Prohlášení o autenticitě

Prohlašuji, že jsem diplomovou práci na téma Off-grid street lamp/Energeticky soběstačná pouliční lampa zpracoval sám a uvedl jsem všechny použité prameny.

Petr Hampl

Acknowledgement

David Karásek,

David Škaroupka,

Dušan Piják,

Hana Hamplová,

Jan Zainer,

Jiří Pospíšil,

Josef Sládek,

Josef Šesták,

Kristýna Fuksová,

Ladislav Křenek,

Lukáš Brza,

Miroslav Hampl,

Oldřich Zmeškal,

Ota Melcher,

Pavel Míček,

Petr Fiala,

thank you.

Synopsis

The problem area of the project depicts the issue of actual transformation of energy resources and supply worldwide with the focus on renewable resources of energy. The stress is primarily laid on values of an object designated for public spaces.

The author's assignment was to design a lighting unit independent of an external power supply. The aim of the new design is to rethink the way in which technologies utilizing solar and wind power are commonly used, and to suggest a solution that brings new features, benefits and values for the user and society.

Generally the author brings forward design that reflects actual global threats and opportunities.

The result is a design of a street lamp that combines a wind turbine with a solar cell module in order to gain electrical energy which is stored in an accumulator and afterwards supplied to a luminaire. The lamp is designed with special consideration of aesthetics and ergonomics.

The designed solution brings financial benefits in terms of saving the nonrenewable resources and possible money savings for the investor. Furthermore, the off-grid street lamp has a lower negative impact on the environment and demonstrates technologies utilizing solar and wind power in a friendly and unintrusive way.

Bibliographic reference

HAMPL, P. Off-grid street lamp design/Energeticky soběstačná pouliční lampa. Brno: Vysoké učení technické v Brně, Fakulta strojního inženýrství, 2009. 95 s. Vedoucí diplomové práce doc. akad. soch. Ladislav Křenek, Ph.D.

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Project goals

In my thesis I aim to present my field of interest as a designer.

By making a design I apply different skills I have acquired at Brno University of Technology (the Czech republic) and Aalborg University (Denmark).

This project responds to a current global concern of energy consumption and supply. I aim to suggest and design a solution that partly solves this problem when being an indispensable product of our every day life.

By doing this design I aim to present an approach of creating better solutions by simply thinking about the essence of the product, its purpose and nature and by being aware of suitable technologies.

The goal is to point out particular technologies and present them to public in a friendly and useful way. This project is also addressed to marketers, engineers and designers to consider realization of this design.

Section 1

PROBLEM AREA

1.1 INTRODUCTION

“It took us five thousand years to put wheels on our luggage.” [William McDonough, S01]

Isn’t such an innovation of our luggage a great idea? It surely is.

We have designed a wheel in order to move things around easily. We have also designed a suitcase to carry our stuff from one place to another with comfort. We considered that as a convenient solution until the suitcase was equipped with a pair of wheels which made the design way better.

Think about those years we had nothing left but to carry a suitcase in hands. Wasn’t it obvious that such a combination of a wheel and a luggage would be an ingenious solution? Apparently, it was not.

Let’s put this into present-day perspective. Let’s assume the wheel is a technology and the suitcase is an inconvenient solution of a certain problem. Do we see any examples of inconveniently designed solutions today? Yes, we do. Besides really smart solutions and literally wrong ones, we are surrounded by acceptable designs which could be - with a bit of ingenuity and effort - transformed into brilliant solutions. This can be done by using either proper technology or having some other design approach.

The world we live in today

Let’s leave all the good things we have achieved and we have been doing today apart for now and have a look at problems and fears we face. Overwhelming majority of us consider war conflicts, malnutrition, climate change, economic depression, unsustainable consumption, ecosystem imbalance, upcoming oil peak and environment devastation problems that need to be solved. These are problems of which we are inherent actors; part of the cause as well as part of the solution.

Let’s pick some of these problems in which designers play an important role and have a closer look at them.

Enormous energy demand

This issue is closely related to an uncontrolled consumption of goods and fuels which is in no case driven only by designers. But on the other hand, designers are the ones who design products which require certain amount of energy to be produced, used, maybe reused and eventually disposed. There are definitely dozens of issues to rethink.

Desired development and increase of richness of mankind will even make the consumption grow in close future. Thus the energy issue will become more relevant.

Imagine a sophisticated design.

Environment devastation

There is no doubt that we have been successful in destroying the environment we live in. Let's leave the question why we keep doing so apart and ask ourselves what could we as designers do to preserve and improve the condition of the environment? Since everything we do has an impact on the environment and since we use and consume products designed by designers and we do so in the way they have created and taught us, it seems apparent that designers play a significant role in this issue.

"80 per cent of the environmental impact of today's products, services and infrastructures is determined at the design stage." [Thackara, S02].

Therefore designers must take on them the responsibility. Even though it would be unfair to blame designers as the ones who harm the environment the most, Thackara reveals a good point.

Imagine a respectful design.

Useless & harmful products

Design is so strongly associated with the idea of commercial manufacturing and building that we often dismiss its real importance. Designers, usually controlled and constrained by powerful market demands, are forced to design products at the expense of quality. Low quality may vary from uselessness of products to products made of life hazardous materials. The consumers face any of these consequences.

The question is whether the designers are really forced to design in this way or not. Shouldn't they be responsible for the way they make things work? Instead of being part of the problem designers shall be part of the solution.

Imagine

Imagine a world where all designers have only good intentions. A world where good intentions are transformed into excellent designs. And above all, a world where all designs are produced, distributed and disposed within a system that has the harmless environmental impact possible.

Imagine the world where design is meaningful.

What is McDonough's statement in the very beginning supposed to tell us?

There are countless numbers of imperfect solutions such as the wheelless suitcase everywhere around us today. We may think most of them are convenient or good enough but, they might be not. And what if an inconvenient solution simply needs to add a pair of wheels to become an excellent design?

Imagine...

Statements the author was inspired by

"Love it or loath it, design has a central role to play in achieving a sustainable future" Jonathan Chapman & Nick Gant

"Our resources grow hand in hand with our wisdom" Julian Simon

"I think we have a design problem" William McDonough

"The Sun does not send bills, nor does the wind" Petr Hampl

"When solar becomes competitive with conventional power, solar power demand is infinite" Jesse Pichel

"Every time you spend money, you are casting a vote for a kind of world you want" Anna Lappe

"Always see product in wide perspective" Finn Schou

"It has to be a meaningful solution which gives a visible value to people" Irune Gonzales Cruz

1.2 STREET LAMP

Definition

“A street lamp is a raised source of light on the edge of a road, which is turned on or lit at a certain time every night.” [S03]

Since the project assignment does not focus on a lamp that only lights up a road to aid drivers’, from now on this report leaves such lamp aside.

Purpose of the street light

A street lamp is a relatively simple device of which the main purpose is to illuminate spaces and objects. There are several reasons to do so:

- to guide pedestrians, cyclists, etc. in low light condition and night time
- to make them feel safer if the lighting unit is installed properly and at right spots
- to create desired atmosphere of a public space
- to allow people walk in the streets at night

As we see, an artificial light gives us more possibilities when the Sun is gone. Besides the pros, street illumination has also negative impacts.

Negative impacts

First of all a lighting unit is a physical product and as such it inevitably harms the environment by the way it is produced, used throughout its life span and disposed.

Secondly, a lamp needs to be supplied with electricity. That does not necessarily have to mean a negative impact per se, however, under present-day circumstances, when most of the energy supply still does not come from environmentally friendly resources, it implies an indirect negative impact.

There exist whole sort of direct impacts on users. It affects only few of them, however, it does so in a explicit way. The following examples have something in common with other badly designed products that surround us:

- a lamp pole may cause serious injuries to drivers or bikers in accidents
- street lights installed and maintained improperly may cause inconveniences such as loss of night vision when a source is too bright or too poor
- improperly designed and constructed lighting units cause serious injuries to people by an

electrostatic discharge

- last but not least, we should bear in mind that poor design degrades the aesthetics of public spaces

Luminous pollution

The International Dark-Sky Association (IDA) defines luminous pollution as:

"Any adverse effect of artificial light including sky glow, glare, light trespass, light clutter, decreased visibility at night, and energy waste." [S04]

Luminous pollution is caused by excessive emission of light particularly in densely populated and highly industrialized areas. Except the fact that lighting is responsible for one-fourth of all energy consumption worldwide [S05], it has direct negative impact on humans and environment. Various types of luminous pollution, such as over-illumination, glare, sky glow and light trespass are disruptive to ecosystems and have effects on human health and psychology.

1.3 MAPPING THE MARKET

Environmental issues have become a growing concern in last few decades and as we entered the new millennium environmental threats have spread worldwide. No wonder that protection of our environment has become a relevant political topic and as a new global priority also an economic issue.

Forced by a massive pressure from media hand in hand with financial governmental supports a development of various environmentally friendly solutions suddenly took place. In developed and transition economies an investment into research and development of so called "green products" and "sustainable designs" is starting to harvest the success.

People are becoming aware of possible (if not inevitable) devastating consequences of their injudicious behaviour and begin to consume "green products" and "green services" rapidly. Abundant amount of products supporting sustainable development and sustainable consumption have become available to everyone.

Street lamps are no exception. Basically the electrical street light design has not evolved much in last hundred years but what has changed recently is the approach to energy supplied. As energy generally is becoming serious concern for designers, they tend to leave fossil fuels as the primary source of energy. They switch to various alternatives, particularly to technology of harvesting daylight and wind.

Mass use of refined technology

Use of photovoltaic panels and numerous types of small scale wind turbines give an opportunity to supply devices such as lamps with an environmentally friendly energy. At the end of the first decade of the 21st century "solar" and "wind" powered products tend to beat conventional products within particular market segments.

Furthermore, technology of Light Emitting Diodes (LED) has developed considerably in recent years. LED as an alternative to conventional Low Pressure Sodium (LPS) or Metal Halide (MH) lamps has proved to be suitable and reliable solution. Characterised by comparatively low energy input the LED put bulbs out of the game.

What is available

Today we see street lamps, garden lamps and park lamps being replaced by LEDs partly or fully powered by photovoltaic modules and even wind turbines. We see amazing concepts, we enjoy good and great designs in the street, however, we also meet poorly designed lights yet. Illustration 1.3.1 shows an example of a functioning but ingeniousness and elegance lacking design of a lighting unit.

Ill. 1.3.1: Product from China by Shenzhen Hongya Opto Electronic Co., Ltd.

1.4 TRENDS AND SIGNS IN TECHNOLOGIES

Renewable resources

Sunny future for solar power

Global production of solar or photovoltaic cells - which convert the Sun's light directly to electricity - increased 51 percent in 2007 [compared to 2006], to 3,733 megawatts. Over the past five years, annual global production of photovoltaic cells has increased nearly sevenfold, and cumulative installations have grown more than fivefold.

As we can see in this short summary, photovoltaic cells exploits its great potential and have become a respected player on the world energy market.

Top-politicians' decisions provide generous support for solar technology development world-wide. Such approach results into a rapid improvement of silicon-based photovoltaic cells and the current shortage of silicon is driving advances in thin-film technologies, which require no silicon.

Thin films are composed of very thin layers of photosensitive materials and require less energy and materials to make than conventional silicon-based solar cells. They are cheaper to produce.

Thin-film production has increased nearly fourfold in the past two years, claiming more than 8 percent of the global market of photovoltaic solutions in 2007.

Performance data for such technologies are relatively limited, and efficiencies remain low compared to conventional solar cells, however, the situation is rapidly changing. Because of the potential for dramatic cost reduction, many researchers view thin films as the future of solar technology.There is a broad agreement that solar electricity is likely to become cost-competitive with the retail price of electricity in many parts of the world in the next several years.

Wind power continues to rise

We see rapidly growing tendency of wind power use similar to the one in solar power industry. Driven by the same forces of massive energy demand and tightening regulations for environment protection wind as the electricity source has experienced a significant rise in recent years.

For instance, 4 per cent of total energy need of the European Union is covered by wind power today. The EU is now committed to markedly increase the proportion of its renewable energy sources and wind power is expected to account for most of that increase. Furthermore wind power will become more and more competitive with coal as more countries start to auction

carbon allowances. Besides this political push there is a fact that the costs of wind-generated electricity have dropped by 50 per cent in last 15 years, while efficiency, reliability, and power rating have all experienced significant improvements.

[S06, S07]

Conclusion

There is evidently an enormous potential in sun and wind energy. Current technologies enable us to use these resources to certain extent, yet, continuous development of technologies hand in hand with the right policies will undoubtedly lead us to be even more effective and efficient in employment of the daylight and the wind.

Although both the solar and wind power are becoming major players in newly installed energy plants in developed countries today, they are not expected to completely replace energy from uranium or fossil fuels in coming decades. But together with other renewables they tend to represent bigger and bigger part of the cake.

Light emitting diodes

“LEDs represent the most significant development in lighting since the invention of the electrical light more than a century ago.” [S08](Assuming LED lighting continues to develop as expected, it is now possible to predict the future with some certainty.

Due to the flexibility of LED technology, LEDs offer lighting solutions, which are not possible with any other existing technologies.

Nowadays we see LED lightings that light up buildings and monuments, LED-based street lamps and garden lamps, applications with desk lights and emergency lighting, LED lights for decorative purposes in hotels and restaurants and gadgets for every day use such as handheld lights.

However, as replacements for conventional general lighting LEDs are still some years off (approximately 5 years) because the cost/lumen ratio is still too high - performance will have to improve to compete.

The price of LED-based lighting solutions today is relatively high, however, as investment continues and volumes increase, the price of LEDs is likely come down by 10 per cent or more a year.

Conclusion

Despite higher price of LED-based lighting solutions, the fact that LEDs have been representing bigger and bigger part of the market with lighting solutions proves usefulness and advantages of LEDs.

Section 2

CONCEPT

2.1 DESIGNER´S OBJECTIVE

How could I as a designer rethink a design of a street lamp by applying existing technology on well-tried standards and thereby add new features and contribute to global threats decline?

2.2 VALUES OF THE DESIGN

After the problem had been said another vital question was brought forward:

“What values should the solution have for the user?”

Since I agree that the primary goal of design is to serve social purpose, the question can be put this way: “How does such device contribute to maintain our well-being?”

Off-grid street lamp design stresses out the commitment to reduce our negative impacts on society, therefore should use energy from renewable resources.

Such design is highly relevant by coping with actual global problems.

Such design approach phases out old unsuitable solutions in a smart way and brings new solutions automatically.

