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The Impact of Light Pollution on Tourism Development in Tourism Destination

What do Involved Tourism Destinations do to Reduce
Light Pollution?

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Abstract

Light pollution has been one of the fast-emerging environmental crisis in the past few decades. Mainly caused by poorly designed and placed artificial lights in outdoor areas that are used extravagantly, light pollution has caused various negative impacts to today's ecosystem and people's experience. However, this issue is often neglected despite of the pollutants and wastes created, partially due to people's dependence on artificial light sources at night time. Same negligence occurs in tourism industry, whether if it is the streetlights provided to navigate people during nights or excessive use of light for public displays. Artificial lights are heavily utilized as an add-on effect to a tourist package. Consequentially, many tourism developments have hindered the night sky quality without proper cares. In this Bachelor Thesis, an in depth look into light pollution's effect to a region and its connection to tourism industry will be accomplished. Furthermore, recommendations are given to avoid further damage to the darkness in night sky and to improve touristic experience.

The method approach of this research paper mainly use quantitative research method, with information dominantly collected from online information as well as expert interviews. The findings of this thesis paper include the critical problem Switzerland has on the topic of light pollution. Of how the nation is lacking in the government's involvement on controlling outdoor light emission as well as general public's insufficient understanding to the issue of light pollution. Addressing to these problems, the author further on provides a few recommendations to tackle on the existing problems to resolve the issue Switzerland has on the use of excessive outdoor artificial light and well as offering suggestions on promoting darkness into a tourism offer.

Keywords: Light pollution, avoiding excessive light, light pollution in Switzerland, tourism industry

Preface

Although identifies as an *Individual Bachelor Thesis*, this paper could not have been completed without many people's help and support. First I would like to address to my advisor Frieder Voll and co-advisor Raimun Rodewald. Thank you for creating this topic and show great interest into it, it helps myself to be really emerge into the paper writing and have a great passion about it. I would also like to thank all the interview experts I have contacted including Lukas Schuler, Roman Gisler, Miriam Schuler and Sébastien Kottelat. Without their the paper would not be completed and I have also learned a lot from the interview we had. Last but not least, I am so grateful for the support from my family and friends and help me go through this process.

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List of Acronyms and Abbreviations

Federal Office for the Environment: FOEN
Dark-Sky Switzerland: DSS
High-Intensity Discharge: HID
High Pressure Sodium lamps: HPS
Illuminating Engineering Society of North America: IES
Important Bird and Biodiversity Area: IBA
International Dark-Sky Association: IDA
Light Emitting Diode: LED
Solid State Lighting: SSL
Swiss Society of Engineers and Architects: SIA

1 Introduction

Lucerne, one of the most frequently visited cities in Switzerland of today, also happens to be the home of the infamous Lion Monument. The city however, had not always been a touristy hotspot, the rise of Lucerne's tourism offer actually started when the lion statue was built in 1821. As a memorial sites, the lion statue mourned for 960 Swiss Guards who dies during a battle of French Revolution. The monument was initially built for the purpose of helping the soldier's family and friends to mourn for their lost, unexpectedly the monument had also attracted outsiders to visit Lucerne for it. Back then, Lucerne was not a touristy developed region, many tourism offers were not saturated and matured enough to be prepared for the sudden burst of tourism market demands. The municipality later on, started to construct tourism facilities in demand of the on growing tourist visits, one of the first tourism infrastructure installments happened to be electric street lamps. Prior to the swift rise of tourists, street lamps were not provided to the citizens because the lack of need in aiding the residents to navigate through their home town. However, the same cannot be said for the tourists, it was necessary to install street lamps for them since they were not as familiar to the region as the locals were. The launch of electric streetlights guides tourists to tour around the city safely (Deuber, 2016).

The installation of streetlight in Lucerne's early stage of tourism development reflects on the importance of light installation to tourism industry. Light continues to carry the crucial influence it has on tourism industry to today. The utilization of lights is no longer limited to be a product that provide clear sights to people in the dark. In tourism industry, light has become a tool that brings out extra emotional experience to people. For instance, Christmas season is a well-lit period of time thanks to all the colorful and bright decorations from the streets, shops and households. A particularly illuminated site is at the Christmas Markets. Annually, many destinations in Switzerland (as well as in many other countries) Christmas Markets are organized to attract tourists to visit their regions. The holiday markets always have dazzling decorations and lightings as one of the main attractions that create a wow factors to the market goers. As much as the lightings provide a tremendously bright and beautiful scenaries to people, it also has negative side effects to the darkness in night time.

With the creation of light bulb, it gives people the convenience to light up places where natural brightness could not. It can be considered as one of the greatest inventions that remains its significant since the day of inventioin. Ironically artificial light also created a critical problem by lighting up places where it is not supposed to, the dark night, and becoming the primary cause of light polltion.

In the following of this paper, the issue of light pollution will be addressed in a global stand point. Next, the focus of the paper will stress specifically on Switzerland and its tourism industry. As it is mentioned above about the importance of light utilization is in the industry, this paper will concentrate on investigaing what approaches tourism destinations have to take to response to lgiht pollution and how can the destination municipal make contributions to reduce light emission.

2 Literature Review

As mentioned above, this the research paper is focusing on the impacts light pollution has on Swiss tourist destination as well as the actions tourist destination had taken to counter-attack to this pollution. The purpose of writing this specific topic is to find out the awareness Swiss tourism industry is to light pollution and whether or not they are willing to make an effort to protect their local environment by reducing light pollution. Moreover, what are the existing regulations or guidelines that tourism industry is already following? Before, all those questions are being explored, this chapter is written in the aim of providing an overview of background information on light pollution and light pollution in Switzerland.

2.1 Light Pollution

To begin with this research paper, one must understand what is light pollution. How could a simple light source that seems to be harmless become a source of pollution? Quoting the International Dark-Sky Association (IDA), a globally recognized and authorized non-profit organization founded with the mission of preserving night skies to present and future generations, “*Light pollution is excessive, misdirected, or obtrusive artificial (usually outdoor) light.*” (Light Pollution, n.d.)

Light pollution, unlike many other environmental damages, can be solved in a literal flick of a switch. By simply turning off artificial lights can reduce the pollution it has induced. The “pollution” that is stated in the issue of light pollution is primarily referring to the inappropriate use of artificial lights that results in lights spilling in previously dark areas (Light Pollution, n.d.), and the negative environmental impacts that subsequently followed.

To describe in more details, the picture to the right illustrates the meaning of excessive light spilling into night sky. Since it is the most planted exterior light facilities that causes light pollution, streetlight serves as a typical example of how light pollution is induced. In *Figure 1*, the streetlight does not only light up the area directly under it, but also the circumference around the streetlight. Supposedly, the light should have lit to the ground to provide visibility for the people at ground level. Unintentionally the light also goes into the direction towards the sky, lighting up where it is supposed to be dark (eSchoolToday, n.d.).



Figure 1: An example of excessive artificial light (eSchoolToday, n.d.)

Except from the disappearance of the starry night as one of the effects of light pollution, this environmental issue also causes negative impacts to ecosystem, animal's biological instincts, as well as astronomical pollution (Globe at Night, n.d.). As it was mentioned, to eliminate light pollution a simple step of switching off the light would be the most effective method. However, living in the digital age, people had become dependent on artificial lights, having brightness at night had become a social norm. Therefore, it can be difficult to find a compromising solution to have the number of artificial lights reduced.

Light pollution comes in many forms, which will be discussed later in this chapter. It is a modern phenomenon caused by a lot of living habitual that people had taken for granted and considered them to be common in their life. For instance, bright LED billboard being light up on display during night after the store's closing hour. It is thing as such, that piles up with the use of artificial lights and creates light emission that spread through the ecosystem and results in light pollution.

2.2 Types of Light Pollution

Light pollution, as it is defined is not simply a phenomenon of using too much artificial lights, it also involves the direction where the light is beamed. It is not necessarily the quantity of lights but rather the inappropriately directed lights. This result of brightening supposedly dark places can be break down into four components: *Sky glow*, *light trespass*, *glare*, *clutter*.

2.2.1 Sky Glow

First off, sky glow is the brightness in the night sky illuminated by both nature as well as human-made sources (Light Research Center, 2007). At first glance, some might find sky glow as a beautiful night-time scenery, however, it is actually the main reason causing stars being blocked and visible to human eye. While sky glow is also an outcome of natural phenomenon caused by sunlight reflecting off to earth, reflection of moonlight, low-grade aurora, as well as the gases emitted from the atmosphere, the primary cause of sky glow in the recent decades falls onto humans' hands (Light Research Center, 2007).



