D1.1

Initial feasibility assessment

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Abstract:	This deliverable conducts an initial market feasibility study by researching the current market situation and assessing the match of the project developments to the market needs, including an analysis of the market situation concerning LED driver systems and a description of the state of the art regarding solid state lighting modules.
Keywords:	Target industry, market, needs, strategic fit, SWOT

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Executive Summary

The aim of the LEDLUM project is to develop a highly integrated very cost competitive light engine technology platform for Solid State Lighting (SSL) which is directly connected to the electrical power grid.

Based on the research performed within the project several objectives are planned to be reached. Attaining the targeted objectives, will allow all project partners to develop new products/services, and/or to significantly improve already existing products/services, which are described in more detail in Chapter 2.

New product developments are for instance wireless charging units for mobiles, laptops and other personal portable equipment, mainly targeted by NPC. Also the smallest LED driver, which is planned to be developed, will mainly result in a new product of TRI, which will allow new designs for spotlights. IPD will develop a high voltage capacitor technology, another novel technology that can be applied where density/temperature and reliability are key differentiating combined with high voltage. Based on their participation and research in the project partner TNIUCC will be able to offer new design services and intellectual property related to silicon integrated magnetic devices optimised for use in LED driver applications. Partner LGR will benefit from the results achieved within LEDLUM. They will create a range of commercial light fittings below 50W power, equipped with the LEDLUM tiny driver, either as a unit or as driver on board. TEC will be able to extend their research services for novel system development. Potential strengths, weaknesses, opportunities and threats that come along with these new and improved products and services have been identified by the partners.

Besides the SWOT analysis, a market assessment for the new and improved products and services was performed. As described in Chapter 3 the LED-luminaire market will grow during the next years and therefore, partners plan to expand their existing markets and have already identified potential new markets. The new product and service developments will allow the partners to strengthen and further improve their market position.

However, entering new markets also entails several risks that must not be neglected. Chapter 4 describes potential new technical risks, such as costs being too high, or that the results derived are not good enough to be sold on the market. The consortium is able to handle the potential risks and to prevent them from materializing. Also other external influences as well as laws and regulations have been taken into consideration.

To conclude the initial feasibility assessment Chapter 5 considers the strategic timeline, which shows that first exploitable results are already expected within a few months after the project end.

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Chapter 1 Introduction

This deliverable describes both new and refined products and services developed during the LEDLUM project, the state-of-the-art and the markets they are targeting. It analyses the strategic fit and risks of the project developments to the market and its environment.

A first overview of the current state of the art is given in Chapter 2. After an overall description of the products and services, a SWOT analysis provides further details of potential internal and external factors.

Chapter 3 provides a short overview of the current market situation as well as an outlook of its development. A growing market will allow partners to expand current markets and to explore new markets with their new product developments. Market opportunities as well as competition in the market have been taken into consideration for each of the new or improved product or service.

The key risks that come along with new product introductions and entering new markets are described in Chapter 4. Additionally, other external influences as well as laws and regulations are described.

Last but not least, Chapter 5 provides an overview of the expected time that is needed to go from the prototype to the final products and services. First exploitable results are already expected within the first few months after the project's end.

The initial feasibility study is a first attempt to analyze the current situation and to identify potential market opportunities for newly developed or refined products and services. The feasibility study helps to narrow the scope of the project to identify the best business scenarios. A concluding market assessment that shows how the market needs are addressed, how the project will create impact on the industry and which exploitation opportunities exist for the partners will be included in D8.4 "Final plan and report on Exploitation, Dissemination & Communication activities" at the end of the project.

Chapter 2 LEDLUM's product and service developments

2.1 State of the art

The LEDLUM project aims to develop a highly integrated very cost competitive light engine technology platform for Solid State Lighting (SSL) connected directly to the electrical power grid.

Currently the majority of solid state light (SSL) systems are using high brightness light emitting diodes (LEDs) as a light source. The whole lighting system consists of the electrical part (light engine), the mechanical part (luminaire) and the optical part (reflector and lens). The bottleneck for size, weight and cost reduction as well as reliability and energy efficiency increase is the light engine. As all of these limitations are originated in the light engine, LEDLUM focuses on the light engine.

The light engine contains an LED module (the actual LEDs and the substrate material they are mounted on) as well as a driver (electrical engine). The LED is responsible for the limit in energy efficacy (lm/W), but the driver is a limiting factor for size, weight, cost and reliability. To operate the LEDs from the electric grid (90 V - 264 V, 50/60 Hz), the driver needs to convert electrical energy from the grid to voltage and current levels, that apply to the LEDs electrical characteristics.

This conversion has to comply with a number of regulations dictating the shape of the electrical current and safety requirements[2] for galvanic isolation.

Today's LED drivers are bulky and expensive and suffer from reliability issues and therefore have a short lifetime, see Figure 1. Hence the drivers limit the scope of the applications.

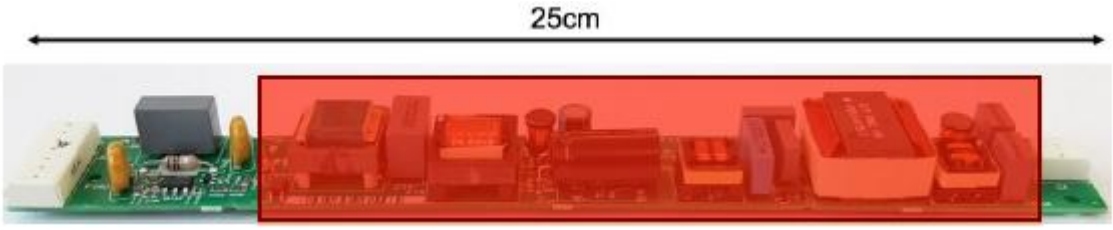

Figure 1: Example of a 75 W LED driver with a volume of 25 cm x 2 cm x 3 cm (150 cm^3), i.e. power density of 0.5 W/cm^3 and an expected lifetime of 5 years.