2.3 THREE VARIANTS OF THE CONCEPT

Based on the problem statement above and the desired values I have tried to develop several variants of the concept. Fundamental notions are translated into different designs of which the basic form, function and features are delineated below. The designs are accompanied by an analysis of competitive products and an economic justification. Three final variants are selected to be presented on the following pages.

The three variants differ in some aspects, e.g. aesthetics, illuminated area, place of installation, construction of the lighting unit and basic form of a lamp pole, whereas the essential components, i.e. fixtures with light emitting diodes, a wind turbine and a solar module all around a lamp pole, are common for all the listed variants.

Variant.1

This design is characterised by pure verticality with overall conic or cylindrical shape. The simplicity is interrupted by several spotlights placed at different heights 360° wide of the basic shape.

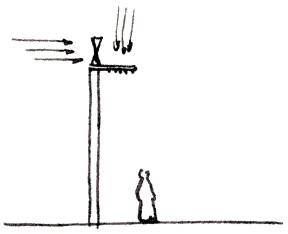
Variant.2

The basic shape is a cylinder S-bent in the upper part of the lamp pole. Climbing up from the ground the cylinder bends, thus the main curve is changed. The tilted part of the lamp pole indicates the location of lighting unit and the second part of the S-bend above forms the curve back to a form essential for proper function of the wind turbine.

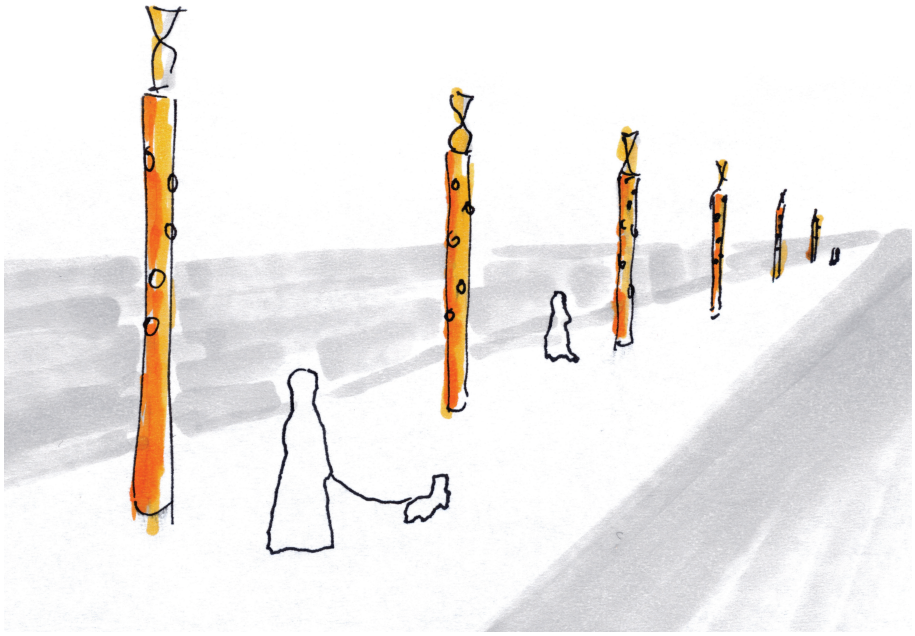
In one variation of this design the bottom part of the lamp pole is fluently widened which results in a balance of entire mass and more stable appearance.

Variant.3

The overall shape is purely cylindrical or conic. The two luminaires stick out from the upper part of the pole perpendicularly and thereby their purpose is clearly defined.



Ill. 2.3.1: Rough sketch of the project concept - a street lamp for pedestrians utilizing solar and wind power

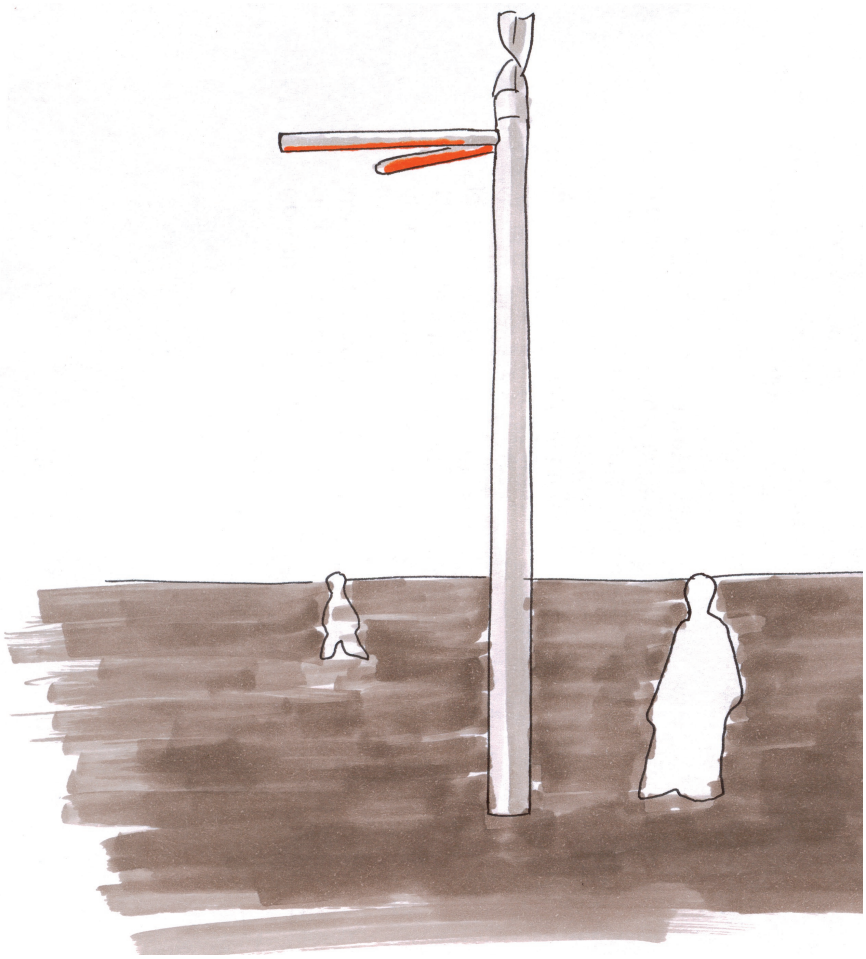


Ill. 2.3.2: Variant.1 sketch

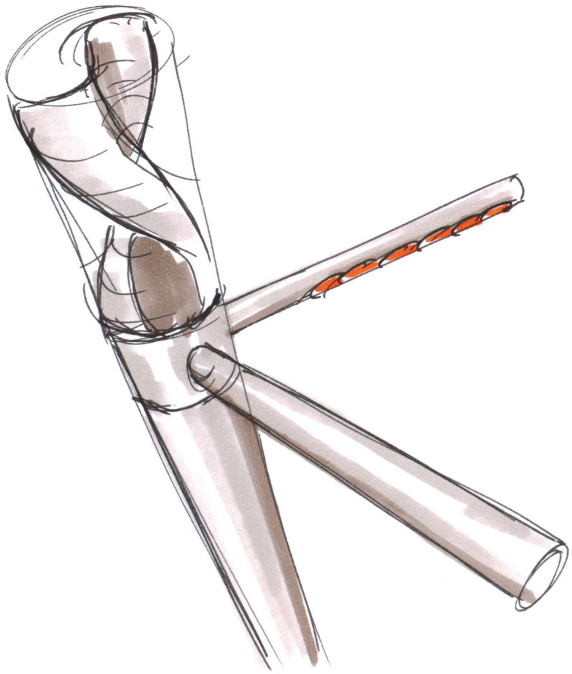
Ill. 2.3.3: Variant.1 sketch

Ill. 2.3.4: Variant.2 sketch

Ill. 2.3.5: Variant.2 sketch



Ill. 2.3.6: Variant.3 sketch



Ill. 2.3.7: Variant.3 sketch

2.4 MARKET OPPORTUNITIES

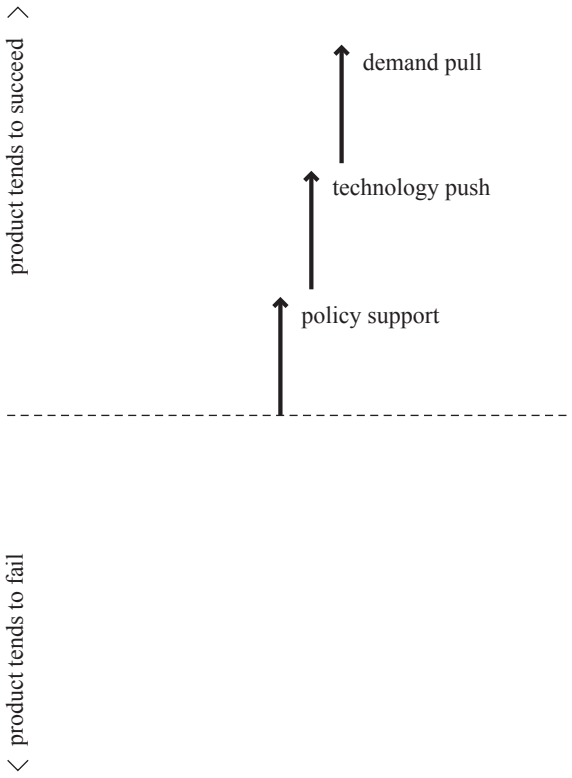
There are number of aspects of the design that need to be seriously considered before a decision to develop the design into a real product (which then is placed on a market) is taken. Despite an undoubted importance of marketing, the depth of elaboration of marketing strategies is not profound in this project, since the goals of the project lies elsewhere. However, as a designer, one must see each problem as a challenge and needs to be aware of actual trends which substantiate the development of a design into a real product. The more and favourable the trends, the bigger the likelihood of success.

The off-grid street lamp is a type of innovation within a market segment of public lighting solutions. As authors of Managing Innovation [S09] claim, there must be an existence of either ’demand pull ’ or ’technology push’ in order to have a chance of innovation success (innovation in terms of new product placement). For successful innovation a presence of both demand pull and technology push and their balance is required.

Under present global market circumstances (meaning turn of the first two decades of the 21st century), there are three major trends observed in developed countries.

There is an evident technology push (described in details in chapter ’1.4 Trends and signs in technologies’ and ’3.4 Technologies’) coming from the area of scientific research and development.

The technology push is accompanied by a demand pull coming from public. The demand for solutions using renewable resources of energy comprises of closely related forces: public consciousness of so called unsustainable behaviour (e.g. extensive consumption with inherent consequences) is rising up along with willingness for a change. This creates business opportunities which are transformed into a supply with convenient solutions. On top of that, a support comes from stronger policies for sustainable development.



Ill. 2.4.1: Figure illustrates the presence and direction of the three forces which favour the idea of the off-grid street lamp design development

2.5 PLACE OF INSTALLATION

The off-grid street lamp gives its valus to everybody, however, it is not an universal lighting solution that can be installed everywhere.

Location is limited by the conditions of the environment. Since the lighting unit is powered by the Sun and wind, it is vital to avoid locations where the lamp is hidden in deep shadow. Additionally, when considering a possible location of installation, it is preferred to avoid spots close to objects taller than the lamp. Tall objects such as trees or buildings cause turbulences of the wind which consequence in decrease of the wind velocity and lower power output.

The off-grid street lamp is meant for open public spaces in urban areas as well as for remote areas.

Ill. 2.5.1: Illustration of a possible location where the lighting unit can be installed. The off-grid lamp is a convenient lighting solution for open public spaces such as squares, parks, gardens, carparks, etc.

Section 3

DESIGN DEVELOPMENT

3.1 CHOSEN VARIANT OF THE CONCEPT

Evaluation of variants

The three variants described in chapter 2.3 are being evaluated on the basis of several criteria in order to choose the one that fits the best with the project goals.

The criteria the conclusion was made upon are the following:

- feasibility
- manufacture cost
- assembly and maintenance costs
- aesthetics in terms of overall appearance
- aesthetics with regards to the goals of the project
- suitability for desired purpose

Justification of the variant choice

Variant.3 is considered to have the greatest potential to fulfil the goals and succeed. The advantages of Variant.3 over Variant.1 and Variant.2 are mentioned below:

Manufacture cost

Variant.3 design is cheaper to manufacture due to the use of less processing steps and uncomplicated manufacture techniques.

What makes the manufacture of Variant.1 design costly is the need of bigger amount of components - up to twenty single spotlights - and higher requirements for manufacture techniques and machine time (complex shape of a lamp pole compared to relatively simply manufactured tube of Variant.3). Design of Variant.2 makes the manufacture cost more expensive likewise design of Variant.1 mainly due to more complex construction of luminaire and its integration on the lamp pole.

Since the off-grid street lamp is generally more costly to manufacture compared to conventional lighting solutions, production cost is likely to play a key role with respect to competitivness.

Ease of assembly

Luminaires of both Variant.1 and Variant.2 designs have more complex construction and need to be mounted more precisely on the lamp pole, whereas luminaires of Variant.3 can be as-

sembled separetely and mounted on the lamp pole on the spot.

A simple cylindrical shape of a lamp pole of Variant.3 enables the photovoltaic module to be attached to the lamp pole more easily.

Ease of maintenance

Contrary to Variant.1 and Variant.2, the chosen design allows the luminaire to be demounted and repaired or replaced by a new one on the spot.

Illumination to right directions

Construction and placement of the luminaire in Variant.3 eliminates illumination to unwanted directions (dazzle, luminous pollution).

Unlike Variant.2 and Variant.3, spotlights in Variant.1 design placed 360° wide always illuminate the space in all directions from the pole which makes the lamp an inconvenient solution for lighting up sidewalks or cycle pathways where lamps are placed next to the illuminated area.

Aesthetics and designer's approach to the form

In Variant.3, each part of the lamp clearly defines its purpose. The overall form put emphasis on what is the core of the design - utilizing solar and wind power.

The name of the lamp

A word from Esperanto is chosen as the name of the off-grid street lamp design. Similarly to Esperanto, the off-grid street lamp is aimed to target users all over the world. The word 'konveni' refers to english 'be suitable' or 'be convenient'.

3.2 CONCEPT DESCRIPTION

Function

The purpose for which the Konveni lamp is designed for is to illuminate public spaces in low light conditions, particularly streets, squares and other open urban areas, in order to aid navigation and improve visibility and comfort of pedestrians and cyclists. This lamp is not meant to improve road drivers' visibility.

Form

External appearance is characterised by a very simple look. The layout of components is clearly conspicuous and function of each main component is distinctly determined.

Features

A turbine placed on the very top makes the use of wind energy evident from distance. From closer look at a lamp pole it is apparent that sun energy is utilized too. The colour of the lamp pole is determined by the colour of photovoltaic modules. Tiny size of luminaires indicates use of some type of unconventional technology.

