Powering a Light by Means of Harnessing Gravitational Potential Energy (Technical Paper)

How the Advancement of Light Sources as a Technology Have Been Influenced By Social Motives (STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Humankind has long since passed the days of needing daylight in order to see. From fire and torches, to kerosene lamps, to Edison bulbs, to fluorescent and LED technologies that are currently around, our understanding of how to best harness light is constantly evolving. While the development of light itself may not be ongoing, our technologies that utilize and manipulate light, as well as our motivations for doing so, are constantly changing. To this end, my capstone group and I have been tasked with designing a mechanical means to power a light. Essentially, the design is to incorporate a mechanical system such that our device is self-sustaining and doesn't need to be plugged in or charged. As we were considering our options, I began to see how our design decisions were fundamentally driven by what we thought was important with respect to our target audience and what we wanted the light to be able to do. I want to research how the development of the technology of light has been driven by the social construction of the technology itself. What factors, such as energy consumption, cost, portability, usability, sustainability, and environmental conscientiousness, have driven the development of this technology throughout the course of its existence?

We decided that we wanted to create a light that would effectively illuminate an area for some amount of time after an initial user input, making the technology passive after that initial input. Eventually, we came to the idea of harnessing gravitational potential energy to power the light. We are currently in the process of developing a gear train, pulley system, and overall design that allows us to hang a weight from a rope that attaches to a generator. A gear train will scale the rotational speed to spin the generator enough to power our light mechanism. As the weight falls slowly, the generator will be turning very quickly. But more importantly, the falling

weight allows the user of the device to do other things and not have to apply constant mechanical work in order to have light.

Our motivations for these design choices were centered around the desire to create a product that could be implemented to provide low cost, sustainable lighting in under-developed areas of the world. However, it became clear that slightly different motivations would have completely redirected the focus of the design. Thus, it is important to identify and assess what STS motivations called for design and innovation decisions as the technology of light has developed over time. By looking at past and current design of these technologies, we can infer what motivations were paramount at that time. Then, we can use society's current motivations to predict where light technology is headed in the future.

Technical Report

Our design group is focused on harnessing the mechanical work of a falling mass and turning that into rotational motion that can turn a generator and power a light. This was primarily aimed at making a light that is self-sustaining, primarily passive, and operates on a one-time cost. These motivations were selected with the intent of producing this product in countries that currently don't have large scale power grids or access to affordable energy. For example, a 2015 survey suggests that there are still nearly ten countries in which less than 10% of residents have access to electricity (Wee, 2016).

In order to do this, we have had to address several design considerations. Since the device will employ a falling weight, that places several constraints on the design. It must be able to attach to something that is far from the ground (e.g. a door frame or tree branch) and have space below it for the weight to fall. As the weight of the falling mass increases, the amount of possible energy increases. Thus, it follows that we would like the design to be able to handle a large

amount of mass. In conjunction with the constraints on attaching the device to a lofted object, this has presented a significant challenge. Currently, our team is working through research and CAD modeling to try to find the best way to attach our device. Ultimately, we want the attachment point to be versatile to accommodate for a variety of possible attachment locations.

Another goal is to have the mass fall quite slowly, using a gear train to scale up the speed of rotation to a meaningful amount for the generator. The ability to have the generator rotating quickly while the weight falls slowly allows light to be produced for a longer period of time. Ideally, the only thing required of the user would be to "re-hang" the weight whenever it hits the floor. Once we settle on the type of generator we plan on using, we will have a better understanding of how much power we can output and what rotational speed is required to achieve that power (Doney et al, 2018).

Another proposed addition to the design is the incorporation of a battery or capacitor. By doing this, the power generated by the falling weight would be directed into some sort of storage device. This would require an added level of complexity with respect to the circuitry of the device (Simpson, 1995). However, this would allow the power to be stored and used on command instead of only being able to create light while the weight is falling. Eventually, we aim to make this aspect of the device modular so that the battery could be disconnected from the rest of the device and used to power other mechanisms.

Because of constraints on our design stemming from a desire to create a compact and portable product, the capacity to generate power also becomes an issue. Thus, we are aiming to choose a light that minimizes power consumption. LED's seemed like the clear choice, as they can last 25 times longer than incandescent bulbs and can also reduce energy costs from 20-80% (Lee, 2013). Reducing energy cost is important to this design to optimize the longevity of light

time and brightness of the light. However, during our research, reading about the different types of light sources illuminated the different motivations for their use. Moving forward, we will have to perform testing to determine the exact model generator and LED that fit our design parameters.

