Electroluminosity

By

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Abstract

This project is an exploration of currently available lighting technology, its creative usage in the landscape, and potential application. Various lighting technologies were examined for their luminous efficacy, lifespan, advantages, limitations, and potential usages. A site was chosen in downtown Sacramento, CA for research into possible lighting options, as well as public art pieces. Sketches, diagrams, and models were created for investigation of possible solutions to site constraints.

Acknowledgements

I would like to thank the following people and businesses for their help and support during my Senior Project.

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Pandora Radio – Dancehall Station – Countless Hours of Work Music

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Preface

When I first chose lighting as the topic of my Senior Project, I was thoroughly excited at the prospect of finding a new, state-of-the-art lighting technology and bringing it to the attention of the Landscape Architecture community. In my naiveté I assumed there was a wonderful technology out there somewhere that was underappreciated or underutilized in the design world. While I have found many interesting technologies, gadgets, toys, and methods for delivering light, I was disappointed in finding that there is no "magic" technology that will put all others to shame. In addition, many companies exaggerate the capabilities of their products, such as efficiency, color temperature, and lifespan.

The most profound thing that I learned from my research is that lighting is a very situational technology. When choosing a light source for a project, careful consideration must be taken to choose the best technology for the application. Many light sources have limitations, such as heat output, inability to work in cold environments, susceptibility to vibration damage, inefficiency, high initial cost, and short life span. In addition, many technologies that have been around for decades, such as linear fluorescents, still have luminous efficacies equal or near-equal to the latest LED and HID technologies available today. When asked whether LED lighting was the best technology available, Kevin Furry of Kiboworks gave a valuable response:

> *LEDs are not best all around. In many installs they are a costly choice. […] A metal halide will last 60-150K hours. This is better than an led and probably 1/10 the cost. Although you cannot light small fixtures with this huge bulb.*
>
> *I would always first search for non led fixtures that can be installed the way you need for your idea. Then look for led versions. Compare the prices, install costs, maintenance costs. Clearly an led up 200 feet as a warning light is better than a $1 incandescent, simply because install costs are probably $2000.*

While many of the newest technologies offer promise for replacing traditional light sources and dramatically reducing our power consumption, many of these products are still expensive, in development, or difficult to produce to the high standards needed for maximum efficiency. It is easy to become excited by the prospect of a bulb saving energy or being more efficient than another option. However, when coupled with installation and maintenance costs, the electricity consumed over the course of the lifetime of the product, and the possibility of failure, careful consideration must be taken to ensure that the light source chosen will actually be the best choice.

Glossary of Lighting Terms

Solid-state lighting (SSL) technology uses semi-conducting materials to convert electricity into light. SSL is an umbrella term encompassing both light-emitting diodes (LEDs) and organic light emitting diodes (OLEDs).

Light-emitting diodes (LEDs) are based on inorganic (non-carbon based) materials. An LED is a semi-conducting device that produces light when an electrical current flows through it. LEDs were first developed in the 1960s but were used only in indicator applications until recently.

Organic light-emitting diodes (OLEDs) are based on organic (carbon based) materials. In contrast to LEDs, which are small point sources, OLEDs are made in sheets which provide a diffuse area light source. OLED technology is developing rapidly and is increasingly used in display applications such as cell phones and PDA screens. However, OLEDs are still some years away from becoming a practical general illumination source. Additional advancements are needed in light output, color, efficiency, cost, and lifetime.

General illumination is a term used to distinguish between lighting that illuminates tasks, spaces, or objects from lighting used in indicator or purely decorative applications. In most cases, general illumination is provided by white light sources, including incandescent, fluorescent, high-intensity discharge sources, and white LEDs. Lighting used for indication or decoration is often monochromatic, as in traffic lights, exit signs, vehicle brake lights, signage, and holiday lights.

Luminous efficacy is the most commonly used measure of the energy efficiency of a light source. It is stated in lumens per watt (lm/W), indicating the amount of light a light source produces for each watt of electricity consumed. For white high-brightness LEDs, luminous efficacy published by LED manufacturers typically refers to the LED chip only, and doesn't include driver losses.

Correlated color temperature (CCT) is the measure used to describe the relative color appearance of a white light source. CCT indicates whether a light source appears more yellow/gold/orange or more blue, in terms of the range of available shades of "white." CCT is given in kelvins (unit of absolute temperature).

Color rendering index (CRI) indicates how well a light source renders colors of people and objects, compared to a reference source.

RGB stands for red, green, and blue, the three primary colors of light. When the primaries are mixed, the resulting light appears white to the human eye. Mixing the light from red, green, and blue LEDs is one way to produce white light. The other approach is known as phosphor conversion [see below].

Phosphor conversion is a method used to generate white light with LEDs. A blue or near-ultraviolet LED is coated with a yellow or multichromatic phosphor, resulting in white light.

Light Sources

Incandescent Lamps

Incandescent lamps are the oldest type of electric lamps still in general use. The incandescent lamp was invented simultaneously in 1879 by Thomas Edison in America, and by Sir Joseph Swan in England. Although numerous changes have occurred over the past 130 years to improve the performance of incandescent bulbs, they still have the lowest luminous efficacy. Despite their inefficiency as a light source, they are still used in almost every application worldwide. In many countries, however, there is increasing legislation aimed to prohibit use and encourage the adoption of more efficient technologies (Hooker).

Uses: General Illumination

Pros: Widely Available
- Requires no Transformer or Ballast
- Inexpensive
- Easily Dimmable
- Perfect Color Rendering Index: 100

Cons: Low Luminous Efficacy (7-24 lm/W)
- Short Life Span (700-1000 hrs.)
- Produces Heat

Fig. 1 – Incandescent Bulbs

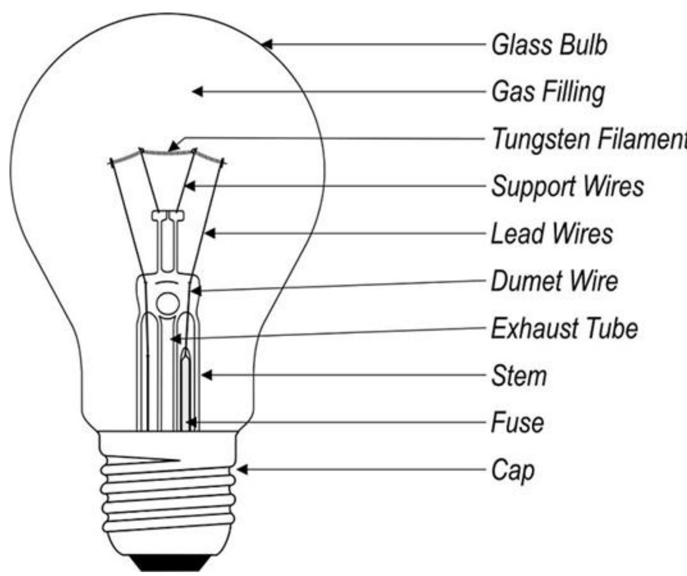

Fig. 2 – Incandescent Lamp Construction

Halogen Lamps

Halogen lamps, also known as tungsten halogen lamps, are a type of incandescent lamp where a tungsten filament was used (instead of the carbon filaments in normal incandescent lamps) along with a halogen gas such as bromine or iodine. The gas combined with the tungsten filament creates a reaction known as the halogen cycle, which increases the life of the bulb while allowing it to run at a higher temperature (Hooker).

Uses:
- General Illumination
- Automotive Headlights
- Task Lighting
- Stage Lighting (PAR lights)
- Floodlights

Pros:
- Small Size
- Longer Life than Incandescent (2,000-4,000 hrs.)
- Bright Light
- Easily Dimmable
- Near-Perfect Color Rendering Index: 95

Cons:
- Low Luminous Efficacy (12-36 lm/W)
- Relatively Short Life (2,000-4000 hrs.)
- Produces High Heat
- More Expensive than Incandescent

Fig. 3 – Halogen Bulb

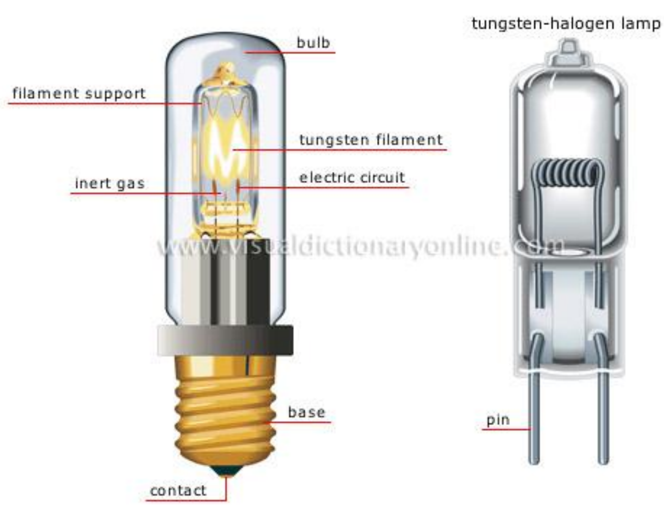

Fig. 4 – Halogen Lamp Construction

Linear Fluorescent Lamps

Linear fluorescent lamps are a type of low pressure mercury discharge lamp. Electricity is emitted from an electric coil (cathode) at either end of a glass tube filled with a small amount of liquid mercury and an inert gas (usually argon and/or krypton). The electricity excites the mercury atoms, which emit short-wave ultra-violet light. This light is then converted to visible light by a phosphor coating on the inside of the glass tube (Hooker).

