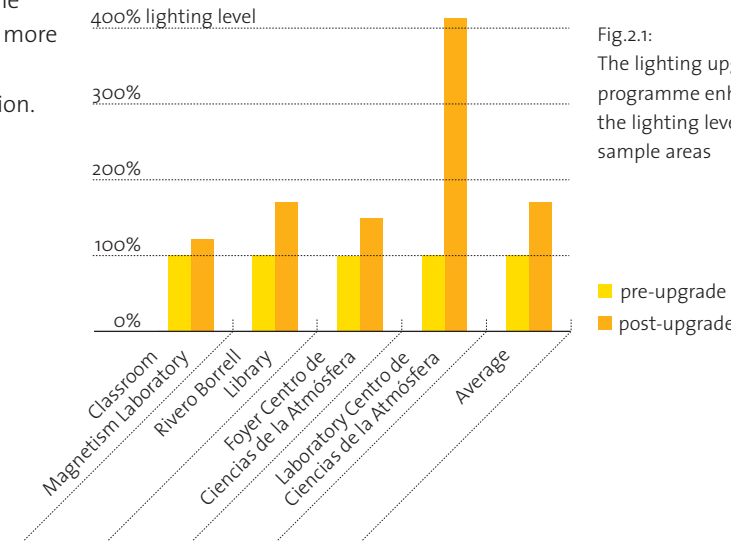


Fig.2.1:
The lighting upgrade programme enhances the lighting level in all sample areas

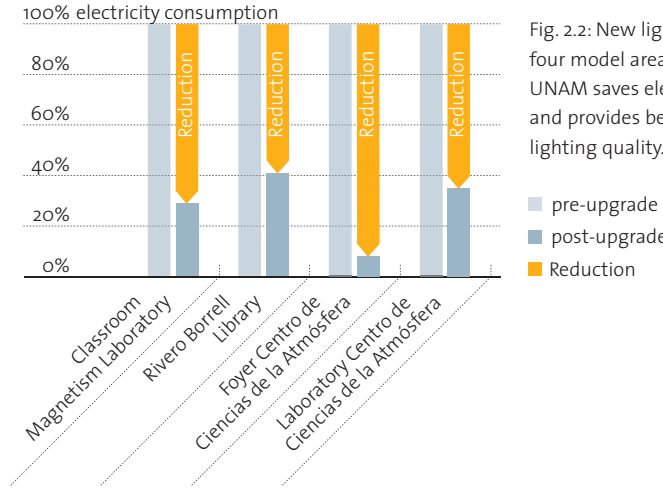


Fig. 2.2: New lighting in four model areas at UNAM saves electricity and provides better lighting quality.

Electricity consumption of the old lighting system was high, because of its constant use, despite the availability of incident daylight. The significantly more efficient lights and a daylight-controlled system as well as presence detectors reduce consumption to an absolute minimum.

The longer payback time for the library can be attributed to several factors:

- The pre-upgrade T8 tubes were already fitted with electronic ballasts, so that compared with the old system, the energy saved with the new, more efficient technology is lower than in other cases.
- The lighting control system only applies to the 12 luminaires that were replaced, meaning that the cost of investing in the light control system is spread over a relatively 'small' saving.
- The illumination level was increased by about 60 percent.

The **average payback** period for all four rooms in the model modernisation project (total investment divided by the overall annual electricity saving in the four areas) is just **under three years**. While this appears to contradict the individual results, it can be explained in that the foyer was the biggest area and was also where the greatest savings were achieved, which made this result the dominant factor in the average results for all four areas.