As Figure 1 shows, it is the passive electrical components (inductors and capacitors, marked with the red box in Figure 1) determining the volume of the driver. It is also those components, which are responsible for approximately half of the whole electrical engines cost. Simultaneously some of the capacitors, namely the electrolytic capacitors are limiting the lifetime of the driver. In recent years Driver-On-Board (DOB) (all driver components surface mounted, typically using semiconductor power converters and eliminating electrolytic capacitors), and so-called "driverless" or "ACLED" (i.e. forming a rectifying bridge using the

LEDs themselves) approaches have been used. Those are not applicable in many types of light engine as they do not fulfil important requirements of low light flicker and mains power factor. The improvement of external drivers is a pressing requirement for the lighting industry.

2.2 Product/service developments

In general, the LEDLUM consortium aims to reach the following ambitious objectives within the course of the project:

- 90% **size and weight reduction** of the power electronics part in the LED driver,
- **reduction of material cost** by a factor of 2,
- **reduction of energy losses** by 45%, and
- **increase** of the expected **lifetime** from 5 to 10 years.

To achieve these objectives, the LEDLUM project expects a number of innovations from which not only project partners will benefit:

- **New soft magnetic thin film inductors** to increase magnetic on silicon energy efficiencies.
- **Use the most competitive power semiconductors** in terms of energy efficiency and combine with drive and control circuitry for operation in the VHF range.
- **Increase the capacitance of ultra high density PICS trench capacitors** for HV applications under stable temperature and voltage linearity and state-of-the-art parasitic inductance and resistance.
- **Use silicon wafers with embedded capacitors** as mechanical and electrical base for other electrical components, especially as magnetic-on-silicon based inductors and power transistors to achieve unprecedented power densities.
- **Combine the above magnetic, capacitors and power semiconductors** in a granular approach with novel ripple port circuit topologies to form a grid-tied AC-DC converter without electrolytic capacitors.

As the project consortium brings together partner organisations from different sectors, several different products and services are developed in the LEDLUM project. Every single product/service has its own target market and customers, and thus also its specific strengths and weaknesses, opportunities and threats. In the following chapter each product or service resulting from the LEDLUM project will be presented and explained. Furthermore, the strengths, weaknesses, opportunities and threats of each product/service will be illustrated Table 1.

The first product to mention, resulting from LEDLUM, is a **wireless charging unit** for mobiles, laptops and other personal portable equipment. Partner NPC Tech APS (**NPC**) is main developer of the product and will outsource the production to Jabil, who will take care of everything from procurement to testing and shipping in accordance with NPC requirements. Jabil is among the 10 largest EMS companies in the world and therefore has the required bargaining power. The key customers for the wireless charging unit depends on which segment to be prioritized first, but the large mobile and handheld manufacturers could be targeted first. The main needs which will be satisfied are the flexibility of design and ease of integration and from that, possibility of differentiation through industrial design.

The **smallest LED-driver**, developed by partner Tridonic GmbH & CO KG (**TRI**), allows new designs for spotlights. Further it enables simple “Driver on Board” light-engines with high lifetime and flexibility and better performance regarding light-ripple compared to AC-LED. The integrated passives will be provided by Tyndall (magnetics), IPDIA (capacitors) and semiconductors probably from TSMC. If the processes for integration of inductors and capacitors are not available from several suppliers then low competition may keep prices high. All current Tridonic customers will be interested in the concept, due to its addressing the customer needs of size reduction, reliability and performance at the lowest cost.

Furthermore, IPDIA SA (**IPD**) will develop a **high voltage capacitor technology**, which can be applied where density / temperature and reliability are key differentiating combined with high voltage. The technology developed in LEDLUM will offer the first basic building blocks for the development of custom products for each foreseen applications, which may require further technological development. The main markets for this technology are automotive, aircraft/space or industrial.

Additionally, partner L.E.D. Lighting and Electrical Distribution Group (**LGR**) will create a range of **commercial light fittings** under 50W equipped with the LEDLUM tiny driver, either as a unit or as driver on board. LGR has a number of Chinese suppliers, who use a range of drivers for LEDs, for example Meanwell and Powerland drivers. Furthermore, LGR has an elite range of platinum suppliers. The key requirement is that the tiny driver must be available at a competitive price from within China to the Chinese supplier manufacturers. The customers for the developed commercial light fittings are mainly wholesalers, including those who supplier prime end users such as project contractors. They seek a competitive price, reliability and warranty extension but also low flicker and the ability to drive at least up to 50W in a single light fitting.

The potential outputs from LEDLUM for the University College Cork – National University of Ireland (**TNIUCC**) are **design services and intellectual property** related to silicon integrated magnetics devices optimised for use in LED driver applications. Potential customers for these services are the consortium partners Tridonic and Murata, Nordic Power Converter, due to their need for miniaturised integrated magnetic devices capable of high efficiency operation at high frequency.

Technikon Forschungs- und Planungsgesellschaft mbH’s (**TEC**) **RTD services** point to the support of industrial technology developments, basically the development of technology roadmaps, impact studies and the evaluation of potential product lines. The market for LED luminaires is booming. This gives Technikon the opportunity, to gain insight for novel LED drivers and technologies. Therefore, the input from the project helps to refine TECs knowledge and therefore to provide better technology based services. Potential customers for the service are players in the European high-tech industry, seeking for LEDLUMs target factors, such as cost reduction, volume reduction etc. of the power electronics part in the LED driver. The success of those services can be measured by the research service turnover which will be generated.

2.3 SWOT analysis

The following table illustrates the strengths, weaknesses, opportunities and threats of each product/service developed during the LEDLUM project.