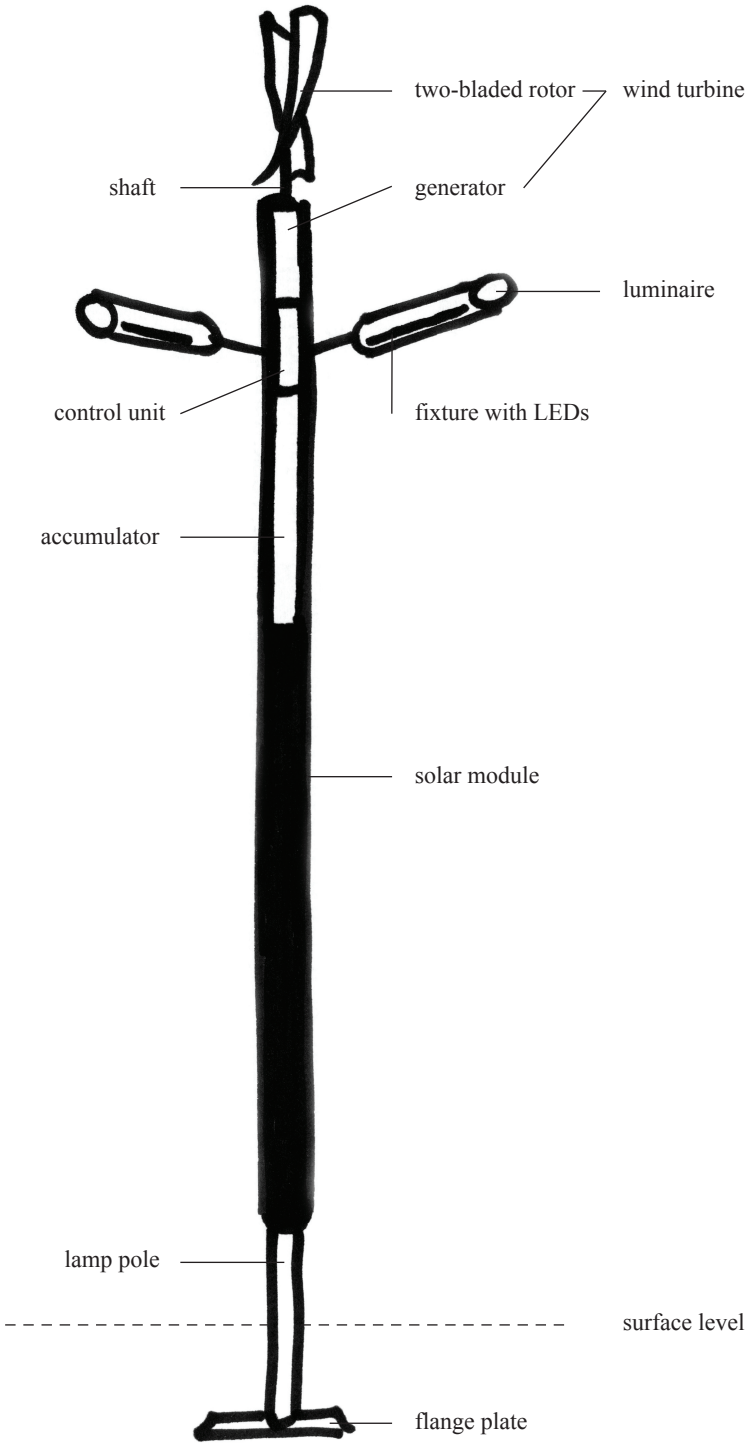
Competitivness

There are several advantages the concept of the off-grid lamp offers. First of all, there are no cables for external power supply thus there is no need to dig trenches and lay down cables. Second, the lamp operates even if a failure in a power supply occurs.

Financial issue

The greatest benefit of the chosen design is definitely the saving aspect. No need of external power supply may not only mean being environmentally friendly, furthermore it results in considerable cost saving throughout the lamp lifetime.

Since nowadays most energy consumed is produced with negative impact on the environment and our wealth, use of "clean source" energy may be converted into money, which brings financial and social benefit in wider sense.

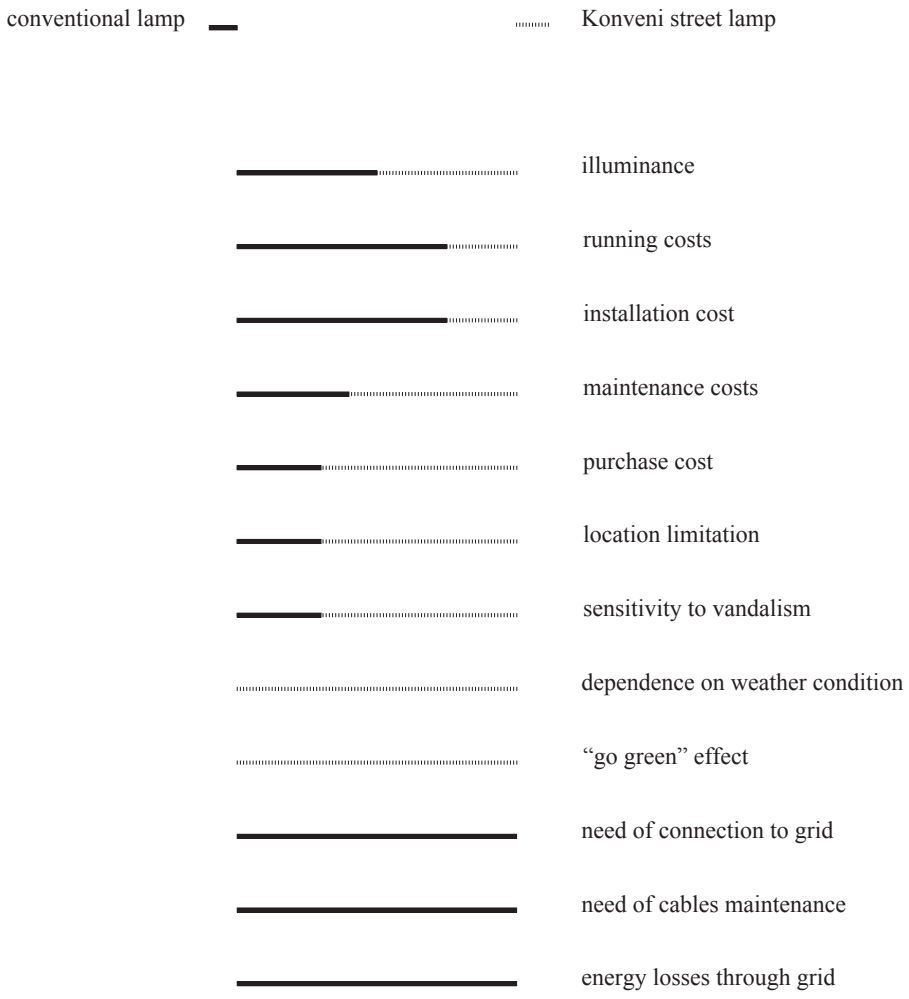


Ill. 3.2.1: Image shows layout of all major components of the lighting unit.

3.3 COMPARISON

The Konveni is likely to find a niche on the market with street lamps. It is essential for such product to be unique and stand out among other products within this particular market segment.

In order to attract customers the advantages of such product must be clearly defined to highlight where the potential is. On figure 3.3.1 the Konveni lamp is confronted by convential lamp to show in which aspects and parameters the two solutions compete with each other.

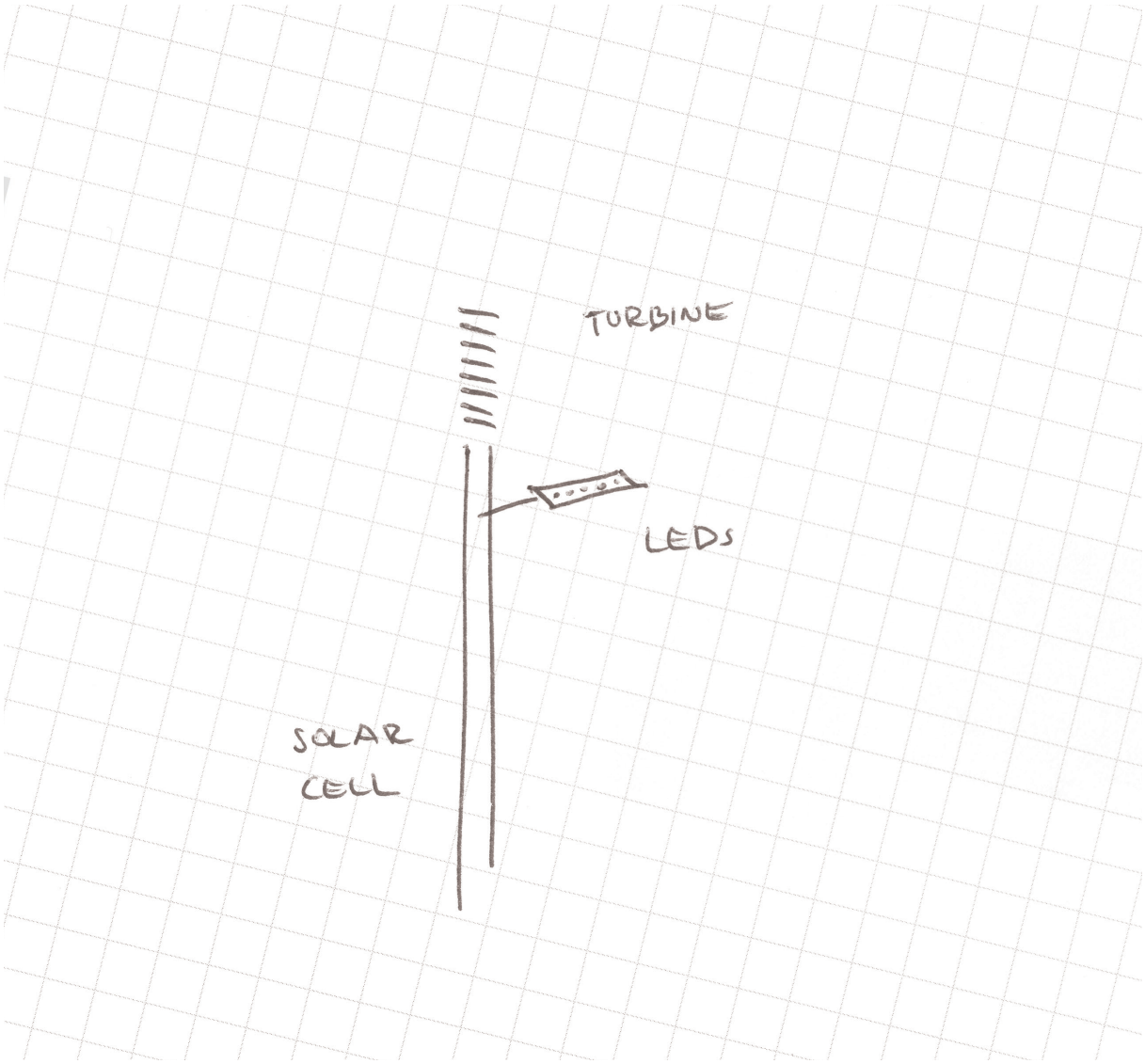


Ill. 3.3.1: Figure shows a comparison of conventional solution and the off-grid Konveni lamp

3.4 TECHNOLOGIES

In section 2 of this report the form, function and main features of the design are outlined. In order to translate these ’must haves’ into a product a research is done. Mapping up-to-date research and development of different branches of science gives a designer an overview of possibilities - shows various options of technologies and validates the right choices.

The following pages sum up my own surveys regarding the three main areas of technology that consist the essence of the Konveni design.



Ill. 3.4.1: Sketch indicating the three major technologies - light emitting diode-based luminaire, solar cell module and wind turbine - in the overall layout of the design

3.4.1 WIND ENERGY AND WIND TURBINES

Wind

Wind is the flow of air. The flow is caused by a mutual move of two air masses of different density, i.e. different temperatures and content of water vapour. The wind speed is always fluctuating, and thus the energy content of the wind is always changing.

The standard atmosphere has an air density of 1.225 kg per cubic meter.

Benefit from wind

Since the air masses never stop moving around the globe the wind represents a renewable resource of energy for a human world. If harnessed in a proper way, it belongs to environmentally friendly resources.

There are several reasons to harness the wind. The most obvious one is that the wind may provide us with a huge amount of energy. There are various methods of converting the wind energy into an electrical power. One of such technologies is a wind turbine.

Wind turbine

The wind turbine is a machine of which the purpose is to convert kinetic energy of the wind into mechanical energy - for this purpose a rotor is employed. Mechanical energy is further converted into electrical energy by a generator.

Types of wind turbines

There are two main types of wind turbines for generating electricity - vertical axis wind turbines and horizontal axis wind turbine (VAWTs and HAWTs respectively). (See illustrations 3.4.1.1 and 3.4.1.5.) HAWT, most commonly seen as a three bladed rotor placed up on the tower, is widely used due to its evident advantages over the VAWT, however, it lacks some of the features which favour the latter. Here are general pros and cons of both types.

- Advantages of VAWTs:
- VAWTs are characterised by easier access for maintenance because most of their parts are located at the ground
- VAWT is a more convenient solution for certain locations such as hilltops, ridge lines and passes where a powerful wind flows near the ground.
- Low installation height is useful where laws do not permit structures to exceed certain height levels.

- VAWTs are less likely to break in high wind speeds.
- VAWTs utilize wind of any direction and strength without having to yaw and adjust to fluctuations all the time.
- VAWTs utilize wind at high speed without having to shut down, i.e. utilize the most powerful period of the wind regime.
- VAWTs generally start to generate power at lower wind speeds.
- VAWTs operate more quietly.

Disadvantages of VAWTs:

- All the weight of the construction puts stress on the bottom bearing thus there might be a need to hold the construction by guy-wires.
- Replacing the main bearing for the rotor necessitates tearing the whole machine down.

Advantages of HAWTs:

- HAWTs generally give considerably higher power output owing its overall construction
- tall tower base allows access to stronger wind in sites with wind shear; in certain wind shear sites, every ten meters up, the power output can be increased by one third

Disadvantages of HAWTs:

- Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape.
- HAWTs need to be shut down at high wind speeds to prevent breakdown.

VAWT

There are two major types of VAWTs: lift- and drag- based rotors. Every rotor is characterised by tip speed ratio (TSR) which is the ratio between the rotational speed of the tip of a blade and the actual velocity of the wind. If the velocity of the tip is exactly the same as the wind speed the tip speed ratio is 1. A higher TSR generally indicates a higher efficiency but is also related to higher noise levels and a need for stronger blades.