Uses: General Illumination
- Flood Lights

Fig. 5 – Fluorescent Bulbs

Pros: Very Efficient (33-100 lm/W)
- Long Life (10,000-20,000 hrs.)
- Burns Cooler than most lamp types (not LED)
- Range of Color Rendering Indices/ Color Temperatures

Cons: Frequent On/Off Cycles Reduce Efficiency
- Contains Mercury (Needs Proper Disposal)
- Problems in Cold Temperatures/Outdoors
- Not Easily Dimmable
- Midrange Cost
- Known to Flicker

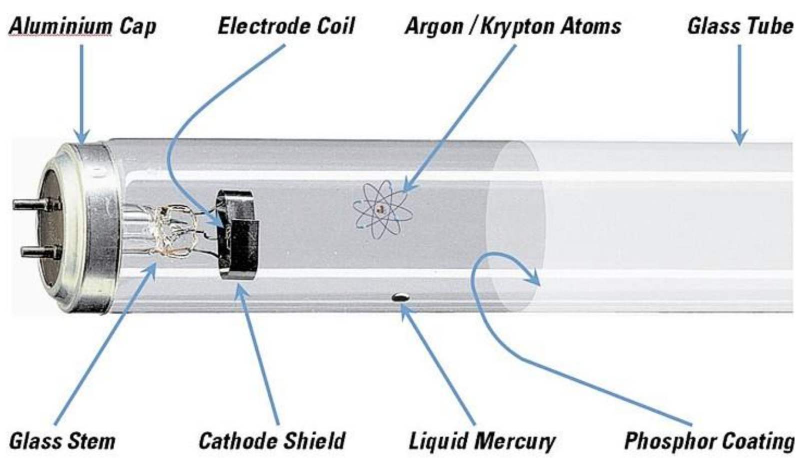

Fig. 6 – Fluorescent Lamp Construction

Compact Fluorescent Lamps

Compact fluorescent lamps operate on the same principle as linear fluorescent lamps, but have been reduced in size in order to allow them to be retrofit into existing incandescent fixtures. While they have a higher initial cost than incandescent lamps, they can save up to $40 in electricity costs over the lamp's lifetime (US DOE). While efforts have been made to increase the use of compact fluorescents through promotion and legislation, the U.S. Department of Energy estimates that only 11% of compatible sockets in the United States have CFLs in them (US DOE).

Uses: Retrofit for Incandescent Lamps

General Illumination

Pros: Very Efficient (44-80 lm/W)

Cooler than Incandescent

Long Life (6,000-10,000 hrs.)

Range of Color Rendering Indices/
Color Temperatures

Fig. 7 – Compact Fluorescent Bulbs

Cons: Higher Cost of Lamp

Problems Fitting Existing Fixtures

Uneven Light Distribution

Frequent On/Off Cycles Reduce Efficiency

Contains Mercury (Needs Proper Disposal)

Slow Warm Up Times

Problems in Cold Temperatures/Outdoors

Not All Lamps Easily Dimmable

Mercury Vapor Lamps

Mercury Vapor lamps operate on the use of electricity to vaporize mercury and produce light. The mercury is encased in a quartz arc tube, suspended in a larger glass bulb, which is either clear or coated with phosphors. While mercury vapor lamps are more efficient than incandescent or halogen, they are the least efficient of the high intensity discharge (HID) lamps. This coupled with their bad color rendering make them a poor choice when compared with similar size halide or sodium lamps (Hooker).

Uses: Outdoor Lighting

Landscape Illumination

Pros: More Efficient than Incandescent,

Halogen (20-63 lm/W)

Pleasant Color on Landscapes

Cons: Least Efficient HID Lamp

Poor Color Rendering Index: 17-49

Bluish-Green Light

Medium Life (1600-6000 hrs.)

Most Require External Ballast

Dims Rapidly

Contains Mercury (Needs Proper Disposal)

Fig. 8 – Mercury Vapor Lamp

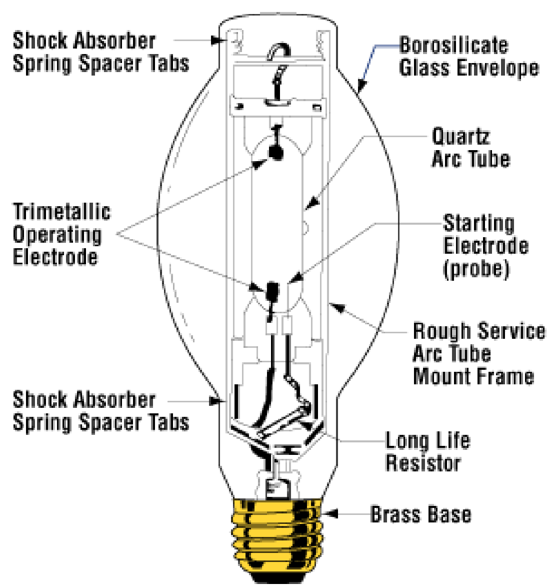

Fig. 9 – Mercury Vapor Lamp Construction

Metal Halide Lamps

Metal Halide lamps are a variation of the Mercury Vapor lamp type where various compounds (usually Sodium iodide or Scandium iodide) are added to the mercury improving the luminous efficacy, color temperature, and color rendering index. Metal Halide lamps are often used to illuminate large areas such as sports arenas, auditoriums, and commercial and industrial buildings (Hooker).

Uses: General Illumination

Sports Arenas

Outdoor Lighting

Commercial/Industrial Lighting

Nursery/Greenhouse Lighting

Fig. 10 – Metal Halide Bulbs

Pros: High Efficiency (60-125 lm/W)

Good Color Rendering Index: 60

Very Bright Light Source

Longer Life than Mercury Vapor (6,000-10,000 hrs ,

Cons: High Cost of Lamp/Ballast

Needs External Ballast

High Temperatures

Contains Mercury (Needs Proper Disposal)

Bulb Usually Needs Specific Orientation

Takes Time to Warm/Light

No Hot Restart

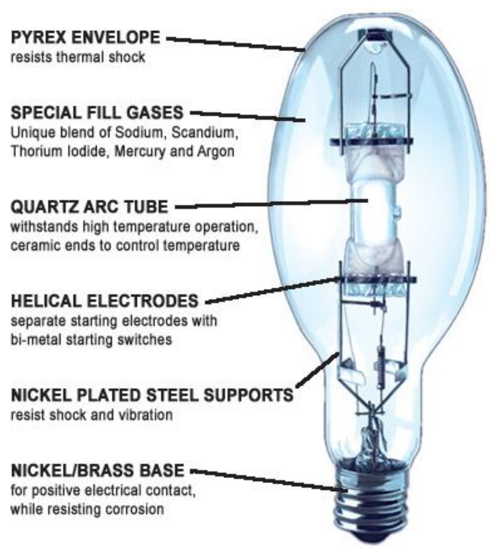

Fig. 11 – Metal Halide Lamp Construction

Sodium Vapor Lamps (High Pressure and Low Pressure)

Sodium Vapor lamps are a type of high intensity discharge lamp that works similar to mercury vapor and metal halide lamps, except that instead exciting mercury to produce light, sodium metal is vaporized instead. The sodium metal is encased in a glass tube filled with argon and neon gas, which initiates the gas discharge. High Pressure Sodium (HPS) lamps are smaller than low pressure lamps (LPS) and contain mercury and other compounds which allow them to render colors better than low pressure sodium lamps, although their color rendering index is still low (Hooker).

Uses:
- Street Lighting
- Industrial/Commercial Lighting
- Nursery/Greenhouse Production
- Outdoor Lighting
- Safety Lighting

Fig. 12 – High Pressure Sodium Bulbs

Pros:
- High Efficiency (60-140 lm/W HPS, 90-180 lm/W LPS)
- Long Life (18,000-24,000 hrs. HPS, 16,000 hrs. LPS)

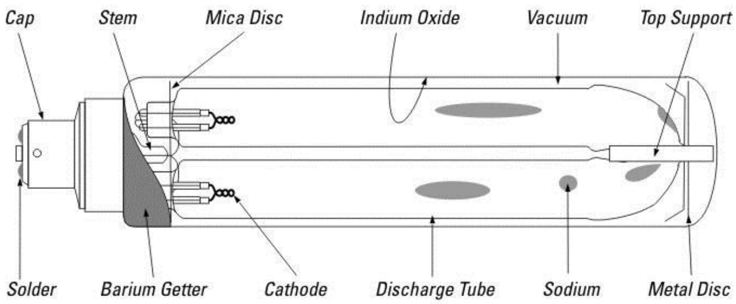

Fig. 13 – Low Pressure Sodium Lamp Construction

Cons:
- High Cost of Lamp/Ballast
- Needs External Ballast
- No Hot Restart
- Yellow-Orange Light
- High Temperatures
- Takes Time to Warm/Light
- Dims over Time
- Contains Mercury (Needs Proper Disposal)
- Poor Color Rendering Index: 5 (LPS) – 25 (HPS)

Solid State Lighting (LEDs and OLEDs)

Solid state lighting refers to the technology of converting electricity directly to light using semiconductor light emitting diodes (LEDs), organic light emitting diodes (OLEDs) and Polymer light emitting diodes. Different LEDs have different applications based on the color of the LED, the material it was made from, and the use of phosphors to convert the light to different CCTs. While solid state lighting now has a luminous efficacy comparable to fluorescent and HID lamps, there is still a price difference that is somewhat prohibitive. This grouped with the relative lack of efficient LEDs available for consumer use continues to hinder the use of solid state lighting technology today. Despite this, LEDs are becoming more common in areas like automotive/aviation lighting, traffic signals, outdoor/street lighting, and commercial/residential lighting. LEDs also offer the advantage of having no filament to break, allowing them to be used in areas with high vibration and in areas of extreme cold (Whitaker).