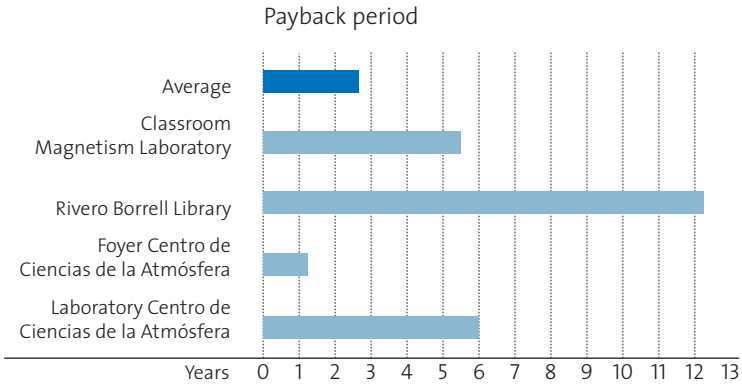


Fig.2.3:
Payback period for four examples of lighting upgrades at UNAM

Room/Area	Investment	Savings in electricity costs	Savings on maintenance costs	Total savings operational costs	Payback period	Electricity saving
	US$	US$/yr	US$/yr	US$/yr	Years	kWh/yr	Percent
Magnetism Laboratory (classroom)	4,400	713	97	811	5.4	4,458	72
Rivero Borrell Library	2,900	224	11	235	12.3	1,402	59
Foyer Centro de Ciencias de la Atmósfera	4,900	3,319	574	3,893	1.3	20,746	92
Workshop/Laboratory Centro de Ciencias de la Atmósfera	1,700	260	30	290	5.9	1,625	65
Total	**13,900**	**4,517**	**712**	**5,229**	**2.7**	**28,231**	**84**

Fig. 2.4:
Investment and annual cost-savings achieved in UNAM model modernisation projects

Saving energy is cheaper than generating electricity

From an economic perspective, there are clear benefits from saving electricity. Even looking simply at the fuel-related costs of electricity generation, the costs involved in saving electricity are lower.

Fig. 2.5 shows a comparison between the fuel costs (excluding capital outlay) per kilowatt hour of electricity generated in an oil-fired power station when the price of oil is low (US$ 50 per barrel) and when the oil price goes up to US$ 100 per barrel as forecast for the longer term. The fuel-related electricity generation costs are compared with the specific investment cost of the energy saving package adopted in each of the four model rooms.

These were calculated based on the investment costs determined as an annuity on a 20-year loan and an interest rate of 8 percent.

The findings show that even leaving out the capital outlay costs and other operational costs for power plants, transport and distribution networks, investing in efficient lighting is the more cost-effective option.

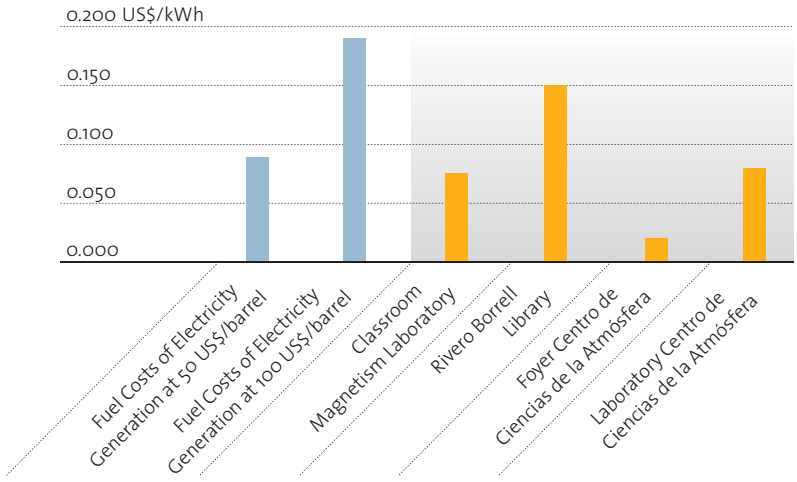


Fig. 2.5: Comparison of electricity generation costs in an oil-fired power plant (fuel costs only) and the costs of Negawatts (cost per saved kWh by the lighting system)

3 Master Plan: New Lighting at UNAM

3.1 Introduction

The master plan for a better lighting at UNAM establishes the broad, strategic principles which have to be followed and gives an estimation of the necessary budget and the returns in energy cost savings which can be achieved.

Providing efficient lighting for a room or a building is a highly complex matter and involves far more than simply replacing old light bulbs or tubes with new ones. An efficient lighting plan has multiple components and because they are interdependent, each step must be implemented in accordance with an integrated approach. For example, daylight-controlled lighting requires the use of dimmable, electronic ballasts. By using latest technology, electricity consumption can be reduced by 90 percent while providing the same lighting level.

When developing this master plan, it was assumed that the following systematic approach would be taken when replacing the lighting system.

1. Determination of lighting level

The desired and required degree of lighting level must be ascertained in lumen per square meter. The task at hand is to find out how much light is needed to perform certain tasks in different areas of a room.

2. Light reflection

The next step involves designing a room so as to provide the best possible conditions for light to be reflected and incident light to be used. The brighter the walls, ceilings and floors, the more light can be reflected.