Figure 2: An example of sky glow. A faint glow is visible in the dark night which is caused by the lighting from the ground (Royal Astronomical Society of Canada, n.d.)

Poorly designed lighting and distorted direction of illumination are to be blamed for as the sources of artificial sky glow. The disoriented artificial light source would then evade outwardly. From city center to country side, and even the wilderness could not escape from the fate of being lighten up at night. Most of the light pollution produced, is from the flash of lighting from the streetlights that are not shielded properly. An unshielded streetlight caused the illumination to not only shine to the ground but also to every direction where the light source is not blocked.

Light pollution – sky glow is categorized as the result of light spills specifically into the night sky (Losing the Dark – Flat Screen Version, 2013). As *Figure 2* has shown, the faint and gloomy white light – sky glow, in the sky is the result of residual lighting that is not shielded, beamed upwardly and in consequence of lighting the dark sky unintentionally (Further details of shielding spill of light emission will be discussed in later subchapter).

With reference to intentionality of excessive light illumination, it is not always the case that sky glow has happened because the spread of light source has exceeded from where it is supposed to under false operational management. In many occasions, lights are switched on and beamed straight towards the dark sky, as a presentation of a show. This type of performance, called the outdoor laser light show, is a display of lighting where streams of laser lights are projected bluntly to the sky and to create visual effects in an open area where people within the light display visible range could enjoy. Typically, the laser light has sufficient ray data to make the light show be seen within a wide range (Laser World, n.d.). Due to its attention grabbing effects, many tourism destinations have events that provided outdoor laser show as an attraction, creating a memorable experience to its visitors. While the visitors are awed from the colorful displays and the destination benefits from the attraction offer, the issue of excessive light emission toward dark sky is omitted.

A Symphony of Lights, the world's largest and longest light show display located in Hong Kong was launched in 2004. Ever since the show was introduced, *A Symphony of Lights* is displayed daily and lasted for 14 minutes each time (Discover Hong Kong, n.d.). While the light show does attract many tourists to stop by and admire the light performance and has become one of the trademarks of Hong Kong's synchronization of modern technology and lively spirits, the issue of light pollution was being paid with little to no consideration. According to Paul Zimmerman, a Hong Kong District Councilor, the problem lying on the light pollution issue in Hong Kong is the absence of regulations that controls the excessive emission of light that is happening in Hong Kong. The government's negligence on light emission policy, and the concentration on touristy aspects of development have indulge the region's constant grow in light planting. To the extent that it has become a unique culture of light display competition between buildings in Hong Kong (Reuters, 2011). In consequence, Hong Kong had been labelled as "the worst on the planet" in light pollution, where in Tsim Sha Tsui the night sky is actually 1'200 times brighter than a natural dark sky (South China Morning Post, 2013). *A Symphony of Lights* is not the only factor responsible for the level of light pollution in Hong Kong, it is the combination of lack of management and indulgence from the authorities on light installment that has the region built up the intensity it has now.

Sky glow being one of the most protruding effects of excessive use of lights, is the main explanation of the absence of stars. While the constellations still exist, it is because of the manmade illumination that has become stronger than the light stars reflect and dimmed the latter's brightness into disappearance.

2.2.2 Light Trespass

Carry on to the next type of light pollution – light trespass, let's again take a look in Hong Kong as a case to explain what light trespass is. Here is a real-life incident, an Australian couple was

looking for an apartment in Hong Kong and found a place where they had visited for a couple of times. Right before the contract was signed, an issue had caused the couple to back away from moving into the apartment, a giant Light Emitting Diode (LED) light advertisement board right outside of the flat window. The problem here was that the LED board was on display long pass bedtime all the way until early morning. Even with blinds the light beamed from the LED board could not be blocked from the apartment (NTDTV, 2011). In this situation, the discomfort caused by the unwanted light source shines into a property is also a form of light pollution, more specifically, light trespass. This type of light pollution typically happens in urban area and has induced direct impact on residents' sleeping pattern. Cause of light trespass once again trace back to the design of exterior light installation. Had a properly covered light source that is only beamed toward the ground, light emission would not have slip into households.

Unlike Hong Kong, where as addressed the government does not take control on light implementation, Swiss authorities step up and set standards upon this modern problem resulted in a drawback of technology advancement. Swiss Society of Engineers and Architects (SIA) is Switzerland's leading professional association for construction who develops, updates and publishes standards and guidelines in Switzerland's construction industry (SIA, n.d.). SIA had introduced construction standard SIA Norm 491: Avoid Unnecessary Light Emissions (recognized by various municipalities and the federal government of Switzerland) which oversight the implementation of outdoor light, as well as regulates that illuminated signs, shop windows and lights on buildings must be switched off from 10 o'clock in the evening to 6 o'clock the next day morning (Dark-Sky Switzerland, 2015). This recommendation standard not only reduce the consumption of electricity, it also is a contribution to reduce light trespass into private properties.

The prime concern of light trespass is the disturbance it induces to people's downtime of a day. Of how misdirected light not only has effects on beaming up dark sky, but also has a blunt impact on people's life inside their house.

2.2.3 Glare

Sharing some similarities with light trespass is the next light pollution component - glare. It is once more caused by excessive and uncontrolled use of artificial lights. Unlike light trespass which is when light is blasted into an indoor property, glare occurs outdoor. Glare is usually prompted by streetlight or LED advertising board, light facilities that create a strong contrast of the black and dark background from the night sky to the intensive brightness from the artificial lights, and results in causing discomfort to human naked eyes (Light Research Center, 2007). For instance, a pedestrian walk on the street at night only accompanied by some streetlights along the journey. The pedestrian could experience glare's effect if the streetlight has an uncontrolled illumination that beams in all directions including the pedestrian's eyes as he/she approaches the light source. As the pedestrian walks closer to the light, the brightness could reach to a degree where his/her eyes have to adapt to it by contracting the pupils. Pupils' reaction to the intense brightness would consequentially allow less light to enter and cause human's eyes to experience a temporary incapability to see in the dark as well as objects that are in their surroundings (Alberta Dark Sky Association, 2016).

While the severity of the discomfort induced by glare is subjective, biologically speaking glare still has indeed forced human eye to adapt to the illumination. Ultimately, created visual inconvenience to human eyes that has the potential to lead to dangers if paths and roads could not be seen clearly at night by the light sources that are supposedly built to create visibility during that time.

2.2.4 Light Clutter

Last but not least, light clutter is the last component of light pollution. Like all the light pollution components mentioned above, they all share the resemblance of originated from overproportionate of artificial light sources. Light clutter concerns the disproportionate amount of light groupings (Federickson Astronomy, n.d.). One of the most common cases of light clutter is from the abundance of LED light board on streets, the issue of light clutter is that having too much LED board or neo light sign on display could be a bombardment to pedestrians also to car drivers that cause them to be distracted while they are passing through streets (Treehuggers, 2016). Las Vegas is a destination that could well- Another critical negative impact caused by light clutter is its disturbance induced from the point of view from the aviation environment. As navigating in dark sky, pilots are relying on the light sources placed on ground to direct them to the appropriate destination, the clutter of streetlights, neon signs could cause confusion to pilots (Federickson Astronomy, n.d.).

To conclude this section, the common cause of all the types of light pollution falls onto the design and direction of the light. More specifically, streets lights have been a common factor that induce the four mentioned component of excessive use of lights. Light pollution, unlike other means of pollutions, can be solved easily by simply switching off all the outdoor artificial lights. However, a flick of a light switch is an effective solution that is typically done in households to prevent needless consumption of electricity, not so much a common action taken place outdoor. There is a reluctance in turning off exterior light emission because of its high utilization in today's society. What many people tend to neglect is the fact that by turning off lights during late nights is an act of reducing light pollution. Multiple questions have arisen here, how is light pollution still a problem to the environment even when it could be solved easily? Is light pollution not as great of a problem as other pollutions are, to be recognized as a problem to be stressed to public? How aware people are on light pollution?

To answer these series of questions, the next part of this chapter will first discuss the solutions and negative impacts of light pollution and address the importance of reducing light pollution is to the environment.

