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Abstract:
The opportunities are in place of implementing media into architecture, and therefore lighting designers needs to understand and use the design qualities of light, but also add to that an understanding on data collected from the environment and the possibilities of combining both, and to incorporate information as a new layer on top of aesthetic and functional qualities into the lighting design.

So in this paper I will investigate the opportunities that lies within this topic, and hopefully use it to be a better designer that designs with function on top of aesthetics.

In this master thesis I want to explore the possibilities to add another layer to the architecture of the Smedstad Recycling station by the use of a light controlled by data, which in turn should reflect on its environmental function to the public and contribute to environmental awareness.

Master Thesis
Andreas Ramdahl
AAU

Façade lighting concept
“Smedstad Gjenbruksstasjon”

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INTRODUCTION

Electric lighting has made huge transformation in our cities and our daily life, and the value of carefully designed lighting for spaces shows that lighting is big part of successful architecture. Also for our cities, lighting act as a tool for wayfinding, create atmosphere, create safe spaces and to give spaces a night time identity.

Technology offers new possibilities for lighting designers to implement more than atmosphere and functionality into architecture and spaces. In our cities today, it is easy to find examples where data collected by different mediums such as sensors or smartphones, is improving existing infrastructure. Real time data is telling you when the next bus is coming, the tickets for the subway or parking can be bought on apps on a smart phone, and your phone can tell you where a rental bike is placed and unlock it for you. This is initiatives that explicitly makes the life in the city easier and more efficient. As of many types of use, especially interesting for this thesis is that information derived from collected data can be used in art projects to create awareness over environmental issues that leads to greener cities. This data could participate to improve and make the life easier and more efficient in cities by implement it into the built environment.

Many cities are focused on changing towards a greener and smarter future, with less air pollution, better public transportation and more green areas. It is a widely agreed that with better environment leads to better cities. That's why I will focus on the exciting possibilities to use light and collected data to contribute to greener and smarter cities in this paper.

Poulsen, Andersen & Jensen (2010) is arguing that the opportunities are in place of implementing media into architecture, and therefore lighting designers needs to understand and use the design qualities of light, but also add to that an understanding on sensors and the possibilities of combining both, and to incorporate information as a new layer on top of aesthetic and functional qualities into the lighting design.

This master thesis aim to explore the possibilities to add another layer to the architecture of the Smestad Recycling station by the use of a light and data, which in turn should reflect on its environmental function to the public and contribute to environmental awareness.

METHOD

To get an understanding of the topic and answer the initial problem statement, the first part is being derived from literature, related projects, interviews and searches on the internet to take part in the discussion in this initial phase.

Based on this, the initial problem statement was changed into a more specified final problem statement. To answer the final problem statement, a case study on the Smestad Recycling plant in Oslo was carried out, and the possibility of using the façade as a key to digital placemaking in the area, was investigated. Information has been gathered, and interviews with management and architects has been carried out along with field trips to the station to get an understanding of the area. Furthermore, it has been carried out registration and a site analysis to find qualities and challenges for the area as it is today. The result from the analysis and the understanding gained has been used in the design part where a façade lighting scheme based on air quality data has been carried out.

"How can one contribute to raise environmental awareness through data driven lighting design?"

Initial problem statement

PART 1: BACKGROUND

1.1 LITTERATURE REVIEW

Based on the initial research question, different fields of research that is related to the topic media architecture, which is an umbrella term for using digital data in architecture, will be presented.

The potential for a new digital layer in architecture is widely discussed by lighting designers, media designers and artists. This section looks into the future prospects by key persons within the research field. Several definitions and terms have emerged from media architecture, such as digital placemaking, which is found interesting for this thesis and will be explored further in the coming section.

This literature review is based on a wide perspective starting with thought on smart cities, narrow it down to media architecture, even more narrow with digital placemaking, and looking at ambient communication as a design philosophy.

1.1.1 Smart City

Our cities are growing and the increased urbanization puts pressure on existing infrastructure. At the same time digital and pervasive technologies seeks to solve some of the new challenges, and at the same time they are redefining notions of space, place and how we experience the city (Williams et. Al 2009). Korsgaard and Brynskov (Korsgaard & Brynskov 2013) argue that smart city represents a tendency towards integrating IT systems and data across departments, sectors and work areas in the city, based what is needed and which challenges needs to be dealt with, instead of letting what is technologically possible be the driver. The continue with arguing that the attention smart city get from city leaders, means that there is a momentum within cities to open up for a broader approach towards smart city solutions, and that the term smart city "is also an opportunity to reconsider the role of technology, people and the city from a more citizen-centered and holistic perspective."

Bawani & Shamsi (2015) defines smart city as an metropolitan area where city operations and services like healthcare, education, transport, parking are supported through information technology to facilitate efficiency and ease of operation. The primary goals of a smart city is to use digital means to support social needs in all daily transactions, adapt the citizen to the notion of information society and to collect information from the public departments and citizens to support a sustainable growth of the city. Ideally, this would lead to an implementation of a citizen- centered public administration, free from corruption and time consuming bureucratic procedures (H. Chourabi et al. 2012). The term smart city has been widely discussed, and researchers have come up with many different definitions and ways to implement the concept of a smart city. What is common in the definitions is that smart city "represent a strategy to mitigate the problems generated by the urban population growth by using information and communication technology" (Bawani, N.Z & Shamsi, J.A 2015). So smart city involves a digital layer over many sectors of operation within a city, and many of these digital layers could be implemented through data driven lighting design into the built environment.

1.1.2 Media architecture

Hespanhol (Hespanhol, 2017) is defining media architecture "as the utilization of information technology in the design of architectural elements that can convey their own dynamic information or prompt transient sensorial experiences." Heusler (Haeusler, 2017) continues by describing the mechanism in our society that has made media architecture into a force to be recon with by suggesting that the technological advances happening in society also influences architecture and the built environment on a large scale. He continues, "digital devices change rapidly and exponentially improve their performance, consequently, architecture has to move from an ontology of being to an ontology of becoming, one that identifies architecture with constant change and development" (Haeusler, 2017). Hence due to the possibilities of technology, to add an information layer to the architecture is present. Lighting design has esthetic and functional qualities, and now also the ability to gather input from citizens and the surroundings. This enables a design that accommodate people by framing their experience of a space and listen and change in response to them. The use of architecture towz provide a statement or dictate sensation is nothing new, this is a big part of why buildings look in a certain way, to express what the building is being used for, or to provoke the senses in different ways. Examples on this could be American embassy in Oslo(fig.1) reflect authority and grandness, but the temples of Kyoto in Japan (fig. 2) want to create atmosphere for awe and calmness.

Figure 1: American Embassy in Oslo, Norway

Figure 2: Daigo-ji Buddhist Temple in Autumn - Kyoto, Japan

But the increasing number of sensors installed across cities that generates large amounts of real time data streams, new opportunities are arising for integrating these data streams into our spaces and architecture that could improve existing city infrastructures (Tomitsch, 2017). This citizen centric media architecture is defined as digital placemaking. This new trend makes links to traditional placemaking, as defined by Jane Jacobs in the 1960's (Jacobs, 1961) . As an idea and toolkit for improving neighborhoods or cities, Placemaking in a city planning perspective is to design cities and spaces for people (Project for public spaces, 2018). Digital placemaking can use data in the design to reflect on its surroundings and give even more back to the city and its citizens as a new layer, and the term explains how media architecture

can contribute to placemaking (Tomitsch, 2017).

Tomitsch (Tomitsch, 2017) is separating digital placemaking into two concepts, spectacle placemaking (fig. 3), and infrastructure placemaking. He is stating that often initiatives in cities concerning light and media, such as festivals and seasonal events, which succeeds in making experience for people and economic benefits but fails to improve the services available in cities. The potential is huge to further explore if same principles and ambition would go into use the built environment and light to improve the life in the city on a permanent basis.

McArthur (McArthur, 2017) states that responsive light combined with an appropriate civic and social agenda might contribute to cities that bring the "smart rhetoric", as introduced earlier in the section regarding smart city, making city infrastructure smart for the citizens, something that is closer to reality. It is also offers opportunities for the urban public to engage with and participate in positive, sustainable placemaking. Artists and designers can use digital media to promote a shared vision about how we might thrive in our cities. He further states that the technology exists for designer or artist to use lighting and interactive design as a tools for interactive communication about the city by the city, allowing us to tell useful stories and in turn see and hear our urban spaces in a new way.

An example here is the project TetraBin (Bai,2014). It was a project that used interactivity to raise awareness about environmental issues. A thrash can was cladded with screens around, and it acted on the people throwing thrash, and made it fun and draw attention towards the act of using garbage cans. This initiative could help in the city, in raising awareness over the act of throwing garbage.

Figure 3. Temporary light installation in Lumere Light festical in London

Figure 4. TetraBin

1.1.3 Media Façade – Non commercial

In the built environment, the building façade has an especially big potential to be part of what is defined as infrastructure placemaking. They cover big parts of our cities, and after work hours many buildings are empty, but by providing both esthetics and information, they could at same time get a night time identity and be useful for the people in the area.

The conventional way of doing lighting for façade is to switch on a design that is set by a designer. However, it is possible to let everything around us control the lighting. A discussion is often where to draw the line between a media façade and a lighting design for a façade. The lines are blurry, and what is a media façade and what is media architecture can be difficult to pin down. All projects are different, and in terms of digital placemaking is it not important with definitions, but to see what serves the community, be a screen or a building façade, it is just tools to reach a goal. In this thesis it will be focused on projects that are using the façade to create awareness and use data as a trigger for the lighting.

Fortin and Hennessy (Fortin & Henessy, 2015) states that private corporations and public institutions are more likely to have access to the resources needed to build and deploy big installations and media facades. Many will associate media façade with commercials and branding, and the power of this is unquestionable. Therefore, it is important for artists and designers to see how we can use urban facades in a way that serves the city. One example of this is a project called “Megaphone”. It was set up in the center of Montreal by Moment factory, and its purpose was to be an architectural-scale interactive “speakers corner”. The installation used a hand-held microphone where people could speak of their chosen subject, and words would be transformed and projected on a large façade on a nearby building. It had two modes: live mode and sleep mode. The live mode projected words in real time, and the sleep mode used words that had been saved during the day and projected it on the façade. So it that sense it was the mood and the topics that people had during the day that would work as an input for the facade lighting during night. Combining political relevance with an emotionally rich artistic experience, Megaphone achieved the ultimate goal of all participatory urban projects: the reappropriation of the public space by its individuals and communities (Fortin and Hennesy, 2015).

1.1.4 Context and participation

For an artwork or installation to be successful in terms of creating awareness, it is important that it is understood. If successful It can create a link between the built environment and its surroundings.

Poulsen, Andersen & Jensen (Poulsen, Andersen & Jensen , 2010) did a study of how it feels to be in a responsive urban environment and which design methodologies can be used to design responsive light scenarios in the context of the public lighting. They made different light scenarios on a square and it was triggered with people walking by and the lights changed accordingly. They found that most people do not change behavior or feel uncomfortable in changing illumination, but that the majority of people in their study did not want to interact with the lighting. Also in their project the people that were inside the square did not always understand that they changed the lighting. But they find that the changing illumination has social and esthetic qualities for people observing from afar, let’s say in a car or a resultant. They underline the importance of that these individuals, which is everyday users of the place, have to be taken seriously in a design of a responsive light system. That’s why a thorough site analysis is important, and that the dynamic lighting scheme fits into the context of the place.

Miller (Miller, 2017) states that engagement and participation does not always mean exchange or dialogue. He continues (Miller,2017): “More often than not, it seems to be about the opportunity or excuse to stop, lingering and contemplating the potential otherness and consider, a heap as a place for laying down, storing and retrieving associations, linkages and writing relationships. “ Auguri (Auguri, 2017) agrees with this and states: “Designing place, not installations: Good designers know better than only look at the buildings boundaries, but seek to re-define place wide relationships.” Thinking and designing holistically is very important. It is not only the technology and its users to take into account, but also physical space and urban form, history, memory culture, socioeconomic conditions and more

(Auguri 2017). So when designing with digital placemaking in mind, a holistic approach is important.

When it comes to art and public installations in general, it has the power to create a thought, give you some hints in a direction of a theme or create associations which may spark a conversation. This leads us to the question about abstraction – how is the infrastructure placemaking work if it is not understood? In many cases it can be even more powerful to use abstraction, instead of text or screen which shows directly what you want to say. An example here is the project "888 Collins Street" (Ramus, 2016), where weather data predicts different patterns that lights up the façade (More information in the example study). It may not be perfectly clear until someone tells you about the concept, and the building immediately gets a new depth. This could relate to all art, that sometimes you need to be told the concept to understand the meaning, and other times the artist don't know or want you to do your own interpretation. But as designers trying to create a better city through digital infrastructure, a meaning should be there, not necessarily direct, but something that may create awareness or tells a story. For people who pass by "888 Collins Street" every day, a rumor may start and in the end most people would know the concept behind the lighting. So the question how clear do you need to be to get your message out is relative and not easy to answer.