Uses:
- Automotive/Aviation Lighting
- Street/Traffic Lighting
- General Illumination
- Task Lighting
- Consumer Electronics
- Special Event Lighting
- Model Lighting

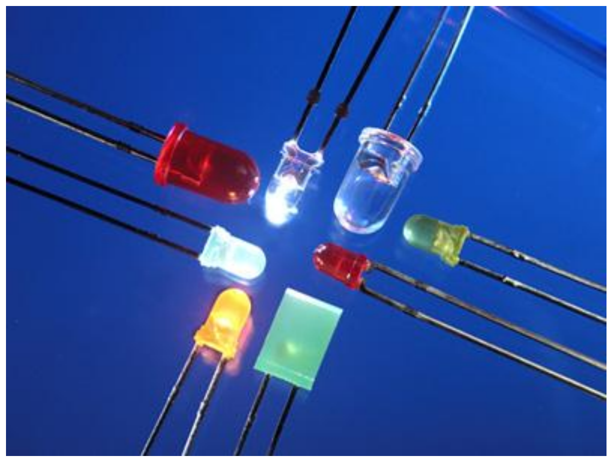

Fig. 14 – LED Bulbs

Pros:
- High Efficiency (30-150 lm/W)
- Long Life (30,000-100,000 hrs.)
- Range of Color Rendering Indices/Color Temperatures
- Easily Dimmable
- Vibration Resistant
- Operates in Cold Temperatures
- Frequent On/Off Cycling Ok
- Low Heat Generation
- Low Maintenance
- Small Size
- Does Not Contain Mercury

Cons:
- High Initial Cost
- Lack of Standardization
- Lack of Availability/Consistent Manufacturers

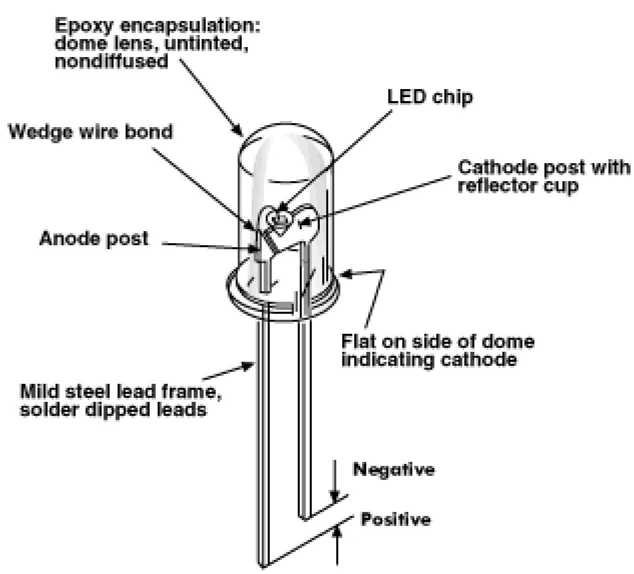

Fig. 15 – LED Lamp Construction

Induction Lighting

Magnetic induction lamps operate similar to fluorescent lamps. Mercury gas encased in a glass tube is put into an excited state, which causes the gas to emit ultraviolet light. The UV light is converted to visible light using the same phosphor coating on the inside of the glass tube. However, instead of delivering the current directly to the mercury gas by means of cathodes, the mercury is excited by the use of powerful electromagnets that are wrapped around a portion of the tube and driven by an external ballast. A variation called an internal induction lamp has an induction coil placed in the center of a standard bulb shape, and excites the gases from the inside. Both lamps have the benefit of removing the electrodes which allows for greater durability and lifespan. With no filament to break, induction lamps fail primarily due to depletion of the mercury amalgam in the bulb, or a failure of the ballast (Roberts).

Uses: General Illumination

Commercial/Industrial Lighting

Pros: Long Life (60,000-75,000 hrs. Internal,

85,000-100,000 hrs. External)

High Efficiency (62-90 lm/W)

Instant ON

Hot Restart (Can restart while hot)

Fig. 16 – Magnetic Induction Lamp

Cons: Contains Mercury (Needs Proper Disposal)

Requires Ballast

Susceptible to Vibration

High Initial Cost

Limited Wattages

Larger than HIDs

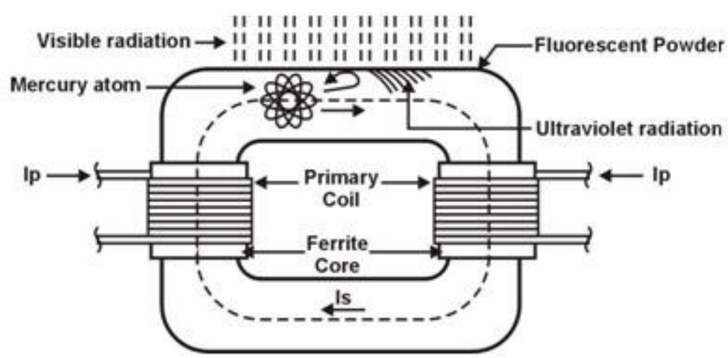

Fig. 17 – External Magnetic Induction Lamp Construction

Fiber Optics

Fiber optic lighting is not a lamp type, but rather a means of delivering light (and data) via a coated cable that reflects light back into itself. Thins strands of highly pure silica glass or plastic are encased in a layer that has a lower index of refraction, which keeps the light contained within the center of the strand. This allows for transmission of light, data, and images over great distances at near the speed of light. Fiber optics are used in many applications and are useful for lighting areas that are difficult to illuminate with traditional lighting. However, an external driver is necessary to create the light to transmit through the cable; meaning efficiency, lifespan, and placement of the light are all influenced by which technology is used as a light source. Many drivers are available using Halogen, HID, and LED lamps. Cables are available in multiple styles that emit light from the end of the cable, the sides, and in points along the cable (Bellis).

Uses: Light/Data Transfer
Pool/Fountain/Grotto Lighting
Accent Lighting

Pros: Waterproof (Cables, Not Driver)
Cables Easily Cut
Various Sizes Available
Illuminates Hard-to-Reach Places

Cons: Efficiency Based on Driver
Difficult to Connect Cables
Need Multiple Drivers for Long Spans
Need Location for Driver

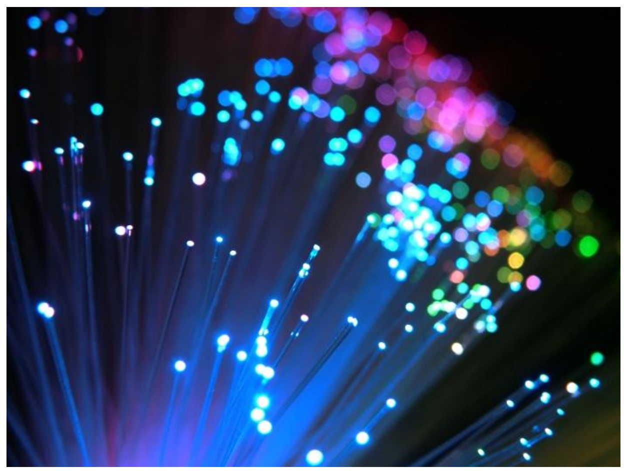

Fig. 18 – Fiber Optic Strands

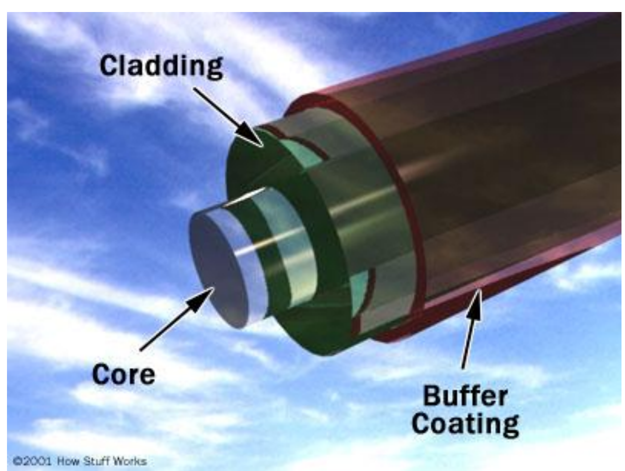

Fig. 19 – Fiber Optic Strand Construction

Electroluminescent Wire/Panels

Electroluminescent (EL) wires and panels are primarily used in costume and hobby lighting. El wires consist of a copper core coated in a phosphor, wrapped in a set of smaller wires, and clad in a protective and then colored PVC coating. The phosphors glow when alternating current is introduced by a driver unit. El panels work on the same principle only the copper is in a sheet and the phosphor is applied flat. El panels are useful in small scale and model lighting, and are easily cut and shaped. El wires are flexible and cool to the touch, allowing them to be integrated into costumes and projects with size and heat constraints (Burnett).

