

Public Lighting, Lighting the Way to Smart City Development

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1. Introduction

Electric public lighting was introduced into the city landscape as early as 1878, **Figure 1** showing Yablochkov candles (early arc lamps) illuminating Avenue de l'Opéra in Paris. Since then public lighting has become an almost unnoticed service which is implemented in most municipal masterplans or town planning development strategies.

So why has this service become so important to the point that it is vital to a city to have it implemented?

Public lighting is one of the services that is most visually seen by the general public within a city (though it almost goes unnoticed). Lighting provides a sense of visual safety and security. This improved sense of safety and security will often lead to an increase and further promotion of community activities, events, sport, trade, industry and commerce to occur beyond normal daylight hours. It is a service that has the power to indirectly promote stimulus into potential economic growth and state of wellbeing within a municipality.

Although public lighting may assist in generating revenue indirectly for a municipality, it does add to the electrical consumption and operational costs of a municipality, for which a budget needs to be reserved, this should include a budget for maintenance and improvements on a city's system which may need to expand as the community's demands grow.

So how can a municipality maintain or improve this service to the general public while reducing overall energy consumption and operational expenditure?

How does public lighting become a source of revenue generation opportunities?

Would securing and improving the public lighting service delivery improve investment opportunities into a municipality?

With all these questions we could agree that public lighting should no longer be considered a singular service, but should rather be viewed as a multi-discipline service. That through small initiatives, the public lighting infrastructure could be used to transform a municipality into a more sustainable and efficient entity that may better serve the general public.



Figure 1: Yablochkov candles illuminating Avenue de l'Opéra in Paris under the Exposition Universelle (1878).

2. The Importance of Public Lighting

Public lighting is an important service to be implemented and maintained by a municipality. But what is public lighting?

Public lighting is any lighting installation or system that provides illumination at night, or during low light conditions (such as stormy weather), or in poorly lighted spaces (such as tunnels) in public places and places that the general public may have access to. These installations and systems form a connected infrastructure throughout a municipality. Thus, public lighting would comprise:

- The lighting of street and roads;
- Area lighting of developed areas such as residential areas, public transport nodes, trading facilities;
- Lighting of parks, zoos and recreational venues;
- Lighting of amenities such as a municipal owned stadium;
- Interior lighting of municipal buildings, municipal owned halls, libraries, clinics or theatre venues; and
- Similar lighting installations that are necessary for public places used by the general public.

Public lighting is a service required by the general public and communities within the municipality. Darkness can create a sense of isolation within communities and may result in business areas becoming deserted through the lack of patronage if these businesses are situated in dark unattractive or unsafe environments. The purpose and importance of public lighting is to illuminate public places to allow the general public to carry out tasks safely, observe and react and to create a safer night time environment for the community through visual security while making many public spaces more usable and enjoyable for by the general public. **Figure 2** below illustrates this importance in conjunction with the following question: Which alleyway is more inviting to walk down?