Product/service development	Strengths	Weaknesses	Opportunities	Threats
Wireless charging unit (NPC)	NPCs technology is capable of miniaturizing the charger part, which will make it possible to get the necessary SMPS for the charger even smaller or include it in the design or even into furniture or the like.	The entrance barrier to the market is high, if partnering with a large vendor is impossible. Price point will be very aggressive due to volume.	The market for chargers is enormous. The first wireless chargers are already in the market and the race for the smallest implementation will take off to miniaturize and embed the charger in our surroundings.	Currently a lot of effort is being put into wireless charging and hence other solutions may end up taking the volume market.
The smallest LED-driver (TRI)	Tridonic's smallest LED-driver offers a very high power-density at low cost due to integration, if it can be pushed to high volume.	One of the weaknesses is that the VHF-technology is a relatively complicated system, which can create cost- and space-benefits only at high-integration of components. This is commercially interesting for high volume only; therefore a universal module-approach seems to be necessary. The "platform-approach" is not really in scope today.	The small geometry allows integration into track lighting systems which are already installed in a huge number of buildings. Through its size benefits, LEDLUM will also stimulate the integration into furniture and directly into the building architecture (i.e. outside a typical luminaire body), which are long-term investments and therefore would highly benefit from increased lifetimes of the architecture as well. Cost and size benefits are key decision criteria for many luminaire types, like spotlights and downlights. It is expected that the number of these luminaire types in Europe will exceed 25 million pcs per year by 2019. Further the DCDC-module	Especially in the low-power domain the AC-LED topology may gain a lot of market-share in applications where very low lightflicker is not so critical. However this risk is mainly seen outside of Europe. Also new and unclear situation in the field of standards, e.g. SELV at very high frequencies, may lower the acceptance of the VHF-solution. And finally the sourcing-situation in the field of GaN which could be single-source especially in the first years of production can slow down the ramp-up, which also keeps the prices high due to

Product/service development	Strengths	Weaknesses	Opportunities	Threats
			could be used stand-alone in the DC-String system from TRI.	too low quantities. This could be a kind of “chicken and egg” problem.
High voltage capacitor technology (IPD)	Superior voltage handling capability / Superior specific capacitance compared to silicon technology SOA. Very limited ESL/ESR compared to all other HV technologies for better ripple control and higher frequency span compliance.	Compared to non silicon based technology (i.e. Film) the absolute capacity will appear to be low although the capacitive density is several orders higher. This is implied by thin film technology.	Many other application fields where density/reliability/temperature are differentiating factors. Target DC and snubbers link, in package with GAN/SIC fast power switches.	No known SOA with the described characteristics.
Commercial light fittings (LGR)	10 year warranty – no electrolytic capacitor. Fit and Forget – maintenance free. Low flicker driver so a premium product. Small footprint so fitting size and materials may be reduced. Reduces fitting size weight, therefore reduces stock holding costs and shipping costs.	Rather high associated costs.	In principle, could be extended to all LGR’s premium light fitting products.	Cost, ability to manufacture cost effectively, limited to 45-50W light fittings.
Design services and intellectual property (TNIUCC)	Integrated magnetics technology optimised for high frequency operation and application in LED drivers is currently not available in the market.	The best case is that the magnetics on silicon can be applied to PFC stage of the converter as well as the DC/DC stage. However this will depend on the voltage handling	If the magnetics on silicon can be applied to PFC stage of the converter the technology could be applied to AC/DC conversion for other markets.	No threats known.

Product/service development	Strengths	Weaknesses	Opportunities	Threats
		capability of the devices.		
RTD services (TEC)	The major strength of LEDLUM solutions are the forefront LED drivers. We are on the way to the introduction of completely new products. This does not only support the partners in the project, but also potential industry partners in Europe. Nevertheless it has to be supervised, that is the IPR that is generated in the project is protected and nothing is forwarded to outside parties without the consent of all stake holders and project partners.	Technikon does not yet have IPR rights of this topic. Any of its potential customers will need to acquire the IPR if they intend to use the information or the technology that is protected.	The LEDLUM project shrinks in size certain technologies, which are widely used in different areas. It could also be used for other solutions, like sensor networks or any applications were discrete parts are still needed This broadens our research services and allows us to further and better advise our customers.	One of the major threats is the real costs connected. It has to be shown that the decrease in volume of the LED driver is also a decrease in the costs per product. The costs are saleable to number of chips per year and per product line. Therefore, there is a threat for such solution, defined by the number of products/month produced. If these figures are lower than calculated, the costs might be too high and the customers might stick to conventional solutions. Another threat might be that our customers might want to design their own integrated solution which leads to additional costs and risks.

Table 1: SWOT Analysis

To ensure a successful project and benefits for each beneficiary, the project consortium has to keep possible mitigation plans in mind. Those mitigation measures range from personal contacts with future customers and partners to clarification of standards and special designs for manufacture.

In order to overcome the mentioned weaknesses regarding the lack of IPR rights, TEC has to convince its customers of the advantages of the new solutions. They should have the feeling that they actually buy a value added product that is worth the price.

To overcome the weaknesses and threats concerning the wireless charging unit, NPCs proof of technology and miniaturization are ongoing in the LED lighting market. Furthermore, contact for strategic partners/customers will be taken, when first proof of concept has been done.

As the VHF-technology is a relative complicated system, which can create cost- and space-benefits only at high-integration of components, the capability of the VHF-technology for a wide range of LED-drivers has to be kept in mind during development of the demonstrators. Furthermore, Tridonic will have to clarify the standards of performance and safety for VHF LED-gear in parallel to the LEDLUM-project.

To mitigate the threat of high costs for commercial light fittings, LGR will aim to create a design for cost-effective manufacture during project

Chapter 3 Positioning and Differentiation

According to market studies, the European LED-luminaire market will grow to €9B and the corresponding LED-driver market to approx. €820M by 2020. The project aims to address the size-driven and low-to-medium power luminaires with a potential of €90M.

This will generate additional business and employees in Europe, as the LEDLUM-approach replaces the older technology made in other countries, which increasingly "swash" into Europe. The impact is even bigger if the European companies address the potential of €350M worldwide. As the consortium composition unites leading players in the field of VHF, integration, LED-Driver and light-fixture-design from science and industry the project is likely to achieve these highly ambitious goals. By developing the world's smallest Light Engine, LEDLUM may position Europe as the world leading innovator in SSL solutions.