Uses: Costume/Hobby Lighting
Safety Lighting
Accent Lighting

Pros: Cool to the Touch
High Efficiency
Small/Portable

Cons: Short Life (2,500-3,000 hrs.)
Relatively Dim
Rated for Indoor Use Only

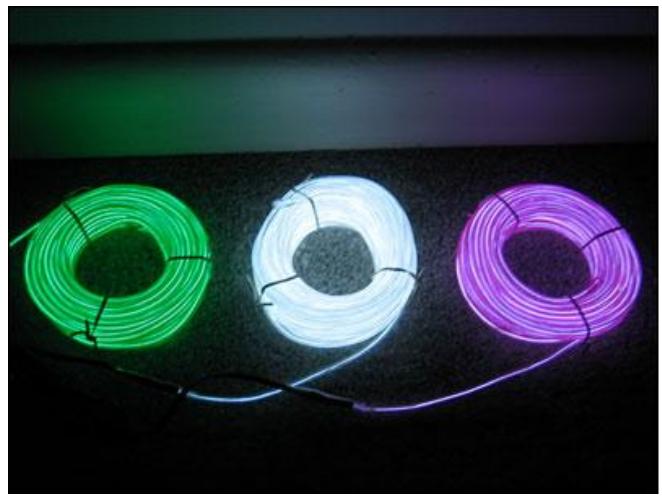

Fig. 20 – Electroluminescent Wire

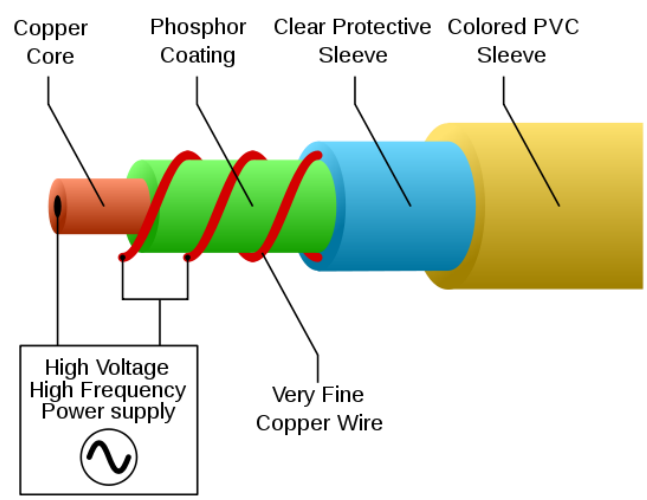

Fig. 21 – Electroluminescent Wire Construction

Neon Lighting

Neon lighting is a simple form of lighting where a vacated glass tube is filled with an inert gas such as neon, argon, krypton, xenon, or helium. At either end of the tube is an electrode which introduces electric current into the tube, exciting the gas and producing visible light. Neon lights are generally expensive due to the need for specialized labor to create, shape, install, and maintain the lights. Although neon lights can last several decades, periodic maintenance is required to ensure that the electrical components are functioning properly (Strattman).

Uses: Accent Lighting

Pros: High Efficiency (12-89 lm/W)

Aesthetically Pleasing

Nostalgic

Cons: High Initial Cost

Requires Periodic Maintenance

High Voltage Required

Specialized Labor Needed

Contains Mercury (Needs Proper Disposal)

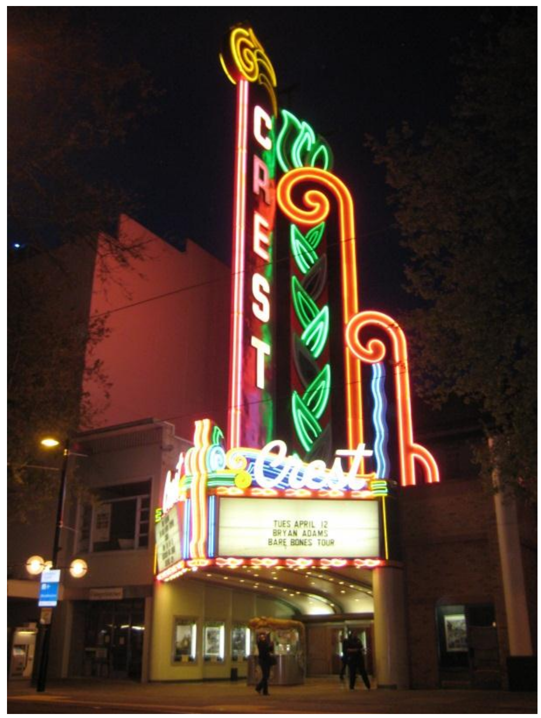

Fig. 22 – Crest Theatre Neon Lights

Inspiration

Upon completion of my research into the various lighting technologies available, I began to look for inspiration and uses of these various technologies.

Fig. 23 – Work by Ingo Maurer

Fig. 24 – Work by Mikyoung Kim

Fig. 25 – Fiber Optic Pool Lights

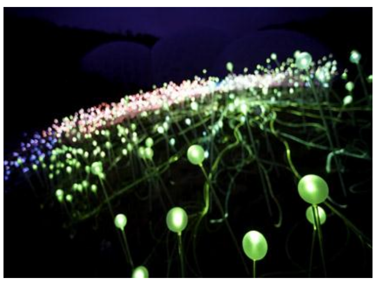

Fig. 26 – Work by Bruce Munroe

Fig. 27 – Assembled Dragon's Cave

Fig. 28 – EL Wire Project

Fig. 29 – Tokyo Lights

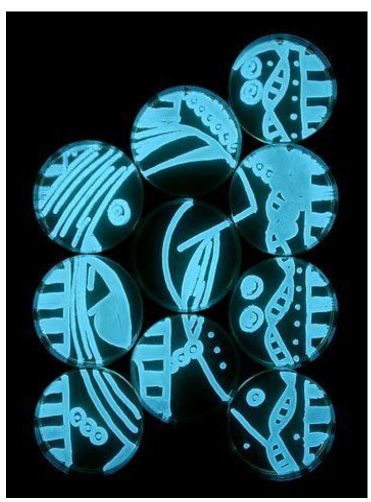

Fig. 30 – Work by Hunter Cole

Fig. 31 – Agbar Tower, Barcelona

Site Precedents

The following sites were chosen due to their use of lighting for creativity, to address site constraints, or to interact with the user. While many sites were examined, these sites have specific features that influenced my design decisions for my chosen site.

Clarke Quay

Location: Singapore

Architect: SMC Alsop

Completed: 2006

Fig. 32 – Singapore and Clarke Quay

Clarke Quay is a historic quay (or wharf) located in Singapore. It was named for Sir Andrew Clarke, who was Singapore's second governor. Historically, the quay was run in conjunction with Boat Quay, which was the commercial center. Items from Boat Quay would be ferried upstream by barges to the warehouses located at Clarke Quay. When the Singapore government moved shipping operations to a more modern facility to reduce pollution along the Singapore River and deal with overcrowding of bumboats, the area rapidly fell into disrepair (Capitaland).

Fig. 33 – Canopies, Fountain, and Lighting

Cleanup efforts for the area and the river culminated in the creation of an outdoor pedestrian mall aimed at revitalizing the area and providing a commercial, residential, and entertainment district. The architecture firm SMC Alsop was tasked with creating a vibrant outdoor pedestrian shopping and entertainment experience while dealing with the Singapore climate, and maintaining the historical integrity of the area. The firm created a large ETFE (a type of plastic) canopy to enclose the whole area and provide protection from the elements. This coupled with a 4,000 square foot recycled water feature, abundant perimeter tree plantings, and large towers with integrated cooling fans creates a climate controlled pedestrian environment (Capitaland).

Fig. 34 – Singapore River and "Lilypads"

Another profound element is the construction of a series of interconnected platforms called "Lilypads" with large colorful overhangs called "Bluebells" which provide outdoor dining areas for a long series of riverfront eateries. Another notable element is the incredible diversity of shops and restaurants available. Nightclubs, shops, pubs, breweries, and Jazz clubs each cater to a different potential customer (Capitaland).

Schouwburgplein

Location: Rotterdam, Netherlands

Architects: West 8

Completed: 1996

Schouwburgplein ("theatre square") is a public plaza located in Rotterdam, Netherlands. The firm West 8, created by Adriaan Geuze, won a competition put forth by the city for the creation of a new multiplex movie theatre on the site, plus aesthetic improvements. Geuze chose to create a void within the city, highlighting the skyline and allowing for festivals, spontaneous usage, and for visitors to interact on a city scale stage (De Rosa).

Fig. 35 - Schouwburgplein

Fig. 36 – Water Feature and Cooling Towers

The entire area was elevated several feet to create the "stage" area, which is covered with a variety of lightweight materials to reduce weight on the underlying parking structure. The materials also are varied into usage zones, which correspond to different anticipated behaviors of visitors over the course of the day (De Rosa).

