

An energy-efficient luminaire dedicated to decentralized electrification

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ABSTRACT

EDF works on building tools and specifications dedicated to Decentralized Services Companies (DSC) for developing countries. DSC are local utilities, well integrated in the local institutional framework, and whose goal is to provide multiple services to customers.

These companies have to be economically viable to last, in spite of the poor solvable level of these types of populations. Thus, the whole energy chain, from production to end uses, including energy transportation and tarification, has to be technico-economically optimized.

In that context, Lighting, which is the most developed usage, has to be particularly well thought out, especially if equipment is provided by the DSC along with services.

Actually, significant consumption reduction may be obtained by dealing with energy-efficient sources. Moreover, the approach may also include luminaire as well as people's behavior to reach real effectiveness.

Thus, the idea consists of not just « bringing Light », as is currently done, but thinking about « lighting a need, in a given environment ».

Our work then concentrated on defining and validating needs for light — not only for the visual task to be accomplished but also cultural use of light—. We also focused the study on the acceptance of artificial lighting within populations using mainly natural lighting and petrol lamps.

Significant background experience through EDF, ADEME and CODEV (a French NGO), especially surveys conducted among Vietnamese villages, helped us to carry out our work.

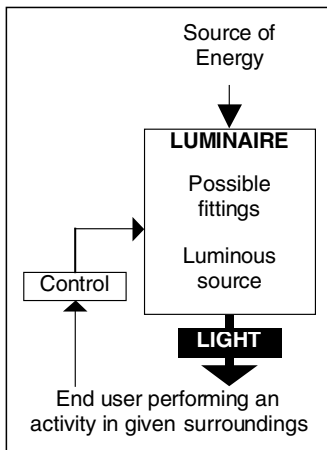
Subsequently, a dedicated luminaire has been designed and a pilot production is now on the way to provide full-size acceptance experiments in Africa and Asia with the luminaire.

INTRODUCTION [I][II]

Today, more than 2 billion people still have no access to electricity. According to the World Bank, this concerns 24% of the urban population and 67% of the rural population in developing countries. Furthermore, connecting them to a national grid is unthinkable for either short or mid-term projects.

Thus, Decentralized Electrification consists of providing these populations with electrical production means (using most likely either renewable or conventional energy), dedicated to an isolated area, a group of villages, a city quarter, or even a small district.

In that context, «Electricité de France » (EDF) is enhancing a global approach for decentralized electrification, specifically aimed at sustainable development [iii][iv][v]. This approach encompasses the institutional, organizational, technical, tariffs and financial aspects, and leads to the use of renewable energies in optimized technico-economics conditions. Ultimately, the goal is to provide not only electricity but multiple services (of course based on electricity but also water, communication and so on) to wide rural areas, so as to balance economic profitability. The users in the world, and especially those who live in developing

Figure 1: Components of lighting equipment

countries, don't care about the electrification system itself. What they expect is a service: lighting, radio or TV sets, even refrigerators for the more well-off.

Using this logic, Decentralized Services Companies (DSC) provided end-user customers with services in return for lump sum payments. Contract prices are mainly assessed according to the kind of services provided (e.g. number of lamps, socket for TV sets), governmental input, and above all, meeting the financial resources of the population concerned.

Thus, assuming that operating DSC needs economic profitability in order to keep its activity running, technical equipment (from production to end-use) has to be particularly optimized in order to accomplish this economic challenge. Therefore, energy efficiency becomes a priority.

More generally, and striving for the similar goal of optimizing functioning and/or investment costs, energy efficiency may interest most organizations involved in electrification programs in developing countries. This may concern non-governmental organizations, such as CODEV that works mainly with very poor rural families.

Finally, the rising global awareness for the environmental aspects along with dealing with international regulations for pollution emission, makes development aimed at innovative energy-efficient equipment particularly favorable.

Among end-uses found in developing countries, lighting is certainly the best aspect to deal with first, at least for the three following reasons:

- Lighting is the most common end-use in developing countries. It makes up 80% of the demand in newly electrified households [ii].
- Lighting contains a huge potential for energy efficient steps. In response to that, numerous efficient lighting programs, such as the Efficient Lighting Initiative (ELI), are developing all over the world. These works may deal with lighting equipment, human behavior or both of these. Yet, one can notice that current programs are more restricted to lamp technology rather than taking into consideration the lighting effectiveness on a whole.

Figure 2: Incandescent lamp in a Malian house

- Enhance lighting equipment requires affordable investment and the equipment is usually quick to install.

In DSC's approach, lighting equipment is included in the service. Consequently, EDF launched two years ago an R&D program in order to define, standardize and then have access to the Best Available Lighting Technology for decentralized electrification. Our work first concerned residential lighting. This document presents the concepts that guided us in the development of a new dedicated luminaire.

THINKING FOR THE BEST AVAILABLE LIGHTING TECHNOLOGY

Preliminary definitions

Before looking at the criteria commonly involved in the choice of lighting equipment, let's first remember what lighting equipment consists of, and define some terms.