Lift-based rotors are determined by TSR over 1 whereas drag-based rotors usually do not exceed the ratio value of 1.

Savonius rotor

Savonius rotor is a drag type rotor. Some designs may slightly exceed TSR of 1. Savonius rotors turn relatively slowly, however, yield a high torque.

Savonius rotors typically only have an efficiency of around 15% - i.e. just 15% of the wind energy hitting the rotor is turned into rotational mechanical energy.

Pros:

- wind-direction insensitive
- easy to manufacture
- rugged construction
- operate at a very low level of noise
- stand winds of high velocity

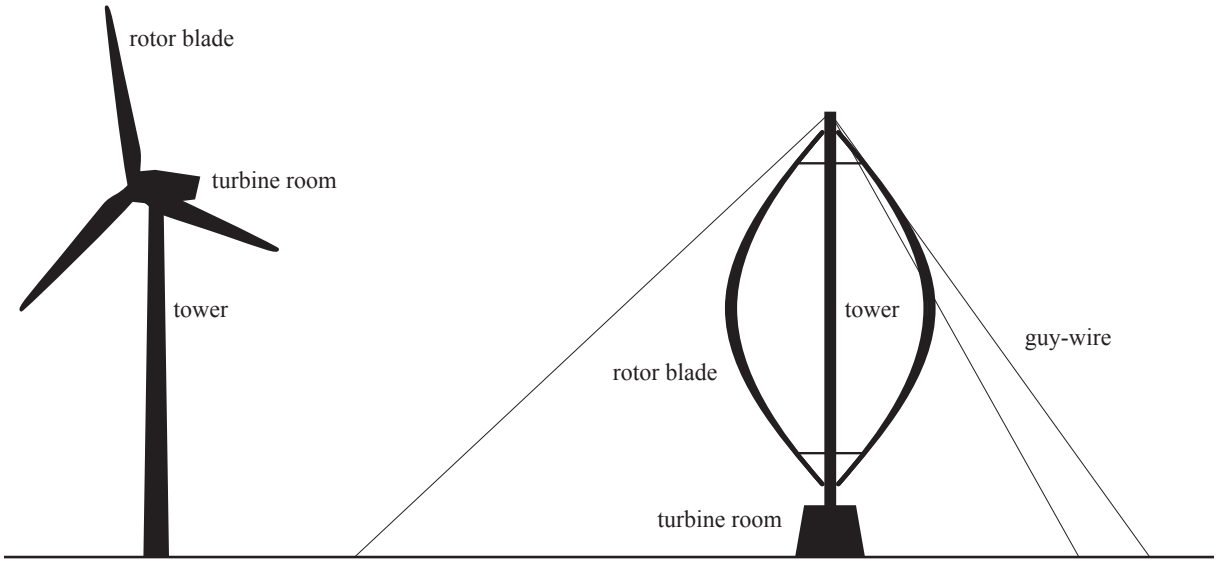
Cons:

- operate relatively slowly (usually less then 100 rpm which makes the output of the generator low)

Ill. 3.4.1.1: Middle size type of a horizontal axis wind turbine

Ill. 3.4.1.2: Big size type of a horizontal axis wind turbine

Ill. 3.4.1.3: Small size type of a horizontal axis wind turbine



3.4.1.4: The most common horizontal axis wind turbine (left) and vertical axis wind turbine with Darrieus rotor

Ill. 3.4.1.5: Vertical axis wind turbine

Ill. 3.4.1.6: Vertical axis wind turbine

Ill. 3.4.1.7: Vertical axis wind turbine

3.4.2 SOLAR ENERGY AND PHOTOVOLTAICS

Solar Energy

Solar energy is radiant light and heat from the Sun. Represented in watts, the surface of the Earth absorbs 89 PW of solar energy annually, which means 6.000 times more energy then human beings worldwide consumed totally in 2005 [S10].

Expressed in other numbers, if the Sun is directly overhead and the sky is clear, radiation on a horizontal surface is about 1000 watts per square meter [S11]

Since the Sun emits radiation all the time and for free, solar power has become reliable and economic renewable resource of energy.

Photovoltaics, one of the solar energy conversion technologies, has recently been undergoing considerable improvements. This fact makes the solar energy even more promising tool to compete with fossil fuels then ever before.

Photovoltaics

Solar energy belongs to radiation energy which must be converted into other type of energy instantly with the purpose of utilization and storage. Photovoltaics (PV) is a means of technology which converts solar energy directly into electricity.

Photovoltaics was established in 1950's when the crystalline silicon cells were developed. In last few decades these conventional solar cells received diverse criticism thus engineers have been developing new generations of solar cells.

Despite a significant efficiency increase (from 4 up to 20 per cent) the silicon based cells have not achieved strong commercial success yet. This is mainly due to its relatively high production cost per unit of output compared to cheaper fossil fuels or nuclear power.

The second generation - a thin-film solar cell (TFSC) - beats the conventional cell in material and manufacture process costs. Whatmore TFSC brings some new features.

When speaking of the rapidly increasing demand for solar cells on the global market a concern of shortages of silicon feedstock has arisen. Such fact together with uncompetitive price drives the development of thin-film technology fast forward.

Thin-film technology

The TFSC is based on the same principle as a conventional silicon solar cell. Thin-film modules (modules are simply a group of cells electrically connected and packaged in one frame) are produced by depositing one or more thin layers of photovoltaic material - semiconductor -

on a substrate. The thickness range of layers is wide and varies from a few nanometers to tens of micrometers. Substrate is usually made of coated glass, stainless metal sheet or plastic.

There are three main types of TFSCs, depending on the type of semiconductor used: the most common are amorphous silicon (a-Si) and the poly crystalline materials: cadmium telluride (CdTe) and copper indium gallium deselenide (CIGS). Different types of materials determine different band gaps, meaning they capture different parts of the solar spectrum.

Conventional vs. thin-film

The theoretical maximum for silicon-based cells is about 50 per cent efficiency, meaning that half of the energy striking the cell gets converted into electricity. In reality, silicon-based cells achieve, on average, 15 to 25 per cent efficiency. TFSCs are becoming competitive. Efficiency of TFSCs is anticipated to rise from a current 6% - 12% to 10% - 15% in the coming years, with a potential of more than 20% in the longer term (in laboratory CdTe solar cells have reached 15 per cent, and CIGS solar cells have reached 20 per cent efficiency [S12].

In recent years the thin-film technology production reached 8 per cent market share of photovoltaics production worldwide [S13] and the demand which is nearly twice as high as the supply indicates the assumed steady rise [S14].

Advantages of the thin-film

Generally non-silicon thin-film modules require less processing steps of manufacture. Besides that, very little raw material is wasted.

Contrary to manufacturing process of conventional modules, the thin-film modules can be produced by a roll-to-roll technology which is a process of creating electronic devices on an endless roll of substrate. The roll-to-roll process resembles offset printing and decreases the manufacturing cost significantly (such processes can bring costs down to 0.50USD per watt.) [S15].

Thin-film modules are light-weight (1 to 2 oz per square feet/300 to 600 grams per square meter) [S16], and water resistant, which implies their higher durability compared to conventional silicon-based cells.

Third generation of PV cells

The third generation technologies aim to enhance poor electrical performance of the precedent generation while maintaining very low production costs.

Current research is targeting conversion efficiencies of 30-60% [S17].

This advanced thin-film technology brings new features and broadens the variety of possible applications. Among the advanced TFSCs one can find a dye-sensitized solar cell (DSSC) which is characterised by ability to work even in low light conditions (cloudy sky or non-direct sunlight) and by relatively high mechanical robustness. The and DSSCs come in various colours and patterns.

Toxic materials concern

One issue that has often raised concerns is the use of cadmium in CdTe solar cells. Cadmium in its metallic form is a toxic substance that has the tendency to accumulate in ecological food chains. Although the amount of cadmium in thin-film modules is relatively small (5-10 g/sqm), this might constitute a barrier to massive expansion.

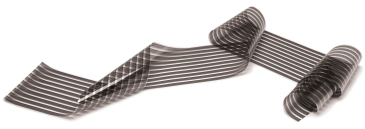
Conclusions

Despite numerous drawbacks of the PV cells, rising cost competitiveness to nonrenewable energy resources makes PV an important player in the transformation of the global energy resources.

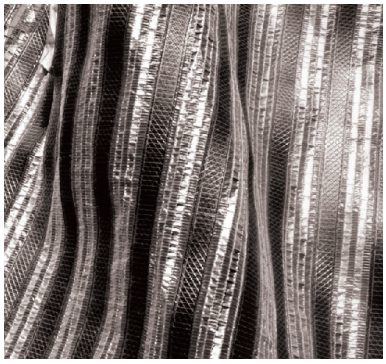
As application of this technology is concerned, the TFSC modules offer countless possibilities to use renewable energy by harvesting the daylight in our every day life. Ranging from pocket gadgets power supply to large scale PV farms which can feed the grid.

The mass application of the TFSCs is imaginable only if the technological flaws are resolved, public awareness of advantages is increased and, supported by right policies, if the TFSCs manage to compete the price of the conventional energy resources on the global market.

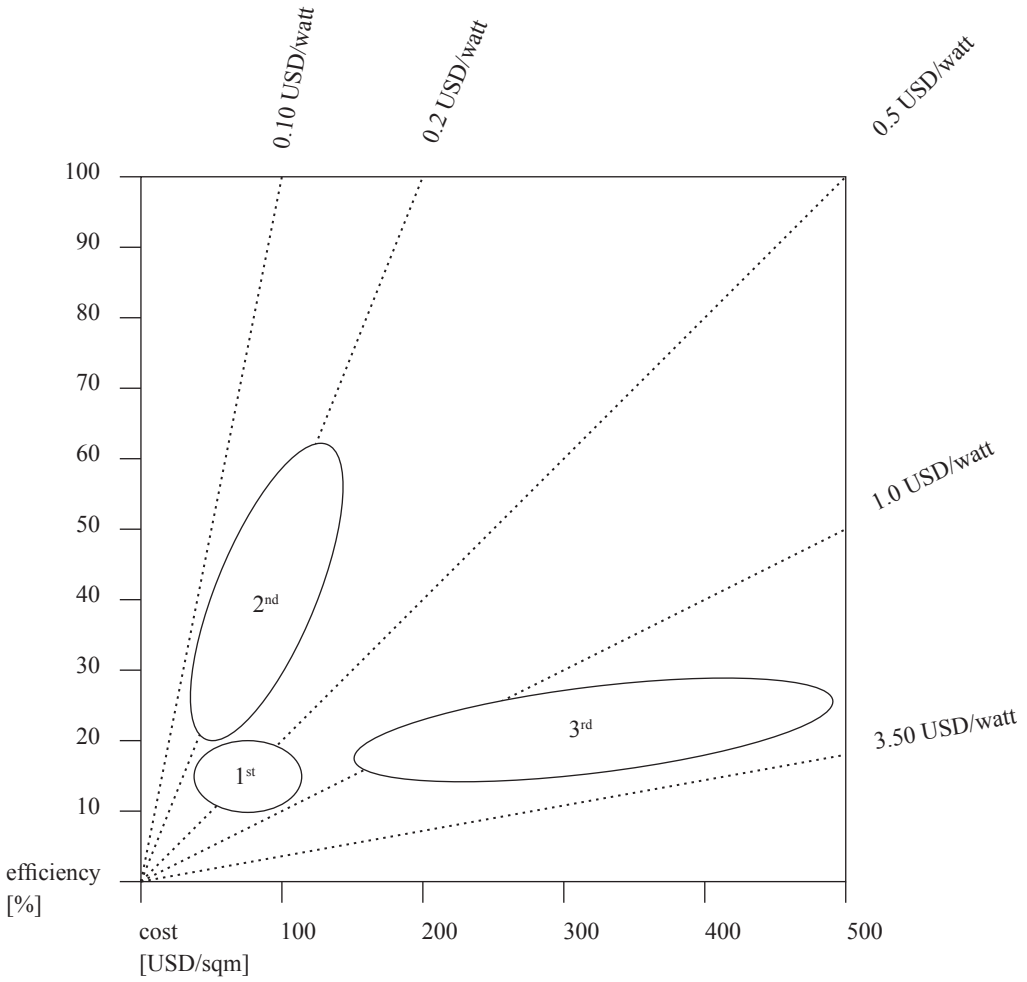
3.4.2.3: Production line of thin-film modules by a roll-to-roll process



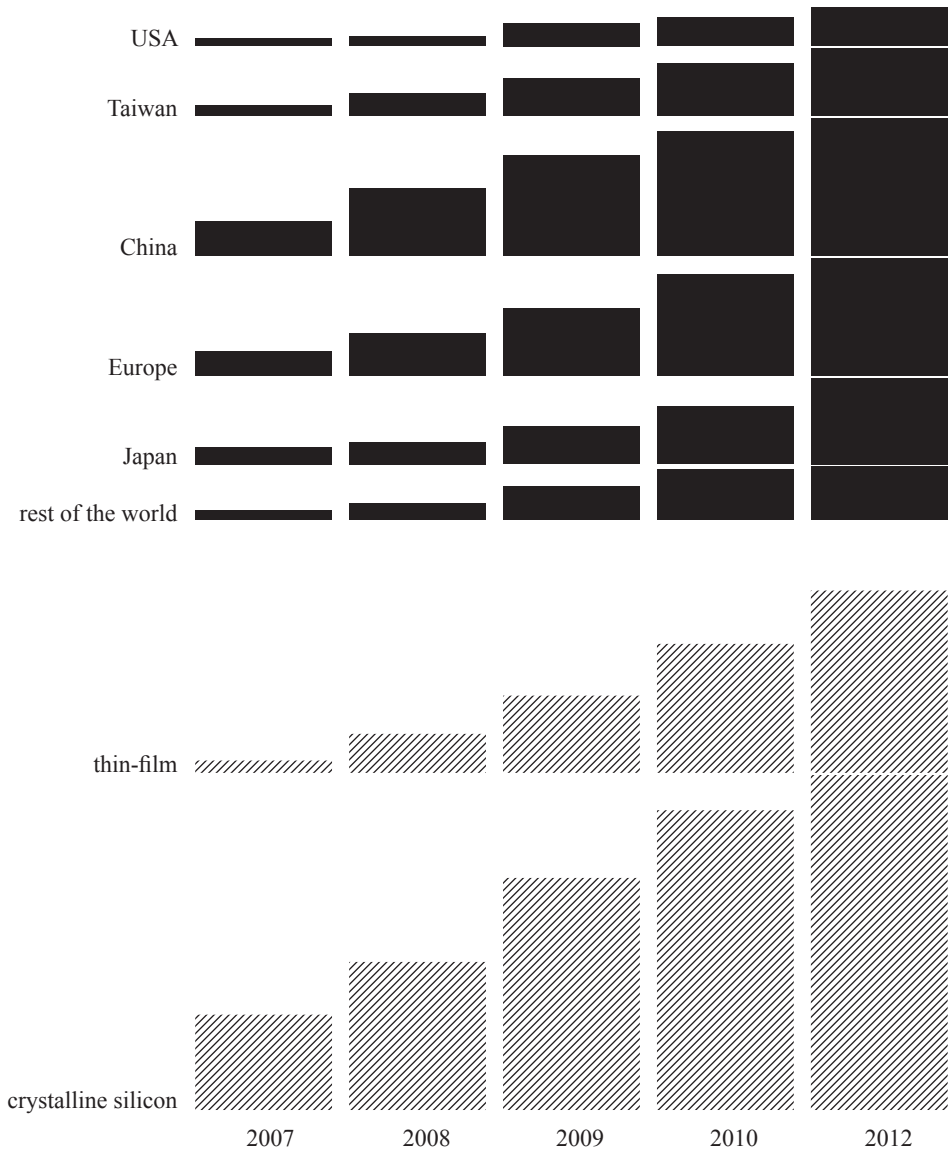
Ill. 3.4.2.4: Flexible thin-film module



Ill. 3.4.2.5: Sheila Kennedy's curtain made of thin-film modules shades and powers an apartment at the same time



Ill. 3.4.2.1: Figure illustrates three generations of solar cells in terms of power output efficiency, manufacture cost of solar cell modules per square meter and price per watt of power output [S15].



