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Looking on the Bright Side

Dissemination of Innovative Lighting Solutions for the Public and Private Sector

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INTRODUCTION

Development to Dissemination in Lighting

The importance of light is easily taken for granted. Good lighting can enhance productivity, heighten safety, and create powerful aesthetic experiences. Poor lighting can disrupt lifestyles and even impact health. Yet, as we develop a more sophisticated understanding of how lighting influences standards of living, and new technical and social innovations emerge, the realms of what is possible with lighting are rapidly expanding. If the benefits of this rapid expansion are to be fully realised then this accumulated knowledge must be shared. The aim of this publication is to aid this knowledge sharing and facilitate the transition towards better lighting in society.

This transition may take many forms. One example of such a transition tool, discussed at multiple points within this publication, is the Product-Service Systems (PSS) model. These systems provide a radical re-conceptualisation of standard business models. However, lighting innovation has applications beyond the market. Dynamic lighting models are being developed that allow for intelligent control of learning environments and ultimately, improved education. These novel lighting approaches herald a shift away from "sufficient lighting to undertake a task" towards "value added by lighting itself".

This publication is a deliverable of the Development to Dissemination (D2D) project, which aims to enable "developed innovations to be commercialised across the North Sea Region". D2D membership includes representatives from business, government and academia, from countries across the North Sea Region. One partner is the International Institute for Industrial Environmental Economics (IIIEE).

Another component of the D2D project is the establishment of the "Samsø Award". In collaboration with the Samsø Energy Academy, Denmark, the Samsø Award aims to "identify, recognise and empower community-led ideas, projects and examples that stimulate a transition towards sustainability". The collaboration between students in the Masters programme in Environmental Sciences, Policy and Management (MESPOM) and the Academy helped inspire the writing of this publication.

The following sections include nine case studies, which discuss models and applications in public, private and off-grid contexts. Case studies within the public sector focus on the social benefits available from novel lighting systems (Section 1). Innovative business models are explored within the lighting sector, including the drivers and barriers to adoption of novel approaches (Section 2). The report also discusses lighting within off-grid systems (Section 3). The document concludes with additional information regarding the MESPOM programme, the Samsø Award and acknowledgement of the people who contributed to the report's development.

This publication forms part of a series, produced by MESPOM students, which can be found in the IIIEE Library at Lund University.

LEASING PUBLIC LIGHT

Drivers and Barriers for Municipal Adoption of LED Leasing Models

By Susana Guerreiro, Chelsea Kehne & Shruti Neelakantan

As local actions concerning energy-efficiency receives greater attention through national policies, municipalities face stricter CO_2 emissions reduction targets. Increasing energy efficiency at all levels is of paramount importance and lighting solutions can be instrumental in achieving greater energy savings. The uptake of Light Emitting Diode (LED) lighting solutions in public procurement can drive demand, help the market grow and thus push down prices. Some of the advantages of this technology – optical performance, energy efficiency, low maintenance costs, and aesthetic quality – are crucial for market segments like municipal lighting. Indeed, municipalities have a wide range of applications – public buildings, bridges, tunnels, parking spaces, and road signs – where lights are often illuminated 24 hours a day and maintenance costs are high. Hence, LED solutions can deliver important savings.[1]

However, the upfront costs of LEDs are high compared with conventional lighting solutions, and the financial burden of such investments may deter many initiatives from taking off.[1] Often, municipalities operate on tight budgets and are increasingly challenged to do more with fewer resources. This makes financing one of the single most important aspects of municipal infrastructural projects, including LED lighting. There are a number of financing models for municipalities to raise capital – taxes and fees; government financing; energy performance contracting; Public-private partnerships; or leasing solutions. In this paper, we will focus on the drivers and barriers of implementing leasing models for financing LED deployment in municipalities.

Leasing Models

In a product ownership based economy, lighting systems have traditionally been sold as products, promoting a wasteful society and the manufacturing of products with a short lifespan.[2] In a leasing system, the producer supplies a lighting service instead of selling luminaires, and thus adds incentive to develop durable products and a quality service.

Diverse leasing models and contracts are available to municipalities. Depending on preferences and goals, municipalities can choose to go directly through lighting companies that offer LED leasing contracts or go through leasing companies or private financiers, without partnering with a lighting vendor. The more commonly used models are summarised below, offering municipalities different alternatives for leasing LED lighting.

> A leasing agreement is a standard rental contract whereby a lighting company, an Energy Service Company Contracts (ESCO) or a utility, provides the initial capital to purchase the LED lighting equipment and associated costs (installation, maintenance, recycling of old luminaires). At the end of the contract the municipality may, depending on the contract, own or buy the remaining cost of the equipment).

Drivers for Adoption

From the municipality's perspective there are a number of drivers for the adoption of a leasing model, especially from a financial point of view. Leasing models do not require high initial investment and provide some flexibility in instalments. Additionally, particular options, such as structuring payments to make them lower than the energy savings from the retrofit, provide a net positive cash flow.[3] The transaction and implementation costs are minimised and in most cases the leasing company provides full service, including maintenance, accounting and/or reporting. Another key incentive for municipalities is that a leasing contract – if properly designed – is not necessarily considered public debt. Therefore, it can feature in the budget as an operating cost and not as a capital expense. This can be particularly appealing to municipalities that do not want to increase their on-the-books debt load.

Furthermore, light leasing is a growing market. An increasing number of companies are offering leasing as a financing option for public lighting, thereby providing municipalities with quality alternatives at competitive prices.

LEDs – with projected electricity savings of 50% to 70% compared with conventional technologies – and the resulting CO_2 emissions reductions, constitute another key driver for local authorities to consider LED lighting solutions. Leasing models allow municipalities, especially smaller ones, to make this change at a lower cost.[1] Additional drivers are listed in the SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis below.

LEASING MODELS	
No ownership	**Ownership**
Operating lease Property owner offers the lessee a fixed term lease and transfers only the right to use the equipment for a fixed monthly rent. Minimises impact in annual capital budgets.	**Capital lease (optional)** Financial institution funds the LED retrofit over a set period, with an option to buy the assets at the end of the lease. Transfers the risks and benefits of asset ownership to the lessee.
	Hire Purchase Agreement (automatic) Gradual payment for the LED equipment over the operating period, which after being fully paid-off become property of the lessee.

Barriers to Adoption

There are also a number of barriers confronting the adoption of leasing models by municipalities, with the most pertinent discussed in more detail here. These barriers can be divided into two categories: structural and external (which correlate, respectively, to the "weaknesses" and "threats" displayed in the SWOT analysis below). Structural barriers are internal to the leasing system itself, while external barriers influence the way a municipality functions.

Structural

One of the fundamental barriers to leasing is the lessee's reduced control of assets. If the municipality is comfortable with moving away from ownership of their lighting systems, then leasing will be an attractive option. However, the principle of ownership is fundamental to many institutions, making the transition to leasing, and potentially other Product-Service Systems (PSS), difficult.

Another problem with standard leasing models is the lack of incentive to utilise energy efficient technologies. Specifically, the lessor might only function as a financier (as with a capital lease) and thus will not be able to provide adequate information concerning the adoption of LED technologies. This shifts the responsibility onto the municipality, which might not possess sufficient resources to make the appropriate selection.

LED leasing often results in higher long-term costs than direct self-financing.[1] However, this barrier is not unique to LED leasing (but rather leasing models in general). If the municipality has the capital to self-finance, leasing simply might not be the best option (especially if the investment is small or the contract term of the project short).

External

For municipalities seeking LED lighting solutions, lack of political support can act as an unexpected barrier. Knowledge and incentives to change differ depending on the municipalities, both within a particular country and between nations. Where the presence of policy mechanisms can drive municipalities to alter behaviours, the lack of such policies could impede municipal adoption of more energy efficient and environmentally sound practices. As countries instate national policies to meet emissions reduction and energy efficiency targets, these frameworks can help municipal governments invest in infrastructure to comply. As a common barrier to municipal infrastructure improvements is the absence of upfront capital, leasing models can provide an alternative source of funding to meet new standards.

Political support can also take the form of knowledge transfers. Although how to best change behaviour and performance may seem implicit for some countries and municipal governments, often a lack of practical knowhow can create a barrier to adopting new practices. If a municipality is unsure of how to transition to energy efficient alternatives (such as LEDs), the option of leasing might not even be discussed. Additionally, if the knowledge capacity for energy efficiency approaches exists, but a lack of understanding concerning leasing models does not, it is also possible that this will create a barrier to adoption.[5]

SWOT ANALYSIS OF LED LEASING FOR MUNICIPALITIES	
STRENGTHS	**WEAKNESSES**
No need for large initial capital & no down payment	Potential for higher long-term cost relative to direct self-financing
Energy savings exceed payments (net positive cash flow)	Lessee risks reduced control over assets & lessor might cut corners to save cost
Possibility of buying remaining equipment	Capital/finance lease might increase lessee's indebtedness, dependent on jurisdiction
Possibility of structuring payments so cost is less than the energy savings	Leases can be complex, long-term & difficult/costly to terminate
Flexibility in the remuneration period	
Relatively easy and quick deal – reduced bureaucracy & administrative costs	Property can lose considerable value over contract period, thereby deterring interest in lease-purchase agreements
Full service by the leasing company – management invoicing, accounting & reporting	
May be considered an operating & not capital expense, so does not feature in the balance sheet (no contribution to debt)	Standard leasing does not provide incentives for innovation & energy efficiency
OPPORTUNITIES	**THREATS**
Drive demand, foster market growth & lower LED prices	Resistance to change
Leasing is a competitive market, possibility of inexpensive rates for municipalities	Lack of knowledge or interest
Focus on services rather than product ownership – dematerialisation and resource efficiency	Absence of policies & incentives
Fosters a long-term approach to product durability – longer service life, lower maintenance and less materials (reuse & recycle of product components)	Preference for ownership
Allows quicker achievement of energy efficiency targets	Technological Uncertainty

Another barrier relates to the technological uncertainty surrounding lighting innovations, such as LEDs. Although LEDs have been around since the 1960s, they have not been competitive on the consumer market until more recently (with the release of the white LED in the 1990s and wattage increase in the 2000s).[6]

Presently, significant LED advancements are taking place, which could drive some municipalities to reconsider whether or not to invest in these newer technologies. Furthermore, as these technologies are quite new, the actual lifespan and energy savings of the products are difficult to assess. If an LED was placed on the market five years ago, but has a projected lifespan of 20 years, then it will be some time before we understand its true life and savings. This can create uncertainty for municipalities when deciding where to seek out energy efficiency solutions.

Guidelines for Adoption

In response to the drivers and barriers discussed above, it is important for municipalities to understand how best to move forward with energy efficiency projects and LED lighting solutions. Establishing guidelines can help municipalities to systematically approach projects and leasing options, especially in the case that there is not sufficient internal or external support. The guidelines are as follows:

1. Identify the need for LED lighting in the prospective physical space;

2. Assess risks and benefits involved in carrying out the project;

3. Conduct an energy audit and compare data with existing consumption patterns and projected savings;

CASE STUDY: SAVING ENERGY ON THE STREETS OF PORTLAND

Location: Portland, Oregon (United States of America)
Year: 2001

Project: Replacing incandescent traffic signal lights with light-emitting diodes (LEDs) through innovative leasing methods initiated by the Portland's Signal and Street Lighting Division.

Results:

- Replaced 13 382 red and green existing incandescent lamps with LEDs
- Savings of 4.9 million (kWh) in energy consumption (representing an 80% reduction in energy usage)
- Reduction of approximately 2 880 tonnes of annual CO_2 emissions

In an effort to improve the rate of energy efficiency in Portland, the city government conducted a feasibility study to replace LEDs in traffic signals and the results encouraged such a change. As opposed to streetlights that are used for twelve hours a day, traffic lights function throughout the day, and substituting the bulbs with more energy efficient ones could lead to economic and environment benefits. Due to limited budgets for retrofitting, the government entered into a Public-private partnership with a leasing service, the Dooling Lease Management Corporation, who facilitated the process. The partnership enables the procurement of lamps, which were leased to the city from a local bank, helping the municipality to remain in control and disperse their capital costs over a six-year agreement, allowing it to pay costs as energy and maintenance savings. Portland's Office of Sustainable Development provided critical support for this project. Staff analysed the project's cost-benefit, facilitated utility rebate requests, and arranged the LED lease option.

The project was successful with a payback period of 3.1 years: following this, the city was motivated to implement LED technology for all red and green traffic light signals by 2009. In 2009, the first generation LED lamps used in 2001 had reached their end-of-life use and, along with many others, were retrofitted by 8-9 W, fourth generation LED modules. The project resulted in over 20% energy savings for the city.[4]

4. Carry out a cost-benefit analysis to observe trends and prepare a budget;

5. Distinguish between supportive and obstructive policies at the national and local level;

6. Recognise incentives and benefits involved in carrying out the project;

7. Create a detailed project plan defining clear goals, objectives and targets;

8. Understand the various existing leasing methods and choose the most suitable one (with the help of a specially appointed team);

9. List down potential leasing companies and select one after thorough cost comparison, interviews and background checks;

10. Actively engage in the lease contract design, emphasising any special conditions related to the management and/or performance of the contract;

11. Develop a list of performance indicators to help evaluation;

12. Establish the most suitable weighting approach and evaluation methodology that suits the project and the leasing scheme; and

13. Launch a functional reporting system to follow up on results.

It is quite probable that municipalities will already have systems in place to manage some of these points. Moreover, some of the later points listed here might be handled entirely by the lessor, leaving less work for the municipality. However, in the case of leases offered by private financiers (e.g. banks), it is important for the municipality to define precisely what it wants 1) from the contract, 2) in terms of LED lighting solutions, and 3) as its short- and long-term energy efficiency targets.

Conclusion

From this analysis and discussion, it is apparent that leasing models can provide a feasible alternative to direct financing or procurement. This is essential for municipalities running on restricted budgets and high sectorial demands, often giving energy efficiency (and even more so, lighting) low priority. As a lease does not require upfront capital, energy efficiency can be considered while enabling the municipalities to invest in the most demanding municipal sectors. Moreover, as national and local policies for energy efficiency standards proliferate, LED leasing models can help meet these targets, while reducing the need for capital investments and increasing energy savings and decreasing costs.

Although LED leasing is a relatively new phenomenon, leasing contracts are historically familiar to municipalities. Whether a municipality wants to utilise existing leasing models, tailor one of these to their specific needs, or design a new model; the familiar framework of leasing facilitates this selection and application.

It should be stressed that leasing models do have structural weaknesses, which can make them unattractive to municipalities. However, contractual design of the lease can eliminate some of these barriers. Nevertheless, external barriers to adoption are of greater concern, in that the municipality might have little influence over them – the most significant of these being the absence of policies and incentives (especially at the national level) that mandate or promote energy efficiency standards.

Standard leasing models do not always promote energy efficiency. The LED leasing model is one response to this problem, though there is no guarantee by lessors that "best available technologies" will be implemented or demanded on the part of the municipality. One attractive alternative to this problem is found in performance-based lighting contracts, such as "pay per lux" and Energy Service Company Contracts (ESCO). Not only do these contracts promote energy efficiency, they also function as models for moving away from product ownership and towards PSS. As LED lighting offers long-life products, the price margins are often higher as the producer sells fewer units. By collecting revenues from a lighting service, rather than from the sale of lamps, the user and the producer both benefit.[7]

These examples are not to detract from the usefulness of LED leasing for municipalities. Rather, it is important to recognise that leasing is but one option to facilitate the integration of LED lighting solutions.