Description in Figure 1 is relative to every kind of lighting equipment, on the condition that some components are slightly displaced. For example, control is sometimes integrated into the luminaire (e.g.: the switch for a table lamp). Also, for oil and petrol lamps, or even candles the source of energy is a part of the luminaire.

In this document, our attention will be focused on electric lighting equipment only.

So, the source of energy is electricity, supplied with a diesel engine, solar cells, a micro hydro turbine or many other types of systems.

The luminous source is a lamp. Two kinds of electrical lamps are commonly used for residential applications: incandescent and fluorescent lamps. The proportion of use between these two technologies varies from one place to another. Though strip lights (SL) are very commonly used in developing countries, it's not rare to find in some places

Figure 3: Both incandescent and fluorescent lamps on a Chinese market



quantities of incandescent lamps, moreover even doubling SLs in the same room¹ in extreme cases. Compact Fluorescent Lamps (CFLs) are still seldom used in comparison.

Whereas incandescent lamps are directly connected to the energy sources (12-24 Vdc or 110/220 Vac), discharge lamps, including fluorescent lamps, need special fittings to work. As for strip lights, external ballast and starters are necessary. Although these two functions are now gathered into one single electronic ballast, traditional ferromagnetic ballast is still very widely used for 110/220 Vac SLs².

Last, but not least, comes the luminaire with multiple primary functions. The luminaire:

- Interfaces the energy source with the lamp;
- Holds on the lamp and its fittings;
- Transforms, optimizes and concentrates the light on the user's task.

Figure 4: Coconut-based luminaire in Vietnam



- Protects the lamp from external aggressions (shocks, dust, insects,);
- Prevents user from glare.

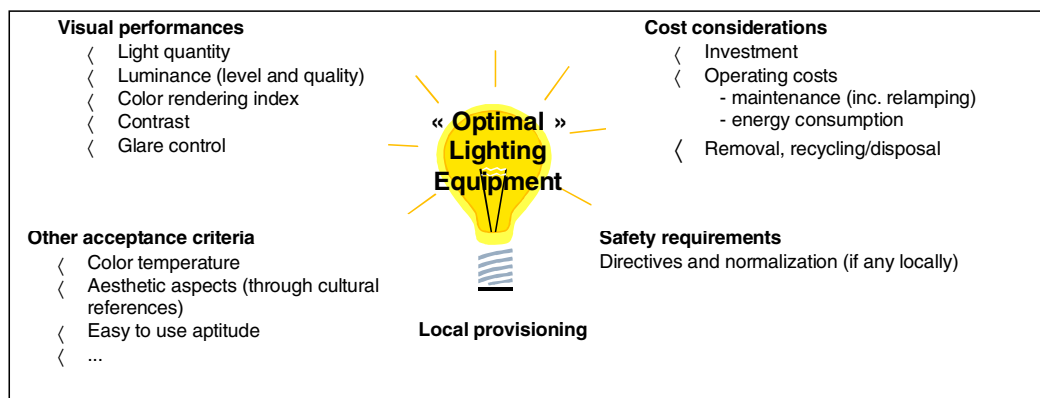
Although the first two functions are always present, the last three functions are often subject to cost criteria. Part of our work was to rehabilitate those properties in order to precisely reduce global costs.

How to select lighting equipment?

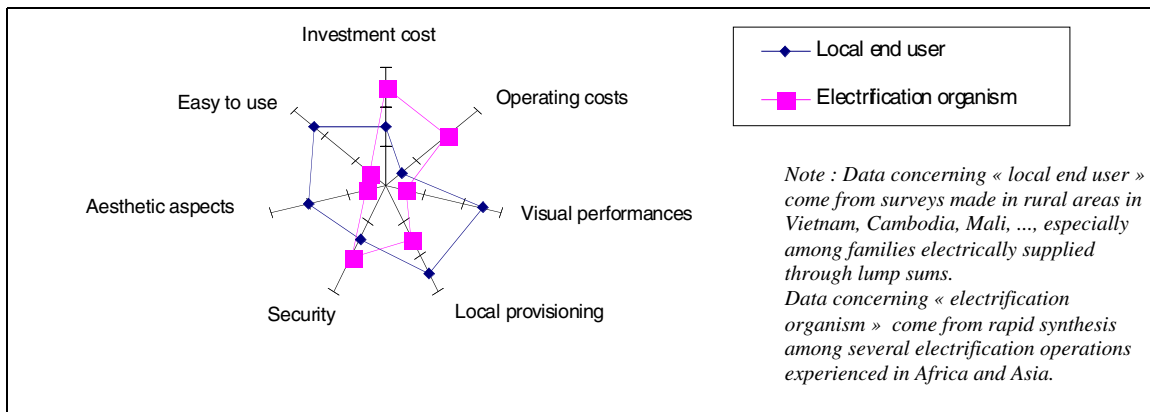
Figure 5 details criteria that may come into play when selecting lighting equipment.