Ill. 3.4.2.2: Rapid rise of worldwide PV production capacity. Production capacity of 8 GW in 2007 and planned capacity of 42 GW in 2012. Upper part shows market share of major producers whereas bottom part shows proportion of conventional crystalline silicon solar cells and TFSCs [S18].

3.4.3 LIGHT EMITTING DIODE

Definition

The light-emitting diode (LED) is a solid-state device that converts electric energy directly into light of a single wavelength, i.e. colour.

A diode is the simplest sort of semiconductor device (a semiconductor is a material with a varying ability to conduct electrical current).

The LEDs are available across the visible, ultraviolet and infra red wavelengths; from now on only the visible portion of light spectrum will be discussed.

Attributes

Colour

The colour of light - colour temperature - is primarily determined by a composition of materials of a diode. For massive expansion of LED into our everyday life applications a white light is desired. Since a true white is not available yet, researchers have developed three alternative ways how to deliver it. The most promising technology is a phosphor coating.

Efficacy

In conventional incandescent bulbs, the light-production process involves generation of heat when the filament is warmed. However that implies wasted energy. Most of the electrical power supplied to LED is converted into radiation in the desired form, with almost no heat production.

Even though the LED is characterised by considerably higher efficacy, a single diode produces light with lower intensity compared to an incandescent bulb. In order to get the required amount of light, for instance as much as a street lamp equipped with a low pressure sodium bulb does, multiple LEDs are grouped together to intensify the brightness.

Light beam width

The core of the diode - a semiconductor - is housed in a plastic bulb (usually up to 10mm in diameter) that concentrates the light in a particular direction. The width of the emitted light beam is determined by a variety of factors. However, generally speaking, LED provides a narrow beam compared to incandescent bulbs. For particular purposes, such as illumination of a public space, relatively wide beam with soft edge of light fade out is required. Accordingly a lens is usually employed to create a beam in a desired form.

Fixtures

Generally there are two ways in which a lamp with LEDs is constructed. Depending on a desired beam, fixtures consist of either tens (or even hundreds) of grouped diodes mounted on a panel or a few diodes equipped with lenses. The former usually uses LEDs with lower light intensity. The latter may employ a single or multiple LEDs with higher efficiency coupled - each or all together - with a plastic or glass lens (see illustrations 3.4.3.1 and 3.4.3.2).

LED fixtures require a driver (analogous to the ballast in fluorescent fixtures). The drivers are typically built into the fixture.

Lumen maintenance

The lumen maintenance is simply the amount of light emitted from a source at any given time relative to the light output of a new device.

Unlike the incandescent light sources which tend to fail completely, LEDs are characterised by gradual degradation over time. The ASSIST [S19] research shows a 30% reduction in light output is acceptable to the majority of users for general lighting applications.

Pros and cons of LEDs

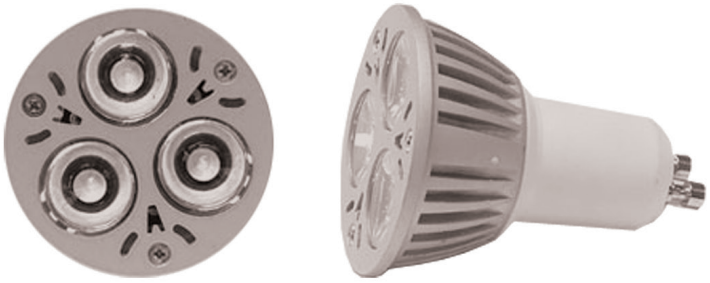
- Below follows a summary of advantages and disadvantages of LEDs compared to incandescent light solutions:
- LEDs produce almost no heat.
- Life span of the LED is significantly longer since it is a simple construction. Additionally LED has no filament that would burn out; when installed properly the LED generally works longer (tens of thousands of hours) compared to a conventional bulb.
- LED does not waste energy owing much higher efficacy of energy conversion.
- LED lights are more rugged and damage-resistant than compact fluorescent and incandescent bulbs due to its simple construction and use of less parts.
- LED lights do not flicker.
- LED contains no mercury.
- LEDs are currently more expensive than conventional lighting technologies.

- LEDs typically cast light in one direction at a narrow angle compared to incandescent or fluorescent lamps thus lenses or reflectors are needed in fixtures to broaden the beam (if desired).

Conclusions

When designing LED lighting systems designer must consider, inter alia, the lighting performance: the total illumination, the minimum light level specified, the expected lamp failure rate (mortality), the desired relamping interval, and the lamp operating conditions.

Although the LED performance is influenced by more parameters than conventional designs, LED technology is a very promising solution thanks to its inherent advantages.



Ill. 3.4.3.1: Three light emitting diodes mounted inside one fixture. Each diode is coupled with a lens.

Ill. 3.4.3.2: Light fixture employs multiple LEDs mounted on a flat panel.

3.5 PRODUCT DESIGN

The off-grid street lamp consists of number of components, uses several technologies to operate (see chapter 3.4) and different technologies and methods are applied in manufacture and assembly process.

In this project the product design development is focused on a layout of main components. These are:

- wind turbine,
- luminaire,
- lamp pole,
- photovoltaic module,
- generator,
- accumulator.

In the following chapters the characteristics, parameters and different features of the components are described in details.

Ill. 3.5.1: Mock-up in scale 1:18 is made to verify the basic proportions before the final decision of the total dimensions is taken.

3.5.1 PHOTOVOLTAIC MODULE

Choice of technology

As described in chapter 3.4.2 Solar energy and photovoltaics, the thin-film solar cell module seems to be the suitable solution for number of specific purposes.

Since it is assumed that the development of Konveni product could possibly start today and due to the fact that the most promising solar cell technology - the third generation - has only been developed in laboratory conditions so far, the second generation of thin-film technology has been chosen.

There are various types of the second generation thin-films which vary in material of semiconductor, used efficiency, colour, price and number of other parameters.

A particular type of the thin-film module is not considered in the design of Konveni since testing of a prototype under real conditions nor co-operation with any solar cell development centre are not parts of this project.

Variety of colours

The Konveni is designed in a range of colours. The variety enables to choose the desired appearance that may be subject to cultural habits in location of Konveni's installment. It may also depend on users' wishes or buyers' personal preferences.

The colour of the solar cell module is determined by the chosen material of the semiconductor. As soon as the dye-sensitized solar cells enter the market, the variety of colour will most-likely widen.

Construction

The solar cell module consists of a thin film of photovoltaic material, an underlay and an overlay. The TFSC is produced in a form of flexible foil; level of flexibility depends on a substrate (see chapter 3.4.2 for more information). The purpose of the underlay is to reinforce the module and to isolate the module from the relatively rough surface of the lamp pole to which the solar module is attached. The overlay is a layer of transparent material that protects the module from the effects of an external environment. The overlay needs to be made of an anti-reflective material in order to capture the most of the solar radiation. Furthermore it needs to be fitted with a coating that avoids the accumulation of dust and enables the self-cleaning effect.

Effects from environment

Often the lower part of a lamp pole is exposed to number of effects of the environment (accumulated dust, funny colouring left by dogs' excretion, etc.) that does not leave an aesthetic delight. The design of the Konveni street lamp reflects this fact; the solar module covers the lamp pole from the very top down to the height of 6´2´´/68 centimetres from the ground.

Vandalism also poses a relevant concern in many possible areas of installation. The maintenance costs of a street lamp during its lifetime usually exceed the purchase cost, for that reason the solar module needs to be easily replaceable in order to enable maintenance on spot without a need of demounting the whole device.

Despite the assumption that the roll-to-roll manufacture technology of the TFSC bares very low production costs per units of power output, the production and maintenance costs of the solar module is likely to amount higher expenses. However, the TFSC module is basically a simple device characterised by overall durability. Spray painting would not affect proper function of the solar module in any way. They might result in a negligible decrease of efficiency.

The thin-film-based solar cells are constructed in a way that even rough scratching or deep carving into the module would not put the function of utilizing the solar energy in danger.

3.5.2 WIND TURBINE

Chosen type of the rotor

Even though the wind turbines equipped with the Savonius rotor are characterised by a relatively lower energy output compared to turbines with lift-based rotors, there are three vital features of the Savonius rotor that other rotors cannot technically posses:

- ability to generate electrical power at low wind speeds (2 - 4 metres per second)
- considerably low noise emission
- aesthetic value - the basic form of the rotor is not that visually intrusive as 3-bladed HAWT, furthermore, the overall cylindrical shape of the rotor stays basically unchanged no matter at what speed the blades rotate

If testing a prototype of the Konveni street lamp in conditions of real environment (or if calculations of a model that simulates real environment) would prove insufficient with respect to the power output of the turbine, another solution would have to be found. Regardless other parameters of the alternative solution, from the designer's point of view features such as low sound emission and visual unintrusiveness should be maintained.

Shape of the blade

The shape of the blades which is used in the Konveni design comes from the conventional type of the Savonius rotor (ill. 3.5.2.2). The conventional design is composed of two semicircular blades. The Konveni design uses an optimalised form in terms of smoothness of torque output and better starting characteristics. The two blades are twisted into a helical form which enables the rotor to expose the active part of the rotor to the wind at every moment. The active blade draws in the mass of the air whereas the passive one lets the mass go out (ill. 3.5.2.1). Compared to the semicircular-based rotor, the twisted bladed rotor has a very good self-starting ability (even at low air velocity), capability of smooth running, high torque and high revolutions per minute, which makes it suitable for electricity generation [S20].

Construction

The blades are attached to a central shaft which drives the generator. One blade is in a mirrored position towards the other one (causing slight overlap) with the shaft in between. There must be a separation gap between the shaft and the blades in order to enable the mass of the air flow from the active blade into the passive counterpart.

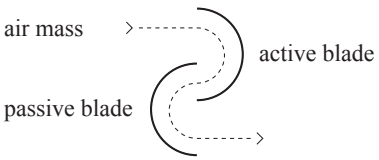
Dimensions

The total dimensions of the rotor are 220mm in diameter and 1100mm of height. Due to the high number of parameters that affect the result of the power output calculations and the necessity to submerge into the fluid mechanics in order to get a reliable result, the shape of the blades and the total dimensions of the rotor are designed in the way that is expected to give the sufficient energy output. In case of further development of the Konveni it is vital for the design to be based on various calculations which would include both internal parameters (construction of the turbine) and external parameters (environment).

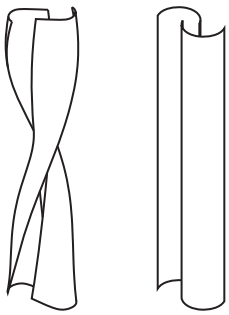
Material

Since the basic calculation of the rotor does not give any result concerning strains in the blades, the choice of the material - implying its colour - offers several options.

The level of details at which the Konveni is designed suggests a composite sheet formed into a helix.



Ill. 3.5.2.1: Cut section of a couple of rotor blades illustrates flow of air mass - active blade draws in the air - air drag initiates the spinning of the blade; the mass then runs into a passive blade and intensifies the spinning and finally goes out of the rotor



Ill. 3.5.2.2: Helical form (left) and conventional semicircular type of Savonius rotor

Ill. 3.5.2.3: Object in the middle illustrates shape in which appears the rotor while spinning - a helix becomes a cylinder that is not visually intrusive, whereas rotors on left and right illustrate the overall shape in standstill

3.5.3 LAMP POLE

Construction

The lamp pole consists of four parts welded on together.

Column and brackets

The column is made of two overlapping tubes. The stepping - a point where the two tubes of different diameters (180mm and 150mm) are connected - is made intentionally for the purpose of stressing out a layered layout of the solar cell module and the column.

Brackets, which contain the fixture with LEDs, are welded to the column.