1.1.5 Ambient Communication

Another essential and interesting term that explains how to communicate within architecture is ambient communication. Light act as an interface between the digital world and the psychical world, and the benefits for using digital content for lighting could be to render the inviseble visible. It could mean visual representation of weather, air traffic, social media traffic and much else in a calm, abstract and subliminal way.

This is backed by the science of human biology by Robert M. Sapolsky which states:

"1. A way of conveying information and aiding human behavior in a peripheral, calm manner.

2. Spaces capable of sensing and responding to people or events to create engaging and informative environments."

Definition of ambient communication by Tapio Rosenius, founder and CEO of Lighting Design Collective (Rosenius 2017)

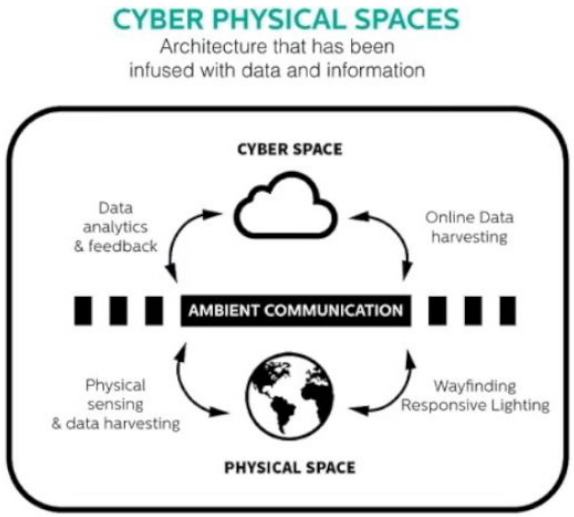


Figure 5. A loop showing ambient communcation between the digital world and the physical space

“Humans have substantial ability to process ambient and peripheral information that directly affects our feelings and subconscious contextual understanding without the need to activate cognitive thought processes. By introducing meaningful digital feeds to our built environments through ambient communication we enhance and extend our conscious and subconscious awareness of what is going in around us.” (Sapolsky 2017)

When information comes to you in an ambient manner, it does not draw your attention or it does not stop what you doing but it seeps in. But we as humans have a huge ability to take that information in. So what Sapolsky is saying is that if we utilize this by using digital feeds in our built environment through the concept and ideas of ambient communication we can enhance and extend our subconscious awareness – becoming aware of things without being aware of them – and it can be potentially powerful in lighting design based on the Hierarchy of focal accents, a research published by Lou Michal in 1996 (Michael, L 1996).

It describes the order of thing we perceive involuntary the first millisecond when entering a new space, before our consciousness takes over and decide where to look, in an order of importance:

1. People
2. Movement
3. Brightness
4. High Contrast
5. Vivid Color
6. Strong Pattern

What can be derived from this, and especially interesting for the lighting designer, is that except people all the other factors is in the vocabulary of light. This research can be used to create a dynamic environment, by aiding people on a functional and emotional level.

Theo Rossiarious (2017) states that movement and meaning creates a powerful combination. Movement creates tension, which leads to attention, and creates a focal point which result in a memory. He also states that ambient communication should be the opposite of all other digital devices and data streams that screams for our attention, ambient communication should be subliminal, to creates an ambience. And if ambient communication is used to create awareness, it can be powerful if the message is clear and not to complicated. Ambient communication is nearable, it is not on you anymore, it is in the architecture and in the surroundings.

Keskinen et al. (2015) states the time we live in and near future to be an gadget free, hyper connected environments, which relates to ambient communication. They states that this is already happening, and that it will inevitable change our relationship to the physical world and our relationships with other people, affecting communities, societies and economies. They also states that these new opportunities are positive and have opportunities to make life better.

1.2 EXAMPLE STUDIES

In this section projects related to digital placemaking and ambient communication will be presented, as derived as interesting concepts to work with from the theory section. They all have in common that they use light and data in an unconventional way. Some of the projects make it possible for people to interact directly with it, and others uses sensor management to trigger the design. They all have in common that they want to raise awareness of environmental issues. The projects range from small installations to large facades.

1.2.1 Tetra Bin

Sidney, Australia 2014
Design: Steven Bai

The vision of the designers behind TetraBin was to explore how digital technology can be used to motivate positive change in urban environments (Bai,2014). They use aspects of gaming, and the act of putting rubbish into a bin is turned into a game, where a piece of rubbish is mapped to an interaction within a game world displayed on a computer-controlled screen surrounding the bin. Display screens consisting of 900 LEDs, with a translucent layer of polycarbonate that covers each screen, is wrapped around the bins. Infrared sensors are used to recognize the thrash put into the can, and code was written to translate the data collected from the sensors into a visual pattern.

This project is a good example in how to use digital media to augment or enhance urban infrastructures, effectively improving the quality of urban life by raising awareness of the trashcans that leads to less garbage in the streets.

Figure 6. TetraBin

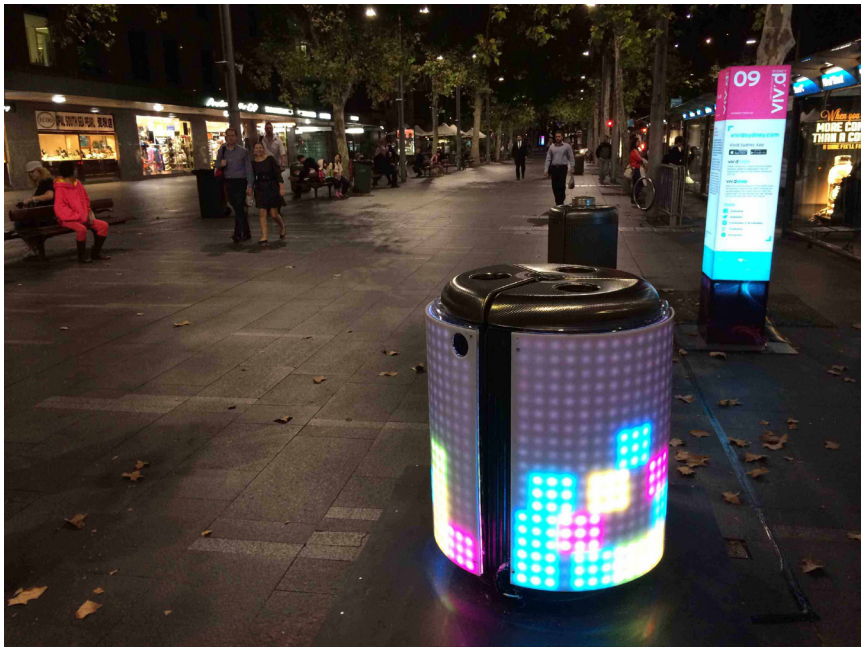


Figure 7. TetraBin

1.2.2 Energy Tower Façade Lighting

Roskilde, Denmark 2014
Concept design: Erick van Egeraat
Lighting Design: Gunver Hansens Tegnestue

This big power plant operated by KARA/NOVEREN, has a 190 meter long body and a 100 meter high tower, and has become a landmark. The lighting design for the power plant gives the possibilities of many variations of dynamic light scenes to play in its facades. The façade is made by dark brown aluminum sheets, with are perforated by a pattern of circular holes ranging from 25 to 100 cm in diameter. RGBW LEDs are hidden behind the façade plates and illuminate the inner building façade at night, and the LEDs are not visible from outside the building. Connected to a light control system, each LED can be controlled and programmed into dynamic light scenes.

Built in 2013, the plant met high environmental standards and its purpose is to create energy of waste that cannot be recycled.

The vision for the project was to make “a structure with the ability to communicate and relay messages of sustainable energy to the public”. Located only a few hundred meters from one of the major inroads to the Danish Capital of Copenhagen, it has a huge reach and potentially thousands of spectators on a daily basis.

The lighting design concept is described like this and aim to sends the message of waste-to-energy to spectators. It is an important message with global relevance:

“At night the backlight perforated façade transforms the incinerator into a gently glowing beacon - a symbol of the plant’s energy production. Several times an hour a spark of light will gradually grow into a burning flame that lights up the entire building. When the metaphorical fire ceases, the building falls back into a state of burning embers.”

It is said that the media façade is used to communicate with citizens, and to align with events, such as Roskilde Festival. The color for the festival is orange, and the photo is taken from the week that this festival was on.

The CEO of the power company states this:

“We’ve already received an overwhelming public support for this project. People respond very well to the idea and the concept, and they really like what it adds to the area in terms of architecture and beautiful lighting. This is extremely valuable to us for branding purposes and to secure a future leading position in waste management. We see it as a great investment on several levels. We’re happy to combine an investment in modern waste management methods with an extraordinarily beautiful structure and landmark for the area” (Martin, 2014).

This shows that a project like this is valuable for the client, as well as the potential for building of infrastructure to be transformed into a beautiful landmark which create awareness over what they do for the city.

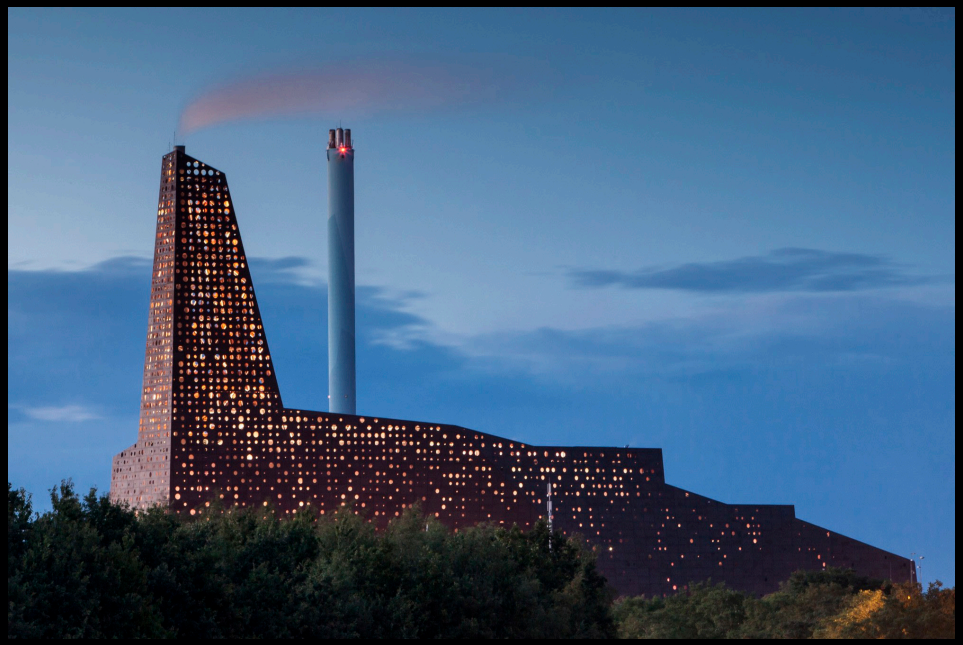


Figure 8. Roskilde Energy Tower

Figure 9. Roskilde Energy Tower

1.2.3 Particle Falls

Temporary art installation in San Jose, USA 2010
Designer: Andrea Polli and Chuck Varga

This project (Polli, 2010) reveals the presence and impact of particle pollution through a real time artistic visualization on the side of the building, in form of a waterfall. The brighter and stronger the waterfall appeared, the higher the concentration of particles in the air.

To get these measurements they used a nephelometer, which is a sensor that measure the particles in the air, and a projector as a light source. The vision for this project was to raise awareness amongst the public about air pollution and thereby encourage behavioral change. Since it measured in real time, it was able to show directly in what way human activity can make the air quality worse.

Since it was only temporary, the artist states that it is hard to measure the effects and if it did raise awareness that lead to better air quality. But according to the website Curating Cities – a database on eco public art, “The work had the capacity, if installed over a longer period of time, to demonstrate how a public works project like a light rail project would improve the quality of life for the people living in San José, i.e, by reducing particulate matter and improving air quality.”

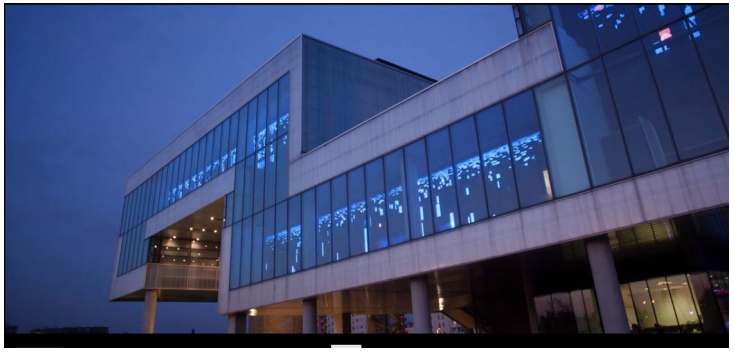


Figure 10. Particle falls.