Balance between those different criteria obviously depends on the lighting equipment buyer, as shown in Figure 6. In this diagram, one can see that the selection criteria may differ from local end-user on one-hand and electrification organizations on the other hand.

Figure 5. Criteria of selection for lighting equipment



1. The explanation given is that an incandescence lamp still lights as voltage drops whereas SL does not.
 2. 12-24 VDC strip light systems need an electronic ballast to work.

Figure 6: Example of selection criteria balance for a « local end user » and an « electrification organism »

The purpose of this development was to try to consolidate these two approaches, as EDF's goal, through DSCs, is to provide customers with « services » and not only with « Light ».

The document will now develop two of those criteria: Costs (in particular investment and operating costs) and Visual Performances.

Later paragraphs will discuss the other criteria such as safety, aesthetical aspects, easy to use aptitude and provisioning.

OPERATING COMPANY CHALLENGE: MINIMIZING COSTS SO THAT TO SURVIVE

DSCs have to be economically viable to last, in spite of the poor solvable level of concerned populations.

Lets now consider every costs inherent in lighting and see how they could be reduced.

Lighting equipment VS Costs

Costs are separated into three categories:

Investment costs:

- Lighting material
- Electricity production, protection and transportation equipment, whose sizing depends on the apparent power, noted S

Operating costs:

- Primary energy
- Maintenance
- Relamping
- Repairing
- Preventive maintenance

End of life costs:

- Removal
- Recycling/disposal

Generally, cost considerations are focused on the luminous source only, in particular on its active power P. That data mainly sizes the electrical system (investment costs) and the operating consumption (operating costs):

Lamps are traditionally chosen complying to fluorescent technology that is definitively the best compromise for these applications today. Yet, referring to SLs, lighting power P is often classified as the lamp's power only, thus neglecting losses in the ballast³ (which type is most generally magnetic).

In other respects, control is handled in the second term, while designing the electric cabling for homes. Luminaire is finally considered, and its function is unfortunately often restricted as a lamp holder!

It can then be more precisely estimated the exact costs involved with lighting systems and demonstrate how luminaire or other lighting effectiveness considerations can drastically reduce these costs.

3. For example, real consumption for a 30 cm long 10W SL is almost 20 W if taking into account ballast consumption.

How to reduce lighting costs

Prime lighting cost may be synthesized in Equation 1.

Equation 1: Prime lighting cost per hour

Prime cost per hour=

$$\frac{24}{\text{Operating duration per day}} \times \sum \frac{C_{\text{equipment}}}{L_{\text{equipment}}} + \frac{P \times (1 + \alpha) \times C_{\text{kWh}}}{1000}$$

Where:

C_{kWh} = prime cost for 1 kWh

$C_{\text{equipment}}$ = cost for lighting equipment and electricity production & transportation ratio equipment

$L_{\text{equipment}}$ = life duration of equipment

P = active power

α characterizes losses in the production and transportation equipment (for AC only)

Note that maintenance's costs are gathered with investment costs in the first term of Equation 1 The second term represents consumption costs.

Assuming that C_{kWh} is an input data, reducing consumption costs leads to minimizing P and/or α .

Reducing active power P

Considering the different components of a lighting system as described in Figure 1, one can see that all of them may contribute to reducing power P:

- Control offers the possibility to switch off the light if unneeded. This seems obvious although we found numerous micro installations where lamps were directly control-less connected to the power supply⁴! This involves the user to be aware of EE behavior.
- Luminous efficacy, that mainly characterizes a lamp, has to be carefully considered. Concerning discharge lamps, one may consider extended MLPW definition that includes ballast losses, as detailed in Equation 2.

Equation 2: « Mean Lumen per Watt » definition

$$\text{MLPW [lm / W]} = \frac{\text{Luminous flux } \Phi}{P_{\text{lamp}} + P_{\text{ballast}}}$$

Table 1: Some Luminous Efficiency for standard technologies

Lamp type	Traditional incandescent	Vehicle incandescent/halogen incandescent	Fluorescent 10W SL + traditional ballast	CFL / SL + elect. Ballast
MLPW	10-12 lm/W	16-24 lm/W	30 lm/W	50-60 lm/W

Table 2: Estimated gain referring to a basic lighting solution

Component	control*	Lamp	luminaire + luminaire's location
Estimated gain	10 to 30 %	250 to 600 %	200 to 400 % + user's comfort

* In fact, the real gain obtained with implementing control is user's comfort.