3. Efficient technology

The third step takes in the choice of efficient luminaires, lamps, reflectors and ballasts to enable the desired degree of light to be achieved with minimum use of energy.

4. Use of daylight and lighting control systems

In step four, all available technology is installed to allow use of incident daylight, for example use of light-directing sunshades. Use of daylight sensors should minimise the need for additional, artificial light.

5. Presence detectors

Presence detectors can ensure that lighting is only activated when a room is actually in use.

Energy savings of up to 90 percent are possible.

3.2 Approach

In drawing up the master plan, a dozen UNAM buildings were analysed and lighting use patterns were monitored in each of the buildings. Four typical lighting situations were identified:

- Lighting in foyers and corridors, both those on the outside and those towards the middle of the building (without incident daylight)
- Libraries
- Seminar rooms and class rooms in which lectures are held
- The offices of the university departments and the administration.

For each lighting situation, an efficient lighting system was designed and both the investment costs and the savings in electricity costs were calculated.

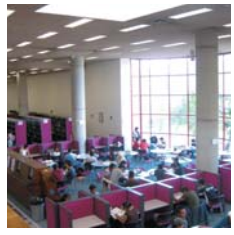
As shown in Fig. 3.2, the profitability of the lighting upgrade differs relative to location and lighting use patterns. To calculate the basic payback period, neither the interest rate on the loans nor the expected price increase were taken into account.

Modernisation schedule

It was assumed that the modernisation work will begin in those areas where savings were greater relative to the amount of money invested (Fig. 3.1). This meant almost all foyers and corridors in the UNAM buildings. The payback period is less than two years (Fig. 3.2).

- In the first year, the lighting in all foyers and corridors are replaced.
- In year two, work is started on one quarter of the libraries. Over a four-year period some 100 of UNAM's 130 libraries receive new lighting.
- In year four, the seminar rooms are tackled with work stretching over four years.
- In the sixth and seventh years, new lighting is installed in all offices.

Foyers/Corridors



Libraries

Seminar rooms

Offices

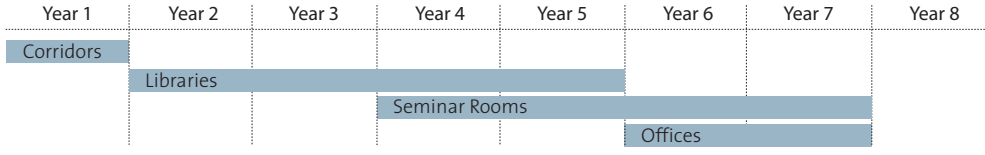


Fig. 3.1: Modernisation schedule for the master plan

3.3 Costs and Benefits

The next step involved calculating the investment-related costs and the annual operational savings to be poured back into the project (see Fig. 3.3).

The total investment from the first to the seventh year amounts to US$ 13.9 million. During the same period, some US$ 13.7 million in energy and maintenance cost savings flow back to the investor.

- New lighting in the foyers and corridors requires an investment of US$ 760,000 in the **first year**. This is offset by annual savings on electricity costs of US$ 444,000 (Fig. 3.3).[6]
- In **year two**, US$ 1.7 million is invested in new lighting for the libraries. The savings on electricity costs arising from the installation of new lighting in the foyers, corridors and some of the libraries amount to US$ 0.92 million in this year alone.
- A further US$ 1.7 million is invested in another 25 libraries during **year three.** The annual savings on energy costs come to US$ 1.4 million.
- In **year four**, the installation of new lighting in yet more libraries and in seminar rooms entails an investment of US$ 2.9 million. Even at this stage of the project, the investment can largely be covered by the savings on energy costs (this includes expenditure that would otherwise have occurred for regular maintenance work).

Hence, in return for an initial investment of US$ 3 million, the savings on energy costs accrued over the lifecycle of the new lighting systems (20 years) amount to US$ 68 million.

After deducting the overall investment of US$ 13.9 million, net returns of US$ 54 million are achieved on an initial investment of just US$ 3 million.

In figure 3.4 the allocation of the investment costs into the different areas is compared with the annual savings in these areas.