2.3 Methods to Reduce Light Pollution

Light pollution, as mentioned previously, can be solved with a simple flick on the light switch. Imagine if all the residents in one city decide to go completely light-free for one night and switched off all light source at once, with the speed light travels, it would only take a matter of seconds for night sky to completely embrace the total darkness and reveal the hidden stars to people, even the Milky Way can be easily visible to everyone (Schuler, L., 2017). In spite of this straightforward solution, it is quite frankly a wishful thinking for this scenario to happen in real life. This idea is halted by the fact that there are many facilities that are needed to be lit in

night time. Facilities such as traffic lights, streetlights and lights in hospitals are required to be turned on for safety requirements. With some light sources as necessity, what are the practices that can be taken to reduce the level of light pollution and simultaneously ensure lights are used as they are deemed necessary?

2.3.1 Raise Awareness

One of the biggest issue of light pollution is not about the critical condition it now has on ecosystem (although also important), but the fact that it does not get the attention it needs. The necessary step of resolving any sort of pollution, is to have people involved in the act of environmental protection concerning to the pollution. However, when thinking of light pollution, many associate the negative impact to the waste of energy and rarely make to the connection of the fact that lights are being used excessively and sometimes unnecessarily (Schuler, L., 2017). Light pollution is a commonly known kind of pollution, but it does not receive the same level of knowledge and alertness from people than air, water or noise pollution have. Raising the general public's awareness can make people be more attentive on how their daily routines have a fair share of damage adding onto the severity of light pollution and also take action to be involved in reducing the abundance of light (Schuler, L., 2017).

2.3.2 Be Familiar with Darkness

It is often misinterpreted that humans are not able to see in dark, it was not until 2013 had scientists finally proven that it is in fact possible for human to see at night (Medical News Today, 2013). It is true that human eye needs lights to see properly, but human eye is also designed to be adaptable to darkness in order to let human to see at night as well. Even though the visibility human has in darkness is not compatible to how it is during day time, human eye can still distinguish different objects in darkness. Human's eye distinguishes light spectrum with its three parts: *Pupils, Photoreceptor Cells, and Photopigments* (CooperVision, 2014). Each part reacts to both brightness and darkness with adjustments to accustom visibility under the two circumstances. Scientifically proven, human eye accommodates to brightness much faster than to darkness. It would take up to hours for a naked eye to be fully accommodated to total darkness. It is because of the constant brightness people are now exposed to, there is a slim chance for a person to wait for hours-long in total darkness for their eyes to get used to the darkness enough to see the effect (CooperVision, 2014). While it is important to this society, artificial light had been heavily relied on to the extent where human eye would one day no longer be able to adapt to darkness anymore. Recognizing and embracing darkness in order to lessen the dependence on manmade light could effective reduce light emission.

2.3.3 Streetlight Shielding

Streetlighting is one of the major cause of today's harsh level of light pollution. Referring to the research information mentioned when introducing types of light pollution, poor design of streetlight has been mentioned for a couple of times. It is because inappropriately streetlight shield is the direct lead to light being beamed toward the sky. Statistically, up to 50% of the sky glow in urban area is induced by the brightness that escaped from streetlight shielding and reflected towards the sky (eSchoolToday, n.d.). Poorly shielded light not just causes sky glow, it also could shine through windows from nearby household results in light trespassing causing

discomfort to the residents. Furthermore, without a proper shielding to cover the direction of lights, it occurs when light is directly exposed to pedestrians or drivers' eye. Streetlights dominated its presence during night time because of its functionality of providing light source as a measure of security to people to navigate their way in darkness. However, with streetlight's societal significance, when a small flaw on an inappropriate/lack of shielding design occurs it would pile up and become the major cause of light pollution today's environment has. Despite of the strong connection there is between poorly shielded streetlight and it causing light pollution, it does not mean a well-designed light shielding does not exist.

According the definition given by Illuminating Engineering Society of North America (IES), a non-profit organization found in New York with the goal to improve lighting situation and protect the environment, expressed that light shielding is "the angle between a horizontal line through the light center and the line of sight at which the bare source first becomes visible (Illuminating Engineering Society, n.d.)." Light shielding is also called "cutoff", meaning the light the source that has been "cut off" because it is blocked by the angle the light is being beamed. Cut off is categorized into four types: *Full Cutoff*, *Cutoff*, *Semi Cutoff*, *Non-Cutoff* (Electrical Notes and Articles, 2015). The picture below illustrates the situation in each shielding lightings.

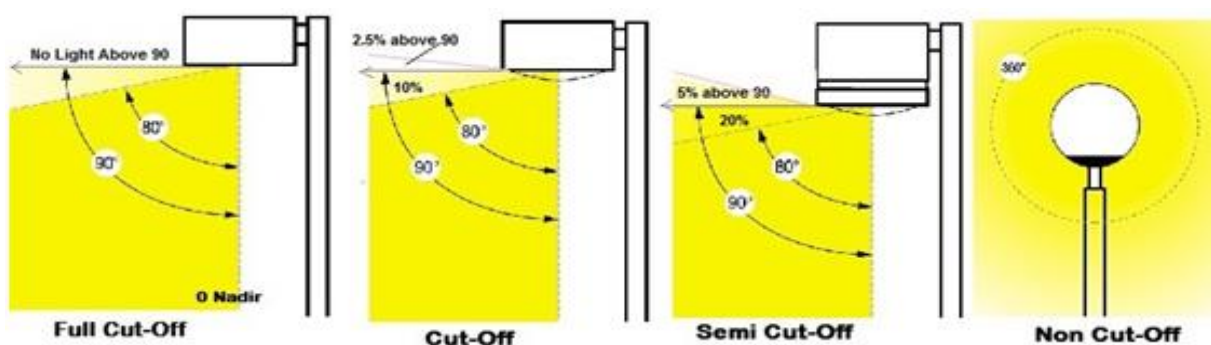


Figure 3: Illustration of different degrees of cutoff. (Electrical Notes and Articles, 2015)

- *Full Cutoff*: This type of shielding fully covers light horizontally, and restricts the emission from spreading upward and beyond the head of the light. This shielding also creates higher concentration on where the light points downwards to avoid overlapping with adjacent lamps and prevent to creating glare. Full Cutoff is the most effective shielding that has the minimum percent of escaped illumination.
- *Cutoff*: With cutoff shielding, around 2.5% of total light emission is spilled toward the sky. Compare to full cutoff, cutoff lights have wider range of light beam, though generating glare, the amount is minimal and with its wide spread of light spatial planning can be arranged more effectively. Cutoff is an emerging light shielding gaining its popularity in the recent years.
- *Semi Cutoff*: Similar to cutoff, semi cutoff is able to cover most of the light emission, with only 5% being uncovered and slipped through to the sky. Semi cutoff creates a wide range of light toward the ground that can be troublesome with the light reflected from ground that goes upward again. It is the most common type of light shielding used on streets.
- *Non-Cutoff*: Non-cutoff, as its name has suggested, does not have any shielding to cover the light in any direction also because it is shaped as a sphere. Throughout

time, this type of lighting is rarely found on street because of the strong glare it beams (Electrical Notes and Articles, 2015).

With the most effective solution (switching off all sources of outdoor lights) being an unrealistic one, having outdoor lights well-covered is the more practical method. Technology today offers different degrees of shielding, and the trend of cutoff utilization has slowly shifted from non-cutoff to semi cutoff shielding. It is a progress that in time would be seen when one day streetlights would all be designed with full cutoff shielding.