Depending on the context, certain options might be more appropriate than others and it is essential for municipalities to be aware of their choices. This discussion provides some of the most significant drivers and barriers for municipalities, relating to LED leasing models. Moreover, the provision of basic guidelines seeks to aid municipalities in approaching whether LED leasing is a suitable model for their particular lighting projects.

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MORE THAN LIGHT

How Copenhagen is Integrating Efficient Lighting with Smart City Solutions

By Jonas Frimmer & Aynur Mammadova

Lighting solutions are in the focus of city administrations from financial and environmental perspectives. Copenhagen is currently implementing a project that could not only benefit the two above-mentioned aims, but also open up unprecedented opportunities for a smart city.

Thus, this paper aims at exploring the drivers behind implementing smart street lighting projects and analysing their potential. For this, it will investigate the street lighting project in Copenhagen, Denmark – the biggest networked LED project currently developed. It will look at the project design, the municipality's motivation and the envisioned goals. Thereafter, it will look at the replicability in other urban areas and possible barriers to implementation. The research methodology is based on literature review, analysis of reports on the Copenhagen smart city project, as well as information obtained during a personal interview with Karolina Huss, project leader at Öresund Smart City Hub.

Introduction

Street lighting is responsible for 40-50% of a modern city administration's electricity consumption.[1] Municipalities, the lighting industry and academia around the world are looking for solutions to make street lighting more efficient while maintaining security and traffic safety. LED-technology is currently transforming the market for street lighting and might deliver the infrastructure for even bigger changes.

By changing traditional lighting systems to LED, one can achieve up to 60-80% energy savings, substantially reduce maintenance costs due to longer life span of bulbs and obtain improved colour identification and illumination.[2] Besides these direct benefits, deployment of LED-based street lamps can lead to positive externalities (as illustrated below), such as reduced crime from improved lighting, safer roadways due to increased visibility, and so on.[2]

Street light changes in Halifax, Nova Scotia, Canada South street

BEFORE
High Pressure Sodium/100 Watt Lamp

AFTER
SAT-48 (48 LEDS) -280 mA / 44 Plug Watts

A recent initiative – The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) – has become a platform for implementing Smart City solutions in European cities. According to the EU Commission, a city is smart when "digital technologies translate into better public services for citizens, better use of resources and less impact on the environment."[3] The application of IT in lighting systems has become one of the areas of focus for achieving this. Components of smart cities include economy, environment, people, governance and mobility.[4]

Generally, existing literature agrees that to achieve sustainable urban development, cities need to invest in higher energy efficiency, better transport solutions and intelligent use of ICT, among others. Thus, smart street lighting solutions become one of the priority areas in sustainable urban development and planning. In this new concept, urban lighting systems are not just viewed as a simple medium for illumination, but a place for application and testing of different possibilities that modern and future ICT offers.[3, 4, 10]

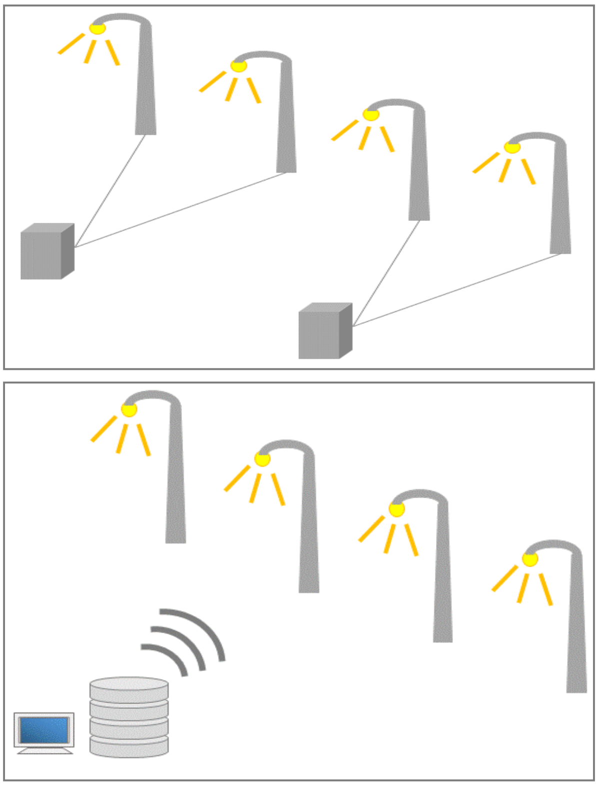
Copenhagen Case Study

To demonstrate the future possibilities of changing public lighting systems, this paper investigates a project by the Copenhagen municipality. Copenhagen is investing DKK 500 million (circa EUR 67 million) into changing over 20 000 street lights from conventional to LED lights. This change also builds the foundation for 'Copenhagen Connecting', an ambitious idea to make the city smarter through the installation of street light sensors that measure and share data in real time.

The project's overall aims are threefold. First and foremost, the municipality needs to maintain and improve traffic safety and security through reliable high quality light.[5] Secondly, the municipality aims at saving costs and energy. Copenhagen has a goal of being CO_2-neutral by 2025 and needs to replace old lighting solutions with more efficient technology, according to the EU Eco-Design Directive.[6] Lastly, and subsequent to fulfilling these two main goals, the municipality also sees an opportunity in using their most common piece of public infrastructure in order to make their city smarter.

The design of the project is remarkable in several ways. Firstly, Copenhagen chose to invest in a detailed and time-intensive technology procurement process, upon starting the project in 2013. The tendering process was not based on technical specification, but on the desired functions. Four competitors advanced to the second stage, where each of them engaged in intensive exchange with several municipal departments. Based on the exchange, the municipality adjusted its call for tenders in several points. Finally, the Citelum group was awarded with the 12-year contract in 2014.[5]

The project itself consists of two main parts. The first part is the exchange of all street lights in Copenhagen with efficient LED-lamps.



Technology differences between conventional street lights and networked LED street lights.

Additional savings are expected through lower operational costs.[1] Additionally, the networked LED-technology differs in structure from conventional lighting. While conventional lights were connected analogously to a switch box nearby, from where they can be turned on and off, the networked LED-technology were controlled wirelessly from a central traffic control centre (see Figure above).

The second part of the project is called 'Copenhagen Connecting', Copenhagen's smart city project, which builds on the network technology of LED street lights. In a pilot study, LED street lights in several areas of Copenhagen will be equipped with sensors to measure traffic movement and other data. These measurements will be available in real time on the city's servers.[5] The municipality hopes that this will give a new, globally unmatched quality of 'big data' in an urban context, with immense possibilities for innovation.

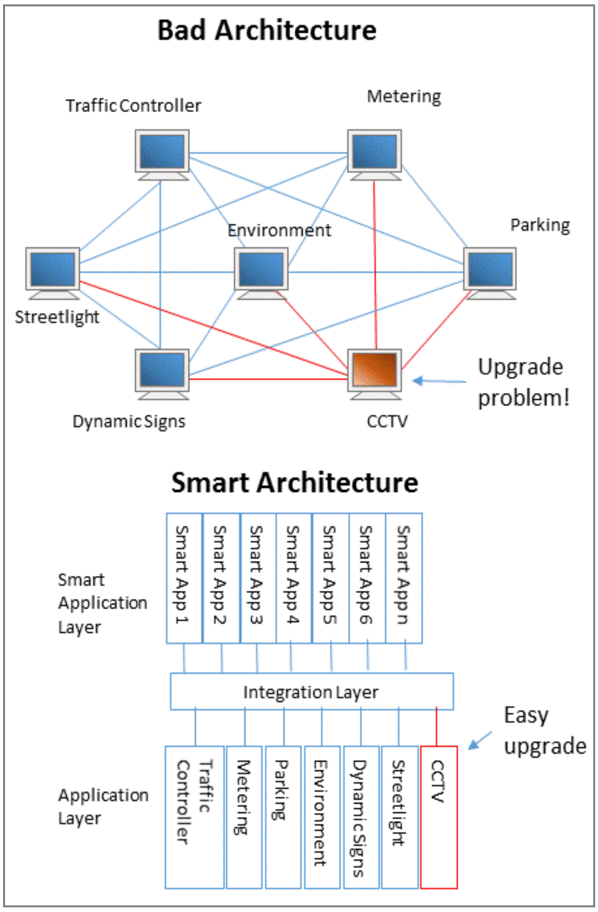
Besides traffic movements, weather indicators such as humidity or temperature or noise and air pollution can be measured. The city will make the data accessible, hoping for the industry to develop innovative services. Also opportunities for asset tracking are envisioned, for example, in car- and bike-sharing systems.[7] The rationale behind this is fairly clear: the municipality provides the digital infrastructure (i.e. the network of sensors and the data traffic) as an open source and companies, as well as individuals, can use it to develop new services.

This avoids silo solutions (socio-economical inefficient development of separate networks; see figure to the right) and attracts brainpower and innovative business from all over the world, in order to make Copenhagen a centre for digital and green development. [7]

Silo solutions (bad architecture) are more difficult to manage than integrated solutions (smart architecture). Adapted from Austrup K.(2014)

When discussing the potential socio-economic gains of the project, 'Copenhagen Connecting' is expecting big numbers. The consultancy company Rambøll estimated annual benefits of DKK 4.4 billion (circa EUR 600 mln). These gains are benefits to the whole population (e.g. through time savings or less fuel costs) and do not reflect the municipalities payback period.

The biggest portion (EUR 229 mln) is assigned to savings in the field of traffic, e.g. more efficient parking through street lights indicating the way to free parking spots (saving time and fuel). Gains through an improved environment (estimated EUR 112 mln), and innovation and growth (EUR 104 mln) are also significant.[8] (see table on page 4). It has to be added that it seems very difficult to predict these gains reliable (not at least due to the uniqueness of this project), as much of the calculations are based on speculations concerning acceptance and use of the system. However the analysis indicates very well the potential of this technology in many different areas of activity for a municipality.



EXPECTED ANNUAL GAINS FROM IMPLEMENTATION OF COPENHAGEN CONNECTING[8]		
AREA	**DESCRIPTION**	**ESTIMATED GAINS (in mln EUR)**
Transport	Increased security, dynamic traffic control, parking aid, etc.	229
Environment	Reduced GHG emissions, reduced car exhaustion	112
Water	Better collection of rain water, dynamic flood control	26.8
Waste	More precise geo-position data, preparation for collectors	0.13
Energy	Optimisation of energy use; energy savings	51.37
Wifi for tourists	Higher service for visitors	4.17
Innovation	Brainpower from all over the world, new valuable patents, strengthen Copenhagen's identity	104
Safety	Overview over crowd movement (e.g. for demonstrations), basis for city planning and zoning	10.76
Emergencies	More precise data from emergencies and accidents (route planning for ambulance)	17.2
Asset tracking	Better control over bike and car-sharing; real time information of incoming/outgoing cars	26.2

Replicability of the Project

According to numbers in the table above, the Copenhagen Connecting project seems to be a highly profitable investment with huge benefits in almost all areas. Why then are other cities not implementing similar structures? Besides the above mentioned advantages, the project has also several shortcomings.

First of all, it requires heavy initial investments: Copenhagen is spending over EUR 67 mln on this project. The payback period will be longer due to the Smart City part with a wider time horizon. Furthermore, the technology is new and – contrary to conventional lighting – city employees have little to no experience with it. Future developments are difficult to predict, so there is uncertainty about the 'right moment' to invest. Last but not least, there is no guarantee that the expected benefits through innovative services are actually realised, the infrastructure might, once created, not be used (either services are not developed, or they do not address the problem appropriately – available parking space

S	Long-time profitability Environmental benefits Modern digital infrastructure Generation of real time Big Data	W	High initial costs Immature technology High uncertainties
O	New innovative services Significant environmental gains Attracting brain power Synergies with other cities	T	No experience/expertise Too little public interest Development happening in other city

SWOT-analysis of Copenhagen lighting project might change to rapidly for street lights to give reliable information).

Business Case for Networked LEDs

In order to look a bit closer at the attractiveness of networked LED street light systems in the future, this paper takes a look at a business case designed by 'Silver Spring networks', one of the contractors of Copenhagen Connecting[1].

Main savings result through energy efficiency and operational improvements. Energy savings result from a lower wattage, dimming possibilities (e.g. during dawn and dusk) and reduced burning time (through remote access). Operational savings result mainly from longer lifetimes (up to 20 years compared to five years for conventional street lighting), and remote monitoring and automatic outage detection (less costs through access over network). The immediate outage detection is also enhancing traffic security as visibility can be restored quicker.

Costs result mainly from the hardware, which is responsible for 70% of the costs (in smaller projects than Copenhagen even more). Deployment, services and the networking software are the other cost points. Overall, the result is that a city would spend EUR 458 per street light while saving EUR 624 over the upcoming 20 years. The calculated payback period is only 6 years for networked LEDs. These numbers are taken from the business case, not real numbers.

The study gives a good indication on the financial viability of LED street lighting. However it has some shortcomings. It does not take into account the value of the still working conventional street lights being replaced (a lifetime of five years and a replacement period of two years would mean that 24% of the value of the old street light set needs to be written off additionally). Also it assumes rather large projects (50 000 lamps to be changed), driving down costs through economies of scale.

The following textbox gives a good example of a previous successful LED exchange project, yet without the smart city component.

Possible Barriers for Smart LED Street Lighting

The case of Copenhagen Connecting, as well as experiences of other cities (see textbox) can provide inspiration and great learning lessons for imitators worldwide. However, studies on these and other smart city projects identified several barriers towards implementing efficient and smart lighting solutions. It is essential to effectively address these issues throughout the process.