Figure 11. Particle falls.

1.2.4 Human BEEing

Helsinki, Finland 2014
Concept Design: The Constitute + Connecting Cities Network
Interaction design, Light design, hardware and content: The Constitute

This temporary project (Piatza & Albert, 2014) demonstrates the use of digital placemaking technologies not only for connecting people with their cities, but also for raising awareness of global pressing issues. The project wanted to create awareness over the very important role of the bees, which is to pollinate plants and produce honey. Bees are misunderstood to be dangerous which they are not, they are on the list of endangered species.

A camera was placed to capture a real hive being built, and an edited material was projected onto a building in a 90 minutes loop.

Figure 12. Human BEEing.

1.2.5 Waterlictht

Various locations, 2015
Design: Studio Roosegarde

This project (Roosegaarde, 2016) are using light and the built environment to create awareness over global issues. In this case it is climate change and the threat of higher sea levels. The Netherlands is especially vulnerable to flooding. This project actually let people experience the power of the ocean, and let them walk under it and experience the height which the sea level is predicted to rise.

The installation uses LEDs, software and lenses to create the visual effect of rolling waves of water. Steam machines were used as a medium to capture the light. The piece has been showed many places and among them the Museumsplein Square in Amsterdam. The size of the square is 32 500 m^2, and on this scale you can imagine the visual impact the artwork gives. The blue color and the visual appearance of the water give clear associations to what the artwork aim to tell, that is the story of water and create a discussion of the power of water, its dangers, and potentials.

It is a good example on the level of abstraction that can be used when using light and the built environment to create awareness. It is possible that most people will from the color and visual appearance connect the artwork to their associations with water.

Figure 13. Waterlicht

Figure 14. Waterlicht

1.2.6 888 Collins Street

Melbourne, Australia 2016
Design: Ramus and Toby K

Melbourne, Australia has a weather that are changing often. The projects (Ramus, 2016) uses the analogy of the collective weather obsessions and use it as a trigger for the content, and uses the building as a real-time weather display.

The building is 15-storeys high, situated close to the Melbourne's central business district. The lighting design has two modes. The first mode displays the forecast for the following day based on data from the Australian Bureau of Meteorology. The second mode the building reflects the actual weather based on real time data provided by a weather station installed in the building's rooftop. The first mode is activated from dusk until midnight for five minutes at each full hour. The second mode is activated on all other times. The lighting responds to rainfall, cloud cover, wind speed and temperature. Low and high temperatures are displayed on the top and bottom of the building. Wind is displayed as light in turbulent motion and clouds as cloud formations on the top of the building, and if its rain, the clouds change to visualize this.

The 5500 square meters façade is covered by 2.4 kilometers of linear LED fixtures .

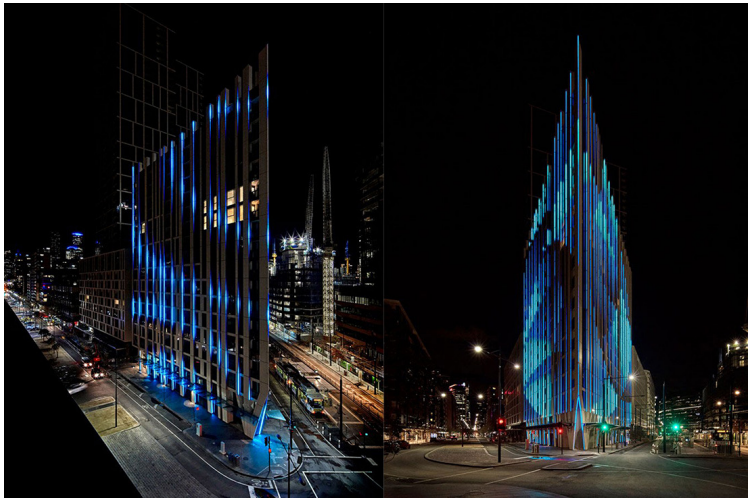


Figure 15. 888 Collins Street

1.2.7 Summary part one

We have seen definitions on the terms media architecture and digital placemaking, and that the technological advances happening in society also influences architecture and the build environment. In this lies possibilities for the lighting designer, to implement citizen centric media architecture that is defined as digital placemaking into buildings of infrastructure.

For example, the above mentioned “888 Collins Street” compared to the previous example, “waterlicht”, and the earlier discussion about level of abstraction, this is an example on a artwork that has a level of abstraction so the audience needs to be told about the meaning to get the full picture, but still have the properties of sparking a conversation.

I would argue that in a case like this façade of “888 Collins Street”, since it is a permanent installation where alot of people live and pass by regularly on their way to work or other places, it is adding to a experience that would last longer since it is not to obvious. The waterlicht project, is of a temporary nature, and a lot of people will just see it as they pass by, and could be more important to get the message to them in a more clear way since it will only be there for a short period of time. This consideration is based on that the projects is trying to raise awareness over a selected cause.

With the optimistic tendency in theory of the power of using data in lighting design, and with the combination of the facts regarding “Particle Falls”, which was believed to make stronger impact if the solution was permanent, and Roskilde Power Plant, which the owner describes great attention to the lighting design and awareness for the building, the potential for Smestad Recycling plant should be in place regarding raising awareness over environmental issues in a way that it serves the citizens through the design principles of digital placemaking and ambient communication.

This shows that light and built environment has a potential to add a new layer to the city infrastructure, in a way that it is serving its citizens. It shows that awareness around topics can be altered through thoughtful use of light and the city.

PART 2: CASE STUDY - SMESTAD RECYCLING PLANT

2.1 MOTIVATION

The interest in what was defined in the introduction as infrastructure placemaking, and how it could be used to be create landmarks and provide information that serve the community, it was decided that Smestad recycling plant would fit for a case study. Interesting architecture (Longva Architects, 2015), combined with simple materials, and no light scheme for the façade at night are in place at the moment. It is located close to the main highway (Ring 3) into Oslo. Parallels can be drawn to the successful project described in the example studies, Roskilde Power station. The activity that happens inside the building is a collective action towards a greener city, and on the other hand the symbol on pollution is right next to it. At the same time, the city of Oslo have announced bold environmental goals. Oslo will be European Green Capital in 2019, and they aiming to reduce CO_2 emissions with 50 % by 2020, and 90 % by 2030. At the same time, their strategy consists of four points:

1. Show the inhabitants of Oslo the “the green change for the people”.

2. Raise the support about a ambitious political environmental- and climate strategy.

3. Strengthen the green commerce.

4. Strengthen the profile of Oslo as an internationally leading green city.
(Bymiljøetaten, 2016)

The main route into Oslo can be a symbol of pollution, but at the same time a place where the results of the Oslo climate strategy can be measured. By the amount of people using bikes, public transport and how many using their car. The location is perfect to reach a broad spectrum of the inhabitants of Oslo and the outskirts. As we will see in the analysis, people passing by is people using the whole range of transportation methods, from bikes to cars.

2.2 SITE ANALYSIS

Figure 16. Map showing location of Smestad Recycling center

2.2.1 Context

Smestad Recycling Station is situated 6 km west of Oslo city Centre. It is placed in a residential area, and close to one of the main highways (Ring 3) into and from Oslo. The road is busy, and on weekdays you have morning and afternoon rush where the traffic is slow. There is not a lot of activity in the area, and facing the station on the other side of the road is office buildings.

Opening hours

Monday to Friday 07:30 to 21:00, and closed on Sundays.

Daylight

By study the hours of darkness the big difference in summer and winter in terms of daylight comes to show. At most, in december, it is 16 hours of darkness on the location, and in july, only 5 hours (fig.20).

Existing lights in the area

During opening hours and darkness outside, the light will pour out of the perforated steel sheets on the facade. So it is only outside of the opening hours it is a potential for a different lighting design, since the building is all dark when closed.

Figure 17. Smestad Recycling center facade

Figure 18. Smestad Recycling center intrerior

2.2.2 Building

Smestad recycling plant was finished in 2016, by Longva Architects (Longva Architects, 2015). The building has high environmental standards and raised with materials with minor degree of treatment both in construction and façade: Elements of concrete, bricks, wood and Corten-steel elements. The building has green roofs with sedum vegetation. The building is 135 m long and 16 m at its highest. (Byggeindustrien, 2017). The corten steel elements are 2 meters wide.

2.2.3 Function

The recycling plant is part of Oslo municipality renovation department, which has the responsibility of waste management in the city. Smestad is the most urban of recycling plants in Oslo, where the others are bigger and located in more hidden in industrial areas. It is a place where residents of Oslo bring their other garbage than household waste, up to 3m³. You enter with your car, and inside you have 16 different containers where people are sorting their garbage, ranging from plastic, to furniture, electrical components, paper, steel, dangerous goods and so on. Nothing is being processed at the site but driven away to a bigger plant for processing. About 33 % is now being recycled and the rest is burned , as confirmed by plant manager Knut Børing in an interview conducted on January 2018.

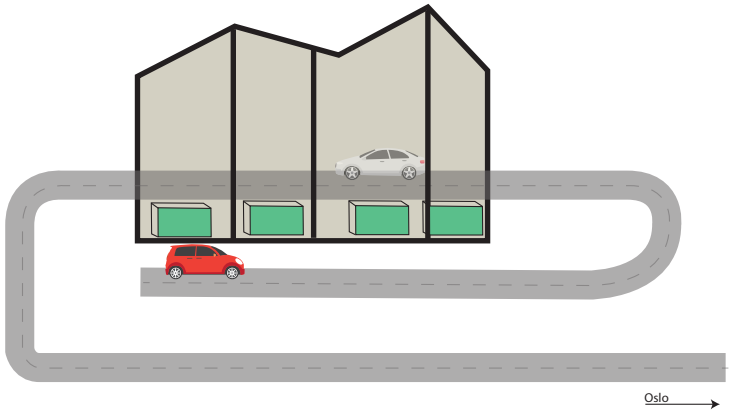


Figure 19. Illustration showing workflow.

Figure 17.

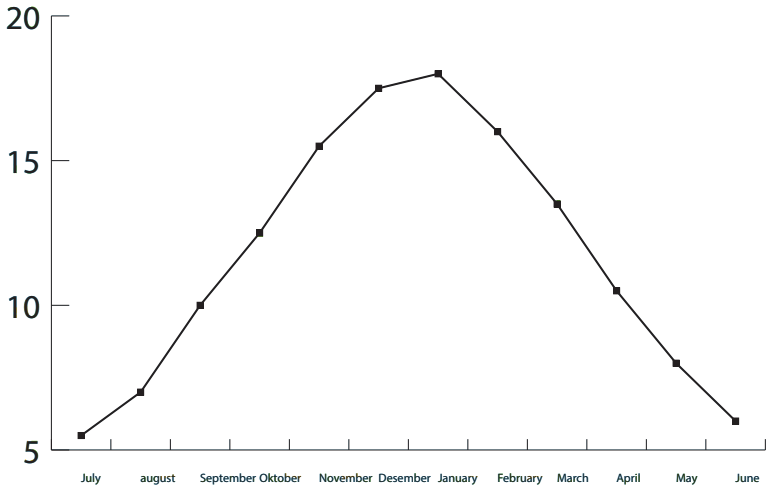


Figure 20. Graph showing hours of darkness at location.

2.2.4 Visibility

When dealing with lighting design for a façade, then the context of the building, who can see it, from where and how long, plays an important role, as stated in the theory section. As we can see in Figure (X) the building is visible from many locations, and some location offers more limited views. As the mobility section points out the traffic in the area are mostly for people passing by. This means that the time people will see the façade is very limited. So this is a very important notion to bring into the design phase, that your message needs to be absorbed in a shot amount of time.

Estimation of time of visibility based on observations:
Bus / Car: 15 sec
Bike : 45 Sec
Walk : 7 min

2.2.5 Mobility

There is a lot of traffic passing by the location, either by car, public transport, people on foot or by bike. Besides the highway there is bike commuter path and a walking path in both directions passing the station, and a bus stop for public transportation.

Cars – Car traffic is high, and rush hour in the morning and the afternoon. It is a 4 lane road, 2 lanes in each direction.

Public Transportation – There are many different bus lines that uses this route to and from the center, both local routes and long distance.

Cyclists - On both sides of the highway you have not designated bicycle paths, but paths used by cyclists when they commute from the suburbs into the city.

Pedestrians – Each side of the road there is a pedestrian route. It is not a place bustling with life for pedestrians, but it is used to get to public transportation or work if you live close by.