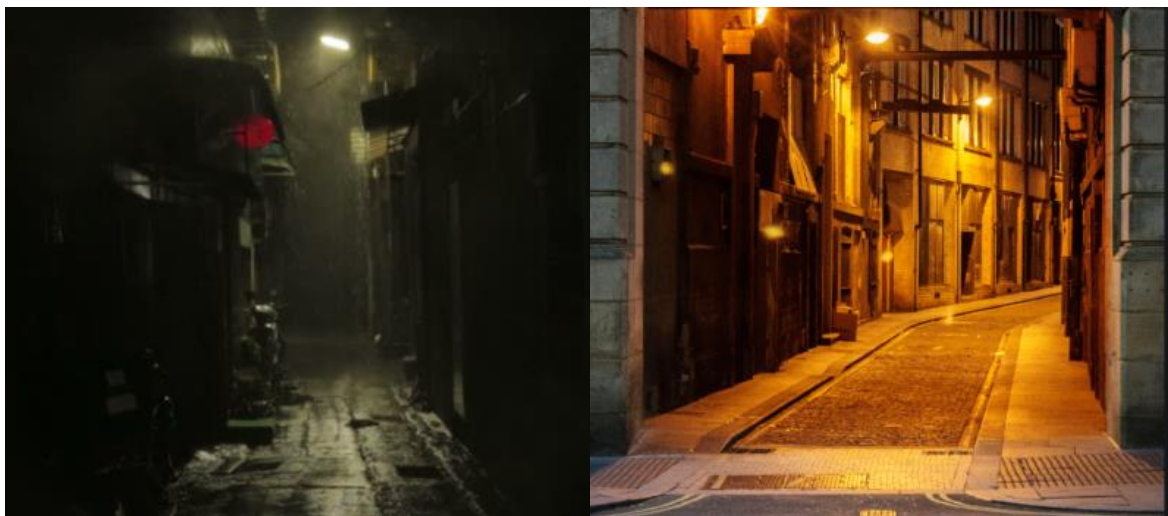


Figure 2 Which alleyway is more inviting to walk down

Was the answer based on facts or on emotion? Take note that the only fact provided is that one alleyway is well lighted and the other not. No facts pertaining to the location, crime statistics, governing law nor municipal operations capabilities for maintaining these lighting installations were provided.

Although public lighting aims to provide practical illumination of public spaces, it is important that these spaces are illuminated to illumination levels in compliance with standards such as

- SANS 10098: Public Lighting (road and street lighting)
- SANS 10389: Exterior Lighting;
- SANS 10114: Interior Lighting; and
- Occupational Health and Safety Act, 1993 Environmental Regulations for Workplaces, 1987,

The way in which these public spaces are illuminated by lighting systems and how these systems are managed, operated and maintained may impact on the visual perception and emotional wellbeing of the general public, rather than facts.

To reduce the risk of public lighting systems being perceived by the general public as poor indicators of service delivery, sustainable and accountable strategies in management, operational maintenance and installation projects of public lighting systems should be developed. These strategies should be implemented efficiently to provide safe and secure quality (good) lighting, not necessarily more lighting.

Through the responsible control of these public lighting system strategies, a municipality may have the benefit of persuading the emotional wellbeing of a community and possibly improving the status and visual perception of a municipality. This may further result in a municipality being more inviting to those looking to reside or invest within a municipality. **Figure 3**; further illustrates this by comparing the night time visual perception of two areas located within Cape Town.



Figure 3: Night time visual perception of areas within Cape Town, top: Zonnebloem area, bottom: Cape Town Waterfront

3. Public Lighting Trends

As municipalities have developed and expanded, so has the demand for service delivery and the need for the associated infrastructure for these services. With public lighting being a visual service provided by a municipality, as a municipality develops the public lighting infrastructure should expand proportionally with the demands and needs of growing communities.

Two concerns that could be associated with ever-expanding service infrastructure, they are:

- How can the service infrastructure be sustainably maintained?
- How can the service infrastructure meet the demands and needs of growing communities?

There are two trends developing in public lighting that may attend to these two concerns. These two trends are identified as:

- The implementation of energy efficient LED (Light Emitting Diode) luminaires; and
- Improving the quality of lighting installations.

Both of these trends promote a favourable service infrastructure and could advance the infrastructure to a status acceptable for IoT (Internet of Things) system implementation and integration. These advancements coupled with IoT systems could be used to further promote revenue generation and may assist in improving the delivery of other services to the general public.

Through the implementation of an energy efficiency initiative, energy efficiency could enhance the competitiveness of economies while helping to alleviate energy poverty as energy becomes more available within a municipality. Energy productivity gains may lower the cost for the economy as a whole, enhance the energy supply security and may reduce the need to develop new sources of energy supply to serve those without access to modern energy services for health and education enhancement. Accelerated energy efficiency could also create attractive green jobs and businesses within a municipality.

By improving the energy efficiency of the public lighting infrastructure, the initiative provides a cost-effective, least-polluting and readily-available energy resource available to a municipality to possibly re-invest into revenue generating opportunities. This initiative also assists in climate change mitigation. The South African Department of Minerals and Energy (DME) promotes energy efficiency initiatives. As an example, the DME requested municipalities to submit proposals for funding consideration for the 2017/18 Energy Efficiency and Demand Side Management (EEDSM) programme, which included the planning and implementation of energy efficient street light luminaires and new LED luminaires on high masts.

The basis of the energy efficiency initiative is to replace existing non-efficient luminaires with modern energy efficient LED luminaires and additionally implement energy efficient luminaires into new public lighting systems. Quality energy efficient LED luminaires have longer operational life than existing non-efficient luminaires, thus the implementation of these LED luminaires would result in a longer lasting, consistent and affordable public lighting infrastructure with reduced maintenance and operational expenditure (excluding the impact of theft and vandalism to these systems). It is estimated that South African municipalities could save at least 40% of the total expenditure per annum allocated to the existing non-efficient public lighting infrastructure by replacing the existing non-efficient luminaires with energy efficient quality LED luminaires.