Figure 7: Small restaurant kitchen in Vietnam

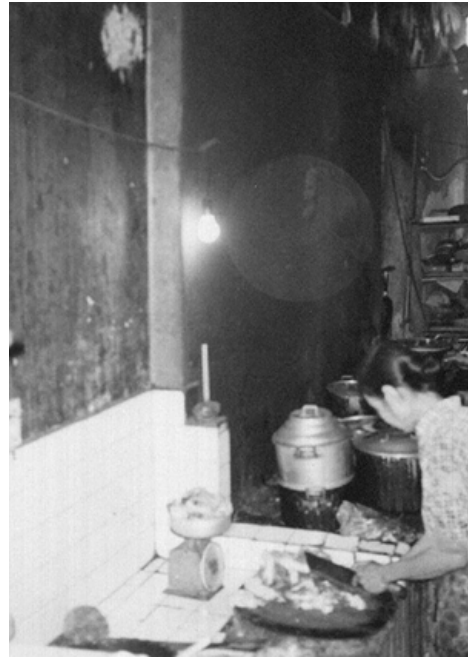


Table 1 indicates some rough values for MLPW, dealing with frequently used lamps.

- The luminaire may also significantly contribute in power reduction. Assuming that one cannot always master the surroundings characteristics (wall reflectance in particular), luminaire directs light to useful areas. In other words, it prevents light from being wasted into « black holes ». In the case shown in Figure 7, to add a simple white reflector to the lamp allows gaining about 100% of efficiency!

Moreover, when associated with a precise location in the room, a specific luminaire drives the light right on the visual task. Consequently, it allows great reduction of lumen expected from the lamp and thus input power, along with a much better visual comfort for the end user. This point will be developed further in the document.

For example, we reduced our lamp requirement from 15 W to 7-9 W thanks to this approach.

Estimated gains on power consumption are summarized in Table 2. Results are referenced to basic lighting equip-

4. In that case a diesel engine operating only at night.

ment, consisting of a control-less 40W incandescent lamp,

Table 3: Data for lighting prime cost calculation through four different systems

Lamp	GLS	Trad. SL	CFL	CFL
Cost	0,4 USD	1,4 USD	5 USD	5 USD
Efficacy	12 lm/W	65 lm/W	55 lm/W	55 lm/W
Life duration	1000 h	5000 h	5000 h	5000 h
Power	40 W	10 W	11 W	7 W
Ballast				
Cost		1,4 USD		
Life duration		40000 h		
Power		8 W		
Luminaire	Without	Without	Without	With
Cost	0,4 USD	1 USD	0,4 USD	6 USD
Life duration	40000 h	40000 h	40000 h	40000 h
Local PF	1	0,4	0,5	0,5
Resulting PF*	1	0,7	0,7	0,7
Actual power*	52 W	25 W	16 W	10 W

* seen from the supply

located just above the entrance door (as shown Figure 2). Calculations are derived through a simulation case presented in a further paragraph.

Concerning derived losses α

Briefly and roughly, losses in the AC production and the transportation means are linked to true RMS current. Current absorbed by a lamp is given in Equation 3.

Equation 3: Current that measures losses

$$I_{eff}[A] = \frac{P[W]}{U_{eff}[V] \times PF}$$

Where PF designs the Power Factor of the load. Indeed, this factor includes two different phenomena that are often confused:

- The dephasing between $I_{50-60Hz}$ and $U_{50-60Hz}$, noted $\cos \phi$.
- The harmonic distortion both in current and voltage, noted THD_I and THD_V .

We measured, through experimental cases, that a bad PF might lead to very significant extra losses and/or to over-size the production and transportation equipment. Lighting systems are directly involved in PF:

Table 5: Input data for digital simulation

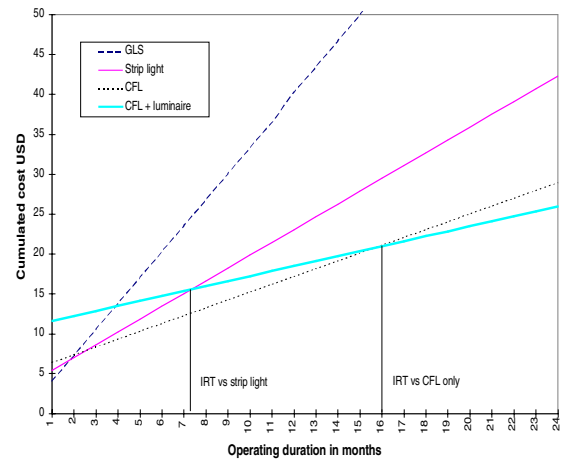
Luminaire	Without_SC	With_SC	Without_ST	With_ST	With_ST(2)	Without_AT	With_AT	original loc
Source	CFL 11W	CFL 11W	CFL 11W	CFL 11W	CFL 11W	CFL 11W	CFL 11W	incan. 40W
Output luminous flux	585 lumen	530 lumen	585 lumen	530 lumen	530 lumen	585 lumen	530 lumen	480 lumen

Where: « with_ » or « without_ » means whether the luminaire is present or not
 _SC means a hanging location in the center of the room
 _ST means a hanging location above the center of the table
 _AT means a bracket location above the table

Table 4: Resulting lighting prime cost (cts USD) VS exploitation duration (1USD\$ = 1.1 Euro)

1 year program	3,72 cts	2,13 cts	1,58 cts	1,70 cts
3 years program	3,67 cts	1,90 cts	1,25 cts	1,03 cts
7 years program	3,67 cts	1,86 cts	1,23 cts	0,98 cts

Figure 8: Investment Return Term (1USD\$ = 1.1 Euro)



- Very bad $\cos \phi$ for non-compensated SLs (very common in practice). THD_I is correct in another way.
- Very bad THD_I for most common CFLs. $\cos \phi$ is almost 1 by another way.