2.3.4 Install Dark Sky Friendly Light System

To effectively lower the amount of light emission reflected towards the sky, proper light shielding is not the only practical approach. Another method is to use light bulb that radiates dark sky friendly illumination. Traditionally, High Pressure Sodium Light (HPS) is used as the light bulbs for streetlights, it is the typical orange glow of light source people see at night. HPS was introduced in 1968 as an energy-efficient lamp for exterior, security, and are particularly installed in streetlighting applications. However, the drawback of using HPS is that it is categorized as a High-Intensity Discharge (HID) light bulb (Energy.gov, 2013). In a discharge lamp, light emission is produced by the charge of electric current through a gas. Even though with HID lamps, it is relatively longer lasting and effectively beam up in darkness, HID lights commonly release components such as mercury that is harmful to environment. Furthermore, HID lamps take more time to produce sufficient brightness to establish the electric arc (Energy.gov, 2013). Under normal operation, HPS light bulb would take approximately 10 minutes to light up to its full potential. With the emerging use of LED technology, HPS lights were outranked by the newer technology, many municipalities have gradually started to change their street lamps light bulbs from HPS to LED technology. Originally, LED lights are more often used on devices, such as smart phones, computers or flashlights, but with LED light's appealing features, it attracts many local governments to opt for LED and replace HPS lights (Universe Today, 2015). The benefits of using LED are the following (LED Luxor, 2012):

1. *Long Lasting Life*: While HPS as mentioned previously, has a long-lasting life around 24,000 hours, LED lights normally can be switched on continuously for 100,000 hours. If a city installs their streetlights with LED lights and only turn them on for 8 hours per day, with LED light's life expectancy, the city would only have to replace the lamp every 20 years.
2. *Energy Saving*: With traditional HID lamp, often when it is switched on, 80% of the energy consumption is generated into heat, and rest into light emission. On the other hand, LED light's energy consumption turns out to be the opposite of HID lights. Around 80 to 90% of the energy is converted into illumination, while 20% is wasted in heating up the light bulb.
3. *Environmental Friendly*: As mentioned before, one of the major problem HPS lighting has is the emission of harmful components such as mercury that spread into the atmosphere. This problem is avoidable with replacing HPS to LED lamps. LED not only does not emit any toxic materials, it also happens to be 100% recyclable.
4. *High Endurance*: HPS lamps comes in the form of a light bulbs, whereas LED light is also called "Solid State Lighting (SSL)" meaning it is made with solid materials, harder to break than bulbs. It is also designed to endure harsh condition such as strong impact,

shock and extreme hot and cold weather. Its high durability makes it suitable to withstand being located at outdoor areas.

5. *High Design Flexibility*: LED lights can be designed into many shapes and forms, the light intensity unlike HPS can be dimmed when necessary, the color of the light can also be changed.
6. *Instant Lighting*: One of the drawback of using HPS is that the light bulbs need around 10 minutes to warm up to light in its full capacity, when LED lights can be light instantly.
7. *Lighting Direction*: LED lights are designed with high concentration on where its lights beam to. With this special feature other type of lamps are lacking of, LED lights have the advantage of direct its light appropriately to the right place, without its source spreading towards sky or private household (LED Luxor, 2012).

With mentioning various benefits of installing LED lights, the drawbacks cannot be neglected. Main concern of implementing LED lights on the street is its high cost and the large work load of maintenance in the beginning of the construction. Although in long-term, LED lights spare money with less replacement frequency and waste of energy consumption, if a city plans to change their streetlights with LED lights, aside from hiring the construction company who changes the lights, the purchase of LED lamps alone is an immense amount of expense as well. To add on the weight of the cost, LED lights require different current of voltage than HPS, that experts are needed to do the redesign and adjustment to the appropriate electronic flow (Continental Inc., n.d.). Furthermore, the brightness intensity LED light generates is much higher than HPS and a much bluer light is produced. Under IDA's recommendation, the preferable temperature of light should not have exceeded over 3000 Kelvin Color Temperature (k) in measurement. Kelvin Color Temperature Scale is the unit of measurement for color temperature. Light bulb under 4000 k is still lit with warm yellowish color, any measurement above would appear in bright blue light (International Dark-Sky Association, n.d.). Strong intensity of blue light increases the glare that cause discomfort to human eye, affect people's sleeping quality, and also has a fair share of light pollution producing (Universe Today, 2015). Therefore, in the case of selecting light temperature, HPS would be the more suitable choice with its warm orange light.

The problem LED light poses shows that installing LED lights although has a great deal of benefits, the maintenance work is really crucial. If the natural light LED lamp generate is too strong, thanks to its ability of dimmed the brightness and directional feature, the issue could be solved with proper care. Not to mention, a new and bluer light neutral LED light are now on the market, what is needed now is the time to fully implement them on the street (Universe Today, 2015).

Along with the types of lamp chosen for the streetlights, the lighting system can also be an approach to create a friendlier setting for the dark sky. What is meant by this statement is that the light setting should be adjustable according to the time of the day it is being used and the exact moment it is being used. One method involving gradually dimming the light throughout the night. The later it is during night time, the less cars on the streets there would be. Consider this late-night traffic characteristic, streetlights should be dimmed to a lower level of brightness, while still serve their function of navigating cars and pedestrians on the paths. Another method worth-considering is to install motion-sensor so the light would only be switched on when it is

needed, and this method is more suitable for paths that cars are not allowed to pass through to avoid accident when the speed of car and light beam is not reacted in proper timing (Schuler, L., 2017).

All in all, other than shielding the light, adjusting the light source itself is another arrangement that could reduce the unseemly use of outdoor lights. Although implementing the right kind of lighting system requires an enormous amount of time, effort and budget, with a well thought out plan and supports, it is not a fantasy to have well-lit streets while also have the environment protected with eco-friendly light setting.

2.3.5 Government's Involvement

So far, the solutions being explore have one thing in common, it would take the government's involvement and taking responsibility to have the solution happened. As the fingers mainly pointing to the streetlights for causing most of the light pollution, it is no longer a simple problem of how people are unaware of the criticalness of light pollution. A mere citizen does not have the power nor the financial support to have a streetlight to be changed because it appears to be a threat to the community's environment, let along the streetlights of a whole city. People who bear the authority are the government. Government should step up not simply for the change of facilities, some law enforcement should also be forced upon light pollution reduction. After all, it is the authorities' responsibility to create laws and orders to protect a community and establish facilities on behave of the citizens' well-being.

To end this subchapter, it is important to emphasis the principal guidelines of planting an outdoor light: restrict the direction of lights downward not upward with proper shielding, avoid causing glare, light only where it is necessary and when it is necessary, and last but least use less energy-consuming light source. These fundamental instructions could reduce the light emission streetlight produces that consequentially become the main source of light pollution. Along with the involvement and cooperation from people and government, the complications light pollution cause to the environment could be lessened greatly.

2.4 Negative Impacts of Light Pollution

When describing different components of light pollution, negative impacts of the pollution had been briefly covered. One of the most noticeable consequences is the disappearance of stars in the night sky. While the loss of stars is generally the connection that is made when light pollution is mentioned, unfortunately it is not the only effects that is carried out by the excessive use of outdoor lights.

2.4.1 Observational Astronomy

Before getting into discussion of other negative impacts of light pollution, let's take a look on the first-hand impact – disappearance of stars. In 1994, Los Angeles had encountered a major blackout after a 6.7 magnitude earthquake early in the morning of 4 o'clock, many residents were shaken up by the earthquake. They then realized the lack of light in their house, however, the lack of brightness inside was soon overtaken by the luminous source from the outside. Soon after the earthquake had woken up the citizens of LA, 911 emergency telephone center had received countless of phone calls. Unexpectedly, the majority of the phone calls were not

called in the demand of asking for aid from injuries caused by the massive earthquake. In fact, phone calls were dialed out of panic reaction from people who claimed that they saw a gooey, whitish, alienated cluster up in the dark sky. Little did they know, what they witnessed was the infamous Milky Way (Timeline, 2017). Back then, Los Angeles and many other major cities in the world had a rapid growth in light pollution measurements due to the fast development of industrialized society, artificial lights had then become an essential product. Contrarily, a hundred years ago from then, people were not as depend to artificial lights. In truth, outdoor light was not a necessity and was switched off during full moon nights since the level of brightness provided by the moonlight was sufficient (Meier et al., 2014).

It is difficult to imagine what is granted by nature is now hindered by human, with artificial light scattered in the atmosphere, people have less and less opportunity to admire a starry night sky. Science Advance, an international scientific research team, estimated approximately two-third of the human population no longer has the privilege to witness the beauty of Milky Way (Cinzano et al., 2001). Light pollution not only burdened humans' means of stargazing, more importantly the study of observational astronomy is disturbed to a great extent. Look back to the example of how little longer than a century ago, humans' visual ability was still adaptable at night where moonlight alone was sufficient to navigate their way. It was not until the dependence society had become to artificial lights, people had gradually lost their willingness and capability to see in darkness. Light pollution is in fact a fairly modern term, excessive use of light was not an environment complication until the 1980s (Schuler, 2017).