Competing technologies are seen mainly in the US. The PowerChip Development program[1] was started in 2004 at Massachusetts Institute of Technology (MIT), making a platform for integrated power supplies. As of August 2016, the MIT team developed a power converter that reduces both cost and power loss. FINsix (www.finsix.com) was spun out of this MIT platform, securing $10M of venture capital in early 2011.

FINsix has announced their first product, the world's smallest and lightest laptop charger, and plans to sell international models starting in 2017. The FINsix 19 Volt/65 Watt power supply is planned to have a retail price of $89, will weigh 45g, and with a volume of 40 cm3, it will have a power density of 1.6 W/cm3.

These patents do not prevent LEDLUM's success as LEDLUM is basing its advantages on different technologies. The only commonality to the patents is the argumentation with VHF power conversion as means to achieve the benefits. The approach used in LEDLUM is totally different from that. LEDLUM proposes to develop integrated magnetic components using Tyndall "magnetics on silicon" technology. The integrated devices will use high performance soft magnetic thin films (amorphous, nanocrystalline) with increased thermal stability. The magnetic cores will utilise laminations to enable higher power density, high efficiency devices. Additionally, a compact model representing the performance of the magnetic device will be developed and would feed into the overall system optimization process. Further process innovations for realising a high aspect ratio, copper structures along with closed magnetic laminated loop will also be developed. Further, LEDLUM allows exploitation of the advantages of miniaturized SSL engines to a higher extend than FINsixs' and MITs' solutions do.

On top of that DTU holds several patents in the field of VHF power conversion, which are licensed to NPC. These fully allow the freedom to operate despite the MIT/FINsix patents.

The following section describes the potential market for the products and services developed during the LEDLUM project, as well as their key performance criteria and expected competitors. Especially, the differentiation from competing products is in focus.

[1] https://arpa-e.energy.gov/?q=slick-sheet-project/advanced-power-electronics-led-drivers

3.1 The wireless charging unit

The wireless charging unit will be a new development, which target market is mobiles, handhelds, tablets and other portable equipment. Premiere focus is the largest manufacturers either directly or together with partners. According to an IHS study, the world market for wireless power is forecasted to reach $8.5 billion in 2018. In this time the wireless charging market in Europe is predicted to increase approximately 50% to $1.85 billion.[2]

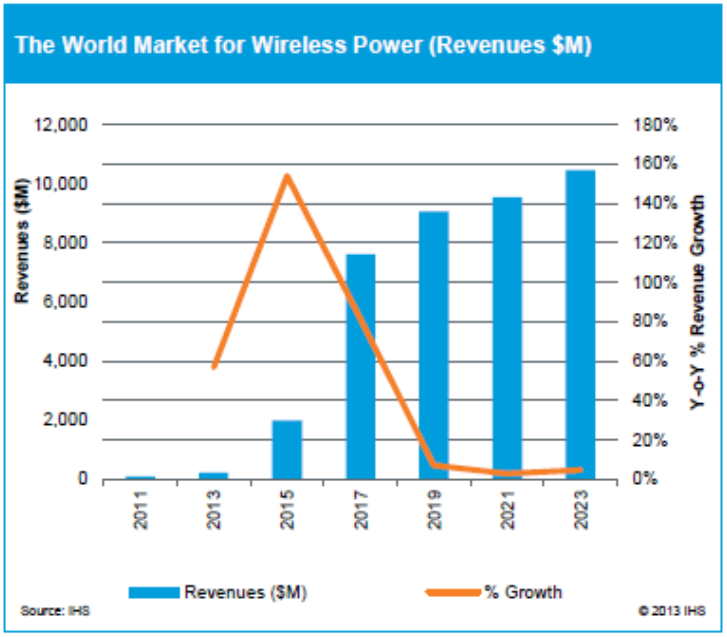

Figure 2: Size of world market for wireless power

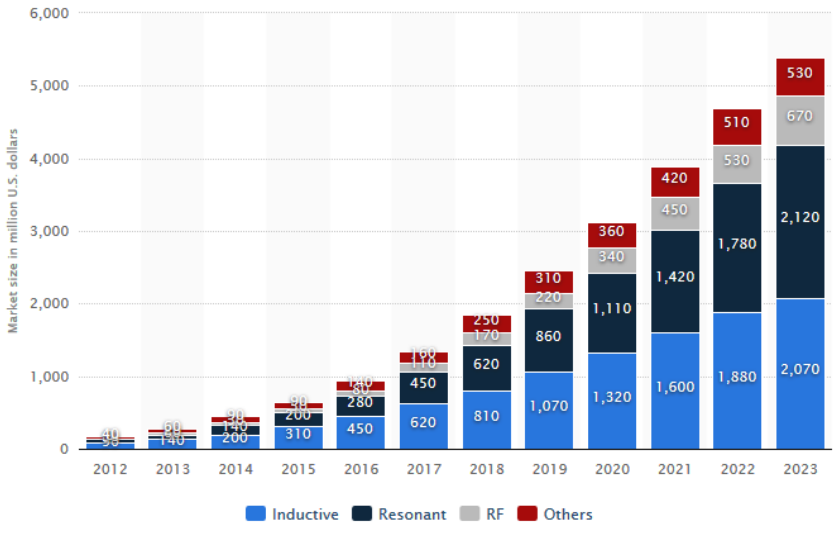

Figure 3: Size of wireless charging market in Europe by technology from 2012 to 2023 (in million U.S. dollars)[3]

[2] IHS Technology (2014). The World Market for Wireless Power –2014 Edition. URL: https://www.ihs.com/Info/0814/wireless-power-charging.html

[3] https://www.statista.com/statistics/681503/wireless-charging-market-in-europe-by-technology/

Substantial additional research is needed, in order to transfer the results of LEDLUM to wireless chargers, but the principles and core technologies developed in LEDLUM can be reused. It is expected that wireless charging is going to be added as a separate application area span out from our core technology.

Having working proof of concept prototypes earlier, would kick start negotiations with partners and from that speed up market introduction and reducing the risk of having an information channel to the market during the development.