FAVORABLE ROLE OF LUMINAIRE ILLUSTRATED THROUGH SIMULATED CASES

Investment return term

The first calculation concerns investment return terms, on four different lighting systems as described in Table 3. Roughly, these 4 cases are able to ensure the same lighting service. Case number 4 involves a specific luminaire which is basically consisted of a well-thought reflector.

Calculation takes into account some network characteristics such as the level of charge, its impedance, the power factor swarming. One kWh is produced at 0.7 USD and electricity is on 8 hours a day.

Table 4 presents prime costs for one hour of lighting depending on selected lighting equipment and electrification

Table 6: Visual performances results

Luminaire	Without_SC	With_SC	Without_ST	With_ST	With_ST(2)	Without AT	With_AT	original loc
Table illuminance (lux)	16	29	87	257	208	160	221	7
Illuminance uniformity	0.87	0.74	0.91	0.69	0.45	0.62	0.61	0.77
Floor illuminance (lux)	10	21	15	25	25	18	24	5

Where: *Table luminance* indicates the average illuminance on a 1 m large x 0.5 m working area, centered on the table (considering that the user is transparent!)

Illuminance uniformity means the ratio between the weakest illuminance and the average illuminance on the working area

Floor illuminance indicates the average illuminance on the floor.

Figure 9: Location of the luminaires in the room

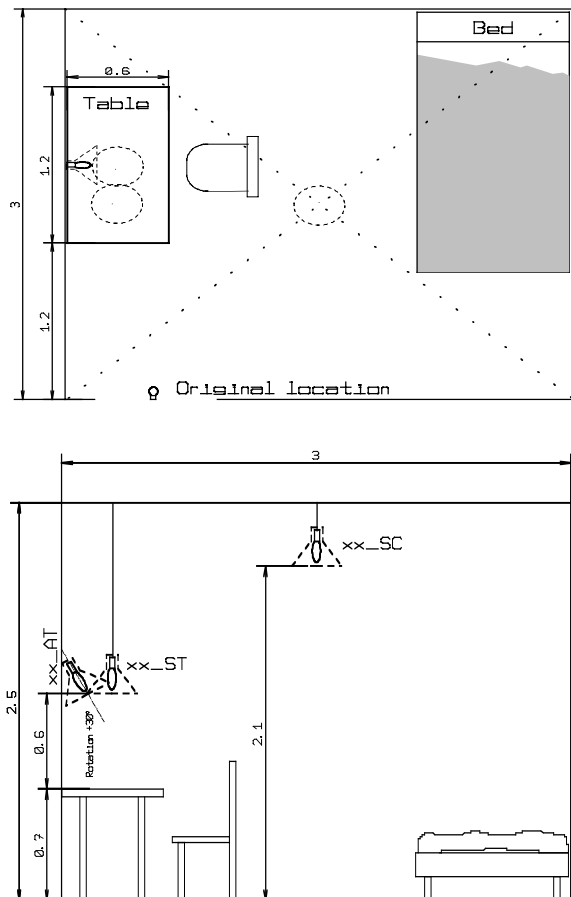
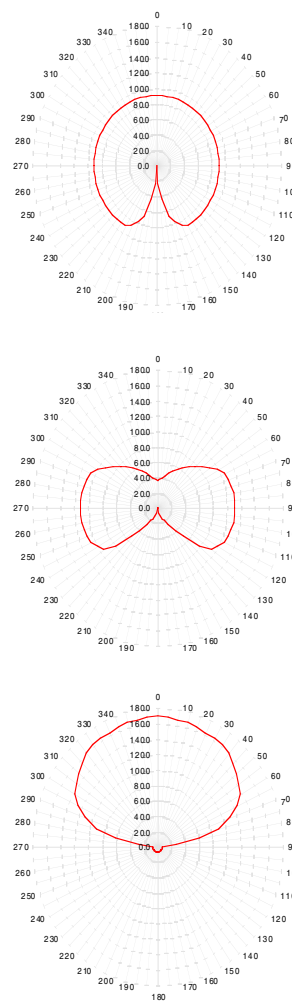


Figure 10: Intensity diagram used for simulation: incandescent lamp, CFL and CFL + luminaire



program’s duration. Prime cost includes both investment and operating costs.

Note that investment cost is small compared to operating cost and has little effect on and after 3 years.

One can define the investment return of system B compared to a reference system A, as for the duration till cumulated cost of using system B equals cumulated cost of using system A. Figure 8 clearly indicates that, in our case, investment return term of using a luminaire is very short and happens around one year.