The most dramatic of the site elements, however, is the creation of four large towers which are equipped with lights and reflectors. The towers have pneumatic drivers and can be repositioned by users via coin operated machines. This allows for spontaneous usage of the area and the ability to interact with the environment in a new and exciting way. Other interesting elements include four large lighted cooling towers which serve as a digital clock, and the seasonal creation of large sculptural forms of geraniums in the plaza (De Rosa).

Fig. 37 – Light Towers at Night

The Rapids/Lumetric River

Location: Sacramento, California

Artist: Michael Hayden

Completed: 2008

“The Rapids” and “Lumetric River” are a combination of sculptures located in the US Bank building in Sacramento, California. The artist Michael Hayden worked with Lighting Science Group to create two sculptural elements that utilized 200 of the company’s 20 inch LED displays. The sculptures simulate the flow of the nearby Sacramento and American river systems, using control modules to create a graceful color shift along the panels. “The Rapids” is located in the lobby and atrium of the building, and is 84 feet long and five stories high. The “Lumetric River” occupies the roof of the building, and is angled to illuminate a 5 story decorative rooftop array. The light from “Lumetric River” is viewable throughout the Sacramento region and provides a beautiful and provocative element to the city skyline (LSG).

Fig. 38 – LED Panels

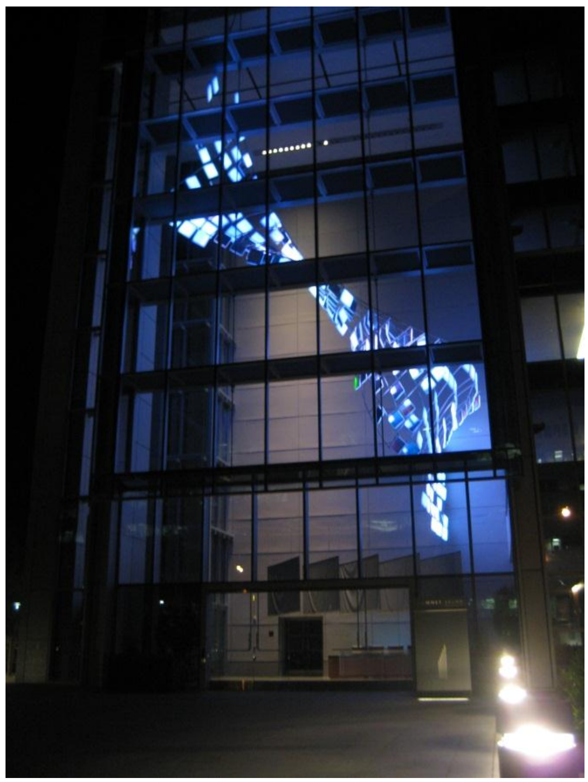

Fig. 39 – “The Rapids”

Design

Site Choice

For my Senior Project I was incredibly eager to create some kind of actual built object, whether it be a sculptural element, a series of lighted example pieces, or a representation of a landscape design. For my chosen site I wanted to find an area that was local, in need of revitalization, and devoid of any sort of creative lighting. I chose a section of K Street in Sacramento due to its meeting of these criteria, and the recent buzz surrounding the current plans to renovate the area.

K Street is located in the heart of downtown Sacramento, and was formerly a vibrant and integral part of the early city. K Street served as a lively shopping entertainment district for early Sacramento residents. However, from the 1940s to the 1960s there was a steady decline in usage of the area. Today, K Street serves as a pedestrian and transportation corridor, being devoted solely to pedestrian and light rail traffic. Recently, though, plans have been adopted to allow vehicular traffic again along a portion of K Street.

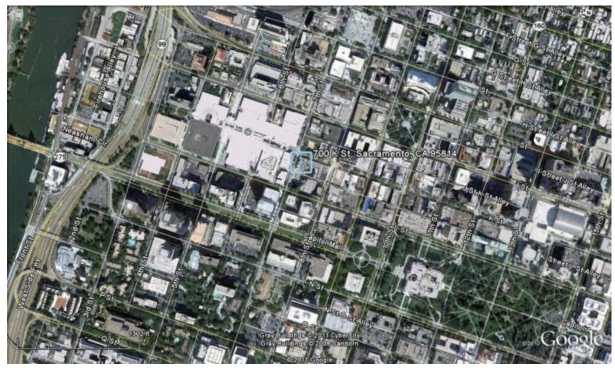

Fig. 40 – Site Location

Fig. 41 – View from Westfield Mall looking East

The specific section of K Street that I focused on was the block containing the St. Rose of Lima Park, an area encompassing the block between 7th and 8th Streets. The park was formerly the site of the St. Rose of Lima Church, but now is mainly an empty space reserved for the annual Downtown Sacramento Ice Rink. The park and pedestrian areas were recently redone by the firm Walker Macy, and the park includes a new lighted water feature. Nearby is the entrance to the Westfield Shopping Center, Sacramento's downtown mall. The Hard Rock Café used to reside near the entrance to the mall, but is currently being converted into an expansion of the adjacent 24-Hour Fitness. The area has a number of historic buildings, including the Pacific States Savings Bank Building (formerly the location of the Men's Wearhouse), the WT Grant Building, and the Ochsner building.

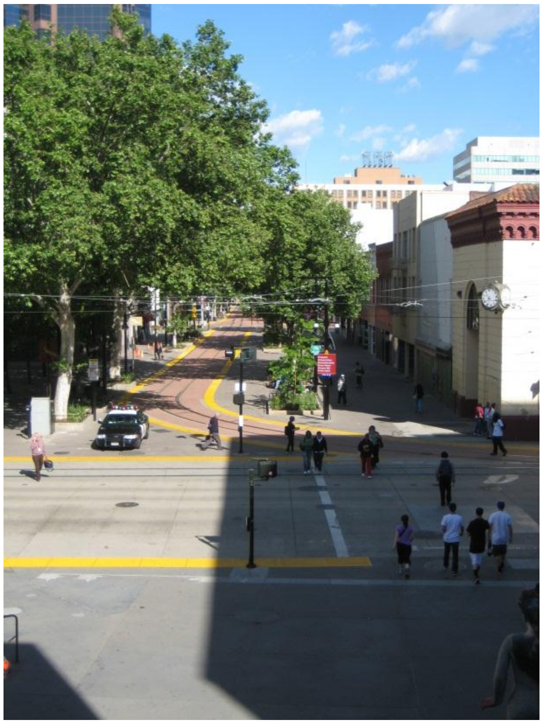

Fig. 42 – Day Activity

During the day the area has a fair number of people traveling from one place to another. I observed businessmen on their way to work or lunch, shopping families enjoying the mall and park, people using the light rail system, and a robust number of transients sitting on most of the recently installed benches. Despite the number of questionable looking people in the area (including myself taking numerous photos), the site overall has a fairly safe feel, with Sacramento Municipal Police regularly present, as well as the security near the mall entrance. During my numerous site visits the only crimes I observed were nuisance crimes such as panhandling.

At night the area is generally devoid of activity, with the mall closing at 8:00 p.m. and most of the businesses in the area similarly closing early. By far the most vibrant part of K Street at night is the area near the Crest Theatre, near which several new businesses have opened. During the evening and night periods, I mostly observed people traveling down the K Street corridor, presumably between Old Sacramento and the aforementioned section of K.

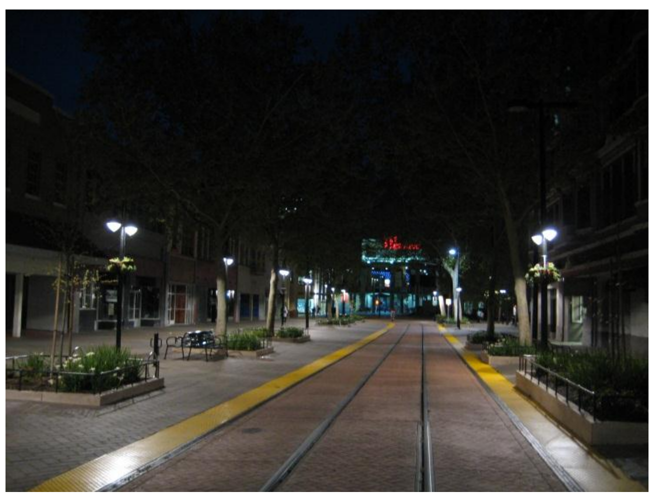

Fig. 43 – Night Activity

Initial Design Sketches

My initial attempts at exploring design ideas were more focused on creating a sculptural element that could be potentially created and installed within my project period. I used simple sketches to tease out ideas of things that could address the lack of lighting and vibrancy along that section of K Street. I came up with a series of ideas, illustrated below, which primarily used EL wire or sideglow fiber optic cable to simulate neon lighting.