The key innovation of the wireless charging unit is the use of VHF switching in the SMPS, which brings down the size of the power supply. NPCs patented VHF switching technology significantly reduces the size of the magnetic and switching elements and therefore enables a higher grade of integration, than standard SMPSs do.

This leads to high efficiency, a low production price and an ease of production.

A number of wireless chargers are already present in the market field – most of them from smaller suppliers. The largest competitor is the existing solutions for Android phones including Samsung. The minor competitors typically deliver standalone solutions, which need adapters for the connected equipment. The new LEDLUM development differs in size and flexibility of the SMPS behind the charger unit, but the level of integration, size and price of the competitors have to be beaten.

Due to the fact that wireless charging is expected to change the way of interacting with the attached equipment, learning from existing products in the field will bring valuable knowledge.

3.2 The smallest LED driver

The smallest LED-driver, developed by Tridonic, allows new designs for spotlights. Therefore, the professional lighting-market in Europe is the most important market for the ultra-small and reliable VHF-driver. Design and Light quality are key drivers in that market and those could come with LEDLUM in unbeaten cost.

The results are useful for a “proof of concept”, but for broad market acceptance some additional requirements and inputs have to be worked out. Also the commercial and supplier issues have to be worked out after the LEDLUM-project.

The market position in the field of highly design-driven luminaires can be strengthened and a clear separation from far-east products due to high quality and performance is possible. As described in before, the potential is also generally in spotlights and downlights alongside with furniture integration resulting in an overall potential of 25 million pcs and beyond for 2019.

With a good design-in support for OEM’s (luminaire manufacturers) regarding the critical issues, like thermal-management and EMI a fast adoption and integration of the new driver-concept will be pushed. The benefits on size, cost and reliability are striking arguments for luminaire OEM’s.

The High performance (light quality) that comes with advantages in size, cost and reliability is the key innovation within the LEDLUM-driver concept

While currently the market runs into commoditisation, price has become dominant as the key purchase driver for LED components (drivers and lightsources). While other products achieve the cost/price benefits at the expense of lower quality and bigger size, the LEDLUM approach would combine the cost benefit with benefits on size and reliability.

Light quality (low ripple/flicker) and efficiency at the level of today’s state-of-the-art premium lighting solutions are the key performance criteria for the product.

The main competitors for the smallest LED-driver are Seoul semiconductor, Philips, Osram, EFORE, TCI, Samsung. Competing products are driverless AC-LED and LED-drivers with high power-density, but considerably higher ripple/flicker.

In comparison, the LEDLUM driver-concept offers no LF-ripple and wide operation-range regarding output-current and voltage and SELV is not possible with AC-LED approach.

The key performance values price and volume are very low for driverless topology currently in Europe as the technology cannot meet customers' quality expectations. Traditional architectures (drivers + lightsources) of leading manufacturers are on comparable level. Achieving a similar performance at lower size and cost would clearly be a game changer.

Some applications may not need the high performance regarding lightflicker and efficacy. Therefore the marketing should focus on the high-quality market, which is dominant in quantity and value in Europe and USA.

3.3 High voltage capacitor technology

The high voltage capacitor technology, is a new development by IPDIA. The application is used where density / temperature and reliability are key differentiating combined with high voltage. Automotive, aircraft/space or industrial are the main markets.

The technology developed in LEDLUM will offer the first basic building blocks for the development of custom products for each foreseen applications, which may require further technological development. IPDiA, a Murata company has a huge access to market through its worldwide positioning. This will be a competitive advantage when entering the market.

The key performance criteria of the product is, that it is handling very high voltage (target 600V), has a large frequency span, with high specific density (=in-package integrable) and capability to withstand harsh environment (mainly temperature)

There are no similar products existing on the market, as no competition is actually combining similar advantages. The closest technology is film technology but not competitive in term of specific density/temperature

3.4 Commercial light fittings

LGRs range of commercial light fittings under 50W equipped with the LEDLUM tiny driver is a replacement for existing light fitting solutions. The current market sectors for such products are general light fitting manufacture and supply, including lighting controls, sensors, emergency drivers, and lighting system controls and are applied in commercial, industrial, residential, emergency, street lighting.

Main target countries are the following:

Ireland	Scotland	England/Wales	France	The Netherlands	Singapore
Belgium	Luxembourg	Finland	Austria	Sweden	South Africa
Estonia	Malta	Iceland	Australia	New Zealand	UAE

Table 2: Main target countries of LGR

For the future with the new developments LGR plans to further target the above mentioned markets and to further expand in France, the Nordic countries, The Netherlands, Poland and Germany.

The LEDLUM results will be fully applicable to the development. LGR expects to use the LEDLUM drivers in high end fittings oriented at professional lighting systems, mostly specified by project engineers

Furthermore, LGR predicts to be able to upgrade several ranges of commercial light fitting to be lighter, more reliable, and to have a 10 year warranty.

A quick market access can be guaranteed, by planning to incorporate the tiny driver in light fitting types which are already on the market, and by preparing to have the tiny driver in mass production three months after the project end, and at a competitive price

The key performance criteria of the new developed commercial light fittings are the 10 year warranty with no electrolytic capacitor and the smaller fitting with lighter weight.

The main competitors of the development are high end general commercial and industrial lighting suppliers, which offer similar products. The LEDLUM tiny driver will enable 10 year warranty and provide lighter weight and better reliability, which differentiates the product from its competitors, which only offer 5 years occasional 7 years, warranty.

Furthermore, it is highly important to have a sub-range of high end light fittings oriented at project specified lighting.

3.5 New design services and intellectual property

The new design services and intellectual property related to silicon integrated magnetics devices optimised for use in LED driver application. The first key market is likely to be drivers used for high end LED lighting for retail and hospitality sectors requiring excellent light quality and the smallest dimensions. Participation in the LEDLUM project will lead to the optimisation of the magnetics on silicon technology for the LED driver application.

At the moment, Tyndall has non-exclusively licensed its magnetics on silicon technology in the consumer electronics area. Application of the technology to the LED driver market would be a significant expansion.

