# Li-Fi: The New Production of Greener, Faster, and Better Energy for the Future of Africa

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**Abstract:** Li-Fi, also known as light fidelity, is the new and innovative internet that uses the speed of light. It allows us to connect to the internet using LED lights from lamps, streetlights, or television. It has become, without question, one of the most widespread technologies. The various use of Li-Fi technologies can be used to change human lives, it can also be used in numerous applications ranging from agriculture to small industries. Li-Fi cannot be easily intercepted by other radio frequencies, which can improve the generation of power within the system, those radio frequencies' energy can be harvested by products that contain Powercast. This energy can be utilized in Light-Fidelity (Li-Fi) devices while simultaneously charging their internal batteries or other connected electronic devices. This phenomenon can help solve many power problems and help humans by improving access to communications, education, and digital services for people globally. The development of Li-Fi helps minimize radio waves and electromagnetic pollution, which affects human and animal life. It acts as a green technology, to help address environmental challenges while delivering faster connectivity than the traditional wireless technology. In this article, the benefits of this new green technology will be discussed, the challenges that will come with this phenomenon, and the future map for the coming generations.

**Keywords: Li-Fi, renewable energy, energy projects, green technology**

## Introduction:

Light fidelity is based on Visible Light Communication (VLC) which uses light-emitting diodes (LEDs) to connect wireless systems [1]. It was first introduced by Prof. Harald Haas in July 2011 at TED Global Talk. Li-Fi allows electronic devices to connect to the internet wirelessly and to develop communication between nodes; it will require a transceiver to transmit the data and a receiver to receive the data within the communication line[2] .

The transceiver will then need a modulation technique that will enable the LED to transmit data by use of light, which is beneficial in the shortage of the current technology. The most commonly known current technology; Wireless fidelity (Wi-Fi), is used to connect devices to the internet through radio frequencies and transmits data at a speed of 150 megabits per second [3]. According to standards of 1EEE 802.11n, this is not sufficient enough to fulfill the user of the network, thus Li-Fi is much more advantageous, which can transmit data at a speed of 10 megabits per second and cannot be detected by the naked eye.

Li-Fi has a new category of light source having a high intensity which leads to clean and brightening solutions especially when it comes to lighting, with highly efficient energy, longer validity, and works better when it comes to conventional approaches [4]. According to Haas, the way the LED works in transmitting the data, in digital terms, when the LED is switched on; is 1, data will be transmitted and when the LED is switched off; which is 0, data will not be transmitted. It gives opportunities to transmit data. The intensity of the LED should also be considered, as it is modulated rapidly, which can be detected by the naked eye and the output appears constant.

Internet penetration in Africa has been the cause of two main issues, lack of infrastructure and cost. In other areas, lack of electricity and communication has been a common issue in the ongoing growth of


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data consumption in this new generation within those areas[5] . This growth has resulted in communication networks and 3G & 4G Wi-Fi becoming much more saturated, which leads to telecom operators requiring powerful transmitters with an increase in the electromagnetic radio waves, which is very harmful and damaging to the health of citizens and highly costly.

**Li-Fi versus Wi-Fi:**

Many electronic devices are connected to the internet through Wi-Fi, being connected to Wi-Fi comes with a couple of drawbacks and to reduce the drawbacks is the latest technology, Li-Fi. A minimum of four devices can be connected to the one-watt LED bulb by the use of light as a carrier, instead of the traditional radio frequencies, as used in Wi-Fi [6]. Li-Fi, with embedded microchips, produces data rates as fast as 150 megabits per second, which is much faster than an average broadband connection [6]. The term Li-Fi was invented by Prof. Haas and refers to the type of visible light communication solution, which is similar to Wi-Fi but uses visible light instead of Wi-Fi. In simpler terms, it is Wi-Fi but using light instead of radio waves.

Li-Fi provides a high-speed, dense, and reliable wireless network. It also provides a method of creating a secured mesh network of connections using streetlights in urban and rural areas[7]. This network of streetlights can work independently from telecom operators by sending and transmitting VOIP and SMS to other digital data that is being emitted from the streetlight [6]. Each unit of the lighting is a node of communication. Li-Fi is also considered to be one of the technologies that has low energy consumption in its cooperation with the LED lighting technologies which help save much more energy and longer lifespan than other lighting technologies. Not only does Li-Fi provide benefits in a broad free spectrum, but it takes a small concept to new levels considering the light spectrum, which is reusable compared to other current mobile radios.