So, this simulation based on realistic situations shows that using a specific luminaire allows a significant savings.

Also, results do not compare visual performances at all. This point, that reinforces the benefit of the luminaire, is approached next paragraph

Right location of the luminaire to improve visual performances and user's comfort

A 9 square meter room has been modeled, and furniture arranged in a similar way as we experienced for example in Mali. Of course, this case is not representative of every kind of room one can find in developing countries, but it still provides interesting data.

Here, the table is designed for tasks such as homework or handicrafts.

So, the aim of lighting this room is to be able to work at a table in good visual conditions as well as to see obstacles

Figure 11: Surveys in Vietnam

in the room for safe movement. Far less requirements are needed by this second function than by the first one.

Digital simulation consisted of determining luminance and contrast with several lighting systems and/or locations for the lamp, as explained in Table 6.

Lamps and luminaires have been modeled through their intensity diagram illustrated in Figure 10.

Wall reflectance is considered equal to 0.2, which roughly corresponds to clear concrete.

In that simulation, the benefit of luminaire is clearly expressed, especially when approaching the working area (see *_ST* cases in Table 5). In that optimal location, the luminaire also prevents the user from glare.

Theoretically in that case, the best location for the luminaire is just above the working table, allowing a luminance almost 40 times better⁵ than the original location without luminaire.

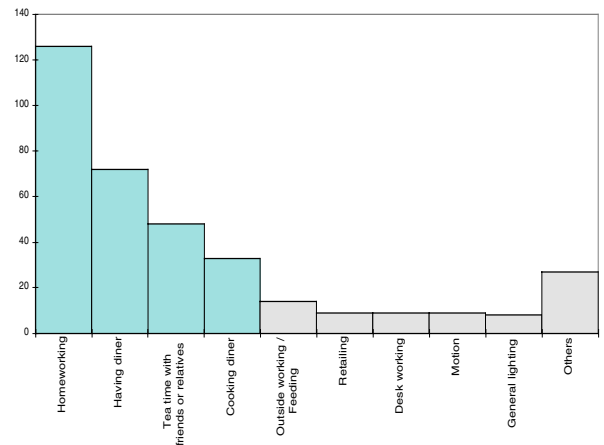
Favorable role of a luminaire: conclusion

As investment returns terms are very short, key elements to reduce global cost are essentially oriented to minimizing operating costs. Luminaire does allow to drop them as well as to greatly improve user's visual comfort and performances

This may be summarized in the following RL3 concept:

« Right Lamp in the Right Luminaire at the Right Location ».

Actually, to meet real lighting effectiveness, one dimension is missing in this RL3 approach: the « Right Need » that we now present.

Figure 12: Lighting an activity: view from the end-user

LIGHTING A USER'S NEED

In the former paragraphs, the document explained the advantages of incorporating a luminaire to lighting systems. Now, let's see the characteristics that the luminaire may have to fulfill its task; that is: lighting a need in the best available conditions.

Identifying the needs

Lighting may cover several very different goals: Lighting to work, to walk, to sell better, to advertise, to ward off bad spirits, to make it nicer, or lighting just so that we are not in the dark!

All these goals need different lighting characteristics and subsequently require different power to be performed. The deal is then to try and distinguish these various necessities so that to provide each need with the right light (which means minimum power at best comfort).

We did first start on what could probably be the most obvious goal for lighting: making possible night activities. This does not necessarily mean to extend daylight activities as rural populations often work outside in the fields during daytime. Night⁶ activities are more oriented to social events, homework, deskwork, handicraft, selling,

Then, thanks to consequent experience obtained through programs along with ADEME (in particular in Mali-Africa) and with CODEV (Vietnam, Cambodia, Africa), we did imagine activities to be lightened up as well as characteristics to better adapt the luminaire to such populations.

These options have been approached with local end-user surveys in the Vietnamese rural areas.

Need and acceptance criteria surveys in Vietnam

In 2001, EDF and CODEV Viet-Phap ran inventive qualitative surveys for two dozen rural families (almost 50 people) in two rural districts of the Phu Tho province (North Vietnam). These surveys were aimed at validating and hi-

5. Note that in practise, these results are even more accentuated with the unavoidable glare effect induced by having a bare lamp in the field of vision.

6. Remember that dusk falls quite early in such countries.

erarchizing formerly imagined activities as well as commenting luminaire design and options aimed at better user's appropriation.

Of course, the Phu Tho population is not representative of every cultural behavior over the world (even in Vietnam!) and these surveys are not sufficient to fully qualify a luminaire for a worldwide usage. Anyway, it resulted in numerous interesting points and allowed us to launch first industrialization, to then be experimented in different countries.