However, the concern with the energy efficiency trend is that the focus is on energy saving and not energy saving while maintaining quality and compliance to luminaire and lighting level standards. This may result in poor lighting installations. Thus, then lends itself to the second trend.

The second trend, improving the quality of lighting installations, pertains to the improvement of the quality of illumination, thereby improving the visual ability and perception of the general public. The trend considers the illumination demands and needs on public lighting systems of growing communities and aims at fulfilling these by creating a safer night time environment for the communities and improving the “look and feel” of a city, town and municipality.

Improving the quality of public lighting installations and infrastructure, could:

- Promote the better use of open spaces by supporting positive evening use of open spaces;
- Promote walking, cycling, public transport and safer driving through quality lighting providing higher visibility;
- Promote the use of open spaces by partially sighted persons and improve the visual facility to persons with universal access desires;
- Reduce greenhouse emissions through the use of fewer or more energy efficient luminaires;
- Promote urbanisation and aesthetic appeal by showcasing urban features;
- Improve safety and security through quality lighting improving visual ability of surveillance and monitoring systems; and

- Promote economically sustainable lighting assets that are easy to install, have low maintenance requirements and are cost effective over the life of the asset.

By adopting and further developing these public lighting trends through the implementation of sustainable initiatives, a municipality should be able to overcome the associated risks and demands of an ever-expanding public lighting service infrastructure.

Should the sustainable initiatives be implemented, IoT systems could be implemented and integrated into the public lighting infrastructure. This integration would further promote the sustainability of the infrastructure while promoting an ability of delivering additional services, other than lighting, to communities within a municipality.

4. Sustainability of Public Lighting

Is it possible to maintain the quality of public lighting while reducing energy consumption and overall operational expenditure, while generating possible revenue opportunities? Various methods and strategies could be implemented to obtain this. These range from manual methods of testing to automated systems and control, security of assets, financially feasible and efficient energy and maintenance schedules, community involvement, personnel training and more.

One of the first steps to take, when commencing the journey to sustainability, is to identify, understand and mitigate the risks that may undermine and challenge the existing and future delivery of the public lighting service. These risks may predispose the public lighting systems and municipalities to a reduced or impaired service delivery. More importantly these risks reduce the safety of the general public in public spaces where these undermined public lighting installations are present.

Without firstly identifying the risks and understanding the causes of the risks impacting public lighting systems, it is not possible to implement effective strategies to mitigate the causes of these risks, to a sustainable level where the risks could be overcome and thereby promote a more secure and sustainable basis from which to improve the quality and efficiency of the public lighting service.

There is possible financial gain if some resources could be utilised to fully understand why the public lighting installations are being affected. Knowing these causes may reduce the costly exercise of continuously repairing and replacing these affected installations, or developing and implementing more resistant and secure lighting installations that may become more difficult and costly to maintain.

Elements of theft and vandalism, behaviour of communities and the ability of municipalities to operate and maintain public lighting infrastructure are some identifiable risks.

It is not possible to eliminate acts of theft and vandalism that may render the state's assets inoperable, but maintainable initiatives could be implemented to reduce the causes of this risk. Acts of theft and vandalism on the infrastructure could be attributes of poverty, criminal activities that require darkness or require the material to operate, community unrest, a game played by children or even an activity undertaken by some adolescents.

Communities are ever evolving as are the service delivery demands of these communities. Various risks influence a community and some of these risks may result in the public lighting service being affected by a community. Unrest within a community, elements of corruption, unemployment, socioeconomic status, education, access to services, crime and sense of being empowered are some factors influencing communities. It may be beneficial to a municipality to install a certain type lighting installation but it may not be beneficial to the wellbeing of the community in which it is installed.

The public lighting infrastructure is only as good as a municipality's ability to manage, operate and maintain it, thus influencing its service to the public. Some risks that may affect a municipality may include limited financial budget allocation; inability to pay for energy, material purchases and other expenditure; having limited or inoperable tools, equipment and plant to carry out the works; not having adequately trained and skilled personnel; shuffling of management due to the changeover of leadership which may result in the changing of directives; accuracy of inventory of the assets installed; various

types of material stocked for maintenance and repair purposes; poor quality assets installed and possibly including the way in which the management, implementation and operational processes are carried out on a day to day basis.