Figure 1: The difference between LI-FI and WI-FI [8].

## 1. Operation Principle of Li-Fi:

LED (light emitting diode) is key in the operation of LI-FI and is used as a visible light transmitter. This has two functions: a high-speed wireless network and acts as a lighting system, unlike Wi-Fi which relies on radio waves. The LED light works at a rapid pace which is faster than the blink of a human eye, since the operating speed is less than a microsecond [9], therefore causing the light source to appear continuously. This enables binary transmission using binary codes. In simple binary terms, if the light is on '1' and if the light is off '0'. The process of modulation is so rapid that humans cannot notice. A light-sensitive device known as a photodetector, receives the signal and converts it back to the original data.

This method of rapid pulse of light to transmit information wirelessly is known as the Visible Light Communication (VLC). This term was introduced to be a potential competition for Wi-Fi. The VLC utilizes visible light ranging from 400THz to 800THz which is equivalent to 375nm to 780nm as an optical barrier for data transmission and illumination [9]. Parallel data transmission using arrays of LEDs at which each LED can transmit data separately and can increase the VLC rate. The light can be dimmed to the point where it is not visible to the human eye, but the transmission of data will be capable of happening [10].

### 1.1 Technical aspects:

*1.1.1 ON/OFF KEYING (OOK):*
The modulation is when the LED switches on which represents in binary term '1' and '0'when it is switched off.

*1.1.2 Pulse-Width Modulation (PWM):*
In the duration of the LED being switched off and on, data can be transmitted and is varied in encoded data but is much more complex than implantation.

*1.1.3 Colour Shift Keying (CSK):*
This involves the varying of the colour of the light emitting by RGB (red, green and blue) LEDs encoded data with each colour representing encoded data to different data rates. It can enhance data rates and use of the visible light spectrum.

*1.1.4 Orthogonal Frequency Division Multiplexing (OFDM):*
This technique divides the light signal into many sub-signals that are transmitted simultaneously at different frequencies and improves interference.

## 1.2 LED as a light source:

Light-emitting diode plays a huge role in the Li-Fi system and can act as a light source. They are highly energy-efficiency, converting important amounts of electrical energy into light with minimal amount of heat and has a long span, which can exceed to 100,000 hours[9] .

LEDs can emit light when the energy levels change in the semiconductor diode. The change in energy generates photons which are emitted as light The wavelength of the emitted light can be varied by the different energy levels and the semiconductor being used to form the LED chip, this allows LED to withstand vibrations, shocks, and extreme environments[11] .

The basic LED consists of semiconductor chip mounted in a reflector cup of lead frame that is connected to electrical wires and surrounded in a solid epoxy lens. Different data rates can be achieved by different LEDs size. A micro-chip sized LED can transmit 3.5 gigabits per second and data rates more than 10 gigabits per second [9].

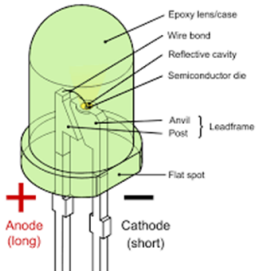

Figure 2: A diagram of a LED[12].

## 2. Components and models:

When building a Li-Fi system, there are many components and mode to ensure efficiency for data transmission by the use of visible light such as:

### 2.1 Transmitter Model:

It refers to the models that, in simple telecommunication terms, transmit signals and/or process the information. LED driver model which controls the LED used to transmit that data and Modulation techniques.

*2.1.1 Channel Model:*
Channel models such as the Optical channel and noise which simulates light through its medium, commonly known as the air and factors including refraction, reflection and absorption. It also accounts for the various sources of noise such as thermal noise and light interference.

*2.1.2 Receiver Model:*
This includes photodetector, amplifier and demodulation scheme models which describe characteristics of the photodiodes that receive the data. Boost the signal received back to its original level and convert the light signal back to the electrical data.

*2.1.3 System Integration Model:*
Access control, interference management and handover models are examples, which manages to accept multiple users and devices access to the Li- Fi network, handles interference and allows seamless transmission between different Li-Fi access points.