Planting depth

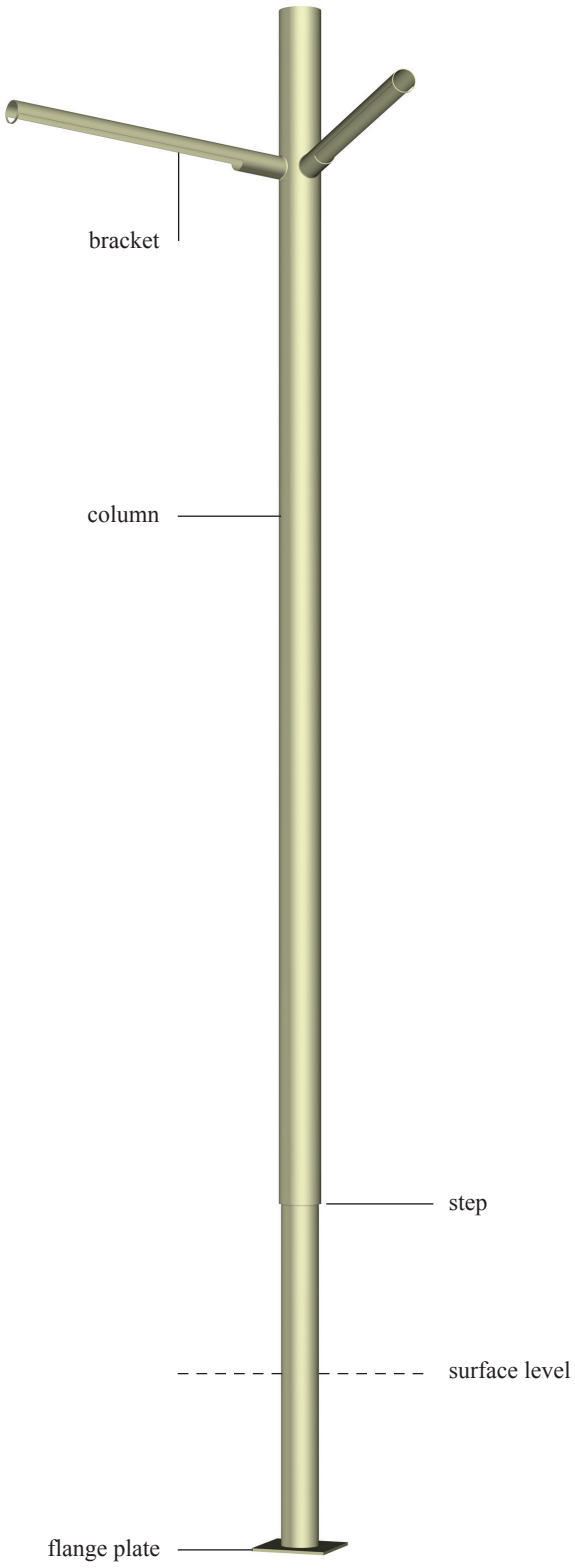
The planting depth of the column depends on the composition of the soil. For lighting units up to height of 6 metres the European standard (EN 40-2) suggests planting depth of 800mm to 1200mm. Various types of flange plates may be attached to the foot of the column in order to strengthen stability of the whole lamp.

Materials

Since the focus of the design lays elsewhere, the lamp pole is not designed in details. However, it is suggested to make the lamp pole of iron tubes coated with zinc.

Access to components

The components inside the lamp pole (outlined in ill. 3.2.1) are not elaborated in this project. The access point to the battery and other components is suggested through the upper end of the column where the demountable shaft of the rotor is attached to the generator.



Ill. 3.5.3.1: Lamp pole consists of four components welded on together.

3.5.4 LUMINAIRE

Construction

The luminaire composes of three main components: a fixture, series of LEDs and a housing, all mounted on a bracket.

The fixture is a component that contains the LEDs. Each diode is coupled with a lens fitted to direct the beam of the light. The fixture is mounted inside the cylindrical hollow of the bracket. The housing has the form of a tube and is made of translucent material. The primary purpose of the housing is to protect the fixture from the environment effects such as dust and water. The tube is open on both sides. When the luminaire is assembled the housing is put on the bracket and closed by a plug.

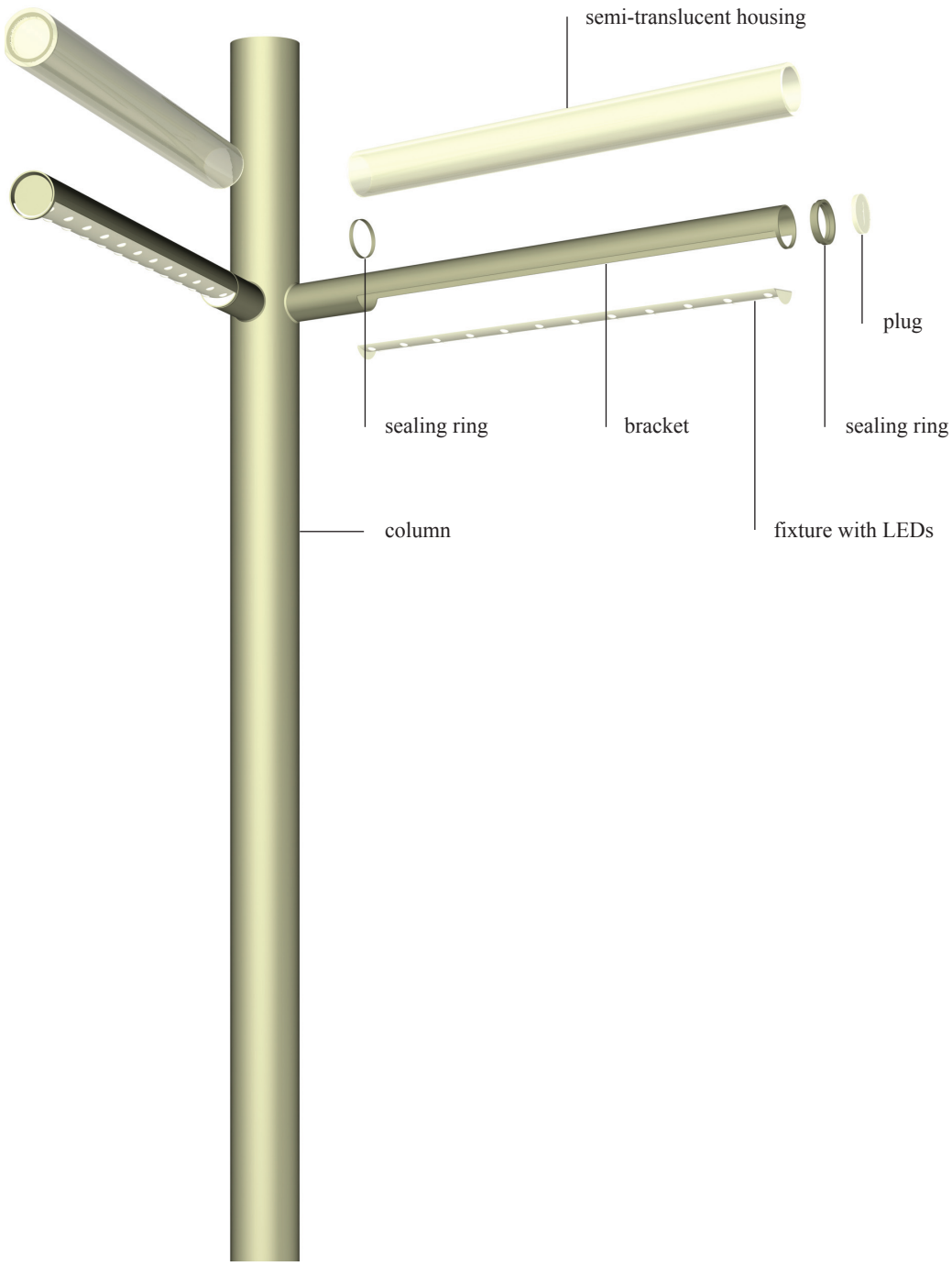
Illuminance uniformity

The diodes are mounted within the fixture in a way that enables uniform illumination of the surface. The light beams of both luminaires cast light of an oval shape onto the surface.

It is desired to illuminate the required area without emission of glare into unwanted directions. Such glare , especially at dark night, results in a brightness contrast in consequence of visual discomfort for the passers by who have the lamp in the visual field. Besides that, emission of glare of conventional lamps towards the sky creates luminous pollution (see chapter 1.2 for more about luminous pollution.)

Control

The lamp itself is managed by a timer or photocell which controls the timing of the lighting.



Ill. 3.5.4.1: Exploded view of all components of which the luminaire is composed - luminaire is attached to a bracket which is attached to a lamp pole.

3.5.5 INTERNAL SYSTEM OF MANAGING POWER

Besides the major components of the lamp mentioned in the previous chapters the whole lighting unit consists of other components necessary to make the design work.

The following devices together compose an internal system which manages transformation, storage and supply of energy.

Generator

is a device that converts mechanical energy of the rotor into an electrical energy.

Accumulator

is an apparatus by means of which energy can be stored; the off-grid street lamp uses a re-chargeable battery.

Charge regulator

limits the rate at which electrical current is added to or drawn from the battery; regulator maintains battery performance, e.g. prevents overcharging and complete draining. Charge regulator performs controlled discharges.

Power unit

is a source of electrical power that energizes the LEDs.

Control unit

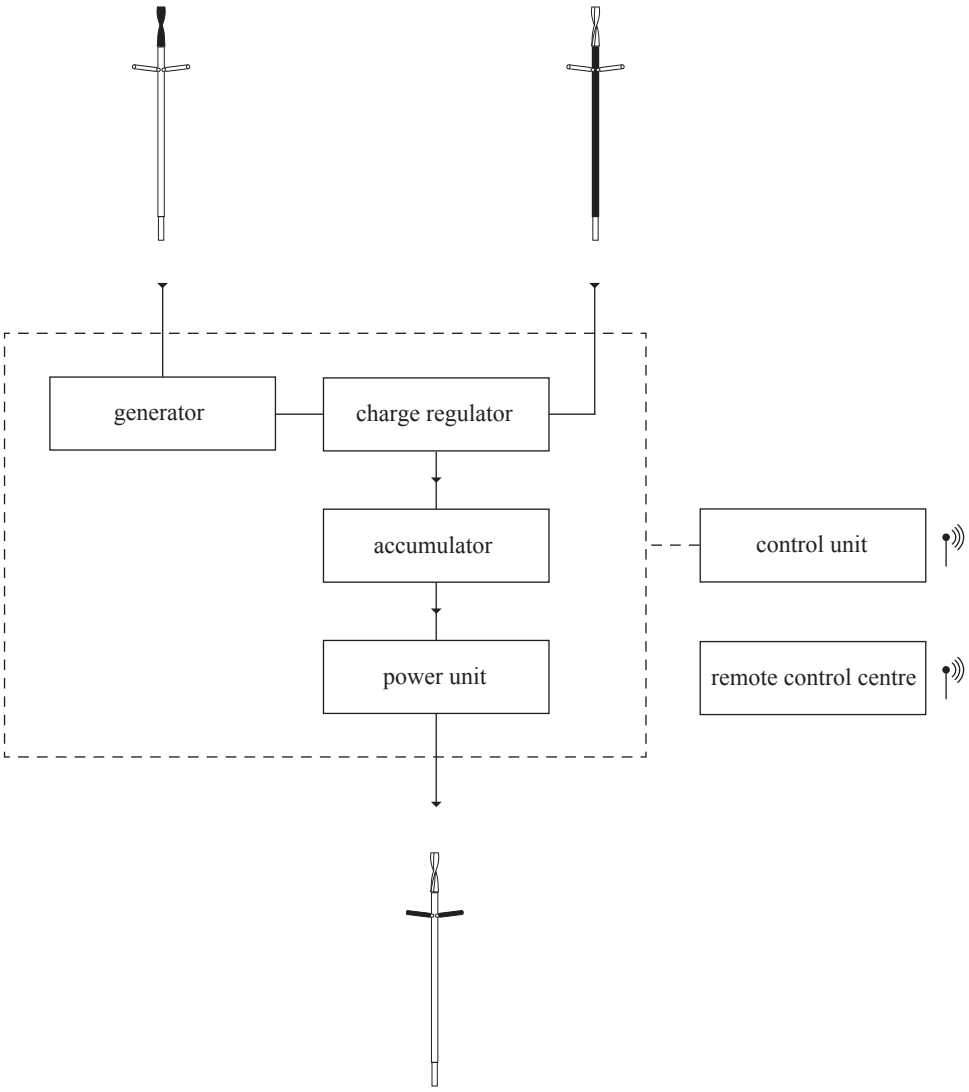
monitors various parameters and controls function of each component of the internal system. For instance the control unit monitors battery's condition, revolutions of the generator and calculates the illumination time remained.

In case of system failure or precautionary maintenance the control unit is equipped with a control panel by which the entire system of managing power may be shut down and serviced on spot.

The control unit enables a wireless exchange of data with an operator from remote central control and maintenance unit.

Remote control centre

employs staff who are responsible for general maintenance.



Ill. 3.5.5.1: Scheme of an internal system of managing power outlines a rough layout of components and illustrates a flow of energy that gained from a wind turbine and a photovoltaic module is stored in a an accumulator and consumed by a luminaire.

3.5.6 AESTHETICS

Designer's approach

Despite of primary focus of my design on considerations of the need and purpose of a product, its function and social benefits, aesthetics is an inherent value of the product and plays a significant role in the complex process of designing.

The overall appearance of the Konveni design is considered hand in hand with other aspects of design; all attributes of the Konveni design perceived by different senses of users (touch, visual sense and hearing) are determined in the stage of the design process where purpose, form and function are treated in close interrelation.

The overall form

The appearance of the Konveni street lamp is dealt with in a specific way that reflects the uniqueness of such product on the market. The form of the lamp is designed so that the main attributes which present the value for the user - utilizing of wind and solar power - are visible but not visually intrusive, clearly defined, easy to read and easy to understand without any add-ons necessary to emphasize the core idea.

The emphasis is laid on the basic composition of the visible components and also on dimensions, proportions and materials of each component. As a result of such design process the Konveni lamp shall contribute to an aesthetic value of its location.

The rotor

In terms of aesthetics, there is a particular reason why the Savonius rotor is preferred among number of other types of wind turbines. As illustration 3.5.2.1 in chapter 3.5.2 shows, helical blades of the Savonius rotor are considered to be less visually intrusive compared to disruptive effect of spinning blades of other types of turbines. No matter what the wind speed is, the Savonius rotor basically keeps a cylindrical form. The spinning effect does not attract much attention.

Materials and colours

The choice of material of each component is subordinated to the function of the component. The solar cell module is given the biggest weight in terms of visual attraction. It is the only component with other colour than grey and is unique in the way in which the solar cells are exposed to users. The solar cell module covers most of the surface of the lamp and might be tempting to touch.

There are various colours and patterns of the solar cell module available (see more in chapter 3.4.2).

The colour of other components is also determined by the materials applied. Where surface finishing is possible or required - e.g. surface treatment of the lamp pole or stainless steel components mounted on the column and the luminaire - the colour of the treatment shall, accordingly, reflect the colour of the material.

Environmental aesthetic concern

Aesthetic issues are always subject to individual taste, however, there has been a common environmental concern for noisy and visually intrusive wind turbines. Together with solar farms such devices may have detrimental effects on public perception of “clean energy” development. Albeit the Konveni design would pose a negligible negative impact on urban areas compared to large scale plants, objects that could possibly improve the aesthetic value of the public space need to be brought forward.

The Konveni design avoids “shadow flicker” caused by rotating horizontal axis wind turbine blades. Additionally it does not illuminate into unwanted directions and a wide range of colour variants enables adaptation to local traditions and habits. The Konveni design presents a symbol of energy independence and local prosperity without being an obtrusive object.