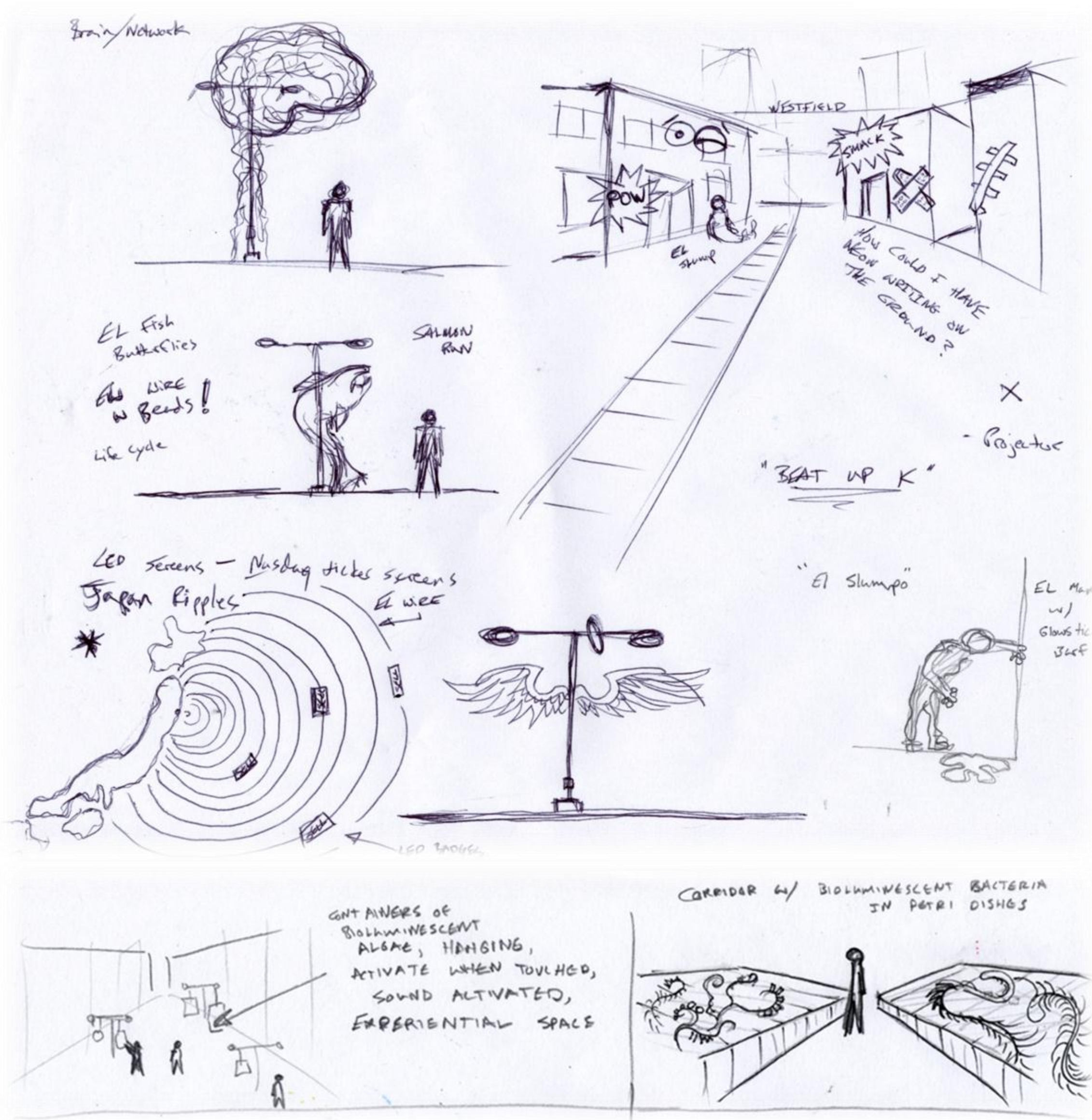

Fig. 44 – Concept Sketches

The problems I encountered at this stage were my repeated use of ornamentation rather than a complete design concept for the whole area. In short, I was focusing too much effort on creating something that could be easily placed on site.

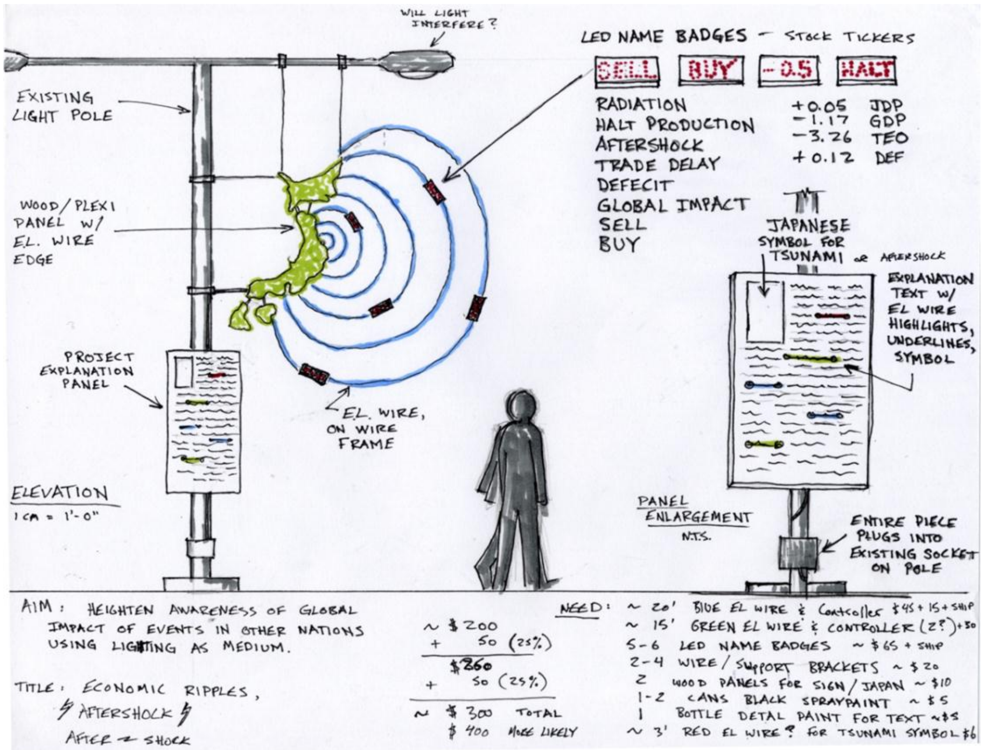

Fig. 45 – Concept Sketch

This sculpture was a commentary on the recent Japan quake and tsunami. Simple LED name badges are attached to radiating wires adorned with EL wire accents. The shape of Japan is similarly lit with EL wire as well as the highlighted areas of the descriptive sign.

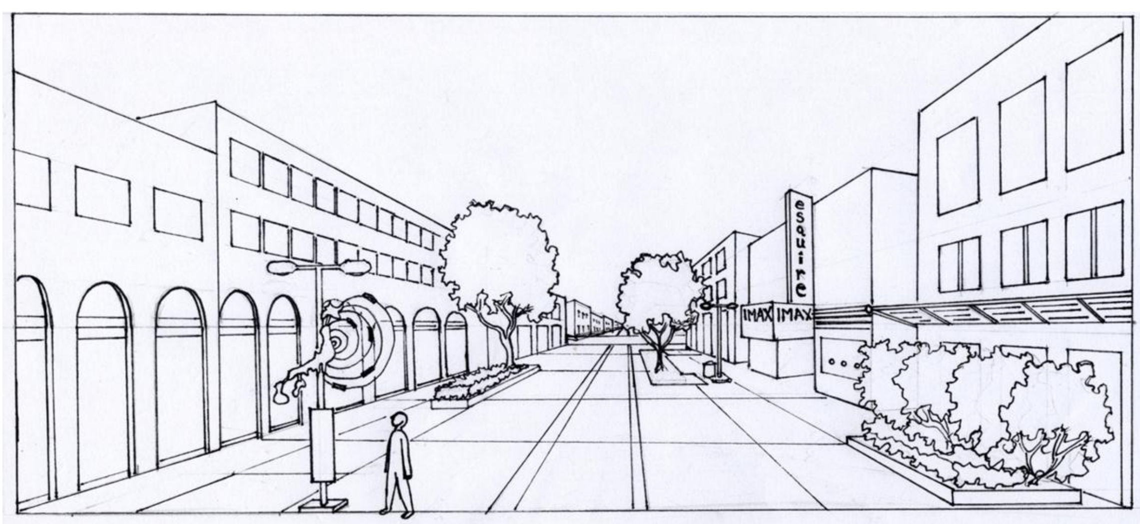

Fig. 46 – Concept Sketch

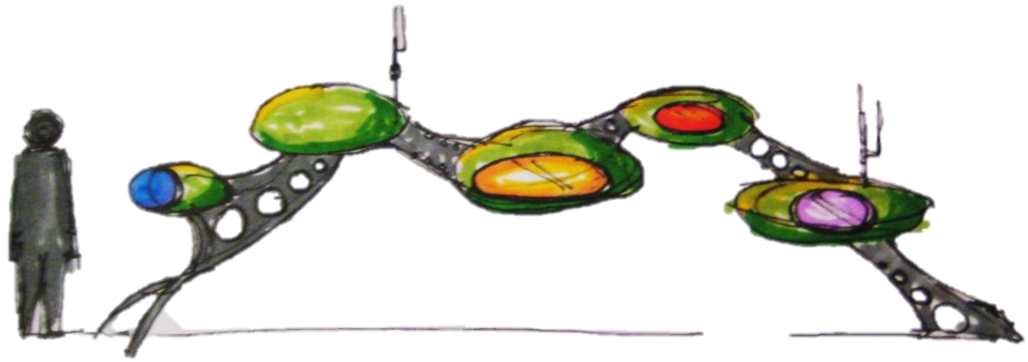

Fig. 47 – Concept Sketch

This sculpture was intended to house small art pieces and installations within the colored domes. When a passerby gets near enough, they trigger a proximity sensor which causes the domes to glow, beckoning for a closer inspection.