Observational astronomy has made an immense amount of contribution throughout human history, first there was astronomers doubt on the theory of "Earth as the center of the universe". Many astronomers and philosophers have established various of theories based on their observation and analysis of tar observation. Even though most of the theories might have its flaws and counter arguments to proof its false, it would always be a significant step in human history where a scientific thinking approach was taken. Today, it is relatively more difficult for astronomers to observe the universe even with much more advance technological supports astronomers have. For the most part, it is due to the permanent sky glow spreading from urban city centers to a large scale of fields, it has become more and more challenging to find a suitable location for observation. To make it more problematic, the chemical compound emitted from artificial light also has a hand on interfering the quality of night sky and consequentially affects the observatory data excellence. Often, astronomers use telescope to observe the spectral of a star, the spectrograph (*Figure 4*) shown from the observation would show multiple white lines, the horizontal line is the light of the galaxy being observed, and the vertical lines are the brightness from artificial lights reflected from the ground (Cornell University Astronomy, 2015). Contrasting the light from the galaxy and the ground, the artificial brightness made it

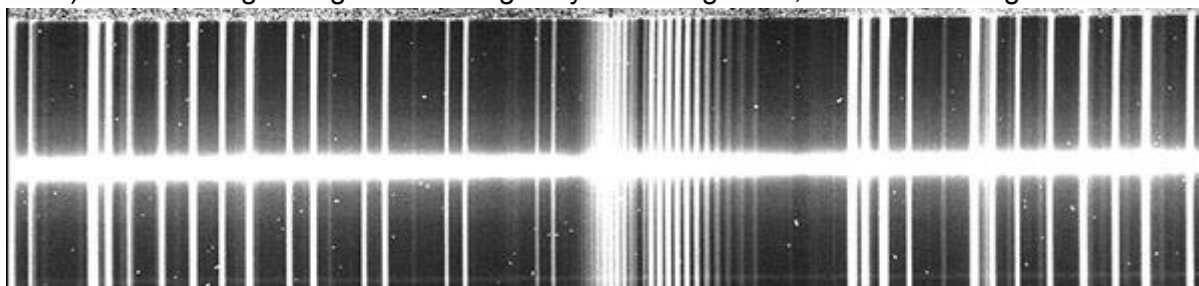


Figure 4: Spectrograph of a galaxy in constellation Hercules. (SciStand, 2017)

difficult for astronomy to precisely identify the location of the galaxy (Cornell University Astronomy, 2015). Have people in present time take the ancients' knowledge for granted and abused the existing technology to an extent where it is no longer visible for human to admire the fundamental knowledge sources of the success people have nowadays?

2.4.2 Wild Animals

Negative impacts light pollution creates not only affect the darkness of sky, wildlife animals are also the victims. Unlike humans, wildlife animals are less likely to be able to adapt to the illuminated environment during night time. It took the wildlife species millions of years to evolve to the biological functions they have today, with the relatively swift development of artificial light, it would be a significantly difficult task for the animals to adapt to society's progress today. Light pollution, being a recently emerged environmental crisis, people are now witnessing the phase where wildlife animals are struggling profoundly with the technological development human made (Seeker, 2016). Excessive light creates distraction and causes confusion to the animal's biological living habits, the ultimate consequence would be the extinction of the affected species from human hands rather than the food chain.

Sea Turtle

One of the wildlife sufferers affected by abundance of light is the sea turtle. A new born sea turtle kickoff their life with a rough start, when born at day time sea turtles have to be vigilant from the predator up in the sky as well as the heat from the sun. Yet, it is not exactly safe for baby sea turtles to be hatched during night time, this time the threat is not from the predator, nor the heat, it is in fact from the light distraction. Sea Turtle Conservancy, the world's first non-profit sea turtle conservation organization, describes night time hatched sea turtles have to "compete" with the tourists reside at the beach side (Sea Turtle Conservancy, n.d.). The non-profit organization took its headquarter base as an example, being based in Florida, majority of the beach sides are owned by hotels to attract visitors on booking their location. However, the ownership does not affect the habitual egg laying and hatching of the sea turtle, what affected the sea turtles' hatching is the installment of lights along the beach side as well as the lights from hotel windows (Sea Turtle Conservancy, n.d.). During day time, sea turtles have a clear view of where the direction of the ocean is, and at night time they have to rely on the light reflection on the ocean from the moonlight.

Today's abundance of artificial light near the area of costal line serves as a misguiding distraction for the new born sea turtles. Having difficulty to decide which light sources to move towards, when the wrong direction is chosen many baby sea turtles could not navigate back to the ocean before they suffer from getting lost, running over by vehicles or dehydration (Sea Turtle Conservancy, n.d.). What the organization has recommended to hotels were to tint the windows that are facing the ocean or to switch off lights that are installed on the sea turtle egg nestling beaches. Consider hatchling disorientation induced by artificial lights had resulted in killing thousands of sea turtles every year alone in Florida, Sea Turtle Conservancy has strategies programmed as well as the involvement of International Dark Sky Association to protect the survival of baby sea turtles (Sea Turtle Conservancy, n.d.).

Migratory Bird

Another species of animals that have difficulty in navigating their way home are the migratory birds. In changing of seasons, migratory birds typically move to areas with climate that is suitable to live on for the rest of the season (World Migratory Bird Day, n.d.). An example being birds migrate from north where they breed, to the south during winter time to avoid the harsher weather in the north. The regular migratory ritual is a long and risky journey. The Red Knot (a shorebird species breed in Canada, Europe and Russia) has one of the longest migratory distance, each year Red Knots have to travel up to 16,000 kilometers twice a year (World Migratory Bird Day, n.d.). Often during night time, migratory birds are again, as the baby sea turtles are, distracted and disoriented from the abundance of lights implemented in the urban area. In fact, light pollution has taken a huge toll on the migration process for the birds, and it does not only limited down to migratory birds. Many birds are found crashed into brightly-lit buildings or circling streetlights until exhaustion has caused them to collapse (National Geographic News, 2003). Quoting from the executive of Fatal Light Awareness Program, a Canadian environmental organization, Mr. Michael Mesure: "Over 450 bird species that migrate at night across North America are susceptible to collisions with night-lit towers, including threatened or endangered species..." (National Geographic News, 2003).

An incident that is worth mentioning happened at the infamous 911 monument, Tribute in Light, in New York, U.S.A. Six months after the tragic terrorist attack on the World Trade Center, the installation of 88 sky beam lights were implanted beside the location of the World Trade Center. The lights are switched on for the first time as a memorial sight on the day 11th of September 2003, the 2 years anniversary of the terrorist attack. Since then, Tribute in Light has become an annual memorial event that attracts not only the families of the victims to mourn for their lost, but also many tourists to marvel at. Unfortunately, birds are among the groups that visit the site, the birds' visitation is due to their attraction to the sky beam lights. To resemble the fallen Twin Towers, the design of the monument is arranged into 2 blocks of laser lights illuminated straight to the sky (Daily Mail, 2015).

As mentioned above, during night time some birds are found circling streetlights, in the case of these 2-gigantic sky beams it is no exception. After the launch of the site, the sky beam has both disoriented birds, had them circle around the beamed tower and even trapped some birds inside the beam lights (See *Appendix 1*). Although this attraction towards birds was unexpected, a solution was not hard to find. Even with the discomfort it has created to the birds, along with the financial and energy waste of the illuminating, and after few rumors of shutting down Tribute in Light, the municipal of New York City recognized the significance of the monument and continue this memorial event. The solution was to switch off the lights every 20 minutes, there are also thousands of volunteers that are on watch and would report whenever the light has trapped too many birds it would be shut then (Mail Online, 2015).

By switching off the light beams every 20 minutes is not a perfect and effective solution, and the birds are still being bewildered by the lights, sometimes it is also important to recognize the cultural importance of the tourism site has to the destination. Can the municipal's solution be justified by emphasizing the monument's importance to U.S.A.'s recent history? Or should

it be solved as the sea turtle case where human have to make a full compromise despite the significance of its role in tourism fields?

2.5 Scale of Light Pollution in Switzerland

Now the phenomenon of light pollution and its effects have been discussed, it is time to take a further step to close the approach to this research paper's topic, and examine light pollution specifically in Switzerland. This section will delve into the scale of light pollution in Switzerland as well as its neighboring countries. As mentioned in the previous section, light pollution has reached to the point where majority of the world population no longer have the chance to admire the beauty of Milky Way. Within this two-third of population, the most is in European and North American countries. To introduce the severity of light pollution globally, the picture from *Appendix 2* is provided. From *Appendix 2*, it shows the global light glow picture captured by American Association for the Advancement of Science. An overlook on the photo, half of the United States is drowned in brightness in night time, practically the whole continent of Europe is exposed in light, as of in Asia, Japan is particularly blazing in lights. To have a closer look in Europe, *Figure 5* is provided, in reference to the brightness level measurement given in *Appendix 3*. Being one of the highest light polluted regions, various red spots (the level where Milky Way is no longer visible) can be seen. Furthermore, in more harsh case of light pollution are the area with white spot in its location. According to *Figure 5* destination with white spot are the main cities in Europe including Milan, Madrid, Paris, London and Moscow. In contrast to its neighboring countries, Switzerland is comparatively less relent in light pollution severity. The table below indicates the brightness figures in different European countries (Falchi et al, 2016).