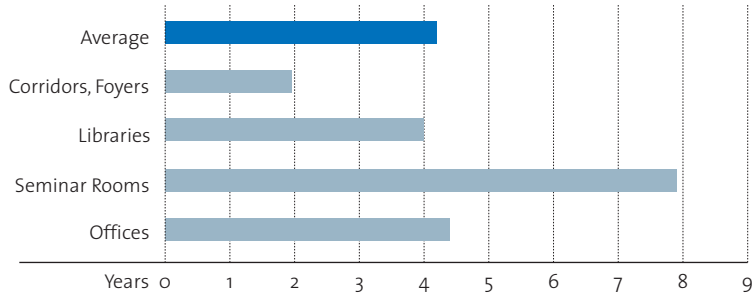


Fig. 3.2.:
Expected payback period on investment in new lighting in typical areas of UNAM

[6] This does not take into account the fact that a portion of the savings in energy costs cannot be achieved at this stage because the investment occurs over the entire year, meaning that the energy savings are not achieved for the whole year.

Climate change mitigation

The total electricity saved per year is estimated at 19 million kWh. The resulting reduction in carbon emissions over the lifecycle (20 years) of the lighting system is 266,000 tonnes.

Minimal risk

Although the calculations contained in this master plan can vary by 10 or 20 percent either way, the logic and economic success of the approach goes uncontested. There is nearly no risk of entering into a bad investment.
A systematic approach coupled with ongoing monitoring and control of expenditure and savings provides great planning and investment-cost security from the outset.

If the existing savings potential is exploited by investing in a large-scale modernisation programme, bulk purchase of the large quantities of energy-saving technologies required allows scope for prices to be negotiated and thus for reductions in implementation costs.

Given the current global financial crisis, investment programmes that promise long-term savings are especially attractive. The master plan shows that with a systematic approach and low upfront investment, great savings in energy and operational costs can be achieved.

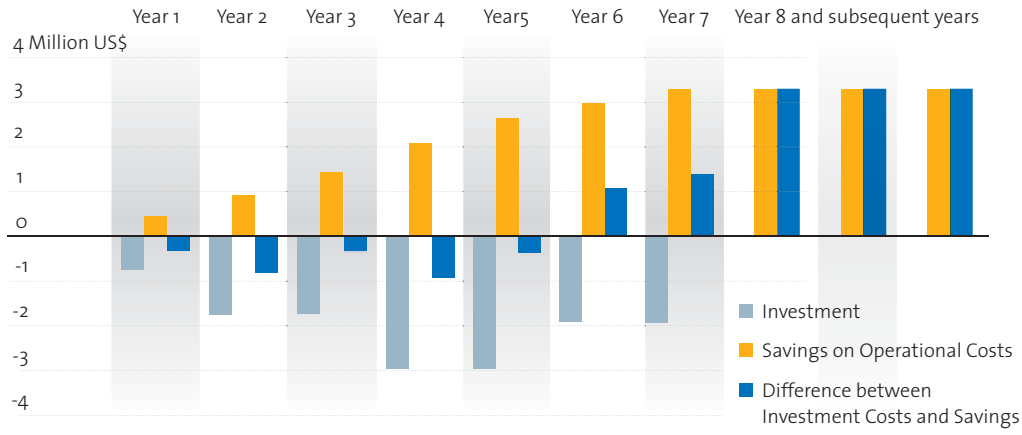


Fig. 3.3: Investment costs for lighting and reinvestment of savings on operational costs (energy and maintenance costs)

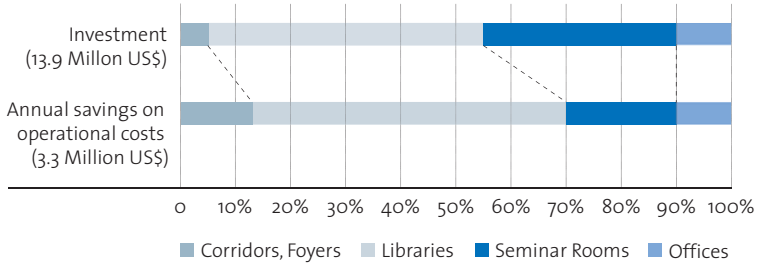


Fig. 3.4: Investment costs for retrofitting in different areas compared to savings on opertional costs.

"The new lighting at UNAM shows beyond doubt that every country has a number of different options when it comes to switching to sustainable management methods and reducing costs in the process. UNAM's new lighting concept could become a lighthouse project for universities around the world".