Activities to be lightened: results from Vietnam surveys

Here, results clearly show that the activities that need the most lighting are performed inside, on a table or on the floor (homework, dinnertime,). Though, the need to light some outside activities (to feed farm animals for example) is not to be neglected. Lighting the preparation of dinner is very specific as surrounding conditions are particularly constraining: smoke, heat, dark walls. More, in most countries, the kitchen is separated from the rest of the house, sometimes even quite removed.

Exploring the characteristics of the luminaire

Specific luminaire options

In order to better adapt the luminaire to the cost, to energy efficiency as well as to user acceptance criteria, many options have been studied and suggested to end-users for comment. For example, we approached the shape⁷, the color the location of the luminaire, its capacity to be handled, to be cleaned, the color of the light, the glare and the sparkle effect,... Here is a presentation of some of these, that we found important to treat.

Displace the luminaire to fit the right location at the right time

As demonstrated in Table 6, this is may be the most effective way of saving energy as well as enhancing comfort. Generally, electric lamps are located on the wall, above the main entrance door so as to light both the whole room and the immediate outside area (unfortunately not very well). Here, the challenge is to locate the luminaire as close as possible to the activity, as it was done with fuel-based lamps! This nomadic aspect has been favorably accepted by end-users, especially by those who had never experienced electric lighting before!

Sealed and easy to clean optics

Dust and insects, that are particularly present in such countries, may reduce efficiency from 30 to 60%, as they greatly interfere with light transmission. Thus, it is fundamental to make the lighting device optically sealed and easy to be wiped off⁸.

7. In particular for shape and color criteria, we tried to define rejected solutions.

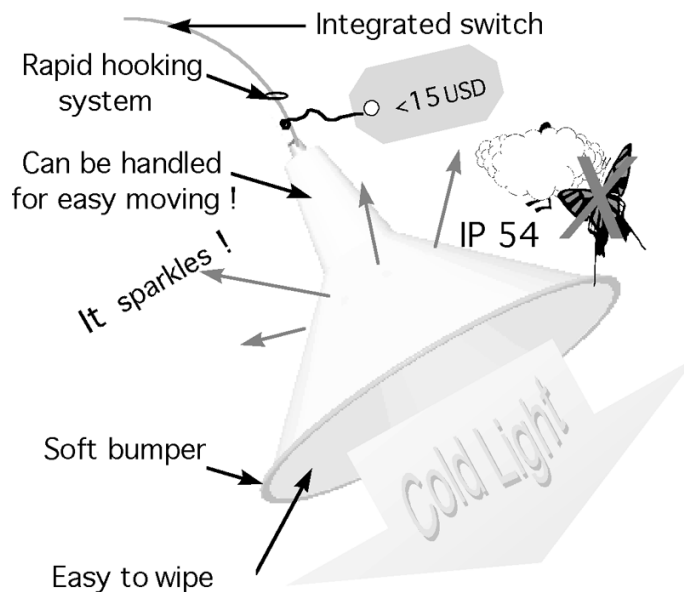
8. And yet, this option does not prove that the luminary will actually be cleaned: this is a personal/cultural behaviour. For example, among interviewed populations in Vietnam, several people said they carefully clean their petrol lamps.

9. In Mali, for example, we saw several rooms -especially children's- where incandescent bulbs were painted (blue or green) to make light and atmosphere more pleasant.

10. Many people work outside by the light of the moon.

11. As designed with professional western equipment.

Figure 13: The luminaire's main characteristics



Color of the light

Surveys indicate significant preference for daylight color. And yet, if that « cold » color temperature is preferred to light work tasks, one noticed that warm white was sometimes suggested for ambient lighting, and associated with luxury. Actually, experience shows that this notion is very culturally dependent⁹.

Therefore, we implemented the aesthetic dimension as an option, making the luminaire easy to color-personalize.

Sparkle and glare effect

Considering that newly electrified users were indeed more accustomed to a light source that shines and twinkles (that means with concentrated luminance such as the sun, the moon¹⁰, a vehicle lamp supplied with a battery, a candle,), we implemented a « sparkle function » in the luminaire. Surveys showed, by comparing many pictures dealing with lighting solutions, that carefully mastering glare and high luminance¹¹ bring interviewees to think that « it does not light »! Opposed to that, direct glare has to be removed for obvious visual performance reasons.

DESIGNING THE LUMINAIRE

Thanks to this global experience, specifications were established to define a standardized luminaire, matching general working activities, in particular desk/table work.

Other specifications were written apart, dealing with the lamp.