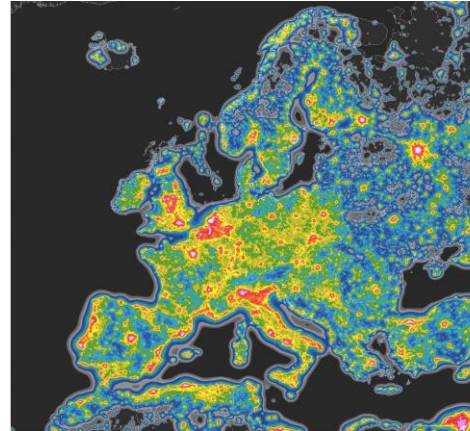


Figure 5: Light measurement in Europe. (Falchi, F. et al, 2016)

Table 1 Brightness measurement in different European countries (American Association for the Advancement of Science, 2016)

Country	Brightness (mCd/m ²)											
	≤1.7	>1.7	>14	>87	>688	>3000	≤1.7	>1.7	>14	>87	>688	>3000
	Population (%)						Area (%)					
Austria	0.0	100	99.9	88.7	35.7	10.3	0.0	100	97.8	40.0	1.8	0.1
France	0.0	100	100	94.3	58.9	26.6	0.0	100	100	64.5	6.7	0.7
Germany	0.0	100	100	96.0	41.6	2.7	0.0	100	100	74.2	4.8	0.1
Italy	0.0	100	100	99.6	76.9	26.7	0.0	100	100	90.3	19.7	1.3
Spain	0.0	100	100	96.1	75.2	41.5	0.0	100	98.6	46.5	6.7	0.9
Switzerland	0.0	100	100	96.9	34.0	0.0	0.0	100	100	57.9	2.6	0.0

UK	0.0	100	99.9	98.2	77.0	26.0	3.6	96.4	86.4	60.9	13.5	1.4
World	8.0	92.0	83.2	63.7	35.9	13.9	60.3	39.7	22.5	8.6	1.2	2

The unit of surface brightness measurement used in the data above is millicandela per square meter (mCd/m^2). Candela per square meter is the international standard unit of luminance, meaning the luminous intensity in a certain amount of surface. When measuring luminous intensity in night sky, due to the natural low in brightness, the common use of unit is millicandela instead of candela/ square meter to adjust to the appropriate unit in scale (Light Pollution Monitoring Laboratory, 2015). Corresponding the measure of brightness level numbers to the color scale provided in *Appendix 3*, 7 countries' brightness intensity are being examined. Almost all the countries are the subjects of measurement from the report provided by American Association for the Advancement of Science. However, for this research paper, these 7 countries are picked out specifically because of the topic circling around light pollution in Switzerland, so it and its neighbors are taken into account for the observation. As for Spain and the United Kingdom are also chosen due to their high popularity in tourism industry.

The evaluation of brightness intensity is broken down into 2 criteria, first the percentage of population that is exposed to the different level of brightness, and second the percentage of the geographic area of the countries that is exposed to each level of brightness intensity. From the first look of the table, 0 percent of the population is living under complete darkness in each country, whereas in the aspect of geographical area, the United Kingdom still has 3.6% of their area in complete darkness. In every country, the majority of population and area are exposed to brightness intensity of $>87 \text{ mCd}/\text{m}^2$. Where it has started to show difference is from the last two level of brightness, while in France, Italy, Spain, and UK more than half of the population is in constant exposure to brightness level of $>688 \text{ mCd}/\text{m}^2$, the rest of the countries have a significant drop in figure at the same level. Looking at the same level on the perspective of the percentage of area, each country has a dramatic fall in percentage. With exception of Italy and UK, the remaining countries all have under 10 percent of area that is uncovered to brightness stronger than 688 millicandela/square meter. From the great difference in percentage between population and area in this level of brightness, the pattern could be assumed that high level of brightness is generated and concentrated in the area that is more likely with considerable amount of population. Coming to the last level of brightness, here is where Switzerland has stood out from all the other countries. Switzerland is the only country with zero population that has been exposed to the intensity level that reach $3000 \text{ mCd}/\text{m}^2$, while Germany is also appraisable in this level, consider only 2.7% of population and Austria reduce the light polluted population to 10.3%. Whereas the remnant nations have a quarter of their population bare to high magnitude of brightness at night. Especially in Spain, a little over 40% populace is living under $3000 \text{ mCd}/\text{m}^2$ of brightness severity.

Despite the relatively fair condition Switzerland has in the level of artificial brightness, it had been measured that there is no longer a place in the country that is in total darkness. Even in the Alpine area, one of the darkest region in Switzerland, the darkness people experience there, "Measurements and simulations show that there is no sky still in its natural state." Claimed by Mr. Schuler, the president of Dark-Sky Switzerland (DSS) (Swissinfo.ch, 2015). In

fact, in 2016, Switzerland had lost its last streetlight-free village, Surrein. Surrein, a village with a population of 250, had voted to install streetlights consider the inconvenience and insecure darkness had caused to the village. "There could be someone in front of me, but if there is I can't see them." said by a local resident (Swissinfo.ch, 2016). In the past decades, Surrein had held election multiple times to argue the need of implementing lights source in night time. The first voting was 40 years ago, and the idea got rejected due to the reasons of high expense, streetlights being too ugly and intense brightness the light would bring. Later years, those concerns remained to be the counterargument of installing light, with the additional worries about light pollution and the disappearance of darkness in natural. Finally, a ballot was once again being organized in 2016, with the result of 84 in favor of streetlight installment, against three. While having light implemented certainly provide the residents some comfort and secure, one of the voter who was against the decision had voiced his reason. "It's staggering to see the sky from Surrein as it is now. That'll soon be gone," he said. "People from Zurich would pay for the kind of darkness we have here." He further expressed that the residents of Surrein had the impression that they were under the social pressure to be more modernized, that additionally pushed the decision of installing streetlights. He suggested that if only there is a channel that would publish on the value of darkness before the vote had taken in place, the result of the ballot would had been different (Swissinfo.ch, 2016). Compromising the increase in brightness at night, all the streetlight installed are the newest technology that was offered at that time. Along with the light control by dimming the brightness after 10pm or installing motion sensor on the streetlights. When being asked, Claudia Maissen, the manager of Surrein's only inn, expressed that she was happy about the changes streetlights had brought to the village and how it gave her a sense of security (Swissinfo.ch, 2016).

To close this section, it can be concluded that while Switzerland does not escape from the damages caused by artificial light, the country does have been exposed to harsh light abundance to a certain extent, the population has still managed to avoid enduring from the immense magnitude of harsh brightness as the compared countries already have. Furthermore, from comparing the different in percentage from both population and area at the last two level of brightness, it can be wrapped up to the conclusion that area with higher population density (most likely the major cities) has caused extensive degree of brightness.

2.6 Swiss Regulation on Light Pollution Protection

Since light pollution is still a young topic, the matter of crisis was not taken care of until 2005 by the Swiss Federal Office for the Environment (FOEN). As it was mentioned from the very beginning of this chapter of the case in Hong Kong, the reason Hong Kong is named one of the most light-polluted destination is because of its government's lack of control on their light emission. Therefore, it is a good sign that FOEN has taken a step upon supervising the status of light emission. However, FOEN does not have regulations established on enforcement of reducing light pollution, instead, the federal office merely gives out recommendation for the prevention of light emission. FOEN provides suggestions of light implementation as well as the impacts light pollution have on people, community and ecosystem, to further encourage cantons, municipals, and communities to treat light abundance with proper actions. The recommendations from FOEN are based on the negative impacts to Switzerland's environment that are posed by light pollution. The suggestions directly tackle the issue light pollution has

specifically on Switzerland. The negative effects of light pollution have on Switzerland are the following:

- *Effect on Landscape in Night Time:* Since the 1990s, lights beam directly toward the sky have increased about 70% in Switzerland, causing darkness becomes more and more scarce. The high brightness exposure rate in areas such as urban or even suburban region not only affects their own landscapes, but the brightness also spread into more rural and natural regions. This results in many natural landscapes lost their natural darkness at night time.
- *Impact on Biodiversity:* Nocturnal animals can be significantly disturbed by artificial light. The habitat of animals can be unnerved by unnatural light source. The wildlife animals' natural survival instinct could be hindered to the extent where it is threatening species to extinction.
- *Impact on Human (night):* Light abundance at night time has the potential of causing sleep disturbance, temporary visual incapability and dizziness in some extreme cases.
- *Impact on Human (day):* At day time, glare caused from sunlight reflected on reflective material on buildings and signs could result in visibility discomfort.