Michael Kuhndt
Head of the UNEP/Wuppertal Institute Collaborating Centre on Sustainable Consumption and Production gGmbH

Excursion: Benefits of efficient lighting

Efficient luminaires

- With optimised reflectors, light can be directed to where it is actually needed
- High-efficiency reflectors made of aluminium achieve 95 percent efficiency
- The desired amount of light can be achieved using fewer luminaires and lamps
- This reduces the costs involved in replacing the lighting system
- Lower electricity costs are achieved with high-efficiency luminaires
- Maintenance costs are lower due to fewer luminaires and fewer lamps per luminaire

Electronic ballasts*

- More light but less electricity consumed
- Better quality light (no flickering)
- Electronic ballasts last longer than conventional ballasts
- Lights last longer if used in conjunction with electronic ballasts
- Lower maintenance costs
- Lighting level can be controlled
- Defective lights are automatically switched off, thus reducing the risk of fire
- Less heat is produced and thus less cooling required

Lighting controls

- Less number of hours in use, both for lights and for ballasts
- Longer lifecycle for lights and ballasts and therefore lower maintenance costs
- Reduced electricity consumption (more than 50 percent in most cases)
- Less heat produced and thus less cooling required

"I was not really surprised by the results of the modernisation programme. They reflect the type of savings that, with good planning and implementation, we achieve in nonresidential buildings like banks, administrative buildings and factories. They are easy to implement and save a lot of money."

Prof. Alex Ramirez
General Manager
at Genertek S.A.

* Electronic ballast has to be premium quality

4 Exploiting Potential: Ideas and Recommendations

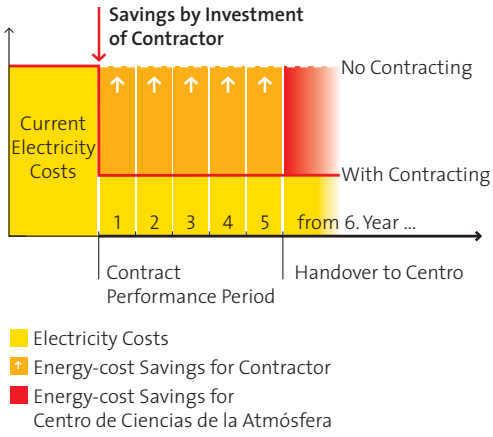
In this chapter we make some suggestions how the implementation of the new lighting system can be realized or supported. Especially in case that UNAM has problems financing the investment or does not want to take any economic risk, the instrument performance contracting can be applied.

Contracting

What is contracting?
Contracting is a services model which is designed to increase efficiency in energy generation and energy use facilities. It is often described as performance contracting.

If, for example, UNAM were reluctant to replace its lighting system as part of an inhouse project because it lacks the technical expertise and economic requirements and cannot produce the necessary funding it can outsource the work to a service provider (the contractor). The saving potential identified at UNAM could be mobilised in this way, with the contractor-provided services of planning, implementation, funding and management of the lighting system during operation being financed from the savings achieved from lower electricity consumption.

Fig. 4.1.
How contracting could work in the modernisation project in the Centro de Ciencias de la Atmósfera



For UNAM, there would be no additional cost and no risk – it would simply benefit from the savings achieved.

Energy performance contracting has proven successful in Germany. The City of Berlin has upgraded some 1,000 buildings in this way.

Example: Contracting for Centro de Ciencias de la Atmósfera
The annual costs for lighting at the Centro (maintenance and electricity for 580 lights) currently amount to US$ 26,000. With the contracting approach, the contractor would guarantee the Centro that for the duration of the contracting performance period and, of course, thereafter, its energy-related costs would be lower than before.

The investment costs involved in upgrading the lighting system would be borne by the contractor. With a contract performance period of five years, the contractor would receive an annual contracting fee of US$ 16,000. Upon completion of the work, the electricity and maintenance costs would only be US$ 9,000, leaving the Centro an annual profit of around US$ 1,000 each year over the five-year period.

Upon completion of the contract, the overall savings would fall to the Centro (that is, to UNAM). From then on, the Centro would save an annual US$ 17,000 in electricity and maintenance costs. With a lifecycle of 20 years, the Centro (UNAM) would gain US$ 258,000 compared with the business as usual model. If electricity prices go up in the 20-year period, the savings are even higher.