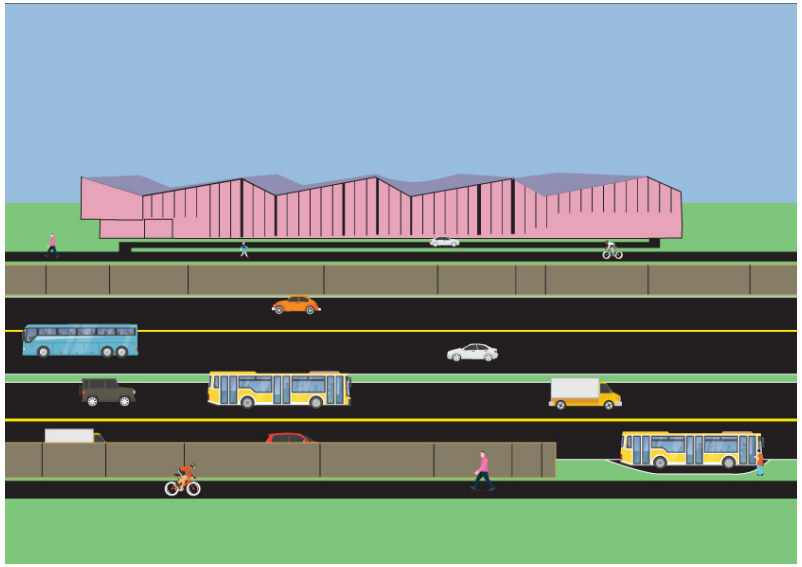


Figure 21. Illustration showing the different users of the area. Local bus, long distance bus, bikes, people on foot and in cars and trucks.

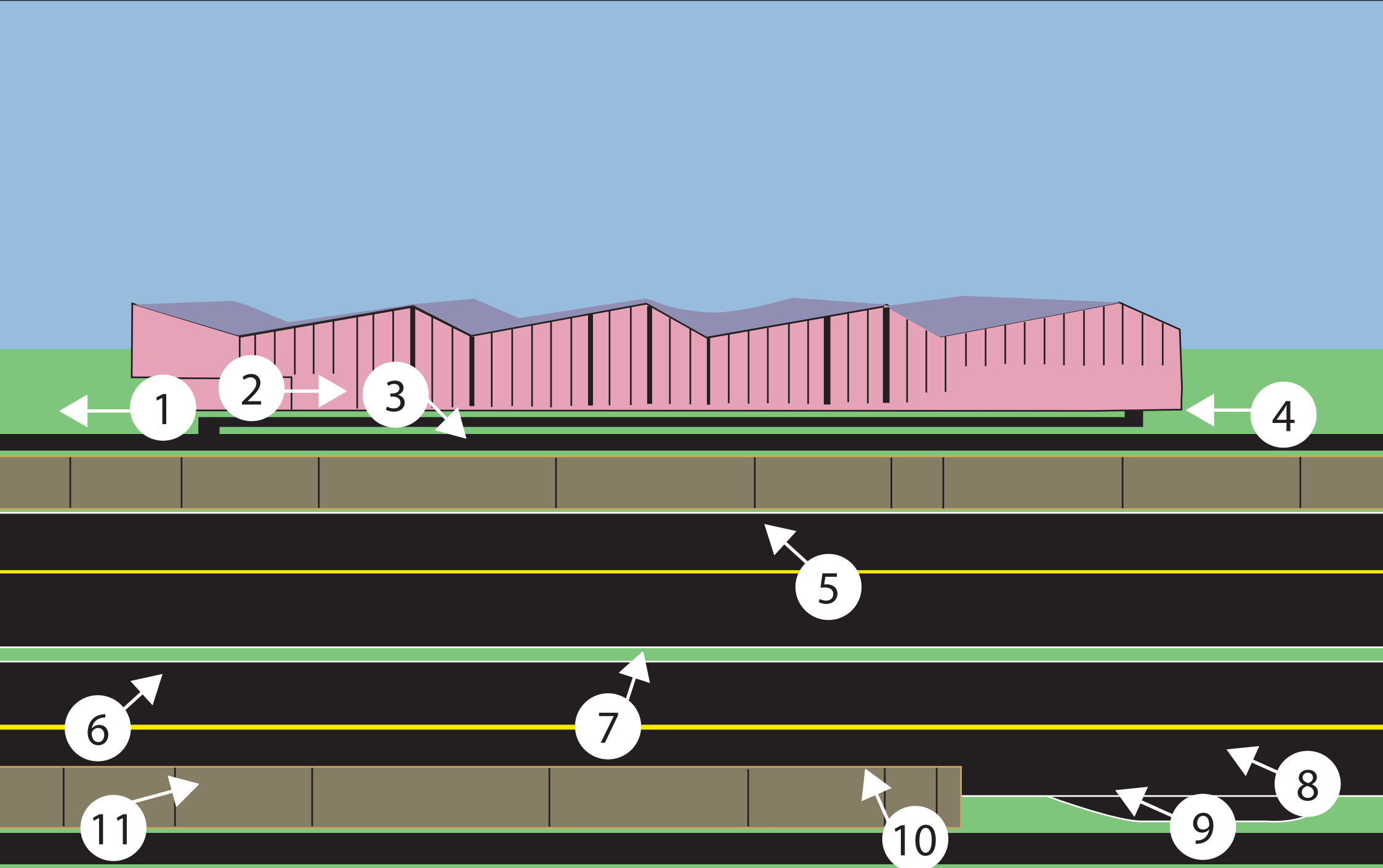


Figure 22. Numbers and arrows shows wich direction the point of view is at the photographs in figure 23.

Figure 23. Photographs showing point of view.

2.3 DATA COLLECTION

Since the aim is to use data in the lighting design, a wide approach was put in to find what is available both locally and on a more municipal level of different types of data and information. The available data was analyzed to find which could be interesting for the public and municipality to create awareness about their contribution to making Oslo a greener city. All the data presented is open to the public. The aim of this section was to find data that could be converted to useful information through lighting design.

2.3.1 Local data at Smestad Recycling Plant

The first natural step was to create a dialogue directly with the management team locally at the station, and to see if there was interesting data collected about the use of this site. A phone interview with Knut Børing, the manager of the plant, was conducted in January 2018, to find out what was being logged.

What	How	How often
No. of people	Counting	Daily
Full containers being driven away	Weight, Count on each segment	Daily
Recycled waste	Fragment of type of goods being recycled	Yearly
Burnt waste	Fragment of type of goods being burnt	Yearly
All containers	Weight	Realtime
All waste collected	Weight	Yearly

Target Goals on recycled waste to burned waste

What	Target 2025	2017
Recycled waste	50 %	32 %

2.3.2 Air Quality measurements locally at Smestad

Real time measurements from 13 different locations in Oslo is carried out, including at the Smestad recycling plant. As stated in the climate strategy for Oslo, less cars, and more people in public transport, by foot or bike, is a goal towards a greener city. The first and biggest contribution to bad air quality is cars, or said in other words, the number one tool towards better air quality is less people in cars. That is why I find measurements of air quality very interesting, since the air quality data at the same time is a symbol if the political strategy towards a greener city works.

The air quality has gotten better in Norway the last 20 years. But local air pollution is still a big problem in many Norwegian cities, and the national goals for local air quality was not reach in 2016 (Norwegian Environment Agency, 2018).

The air-quality in real time is measured by three components:
1. PM10- Particles in size of 10 micrometers or less
2. PM2.5 – Particles in size of 2.5 micrometers or less
3. NO2

Consequences of bad air quality
Particulate matter in the air is what mainly contributes to bad air quality. Children, pregnant woman, the elderly and people with asthma and respiratory diseases are particularly vulnerable. It is well documented that air pollution contributes to death and loss of healthy life in Norway (Norwegian Environment Agency, 2018). Particulate matter consists of a size so small that they can be inhaled. The larger particles will be stopped in our airways, but smaller (called PM10 and PM2.5) can penetrate deep into our lungs.

2.3.3 Data and targets from Oslo municipality

"The Climate and Energy Strategy for Oslo" (Bymiljøetaten, 2015) was released and adopted by the municipality in June 2016. This strategy is outlining how to implement a green shift for the city, and initiatives on how to meet the bold targets for reduction in CO_2 emissions. Greenhouse gases has increased with 25 % since 1990. In 2013, CO_2 emissions were approximately 1,400,000 tons. To achieve the target of a 50 per cent reduction by 2020 from 1990 levels, we will have to cut CO_2 emissions with about 800,000 tons.

This targets could be interesting for this project, as it is seen as an effort only possible if all citizens of Oslo participate through waste management, using public transport instead of the car and other environmental actions, and if the government is making right decisions and planning so it becomes possible. It is also a factor why a lighting project to create awareness on these issues is relevant for the city.

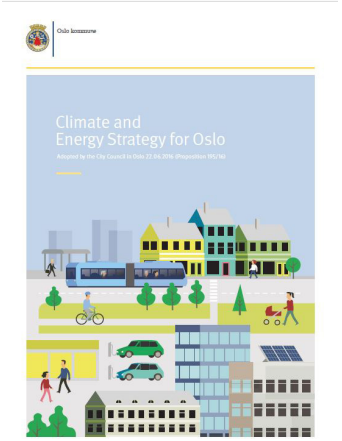


Figure 24. Climate and Energy Strategy for Oslo

Figure 25. Targets of the Climate and Energy Strategy for Oslo

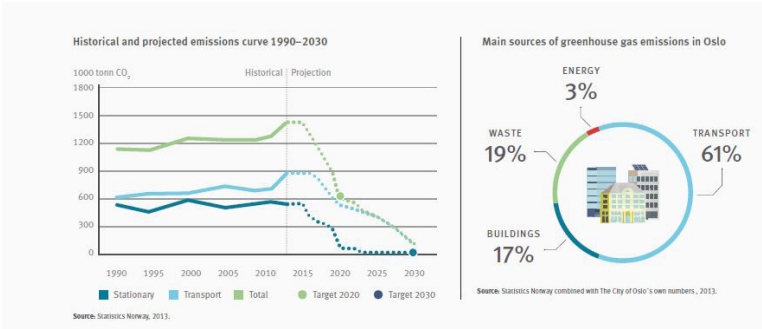


Figure 26. Transport as the main source for greenhouse gas emission in Oslo

2.3.4 Conclusion data collection and choice of data set

The data representing daily activity would prove to be difficult to show on the building without getting closer to a screen, and to use abstraction. Then the approach was made wider, and with the symbolic value of the recycling station in mind. The municipality was approached, particulary interesting were the goals the city had set for reduction in CO_2 emissions for the next years. The measurement of CO_2 emissions for a city is a huge task, complicated and of course discussed since it is so many factors. Tought was put into Smestad recycling plant and its exact function in the city. Let's say that the recycling station makes way for people to sort their thrash so it is possible to recycle near half of it instead of burning everything to create bigger emissions. In this way the recycling plant is doing a great deal for the total of CO_2 emmsioissns for the city. So this symbolic value of the station is something to use.

Further, one of the key contributors to the $C0_2$ emissions is traffic, which create air pollution and bad air quality. So the link to the main highway passing by the recycling station is interesting. As stated in the climate strategy for Oslo, less cars, and more people in public transport, by foot or bike, is a goal towards a greener city and better air quality. The first and biggest contribution to bad air quality is cars, or said in other words, the number one tool towards better air quality is less people in cars. That is why the measurements of air quality were found very interesting, since the air quality data at the same time is a symbol if the political strategy towards a greener city works or not.

So the connection here is that all small things contribute to the city as a whole. The people passing by in their cars every day, the people on foot or by bike, or the people in public transport, they all contribute to the environmental issues. So wouldn't it be nice to use the skin of the building to tell them what the quality of the air was, and if the trend goes towards better or worse? It could create a dialogue and it would be related to the place and the context of the whole climatic strategy for Oslo.

For this to be successful it is important that the air quality data would be presented in a way that it is understandable and possible to grasp. To make this possible, concept from ambient communication was used. The goal is not to let the façade become a screen showing numbers, but to show it by how the façade is lit, in a subliminal, subtle way. A careful analysis of the degree of abstraction is here important, to be sure that the message is understood. Another aspect is again how to present the air quality – real time, daily average, monthly average, as a trend if it goes up or if it goes down?

We already seen in project "Particle Falls" that the wat they use real time data from air pollution works very well. That's why it was decided for this project to use air quality data measured locally. Smestad recycling plant is a symbol for environment and recycling, and its identity is to work towards a greener city. That is why this data could fit to the context. It is close to the main road into Oslo, so at the same time you have people in cars, people in public transportation and people on foot or on bike. The whole scale is represented, and it is a location where you meet all the "players" in the quest for better air quality.

The recycling plant is owned and operated by the municipality of Oslo and is a modern facility which identity with environmental issues and recycling. The building reflects this, with humble materials and green roof. The idea is to support the architecture for the building, and to give it night time identity. But can I give the building a night time identity to reflect environmental causes, and at the same time let the light be driven by data and presented in a way that it is understood by the public?

With the optimistic tendency in theory of the power of using data in lighting design, and with the combination of the facts regarding "Particle Falls", which was believed to make stronger impact if the solution was permanent, and Roskilde Power Plant, which the owner describes great attention to the lighting design and awareness for the building, the potential for Smestad Recycling plant should be in place regarding raising awareness over environmental issues in a way that it serves the citizens through the design principles of digital placemaking and ambient communication.