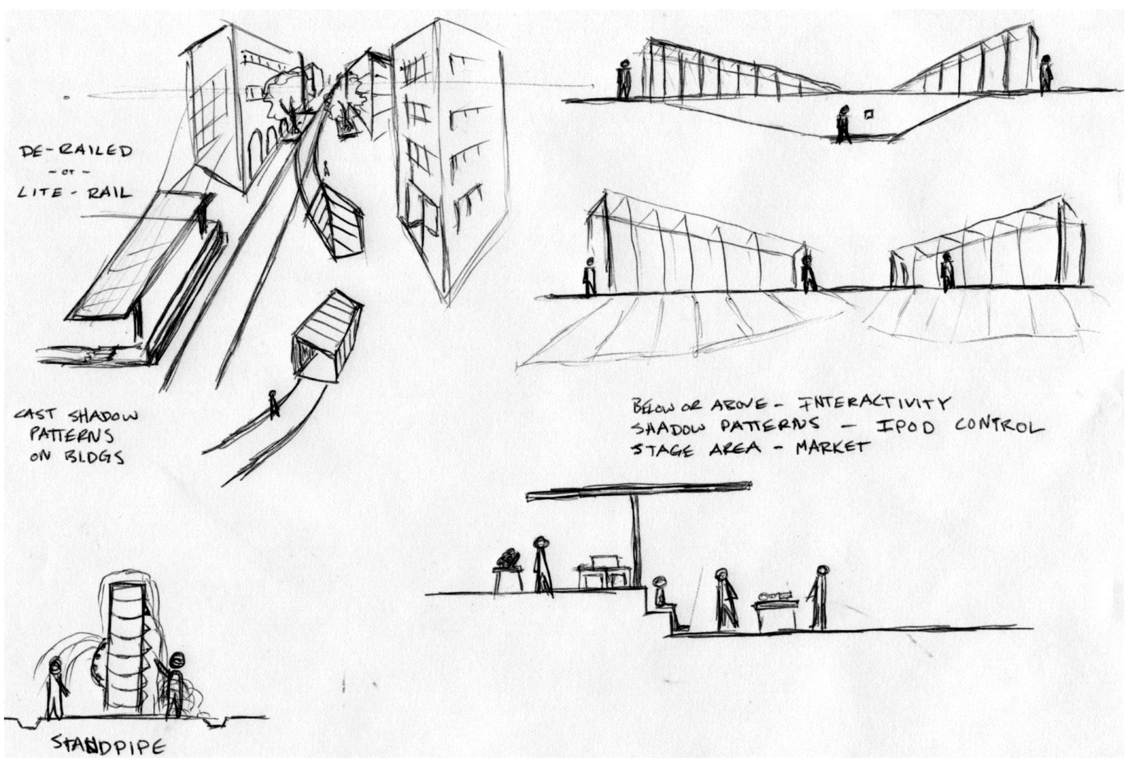

Fig. 48 – Concept Sketch

After encouragement during my midterm review to branch out with my design ideas, I took a more integrated approach to making the entire area an interactive lighted experience. This idea focused on user interactivity. Shadows cast by the rail-car inspired forms correspond to shapes on the ground plane, aligning on certain dates with the sun as a light source, and by user controlled lighting elements on the structures at night.

I was also encouraged to obtain samples of available lighting technology and to begin experimentation. I obtained a sample of EL wire and a sound activated driver unit and began experimenting with usages.

This piece is titled "Silence is Golden" and consists of EL wire mounted to a semi-transparent acrylic panel. The box was created by hand (and power drill) and hides the driver, EL wire, and light. When someone speaks near the box, the EL wire will illuminate, becoming visible from behind the acrylic. This project explored user interaction with the light source, and it was fun to watch various people yell into it repeatedly.


Fig. 49 – Box Construction

Fig. 50 – Spray Painted Acrylic Panel


Fig. 51 – EL Wire Interior Work

Fig. 52 – Near Completed Concept

Upon completion of my lighted box, I decided to embark on the creation of a detailed scale model of my chosen site on K Street.

Initial attempts were made to create the model in Google Sketchup 8, but limitations with the software moved my interest toward making an actual built model. One limitation that I found with Sketchup was the fact that the human-computer interface changes the way that an area is designed. Irregular shapes are harder to make, and as a result the designs begin to take on very geometric forms. Another limitation is the lack of lighting control within the program. It is possible to take a Sketchup model into other programs to add lighting effects more realistically, but the process is long and arduous.

Fig. 53 – Sketchup Model looking South on 7th Street

Early forms in my model were based loosely on Art Deco style designs, and my own sketches. A kiosk was added near the entrance to the St. Rose of Lima park along with a newsstand on the other side of the light rail tracks.

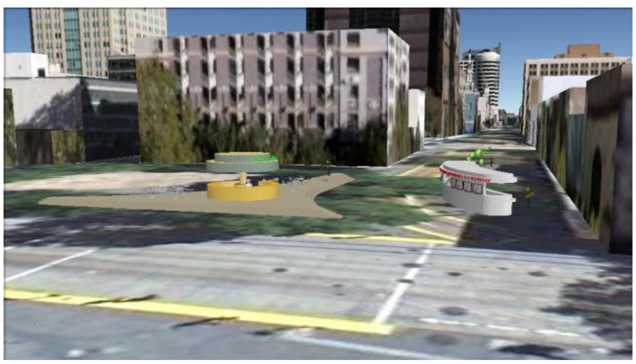

Fig. 54 – Sketchup Model looking East on K Street

A model was also created based on a concept sketch of a structure designed to showcase small art pieces and installations. The structure is lighted and responds to the viewer based on proximity. However, due to the aforementioned problems, the Sketchup modeling process was abandoned in favor of a more hands-on and potentially risky approach.

Fig. 55 – Sketchup Model looking West toward Mall

I decided to make a model of the site in TT scale (1”=1’-0”), thinking the conversion would be fairly easy using my engineer’s ruler (later I learned HO scale or 1/8 scale would have been more appropriate). I began constructing the surrounding buildings using chipboard for the walls and cut acrylic panels for the windows.

Fig. 56 – Chipboard Buildings

The basemap was printed from Google Earth and laid over a 36” x 48” piece of tri-ply wood paneling. Many of the site features were obscured and numerous measurements had to be taken to achieve an adequate level of accuracy.

Fig. 57 – Basemap Layout

Special attention was paid to the buildings in order to give an accurate representation of any wayward lighting effects caused by the intended design. The buildings were intended to be lit using simple LED string lights to reduce heat buildup. The decorative tops at the corners of this building are made from the bottoms of the plastic shells dispensed from gumball machines.

Fig. 58 – Sample Illumination

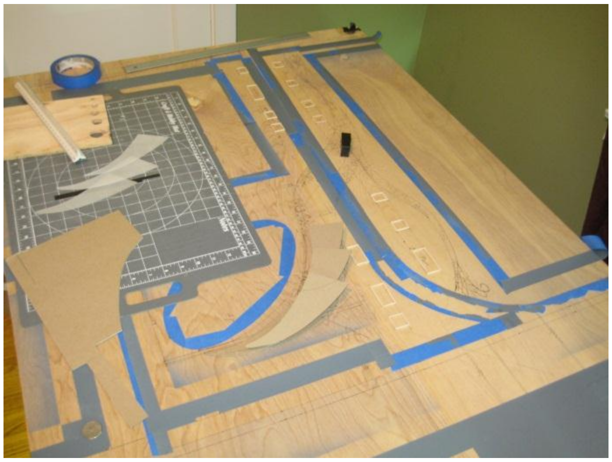

Fig. 59 – Painting Ground Plane

The layout for the ground plane was sketched free-form by hand and later painted using simple craft paints. The sinuous design was intended to lead users around the area in a less linear fashion, encouraging them to explore the shops, restaurants, and sculptural pieces while not becoming an obstacle to those on a more direct route through the site.

Fig. 60 – Examination of Scale

Fake trees and people were used to ensure a fairly accurate representation of scale (despite the use of 1/8 scale people on a TT scale model, making everyone 7 ½ feet tall).

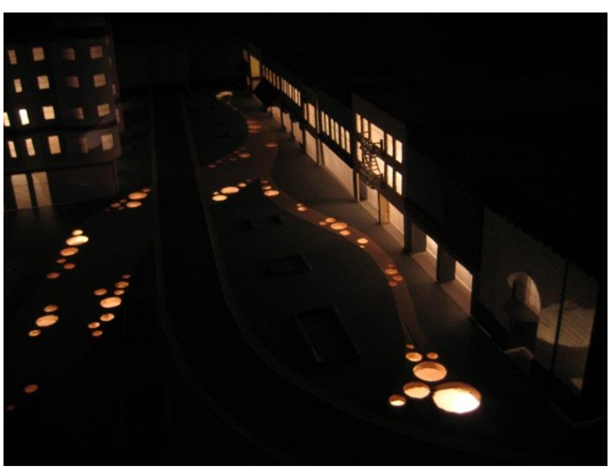

Fig. 61 – Test of Interior Lights

The model was illuminated repeated times during production to look for light leaks, potential conflicts, and overall effect. The holes in the pathway are covered with semitransparent acrylic to soften the glow and hide the underlying lighting systems. In the real world, many of the circular areas would be equipped with motion sensors that react to pedestrians as they walk or stand on the circles.