Political short-sightedness – As big infrastructure changes require high investments, in most of the cases it is very difficult to convince decision makers of the importance of the issue. This issue couples with the fact that most of these

LED in Los Angeles

One of the bright examples of LED based street lighting project is from the city of Los Angeles, CA. Within 4 years period starting from 2009, the LED Streetlight Replacement Program has replaced over 140 000 existing light fixtures, resulting in 63.1% of annual energy savings and reduction of 47 583 metric tons CO2 emissions. Additional savings are expected to be made through reduced maintenance costs as well. The payback period is expected to be 7 years. In order to avoid lock-in with specific technology or provider, the Bureau of Street Lighting developed a minimum set of requirements for all new LED streetlights. Although main drivers for this program were environmental considerations such as excessive energy use, light pollution, glare, hazardous materials, etc., this infrastructure change can lay a foundation for other smart innovations leading to sustainable urban development. It is a bright example of how green technology can be environmentally responsible and cost effective at the same time. [9]

changes might not bring benefits in the near future. Political changes might slow down already made commitments or plans Federal governments might engage and support municipalities in financing this change, as for example is happening in Germany.[7, 10, 11]

Complexity of cooperation and organizational inertia – Managing transition requires involvement of numerous actors and the process can get complicated and overwhelming. Each actor is driven by their own priorities and experiences, sometimes causing a pushback against innovation. Municipalities need to be versatile and communicate their plans effectively to all stakeholders.[7]

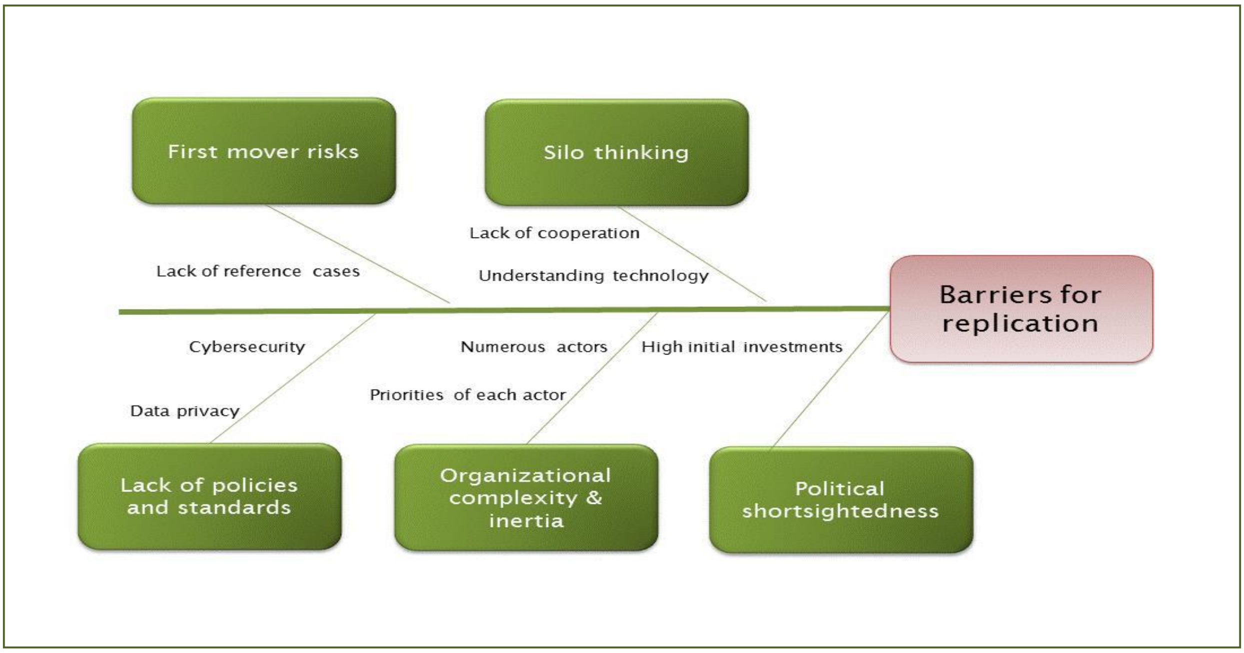
Silo thinking – Little understanding of and cooperation with other sectors can lead to missing out on synergy effects and platform solutions. According to survey results conducted by Cisco in 2014, silo thinking can be identified as both internal and external inhibitor of the process. Internal silos occur when there is no clear understanding of technology solutions and a lack of coordination and alignment. Cross-departmental teams can help address this issue. External silos are the result of poor cooperation among industry, city councils and Academia.[5, 7, 10]

Lack of policies and standards in place – Application of smart solutions in city infrastructure involves issues related to privacy and security. Thus, it is essential to have policies and standards on data privacy, cybersecurity, data collection and management in place before initiating such ambitious projects.[10] A publicly driven development of digital infrastructure can (but does not necessarily) achieve this.

First mover risks – While first-mover tactics offer many advantages, there is also a lack of reliable business models showing how to financially sustain the new technologies. This can cause politicians to avoid such emerging technologies, making it even more difficult to gain best practices for reference. [11]

Conclusion

The landscape of street lighting is in a phase of dynamic technological progress. Copenhagen has noticed the opportunities resulting from this and is investing heavily in a new street light system based on networked LED-lamps. This system is not only supposed to be more energy ef-



Fishbone-diagram after Ishikawa for possible barriers for technology transformation to LED street lights ficient (up to 80% reduction of electricity consumption for street lighting) and reliable, but could also be the foundation of a new digital infrastructure to generate a dense web of data in real time, helping to make the city smarter.

The project developers also hope to attract innovative business ideas and economic growth by making the data available as open source. Possible areas of use are indication of free parking spots, weather monitoring and warning, allergy warnings, emission and noise measurements and many more. A study by Rambøll envisions great potential and socio-economic gains of circa EUR 600 mln per year.[8]

In other projects worldwide, the potential of LED street lights has been demonstrated and the market is increasingly shifting in that direction as governments see an opportunity to both save money and improve their carbon footprint. Networked LED lights, however, are a completely different technology than the prevalent high-pressure sodium and mercury street lights. This causes several organisational challenges to municipalities (e.g. high initial costs, avoiding silo solutions, organisational inertia, standard setting for data security and first mover risks). When addressing these types of problems, LED street lights can both increase a city's energy efficiency today and serve as digital infrastructure for the smart city solutions of tomorrow.

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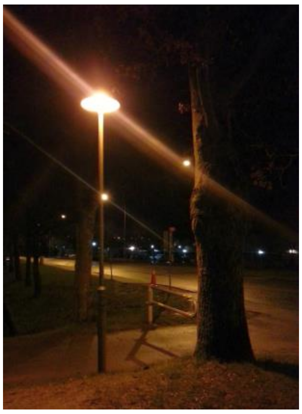
Jacob Surland. February 20, 2014. *One of the major sites lies in the heart of Copenhagen. (Title picture)* https://www.flickr.com/photos/jacobsurland/12880244275/. Creative Commons Licence

Andrew Herygers. 2014. *Street light changes in Halifax, Nova Scotia, Canada South street.* LED Roadway Lighting license

LIGHTING & SAFETY

Impact of Street Lighting on Crime and Perception of Safety



By Aybuke Ozdamar

There is a shift towards finding more energy efficient solutions for outdoor lighting in order to create sustainable cities.[1] Sustainable cities need to provide a good and healthy living environment that supports every member of the community's ability to interact with public space.[2] It is therefore important to ensure safety and security for everyone in these spaces after dark.[1, 2]

Lack of perceived safety may negatively impact health and psychological well-being. Crime itself also has negative health impacts; and fear of crime may cause mental health problems, as well as induce reduction in social and physical activities.[3] This issue needs attention when designing the environment to improve accessibility and safety for everyone.[2] This concept is called "Crime Prevention through Environmental Design" (CPTED).

CPTED is defined as "the proper design and effective use of the built environment [that] leads to a reduction in the fear and incidence of crime, and an improvement in the quality of life".[4] It provides various tools under six broad headings: territoriality, surveillance, access control, activity support, image/management, and target hardening. There are three different surveillance strategies: natural (e.g. resident observation), organised (e.g. police) and mechanical (e.g. Closed-circuit television (CCTV) and street lighting).[4]

Starting from the 1960s, street lighting programmes have been used to reduce crime rates in many cities.[4]

Lighting helps the pedestrians to

- Detect obstacles;
- Increase their visual orientation;
- Recognise other pedestrians' faces; and
- Gain general comfort.[2,5]

The aim of this paper is to explore relationships between street lighting, and crime and perception of safety. Additionally, the paper also focuses on the cost-effectiveness of street lighting for reducing crime and increasing perceived safety. The paper concludes with recommendations for policymakers.

Street Lighting & Safety

Throughout history, street lighting has been a popular tool for crime prevention. There are two primary benefits of improving streetlights: reduction in crime, and reduction in the fear of crime.[6]

Crime

According to the British Crime Survey, majority of criminal acts occur in public areas between 1800h and midnight. There are many types of crime that can be discouraged by improving streetlights, including robberies, physical and sexual assaults, vandalism, sexual and verbal harassment, threatening, and drunken and disorderly behaviour.[7]

Studies show that improving streetlights can result in a reduction in these crimes (see the table below).

Case studies reviewed	Effectiveness (crime reduction)
Wandsworth, London, UK[7]	Limited effectiveness
Atlanta, USA[8]	Effective
Milwaukee, USA[8]	Effective
Portland, USA[8]	Ineffective
Kansas City, USA[8]	Effective
Harrisburg, USA[8]	Ineffective
New Orleans, USA[8]	Ineffective
Fort Worth, USA[8]	Effective
Indianapolis, USA[8]	Ineffective
Dover, UK[8]	Effective
Bristol, UK[8]	Effective
Birmingham, UK[8]	Effective
Dudley, UK[8]	Effective
Stoke-on-Trent, UK[8]	Effective

The reasons for crime reduction can be explained from a criminal's perspective of a risk increase and a reward decrease due to higher visibility caused by improved street lighting. Furthermore, reducing opportunities for criminal activities by increasing potential witnesses can result in fewer acts of crime.[8]

Although a majority of the studies noted a relationship between street lighting improvements and reduction in crime, there are some studies that offers contrasting results. They claim that an increase in street lighting only acts as a psychological prevention mechanism to offenders, and does not directly reduce crime.[7] Instead, this may displace the crime to another place or time.[6]

Some studies have also concluded that improved street lighting could increase opportunities for crime. Increased visibility may display vulnerabilities of potential victims. Additionally, better lighting can provide the offender with the opportunity of an easier escape.[8]

On the other hand, a number of studies found that the design of outdoor lighting is important for reducing perceived danger,[5] especially in poorly-lit areas.[8]

Further insight was gained through a quick search using key words such as "street lighting", "theft" and "burglary" in Turkish and English. In Turkish, the search results were mainly related to complaints about the increase in burglary rates due to non-functional streetlights. However, in the English search results, there was no emphasis on an increase in burglary rate due to non-functional streetlights. These results may indicate that the relationship between street lighting and crime can be different in different areas and countries.

Furthermore, improving the lighting environment and informing residents about these efforts may improve their perception of the area. Not only would this led to a reduction in night-time crime, but an improvement in the day-time crime can also be achieved.[8]

Walking alone during dark hours increases the fear of crime

Fear of Crime

Reduction in visual accessibility and fear of victimisation can limit mobility of people during dark hours. The primary reasons behind the fear of walking alone during such hours are the lack of guardians that can help in the event of an attack and the vulnerability of being targeted when unaccompanied.[7] The fear of crime is higher among women and elderly people in poorly-lit areas.

One approach to changing this perception is related to increasing personal safety. Adequate street lighting facilitates the recognition of others and increases the number of people using the streets.[7] This can result in increasing the visual accessibility and feeling of safety.[3] That being said, similar results can be achieved by assigning more police patrols. It is important to conduct a cost-benefit analysis to decide which of these options is more suitable for an area.

Studies showed that with an improvement of street lighting, among, there is an observed increase in the mobility of the elderly population and an observed fear decrease.[3] Lighting improvements have had a similar influence on the women's perceptions of safety as well.[6]

However, there is a geographical factor in the feeling of safety. According to Johansson, although more than half of the women worried about walking alone after dark in Canada, in Sweden, personal security concerns are not as high.[5]

Cost-Benefit Analysis

In order to identify the cost savings and benefits of improved street lighting, both the financial cost of crime and the cost of the lighting system needs to be investigated. There are two main financial costs of crime: (1) tangible costs such as medical, police and social costs, the cost of stolen property etc., and (2) intangible costs such as the cost of suffering. Although, it is difficult to measure intangible costs, it can be measured by willingness to pay in order to avoid the cost of crime. With the cost of lighting, there is a capital cost of street lighting im-

Case Studies: Cost-Benefit Analysis of Improved Street Lighting in Dudley and Stoke-on-Trent, UK[9]

A cost-benefit analysis of street lighting improvement was conducted for Dudley and Stoke-on Trent projects. Financial cost of crime was calculated considering both tangible and intangible costs. Some of the estimated costs of crimes were:

- Vandalism: GBP 359 (EUR 453)
- Vehicle crime: GBP 751 (EUR 947)
- Robbery: GBP 1 338 (EUR 1 669)
- Assault: GBP 3 882 (EUR 4 897)

The Dudley Project: After improvement in the quality of streetlights, the frequency of acts of crime decreased by 41%. The capital cost of street lighting improvement was GBP 55 000 (EUR 69 374). The annual electrical and maintenance cost of the new lighting system was GBP 2 611 (EUR 3 293). From this information, the total savings were calculated as GBP 558 415 (EUR 704 357). The cost-benefit ratio of the project was 6.2:1 after one year.

The Stoke-on-Trent Project: Similarly, the frequency of acts of crime decreased by 43% after the project was initiated. The capital cost was GBP 77 071 (EUR 97 214). The annual electrical and maintenance cost of the new lighting system was higher than the previously existing system and equal to GBP 1 102 (EUR 1 390). From this information, the total savings were calculated as GBP 118 170 (EUR 149 054). The total cost-benefit ratio of the project after one year was 5.4:1.

provement as well as maintenance and electrical energy costs.[9]

The different case studies (see the text box above) found that street lighting improvements can be extremely cost-effective if resulting in a reduced crime rate in the area.

Moreover, street lighting improvements have a short payback time.[8] However, it should be noted that the payback period and effectiveness may vary based on the location and the cases.[9] In order to identify the most effective solution, different crime prevention methods need to be evaluated for each cases.

In conclusion, street lighting improvement is a less costly method to adopt when compared with the financial cost of crime.[9] Also, street lighting improvement schemes for crime reduction tend to be financially beneficial with short payback periods.[4]

Suggestions for Policy-makers

Crime prevention approaches modify the environment thereby making criminal acts more challenging with higher risks and lower rewards. For implementing effective crime reduction programmes, a thorough analysis of the social, economic and cultural factors is required. After which, the programme can to be developed and implemented. More generally, street lighting improvements should be considered under any crime reduction programme due to their feasibility, effectiveness and cost.[10]

That being said, it is important to keep in mind that poorly-lit areas do not necessarily have high rates of acts of crime. It would be a misconception if policymakers believed that lighting is the tool to reduce crime and fear. Depending on the case, harsher punishment for offenders, more recreational facilities for young people, more police patrols, and self-defence training programmes can be introduced to reduce crime and fear.[7]

Combining improved street lighting with other surveillance methods such as CCTV may result in greater outcomes for decreasing crime rates. However, public resistance to CCTVs needs to be taken into account during the decision-making process.[11]

Lastly, policymakers have to understand the connection between public awareness and community safety strategies, especially considering that with acts of crime, greater awareness has the potential to increase fear.[6] Public opinion about crime prevention should be taken into consideration and the community should be informed of policy development.[7]

Discussion

As presented in this paper, street lighting impacts safety and the perception of safety. Additionally, increased street lighting has both financial and environmental impacts. In the USA, it is estimated that street lighting was responsible for approximately half of the country's outdoor energy consumption in 2001, which is equal to 6.5 million tonnes of CO_2 emissions. Moreover, in 2011 the Netherlands reported the emission of 1.6 million tonnes of CO_2 for the generation of electricity to power streetlights.[12] Therefore, efficient use of resources is another factor that needs to be considered when developing street lighting improvement projects.

In addition, the increase of light usage creates light pollution. In some areas, this can destroy the ambience of the environment.[2] It is therefore important to balance safety with both environmental and economic impacts when designing street lighting.

Conclusion

The main reasons for the improvement of street lighting having a significant impact on a community are: change is easily recognisable; it increases the confidence of the people; and it gives immediate and measureable results.[6]

There are four main benefits arising from improved street lighting:

1. Crime reduction during dark hours;
2. Crime prevention effect, in some cases;
3. Crime reduction during day-time, in some cases; and
4. Enhanced perception of community safety.[13]

In general, surveillance tools have demonstrated their effectiveness in reducing crime and fear of crime. Among them, improved street lighting can be a feasible, inexpensive and effective strategy for crime prevention.[4, 10]

However, the degree of effectiveness is contextual. Before implementing a street lighting improvement programme, it is important to gain an understanding of the social, economic and cultural context. Additionally, the environmental and economic impacts of the programme need to be analysed.

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LIGHTING UP STUDENTS

Lighting companies working with schools

By Cillian McMahon & Tatiana Pasquel

In recent times, the lighting sector is becoming increasingly interested in collaborating with the education sector. Major technological innovations have occurred in the lighting sector such as the development of highly efficient, environmentally friendly light bulbs and dynamic lighting systems which can improve human performance. As the education sector is one of the major users of light in the world, schools can reap the benefits of upgrading their lighting systems with the new technologies developed by lighting companies. Several interesting business models have been established to finance the installation of these new lighting systems in schools.