Some may think why would it be necessary to change when a specific task has been done this way for years? Yes, this way of thinking may work for some tasks. However, if the public lighting infrastructure is to evolve with changing technology and changing community demands the same method cannot be used and there is no one-size-fits all solution. Furthermore, if the public lighting infrastructure is to merge with IoT systems and be used to assist in growing and advancing a municipality, new strategies and plans should be developed and implemented.

Continuing the journey to the sustainability of the public lighting infrastructure, a municipality may consider developing a set of sustainable public lighting guidelines. Although similar guidelines may exist within some municipalities, where some municipalities have adopted the recommended practice guidelines of ARP 035, it remains crucial that these guidelines should evolve and support a sustainable, intensifying and progressing public lighting infrastructure. These guidelines should also consider the various demands of communities, which vary from municipality to municipality.

When developing or revising a set of sustainable public lighting guidelines, these guidelines should consider including the following significant measures.

1. The overall aim of the guidelines should be to ensure that new and existing lighting is energy efficient, well designed, well located and that it complies with the South African Standards applicable to lighting.
2. Identify, understand and mitigate the risks affecting public lighting infrastructure. It is important that these strategies include constant revision and review so as to keep abreast of the changing risks.
3. Know who the lighting is for. Communication is a vital tool to maintain, particularly with communities. Build and maintain community relationships. Informing, involving and educating a community may assist in improving the security of a lighting system as will implementing efficient, reliable and responsive call centres.
4. A municipality should maintain its commitment to sustainability. Ensuring commitment would promote service delivery, security of the service and maximise potential financial savings. Commitment may also assist in promoting community wellbeing.
5. Develop or revise auditable management, implementation and operational processes. The aim is to ensure the efficiency and quality of these processes are upheld and prevent a backlog in service delivery that may impact on a municipality's commitment to sustainability.
6. Ensure that the people appointed for the task are properly qualified and develop continual upliftment programmes to improve the knowledge and skills of personnel through higher education and training. Coupling upliftment programmes with resource planning and allocation would assist in providing a sustainable workforce for a sustainable infrastructure.
7. Develop and define public lighting minimum efficiency and quality performance standards and standard design requirements. It is important that luminaires and other assets are tested by a municipality to verify compliance to these standards.
8. Define the recommended lighting categories for open space lighting, referencing the applicable South African lighting standards. No one municipality is the same, thus identify the categories for open space lighting applicable to a municipality.
9. The guidelines should assist in informing and guiding and municipality's decision making for public lighting installations. This may involve decisions of where and when public lighting is required, and if so, what sort of lighting should be installed to best serve the public space.

10. The guidelines should assist municipal staff, lighting design consultants and others to consistently apply sustainable lighting principles to new public lighting installation implementation, replacement, maintenance and repair initiatives to existing lighting installations.
11. Develop a design process for the lighting of public spaces. This guideline should assist municipal staff to develop bids and to easily evaluate designs and installations for compliance.
12. Investigate the open spaces within a municipality that are accessible to the general public during the day. Consider promoting the use of spaces in the evening if beneficial to the community and economy.
13. Assist in improving safety through illumination and proactive surveillance and monitoring to create a safer night time environment for the community.
14. Use public lighting to promote walking, cycling, and public transport facilities. The quality of public lighting may promote the use of these facilities by partially sighted persons and persons with universal access desires. It may improve the visibility and safety of pedestrians and safer driving for motorists.
15. Select assets and implement lighting installations that consider reducing greenhouse emissions and promote the environmental consciousness of recyclable waste, light pollution and sensitivity to biodiversity.
16. Promote the acquisition and installation of economically sustainable quality assets, ensuring that the assets can be managed sustainably over their lifetime. These assets should promote an efficient circular economy.
17. Identify, investigate and select urban features for aesthetic beautification or show casing in an efficient and sustainable way. This form of public lighting aims at improving the look and feel of a city or municipality with the potential of improving community wellbeing and promoting investors, tourists and new inhabitants.
18. Identify the methods or systems by which the public lighting infrastructure is to be controlled and monitored through manual and autonomous telemanagement systems. These methods and systems should assist in risk mitigation, efficient maintenance scheduling and in tracking and auditing the efficiency of assets and operations.
19. Undertake testing of lighting installations and the measurement of illumination levels to ensure that these installations continue to fulfil a municipality's commitment to sustainability, efficiency and compliance to lighting standards. It is important to verify that the public lighting installations continue to promote the use of a public space.
20. Develop efficient cleaning, maintenance, repair and replacement operation schedules that evolve with the aging and operational conditions of the assets. These schedules should be developed, managed and fulfilled to promote sustainability and feasible expenditure.