Final Problem statement:

“How can a recycling station next to a highway turn into a beacon that make peoples interpretation lead against environmental issues and air quality at night by the aid of air quality data, light and the recycling station facade?”

2.4 LIGHTING DESIGN FOR THE FACADE

2.4.1 Use of data

As described earlier the data is collected in real time, and three components are measured, PM10, PM2.5 and NOx. A vital factor for the design is to represent the data correctly and to give them back as useful information. Following is an analysis on four different ways to use the data, in a search to best represent the data and be able to convert them to useful information.

Real time

Real time measurements mean that every single change in the air quality is reflected in the lighting design, as seen in some of the example projects. The site analysis shown that the attention span is very short for the people passing by, and there is not much time to stop and reflect on the constant changes. Due to this fact this is not the best way to reflect the data. The lighting would be rather hectic, which breaks with the principles of ambient communication, and the real-time changes would be difficult to visualize in such a short attention span. Also, since this is on the side of the highway, care should be taken by stealing to much attention from the drivers.

Daily

The lighting design could reflect the air quality during the day. This would be a better approach, because it is no need for constant change, and it support better the design principles of ambient communication that a subtle change create awareness in a situation where the attention span is short. Another positive thing is that is the watchdog-approach, by providing a summary concerning if the air quality has been under the accepted limits more than the opposite. Since the most traffic is during the day, this approach makes sense since daytime is the time of most air pollution, and the data will be reflected on the façade during the evening.

The message is easy, it gives a lot of information about the success of the city's strategy, and the individuals own participation in terms of working together towards a green city. Since the message is quite clear, it should be easy for the meaning of the lighting design to spread to the citizens and after a while people will understand the meaning of change due to the lighting.

Better or worse / same week last year, Tendency/Trend

This approach takes the data measured the same day and compares it with the same data from last year. This approach could be a good way of reflecting the results of the green strategy for the city, since the best way to get less air pollution is to lower the traffic and get more people using the public transportation or bikes. So the air quality that day is better than last year, this could be reflected on the façade. This will follow nicely along the next two years with the city's goal of reducing the CO_2 emissions, due to the fact that air quality plays a part in this calculation.

Conclusion on use of data

After an interview with Dag Tønnesen, senior researcher at Norwegian Institute for Air research, we concluded that a day summary is the best way to reflect the air quality locally. It is less complex and more important to citizens than a tendency or comparison of today to the same day year. With tendency, you get more complexity regarding the interpretation of the data.

Weather plays a big part, and to compare one day with the same day last year does not really say something about whether the air quality is better and does not depict a tendency. It is more complex to find trends in this data, which includes too many factors that could make the message too complicated for the lighting design.

After the analysis based on findings in theory section and site analysis, it was found that the best way to tell a lot of information useful to the citizens on a short attention span and in a subtle way, is by using two main lighting schemes which represents a reflection on the air quality every day. If any of the parameters has reached levels higher than the recommendations for daily levels, the lighting scheme for bad air quality will be triggered. The point is rather easy, and it makes up for a good story that an abstract lighting design could quickly provide meaning and usefulness for the citizens. It also dictates the need for two very distinct design, one for normal days and one where the air quality levels has been under accepted levels.

2.4.2 Data Values

Air quality limit values gives the minimum quality for the air, and these are stated in the Norwegian law regarding air quality, and it is found in Forurensingsforskriften chapter 7. (Forurensningsforskriften, 2018).

PM10: 50 µg/m³
PM2.5: 15 µg/m³
NO_2 :40 µg/m³

2.4.3 Lighting Scenarios based on data values

Two lighting scenarios will be established:

Lighting scenario #1 will be triggered if all measurements during the day is below the levels mentioned in figure 27.

Lighting scenario #2 will be triggered if any measurements during the day is above the levels mentioned in figure 27.

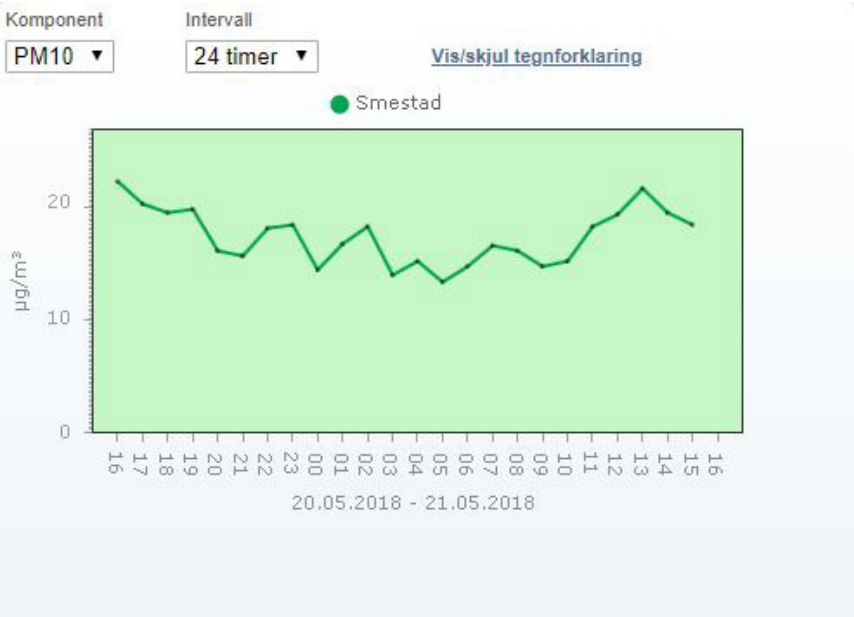


Figure 27. Graph showing data for PM10. This data is viewed on the website http://www.luftkvalitet.info/ in real time and can be derived from there when needed in the programming of the lighting scenarios.

2.4.4 Concept Development

After the kind of data was decided to be used and how, two different lighting schemes were planned. An important factor was to have two schemes of a significant difference, so it's clear when the lighting scheme change on the façade. It is clearly that the façade will show the scheme for good air quality most of the time. Due to this, the first scheme will be static, and subtle. The lighting will celebrate the building and the material, and in that way draw attention to the building. The second scheme will introduce color in combination with movement to create a dialogue regarding air quality, as inspired by the literature concerning ambient communication.

To reach the final design, the progress in this section is as follows:
Design criteria's for each lighting scenario was set. To figure out how to meet the design criteria's, a hypothesis for each criteria was set and an experiment was carried out to see if the hypothesis was rejected or not. The result of the experiment was then used in the final design.

Some early sketches were done with free experimentation regarding the spatial qualities of the building and how different light settings affected the façade and highlighted different parts. This gave valuable information in the design phase of what to do and what not to do. They are shown on the next page.






Figure 28. Spatial experiments.

2.4.4.1 Lighting Scheme #1:

Design for façade when air quality measurements is in accepted levels. Good air quality.

Lighting Scheme #1 should not reach for attention on the same level as Lighting Scheme #2, but rather celebrate the building and use light to enhance the architecture, and by that also throw attention to the building and its operations. Early experimenting and sketching led to the feeling that the façade easy becomes a screen, and the architecture itself is not put in light. So, for this reason this scheme will be a celebration of the building and its materiality.

Figure 29. Perforated steel sheets

The concept for this scheme builds on the perforated steel plates, and the process of corrosion. The sheets are made of Corten steel, and corrosion is part of their look. The process of oxidization comes from nature and is an ongoing process that decompose the material. This process is known to everybody an often has bad connotation that the material is old of bad quality. Put in the right light their true beauty will show, and the whole range of golden color tones will be enhanced through careful color matching with the light, that is key to this concept. It could be fair to say that the perforated plates play the lead in the architecture of Smestad recycling plant, and due to this light will be planned for the plates only. It will give the impression that the plates are the building alone, and the rest of the structure will be silhouettes side by side the lit plates. It's a big part of the architecture, so why not enhance it also for the night time identity?

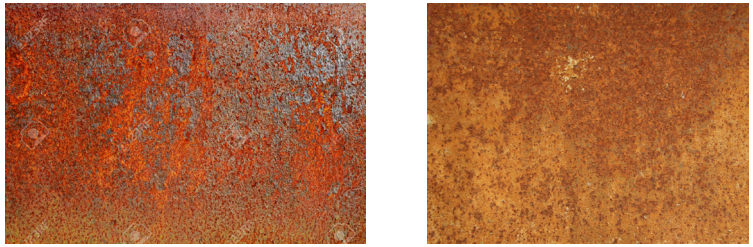


Figure 30. Picture showing the large color vairations in corroded steel

A nod to the process of oxidization, a gradient of light starting from the bottom and fades up to the roof, this hints to the oxidization as a constant process, and will also represent the many shades of color that exist in the material. Due to the natural appearance of the material, light in the white color spectrum will be used to reflect daylight in different times, light temperatures that occurs naturally.

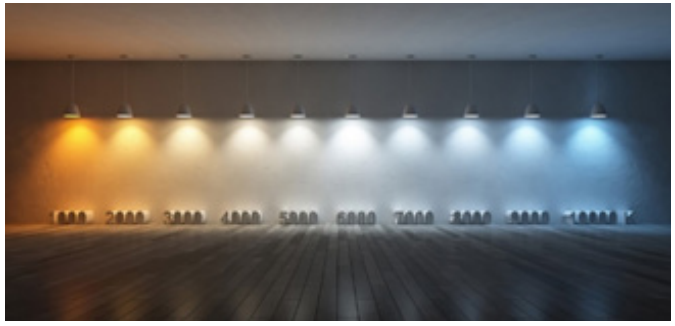


Figure 31. Comparison on color temperatures.

The steel sheets are perforated, and during opening hours and darkness light from inside will pour out of the building. The placement of light source could give very different results on a material like this, and experiments will be carried out to find the best solution.
To get more knowledge on how the material behaves under different color temperatures and placement of lights, an experiment will be carried out in a controlled environment with a corroded, perforated steel plate similar to what is used on site.

This conceptual ideas led to three design criteria's that should be met, and a quick sketch was used as a guideline for how to make the concept into a final design.

Design Criteria

1. *Material*

The light should enhance the golden color tones of the material and represent the spectrum of colors found in oxidization of steel.

2. *Process*

The process of oxidization's different colors needs to be put in focus by a gradient of light showing the variations.

3. *Placement of light source*

The light should be put in a place where it best supports the architecture and the materiality.

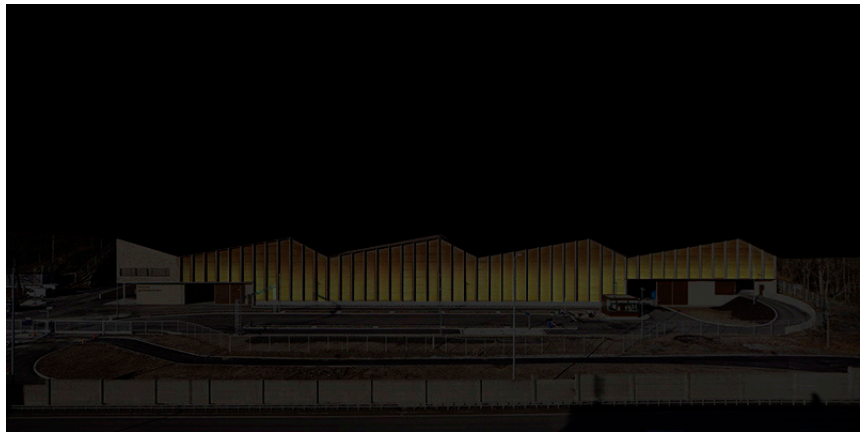


Figure 32: A sketch of the lighting design celebrating the material, and a reference for the experiment.

2.4.4.1.2 Experiment

An acid-treated perforated steel plate, with corrosion and pattern similar to the material on the site, was used to simulate the façade material. A range of LED- Strips in temperatures from 2000 K to 4500 K was used and judged in what way they are enhancing the material properties.

