Technological LED Lighting Adoption

A System Dynamics Approach

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Abstract— The purpose of this research is to analyze with dynamic LED lighting systems in Colombia focused on household consumption in urban areas, adoption of LED lighting and impact on energy expenditure. This paper aims to show the advantage of introducing new renewable technologies in the market given its benefits in different areas such as innovation, intelligent savings, sustainability, energy efficiency, among others. The model is intended to give a clear government idea and different entities of what is necessary to achieve that in 2030 we have a 100% usage of this technology with incentives to education, price subsidies and energy companies from the country.

Keywords— lighting, sustainable development goals, fluorescent, LED, environmental, public policies, production, new technology, electricity, saving

I. INTRODUCTION

Science, technology and innovation has entered all areas and social levels and is critical to the global economy, with rapid development and with big influence in human life, nowadays the new technology has become one of the key products of consumption of modernity. Colombia is participating active all of this changes because of the particular and special politic moment that is embroiling, as developing country part of Latin America and the special moment focus on citizens, environment sustainability and post conflict.

The adoption of new technology has facilitated the development of society and have given us tools to deal with problems that the humanity must solve and care. In this revolution of improvement most of the industries have been involve and lighting industry had have many changes aligned with increased energy efficiency requirements in special this technology had evolve for half a century, with participation by tens of thousands of researchers in universities, national laboratories, and firms. (greenpeace, 2015). The year of 1994 was very important for the industry because of the adoption of commercial use of LED (Light-emitting diode) which is an electric component that emits light when connected to direct current. It works on electroluminescent principle and can emit light in visible specter as well as in infrared and ultraviolet and the impact that this change brought to the country in different sectors as government, industry and environment.

This research aim to help to understand technological LED lighting adoption in Colombia with a System Dynamics approach, helping decisions makers at different levels. (Producción & Desecho, 2012) In 2015, world leaders adopted 17 Sustainable Development Goals (SDGs) at an historic UN Summit. Colombia as part of it has the compromise mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that one of the goals is behind; "The SDGs build on the success of the Millennium Development Goals (MDGs) and aim to go further to end all forms of poverty. The new Goals are unique in that they call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection". (Office, 2016). When it comes to lighting, it affects three of seventeen SDGs: Energy for sustainable development, sustainable and resilient cities and Improving the efficiency and sustainability in the use of resources (sustainable patterns of production and consumption). In addition, one of the most important goal is that in 2030 the countries have to ensure the use of efficient lighting systems — LED of 100% in residential and commercial projects. The other hand this goal has a straight impact in the use of CFL (compact fluorescent lamp) be 0% in residential and commercial constructions.

History and importance of LED lighting technology

A LED is an electronic component of two terminals that allows the flow of electric current through it in one way, without the intervention of elements such as gas, as in traditional bulbs. Holonyak developed the LED emitting a red light of low intensity. Today, however, there are devices that emit the same technology and high brightness light of any color. Initially, the LED bulbs industry invaded the Christmas decorations. Families are using more this technology because

they have knowledge about smart saving or by imitation however, with the development of the LED in various colors, they are now the source of all spaces. This is a revolutionary development, because it has allowed generating light at a lower cost and longer than traditional lighting of infrared radiation. European Union is one of our examples because has proposed selling only LED lighting by 2016 (Energy & Voltage, 2010)

LED provides a high luminous and high efficient for using as a lighting source. Because of the advent for LED as lighting device, LED lighting becomes one of the new trends in the lighting industry (Cheng, 2006).

The aim is to encourage the use and technological development of more energy-efficient lighting alternatives LED lamps. Consumers are being encouraged to switch outdated incandescent bulbs to these more energy efficient alternatives. LEDs are more efficient than CFLs and the cost is now very competitive. However, LEDs last much longer—over 20 years—so they will pay for themselves many times over their lifespan. (Solutions, 2011)

We don't have national or international companies that produce complete LED products in Colombia. This is an important factor that affect the model because the need to import the products ready for consume of products such a LED to be assembled here. We have RETILAP (Technical Regulations Lighting and Public Lighting) the fundamental purpose of the regulations is to establish requirements and measures to be met by lighting systems and street lighting, aimed at ensuring: levels and qualities of light energy required visual activity, security of energy supply, protection consumer and environmental preservation. (Pais, 2016).

What we are trying to answer in this document is: ¿What are the stakeholders involve in the model? ¿what is the role of each of institutions and actors involve? ¿what are the politics and decisions to make in order to achieve the goal of 100% LED usage in 2030?