The key performance criteria of the new development, are inductance density (nH / mm2), current density (A/mm2), inductance / DCR (nH/mOhm), efficiency (%) and will be served by the integrated inductors on silicon, which are capable of operating with low loss at high frequency i.e. 30 to 300 MHz and delivering high currents suitable for LED drivers.

The main competitor for this sector is Ferric, a start-up company in New York City. Ferric is commercializing DC-DC power converter chips and circuit IP based on patented thin-film power inductors for customers in both the mobile and cloud computing spaces. The Ferric technology uses solenoidal inductors and has less current handling capability (Inductance / DCR = 0.11 nH/mOhm). The focus of Ferric is on high inductance density but with relatively high DCR which limits the current handling of the devices.

3.6 Research services

Technikon’s research services are upgraded/enlarged by the content and the exploitable knowledge created in the project and add on to its existing services. It fosters TECs knowledge in the field of smart industrial integrated circuits and especially for area of LED luminaries. TEC is mainly active selling its services in the Europe. The centre of gravity is located in Germany, France and Austria. Potential future markets of LEDLUM related services are in Italy and the Nederland’s.

Not all results from the LEDLUM project are applicable to our services. There are areas which are better suited, for example the strategic approach to the shrink process. Also the

strategic approach of integrating new solutions into existing products is part of our core targets. Important questions we have to consider are for instance, what kind of radical innovations and improvements are possible with current technologies and which kind of shrink factors/cost factors are feasible. We have to be able to answer those questions in order to provide advice to our customers.

TEC expects that their research services can be expanded by up to 10% with this new information within 3 years from the end of this project. Our window of opportunity is 3 years after the project end. TEC's USP is its independence from any technology provider. TEC gathers different kind of information, find out how to generate novel solutions and how much effort is needed to derive the research results. Therefore, TEC can derive target figures and market opportunities for our potential customers in this field. TEC's USP gives them the opportunity to be at the forefront of technology development. The key performance criteria are to incorporate the newest information and developments about the technology integration and cost factors to technology roadmaps.

In the field of RTD services (especially in research services which are dedicated to project development and technology roadmap development) competition is tough. There are companies working for the different industries, coming from top level technology assessors like McKinsey and Accenture. They offer similar services, but their information might come from other sources. Since TEC is directly engaged in the RTD process, the information/sources are more stable, accurate and valuable than the ones from the competitors.

Chapter 4 Key Risk Factors and other influences

This chapter describes potential new technical risks, other external influences and laws and regulations arising from the developments of the LEDLUM projects.

4.1 Potential new technical risks

Prior the project start 27 risks for the overall project have been identified in the proposal creation. Continuous risk assessment is performed every few months and a detailed risk assessment will be part of D8.2 Risk Assessment Plan, which is due in M12.

One of the most important potential risks is a not sustainable solution from LEDLUM and that results derived are not good enough to be sold on the market. It might happen that the demonstrators do not prove what they have promised (e.g. increased lifetime, decreased energy consumption, etc.). To mitigate this risk, all WP leaders and the industry parties are involved in each stage of the specification process. Particularly, partner LGR will give guidance on ongoing market price trends and requirements for performance. All other consortium partners ensure that the technology is designed for compliance with legislative requirements, and ideally with government incentive scheme requirements, while at a competitive cost price. Some "soft" requirements may not be achieved, but due to common focus of research on the key-requirements the output should be usable for some applications.

A further risk is related to the costs. If costs are not considered in the project there is a great risk that the solution developed in LEDLUM will be too expensive. LEDLUM doesn't consider the control and wireless power transfer needed for wireless charging, but the components and topologies used for the inverters and rectifiers can be reused. Costs can be reduced by automated surface mount manufacturing as a driver on board, eliminating the need for housing. This type of high end driver will command a premium price, and will use substantially less housing material, so in principle the impact of this risk is low from an exploitation viewpoint.

The consortium detected the risk that the absolute capacitive value is achieved at the desired voltage. This is inherent to thin film technologies - thus low polarizable volume. Partners might induce limitations on adopted converter topologies and/or performances. This has to be cleared with passive spec. In case the specific capacitor density for HV capacitor do not meet spec, alternate technologies might be used to integrate those elements. However, this could have an impact on the integration level. The aim of the HV capacitive development task is one the one hand to optimize the 3D capacitive structure to maximize BV AND specific density and on the other hand to investigate besides actual available dielectric another material type (DLC) with higher breakdown field (x4) to enhance capacitance or robustness. Some of the specifications with respect to 10 year reliability were challenging. The capacitor type is new, as is the use of planar magnetic inductors. We propose to operate in the 100 MHz range – a different switching speed range to current practice. Reliability could run into unexpected challenges from the new technology.

Possible new phosphors which may eliminate the flicker in AC-LED's at still good efficacy are a technological risk. Also improved switching-circuits are possible to increase utilization of LED's in an AC-LED and so reduce price and flicker further. But the probability for these two risks is not very high.

The LEDLUM consortium is able to handle the potential risks and to prevent them from materializing. Risk Assessment is a process which will last throughout the lifetime of the

project. Updates and assessments will be regularly performed by the consortium and reported within D8.2 and the Periodic Reports.