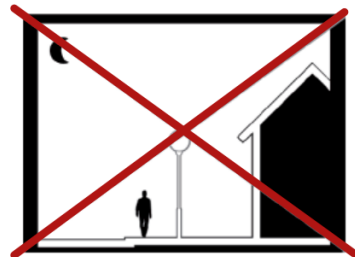
Focusing on these negative impacts, FOEN proposed a list of outdoor light implementation methods to prevent having further impacts to the victims of light pollution in the future construction or light installation projects as well as restrict unnecessary light installments. In addition, the recommendation FOEN provided is heavily based on the construction standard SIA Norm 491 that was mentioned briefly in the previous section of this chapter.

The recommendation includes (photos are included for clearer explanation):

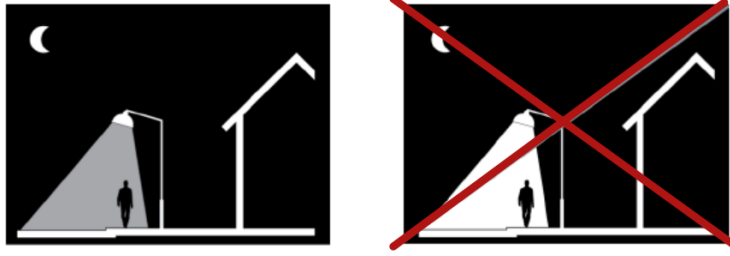
- **Necessity:** The lights and the operation of the installation required planning and remove unnecessary light plants.



- **Alignment:** Set the luminous flux from the top to the bottom. Avoid light steering from the bottom to the top.



- Light Control: Avoiding unnecessary emissions through precise light control.



- Brightness: Light objects only as bright as necessary.



- Lighting Control: Consideration of night rest by switching off or using motion detectors.

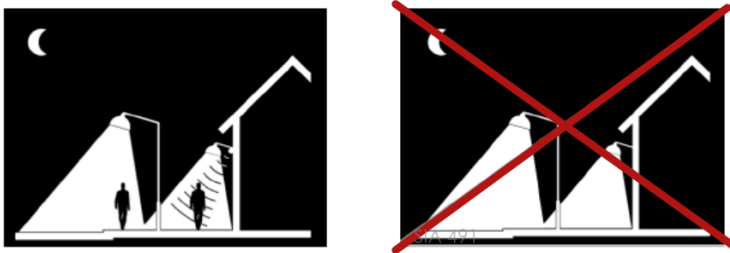


Figure 6: Light Control Based on SIA Norm 491. (SIA.ch, n.d.)

These light installation advices are given along with the lighting switch off time range between 10pm to 6am, and switch off time from 1am to 6am during Christmas season (now approved by federal office as a time restriction for disturbing light source) (Schuler, L., 2017).

Once again, these are merely suggestions that are approved by the federal government, construction companies are not legally bind to follow the recommendations, unless, the cantonal government where the construction companies are based in set light installation laws. Fortunately, with DSS, FOEN and more NGO's efforts on spreading the information on light pollution on multiple media platforms, more and more cantonal governments and municipalities have established regulation on light protection.

3 Knowledge Gaps and Problem Recognition

The following chapter detects parts of the topic which are not or only partly covered by literature. These knowledge gaps lead then to the research question and research objectives which form the basis for the onward research.

3.1 Knowledge Gaps

The aim of the literature review is to have a background information on light pollution from existing literature sources on the definition of light pollution, what impacts it creates. Furthermore, the critical level of light pollution in Switzerland and how it is treated in the legal aspects.

First off the research process of knowing what is the definition of light pollution, many sources are provided mainly from environmental preservation association and astronomical research center. All the sources commonly used the definition provided from IDA, which was mentioned in chapter 2.1, and further on provide more details on the types of light pollution as well as the negative impacts. This information is fairly accessible to all, a connection between light pollution and tourism attraction could also be found in some case studies of light emission created from said attractions. However, there is still a lack in information on what direct impact light pollution has on tourist destination. Most knowledge collected is, as mentioned, on how some tourism attractions have result in emitting light pollution, and rarely how tourism industry adapt and make changes to reduce light pollution.

All in all, after understanding of how light pollution is induced, what impacts it has and how severe it is in Switzerland from the literature review, comes into the discussion of light pollution and its relation to tourism industry. Correlating to the importance of artificial light in tourism industry, many artificial lights are used as tourism complementary products not only as a guide of direction, but also as attractions. For instance, Basel Autumn Fair, the largest and oldest



Figure 7: Basel Autumn Fair at night. (Kanton Basel-Stadt, n.d.)

amusement fair in Switzerland, is held annually for around two weeks, from noon until 10 or 11 at night. Being one of the oldest cultural heritage, additionally a place where people can have a quality night time, the fair along attracts up to a million people a year (Kanton Basel-Stadt, n.d.). However, information specifically on the relation between Swiss tourism industry and light pollution is particularly deficient.

After concluding what were found from the background research process, few questions arise here:

- Are the destination management organization (DMO)/ municipalities aware of how much light pollution is produced?
- Are they willing to compensate the pollution by sacrificing light display?
- What are some actions that are taken to reduce light pollution?

3.2 Objective of Research

The purpose of the research paper, is to understand the importance of acknowledging the critical impacts light pollution has and how it is slow altering our ecosystem. Furthermore, from the point of view of tourism industry, should the industry take some responsibilities on adding pressure on producing light pollution and make some changes with the products and services they provide to reduce emission of unnecessary light source. It is a crucial subject that many should regard carefully, since tourism industry is a fast-growing business, with the critical level of light pollution many touristy popular cities have, it is only a matter of time people start to disregard the subject of light pollution and fully embrace light in night time.

4 Methodology

The methods of data collecting of this bachelor thesis is not limit down to only one research method. In order to maximize the research results and minimize the knowledge gaps, various research methods are necessary.

4.1 Literature Review

A literature review involves two research methods: *qualitative* and *quantitative methods*. Qualitative method consists of “reading, understanding, organizing, processing, comparing, contrasting, [...] and analyzing relevant information” (Steffner, 2015) gained from secondary data. As for quantitative method, it emphasizes objective measurements and the statistical, or analysis of data collected through questionnaires, and surveys (USC Libraries, 2017). Many of the data collected in this thesis would be from secondary data that are provided from various means of source. For example, books, news articles, scientific papers that are already existed related to the subject. Most of the sources will be retrieved from the internet, with the exception of the books. These literatures would come in aid to strengthen the background knowledge of the thesis topic and evaluate the knowledge gaps.