*2.1.4 Performance Evaluation Model:*
At which it evaluates the accuracy of the data transmission of Li-Fi, measures the data and the delay with the data transmission in Bit error rate (BER), throughput and latency models.

Additional models such as the environmental models which stimulates the impact of the different weather conditions which can have an impact on Li-Fi network and security models which ensures that the transmission of data by the LI-FI network for unauthorized access[11]. Each model plays a crucial part in the efficiency of Li-Fi.

## 3 Implementation of Li-F in Africa:

### 3.1 Infrastructure Assessment and Planning:

*3.1.1 Identifying suitable areas:*
First, determine the areas where Li-Fi will be more suitable such as schools, hospitals, offices, public transport and home and consider areas where Wi-Fi is unreliable and limited.

*3.1.2 Assess the existing infrastructures:*
By identifying areas where new LED lighting systems are required and evaluate existing infrastructures which are compatible with Li-Fi technology.

*3.1.3 Plan out the network layout:*
Building and forming out a network helps determine the number of LEDs and placement to ensure the data transmission and illumination.

### 3.2 Hardware Installation:

*3.2.1 Install LED fixtures:*
Replace the existing lights with LED light for adequate lighting and data coverage.

*3.2.2 Setting up Transceivers:*
By installing transceivers, it can help modulate the light to transmit data and receivers to maximize its data transmission rates.

### 3.3 Network Configuration:

*3.3.1 Configuration Modulation Techniques:*
The implementation of proper modulation techniques such as OOK and PSK are vital.

### 3.4 Software Setup:

*3.4.1 Install Network Management Software:*

The usage of software and monitors helps manage the Li-Fi network ensures that it provides proper functionalities such as bandwidth allocation, network security and performance.

**3.5 Testing and optimization:**

*3.5.1 Conduct Initial Testing:*

Test the Li-Fi system for the data transmission rates, coverage and reliability.

*3.5.2 Optimization performance:*

Adjusting the placement of the LED fixtures and transceivers for optimal coverage and performance. Relating back to the modulation techniques will help.

**3.6 Training and support:**

*3.6.1 Train technicians and users:*

There will be training required for the technicians when installing, configurating and maintaining this system and educating users on how to connect and use this system. It will also be beneficial to provide support for technicians through the process.

**3.7 Regulatory Compliance and Security:**

*3.7.1 Ensure Compliance:*

Stick to the regulations and standards relating to light wireless communication and obtain certifications for the Li-Fi equipment used in the system.

*3.7.2 Implement Security Measures:*

There should be regular updates to address security vulnerabilities.

By following these steps, Li-Fi can be a high- speed, energy-efficient and secure system across various areas.

## 4 Li-Fi and its benefits to Africa:

Light fidelity has multiple benefits to Africa, as a continent, by addressing the challenges that are faced and leveraging on the strengths that the continent has. These are key benefits Li-Fi would have on Africa:

***4.1 Infrastructure Development:***

Infrastructure is straight linked to economic development and growth, which refer to the structure, facilities, and systems that have a contribution to the function of the country. It is known that there are countries within Africa that have poor levels of infrastructure and lack RF communication infrastructure, whereas installing Li-Fi lighting infrastructure (streetlights and indoor lighting) can help reduce the costs of infrastructure installation. Setting up the Li-Fi system is much quicker than installing traditional RF connection networks, which expands faster internet access.

***4.2 Energy Efficiency:***

Energy efficiency is the use of less energy to perform the system of Li-Fi. The utilization of LED lights is more energy-efficient than other traditional light sources and communication technologies, which is beneficial in other areas with limited and expensive electricity. It also provides sustainability and cost- effectiveness [13].

***4.3 Economic Growth:***

Li-Fi helps support education and healthcare, by providing internet access to schools, and healthcare facilities, by amplifying educational resources and telemedicine in remote areas. It

can help boost businesses, by connecting businesses such as small and local businesses to global markets and resources.

***4.4 Environmental Benefits:***

Li-Fi, also known as the 'green technology' helps promote sustainability because it is more recyclable, utilizes eco-friendly materials, and reduces electronic waste. It also helps minimize electromagnetic pollution, which decreases the damage to human cells and DNA, it also demolishes the ecosystem such as plant and animal life.