An object for street art

It is expected that the Konveni street lamp would become a part of the public space. Consequently it might attract various kinds of street art. Nevertheless, even with spray paint and stickers on its surface the Konveni lamp still gives intended value to people.

Ill. 3.5.6.1: Applied street art.

3.5.7 ERGONOMICS

As far as direct relation between people and the off-grid street lamp is concerned, this project focuses its design on emission of noise, or unwanted sound.

Human perception of sound and noise

Public authorities around the world use the so called dB(A), or decibel (A), scale to quantify the sound emission. The scale ranges from threshold of hearing at 0 dB(A) up to a threshold of pain at around 120 dB(A). An increase of the dB(A) by 10 doubles the subjective loudness of the sound.

The sound intensity drops with the square of the distance to the sound source. In other words, if you move 20 m away from a wind turbine, the sound level will generally be one quarter of what it is at 10 metres distance.

An issue of perception of sound is subjective, however, people are usually bothered by noise which the brain discerns and thus inevitably analyses even though the actual sound level may be relatively low. A recent study done by the Danish research institute DK Teknik seems to indicate that people's perception of noise from wind turbines is subject to their attitude to the source of the noise, rather than to the actual noise itself.

Sound emission from Savonius rotor

Due to the fact that Savonius rotor is a drag-based rotor, the emission of sound is far lower than the one of the lift-based rotors. The blades of the Savonius rotor do not whizz.

It is difficult to measure the sound of the operating wind turbine because the sound level has to be some 10 dB(A) above the background noise in order to be properly measurable. The sound emitted by Savonius rotors does not usually exceed the sound level of its environment, especially in speaking of urban areas. As such the emission of sound from the Savonius rotors should be imperceptible.

3.6 FINANCIAL ISSUE

Manufacture cost

The fact that the Konveni street lamp is a relatively complex unit (compared to the conventional lighting solutions) implies a considerable increase in product development and production cost. The uniqueness of being independent of power supply comes as a trade-off with overall complexity.

The solar module

Despite the assumed low cost production of the TFSCs, the price of the solar module the Konveni lamp utilizes the energy from is assumed to be relatively high. On the other hand, the TFSC seems to be specific for its high durability thus the maintenance cost during the lifetime of the lamp is not supposed to exceed the production cost of the component.

The wind turbine

The Savonius rotor may seem breakable, however, it is a simple device in terms of manufacture cost and construction complexity. Thus, a possible damage caused by any kind of accident (act of vandalism for instance) may temporarily put the wind turbine out of operation, however, the shaft (with mounted blades on it) can be easily replaced.

The accumulation of energy

The battery (in which the energy is stored) is assumed to require a regular service, however, the purchase price is assumed to be acceptable since there is a high competition in the market with batteries. Furthermore new types of batteries are being developed constantly. Regarding the frequency of the regular maintenance new technologies seem to be very promising.

The lamp pole

The lamp pole of the Konveni design uses the same production technologies as the conventional street lamps - seamless iron tubes - thus the manufacture costs are alike.

Financial benefit for investors

Considerably higher production cost of the Konveni street lamp certainly does not mean higher total expenses for the investor during the lifetime of the lamp.

Advantage of being off-grid

One of the features by which the Konveni design stands out is the fact that the off-grid lamp requires no cables. Digging out trenches, laying down cables for power supply and - the most costly factor - maintenance of the cables require regular service and result in considerably

higher installation costs. That may be particularly relevant in urban areas where maintenance costs of cables laid under a concrete surface may be five times higher than of cables laid under a green ground [S21]. Similarly, the installation cost may be significantly reduced if off-grid lamps illuminate a long path in city outskirts and especially in distant areas.

Electricity bills

There is an obvious fact, that the Sun and the wind do not send bills for electricity consumed.

Emergency case

The Konveni lamp operates at any kind of emergency case, for instance when a local power plant does not supply electrical power into the city infrastructure.

Financial benefit for common users

Viewed from a broader perspective, being an environmetally friendly solution results in money savings for all of us. This factor is uneasy to calculate moneywise, however, the lower the negative impact on our environment the lower the money spent on regeneration and treatment of the environment. Since the protection and regeneration of the environment are financed namely from the governmental money resources, every tax payer is concerned.

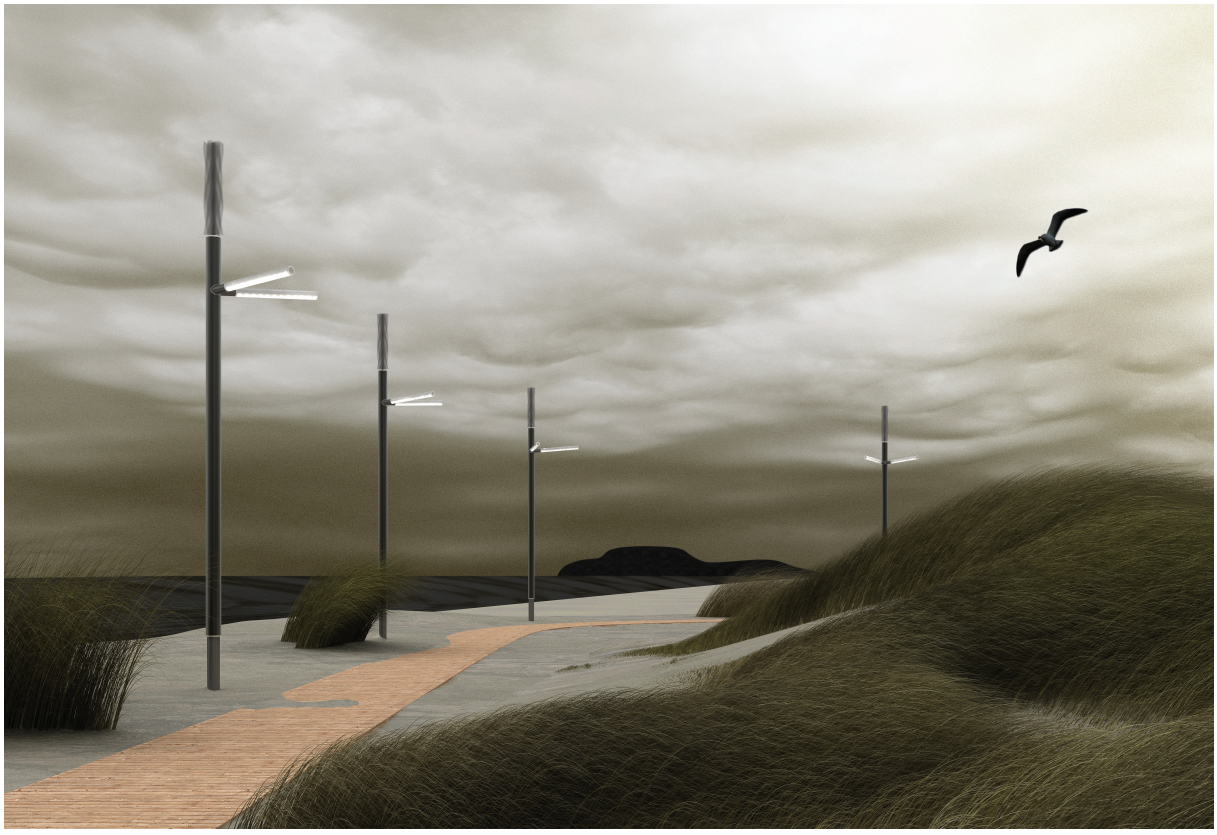
Section 4

RESULT - THE KONVENI LAMP

Ill. 4.1: Logo of the Konveni street lamp

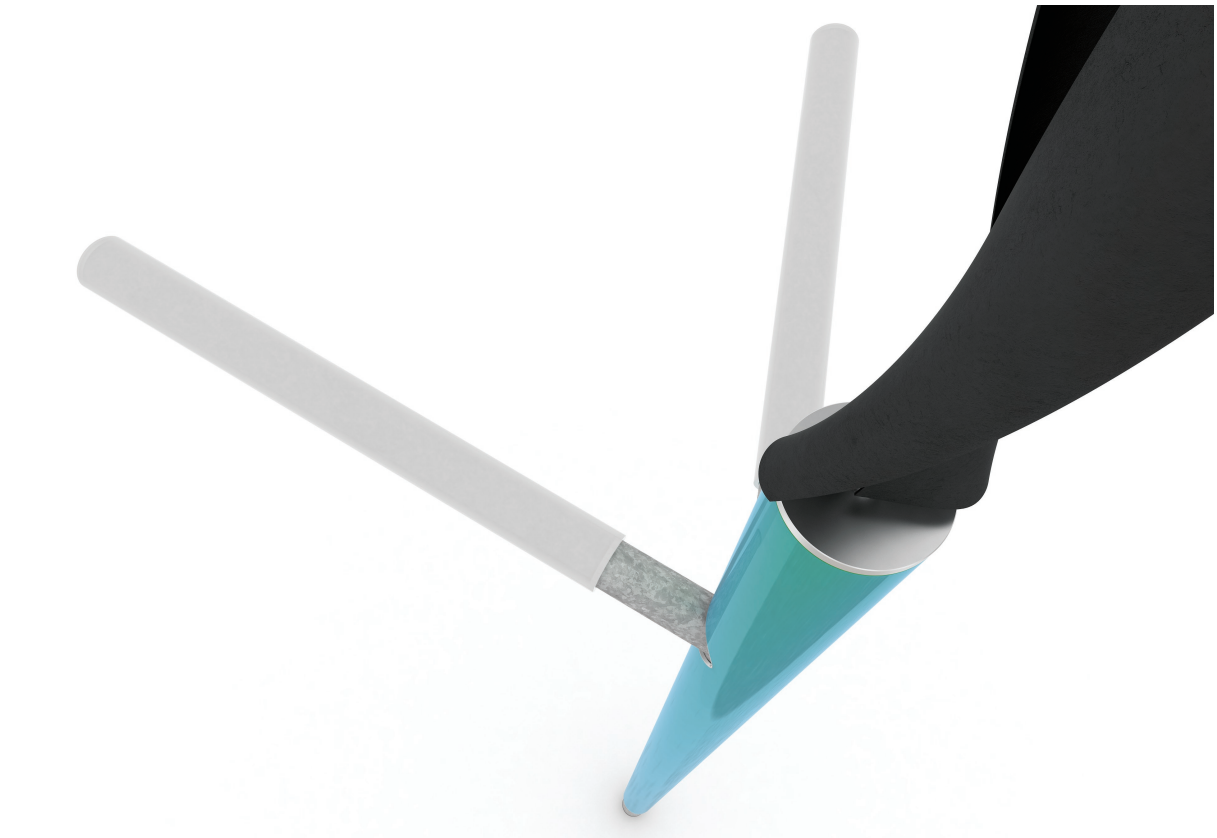
Ill. 4.2: The Konveni street lamp

Ill. 4.3: The Konveni street lamp installed in a city



Ill. 4.4: The Konveni street lamp installed outside urban areas

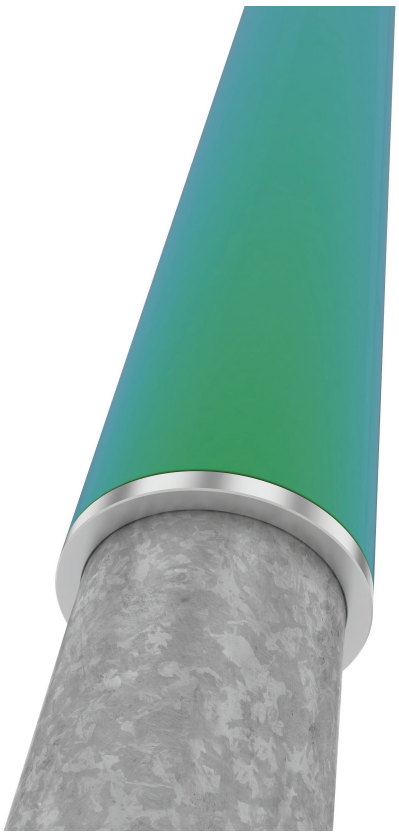
Ill. 4.5: The Konveni street lamp installed in a city park