4.2 External influences

If LEDLUM's participating countries would exit the EU, we would most likely not be able to deliver as easily as now our services within Europe. Currently we provide services without any border restrictions.
The trust that the customers put in our knowledge and services are of vital factors. Some partners are small companies and dependent on good reputation and word-of-mouth. Satisfied customers that put trust in our services are of great importance. Once the customers trust our services, we can overcome obstacles and have a clear advantage over potential competitors.
The developed product is comparable with a standard charger for mobile devices, which is why political factors probably is without influence. If the technology can be proven to reduce electronic waste significantly, then initiatives as cradle-to-cradle and the like can result in further interest, but it is doubtful in the current state. To be competitive in a volume marked as chargers the right partner is the key parameter, both to get the right volume/competitive price from the beginning and to have the channel to the consumers from day one.
Wireless charging technology must be widely accepted by the majority of the customers, and for a long period, it has to co-exist with wired chargers, due to the large number of devices existing in the market. The entrance to the market is therefore either slow or through a large vendor of mobile devices (e.g. the closed universe around Apple products).
Wireless charging is in its early state and only the Innovators/Early Adopters in the market has accepted the technology yet. Other ways of easy connection to the grid may therefore win the battle. It is nothing other than the usual regulations for electronic equipment, such as CE, UL, Reach, RoHS, WEEE, etc.
The freedom to operate in regard to wireless charging has not been investigated yet, but it is expected that certain areas will be covered by patents. On the VHF SMPS site the technology is covered by our own patent portfolio.
Slow updating of the standards for safety at VHF-operation will inhibit market-penetration. Electrosmog will not be an issue, because the VHF is kept inside the driver and luminaire. Maybe also regulations on the recycling/replacement of LED lighting components might have an impact. The trend to the cheapest products with acceptance of weaker performance is a big threat. This trend is driven by investor-thinking instead of sustainability- and user-oriented decisions.
Having the drivers made in China is critical for most companies in the lighting industry. There is a 17% import duty for drivers made outside China. Chinese companies will push for their own drivers and LEDLUM will have to be specified. The only way around this would be to make the driver plug-and-play in cassette format, and have driverless light fittings made in China which could accept the LEDLUM cassette driver module, made in Europe. LEDLUM will also face all tariffs on export of products to whatever parts of the UK exit the EU, including the substantial England and Wales market. CE marking is legally required, as is EMC compliance. We must be able to have the drivers available in China at competitive prices. Project customers specifying high end light fittings, or low flicker, or both, may orient this product towards schools, hospitals, care homes, prisons, offices, major buildings emergence of a low cost 10 year warranty driver with no electrolytic capacitor on the open Chinese market.
LEDLUM could allow fitting sizes and materials to be reduced, as well as sustaining them longer term to ten year lifetime before failure and replacement. This will contribute positively towards the circular economy. Other companies may assert their driver patents against branded manufacturers using LEDLUM if there is infringement of validly maintained prior art patents.

Higher lighting efficiency targets will help the adoption of LED lighting and good economic growth would help the adoption of new technologies. The project is very much in line with the drive to higher energy efficiency. Also the dramatically improved product lifetime resulting from the elimination of electrolytic capacitors fits with green technology goals.
The research work is highly protected by IPR and results will most likely lead to patents. Future customers will have to obey those patents and may have to pay fees. Those fees might be included in higher prices of the new technology. Cross-licensing could be another possibility to overcome some limiting factors.

4.3 Laws and regulations

In the circumstance that the new technology would reduce electronic waste remarkably, a regulation could speed up market introduction, but the difference between the existing solutions and the wireless solution is probably too small for that and effects only the standard regulation for electronic equipment as UL, CE, etc.
Regulations on recycling, replacement and exchangeability of LED components may have a disruptive impact to the product. With a small probability the extension of flicker-frequency to higher values than 20 kHz can be critical.
The commission delegated a regulation (No 874/2012) that supplements the directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaries.
In general, the Consortium Agreement (CA) defines what results we are allowed to use and share. We have strong IPR regulations in force. Our information that we provide to our customers will mainly be based on public deliverables, since this information is publically available. Our main advantage is that we will be able to transfer the information directly and tailored to our customers and they do not have read through several documents to obtain the information they are looking for.

Chapter 5 Strategic Timeline

The following chapter discusses the expected time (months) that is needed to go from the prototype to the final products and services. It further estimates in how many months from now (February 2017) it is expected to get the green light from the management for the products and services. Also the products and services lifetime was estimated and if major updates and refinements will be performed during this time.

The overall planning of work packages, deliverables and milestones which will influence the project results in form of products and services is illustrated below:

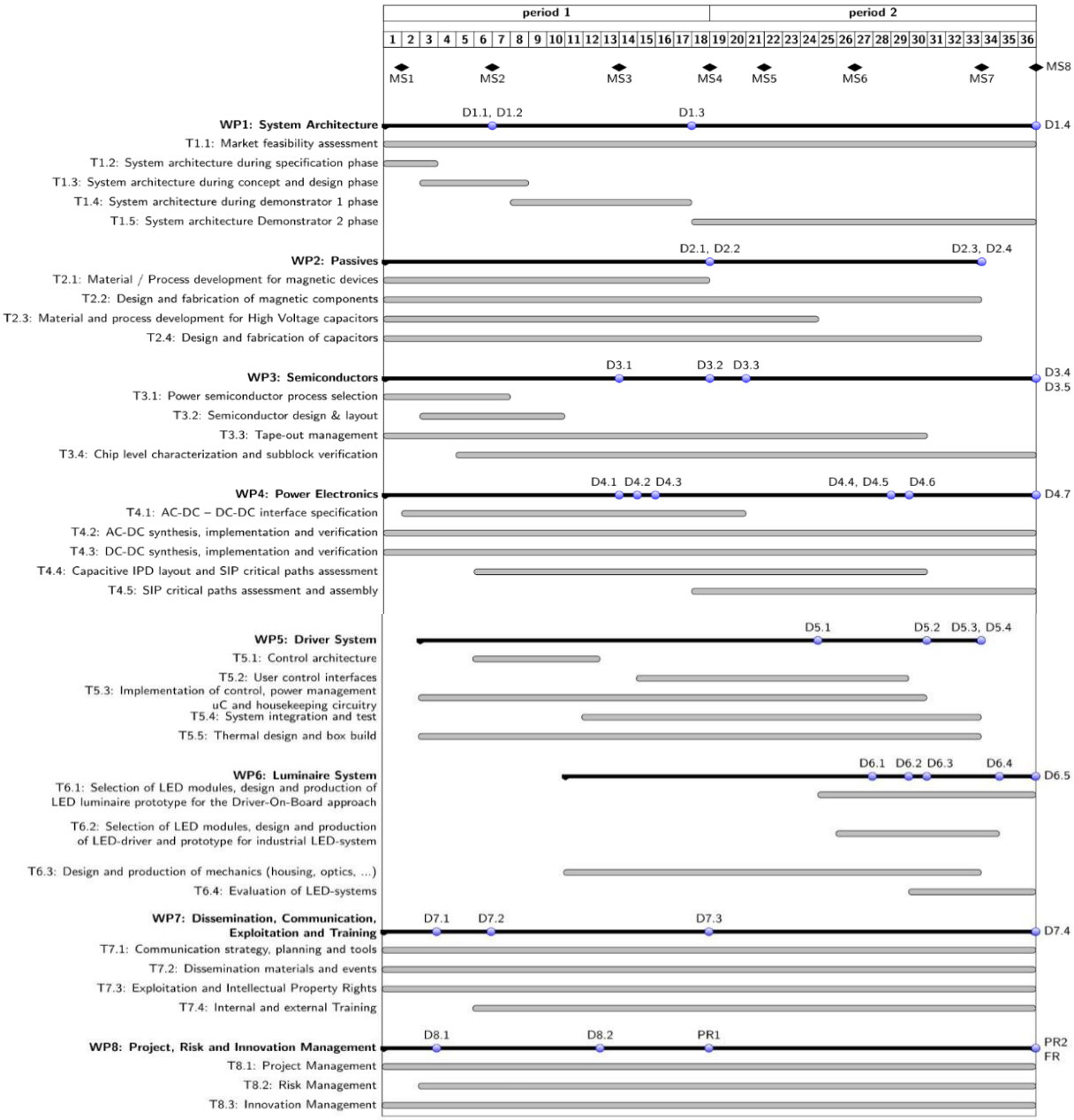

Figure 4: Timing of WPs and their components

5.1 Wireless charging unit

From the release of a prototype fulfilling all specifications, 3 months are expected for certification and testing. In parallel production ramp up will be prepared and delivery in volume will be ready. The development of a specific product will be initiated, when a partnership agreement has been signed with an appropriate business case behind. The lifetime above 5 years will probably be fine for a fast changing consumer product.

Warranties are set by law to 2 years in some countries. It is not expected that sold products will be updated. On the other hand, a very limited lifetime of each design must be expected before a new design must hit the shelves in the shops.

5.2 The smallest LED-driver

For the smallest LED-driver it is expected that it takes about 12 months to go from the prototype to the final product. After the evaluation of the first prototype which is built on the combined modules in a single LED-driver, the management can be convinced for a “Go”. This will be in approximately 24 months. Depending on the integration level a typical product lifetime would be between 2 and 4 years. The major updates and refinements assume several cost-down projects as well as extensions to the platform and design of additional power-ranges and output-windows.

5.3 High voltage capacitor technology

For the high voltage capacitor technology from partner IPDIA, it is expected that it takes about 18 months from now to go from the prototype to the final product and to get the green light from the management. Considering the product lifecycle on the addressable markets (other than luminaire), lifetime is likely to exceed a decade. We can project that DLC material suppliers / deposition equipment suppliers will develop their capability to improve deposition on higher porosity orders. As IPDIA is developing per platform, we can project that several technological nodes will benefits from LEDLUM development, adapting DC to more aggressive structure. Also power switches roadmap is developing (with voltage >1.2kV for gan and > 2kV for SiC), capacitive technology flavours adapted to those roadmap are likely to emerge.

5.4 Commercial light fittings

If LGR can engineer for manufacture, it could take three months to tool up and prototype on the line, at least one month to test, and a further three months to get to market with the commercial light fittings. This means it takes approx. 28 months from to get the “Go” from the management for the product. It is expected that the product lifetime will be about 10 years. It might be that during the products lifetime several updates and refinements will be performed.

5.5 Design services and intellectual property

TNIUCC expects that it will take about 12 months to go from the prototype of the design services and intellectual property to the final service. As from the current status the services will get the management’s green light by the end of the project. It is guessed that the service life time will be about 5 years. During the project lifetime 2 refinements are expected.

5.6 Research services

Once the project has shown that the results are working, we go to the market and upgrade our service offers with the new findings. We will be targeting our customers by the year 2019. The expected lifetime of our services derived from LEDLUM is approximately 3-4 years. After this we will have to see whether the novelty of the technology has been overhauled. Refinements and updates may be done with the end results of the project, by the end of 2019.

Chapter 6 Summary and Conclusion

The aim of this initial feasibility assessment was to perform a first study of the current market situation and to analyze the market opportunities for the new and refined products and services developed within the LEDLUM project. After a short analysis of the state of the art, the new product and service developments as well as the advancement of already existing products and services were analyzed and described. In a second step, their strengths, weaknesses, opportunities and threats were assessed in order to get a better understanding of each product's and service's potential. After that the current market situation was assessed and market studies helped to get an understanding of the market development and arising opportunities thereof. Each product's and service's market opportunities as well as their competition in the market were analyzed. A first description of their possible positioning and differentiation is also provided. Naturally, each advancement in a new market entails certain risks. Potential new risks as well as external influences and laws and regulations were taken into consideration.

Summing up, one can say that there are several new product and service developments that arise within the project work of LEDLUM. All partners will benefit from the project's results and will be able to either develop new products or services, or significantly improve their current product lines. As the LED-luminaire market is expected to grow over the next years, several interesting exploitation opportunities will emerge for the partners.

Chapter 7 List of Abbreviations

Abbreviation	Translation
AC	Alternating Current
DC	Direct Current
DoB	Driver-on-Board
GaN	Gallium Nitride
Hz	Hertz
IPR	Intellectual Property Rights
LED	Light Emitting Diodes
MHz	Megahertz
OEM	Original Equipment Manufacturer
PFC	Power Factor Correction
RTD	Research and technology development
SELV	Safety Extra Low Voltage
SIC	Silicon Carbide
SMPS	Switched Mode Power Supply
SSL	Solid State Lighting
V	Voltage
VHF	Very High Frequency