***4.5 Security and Reliability:***

Light fidelity offers a much more improved data security, which helps protect the citizens or users' data from being stolen or lost and since light cannot be easily penetrated, reducing the risk of unauthorized access from the outside, or where light is present. It reduces the inference in the RF communication channels in rural areas[14].

***4.6 Innovative Applications:***

Li-Fi can help promote an innovative system within smart cities, by providing efficient lighting and communication infrastructure that supports traffic management, environmental monitoring, and public safety. It can also help in monitoring and managing agricultural processes through IoT devices such as sensors and actuators, which help promote productivity and sustainability.

***4.7 Bridging the Digital Device:***

In most rural areas, traditional internet services are used. By leveraging the existing infrastructure such as solar-powered streetlights can help extend internet access in those regions and provide cost-effective solutions.

In addition to addressing economic and infrastructural challenges, Li-Fi can play a pivotal role in developing and improving the quality of living in Africa.

## 3. Challenges and solutions of Li-Fi:

The implementation of the Li-Fi system poses possible challenges due to the continent's socio-economic and infrastructure. Many regions in Africa have insufficient power storage and limited infrastructure, which can be a disadvantage in supplying power for LED operations. By using solar panels which supply sufficient power in rural and off-grid areas, implementing hybrid systems which help combine the grid electricity with batteries to ensure uninterrupted power supply and collaborating with the government and/or international companies to help improve the infrastructure.

The initial cost of the Li-Fi infrastructure can be high and is not beneficial to the economy, but projects such as Piolet projects help build a case for further investments by seeking international companies that would love to be involved in technological and innovative projects. There is also a lack of expertise in the installation of the network, providing and developing programs to educate technicians on the system, and partnering with other institutions such as universities, technical universities, and colleges, to help provide support training.

There will be a lack of awareness and understanding of the Li-Fi technology amongst the population and potential stakeholders. Launching awareness programs to educate the communities about the benefits of the uses of the technology and demonstrate in public spaces, schools, and government buildings to showcase this technology. It is vital to build trust when promoting this technology to make the citizens feel comfortable with this new technology and be accepting of it. In many rural areas, there is only limited access to the robust internet, which provides high-speed internet services.

The usage of satellite internet as a backup provides connectivity in remote areas where terrestrial infrastructure is lacking. Develop local data centers that decrease the reliance on distant internet data

and work with the government to improve and expand fiber optic networks and other high-capacity internet infrastructure.

There are challenges that should be considered when implementing Li-Fi in Africa and each challenge can be addressed with innovative solutions. By leveraging renewable energy, fostering partnerships, building local expertise, raising awareness and promoting trust to the population, Li-Fi can provide viable and transformative solutions which can improve internet connectivity.

## Conclusion:

Li-Fi (Light Fidelity) is a transformative technology with the potential to significantly benefit Africa by addressing infrastructural, economic, and environmental challenges. By leveraging and functionality of LED lighting can be used for illumination and data transmission purposes, which is a cost-effective and energy-efficient solution for expanding internet access in remote areas with limited existing infrastructure. This technology's deployment capabilities with its low consumption of energy and reduced electromagnetic pollution, make it a suitable candidate for development across the continent.

The capabilities of Li-Fi can help enhance educational resources, the delivery of healthcare, and business connectivity, which can drive economic growth and improve the quality of life, in many African communities. It provides secure and reliable data transmission, noninterference RF, provides an alternative to traditional communication networks, and ensures data protection. Furthermore, innovative applications in smart cities, environmental monitoring, and agricultural management underscores Li-Fi's versatility and potential innovation.

By bridging the gap between the digital divide and extending internet access in rural areas, Li-Fi can play a pivotal role in Africa's development. Not only will it address immediate needs, but it will also lay a foundation for a more connected, efficient, and sustainable future. As Africa continues to embrace technological advancements, Li-Fi stands out as a promising solution that aligns with the continent's goal for economic growth, quality of life, and environmental sustainability.

In conclusion, Li-Fi technology holds great promise for the future of wireless communication. With ongoing research and development, the challenges currently facing Li-Fi can be addressed, paving the way for its widespread adoption. As the world moves towards more connected and smart environments, Li-Fi will play a crucial role in shaping the next generation of communication systems, offering fast, secure, and reliable data transmission.

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