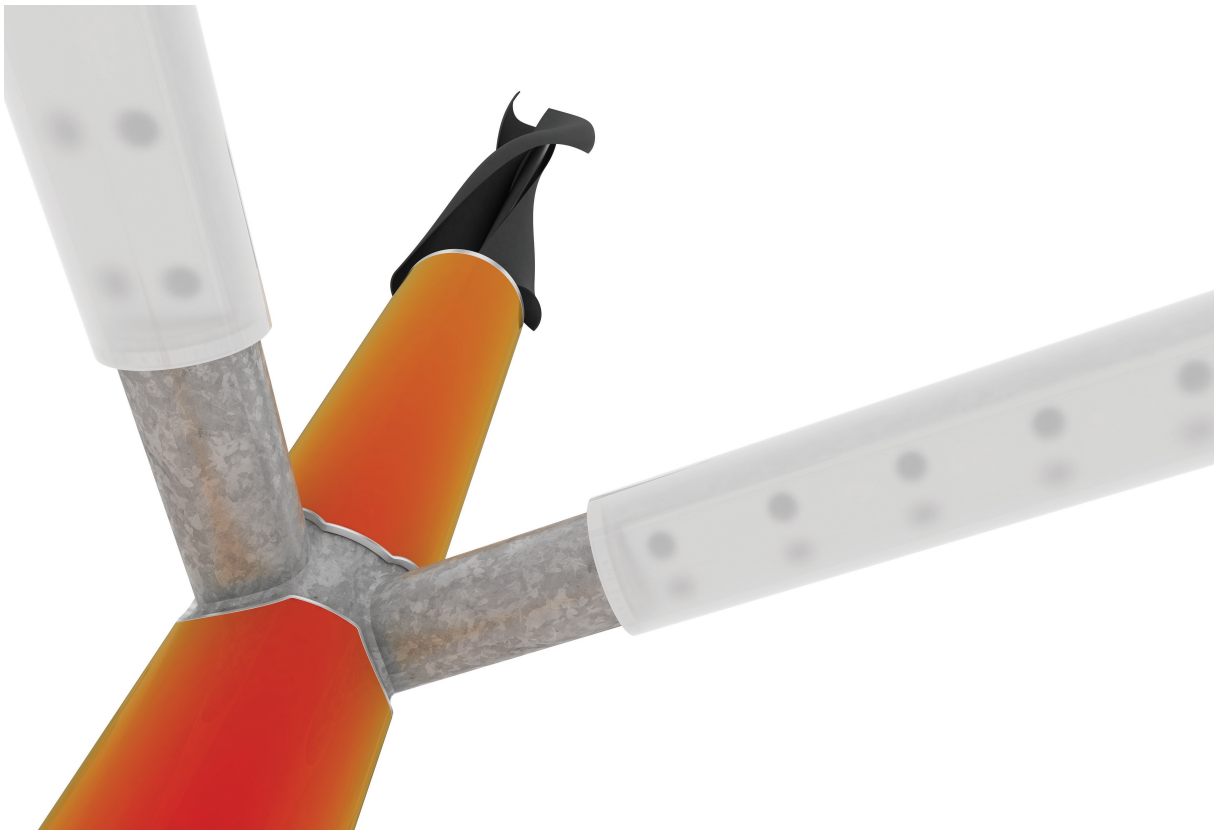
Ill. 4.6: The Konveni street lamp

Ill. 4.7: The Konveni street lamp

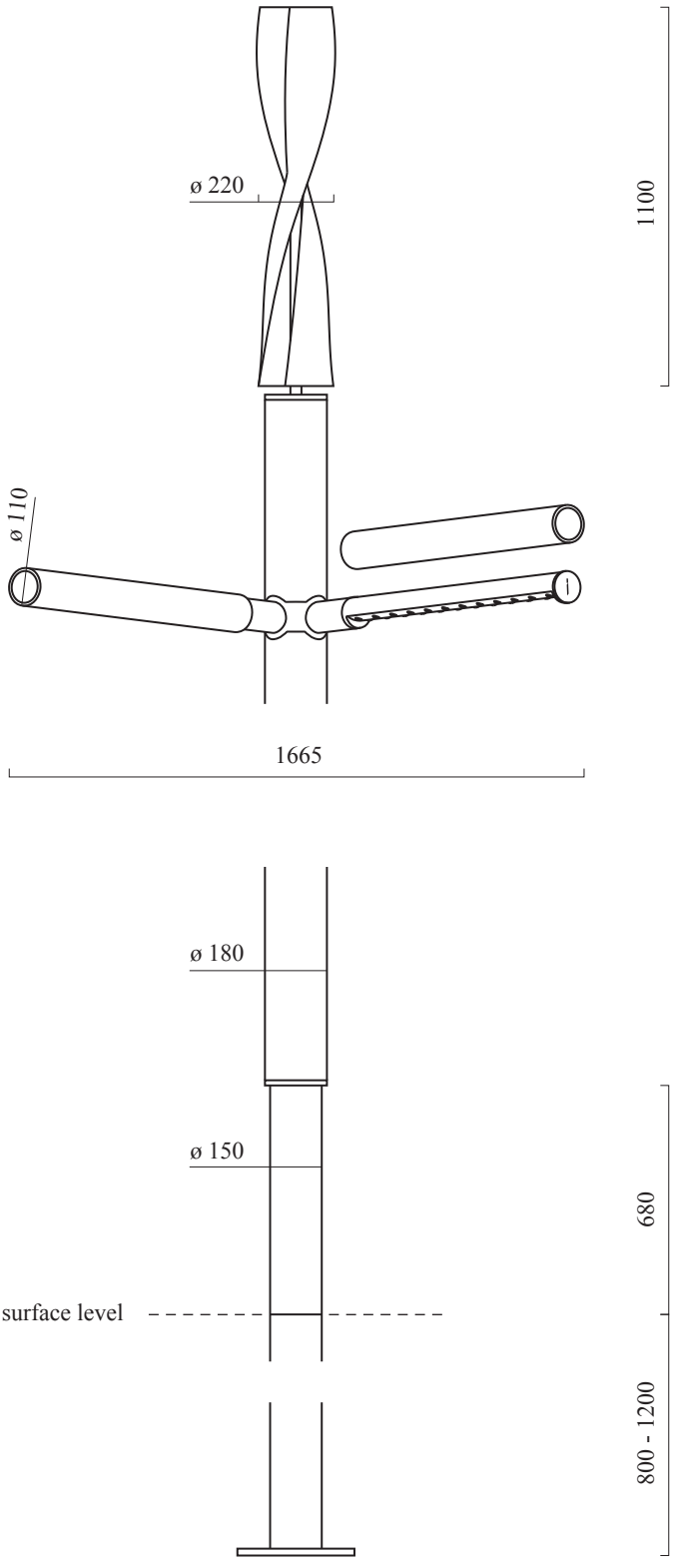
Ill. 4.8: Detail of luminaire semi-translucent housing



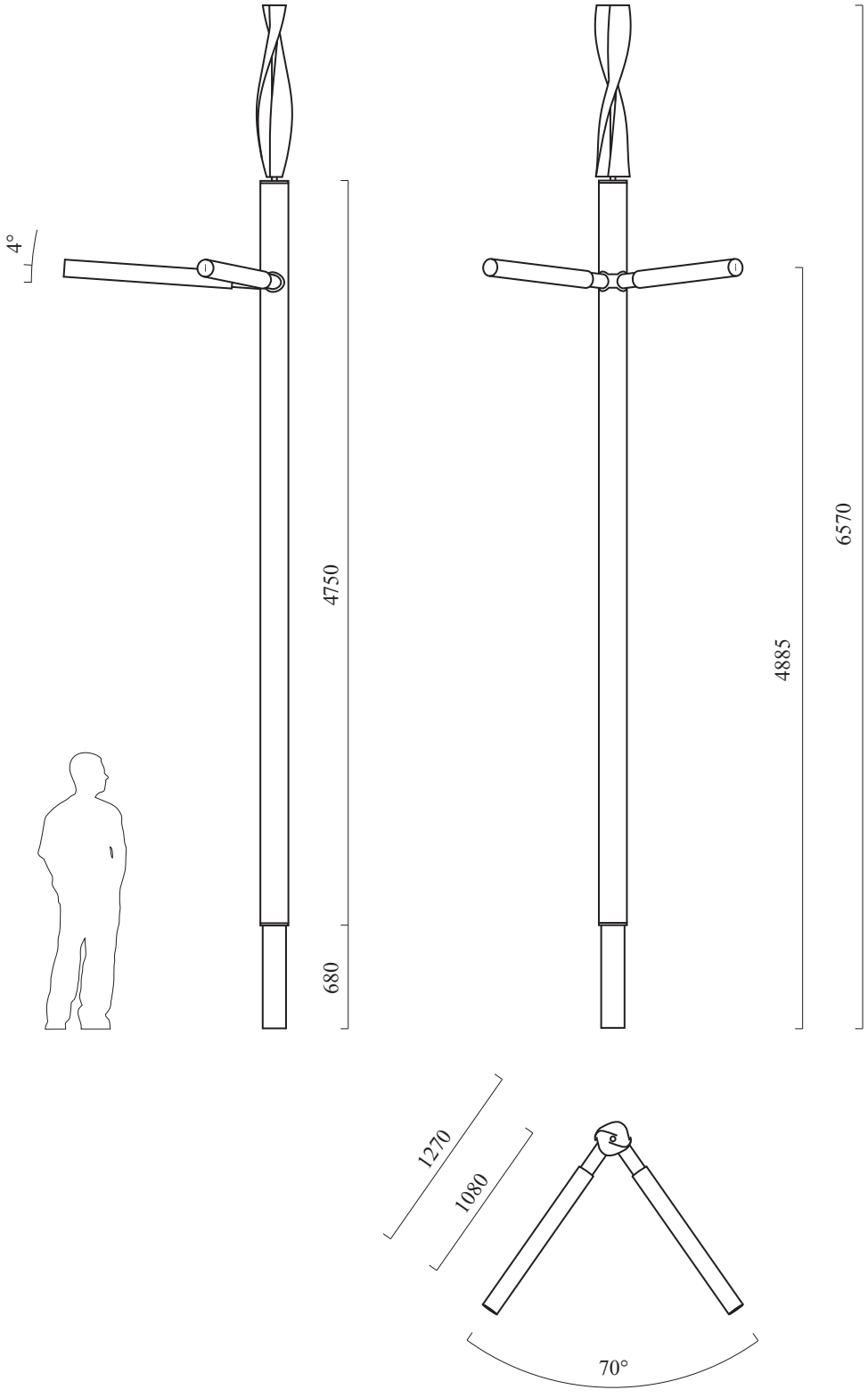
Ill. 4.9: Detail of stepping - solar cell module covers the column of the lamp



Ill. 4.10: The Konveni street lamp



Ill. 4.11: The Konveni street lamp - view (dimensions in mm)



Ill. 4.12: The Konveni street lamp - views (dimensions in mm)

Section 5

FUTURE PERSPECTIVES AND CONCLUSIONS

5.1 FUTURE PERSPECTIVES

Konveni unveils a smart way how to approach the issue of public lighting. There is a considerable potential in the design of Konveni street lamp. Konveni takes the undisputed advantages of technologies that utilizes solar and wind power.

The design of the off-grid street lamp comes in the time when “clean energy resources” are favoured not only by number of politicians but, also by increasing number of users who are willing and even eager to invest into products supporting sustainable development. The more common such environmentally friendly designs will be, the higher the demand and business potential.

It is assumed that the Konveni off-grid street lamp would be first favoured in regions where renewable sources of energy have already gained high social recognition. As soon as the quality of the product is proved, the Konveni street lamp may enter markets elsewhere.

5.2 CONCLUSIONS

Konveni, the off-grid street lamp, is my answer to the challenge framed in the objective above:

´How could I as a designer rethink a design of a street lamp by applying existing technology on well-tried standards and thereby add new features and contribute to global threats decline?´

As a common street lamp, Konveni is a simple device which provides a public space with a light. As a design for the world we live in today, Konveni employs state-of-the-art technologies that put the idea of sustainable development into practice. Konveni competes with a range of conventional lighting solutions in saving energy - by using energy from renewable resources - hence money savings.

By Konveni design I reflect some of the actual global problems, particularly issues of increasing energy demand worldwide and “clean energy” supply.

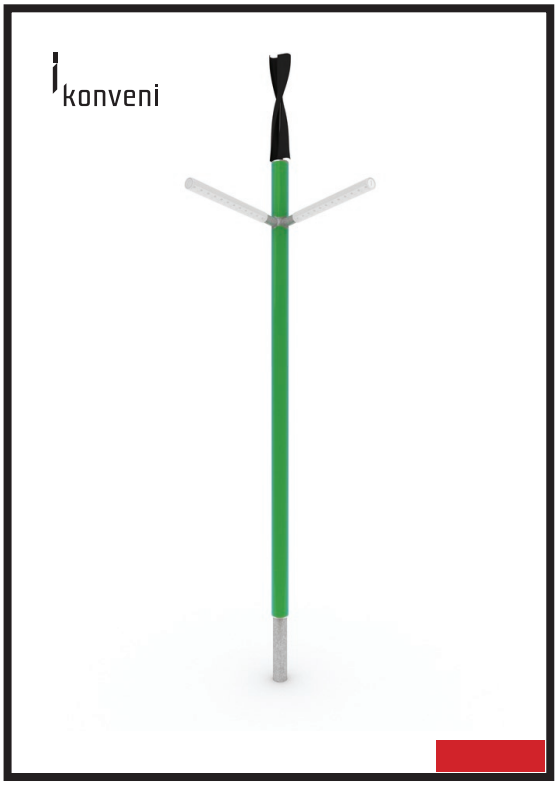
Konveni design is technically a part of the solution. Furthermore, I have designed the Konveni street lamp as a tool by which technologies of thin-film solar cells, light emitting diodes and wind power utilization are brought closer to public in order to demonstrate their enormous potential for our every day life.

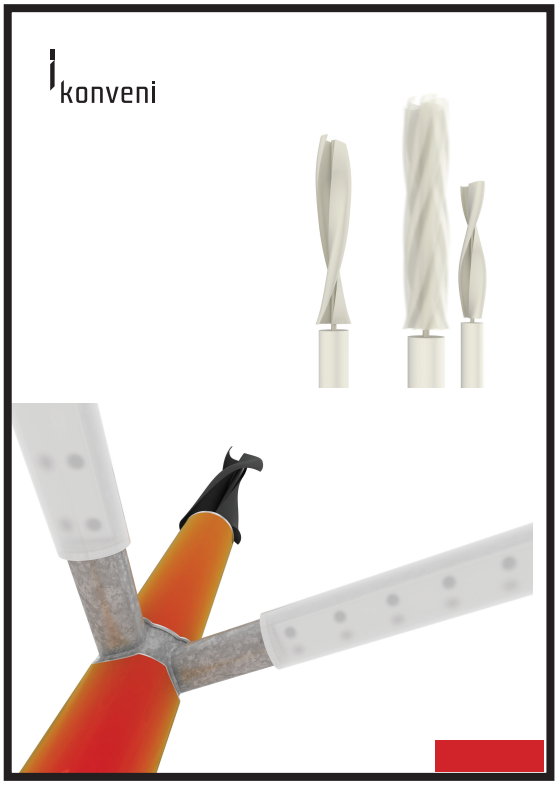
Utilizing energy from the Sun and wind is intentionally emphasized in the physical form of the design, however, it is expressed so in a catching and undisturbing way.

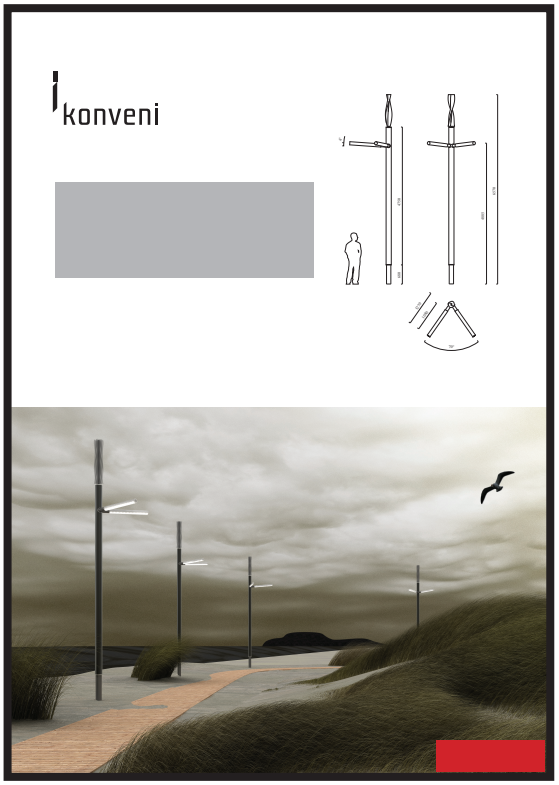
Konveni is a design that aims to convey a message to people; a message that encourages people to rethink the way they consume and act.

Konveni is designed for people, Konveni is designed for today.

Appendix - Preview of posters







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