Table 7: Criteria for selecting the lamp

Type of lamp	Provisioning	Technical aspects	Cost
Strip light	Very good	Better results with electronic ballast. And yet, it has to be adaptable to any « local » SL.	Expensive because of the « universal » ballast
Integral CFL	Good	Good, but pay attention to avoid snapback (GLS settlement once CFL is out of order).	Good
Dedicated CFL	Poor	Prevent lamp theft (in public location) and from snapback. Better results with electronic ballast, that may be more easily suited to the lamp in that case (compared to SL).	Slightly more expensive than CFL

Main characteristics for the luminaire

Figure 13 summarizes the main characteristics for this first developed luminaire:

- Hanging luminaire
- Plastic reflector permitting about 80% direct lighting and 20% diffused light
- Reflector designed for up to 15W CFL
- Simple reflector shape permitting easy do-it-yourself fittings (without affecting efficiency!)
- Circular multi-colored interchangeable lens to personalize the sparkle effect
- IP 54 for in/out usage as well as for insect and dust barrier
- Easy to wipe PMMA diffuser
- Handle for easy to grab / handle aptitude
- Soft rubber bumper to absorb shocks during handling
- CE specification fulfillment for safety
- Assembly of easy interchangeable¹² single-material components, to minimize disposal and improve recycling capability
- Expected price < 15 USD, delivered with a high performance 12V or 220 HPF CFL

As we did not find any existing luminaire capable to match or approach these characteristics, specific industrial development was undertaken last year.

Selecting a lamp**What technology?**

Fluorescence is clearly adapted for this application for it is a worldwide cheap and efficient technology, and well-developed in non-professional lamp markets.

What power?

Former studies discussed in the document showed that a 9 to 11 W (even 7W) fluorescent lamp could be enough

for specified applications. Nevertheless, the luminaire is designed to receive CFLs up to 15 W in good thermal conditions¹³, for example, for collectivities or small professional units.

What type of fluorescent lamp [vi]?

In practice, three types are available:

- Strip lights with electronic or magnetic external ballast;
- Integral CFLs, intended for use in fixtures designed to take standard incandescent bulbs, and that have a screw or a bayonet base. Integral units are those where the ballast (electronic) and CFL are incorporated into a single assembly.
- Dedicated CFLs, to include the fixture. The ballast is then mounted separately.
- Our choice mostly resulted from the compromise between those criteria, detailed in Table 7:
- Locally available, for first-aid provisioning
- Technical aspects to ensure performances
- Cost

Conclusion

First development deals with a 9 W integral E27 CFL, 12 VDC or HPF 220 VAC.

12. Let's remember that luminary belongs to the DSC.

13. Over temperature may degrade luminous efficacy.

INDUSTRIALIZATION

First thousands of luminaires to be tested in Africa and Asia within 2002

Industrialization started early 2002 with an Asian partner, where specific moulds for injected parts are developed. The first series expected mid 2002 will supply some already launched EDF and CODEV electrification programs in Morocco, South Africa, Vietnam and Cambodia with the objective to fully validate some remaining options such as the length of the cable (for displacement aptitude acceptance).

Mass production is then expected in 2003.

In parallel, international lamps manufacturers are being consulted to provide the programs with HPF 220 Vac and 12Vdc fluocompact lamps.

Which market for the luminaire?

Internal needs for EDF are estimated at several tens of thousand units per year, dispatched within 2 to 4 new DSCs a year. Luminaires are directly bought and installed by the DSCs themselves.

This luminaire will also supply programs handled by NGOs (such as CODEV) or ADEME and will be quickly available for the international market.

Actually, the specifications adopted for the luminaire are not only convenient for decentralized electrification, but may indeed also fit numerous social DSM programs in western countries.

CONCLUSION

This development was aimed at specifying and making accessible a low cost lighting effectiveness equipment for decentralized electrification.

Several studies, in particular user's need orientation, allowed us to design a specific luminaire.

Numerous characteristics may enhance energy efficiency for this system assumes very good visual performances with a just 7-9 W integral CFL.

Yet, end user's acceptance is not neglected and many options are dedicated to that.

Industrial series will be fully tested this year.

The luminaire will be widely accessible to promote the use of EE lighting in developing countries as well as for western social needs.

Of course, the opportunity to conciliate this development with other international works such as the ELI approach is deeply expected.

Studies will now continue for lighting applications, such as public street lighting, night-lights...

GLOSSARY

AC, Alternative Current

ADEME, Agence de l'Environnement et de la Maitrise en Energie (French agency)

BALT, Best Available Lighting Technology

CFL, Compact Fluorescent Lamp

CODEV, COoperation DEVeloppement is a French NGO supported by the EDF Foundation. It gathers about twenty local associations, such as CODEV Viet- Phap.

DSC, Decentralized Service Company

EDF, Electricité de France (French and International utility)

EE, Energy Efficient

ELI, The Efficient Lighting Initiative is a 15 US\$15 million effort that will promote energy-efficient lighting products through a variety of programs to be run over three years in several countries over the world.

HPF, High Power Factor

MLPW, Mean Lumen Per Watt

NGO, Non Governmental Organization

PF, Power factor

SL, Strip Light

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- [vi] DELight (Domestic Efficient Lighting) Report from Environmental Change Unit Research - Oxford 1998

WEB LINKS FOR FURTHER INFORMATION

www.edf.fr

www.ademe.fr

www.iaeel.org/ (contains also many links to international programs)

www.cerf.org/iiec/eli.htm (eli@kateconway.cc)