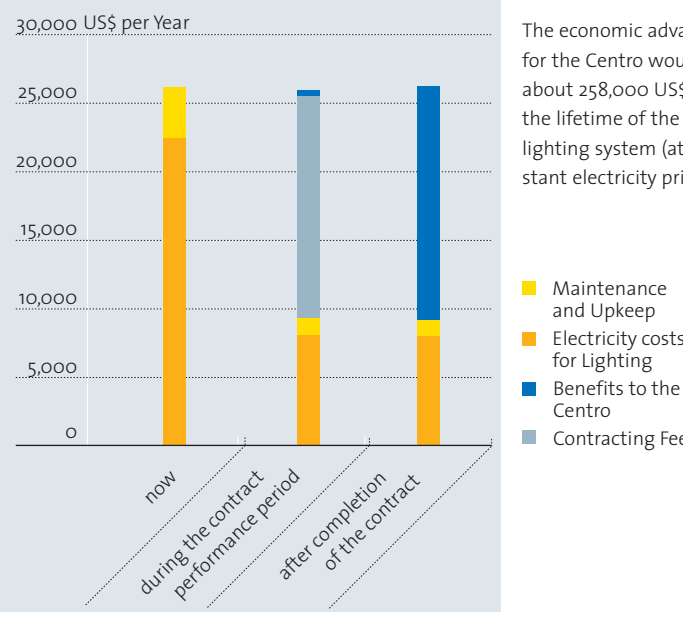
Advantage: The Centro (or UNAM) would face no risk and would be relieved from planning and implementing the cost-cutting measures.

"The new lighting installed in our Centro has had impressive results, with energy savings of 90 percent and better lighting quality. The benefits to the UNAM budget, the environment and the climate are plain to see."

Dr. Carlos Gay García
Director, Centro de Ciencias de la Atmósfera
Universidad Nacional Autónoma de México

Fig.4.2.
Costs involved in a performance contracting project at the Centro (estimate)

The economic advantage for the Centro would be about 258,000 US$ over the lifetime of the new lighting system (at constant electricity prices).



Clean Development Mechanism

Under the Kyoto Protocol, the signatory states have agreed to reduce their greenhouse gas emissions by specific amounts with the first commitment period running from 2008 to 2012. By investing in projects in emerging economies and developing countries, industrialised nations who have agreed to cut their carbon emissions (known as Annex I states) can count the carbon credits generated by these activities towards their national targets as long as their investment serves climate change mitigation and sustainable development.

Projects with great CO_2 reduction potential are highly attractive to investors because the sale of the Certified Emission Reductions (CERs) generated by the projects provides an additional source of income or allows them to offer more favourable contract terms.

Systematic renewal of the lighting on the UNAM campus could generate additional income through the surrender of carbon credits to the Mexican Carbon Fund (FOMECAR). This approach could be used to refinance a portion of the necessary capital investment.

The emission reductions achieved in the lighting upgrade can amount to some 13,000 tonnes CO_2 per year and to 266,000 tonnes over the entire project lifecycle. The sale of carbon credits at an assumed average price of US$ 10 per tonne CO_2 could result in income of US$ 2.7 million over the lifecycle of the lighting system.

Showroom

Energy efficiency offers numerous cost-effective opportunities to cut electricity consumption. However, decisionmakers are not always aware of the type of technology that is needed or available. Investing in a new lighting system in UNAM buildings can be used to demonstrate, explain and provide proof of the benefits and especially the viability of efficient lighting technology to students and to professors.

With a small exhibition or showroom, the different components of an efficient lighting plan can be presented and explained using models. Information boards and interactive models will be used to inform as many UNAM students as possible. After all, today's students are tomorrow's decision makers. It is therefore important to sensitise students to the option of energy-efficient lighting and its role in mitigating climate change.

For example, in the classrooms at the department of architecture, practical use of modern, efficient lighting should be a given.

A visible, modern and efficient lighting system would not only serve as a teaching aid but would confirm and enhance UNAM's image as a contemporary university.

"We must manage limited energy resources more efficiently than we have so far. Investing in high-performance lighting technology would help us switch to sustainable management practices. This study and the measures already implemented at UNAM show that this approach pays off. By installing efficient lighting at our university, we can improve students' learning environment. The subject could also receive greater focus in engineering studies."