Educational Performance and Lighting

It is well known that access to both natural and artificial lighting can be beneficial for one's mood, health, alertness and sense of well-being. These facts have been validated by countless scientific studies which have shown that lighting helps to synchronise the human circadian rhythm and suppresses the release of melatonin.[1]

Another study carried out by Mills et al. found that a reduction in the colour temperature of the lighting lead to an increased level of concentration and alertness by office workers.[2] Energy and lighting companies are using this evidence to design innovative lighting systems to enhance the educational performance of students in schools.

Philips SchoolVision

Philips has been at the cutting edge in developing lighting solutions to maximise educational performance.[3] Philips has created a pioneering lighting solution called 'SchoolVision' which aims to mimic the dynamics of daylight inside the classroom.[3] SchoolVision has four succinct lighting scenes which teachers can control by using a touchpad.[3] The scenes are created by modifying the balance of light intensity (lux) and colour temperature (Kelvin) which create a specific atmosphere for particular tasks or time of day.[3] Details of the SchoolVision Lighting System and which levels of intensity and temperature used for different activities can be found in the table below.

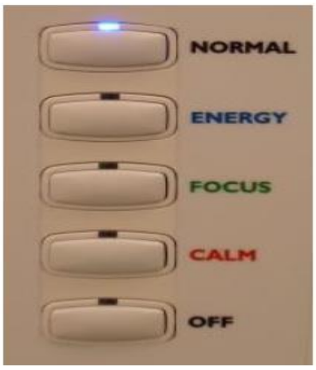
PHILIPS SCHOOLVISION LIGHTING SYSTEM SETTINGS			
Setting	**Activity**	**lux**	**Kelvin**
Normal	Regular classroom activities	500	3 500 (A Standard white light)
Focus	Activities requiring concentration e.g test	1 000	6 500 (A bright white light)
Energy	Used in morning/after lunch when student energy levels are low	650	12 000 (A cold blue-rich white light)
Calm	Group activities or settle down overactive students	300	29 000 (A white light with red tone)

The SchoolVision lighting system has been used in schools all over the world and the educational performance outcomes have been analysed by a wide variety of researchers. One such study was carried out in an elementary school in Hamburg by the University Medical Centre Hamburg-Eppendorf on behalf of Philips to asses to what extent light could affect the learning behaviour of students.[3] The results of the study in Hamburg suggested that effects from using the SchoolVision lighting system were mainly positive with an:

- Increased speed of reading by 35%;
- Amount of errors dropped by 45%; and
- Reduction in hyperactivity by 76%.

Other scientific studies have also confirmed the positive relationship between the SchoolVision lighting system and beneficial educational outcomes. A similar study carried out in an Finnish elementary using SchoolVision revealed that that the Energy and Focus settings were particularly useful in waking students in the mornings and improving overall concentration levels.[4] An additional study carried out by the University of Mississippi in an Elementary School in the U.S.A. found that students who have been taught using the SchoolVision improved their Oral Reading fluency(ORF) performance at much higher rate than a control group who were using standard lighting.[5]

Philips SchoolVision Control Panel[5]



Despite the many positive educational achievements associated with using the Philips SchoolVision system, there are also many potential areas of improvement. The study carried out in the elementary school in Helsinki found that the calm setting was more useful with younger students in comparison with older ones. The Finnish study also found that altering the lighting settings distracted students and that the high intensity lighting gave some students headaches The research carried out by the University of Mississipi found that the SchoolVision system had little effect on the motivation or concentrations levels of the students.[5]
Overall, there is substantial amount of evidence from the Philips SchoolVision case study that dynamic lighting in the classroom can enhance student performance. With further research and innovation in this sector, the benefits of lighting systems and student performance will continue to advance in the future.

Environmental Benefits

As schools are one of the largest consumers of light, there is consequently a large environmental impact associated with operating their lighting systems. This is particularly true in schools in Northern Europe where short days during the winter limit the amount of natural light entering the classroom. With technological advancements made in energy-efficient light-emitting diodes (LEDs) and Compact Fluorescent Lamps (CFLs), schools can improve their environmental performance by upgrading their lighting system to more energy -efficient alternatives. Many lighting and energy companies have started partnerships with schools in order to upgrade their lighting systems. Lighting and energy companies and the education sector have realised the mutual benefits of upgrading their lighting systems in schools which are explained in more detail the following table:

BENEFITS OF RETROFITTING LIHGTING SYSTEMS	
Benefits for schools	**Benefits for lighting companies**
Better environmental performance	Market for new lighting technologies
Save money on energy costs	Positive corporate social responsibility
Better classroom ambiance	

Project Green Classroom

In Ireland, a partnership scheme between energy provider Energia and Irish lighting firm e-Light has been established aiming at reducing the carbon footprint of schools in Ireland by replacing the current lighting system with LED lighting.[6] The scheme is called 'Project Green Classroom". Energia and eLight will invest ten million Euro into the scheme and anticipate that 1 000 schools will take part. Schools who participate in the scheme will benefits from savings of approximately 60% on their lighting and lighting maintenance bills.[6]

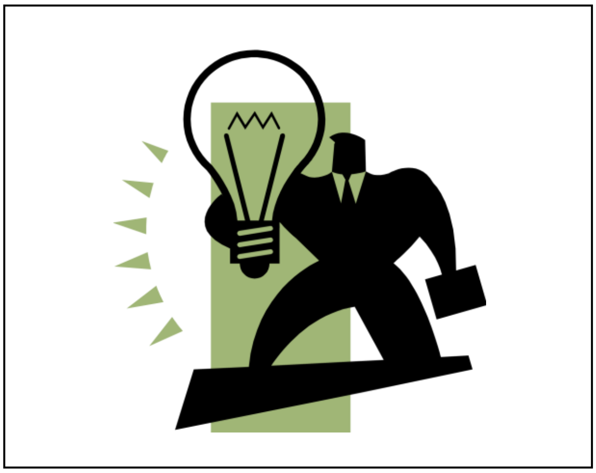
Schneider Electric and Lighting in Schools

Schneider Electric has been heavily involved in projects throughout the world which involve updating the lighting systems of schools. Schneider collaborated with two schools in Jacksonville, Alabama, by replacing the existing lighting system with energy efficient lighting .[7] The scheme has been very successful and has reduced electricity consumption by 800 000 kWh and reduced $C0_2$ emissions. The scheme helped schools in Jacksonville save more than USD 65 000 dollars on energy costs.[7]

TAC Sweden which is now part of Schneider Electric worked together with Malmö Municipality to upgrade the energy efficiency of the Strand School in Klagshamn.[8] One of the features of the project was the installation of a lighting control system whereby the lights are automatically turned off 20 minutes after the last student has left the room.[8] In collaboration with other energy efficiency measures, the Strand School at Klagshamn has managed to consume 55 kWh/m^2 annually compared with 120 kWh/m^2 used by other schools in Malmö.[8]

Integrated Lighting Solutions for Schools

As we have discussed, there are many new lighting innovations that have been developed which can be applied in schools. However, these new innovations are expensive and many schools' budgets are limited and are not able to afford these new lighting technologies. In order to overcome these financial barriers, many new innovative business models have been established which are both affordable for the schools and profitable for the companies in the lighting sector.



Product–Service Systems

Based on the concept of a Circular Economy, lighting manufacturers are now more encouraged than ever to not only offer state-of-the-art products but also to add value and quality on the performance of their products for their customers.[9] For some time now, a growing number of business model ideas based on the capability of coming out of the 'traditional' relationship between products, manufacturers and consumers are emerging in the lighting market.[10] Within this context, the concept of Product-Service Systems (PSS) arises as an attractive and engaging alternative to address the demand side of business.

As itself PSS seeks to improve the overall efficiency of a given system, along with improving efficiency of each system element. It offers integrated solutions: products and services. The manufacturer stays with the ownership of the product and as part of its services, provides maintenance, management, repair and other services that would ensure the functioning of the product. Hence, since the manufacturer provides and guarantees function instead of product, it is its major interest that the equipment is used as efficiently as possible.[11]

PSS are heavily linked with sustainability-oriented innovations (SOI), embracing concepts, criteria and processes to lever more sustainable products and services. Whilst creating value for their customers through enhancing performance, instead of focusing exclusively on the product, PSS are seen as a component of competitiveness. It is also highly sustained by its built-in environmentally friendly aspects. Benefits such as resource efficiency and waste reductions are achieved at a lower cost as a consequences outlined in the table below:

As expected, PSS have spread out along many different industry sectors, and the energy sector was not an exception. Lighting systems and lighting control systems in schools can be sold as products, however, by adding services such as installation, maintenance, utilities, commissioning, repair and operations, the aggregated value of the final outcome for the costumer is undeniable.

PSS SUSTAINABILITY BENEFITS	
Aspects	**Sustainability Benefits**
Economic	Lower energy costs. Creation of new markets
Environmental	Reduction of CO2 emissions. Easier recycling procedures. Waste reduction.
Social	Access to improved lighting

Energy Service Companies

Within the energy sector, a “product-service integrated package” is performed by Energy Service Companies (ESCOs). ESCOs work under the core premise of PSS: creating and capturing value through a value network.[12]

Literature does not offer a unique definition of ESCOs, however, it is widely accepted that ESCOs’ main target is energy efficiency. By selling efficiency, which usually translates in the decrease of energy consumption, one can say that ESCOs sell energy conservation (or absence) and energy management. In the U.S.A., ESCOs have found a very profitable market along many industry sectors. However, the so-called MUSH market (municipalities, universities, schools and hospitals) is by far their strongest and most attractive market. Market forecasts show that schools will provide USD 22 (EUR 17.65) billion in cumulative ESCO revenue from 2013 through 2020.[13]

ESCOs offer a large range of energy efficiency financing instruments, but perhaps Energy Performance Contracting (EPC) is the best example for this business model. EPC aims to provide energy savings to their customers for a fee. The fee is calculated in response to the functional performance of the upgraded product-service. In the case of schools in the U.S.A., under EPC, the fee is also calculated and paid through the future energy savings generated by the achieved efficiency.

ESCOs and EPC come as an optimal alternative to upgrade the lighting systems in schools. By ‘renting’ a ‘product-service integrated package’, rather than acquiring ownership of lighting products, they can upgrade their lighting systems at lower costs. On the other hand, manufacturers benefit from this system as well. For instance, in the case of LED lighting systems, as adoption rates are rising, forecasts project that the worldwide share of LED lighting technologies will reach to 63% by 2021.[13] However, this will not be enough to maintain the manufacturers' growth. Due to the larger lifespan of LED lighting systems, the revenue from their sales will decline. Thus, the expansion to 'integrated product-services packages' will not be only an alternative business model, but a 'must' do in order to stay in the market.[14]

ESCOs in Schools – Örebro

Schneider Electric (ESCO) and the City of Örebro, Sweden engaged in an EPC in order to achieve energy conservation measures within the Municipality's facilities, including schools and pre-schools.[16] With a total investment of SEK 156 million (EUR 17 million), 100 municipality-owned buildings were provided with: energy management system, lighting, metering equipment, heating systems and ventilation systems.[15] Within two and half years, the project aimed to achieve a 26% savings potential and take the opportunity to train municipality staff (60 people in total) in sustainable energy maintenance operations.[15] Moreover, the Municipality financed approximately 30% of the project through governmental grants and managed to reduce operational expenditures for reactive maintenance of their facilities.[15] The results of the programme were exceedingly successful and the Municipality achieved: (i) an increased cost control over their buildings; (ii) a reduction in greenhouse gas emissions; and (iii) created a platform for continuous improvement of their buildings operation and maintenance work.[15]

Students in lit classroom in IIIEE, Lund, Sweden.

Conclusion

The benefits from improved lighting systems in schools have been largely studied and are widely accepted. Students benefit from a lighting system that offers state of the art lighting design combined with a fair exposure to natural light. However, under traditional business schemes, lighting improvements for schools could be almost impossible to achieve. It is within this context that ESCOs offer an attractive business model to surpass schools' financial constraints. By selling "savings" instead of "consumption", both parties benefit. ESCOs have found in schools a rich market, thus, are encouraged to offer a reliable performance of the lighting system. Schools can ensure a brighter learning experience for their students.

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B2B LIGHT LEASING

The Benefits, Barriers and Solutions

By Giorgi Kochoradze & Huajun Yu

The technological breakthrough that light-emitting diodes (LED) brought on has had an effective impact both in the public and private sectors. As numerous scientific studies have evaluated the performance parameters, luminous efficacy or even colour-rendering indexes of LED-based illumination, a common positive conclusion is reached that LED are far more energy efficient than other lighting sources (whilst providing the same or even better performance). Owing to these factors, LED lighting is becoming an increasingly popular source of illumination.[1]

Light Leasing Models

Considering the circumstances, more recently, a number of companies such as Philips, Osram, GE, WB Financial, Leased Lighting, and Columbus Leasing, have developed leasing models that ensure cost-beneficial instalments of LED lighting systems for businesses.[2,3,4,5,6] As businesses like hotels, restaurants and firms become more aware of the superiority of LED lighting, compared to conventional lighting, the demand for LED lighting will increase.

Within these light leasing models, the producers not only offer the setup of LED lamps, but also provide optimum light management systems, maintenance, as well as upgrade and take-back services – yet, the ownership shifts to the producers.[7,8] Similarly, there have been strategic approaches such as the "pay per lux" – customers pay by the lighting performance – a formulated concept developed by Philips.[9,10]

The Benefits of Leasing

Leasing lighting is in line with both the lessor and lessee's interests. Medium-sized hotels, for instance, need to have electricity running all day for various reasons, be it service or facility attractiveness, comfortable illumination for clients, or visibility range for all incoming guests. It is in the hotel's managerial interest to have an extended lifecycle of their lighting devices functioning in an energy efficient manner; this in turn promotes reduced energy consumption and sustainable practice methods, which offer benefits to all stakeholders. In this sense, it is of high interest for light leasing companies to deliver a sustainable method of energy consumption, which is also profitable both for them and the lessees.[11]

Competitive Advantage and New Market

In light of the vested interests mentioned above, both actors gain a competitive advantage – Sustainability-Oriented Innovation (SOI) within the area of service. SOI is starting to be largely understood by conventional lighting manufacturing companies, eager to shift from product sales to a more prospective method of profitability – lighting as a service gaining an "increased market share."[12,13] Now, the transition from product-oriented to service-oriented business models can be regarded as a modern sustainability shift, which is taking place not only in the lighting sector, but in various other industries as well. From an economic perspective, LED light leasing is to be viewed as an innovative business model. Accordingly, leasing companies in themselves take a strategic opportunity in offering tangible and intangible benefits, alongside optimised sustainable lighting solutions that serve as a consumption reduction mechanism for potential customers. This notion also implies that potential customers will have an increased demand for reduced energy consumption on the market.

Economic and Environmental Gains

Companies using light leasing models only pay for the light leased, which typically saves money on the companies' energy bills.[11] Depending on the LED lighting components that the lessor supplies, the lease payment can be determined according to varying time periods (depending on the company's terms and conditions).[12]

Some light leasing companies, such as Leased Lighting, describe the advantages of their lease in the following manner: basing calculations over a five year period, the company's "monthly payments will equate to 90%"[4] of the contracted customer's annual energy cost savings. As a result, the customer saves money, while not worrying about the maintenance issues that might arise.

Moreover, customers are granted credible valuation of paying off the costs associated with initial leasing instalments. As most leasing companies suggest, the leasing instalments usually cost less than the monthly savings made from reduced energy use. The timeframe and given costs may be within the first incurring month or the proceeding.