Lastly, the rate at which sustainability of the public lighting infrastructure can be achieved is inversely proportional to predisposing risks while being proportional to the amount of quality resources available. This is similarly applicable to the growth and evolution of the public lighting infrastructure.

5. Concluding with a Look to the Future

The efficiency and quality of a municipality's sustainable public lighting service could be seen as the municipality's advancement further into the 4th industrial revolution era.

By implementing even small initiatives, a more sustainable public lighting infrastructure may be obtained. As sections of the public lighting infrastructure become efficiently and reliably sustainable, there exists the potential of merging IoT systems with the infrastructure. The integration of various

services into the public lighting service would transform this sustainable singular service into a sustainable and multi-discipline service that may enable a municipality to advance into a more sustainable and efficient entity that may better serve the general public.

By integrating various services into a sustainable and adaptable public lighting infrastructure, public places and road reserves no longer need to become additionally congested with new surface and underground infrastructure. This would avoid additional obstacles that may otherwise reduce public safety and a municipality's ability to efficiently sustain and gain access to other services.

Consider the possibilities that a sustainable and adaptable public lighting infrastructure could provide by supporting services such as:

- Municipal wide surveillance systems used by local enforcement and emergency services;
- Micro-communication towers that could be leased out by the municipality to communication service providers;
- Wi-Fi hot-spots that may connect communities, businesses and individuals.
- These same Wi-Fi hot-spots could be used to retrieve real-time power and water demand from wireless metering devices or be used to assist in automated monitoring and control of these and other bulk services;
- Intelligent traffic systems that assist in reducing congestion, as well as, monitoring pedestrian and motorist behaviour and volumes, which could be used in future town planning and developments;
- Climatology sensing instruments may assist in accurate weather indication;
- Waste sensing instruments which may assist in efficient waste identification and removal;
- Air pollution sensing instruments which may assist in informing individuals or investors which municipality has a higher quality of air. These same sensors could be used to impose greenhouse emission or air pollutant penalties on identifiable industries.
- Electronic advertising and news boards that may improve revenue generation for a municipality, as well as, the local economy;
- Electronic vehicle charging stations that promote the use of hybrid and electric vehicles, as well as, being a further source of revenue generation for a municipality;
- Available public parking indication could be implemented to assist motorists in safely identifying parking bays;
- Universal access assistance systems that further enable persons to navigate safely to a destination; and
- Various other services that are able to be integrated and sustained on the public lighting infrastructure.

The importance and potential of the public lighting infrastructure should not be underestimated. The public lighting infrastructure should be considered a financial investment, the earlier one begins to invest, the greater the return on investment. The return on investment could be secured through the implementation of responsible initiatives and strategies that promote a sustainable and efficient quality public lighting infrastructure. These initiatives and strategies should be developed from a well-structured and evolving set of sustainable public lighting guidelines.

Through responsible sustainability and adherence to these guidelines, an adaptable public lighting infrastructure may evolve to support other services and sources of revenue generation for a municipality.

By bringing sustainable light into darkness, communities may no longer have a sense of isolation. This sustainable light may promote the upliftment of the emotional wellbeing of a community and may improve the status and visual perception of an advancing municipality. Where municipalities can be seen to be developing and advancing, these municipalities are seen to be more inviting to those looking to reside or invest within a municipality.

Thus, sustainable and efficient quality public lighting could ignite the possibilities of developing and advancing municipalities, communities, industry, businesses, families and individuals to an improved state of wellbeing or Smart City status worthy of the 4th industrial revolution era.

6. References

Images contained within this paper were extracted from the referenced websites:

Figure_1: https://www.researchgate.net/figure/The-sensational-lighting-of-Avenue-de-lOpera-in-Paris-by-means-of-Yablochkov-candles_fig7_308672793

Figure_2: <https://www.shutterstock.com/video/clip-12036653-establishing-shot-dark-alleyway-chinese-lantern-blowing>

Figure_2: https://www.trekearth.com/gallery/Europe/United_Kingdom/England/Merseyside/Liverpool/photo1477502.htm

Figure_3: <https://www.flickr.com/photos/nixiepixiez/328186001>

Figure_3: <https://blog.junkmail.co.za/wp-content/uploads/2014/10/cape-town-night.jpg>

The following resources were researched for the paper:

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SANS 10389-1, -2 & -3: Exterior Lighting

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