DR. José Luis Fernández Zayas
Ex Director, Instituto de Ingenieria at UNAM

Training

Given the outdated lighting in many areas, Mexico and other countries harbour huge potential for the use of efficient lighting technology. This potential provides numerous opportunities for investment and for even greater returns on capital outlay. This could benefit the Mexican economy and the environment. Low lighting costs in the commercial sector can serve to boost competitive standing.

Only a few electronic engineering students at UNAM receive training on efficient lighting. An average of 10 to 15 students opt to study lighting each year. However even if after leaving university, all found work planning efficient lighting systems they would not meet objective demand for qualified planners.

Supervised by Professor Alex Ramirez, students measure the amount of light provided by the new lighting system in the Centre de Ciencias de la Atmósfera foyer

Professor Alex Ramirez and some of his students

Structural change

The departments, institutes and administrative buildings at UNAM are not equipped with individual electricity meters. Despite the fact that the university uses 70,000 MWh of electricity each year, there are only two meters on the entire campus. Electricity is seen as a free resource: it apparently costs nothing and there is no way to trace its usage. It is thus recommended that for each building, at least one electricity meter be installed to enable the electricity costs to be monitored for each building and user. Electricity meters can also help to detect hidden electricity eaters and save costs.

At present, the university administration bears the full costs of electricity used around the campus, which means that the individual departments and institutes have little interest in energy-saving measures because their budgets are not at risk. If the institutes and departments were to invest in lighting, they would not conduct a feasibility study in relation to the electricity costs over the lifecycle of the lighting system. They would be more likely to decide in favour of the solution involving the lowest investment costs because they do not have to bear the costs of the electricity. With this approach, the cheap solution for the institute becomes an expensive one for the society.

A further aspect speaks in favour of measurement and costing of electricity consumption. It can be assumed that the various institutes and departments would be far more careful about the amount of electricity they use if they had to pay for it out of their own funds. By restructuring the budget and reassigning responsibilities, user behaviour could be changed, demand for electricity would drop and the costs to society would be reduced.

5 Summary and Recommendations

The model modernisation plan and the subsequent model calculations in the master plan illustrate the many benefits of upgrading the lighting at UNAM and show that timely, strategically planned modernisation measures make eminent sense.

High profit investment
The investment of US$ 14 million promises savings from lower electricity costs of US$ 68 million over the 20-year lifecycle of the new lighting system.

With an initial investment of around US$ 3 million and reinvestment of the savings achieved from upgrading the lighting and cutting electricity costs, the US$ 14 million needed for a full upgrade of the lighting on the entire UNAM campus could be financed over a period of seven years.

The annual savings in electricity consumption amount to 19 million kilowatt hours. This quantity of electricity that no longer needs to be generated saves the Mexican oil company an annual 36,000 barrels of oil which, instead of being burned in power plants, could be put to other uses or sold on the global market.

Protecting the environment and mitigating climate change
Another benefit to society involves the reduction of external costs from less electricity production. Lowering the emissions of nitrogen oxides, sulphur dioxide and soot lessens pressure on the environment and lowers the external costs of electricity production (such as lower yields due to crop damage, the treatment of pollution-related disease and higher operational costs in industry).

The resulting reduction in carbon emissions is 13,300 tonnes per year.

Better light, better learning environment
The provision of better lighting in the libraries and seminar rooms enhances students' learning conditions which in turn has a positive impact on performance and achievement. While this cannot be measured in monetary terms, it can be assumed that more than a million students will benefit from the new lighting over the next twenty years. The importance of enhanced lighting comfort thus speaks for itself.

Lighthouse project with broad scope
Given the problems of climate change and ever-scarcer resource supplies, wise and efficient use of limited energy resources and investment in high-performance technology are fundamental in the switch to sustainable management practices. The lighting upgrade at UNAM could become a lighthouse project for efficient lighting and the impact could spread far beyond the boundaries of the university campus.

6 Beyond UNAM

Metrostation in Mexico City.

Opportunities beyond the UNAM campus

The lighting situation at UNAM is not unusual and is representative of other universities and of schools, offices, service sector buildings and banks throughout Mexico.

The fact is that wherever out-dated lights fitted with T12 tubes and conventional ballasts are still in use, the entire lighting system should be renewed if it is used for more than 1,000 hours per year. The longer the existing lighting is in use, the shorter the payback time on the investment in new, efficient lighting technology.