The leasing companies also take responsibility for any potential maintenance costs, manual intervention and engineering, replacements, and so on. Thus, if a specific unit of the installed lighting system fails, the lessor dispatches an employee that fixes the problem at their own expense. This is another cost-beneficial aspect for interested customers to take into consideration, apart from energy cost savings. Light leasing provides smart solutions for companies who require reduced carbon emissions and seek to eliminate maintenance costs.[8]

Improved and Customised Services

Light leasing companies have a diverse range regarding their terms of service. For example, some suppliers offer LED light fittings (that ensure varied energy savings), coverage of maintenance and replacement cost, while other might include more sophisticated equipment, such as smart, centralised systems that automatically operate sensor usage, dimming functions, etc. Leasing companies, such as Novel LED Lighting systems, also distribute electricity through "diodes via network cabling" instead of the conventional cables. In turn, these cables have the ability to transfer data to sensors or dimmers that are centrally managed.[4]

All lighting elements – including upgraded transmitters, cables and infrastructure – are part of an integrated LED lighting system technology. Given that these technological capacities carry through leasing companies to

THE BENEFITS OF LEASING	
Lessor	**Lessee**
Competitive advantage – Sustainability-Oriented Innovation	Highly reduced upfront costs and energy savings
New market and customers	Reduced carbon footprint
Stable and increased benefits	Improved and customised services

another, the costs also vary. However, because of the technological advantages that these systems provide, the end result is reduced energy consumption that may even reach up to 80-90% savings of a company's energy usage.[3]

These systems provide mechanisms for regulating and controlling each and every individual lighting unit, proving to be very efficient. The central lighting hub can be installed within a particular building, granting direct access to the LEDs and the cables. These cables allow each lighting unit to be equipped with sensors that can determine whether a person is in the vicinity and what the temperature is, then automatically transmit this information to the central server.

Customers have the advantage of benefiting from these leasing models, since facilities are most often affected by electricity costs, as these optimised systems offer energy savings ranging from 60-90%.[3] This factor drastically alters a company's performance, be it in a positive cash flow or through sustainable consumption.

As a result, typical businesses and facilities take control over their energy consumption, taking advantage of their role as a sustainable contributor to environmentally friendly practices. These models practically commit the customer to hand over the responsibility of sustainability (and of their precious time) to lighting experts, who initiate future energy saving practices.[14]

The Barriers to Leasing

Light leasing model can brings various tangible and intangible benefits; reduced upfront costs, energy consumption and GHGs reduction (with improved and customised services for the lessee), stable profits, a new market and customers, and competitive advantages for the lessor.[8,12,15,16] As a rule of thumb, Product-Service Systems (PSS) are normally more successful in the business-to-business (B2B) field.[12] Therefore, it might be assumed that the new business model will quickly diffuse and grow into the market. However, in reality there are only a handful of light leasing examples found in private sectors – offices, hotels, stores, etc. – namely, Philips' two pay per lux projects.[9,10] Meanwhile, light leasing models develop quickly in the public sector, such as Osram's project in the Vatican's Sistine Chapel and Philips' projects in Washington DC and Paris.[6] So why do light leasing models develop slowly in private sectors and what are the key barriers?

Internal Barriers

A radical shift, from producing products to providing services or solutions, is difficult. It requires that the lighting producer change its company's culture; making profits by selling less with more services. This cultural shift can be challenging, not only for top managers but also the general staff. For top management, changing business strategies will bring about financial risks and uncertainties. Considerations, such as reduced profits if fewer products are sold, might deter the manager to change. The pursuit of a new business strategy needs a variety of human, capital and technical resources, which can distract a company from its core business and undermine its previous market position. Consequently, the top manager tends to be conservative and unwilling to change. For the general staff, sales people in particular, the new business model can be directly conflicting with their economic interests, as often their incomes are linked to sales.[12]

Secondly, the lighting producer needs to develop new capacities for servicing, like developing new products or solutions, market strategies, technologies, customers communication strategies, and so on. Under light leasing models, providing the physical products (lamps) alone is not enough: the lighting producer should also maintain and upgrade customers' lighting systems, and give advice for further energy consumption reduction. Therefore, skills and experts are of high necessity, such as those that can develop software for recording and analysing energy consumption patterns. Servicing is more customer-oriented and needs deeper customer involvement. Competencies, such as identifying needs and maintaining new customer relations (a closer relationship), are critical.[12,17] In addition, the light leasing models also require the manufacturer to cooperate closely with its partners and suppliers. Philips' RAU architects pay per lux project is a perfect example. In this project, in order to provide better lighting solutions, Philips collaborated with its installation partner – CasSombroek – who designed a special ceiling system for its lighting solutions.[9] A company can acquire new capacities by investing in R&D or acquiring, which can pose financial risks to it and then deter the manager to change.

Thirdly, lighting producers need a functional product development process (FPD). Unlike conventional product development processes, FPD is customer-focused and function-oriented, and requires various departments to coordinate. Within this new business model, the lighting manufacturers have to redesign their products to make them easier to maintain, upgrade, and recycle, as well as include built in sensors for data collection.[17,18] Again, the shift to FPD is difficult and needs new capacities.

External Barriers

This new business model is also confronted with many external challenges. Firstly, it is tricky to change the cultural mind-set of ownership. Ownership is strongly linked to taxation and legal issues; changing ownership can sometimes bring about legal risks. For private sectors, it is of high importance to avoid legal risks.[19] Ownership change can also lead to management risks, because the customers lose control of their own facilities (in this case, lighting). This can further cause conflicts between the lessor and lessee, which have been observed in other PSS cases. Previously, it was the operation manager's responsibility to take care of facilities, yet later the lessor took over, which conflicted with the interests of the manager.[12]

Secondly, customers normally look at the upfront costs, not the total costs of ownership and the associated environmental impacts.[18] This requires a shift of culture in customers, and as Mont has stated it is a main barrier to PSS.[15] In both of the Philips pay per lux cases, it was the customers choice to buy services.[9,10]

Customers also face numerous uncertainties under long-term contracts and closer relationships. For example, typically the customers are charged by the energy saving they accrued, with a fixed fee for maintaining and other services. If the energy price varies every year, the customers risk high uncertainty.[20] To date, there are only a few companies that can provide the leasing service; specifically Philips, Osram and GE. The customers can lose benefits, because they have less leverage to bargain.

Solutions

Drawn from experiences from successful lighting leasing cases and other PSS cases, the following actions can be taken for lighting producers:[12,17]

- Communication of the new business model to the top managers, who can communi-

THE BARRIERS TO ADOPT LEASING	
Internal barriers	**External barriers**
Financial and market risks of culture shift	The mind-set of ownership
Resistance from staff	The management and legal risks of changing ownership
Requires new capacities	Uncertainties of the closer and long-term relation
Needs a functional product development process (FPD)	Few suppliers available

cate to their staff and continuously reduce the resistance;

- Changing incentives, such as delinking salary from sales;
- Building new competencies, like new customer communication strategies, through R&D, networking, partnership, acquiring, and so on;
- Redefining the basis for profit in contracts. The new contract should incentivise the providers for further optimisation and create win-win scenarios, which bring benefits to both parties (e.g. pay for the energy savings); and
- Developing a new product development process - FPD.

Conclusions

As technology develops, LED will become more efficient and display better performance. Alongside the considerations of climate change and sustainability, it is believed that LED will gradually takeover the lighting market.[1,2] Concerning LED's unique characteristics, e.g. various design, long life span and high initial costs, leasing models are promising. The new business model has various benefits, like reduced upfront costs, energy consumption and GHG reduction, with improved and customised services for the lessee; stable profits, new market and customers, and competitive advantages for the lessor.[8,12,15,16]

However, by far, these business models are rather a niche market in private sectors. There are a number of barriers confronting its expansion. For companies who want to take the initiative, the main barriers are financial and marketing risks of a company culture shift, resistance from its staff, and the need for new capacities.[12,17] For customers, the obstacles are the mindset of ownership, the risks and uncertainties of changing ownership, like management, and legal risks.[12,15,18, 19,20] The barriers can be overcome by better communication, building new capacities through R&D, partnership and acquisition, changing the incentives of staff, and redefining the basis of interests in contracts.[12,17]

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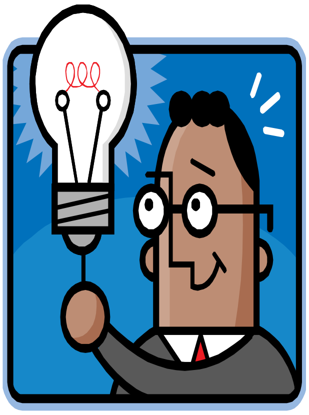
PURCHASING PHOTONS

Drivers and Barriers for Lighting Producers to Sell 'Light'



By Indika Arulingam & Jingxin Wang

As demand grows, and volatility and scarcity of supply increases, it is increasingly challenging to continue with a linear model of production, which is the current trend. Substantial improvement in sustainable resource use is in quest. The concept of a "circular economy" can be a possible part of the solution.

In the lighting business, one adaptation of this concept is in the selling of "light" instead of lighting products. In this new business model, lighting producers retain ownership of the product, while customers attain the service of lighting.

This paper will first introduce the concept of a circular economy, followed by an introduction of the Product-Service System (PSS) business model, as an application of this concept. The focus will be on lighting.

A case study is used to demonstrate the practical application of the concept, following which, the drivers for a producer of lighting to adopt this model, as well as the challenges that may have to be overcome, are discussed.

> Circular economy is a concept that has been inspired by natural systems and one that aims to adopt and apply the same non-linear approaches to production in industrial systems. It provides a new industrial model, which decouples revenues from material input (see figure on the following page). The estimated economic benefit of adopting this approach can generate savings of more than EUR 0.8 trillion, annually.[1]

Why Circular Economy?

According to the OECD, the population of the middle class will increase from 1.9 billion in 2009 to 4.9 billion by 2030.[1] This would result in an increase in disposable incomes, which could translate into an increase in consumption. This, in turn, could drive an increase in the demand for raw materials; it is expected that the economic system will require 82 billion tonnes of raw material by 2020. Additionally, this could mean a constant depletion of non-renewable resources, especially of some vital industrial elements, driving their scarcity.[2] These developments result in the current "take-make-dispose" method of production and disposal, which is being strained to a breaking point.

Circular Economy Principles

Circular economy attempts to follow a way of thinking that focuses on a reduction in the use of toxic chemicals that can prevent the reuse of materials, transition to renewable forms of energy, minimisation of the generation of pollution, and a focus on restoration at the end of the life of a product, instead of disposal. The focus is on finding novel business models within these principles of production.[1]

According to the Ellen MacArthur Foundation, the guiding principles for circular economy are:

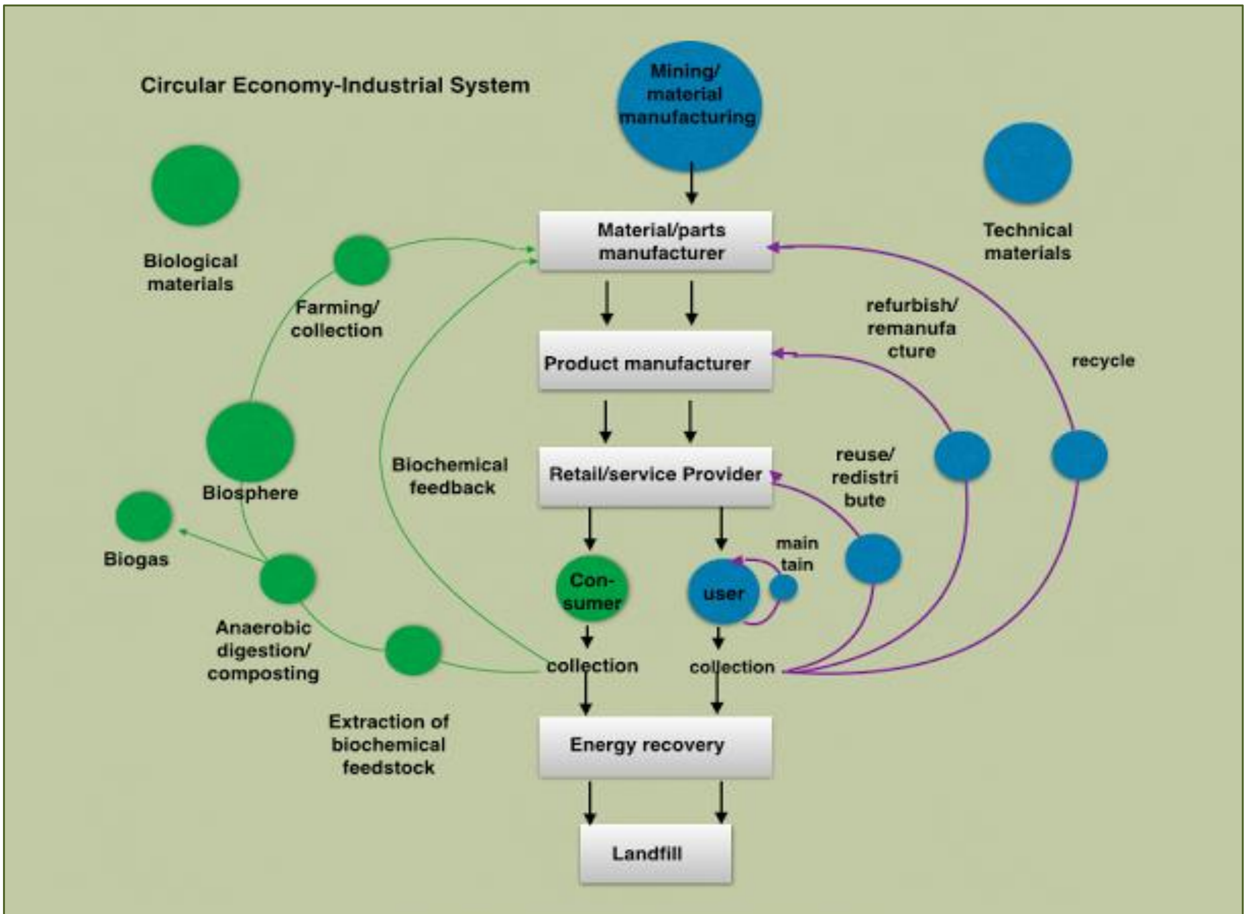
- Design out waste: intentionally design products to fit within a biological or technical materials cycle, for disassembly and re-purposing, so that waste will not exist;
- Build resilience through diversity: prioritise features of modularity, versatility and adaptability;
- Work towards using energy from renewable sources: aim to run on renewable energy;
- Think in 'systems': understand how parts and the whole interact with each other; and
- Think in cascades: extract additional value from biological products and materials by cascading them through other applications.[3]

Selling of a Service as a Business Model

The potential value of the circular economy is not only in recycling, but is also embedded in the reuse, maintenance, refurbishment, and remanufacturing of products.[4] To fully explore its value, and to apply the concept in practice, new innovative business models are to be adopted.

The PSS model, has been put forward as one such example, to exploit new opportunities that a circular economy can offer.[5]

In this model, customers do not purchase goods directly. Thus, ownership does not transfer to the customer, as in traditional systems. Instead, they pay a fee for use and return the product, after a certain period. For manufacturers and/or service providers, their in-



Data source: Adapted from Ellen MacArthur Foundation (2013)[1] volvement and responsibility extends to the product's whole lifecycle. The extension includes, but is not limited to, arranging systems for reuse, remanufacturing and recycling, while also educating customers about efficient ways of product use, along with maintenance and upgrading of the product during the time it is retained by the customer.

With this model, it is easier to incorporate information and economic benefits from the use stage into the product development and design phase, and the manufacturing phase, due to better integration of these stages, which have been traditionally separated. Therefore, the entire system is more responsive to changes of different market parameters and is more likely to stimulate innovation.[6]

While there are several business models, this article focuses on the selling of the service of lighting by producers. The following case study further illustrates this concept.