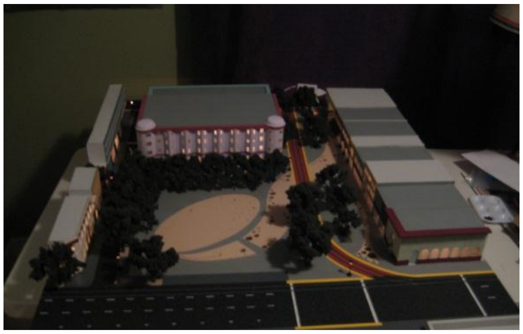

Fig. 62 - Near Completed Project

The final assembly of the model was delayed due to lack of communication from a lighting vendor. EL wire accents were intended for the detailing on the overhangs, and a more controllable string of LED lights was to be acquired for the lighted pathway. However, the overall quality of the model only suffered slightly.

In the real-life version of the design, the lighting under the plaza and walkway swirls with colors and patterns, creating an ambient lighting effect that changes with usage. During periods of high evening activity the lights will have a brighter appearance, warmer colors and the changes that occur will happen more rapidly. Low activity periods will be accompanied by cooler colors and slower shifts in effects. Sensors strategically placed around the area will interact with pedestrians by causing changes in the light patterns based on movement.

The entire light system will interact with the arrival of the light rail train by creating a trailing pattern that sweeps alongside the train as it arrives. The lights will intensify and areas that cross the train tracks will exhibit red warning lights to discourage crossing. The interaction can be accomplished with a set of sensors on site, or with GPS or proximity tracking technologies placed on the train.

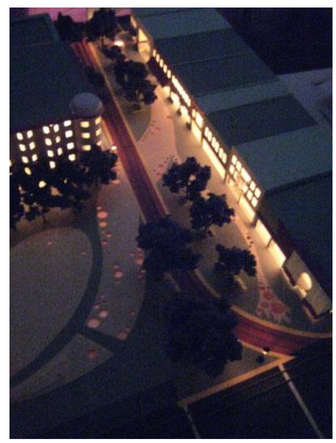

Fig. 63 - Path Lights

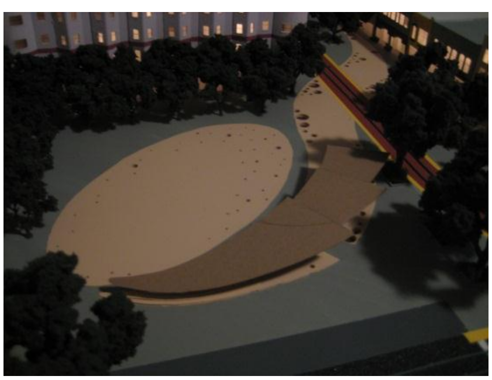

Fig. 64 - Pavilion and Skating Rink

The pavilion area consists of three frosted acrylic panels suspended on a decorative framework. The panels reflect light back from the circular openings on the ground below and shelter the area enabling year-round use for special events. A set of long steps provides a seating area and viewpoint for the central water feature and seasonal skating rink. LED lights set below the plaza will project through the ice during duration of the skating rink operation, providing entertainment and directional encouragement to the skaters with light patterns rotating in one direction.

Summary/Lessons Learned

As stated in the preface, the most useful thing learned from my explorations is that the best lighting for a situation heavily depends on the usage. Every technology has limitations and often the best choice in a light source is one that balances efficiency, longevity, cost, and upkeep. As more "green" light sources enter the market, careful examination of each product will be increasingly important to determine which technologies really live up to their expectations. Furthermore, with conversion to these "green" light sources happening at a dramatically slow pace, further incentives may need to be offered to consumers to encourage upgrading.

Works Cited

Bellis, Mary. 2011. *The Birth of Fiber Optics*. Web. 27 May 2011. http://inventors.about.com/library/weekly/aa980407.htm

Burnett, Colin. 29 Jan 2011. *New Project: Electroluminescent Wire Nixie-tube-styled Clock*. Web. 6 June 2011. http://blog.candysporks.org/2011/01/29/new-project-electroluminescent-wire-nixie-tube-styled-clock/

Capitaland. 2006. *CapitaLand Celebrates the Completion of Clarke Quay's $85 million Redevelopment Works.* PDF. 24 Apr 2011. http://www.clarkequay.com.sg/

De Rosa, Floriana. *Floornature*. Web. 6 June 2011. http://www.floornature.com/progetto.php?id=4247&sez=30

Furry, Kevin. 2011. *Response to LED Inquiry*. Email. 27 May 2011.

Hooker, J.D. 2011. *Lamptech: Museum of Lighting Technology*. Web. 12 May 2011. http://www.lamptech.co.uk

Kremer, Jonathan Z. 2011. *Light Bulbs at a Glance*. Web. 15 May 2011. http://www.megavolt.co.il/Tips_and_info/bulbs_at_glance.html

Lighting Science Group. 2008. *Lighting Science Group and Michael Hayden Unveil LED-Based 'RIVER' on the Facade of New California Building*. Web. 24 Apr 2011. http://investor.lsgc.com/releasedetail.cfm?ReleaseID=301562

Phillips, D. 2002. *The Lit Environment*. Woburn, MA: Architectural Press.

Roberts, Michael L. 2009. *How Magnetic Induction Lamps Work*. Web. 6 June 2011. http://knol.google.com/k/how-induction-lamps-work#

Strattman, Wayne. 2001. *The Luminous Tube.* Web. 27 May 2011. http://www.strattman.com/articles/luminoustubes.html

Thielen, Marcus. 2003. *Comparison: LED, Standard-Neon / Cold Cathode and HOTFIL-tubes*. Web. 12 May 2011. http://hotfil.com/compare.htm

Webb, M. 2003. *Ingo Maurer*. San Francisco, CA: Chronicle Books.

Whitaker, Tim. 2005. *Benefits and Drawbacks of LEDS*. Web. 6 June 2011.

United States Department of Energy. 2009. *CFL Market Profile*. PDF. 24 Apr 2011. http://www.energystar.gov/ia/products/downloads/CFL_Market_Profile.pdf

Image Resources

http://mysavingcents.com/2008/12/energy-light-bulbs.html

http://www.lamptech.co.uk/

http://www.archithings.com/osram-ceramic-lamps-now-as-100w-systems/2009/08/10

http://visual.merriam-webster.com/house/electricity/lighting/tungsten-halogen-lamp.php

http://motohata.com/2011/05/10/fluorescent-lamps-energy-efficient/olympus-digital-camera/

http://ablamp.wordpress.com/2007/06/12/save-energy-money-and-the-environment-with-compact-fluorescent-light-bulbs/

http://www.search.com/reference/Mercury-vapor_lamp

http://www.powerprosites.com/commerciallightingtampa/index.asp?Page=Mercury+Vapor+Lamp+Diagram

http://houseconstructionindia.blogspot.com/2010/04/lamps-metal-halides.html

http://www.superiorlampinc.com/product_line/hid.htm

http://www.diytrade.com/china/4/products/1398831/High_Pressure_Sodium_Lamp.html

http://dev.emcelettronica.com/cheap-high-current-led-driver

http://www.fiberopticproducts.com/Led.htm

http://www.energysaving247.co.uk/150w-high-bay-circular-induction-lamp-ip20.html

http://eneri-source.wikispaces.com/Induction

http://linzworld.wordpress.com/tag/korean/

http://www.mohamedmalik.com/?p=39

http://blog.joelogon.com/2006/01/cheap-el-wire-at-ikea-winter-sale.html

vhttp://blog.candysporks.org/2011/01/29/new-project-electroluminescent-wire-nixie-tube-styled-clock/

http://www.bahnbilder.de/name/einzelbild/number/42803/kategorie/deutschland~stadtbahnen-und-u-bahnen~u-bahn-munchen-stationen.html

http://www.dezeen.com/2009/03/23/barcode-luminescence-by-mikyoung-kim-design/

http://www.archithings.com/custom-swimming-pool-and-spa-designs-by-cipriano-landscape-design/2009/12/23/deck-jet-pool

Image Resources (Cont'd)

http://www.enlightermagazine.com/projects/fields-light-bruce-munro

http://havingalovelytimewriting.wordpress.com/page/2/

http://www.automotto.com/entry/el-wire-graphics-add-glow-to-motorcycle-fender-and-tank/

http://trialx.com/i/2011/05/25/photos-and-information-about-tokyo/

http://www.sciencephoto.com/media/117337/enlarge

http://technabob.com/blog/2007/12/16/barcelonas-agbar-tower-covered-with-led-lighting/

http://www.arcspace.com/architects/alsop/cq/cq.html

http://www.west8.nl/projects/all/schouwburgplein/

Google Earth

Electroluminosity

A Senior Project for the Landscape Architecture Department – UC Davis

Project Approved by:

Claire Napawan – Senior Project Advisor

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Christine Talbot – Committee Member

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Kevin Furry – Committee Member

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Shelly Willis – Committee Member

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