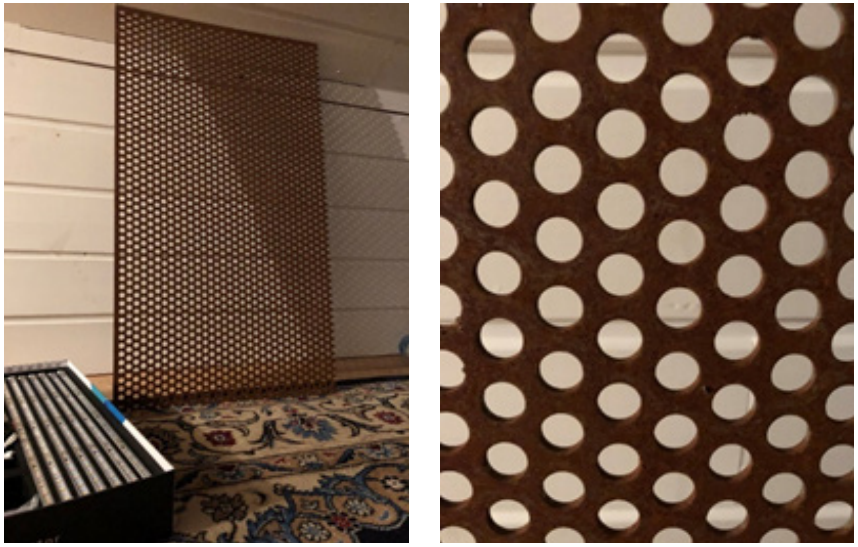


Figure 31. Setup for experiment Perforated steel sheet and LED strips

Hypothesis related to Design Criteria 1 / 2 – Material and process

By using a gradient of 5 different color temperatures, 2000K, 3400K, 4700K, 3000K, 3500K, 4000K, 4500K, a good representation of the golden spectrum of oxidization is in place.

Hypothesis related to Design Criteria 2 – Placement of light source

Placement of Led strips in front of the metal sheets gives the best possibilities to show the nature of the material and is most visually pleasing.

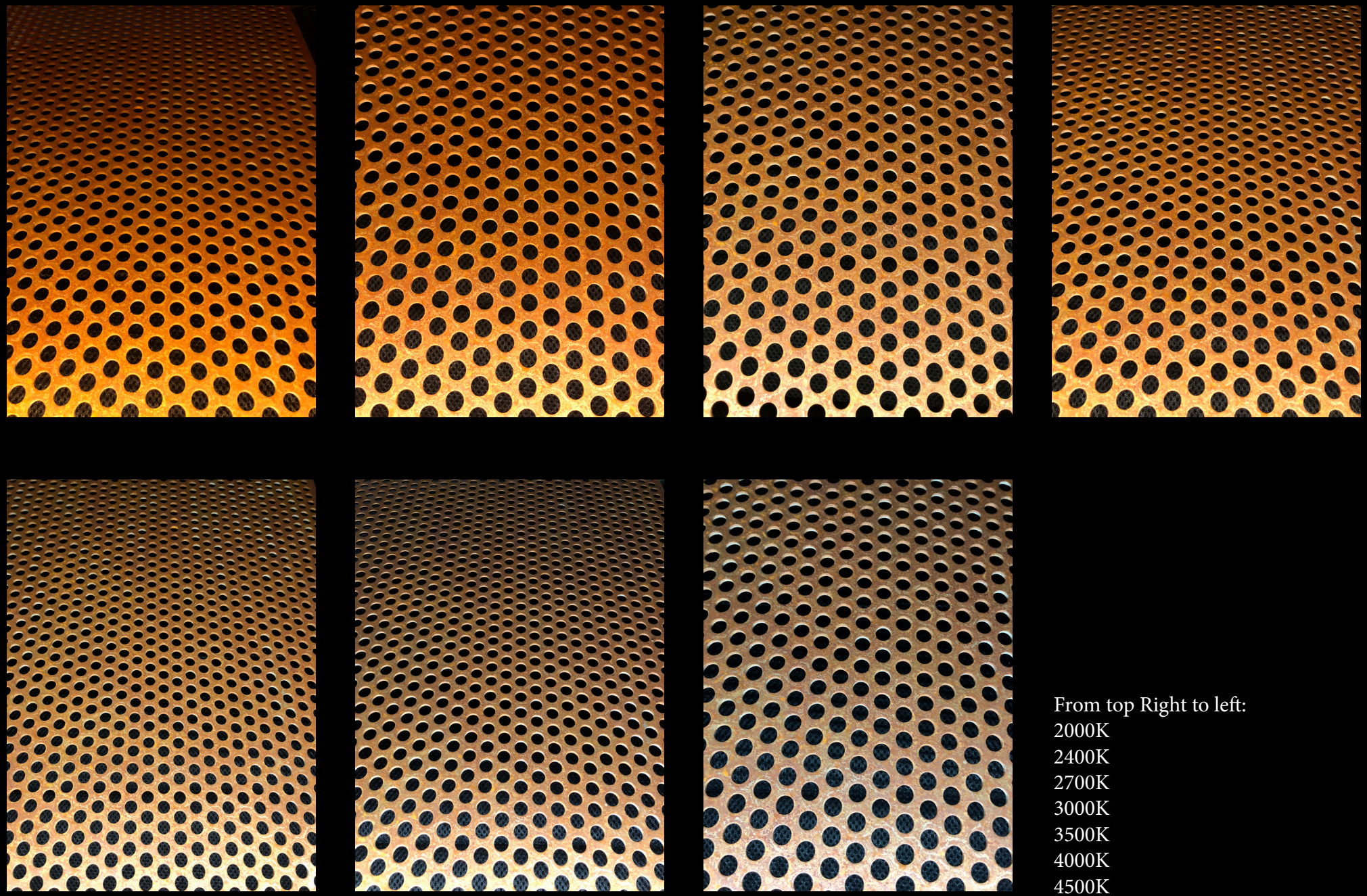
Experiment 1: Enhancing the material and process

"By using a gradient of 5 different color temperatures, 2600 K, 3000K, 4000K, 5000 K and 6500K a good representation of the golden spectrum of oxidization is in place."

Results:

CCT	Evaluation
2000 K	Beautiful glow, gives a deep golden color
2400 K	Beautiful glow, but brighter
2700 K	Beautiful glow, but brighter
3000 K	Beautiful glow, but brighter
3500 K	Starting to lose the color, and look less corroded
4000 K	Golden color lost and not visually pleasing.
4500 K	Golden color lost and not visually pleasing.

Result: The hypothesis was rejected since CCT over 3000 K was not enhancing the material at all, rather made it look bad.



From top Right to left:
2000K
2400K
2700K
3000K
3500K
4000K
4500K

Figure 34. Photographs from experiment.

Experiment 2: Placement of light source
"Placement of Led strips in front of the metal sheets gives the best possibilities to show the nature of the material.

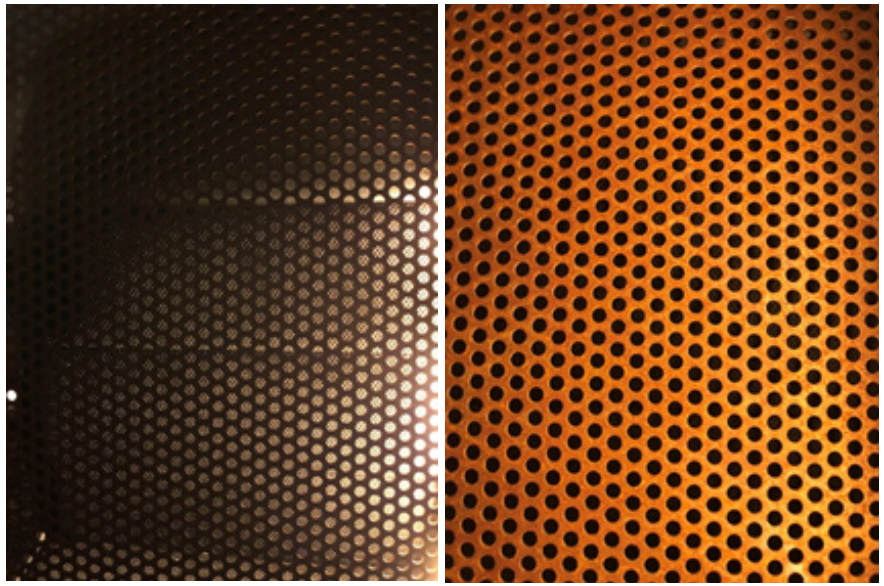


Figure 35. Lightsource behind / Lightsource in front

Results: The hypothesis was proven to be correct. When putting the light source behind there is no material to catch the light, since there is an open space behind.

Conclusion:
Based on the results a gradient of light reaching from 2000 K to 3000 K will be used. These temperatures gave the corroded steel plate an surprisingly beautiful color. Second, the light fixtures must be installed in front of the plates to get the desired result.

2.3.4.2 Lighting Scheme #2:

Design for façade when air quality measurements is above accepted levels

For Lighting Scheme #2, the information layer is added to the design. Having figured out how to use the air-quality data in a way that they make sense and can actually tell something useful, this scheme aims to turn the façade into a watch dog for the community and let them know if the air quality measurements has been above the accepted levels during the day. A design decision was taken that this lighting scheme should separate itself clearly from the first scheme. Most days the conventional lighting design scheme will be present and will fit into people's memory of the place. That's why with a clearly different look people will give their attention to the change and question what it means. This could lead to a public awareness concerning local air quality, and all the key persons contributing to this will have the possibility to reflect over what air quality is and how each of us is contributing. If there is many red days it means that the strategy for the city is not going in the right direction, and that the initiatives from the city does not work towards getting a cleaner city.

As stated by Tapio Rosenius (2017), dynamic light help a design to slip into people unconsciousness. The movement is to symbolize and to visualize the air around us, which has a mass. Red air will slowly move on the façade to remind people that we all contribute to air quality and that it provide a real danger for people that are sick and the importance of a good strategy to make the air quality better.

Color is added based on the findings in the Hierarchy of focal accents (Michael, L 1996), to separate itself from the first scheme, and to trigger our biological response to color. The building and the material does not play the lead role anymore, now it is the message that is the most important. Associations to flow of air was used as an inspiration in the design phase for how to visualize the data.

Figure 36. Air pollution.

Figure 37. Traffic and air pollution.

Figure 38. Inspirational photograph

These conceptual ideas led to 2 design criteria's that should be met, and a sketch that was used as a guideline to how to make the concept into a final design.

Design Criteria

1.The right color as to strengthen associations to danger and grab attention
The color should correspond to the message and get people to reflect on the serious consequences of air pollution.

2. Introduction of movement to create associations to flow of air

A dynamic light scheme to help the design to slip into people unconsciousness and raise the possibility of the message is understood. Movement should correspond to the message and create associations to flow of air.

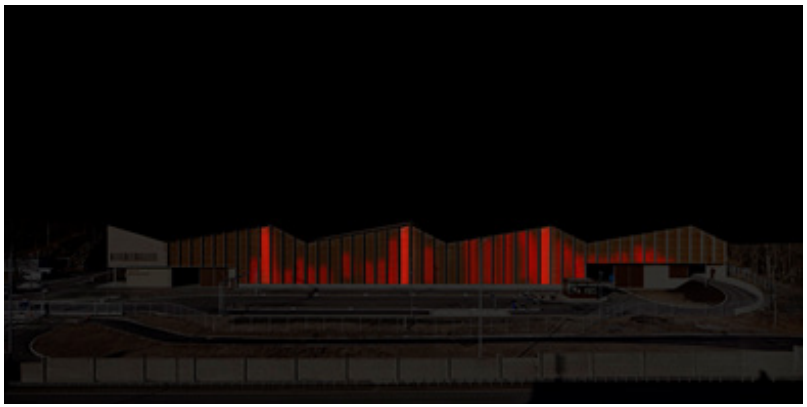


Figure 40: Sketch of the lighting design providing information. Sketch as a reference for the experiment

2.4.4.2.1 Experiment
To test dynamic scenarios, a mockup was built. Dynamic settings where programmed using Touch Designer and projected on the mock-up in scale 1:100. The mockup represents one third of the building. Before we go into the experiments, a thorough description of the process of making the visuals and the tools used will follow.

The visual material comes from manipulated video and from manipulated code Sketches in the processing programming language. The phenomenon of Perlin noise is a way to digitally represent natural patterns and movement and were used as the inspiration for the movement in the lighting scheme and foundation for the experiments.

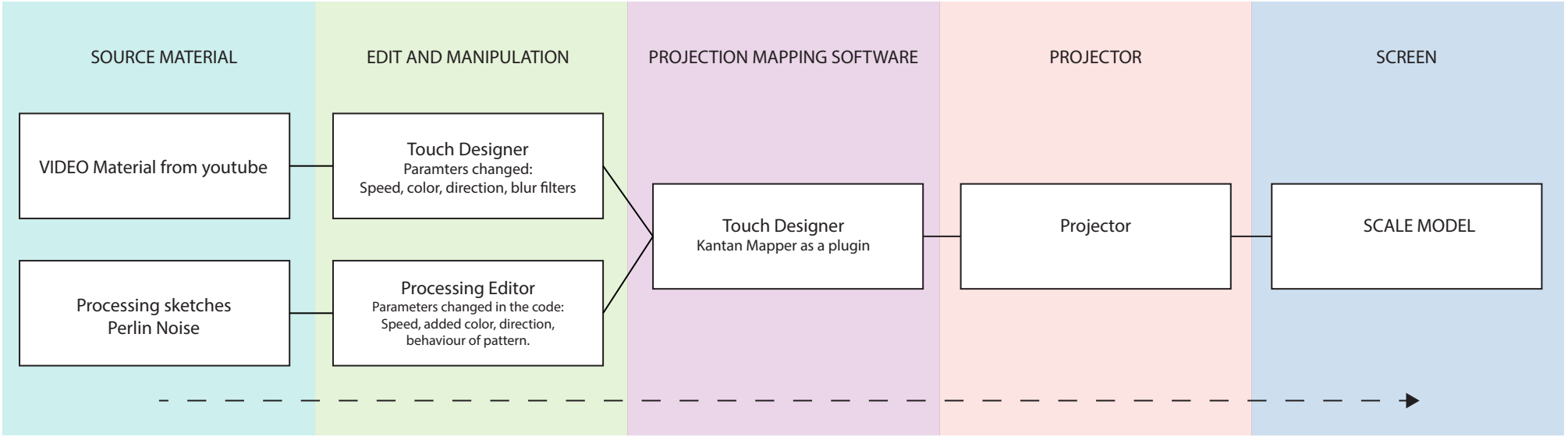


Figure 41. Process model of experiment

Projection mapping was used as a tool for the experiments. This scheme includes movement and experimentation with different scenarios, and this technique gives great flexibility when it comes to easy manipulate and experiment with velocities, appearance and colors in real time.