Pay per Lux

Philips, one of the leading producers in the world of lighting products, as part of its EcoVision programme, collaborated with the Ellen MacArthur Foundation to initiate the concept of circular economy into its business strategy. While several aspects of the concept were looked at, in practice, Philips decided to pursue practical implementation using a revolutionary business model – "pay per lux".[7]

Other drivers for this decision included the want to accelerate the utilisation of more energy efficient lighting technologies such as Light Emitting Diodes (LEDs). Despite energy savings of up to 80%, when compared to incandescent lamps, the market penetration of such technologies was considered to be low. Furthermore, it was an avenue through which Philips could reclaim the materials found in its lighting products, some of whose values are expected to rise in the future.[8]

The pay per lux concept is a business model that sells light to customers, instead of lighting products.[8] Thus, it embodies the main characteristics of a PSS. Philips would retain ownership of the lighting product, with the right to reclaim all of the used components at the end of the contract. In addition, Philips would be responsible for the maintenance of the system during this time.[2]

The first project initiated using this model, was in collaboration with RAU Architects. Philips was contracted with the task of providing RAU Architects with the service of lighting their office building. RAU Architects was interested in purchasing only the light, under a pay per lux model. The result consisted of a lighting system that used LED technology in conjunction with sensors and control systems that adjusted illumination according to the availability of daylight and the specific lighting requirements of the situation.[9] The installation of LED technology, and optimisation of the system also resulted in energy savings by as much as 60%.[10]

The second pay per lux project by Philips was in collaboration with the Washington Metropolitan Area Transit Authority (WMATA), and involved a makeover of 25 parking facilities, with newer lighting technologies. Following the same direction as the previous case, lighting was optimised such that it was provided at ambient levels. The effectiveness of the security camera system, and general safety, increased as a result of the improved lighting. A 68% reduction in the energy consumed as well as significant electricity cost savings meant that the system was paying for itself.[11]

The third project involved the building occupied by the National Union of Students (NUS) in the UK. Being a non-profit organisation, the arrangement suited the needs of NUS, as it did not require capital investments upfront, and as all of the resources spent on the maintenance of the system could now be redirected. As in the previous two cases, significant energy savings were noted.[12]

Drivers for Lighting Producers

The adoption of a PSS model that focuses on providing light can have many distinct advantages for the producer. Some of these are in the realm of environmental sustainability, as discussed earlier. Here, we discuss why it can also make good business sense.

Creation of New Markets

Expansion of the usage of LED lighting and associated technology makes it possible for lighting to be integrated into the PSS model, and offered as a service, for the following reasons.

Rapid changes in the efficiency of light technologies: at present, lighting accounts for almost 19% of the world's electricity use and financial expenditure.[13] In the recent past, LED technology has evolved to become more efficient and to provide a wider range of applications. In addition, it has also been used as replacements for incandescent and fluorescent lighting fixtures. Mr. van Houten, CEO of Philips, is of the opinion that both of the above reasons make the marketing of light as a service an attractive option.[14] For customers that require large-scale and long-term lighting projects, such as business customers or public bodies, it would be advantageous if they would not be locked into a technology, both with regard to the initial investment of the system and potential cost savings if they consume less.

> Mr. Johansson, Project Manager at Business Innovation at E.ON, is positive that there is a future market for this idea. He believes this trajectory, can be used to "step up the business", and can be quite successful, if the right business model is picked and marketed well.

Thus, a system, where only the light is paid for, and the producer is responsible for updating and maintaining the system, can be seen as an attractive option.

Increasing complexity of lighting systems: rapid changes in LED technology are not limited to efficiency alone, but extend to its potential to be incorporated into 'smart' lighting systems, which are customised to match the requirements of the user. While, this would provide disincentives to potential customers for the reasons discussed above (cost and future improvements), the increasing complexity would also mean that external expertise would be required to set up the system.

Thus, this provides a good opening for the development of a new market to which lighting solutions are offered, instead of the physical product. Lighting, as a PSS, where the system is designed to provide lighting to fit exact requirements, could be a potential avenue to meet this demand.

Decreased Costs and Increased Profits

The advantages to a lighting producer can be more internal, including ensuring a more secure supply of raw materials, and a decrease in costs in different stages of the production process.

The challenge to generate high profit margins: LED bulbs can last as much as five times longer when compared with competitors,[14] which would mean that sales of the bulb can fall as customers purchase them less frequently. Thus, superior profit margins would have to be earned from the sale of each product.

A study of long-life fluorescent tubes (which last four times longer than standard fluorescent tubes) produced by Aura Light International AB indicates that the challenge to compete with products of lower prices, which may be an incentive for a customer to purchase this alternative regardless of lifecycle costs, make this system more suitable to be sold under a PSS.[15]

Possibility to secure supply of raw materials: Raw materials used in the production of LED bulbs include valuable metals such as gallium, indium, silver and gold. These materials are of economic importance.[16] In case of fluctuations in prices of these raw materials due to scarcity, the producer could be better insured if used products are easily available for recycling. A PSS would ensure continued ownership of products and their materials. The decreased costs would also apply to legislative requirements related to "Extended Producer Responsibility", the release of toxic materials into the environment and the costs of compliance with applicable regulations.

Challenges to Overcome

Concerns regarding customer perception as well as costs for producers are explored in this section.

Customer Perception

According to Mr. van Houten, customers may feel reluctant to accept products that they may view as 'secondhand'.[14] Customers could also be reluctant to give up ownership of the physical product. This may be particularly true of private customers (individual customers), as the investment and disposal costs of the lighting system may be too small for them to feel the need for alternative models of ownership (for business and municipal customers, this may be an incentive to change producers).

In order to overcome such challenges, carefully planned and executed communication is important. However, this may be especially difficult with private customers, as the opportunity to provide information before they make a purchasing decision is short, and the information has to be effectively provided. Communicating and convincing them of such a different means of providing value, may be particularly tricky.[17]

> Mr. Johansson of E.ON feels that the biggest barrier to overcome is convincing the existing network and actors to change. He believes that actors utilising traditional business models would be largely hesitant to convert to the new system.

Additionally, customers may have an incorrect understanding of the financial costs of owning and maintaining a product over its entire lifecycle. In the case of light fixtures, if the price of the PSS is too high, the customer may make the decision to continue with the traditional product, as they may not be aware of the lifecycle costs, or are not interested in factoring it into their purchasing decision.

Producer Concerns

Producers may be concerned about internalising costs related to the impacts of customer usage.[17] This may be due to concerns that customers are less inclined and have fewer incentives to look after a particular product, if they do not have ownership of it and if the costs of maintenance are not borne by them.

In addition, according to Mr. van Houten, collection of the used product may become an issue, particularly from private customers.[14] For such customers, volumes and disposal costs may be too marginal to motivate a switch from traditional methods of disposal.

Secondly, a PSS, would only make sense to producers, if the financial costs of repairing, remanufacturing or recycling products do not exceed that of producing brand new products.

In the case of LED lamps, there exist many opportunities to ensure "green design", so that the above processes can be facilitated with ease. These include:

Design for disassembly: This involves design principles that make it easier to take apart the lamp into individual components. This also involves minimising, wherever possible, the number of components and the number of materials used. The end goal is to facilitate the separation of individual components or materials into homogenous groups, for further processing.

Design for remanufacturing: If disassembly can be done in non-destructive methods, certain individual components can be, with some processing (e.g. cleaning), used to remanufacture the lamp, along with other replacement parts.

Design for materials recovery: Under this, after disassembly, materials are recovered either for the purpose of recycling or disposal. At present, the proportions of aluminium and plastic present in LED lamps make it economically feasible to recover for recycling. Future increases in demand for scarce elements such as gallium, gold and silver, along with potential scarcities and price fluctuations may result even higher levels in recovery and recycling of these materials.[18]

Conclusion

With the rapid evolution of LED technology, in terms of efficiency and increasingly sophisticated applications in conjunction with electronic and IT systems, there exist opportunities to provide lighting services in novel ways. This creates a new avenue for it to be offered in the form of PSS right from the start. In contrast to PSS for other products, in the lighting sector opportunities to offer the PSS to new markets exist. It is therefore recommended that the lighting industry capitalises on this.

The challenge for PSS in lighting centres largely on translating the success that has been seen with municipal and business customers to private customers. To overcome this, producers should focus on marketing 'smart solutions', which extend beyond merely the function of lighting, and instead provide an integrated and holistic service.

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PAYING PER LUX

Lighting and Product-Service Systems

By Alex Cukor, Thomas Pienkowski & Ruth Pinto

Unsustainable material and energy flows associated with modern consumption patterns are exceeding the earth's long-term carrying capacity.[1] This unsustainability is predicted to worsen as both global populations and per capita consumption increase.[2]

This has led many to suggest that paradigmatic changes in consumption patterns are needed, if we are to simultaneously harmonise global quality of life whilst maintaining the natural resource base that underpins human wellbeing.[3,4]

Product-Service Systems (PSS) may be a powerful model for moving towards a more sustainable future, through the transformation of consumption patterns.[5] PSS involve moving from business models, based on the retailing and consumption of products, towards the sale of the amenities that those products previously fulfilled – the "function-oriented business model".[6]

This paper introduces PSS in lighting. It goes on to explore the barriers and drivers to the uptake of PSS by critically exploring the collaboration between the National Union of Students (NUS), in the UK, and Philips Electronics within their "pay per lux" model. By identifying these barriers and drivers, we hope to highlight potential solutions, thereby promoting the pay per lux model and PSS more broadly.

Appropriate and attractive lighting within the NUS headquarters. Photo courtesy of Mr. Agombar.

PSS Theory & Practice

Contemporary consumption patterns involve the sale of products that are subsequently used to generate value by customers. Advocates of PSS ask "instead of selling a product, is it possible to sell the value that is generated by the product, whilst retaining the physical ownership of the item?" Within the core PSS model, customers receive "result-oriented services": they acquire essentially the same utility, yet product ownership remains with the service provider.[7]

This *dematerialisation* has a number of key sustainability and business benefits. Producers are incentivised to develop products that last longer and are more easily repaired, recycled, refurbished and reused.[5] Customers, in turn, dispose of less waste and reduce operational redundancy (where a resource-intensive product is used infrequently, for example). Customers can also benefit from greater service customisation and improved quality.[8]

However, the relationship between producer and customer also changes; the producer is incentivised to offer more resource efficient products during the use phase, and the customer to only pay for the level of use that they actually require.[9]

This also creates strategic benefits for business. Producers are able to create "Sustainable Value Innovation" – new markets without existing competitors. As well as creating competitive advantages, PSS allows companies to reduce manufacturing costs through increased recycling, reuse and repair of products that would otherwise be disposed of by customers.[10]

Limits to PSS

PSS may be inappropriate for some goods, especially where ownership is necessary to confer value. For example, a PSS for goods that are altered through use, such as food, is obviously inappropriate. Mainstreaming PSS also requires cultural shifts away from valuing ownership in its own right, and the transformation of business models.[11,12] These corporate challenges include establishing appropriate prices, managing risks that had been borne by customers, and restructuring organisations to be able to manage PSS.[9,13]

PSS & Lighting

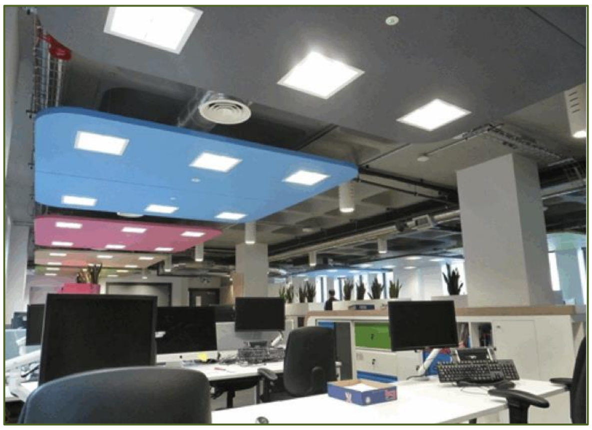
Lighting provides a promising example of where PSS could be implemented. Within a result-oriented pay per lux model, instead of the customer purchasing the lighting installation, maintenance and electricity, customers pay for the value-generating service – the lighting of a space. A variation of strict PSS model includes leasing contracts where the producer retains the lighting equipment, performs maintenance, and replaces and upgrades components with "best available technology", while the customer pays the electricity costs and service fee. The pay per lux business model is considered to be beneficial for both the producer and customer, with the common objective being to reduce costs.[14]

Within pay per lux models, intelligent lighting systems (often including LED technology) are used to ensure high performance levels. This has multiple environmental and business benefits, particularly energy savings.[5]

When designing and delivering PSS, it is important to consider the customer's perspective on a case-by-case basis.[9] The following section explores the drivers and barriers for adoption of a pay per lux model from the customer perspective, citing the result-oriented PSS collaboration between NUS and Philips.

NUS Case Study

The National Union of Students is a confederation of 600 student unions, which supports students and student unions across the UK. Areas of interest include student rights, discrimination and research.[15] NUS and Philips began their partnership in 2012 when NUS acquired new headquarters in London. In an effort to reflect student interests in sustainability and to inspire employees, NUS set out to



Paying per lux within the NUS headquarters in London. Photo courtesy of Mr. Agombar.

design one of the most sustainable offices in the country. The agreement between NUS and Philips would represent one of the first PSS-styled lighting contracts in the world.[16]

According to the 15-year contract, NUS pays a quarterly fee to Philips and the electricity costs. In turn, Philips supplies LED luminaires, maintenance, annual reports on electricity usage, and upgrades with the best available technology. During the refurbishment of the office, Philips worked with NUS to minimise luminaires, maximise lighting quality and facilitate maintenance. Furthermore, Philips and NUS have set an electricity usage threshold whereupon Philips reimburses NUS should electricity use exceed the threshold. This incentivises Philips to minimise electricity usage through energy efficient lighting.

To gain further insight into the drivers and barriers behind NUS's PSS partnership with Philips, an interview was conducted with Mr. Agombar (Ethical and Environmental Manager at NUS). The key drivers and barriers, and their generalisability, are discussed in the following sections.

Drivers

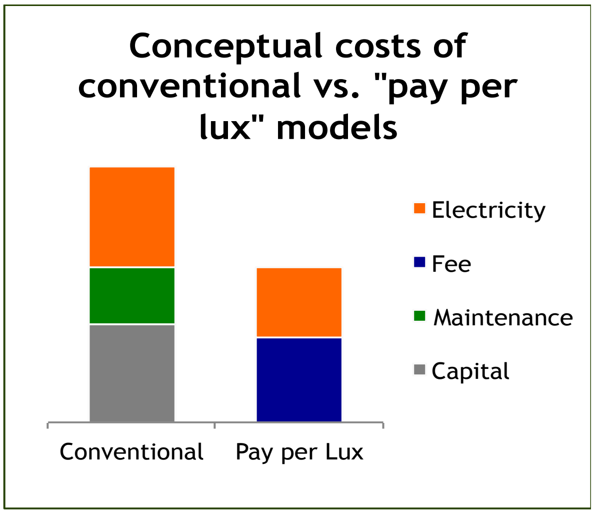
Organisational interest: NUS pursued pay per lux in order to reflect the interests of the students they represent. The building was intended to symbolise the organisation's goals, values and commitment to sustainability as well as to inspire employees. This commitment to "lead change" was key to their pursuit of the PSS model. Moreover, it was important for overcoming what Mont has identified as a key barrier to adoption of PSS – the need to change cultures of practice.[5]

No capital costs: purchasing equivalent LEDs for the office refurbishment would have cost NUS over EUR 150 000. Within the pay per lux model, the capital costs are instead borne by Philips, allowing NUS to invest in other initiatives, including photovoltaic panelling.