I. METHODOLOGY

This methodology is capable to assisting with practical problems definition, analysis and change in a wide systems because it combines modeling and systems approach and simulation. (E.F Wonstenholme, 1983)

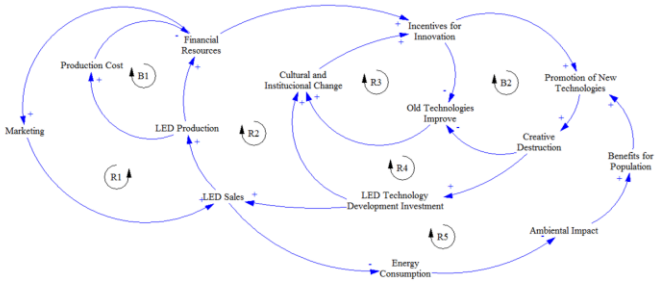
II. THE MODEL

The model aim to provide insight into the use of system dynamics to evaluate potential adoption of LED lighting new technology.

Understand the impact of each variable by updating all variables in small time increments with positive and negative feedbacks and time delays structuring the interactions and control.

Create information to public policy makers.(Ye & Zealand, n.d.)

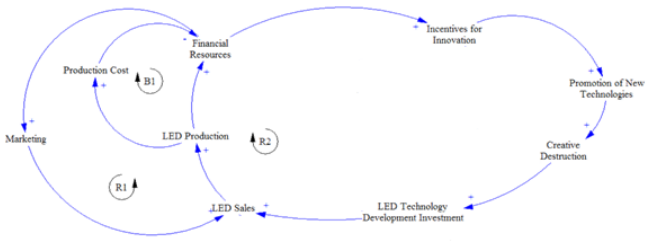
Figure 1. Causal Loop Diagram for LED Technology Implementation



Industry

A succession of LED market niches advanced the technology and provided profits to incentivize continuing research while reducing cost and improving efficacy of LEDs. Innovating firms developed a thicket of patents and captured substantial profit, but were embroiled in extensive litigation that was ultimately resolved through cross licensing. A major new generation of lighting products is now disrupting the traditional lighting industry. Although the leading incumbent lighting firms all invested early and heavily in SSL, the industry's future leadership is uncertain. (Simons & Ph, n.d.)

Figure 3. Causal Loop Diagram for LED industry



This figure explains in 3 loops the industry. B1: (Balance loop) a more incentives for innovation, more promotion of new technologies, more creative destruction, more LED technology development investment, more LED sales, that has an impact to LED production, more LED production cost and less financial resources.

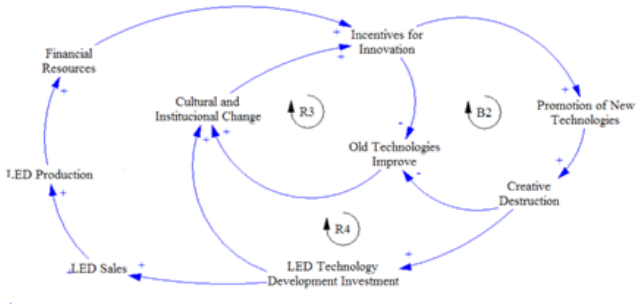
R1: (Reinforcing loop) more LED sales that has an impact to LED production and less financial resources, more marketing that brings more LED sales.

R2: (Reinforcing loop) a more incentives for innovation, more promotion of new technologies, more creative destruction, more LED technology development investment, more LED sales, which has an impact to LED production and more financial resources.

Government policies

Core Technology Research – Applied research encompassing scientific efforts that focus on new knowledge or understanding of the subject under study, with specific application to SSL. Core Technology Research aims to demonstrate scientific principles, technical application, and application benefits (Hansen, 2015).

Figure 4. Causal Loop Diagram for LED Government



This figure explains in 3 loops the Government policies. B2: To more incentives for innovation, more promotion of new technologies, more creative destruction, more LED technology development investment, more cultural and institutional change.
R3: To more incentives for innovation, more old technology to improve, more cultural and institutional change.
R4: To more incentives for innovation, more promotion of new technologies, more creative destruction, more LED technology development investment, more LED sales, that has an impact to LED production and more financial resources.