This was confirmed in a feasibility study conducted by Büro Ö-quadrat in connection with a lighting upgrade project for Mexico City's Metro train system. The study showed that over 50 percent of the electricity used in the Metro for lighting stations and transport routes could be saved under extremely cost-effective conditions and with an average payback time of merely two to three years[7].

Huge global potential

Opportunities for cost-effective investment in lighting technology are by no means limited to Mexico or Latin America. They are available all over the world. The picture below shows a building at the University of Freiburg in Germany, where the out-dated, inefficient lighting system has yet to be replaced despite the prospect of an upgrade providing good returns on investment and an excellent cost-benefit ratio.

As shown, efficient lighting is one of the technologies which can easily and profitably be used to fight climate change. „The challenge now is to build the political will to do so. Saving civilization is not a spectator sport. Each of us has a leading role to play."[8]

Outdoor lighting at a school in Mexico City

A bank in Mexico City at Saturday Night

University of Freiburg

7 Büro Ö-quadrat: Feasibility Study for Lighting Refurbishment of the Pedestrian Underpass at Alexanderplatz in Berlin, Germany and for the Subway System in Mexico City, June 2006. It was assumed that the degree of light provided would remain the same as before.

8 Lester R. Brown: Plan B 3.0 Mobilizing to save civilization. Earth Policy Institute, 2008

7 Project Partners

WISIONS of Sustainability

WISIONS is an initiative of the Wuppertal Institute for Climate, Environment and Energy, organised with the support of the Swiss-based foundation ProEvolution, to foster practical sustainable energy projects.
Contact: info@wision.net · www.wisions.net

Büro Ö-quadrat

The consultancy "Büro Ö-quadrat", established in 1999 and owned by Dieter Seifried, is working on ecological and economical concepts. The aim of the company is to initiate projects and develop concepts for climate protection in industrial and developing countries.
Contact: seifried@oe2.de · www.oe2.de

UNEP-Centre on Sustainable Consumption and Production (CSCP)

The Centre provides scientific support to activities undertaken by UNEP and other organisations in the field of sustainable consumption and production (SCP). This support includes the development, testing, implementation and monitoring of concrete projects, especially in developing countries, which enables these countries to leapfrog to sustainable consumption and production patterns using life cycle thinking and regional perspectives as guiding principles.
Contact: info@scp-centre.org · www.scp-centre.org

Genertek S.A.

Genertek S.A. is a well known company in Mexico, specialized in efficient lighting.
It has realised more than 300 energy saving projects in 12 countries and has won 11 national and international awards. The CEO of the company is Alex Ramirez who also teaches at UNAM the subject "lighting".
Contact: genertek@avantel.net

Instituto de Ingeniería

The Institute of Engineering of the National Autonomous University of Mexico (II UNAM) is the research center in several engineering areas productive in the country. Since its creation, the policy of the institute has been to perform research oriented toward general engineering problems, to cooperate with public and private entities in order to improve engineering practice at national level, and to supply engineering services to the various sectors of society.
Contact: jfernandezz@ii.unam.mx · www.iingen.unam.mx

Centro de Ciencias de la Atmósfera

In the context of the substantive activities of UNAM – research, teaching and diffusion of culture – the Center for Atmospheric Sciences has the general objective of development and promotion of the atmospheric and environmental sciences in UNAM and in Mexico.
Contact: info@atmosfera.unam.mx · www.atmosfera.unam.mx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Efficient lighting helps mitigate climate change and save money. This is illustrated in the report on a model energy saving project conducted at the National Autonomous University of Mexico (UNAM). With around 300,000 students, UNAM is one of the biggest universities in the world. Its annual electricity consumption of 70,000 MWh makes it an extremely energy-intensive organisation. In cooperation with UNAM's Instituto de Ingenieria (Institute of Engineering) and Centro de Ciencias de la Atmósfera (Centre for Atmospheric Research), the lighting in selected areas of the university campus was upgraded as part of a model project. If the results of the model project are applied to the entire campus, electricity savings of 60 percent could be achieved.

The investment of US$ 14 million promises savings in electricity costs of US$ 68 million, thus providing evidence of the viability of efficient lighting. Additionally the quality of light in many parts of the UNAM campus would be significantly improved.

The UNAM example is representative of other buildings in Mexico. It shows that determined use of the energy-saving potential offered by modern lighting technology eases the burden on state finances, enhances user comfort and is an extremely worthwhile investment in efforts to mitigate climate change.

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