Consistent costs: the 15-year contract with Philips reduces cost fluctuations for NUS. This stability largely originates from the fixed quarterly fee paid to Philips, which includes maintenance and refurbishment costs. Although NUS pays for the electricity they use, volatility in electricity costs are limited by the threshold described above (where Philips reimburses NUS for costs exceeding the threshold).

Reduced total cost: as Philips supplies the expensive but highly efficient LED bulbs, NUS saves money on their electricity costs, without paying the high capital costs of acquiring LEDs. Additionally, NUS no longer pays for maintenance and bulb replacement. The conceptual diagram at the bottom of this page describes the relative costs of conventional and pay per lux models.

Continual improvement: NUS was interested in the agreement since Philips will optimise the system with the best available technology over the course of the contract. This eliminates an-



Comparing costs: conceptual diagram of conventional and pay per lux models over a fixed time period. Philips pay per lux model offers cost savings to customers through superior energy efficiency and eliminated maintenance and capital costs. The remaining costs of the model are the quarterly fee and electricity usage.

other cost to NUS, enables future proofing and supports their sustainability values.

Attractive luminaires: another benefit of the agreement was the high quality office lighting and attractive luminaires.

Barriers

Communication: due to the collaborative nature of the project, on-going communication is of key importance. For example, development of the terms of the contract was significantly influenced by the context, which had to be explored by the two partners. However, communication was sometimes challenging. While it was speculated that the size of the company could have been the cause, other factors such as the novelty of the lighting system may have also played a role.

Contract length: while the 15-year contract enabled NUS to capitalise on consistent costs, this structure may not benefit other organisations. For instance, other potential customers may not have stable electricity providers – in particular those subject to procurement guidelines. Further, parties renting space may not have a long-term lease or the authority necessary to commit to a long-term contract. It may be questionable whether lighting companies will cooperate with cases that cannot offer long-term commitments.

Lack of establishment: as PSS, especially within the lighting sector, is a new concept. The absence of cases to draw upon may make potential customers wary of this novel business model. Lack of establishment also means that few suppliers offer PSS lighting packages. Consequently, NUS found it challenging to find a partner willing to offer this alternative system. At the time, Philips was the only supplier offering alternative models. If NUS lacked motivation in this first stage, it is unclear if the system would have materialised. However, Wong claims that PSS may be more acceptable in communal cultures, and subsequently novelty may be less of a barrier in different cultural contexts.[17]

Payment for electricity: the separate payment for electricity, in addition to the quarterly fee, may be less attractive than a pure PSS model (where all operational costs would be borne by the service provider). While NUS accepted the partnership, this may discourage others.

Lessons Learned

When generalising these findings, a number of case-specific conditions should be considered, as they make pay per lux uniquely attractive to NUS. Firstly, refurbishing the building enabled Philips and NUS to reduce the number of luminaires, and this saved costs for both parties. Secondly, NUS staff were supportive of the initiative. Such support helped overcome the difficulties involved with establishing alternative approaches, such as PSS. Thirdly, Philips, in an effort to create demand for their new pay per lux package, may be offering unique incentives to first movers. In future applications, such systems may not contain such advantages.

Despite these considerations, there are a number of key drivers that could help promote PSS both within the lighting sector, and in other

With the funds saved as a result of the zero capital cost, NUS was able to invest in other sustainability initiatives, including a photovoltaic system. Photo courtesy of Mr. Agombar.

applications. Of the drivers identified in the case study, the most significant and generalisable are organisational commitment, eliminated capital costs and reduced total costs. Organisational commitment is a critical driver because the system's novelty entails higher resource costs to establish. The support of key staff must provide adequate momentum and resources for overcoming these barriers to adoption. Eliminated capital costs and lower system costs are also critical, as they provide strong economic incentives for challenging conventional operating models.

On the other hand, key barriers include communication, length of contract and lack of establishment. Given that PSS models require increased interactions between suppliers and customers,[5] communication becomes a vital part of developing and maintaining the system. Early communication, as seen in the NUS case where Philips helped design the building lighting, can also enhance the benefits of PSS. However, being a pilot project, it is expected that Philips invested additional resources to ensure the success of the initiative, including communicating with NUS. Despite this, there were communication challenges. These challenges may worsen as the initiative expands to new clients.

The length of the contract is also important because this aspect can make or break a PSS agreement for both customers and suppliers. For a variety of reasons, customers may not have the ability to commit to a long-term contract. On the other hand, suppliers may have difficulty finding profit in shorter contracts. Finally, the lack of established PSS models within the lighting sector means that few suppliers exist, and costs of establishing systems are high. This alone necessitates strong drivers to counterbalance resistance and facilitate future adoption of PSS.

Conclusion

Modern-day consumption patterns threaten to overuse the earth's natural resource base.[1] PSS offer a means to shift towards more sustainable resource consumption. The collaboration between NUS and Philips illustrates one of the first implementations of such a system in the lighting sector. A review of the drivers and barriers for the adoption of this system by NUS enhances our understanding regarding the possibilities of adopting PSS in lighting, as well as for other sectors. Lessons drawn from such cases can hopefully promote a transition towards a more sustainable future.

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All photographs used were provided courtesy of Mr. Agombar, Ethical and Environmental Manager at the National Union of Students, UK.

LED & MARKET COMMUNICATION

A Case Study of Packaging Information

By Zhe Wu

Due to an increasing concern about climate change and energy security, our society has started its journey on an energy system transition, towards a more energy-efficient and sustainable future.

Since lighting accounts for nearly 6% of global CO_2 emissions and 20% of the world's total energy consumption, attention has been given to the lighting sector's energy consumption reduction potential.

As a result, national regulation has become stricter on high energy-consuming light sources: the EU has launched the European Eco-design Directive Green Public Procurement and banned incandescent lamps in 2009,[3] while China has phased out 100 W incandescent bulbs.[4]

On the other hand, with technological progress owing to increasing energy-efficiency and cost-saving properties, LEDs are entering the market and available to consumers as rational alternatives. It has been claimed that LED can cut CO_2 emission from 50% to 70%.[1]

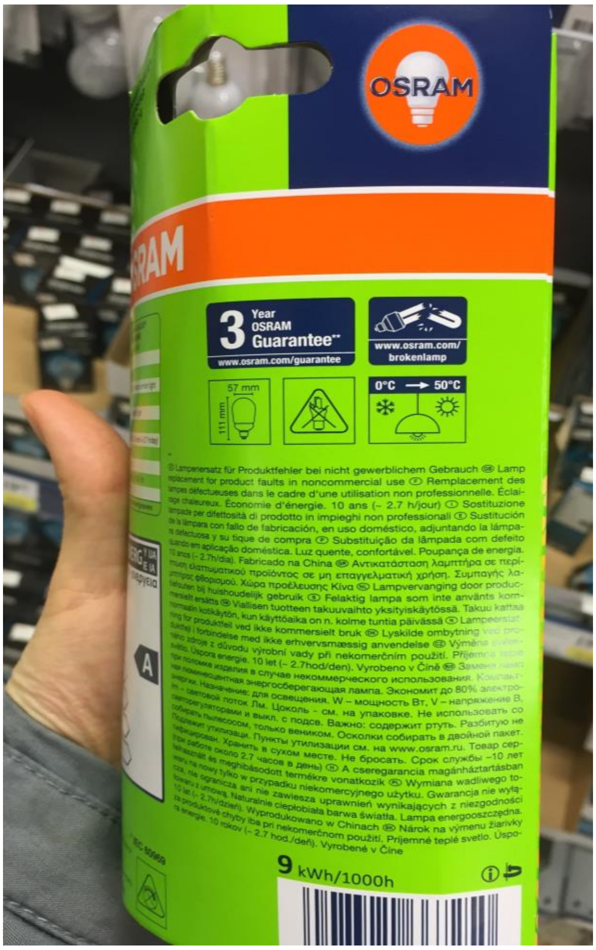
The European Commission considers LED bulbs as the future of lighting and China has the objective to achieve 30% of its lighting to be LED-based by 2015.[4] According to McKinsey's 2012 Global Lighting Market Model calculation, LED will overtake 45% of the market share of general lighting in 2016 and hit approximately 70% in 2020.[5]

However, these predictions of LED adoption seem overly optimistic, considering the fact that LED penetration is relatively low and only accounted for 12% of the market in 2011.[4] Based on my field observation in domestic supermarkets – in the town of Lund, Sweden – LED light bulbs are hardly found. What then hinders the adoption of LEDs?

Background

LEDs have been criticised for having a very narrow light spectrum and, therefore, do not provide the 'natural' colour of light that people prefer. A survey result used by Edison[4] points out that 85% of early adopters who bought LED lamps were unhappy with the quality of light produced and would not be purchasing them again. LEDs are the best lighting source when it comes to efficiency, but in terms of light quality, are rarely preferred to traditional incandescent bulbs at similar price. In Edison's report, it says these problems are being solved and there are few, if any, significant technological reasons why LED lighting cannot be used in most applications.[4] The main issue, therefore, is cost.

Though, from the perspective of the whole life span, LEDs are considered as low cost lighting sources compared to traditional incandescent and halogen bulbs. However, low market penetration of LEDs indicates that the high initial cost could be the constraint on LED's diffusion on the market. Though the cost will reduce as the technology improves, LEDs are unlikely to ever be as cheap as traditional incandescent bulbs.[4] Thus, a change in consumer understanding of lifetime costs, as well as the perception of other advantages of LED lighting, will be as important as price reduction.[4] One of the possible ways to achieve this would be better market communication, as communication is essential to LED diffusion and acceptance.



Interviews & Findings

To understand whether information helps consumers to navigate available lighting options, as well as leverage the complex market, it is necessary to assess the information provided to consumers: whether the market communication is comprehensible, if the information is relevant to their choice, and what information gaps might exist.

In order to figure out the situation in Lund, three supermarkets were visited. The available LED products were observed and shop assistants and customers were interviewed to test their knowledge about LED light bulbs.

For the current market, only a few LED products are available. As shown in the provided pictures (one is the Osram "energy saver superstar" and the other, the Konst Smide small light bulb for decoration purpose), and looking at the respective prices, these prices are much higher than for other lighting options. Moreover, the Osram bulb actually does not have any written words to show whether it is a LED bulb or not – consumers can only know this based on the tag displayed on the shelf. However, the wattage written on the price tag does not match with the wattage shown on the package (as shown in the picture to the left). So, is the Osram bulb a LED or not? It was confusing to consumers, and surprisingly, it was confusing to the shop assistant as well. Another shelf was supposed to display an additional type of LED light, but it was out of stock.

Shop assistants and customers were questioned about the information on the package: no shop assistant was able to explain the technical terms on the package, like the 'Ra>=80' (a term displayed on the Osram pakage) and most of them do not know which ones are LED light bulbs. This is true for costumers as well, as they showed little interests in LEDs and were completely unfamiliar with the technical terms. Only one of the customers was able to explain the information on the Konst Smide packaging, though this package does not contain as much technical information, in comparison to the Osram bulbs.

Looking at the Osram package, it provides information according to EU standards, which includes colour rendering, wattage, life span, and mercury content, and so on. It also has a notable energy efficiency label and some catchy wording like “energy saver”, “superstar”, “warm”, “comfort”, “80% energy” reduction arrow, and a bold-sized “10 years” implication.

The other Konst Smide bulb also utilises catchy wording like “long life” and “energy saving”, highlighting for recognition, and the ‘LED’ word is present and easy for consumers to differentiate the product from others. On the other hand, it has no complex index provided like the Osram bulb.

Both LED products provide substantial information for consumers, however, according to the pictures and interviews, the package information of Osram seems to be too technical for the average customer.

Performance Analysis

With differences between geography, sectors and stakeholders, customers require different lighting. For example, southern European people tend to prefer cold colour temperatures brought by light, while Nordic people prefer warm colour to offset the lack of daylight during the winter.[6]

For the residential sector, according to a study by Jensen in 2012, the interviewees mostly talked about the atmosphere of the light and the “strength” of light in terms of wattage, but not lumens.[2]

People tend to care about their mood relative to the light zone and the functionality of the light, but rarely mention colour-rendering capabilities. The energy aspect is often mentioned, but not as a top criteria for selecting light bulbs.

The residents Jensen interviewed used no technical language when talking about lighting and showed little interest in technology. Jensen also assessed the information on different light packaging available in domestic supermarkets and assessed technical information available on the packages. How well the public is informed does not really matter to consumers, and neither does the comprehensibility of the information.[2]

If more information were indicated on the package, would it actually help the consumer to understand and evaluate light? Take the European Eco-design Directive as an example: public bodies try to use increasing technical aspects and scientific language to facilitate the neutral and best choice, and the application of this information aims to help consumers make optimal choices. However, including practical practical applications for household purposes, in the packaging information, may be more meaningful for consumers than complex scientific indicators.

On top of this, a 2009 consumer survey found that though 75% of respondents stated energy-efficient products were important, not even half of them had in fact bought one.[7] The majority of consumers still prioritise traditional product features and show low interest in socially responsible products, like energy-efficient LED light bulbs. Hence, only providing technical information about energy performance will not be persuasive enough for people to choose the more energy efficient bulb.

If one insists on the importance of informing the consumer, it should be done in a standardised manner of packaging information. It needs to present relevant information that is also comprehensible to the consumer. Additionally it should correspond to the way consumers think when choosing the lighting products.[2]

Conclusion

This paper studied the LED market potential, with a particular focus on packaging information and communication. The current market of LEDs is not substantial and somehow it reflects people's understanding of LEDs and relevant scientific terms. Knowing the information that people are most concerned about when making decisions will be important and can help to provide better market communication.

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AFFORDABLE LIGHT IN DEVELOPING COUNTRIES

A Review of Lao PDR, Kenya and Brazil's Leasing Systems

By Prisila Castro & Jessica Gámez

In current times, population growth and the increasing demand for electricity are a reality. Furthermore, lack of electrification, especially in rural communities in different parts of the world, has promoted the development of off-grid or more decentralised electrification systems as more feasible solutions to provide access to electricity.[1]

Currently, lighting systems for rural areas based on kerosene are still predominant. However, elements such as low income of rural households, health and environmental effects from the use of fossil fuels, and improvements on the efficiency of lighting technologies with the scattering of LED lights, have been starting points to the development and implementation of lighting systems These have typically been based on a combination of cleaner energies, such as solar energy and efficient LED lights.[2]

In spite of this, high investment costs of solar systems have been a main barrier for their implementation, affordability being an important aspect. In order to overcome this barrier, the leasing concept comes into place as a feasible distribution model for the adoption of cleaner and safer off-grid lighting solutions.[2] In leasing models, companies contract micro-entrepreneurs that set up solar charging points; these entrepreneurs can either rent the products to final consumers or sell the lighting devices without any power source (and offer a fee for charging the devices).[2]

In the present paper, a review of leasing systems in three different countries across Asia, Africa and Latin America is provided with the aim of offering an overview of how leasing systems are implemented in different contexts. Additionally, after analysing the structure, implementation and results of each system, it goes on to provide a general conclusion and key lessons learned from the three cases.

Asia: Lao PDR

Lao People's Democratic Republic (Lao PDR) is one of the poorest countries in the world with 74% of its population living with less than EUR 1.61 per day; the national average electrification rate is 55%, with a rural electrification rate of 42%.[3] Moreover, kerosene-light sources have dominated the Lao PDR's market due to the failure of solar lanterns; this is mainly because of the use of low-quality components in order to maintain low prices, and also because of the misuse of batteries.