STS Report

Frameworks Introduction

There are a couple STS frameworks that can be used to analyze the social aspects of light as a technology. First, the social construction of technology (SCOT) is useful in examining the development of light as a technology. SCOT posits that the success of a technology is defined not by how well it works in comparison to other technologies, but by the social context through which the technology is viewed. Thus, it is up to the analyzer to determine what social contexts have promoted a given innovation. This framework introduces the concept of relevant social groups, which will allow us to examine the technological development of light sources from the perspectives of those who are driving its development in a particular direction. Using this framework will allow me to look back at past innovations of light source technology and examine what social factors were in play as these technologies came about.

Motivations of the Development of Light Source Technology

Long ago, natural sunlight, torches, and fires were paramount to keeping people safe from terrain, animals, and weather. However, there were limitations on this technology. Naturally, burning traditional fire fuel, such as wood, produces smoke. Since the technology behind ventilation systems was poor, there was a need to develop a means for harnessing light that could be used in shelters without producing too much smoke. This gave way to the creation

of candles and wicks (Staff, n.d.). This introduces a recurring theme: the need for a light source and exterior factor influencing the development of the technology.

Fast-forward thousands of years, and social contexts are still governing society's decisions about the development of light source technology. In recent years, conversations about energy efficiency have pushed forward laws that ultimately phase out incandescent bulbs for compact fluorescent bulbs (CFLs) or light-emitting diodes (LEDs). For example, the Energy Independence and Security Act of 2007 called for a 25% increase in efficiency of household bulbs (How the Energy Independence and Security Act of 2007 Affects Light Bulbs, 2019). While this Act did not explicitly state that CFLs must be used, the added constraints do call for the advancement of the technology itself. This is one of many considerations in which the social context has driven this technology to develop into something else.

Assessment of Motivations Through STS Frameworks

Public perception of the technology itself is also an important consideration under SCOT. In 2013, a USA Today article listed a variety of reasons why various homeowners might be holding off on making the switch from incandescent bulbs to CFLs. Several of these reasons have to do with the technology of CFLs themselves. Some of these reasons include: the color given off by the bulbs, a non-noticeable difference in electric bill cost, and habits of the buyers (Lee, 2013). Perhaps most notably, the article stated that many complained about the "weird look" that CFL bulbs had, claiming that the unusual shape was not as aesthetically pleasing as a traditional bulb (Lee, 2013). With these examples in mind, it is evident that SCOT is capable of uncovering a variety of social factors which are inherently driving the development of lighting technologies forward.

Actor network theory (ANT) is another viable way to frame my analysis of this topic. By assigning agency to nonhuman entities, I will be able to assess the role of various important actors on the direction in which lighting technologies develop. For example, the expansion of power grids throughout the 20th century provided the infrastructure for electric lighting to become commonplace with a freedom that was unknown to prior generations (Brox, 2011). ANT allows for a closer look at the infrastructure of power grids as an actor to examine its impact on the technology of light as an actor, and those who are responsible for building design. Additionally, this theory allows us to look at where lighting technologies will head next by identifying and evaluating the actors which are currently at play. Among these actors could be groups pushing for sustainability and efficiency, as well the percentage of the world which is still without access to a power grid. In order to accurately assess the factors that are driving lighting technology forward, all the actors in the network must be identified. Further, I can also attest to the actors (ANT) and social influences and relevant groups (SCOT) that directed our team's technical project into what it has become. These two STS theories will be paramount in answering the research question.

Research & Analysis Methods

I plan to continue to conduct research on the development of light, as well as search for various case studies in which actors influencing design decisions are evident and relevant. I will look not only at past technological advancements in this field, but assess the current state of the technology with the goal of figuring out what is currently driving design decisions. To assess the current technologies, I will compare the current light source technologies and evaluate the differences between different light sources from a social, technical, and economical perspective. I will conduct research to explore the laws, regulations, and other public influencers that have

influenced the technology in recent years. I will also look at the coexisting technological advancements in parallel fields that allowed for advancement of light source technology, such as the introduction of the power grid infrastructure.

Conclusions

By the end of the capstone course, my design team and I hope to have implemented a mechanical means to harness gravitational potential and use it to power a light. This device will be created to be completely self-sustaining and versatile, with the aim at being produced for those without access to power grids. At the conclusion of my STS project, I hope to have identified all of the actors and social motivations that have driven lighting technology forward to this point. Moreover, I hope to look at what is currently being done technologically to push lighting technology. By using my own design project as a case study, I can offer insight into the actors that influenced our decision making. Using this understanding of the social context that has propelled our technology to this point, I aim to identify which social considerations will become paramount in influencing this technology moving forward.

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Potential Future Sources

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