Projection mapping is a technique widely used in theater and entertainment, and for more temporary light installations and art installations.

Equipment used:

1 x Projector
1 x Scale model 1:100, to represent 1/3 of the building mass

Software used:

Touch Designer with Kantan Mapper plug in

Touch designer is a node based visual programming language for real time interactive multimedia content. Is it used by artists, programmers, creative coders, software designers and performers to create performances, installations, and fixed media works. Kantan mapper is a plugin that provides tools for projection mapping.

Processing

Processing is a programming language developed for visual artists to generate and modify images, and relates software concepts to principles of visual form, motion and interaction. A sketch is in this context a piece of code written and put on the internet. This makes it possible to use pieces of different code and manipulate it to serve the purpose that you need, whether it is interactivity by sensors, graphic images, web application or concepts (Raes & Fry 2007).

Visual content used as a base and manipulated in TouchDesigner:

Perlin Noise

As the design criteria dictates that the pattern should have natural, organic movement that creates associations with air, the concept of "Perlin noise" was chosen as a way of digitally represent pattern and movement that occur in nature. Perlin noise was developed by Ken Perlin in 1983 as a code to simulating natural textures through subtle irregularities (Raes & Fry 2007). Perlin noise are often used in CGI (Computer-generated into make computer-generated visual elements – such as object surfaces, fire, smoke, or clouds – appear more natural, by imitating the controlled random appearance of textures in nature.

Video from YouTube manipulated in Touch Designer

Video as a light source is widely used (Rosenius 2017), since a video can be projected through LED strips as a screen and create a more abstract representation of the content in the video. To achieve the same effect by projection mapping a blur filter were added to get more abstract results.

Figure 42. Scale model 1:100, representing one third of the façade.

Hypothesis related to design criteria #1: Color

Red will be used for its simple effect that people have associations with danger. Over the building façade red smoke will move, and create associations of air and danger and clearly separates itself from the other scheme and it is possible to grasp for the people passing by.

Experiment #1:

Different visuals in different colors were evaluated.

The experiment led to the notion that red had the most significant effect that its stealing the attention and gives a more disturbed feeling than the other colors. For this purpose the color red will be chosen in the final design.

Hypothesis related to design criteria #2: Movement

It is possible to light the façade with a dynamic pattern that resembles air flow.

Experiment #2:

Different Patterns were evaluated. Horizontal motion gave the best results since the aim is to have an abstract representation, and this gives a nice representation of air flow. Also it breaks with the vertical lines in the architecture, and gives an impression that something is wrong. Due to this vertical motion will be chosen for the final design.

Hypothesis related to design criteia #1 and #2:

By choosing the best suited visual, color and movement, the message of bad air quality is believed to be possible to understand when lighting scenario #1 and lighting scenario #2 is compared. Further research on this is needed on a bigger scale setup.

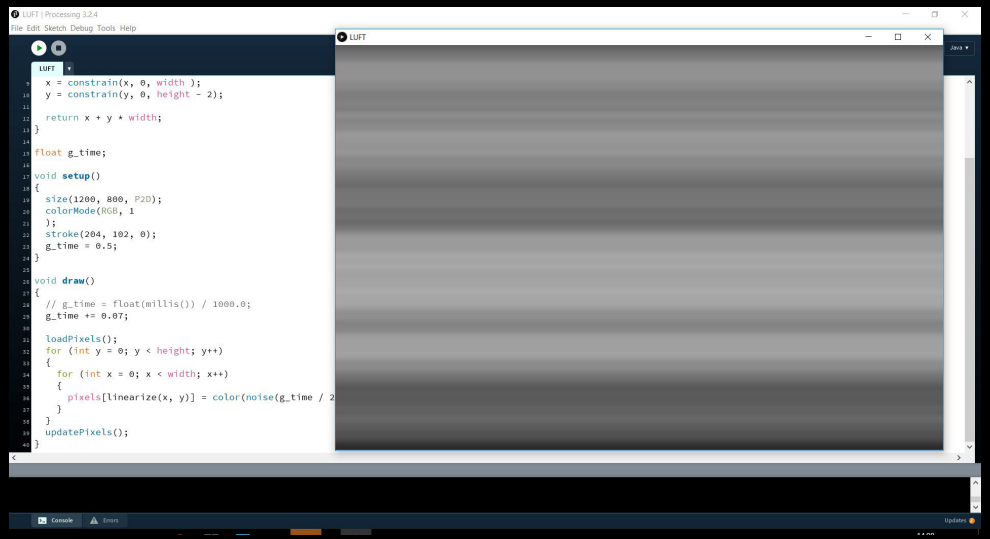
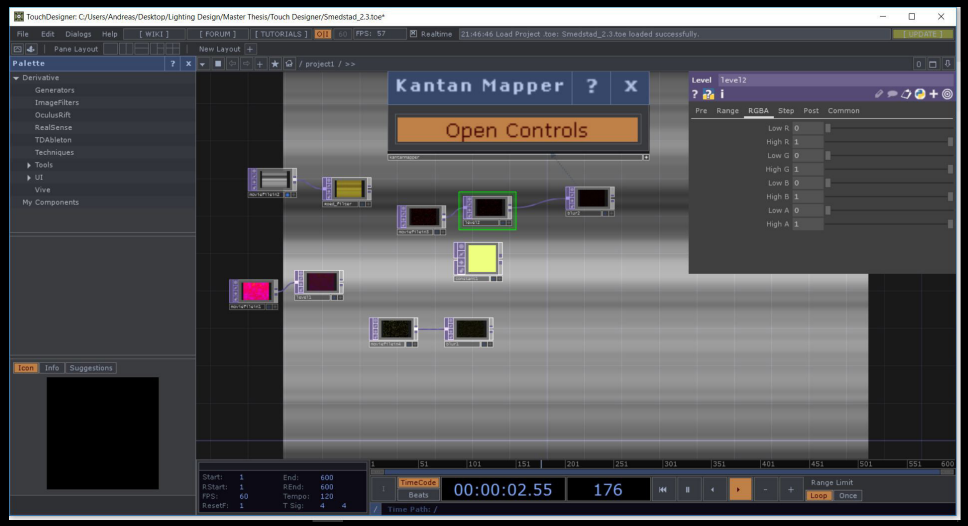


Figure 40: Perlin noise as a digital representation of movement of air. Code written in the processing programming language.



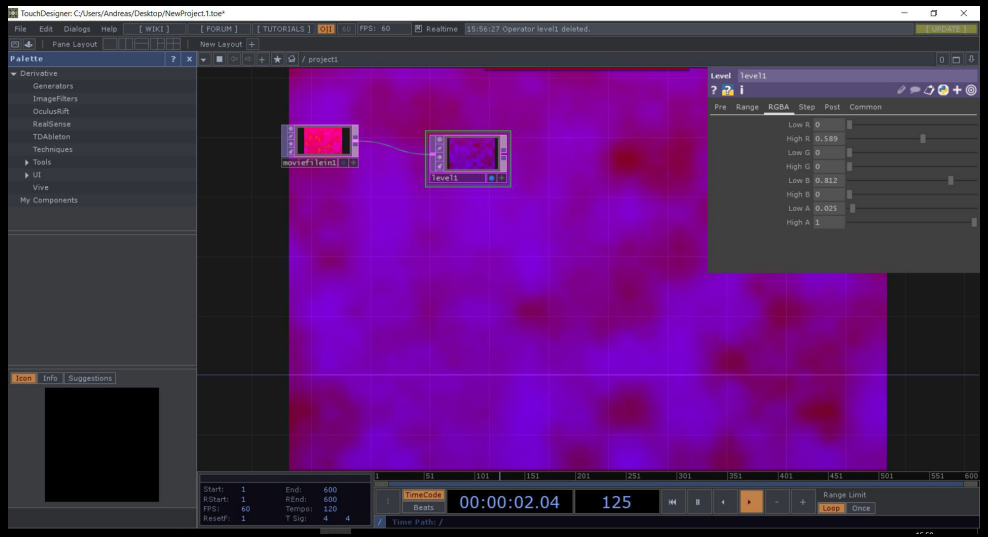


Figure 43. Manipulating video content in touch designer

Figure 44. Experiment with different color and pattern

2.4.5 Technical Considerations

After experiments are carried out, the last thing to consider before going for the final design is the technical considerations. This section contains a very brief consideration regarding technology and limitations of the technology to have this in mind for the final design. For limitation purposes, this master thesis case study will be kept strictly conceptual, and not go into further details considering the technical solutions.

In the experiments there have been used projection mapping and led strip. For a project like this, with the size of the façade, a solution where you are using a projector as a light source may not be ideal. First the equipment is expensive, since it need to be outside all the time in all sorts of weather. Second, it need to be extremely fixed, to fulfill the design criteria that the vertical beams will be without light. So, for this project, I have chosen to include in the design a technical criteria that the light source will be two vertical LED strips in front of each steel plate, one on each side of the vertical beams. For lighting scheme #2 the chosen pattern needs to be compatible with this kind of light solution and cannot require video mapping.

Control System

DMX will be the best system for this due to the dynamic pattern. Code in the processing language can be converted to DMX signal for the dynamic pattern.

Placement of fixtures

As we saw in the experiment the fixtures need to be installed in front of the plates, since there is no material behind the plates to show reflect the light. Installation inside would be ideal to minimize structure on the vertical beams, so focus on a small and discrete LED-strip will have to be prioritized. The LED-strips needs to be addressable and of RGBW specification. Ideally, installation in the beams would be ideal. Further investigation is needed to find a solution that is not making unnecessary degree of visible fixtures on the facade. A focus on a small and discrete LED-strip will have to be prioritized.

Data processing

The data can be accessed through the website luftkvalitet.info, and by an API (application programming interface) convert the values to triggers for lighting scheme #1 or lighting scheme #2.

2.4.6 Final Design

Lighting Scheme #1, the scenarios for the good air quality will be there most of the time, and be what people seem to recognize on the building. The aim is to create a positive connection with the building. To support the architecture, the decision was to do a simple, but beautiful lighting design with focus on enhancing the honest materiality, and the shades of color of the perforated steel plates by using different color temperatures of white light to represent the color variation in the corroded material. But when the air quality gets bad, the building takes on its other role, to inform the public about the situation in a more dramatic way.