Environment impact

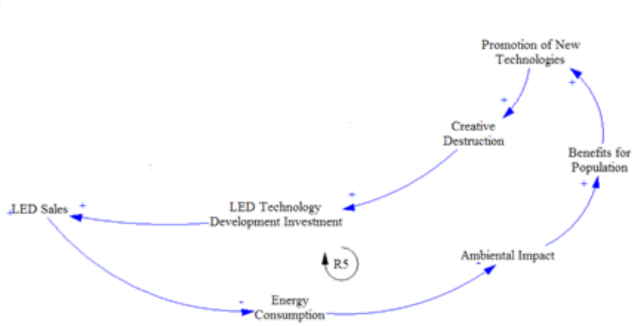
In response to the environmental impact of climate change, carbon emissions reduction has become a common global goal. This goal has led to the formulation of policies and measures to meet carbon reduction targets in various countries. Therefore, the assessment of the effects of energy conservation and the reduction of carbon emissions is important for the promotion of policies and measures for carbon reduction. Using system dynamics modeling, this study evaluates the effects of reduced carbon emissions when switching to LED lighting. Unlike conventional light sources that save energy, LED lighting products reduce carbon emissions and have longer lives. In Taiwan, the promotion of such products will help achieve its carbon reduction target. However, because LED lighting products are more expensive than conventional lighting products, their use by the public remains limited. The government has therefore adopted certain policies to increase the usage of LED lighting products. This study uses a system dynamics model to simulate the consumption of LED lighting products in Taiwan and thus assess the effectiveness of government policy. The simulation results show that the government's promotion policies effectively increase domestic LED lighting usage and thereby help reduce carbon emissions.
One of the metals with the greatest impact on ecosystems and for several decades has been the subject of countless studies by the researchers, is mercury.(Gomez & Diaz, 2015)
Technological Change and the Evolution of Corporate Innovation details historically how the innovative and competitive landscapes within industrialized societies have become increasingly complex. This book will appeal to industrial and business economists, technology historians, researchers, students, policymakers and business analysts. (Andersen, 2001)

LED technology will be part of the development, but hybrid illumination systems can also play an important role for the future illumination systems in the tertiary sector in the future. From the eco-design perspective, the study points out that some of the major technological and economic challenges are met in conjunction with situations, where the esthetical design issues are addressed. Finally, our study also points out to the necessity of finding a trans-disciplinary cooperation across sectors to more effectively answer to the climate change challenge, when designing low-carbon technologies for the future. (Bjarklev, 2010)

Relatively new regulations drafted to reduce the environmental impact and mainly CO2 emissions have led to both developed and developing to consider short-term goals to reduce energy consumption as much as possible and in the shortest period of time countries. This has led to the introduction in the lighting market of new types of light sources or even prohibit the use of other as in the case of less efficient incandescent light traditional sources. (Producción & Desecho, 2012)
The purpose of the present study is to design a current control system which is robust to the system dynamics uncertainty and the disturbance of ambient temperature to assure a stable optical output property of LED. The system dynamics model of the LED lighting system was first derived. A 96 W high-power LED luminaire was designed and built in the present study. The linearly perturbed system dynamics model for the LED luminaire is derived experimentally. The dynamics model of LED lighting system is of a multiple-input–multiple-output (MIMO) system with two inputs (applied voltage and ambient temperature) and two outputs (forward current and heat conducting body temperature). A step response test method was employed to the 96 W LED luminaire to identify the system dynamics model. It is found that the current model is just a constant gain (resistance) and the disturbance model is of first order, both changing with operating conditions

(voltage and ambient temperature). A feedback control system using PI algorithm was designed using the results of the system dynamics model. The control system was implemented on a PIC microprocessor. Experimental results show that the control system can stably and accurately control the LED current to a constant value at the variation of ambient temperature up to 40 °C. The control system is shown to have a robust property with respect to the plant uncertainty and the ambient temperature disturbance.

Figure 5. Causal Loop Diagram for LED Environment impact



This figure explains in 1 loop the Environment impact. R5: To more promotion of new technologies, more creative destruction, more LED technology development investment, more LED sales, more energy consumption, more environmental impact and more benefits for population.

III. Conclusions

Countries are faced with a dynamic, complex and uncertain environment in which to make decisions and to implement different public policies when it comes to the adoption and integration of a new technology such LED lighting in Colombia. The system dynamics model allow decisions makers to learn about the potential implications of current decisions and the analysis in different areas as innovation, sustainability, energy efficiency. They present information in an easy to understand, visual context. The purpose of this work is to demonstrate the advantage to introduce new technology in lighting in Colombia in production, ambient impact and integration.

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Author Biography

Catalina Henao Tobon holds a M.A. System Dynamics from University of Bergen in Norway and B.A. in Manager Engineer from University National of Colombia. Participant of MCC15 United Nations; She is a professional with a solid background in management, systems, strategy, marketing, and

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