Lao PDR's rural communities have different sources of income depending on the season; during the wet season their work is based on farming, and during the dry season their work is primarily craftwork such as basket-making, weaving skirts and making incense sticks. Therefore, their seasonal source of income is considered to be an important barrier to obtaining access to electricity.[4]

In order to overcome this, the privately-owned Company Sunlabob in Lao PDR has developed a solution to provide affordable access to electricity, while at the same time generating multiple benefits for Lao PDR's rural communities.[4]

Solar Lantern Rental System

The Solar Lantern Rental System (SLRS) is based on a 'fee-for-service' concept that was established in 2006 with the aim of providing a good quality Photovoltaic lighting service based on renewable energy, rather than providing just equipments for users. The SLRS works through the participation of Sunlabob together with members of the communities. Sunlabob is responsible for the quality control of the service, maintenance of equipment, and training of people related to supplying the service.[1]

An interesting feature about this system is that Sunlabob does not rent the equipment directly to users, but instead requires community participation through a so-called Village Energy Committee (VEC) and a Village Technician (VT). The solar equipment is rented to the VECs and they are responsible for charging the marginal fee to individual households as well as the day-to-day running of the solar lamp charging station. To start running the system, a deposit is charged to households for the first fully-charged lantern; after which, lamps depleted of their charge can be brought to the VECs to be replaced by a newly-charged lamp for a fee of EUR 0.47.[4]

In terms of financing the system, within the SLRS there is a Private-Public Partnership with public donors. These donors provide the required funding to the VECs to buy the first batch of solar lamps as well as private investment to pay for the construction of charging stations.[4]

To compare the SLRS with the conventional kerosene-lighting system, the use of solar lanterns offers nearly 75% reduction in a typical household's lighting bill.[1] Therefore, besides avoiding health issues from burning kerosene, people from Lao PDR's communities could actually save money by using SLRS. During Phase 1 of the SLRS implementation, 204 households with 1 204 people benefited from the SLRS. Phase 3 of implementation has a target of 8 000 households with 47 200 beneficiaries.[4]

Along with high levels of acceptance among people, the SLRS concept has been considered successful in Lao PDR. This is because it produced other benefits to the communities, such as the creation of job opportunities.[4]

Regarding the distribution of income from the fees, 42% is for the maintenance and purchase of new solar lamps; 25% is retained by the VT as a salary; 22% goes to Sunlabob as rent for the charging station; and the remaining 11% is distributed among the VECs for their administrative services.[4] Therefore, 36% of the income generated remains within the community.

Africa: Kenya

The African continent encompasses 105 million households without access to electricity, of which 7.5 million households are

A Village Technician providing service to the community (Source: Sunlabob) located in the region surrounding Lake Victoria in Kenya.[5] In comparison with the national average, these communities live below the Human Development Index, due to a high rate of water borne diseases.[6] Meanwhile the primary sources of income for these communities are directly or indirectly related to fishing or farming activities.[6]

In 2007, the German leading light manufacturer OSRAM, took the initiative to develop a social business to provide sustainable energy and off-grid lighting. In partnership with Global Nature Fund, OSRAM began to evaluate the situation in Victoria Lake, reporting political instability and corruption as main constrains for which they decided to not partner with the local government. Additionally, by partnering with local businesses, challenges, such as the lack of education and cultural differences could be overcome. Due to the high levels of poverty in the region, it was decided that local micro-credit could ensure affordability of a low-cost service.[6]

Furthermore, kerosene lamps played an important role while fishing, as the activity was carried out at night in order to attract a sizeable catch. OSRAM assessed that the total fishing activity in Victoria Lake would annually add up to 20 million litres of kerosene, equal to 50 tonnes of CO_2 per year. OSRAM focused on replicating the accessibility of the low-income community to kerosene independently of their irregular income. Based on this preliminary study, OSRAM designed a leasing system of energy and lighting called "Umeme Kwa Wote" or "Energy for All". [6]

Umeme Kwa Wote (Energy for All)

OSRAM's programme "Energy for All", began in April 2008 with the installation of three simple water-energy stations called 'O-Hubs', around the shores of Victoria Lake. Each O-Hub provides energy and lighting services through two lighting-energy products (battery plus a luminaire), which are leased to customers. O-Hubs are fed by a photovoltaic system. Each station has battery and mobile phone charging rooms, charge controllers, plus a storage and sales office.[7] Additionally, these stations function as a collection point for the end of life of the products used in the system.[6]

The lighting products that are leased to their customers are: the "O-box Solar" and "O-lantern LED". The O-box Solar was designed for large households, businesses or night-fishing. Able to operate for up to 14 hours, it comprises of Lithium-ion batteries, which are connected to a luminaire, and can also charge small electronic devices. Meanwhile, the O-lantern LED can operate up to 12 hours, equally powered by a Lithium-ion battery, but connected to Light Emitting Diodes (LED). Both products are charged in the O-Hubs, ensuring maintenance, repair and collection of lifespan parts takes place when necessary. For this task, local technicians are trained in each station to maintain and service the O-Hubs as well as their products guaranteeing a long service life.[8]

Before leasing any lighting product, customers must register themselves in a database at the

Multiple uses of O-lantern LED, illumination and charging devices. (Source: GNF)

O-Hub, and pay a refundable deposit of EUR 8.96 for the O-box Solar or EUR 6.7 for the O-lantern LED.[5] After the product runs out of battery the customer will return it to the O-Hub to be charged for fee regulated by social business guidelines. This fee is at least 30% lower than the kerosene equivalent value.[6] Each customer will receive training to operate and handle the lighting products.[7]

The purpose of the O-Hubs was to replace kerosene lamps with a more sustainable source of energy. However, it took a more holistic approach in order to facilitate access to water and energy, financing, infrastructure maintenance and recycling. In order to provide community services in Kenya, the programme was designed to be a self-sustaining social business model, by including communities in the operation of the system through appropriate training and financing. Additionally, the programme embraces the concept of increasing the income of the community by conducting free training and providing mentorship for young entrepreneurs to develop their own business.[6]

The programme of O-Hubs set up a total number of eight stations and developed them further to include internet services. These stations were renamed as WE-Hubs. This advanced system provided energy, light, clean water, and internet facilities, plus training and job opportunities (each station employs 10 members of the community).[6] These stations are also aimed at increasing the income of the community through entrepreneur development, indirectly related with the WE-Hub. However, how revenues are distributed and what percentage would remain with the community is unreported. Nevertheless, each station employees members of the community and uses local business in order to deliver basic services at an affordable price. Over the past four years, the stations have also provided other benefits such as betterment of health and the capacity to increase individual income.

Latin America: Brazil

Latin America reports a 73.6% access rate to electricity for rural populations. However, this is unevenly distributed, with 31 million people living without electricity access.[9] In Brazil, a majority of these people are located in isolated regions characterised by low population density.[10]

In 1997, years before the government recognised the problem, the Institute for the Development of Natural Energy and Sustainability (Instituto para o Desenvolvimiento de Energias Alternativas e da Auto Sustentabilidade or IDEAAS) founded by Mr. Rosa, took action to develop highly efficient, low-cost clean energy solutions for communities without access to electricity. IDEAAS used grants to develop pilot projects, run market assessments, evaluate local needs, and test energy systems in the locality.[11]

The Sun Shines for All

The Sun Shines for All (TSSFA) was launched by IDEAAS in 2001. It began by assessing rural communities in Rio Grande do Sul, evaluating the availability and willingness to pay in this sector. They surveyed 77 families in six rural municipalities of Rio Grande do Sul, reporting that nearly 70% of the interviewed families spent EUR 8.83 per month in non-renewable energy sources such as kerosene, candles, batteries and liquid petroleum gas.[12] The economic assessment made in this first stage was the base for the development of a pilot project targeting two communities in the Bank of the river Tapajos, named Santi and Maripa.

The pilot project installed 41 solar kits, for which customers paid an installation fee estimated to be equivalent to 40% of their investment, plus a monthly fee. The monthly fee was based on previous assessments of how much people would spend for non-renewable energy systems.[11] By the end of the pilot phase, IDEAAS revealed the following to be important for the success of the project's solar kits:

- Necessity of isolating the battery in a transparent plastic box to protect it from humidity;
- Reminding the user of the importance of the battery safety by including a sacred Catholic image in the box, which also facilitates the acceptance into a Catholic community; and
- Necessity of local maintenance and review of performance of the system.

After adapting the solar kits, the project aimed at delivering 6 100 kits in four years, starting in 2006.[11] Each home solar kit included LED bulbs, a 12 volt electrical outlet, wiring, a battery and a photovoltaic panel. Most of the contents of the kit were sourced locally, from Sistemas de Tecnologia Adequada Agroeletro (STA).[11] The LED bulbs and photovoltaic panels were imported and obtained with support from donations or through grants.[12]

The leasing fee was EUR 8.03 per month, and the installation fee was EUR 120.38, which could be paid in instalments over several months.[11] Customers signed a contract of 3 years for leasing the equipment, but they were allowed to withdraw at any time after paying the full installation fee.

IDEAAS was responsible for the maintenance of the system as well as battery replacement. Towards this, the project selected an individual from among the community who would be trained to supervise the correct usage and provide proper maintenance to the systems. In exchange, this person would have access to the system without having to pay any fee.[12]

The latest report on this case, revealed that one of the challenges of the model was the collection of the monthly leasing fee, due to the remote location of the communities in the Amazonia.[11] However, results vary greatly from one community to the next (from 80% to a mere 15%). In order to make the current system feasible, IDEAAS plans to introduce a prepaid card that will allow villagers to access the service for two additional months before denying access if the payment is not made.[11]

It should be noted that the kit did not initially include LEDs bulbs, which were introduced after the pilot stage in order to increase the efficiency of the kit and to provide more hours of light.[11]

This project enables individual members of the

	LOCAL CONTEXT	PROGRAMME CHARACTERISTICS	
	INCOME	STAKEHOLDER PARTICIPATION	BENEFITS
Lao PDR	Below poverty line	Private company and community members	Lighting service; and Job creation
Kenya	Below poverty line	Private international company, local company and community members	Energy and lighting access; Increased income; Job creation; and Training
Brazil	At poverty line	Non-profit organisation, private company and community members	Energy and lighting independent service

Amazonia to access light and energy with total independence overcoming the low population density challenge that characterises this area. Furthermore, it increases their financial savings in the short- and long-term when compared with earlier expenditure on non-renewable energy sources. This also allows for further engagement in other areas, such as agriculture, in order to increase their income.

Key Lessons Learned

In all three case studies, the aim was to make lighting systems affordable to households with relatively low incomes, either at or below the poverty line. The success of the three programmes relies heavily on how they were adapted to the local context and needs of the different communities. Additionally, considering both the nature of previous non-renewable sources of light used and their costs, it can be concluded that cleaner and more affordable lighting sources were promoted through the implementation of these light leasing mechanisms.

Stakeholder engagement was another key feature that allowed for success of these programmes, while simultaneously enhancing sustainability within these innovative lighting systems.

Among the three systems that were studied, the benefits or outcomes were similar. In addition to the cleaner and safer lighting as well as energy services provided, the different communities also benefited from job creation, training activities and improvement of their quality of life. Furthermore, access to electricity promotes spill over effects such as improved education and performance of children at schools.[2]

Conclusion

Independent of the different regional contexts, it can be concluded that, in these cases, the low-income barrier had been overcome through the implementation of locally-adapted energy and light leasing systems. As fossil fuel prices play a key role in the adoption of the above-mentioned lighting systems, government subsidies on fossil fuels can jeopardise their acceptance among communities with respect to affordability.

Finally, if light leasing systems are to be replicable they should be specifically adapted to the local context (social, economic and environmental), ensuring community participation to increase the likelihood of their success.

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SAMSØ 100% RE ISLAND

MESPOM Helps Create the Samsø Award

By Susana Guerreiro

As part of the Strategic Environmental Development course, the MESPOM students went on a field trip to Samsø island in Denmark, on November 13th and 14th of 2014. One purpose of the trip was to help create the Samsø Award.

The island of Samsø, in Denmark, has shifted to 100% renewable energy in 10 years – a project led by local citizens, with an initial capital investment from the government. The 11 MW wind turbines are owned by local cooperatives and individuals. Besides the wind turbines, the island relies on solar energy, district heating from biomass and biodiesel production from rapeseed oil, in order to compensate for the CO_2 emissions from the transport sector.

The trip was preceded by a Development to Dissemination (D2D) workshop held at the IIIEE on October 15th, where MESPOM students participated in a brainstorming session with Mr. Hermansen (Energy Academy Director) and other D2D partners.

Samsø Award

The ideas generated during the brainstorming session fed into the discussions that took place during the inspiring, two-day visit to the Energy Academy. The entire group first discussed the overall purpose and vision for the Samsø Award.

The details of the award were then discussed in breakout sessions, where smaller groups designed the different components of the award. The sessions were combined with site visits to renewable projects on Samsø: Biomass district heating, wind farms and some small businesses have sprouted on the island in recent years, as a result of Samsø's sustainability efforts.

The visits served as inspiration for understanding the uniqueness of the island's initiative and helped to frame the award, as well as identify the quality of projects it wants to attract. The result of this work was an innovative award that aims to recognise and empower community led ideas, projects and examples that stimulate a transition towards sustainability. The Samsø Award will be launched in early 2015.

MESPOM group and Energy Academy staff in Samsø. Photo courtesy of Ms. Richter.

THE AUTHORS

Masters in Environmental Sciences, Policy and Management

MESPOM

This report was compiled by students of the Masters course in Environmental Sciences, Policy and Management (MESPOM). MESPOM is a two-year Erasmus Mundus programme supported by the European Commission, and operated by four European and two North American universities.

Students study in at least three out of six of the consortium universities: Central European University (Hungary); University of the Aegean (Greece); Lund University (Sweden); Manchester University (United Kingdom); Monterey Institute for International Studies (United States); and University of Saskatchewan (Canada).

MESPOM Batch 9 consists of 27 students from 20 countries around the world. The authors are 18 (of the 27) students studying at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University during autumn of 2014. These 18 students represent Azerbaijan, Canada, China, Ecuador, Georgia, Germany, India, Ireland, Peru, Portugal, Sri Lanka, Turkey, UK, USA and Venezuela.

The report is part of a course in Strategic Environmental Development, led by Professors Thomas Lindhqvist and Mikael Backman, who steered the writing and publication process.

IIIEE:

THE INTERNATIONAL INSTITUTE FOR INDUSTRIAL ENVIRONMENTAL ECONOMICS

Established in 1994 by the Swedish Parliament, the International Institute for Industrial Environmental Economics (IIIEE) has grown to become a leading international research and teaching centre, pursuing strategic preventative solutions in sustainable development. As part of Lund University, the IIIEE offers undergraduate and postgraduate programmes in a multidisciplinary environment, focusing on pragmatic approaches to foster the transition towards an environmentally conscious society.

The IIIEE seeks to facilitate this transition by engaging in education and research activities, with a focus on connecting academia and practice. The Institute, with its international students, faculty and staff, is proud of its multidisciplinary and multicultural approaches to sustainability.

By collaborating with other departments at Lund University and various universities worldwide, the Institute explores and advances knowledge in design, application and evaluation of strategies, policies and tools for addressing global environmental challenges. Working at the nexus of economy, industry and the environment, the IIIEE emphasises the need for sustainability in industry.

The Institute currently operates two international Master's programmes, as well as independent courses, a broad range of pioneering research projects, and numerous outreach activities.

Alumni are found within consulting, industry, research, NGOs, international, and national governments, and other fields. The IIIEE has a strong alumni network consisting of more than 700 members representing over 90 countries.

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