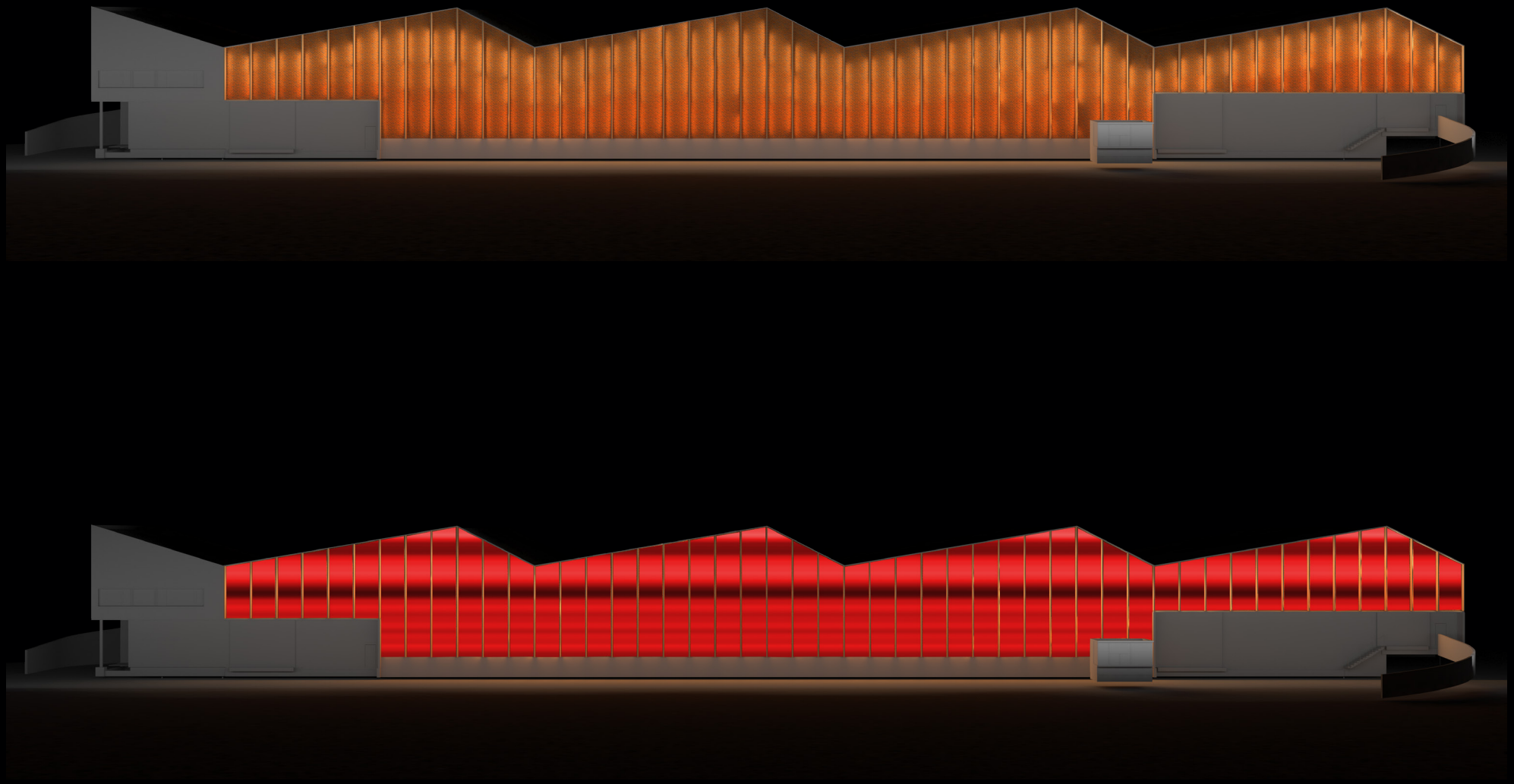


Figure 45. Final design. Light Scenario #1 and Light Scenario #2.

LIGHTING SCHEME #1

Lighting Scheme #1:
Materiality and the oxidation process
Lit in a gradient of CCT 2000K – 3000K.
Triggered when values measured is below accepted limits.

WHY	CONCEPT
Gradient	Shades of color of corrosion
Light from front	Best representation of material
Only Metal sheets	Enhance the critical role of the architecture and strip down the building to essentials
Vertical gradient	Follow the natural direction and rhythm of the architecture

Each sheet is divided in 4 different zones, ranging from 2000K, 2500K, and 3000K and than off. The gradient will fade out under the roof. Depending on the height on each sheet, this system secure the continuation the roof shape where the color temperature change on the facade.

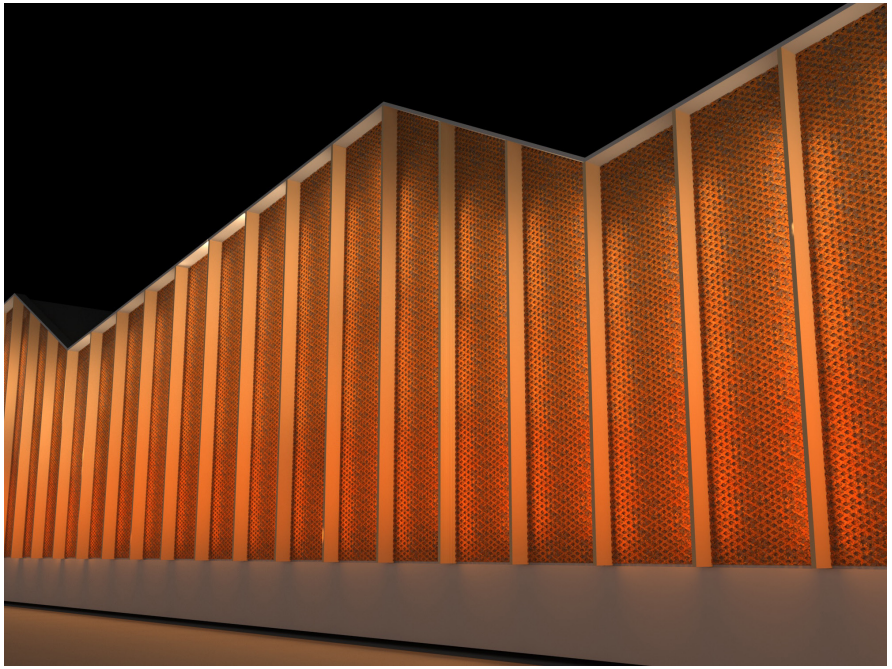


Figure 46. Illustration showing mellow transitions between different color temperatures (CCT).

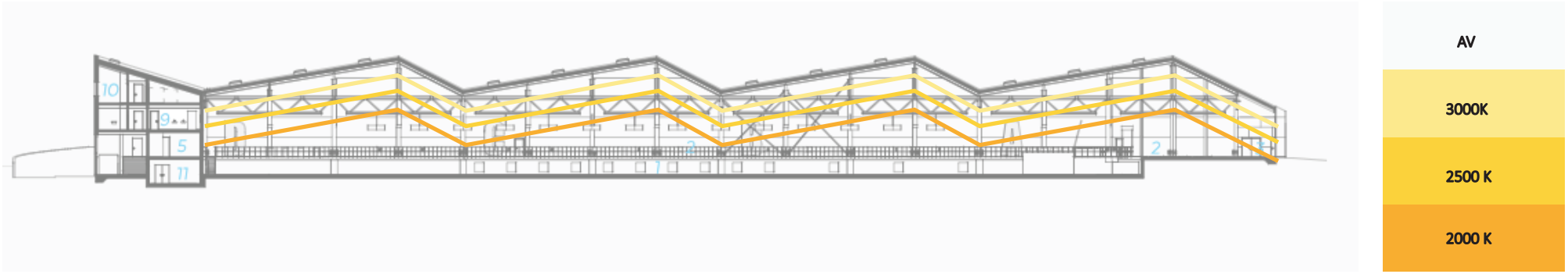


Figure 47. Illustration showing mellow transitions between different color temperatures (CCT).

Figure 48. Final design. Light Scheme #1

LIGHTING SCHEME #2

Lighting Scheme #2: Symbolizes flow of air and air pollution.
Triggered when values measured is above accepted limits.

VIDEO: https://youtu.be/ZQeEQo2TT0g
Code is found in the appendix 1 for the dynamic pattern.

To select the hue and saturation, an experiment has to be carried out to find the specific color of lighting that the best accentuate the narrative.

WHY	CONSEPT
Horizontal lines	Act disturbing since it breaks with the building natural direction (vertical beams). Catches eye
Color Red	An easy connection to the color of warning. A color that is of a deep hue, gives a disturbing feeling to the viewer
Movement	To resemble air flow, same direction as the travelers. Works from both ways. Possible to attain the effect with boundaries of the technical solution chosen.

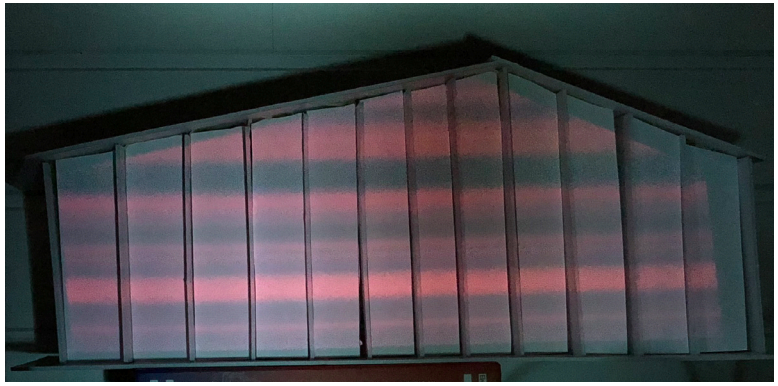


Figure 49. Animation projected from source code on scale model.

Figure 50. Animation from code in processing language (see appendix 1).

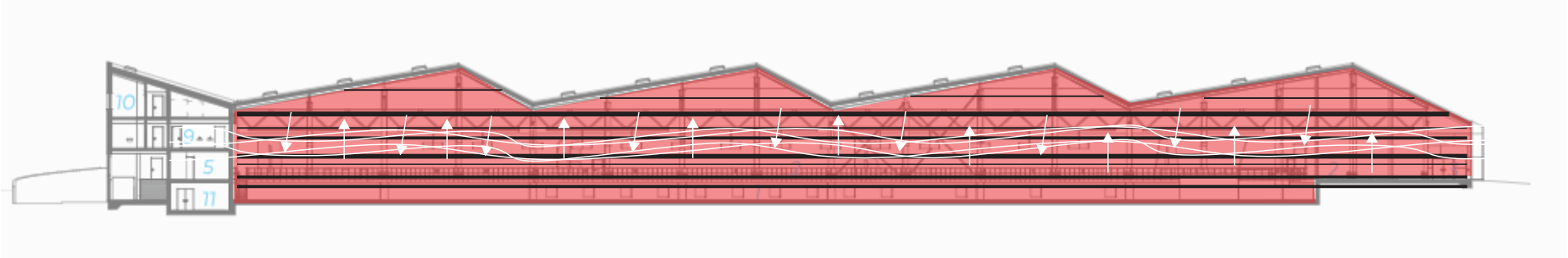


Figure 51. Illustration showing movement of pattern, lines moving up and down to resemble flow.

Figure 52. Final design. Light Scheme #2

CONCLUSION

The main goal for this master thesis was to invesitgate how a lighting design could contribute to enviromental awareness through data collected from the environment and light, and to create an overall design concept for Smedstad recycling station.

Final Problem statement:

"How can a recycling station next to a highway turn into a beacon that make peoples interpretation lead against environmental issues and air quality at night by the aid of air quality data, light and the recycling station facade?"

To answear the research question in the best possible way, several analysis where conducted. A litterature review, example studies, site analysis, data collcetion and data analyisis lead to a concept development stage. With the collected knowledge and the findings from the analysis, it was possible to choose a data set to use in the final design proposal. Different types of data collected in the location was analyzed, and measurments of the air quality was chosen as a data set to use in the lighting design.

The concept development phase was built on research in the areas of media architecture, digital placemaking and ambient communication.

The design concept was divided in into two lighting schemes.

Lighting Scheme #1 is a lighting design that aims to support the archtetcure an dthe material of the perforated steel sheets that dominate the facade.

Lighting Scheme #2 adds an information layer to the buidling, and gets triggered when the air quality reach unacceptable levels during the day, and uses red color and movement resembelign the flow of air to raise awareness on thye issue air quality. The pattern that was chosen to remeble air out of many, was based on the Perlin noise algorithm, developed by Ken Perlin in 1989.

Though it was not possible to claim that the lighting scenario #2 create awareness on air quality, as this is largely subjective and needs to be tested on a big scale to let observers get the full experience to get any valid results. The observations during experiments provided essential criteria for the visual expression of the lighting.

APPENDIX 1

Perlin Noise Code in the processing language.

Can be edited and visualized in a processing language editor.
Parameters edited: Direction, speed, visual apparence, changed from clouds to lines.

To be used for Lighting Scheme #2.

Original code written by: Jakob Thomsen
(https://www.openprocessing.org/sketch/101603).

```
int linearize(int x, int y)
{
 x = constrain(x, 0, width );
 y = constrain(y, 0, height- 2);
return x + y * width;
}
float g_time;

void setup()
{
 size(1200, 800, P2D);
 colorMode(RGB, 1
 );
 stroke(204, 102, 0);
 g_time = 0.2;
}

void draw()
{
 // g_time = float(millis()) / 1000.0;
 g_time += 0.07;

 loadPixels();
 for (int y = 0; y < height; y++)
 {
  for (int x = 0; x < width; x++)
  {
  pixels[linearize(x, y)] = color(noise(g_time / 2,300 / 100.0, float(y) / 100.0));
  }
 }
 updatePixels();
}
```

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Figure 36: Image downloaded from http://www.southeastradio.ie/2016/11/air-pollution-growing-problem-in-ireland/ in April 2018.

Figure 37: Image downloaded from https://www.japantimes.co.jp/news/2013/02/08/reference/chinese-smog-bomb-floats-toward-japan/#.WwxYe76FNaQ in April 2018.

Figure 38: Image downloaded from https://www.youtube.com/watch?v=vg_8i2N_GHg. Snippet from video in April 2018.

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Figure 50: Own illustration.

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Figure 52: Own illustration. 3D Model from Longva Architects.

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