4.2 Expert Interviews

Interviews with people who are involved in the field of research for this bachelor thesis are needed in order to collect firsthand information as well as in depth and specific knowledge for the research topic. Interviews are also more flexible with questions that could come during the conversation and answers can be provided immediately. For this bachelor thesis, interviews with different tourist destinations would be conducted. Interviews with DMOs would be held to understand what are the touristy situation of light pollution control in each DMOs, as well as their strategies of reducing light pollution. Not only with DMOs, having conferences with experts in the field of light pollution are also crucial steps to gather data. Associations such as Dark-Sky Switzerland are the professionals who have firsthand information of how sever light pollution is in Switzerland, additionally the experts who know in which approach would aid Switzerland into reducing light pollution. The following is a list of contacted experts and their information:

Name	Association	Occupation	What is expected from them?
Lukas Schuler	Dark-Sky Switzerland	President of Dark-Sky Switzerland	<ul style="list-style-type: none"> - Background information on light pollution - Light pollution situation in Switzerland - Acts and regulations of light pollution reduction in Switzerland
Roman Gisler	Canton Uri Governmental Office	<ul style="list-style-type: none"> - Technical Staff - Light monitoring project leader 	<ul style="list-style-type: none"> - Light monitoring project in Andermatt
Miriam Schuler	Andermatt Tourism Office	Marketing and Sales Manager	<ul style="list-style-type: none"> - The effect of light monitoring project has on the tourism market

Sébastien Kottelat	SBK-Laser	Representative	<ul style="list-style-type: none"> - Regulations relating to laser light performance - Any difficulty in balancing the care of performance and environmental protection
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4.3 Limitation

Similar to many research paper, in the process of writing, one can encounter difficulties and limitations, and there would be no exception in the case of proceeding this bachelor thesis topic. One of the major limitation of conducting this thesis topic is the language barrier, being a Mandarin and English-speaking person, there are times that information available is only in either German or French consider the scope of research topic is located geographically in Switzerland and many data are provided in their two main official languages. Another limit to this topic is the responsiveness of related organization contacted, due to the research method of this bachelor thesis, interviews are required as an information retrieving approach. However, it is not all the case that the contacted organization would like to participate in this research process. Last but not least, the issue of light pollution is still a relatively new subject compare to the other means of pollution and waste. Therefore, data and statistic may be lack in the field of light pollution causing insufficient information to properly approach the topic of this bachelor thesis. Hence, some of the information omitted unintentionally.

5 Findings

In this chapter, all the discovery on knowledge gaps will be discussed. The information collected in this chapter is mainly via expert interviews. In some cases, a discussion being carried out during interviews does not have sufficient time to be further explored, then additional personal research on the topic is required.

5.1 People's Awareness on Light Pollution

Many of the pollutions and wastes are produced in the hands of human, and the negative consequences are however shared among all of the inhabitants on this planet. The common solution of all the wastes and pollutions lie on people's contribution in their daily routine. One hour less of TV watching or one less PET bottled water purchased can show a difference if one managed to keep it as a habit for a long period of time. However, those harmful substances were created from the living habit people have nowadays and it could be difficult to change one's life style even when the effects are obvious. This is where the media comes in handy. In the power of media, it can spread the information quickly and bring along a huge emotional impact on viewers. In today's society, the progressive advancement of internet supports the rise of social media, where people exchange information within seconds and just with a click of a button. Many information circulates around media platforms albeit fraud or credible is sometimes undefined, it is no doubt where most people gain their knowledge from. Using social media as a promotion platform is a common practiced and effective method, governments and non-profit organizations often use it as the stream to spread information on the environmental crisis that is happening right now.

5.1.1 Dark-Sky Switzerland

Dark-Sky Switzerland (DSS), a Swiss non-profit organization, was founded primarily in the aim of spreading information on light pollution in Switzerland to the locals as well as to experts from foreign countries. The goal of the association is to raise people's awareness on light pollution, knowing excessive use of light is a fairly new environmental issue and with only commonly known and narrow knowledge about the pollution. "Light pollution was already an issue in the 1980s, therefore the growth in awareness was not because light pollution is a sudden burst of problem.", stated by the president of DSS Mr. Lukas Schuler during an interview. In his statement, he implied the problem now in Switzerland, and also globally, is that people ought to acknowledge the damages light abundance brings to their life and step in to be involved in reducing additional light emission (Schuler L., 2017). With the goal in mind, DSS hands out flyer with the information of light pollution's impact, relation to security and regulation and recommendation to people. Furthermore, DSS have their own research projects to examine the impacts light pollution has on Swiss ecosystem and report the results to various stream of media like magazines and newspapers. The association also is involved in construction projects to monitor and ensure the construction phase the light installation pass the construction standard of SIA Norm 491. With their effort, Mr. Schuler stated that "people are much more informed about light pollution than they were ten years ago." The standard enforcement on excessive light is increasing in a slow pace but constantly, with more and more municipalities taken the issue of light pollution seriously and also take account of the issue during the planning and construction phases of their projects. The involvement of local

authorities is always welcomed, however, when mentioning about the progress of Switzerland's neighboring countries, president Schuler said that in comparison, France and Germany are much more developed in the field of light pollution awareness and reduction. Consider both countries have 'Dark Sky Places (detail of these places will be discussed later in this chapter)' recognized by IDA. Whereas Switzerland due to its smaller geographic landscape capacity, creates a disadvantage on the expanding on this niche tourism offer of Dark Sky Place.

DSS can be said as the most involved and affective organization/party within Switzerland that is highly committed to build a future with reduced light emission. With the researches they conducted that is available in different channels, the association has a certain power on influencing different fields of individuals' perspective on light pollution. However, as Mr. Schuler suggested, without government's legal prosecution, DSS' effort could be limited and a simple awareness from people would not be sufficient.

5.1.2 People's Negligence on Light Pollution

Mr. Schuler further stated that there are two main reasons of why people are not taking light pollution as an issue seriously. First of all, as stated previously, light pollution is not a sudden burst of environmental crisis, many of the population born and grow in a light polluted environment unknowing to the issue. To the generations that are living under the constant beam of natural and artificial light, people are physically and mentally adjusted to the life with brightness even at night time. Compare to past generations, nowadays people have much distinguish sleeping pattern, mainly the sleeping hours have gone less. With poor sleep quality, in long-term it would induce health risks (Mizon, 2012). Having shorter sleeping time can be a habit that people get used to, however, biologically human body is still built needing a well-rested sleep to function properly.

Speaking of long-term health risks, this brings up the second explanation of negligence on light abundance. In spite of the health effects excessive use of light brings along, the negative impacts are not immediate and apparent enough for people to feel threatened by its presence. In contrast to, for instance air pollution, the pollutant is visible and tangible for human to realized its presence. From the chemical vehicles emissions to fog-like toxic gas substance flowing in the sky, the effects polluted air has on the environment is easily detectable for human eye. Unlike the quality of air substances, the brightness level of a light is not so easily distinguishable for human eye, not to mention the capability of adjusting to brightness human has (Schuler L., 2017). Human eye cannot detect and measure the intensity of brightness, they can only tell when they find the intensity disturbing and the judgement is mostly objective. The difference between these two pollutions makes the former one harder to ignore while the latter's intangibility hid its existence. Due to light pollution's concealed negative influences from the environment and human health, people's attention on the damages of society is mainly focused on other means of pollution. While artificial light implementation is not discussed but growing in quantity and frequency, leading society unknowingly moving forward to a literal brighter future during night time.

5.1.3 Darkness and Danger

Reflecting to one of the points mentioned in the previous sub-section, people are now living in a society that lights are continuously beamed on them. This modern phenomenon is not criticized to be excessive but viewed as a necessity. One of the reason light is heavily used in modern society is because the sense of security light gives to people. Lights provide psychological sense of security and comfort to people and consequentially lead to the growth in planting more and more outdoor lights (Schuler, L., 2017). As one of the suggestion on SIA Norm 491 stated that exterior lights should only be installed at places where they are needed. It occurs sometimes that the quantity of streetlights planted has exceeded the demand to the point where light sources overlap one another and further illuminated toward the sky (Schuler L., 2017). People tend to embrace the excessive, sometimes unnecessary, use of light because of the commonly belief people have on the close relation of darkness and danger. Typically, streetlights are switched on not long before sunset, it is set to minimize the time of darkness after the sun completely set and before the time the light bulb totally lights up (since most of the streetlights still use HPS, which take around 10 minutes to light up to its full capacity) and reduce the danger people might encounter while navigating in darkness. However, with this setting it means that within a day, people, animals and the sky have no opportunity to be in contact with total darkness. The more people are used to the company of light at night time, the more people would be dependent on it and become resistant to darkness. It would further tighten the link people generally make with darkness being a pose of danger, where in reality there is no scientific proof that confirm with this association (Schuler L., 2017). In Switzerland, it is not statistically proven that the increase in amount of streetlights has caused the decreased the number of crimes. Nonetheless, many people still think otherwise, leading to misunderstandings that dark places have more reported crimes than lit areas. Another reliance of streetlights is the car drivers, this reliance involves with yet another misleading common belief of unlit areas have more car accidents and lit areas. Albeit statistically this statement is true, the fact that proportionally there are more dark areas than lit areas is often left unsaid. Therefore, it is also theoretically inaccurate to say that dark areas cause danger to drivers more than in a bright area (Schuler L., 2017).

People often tend to associate darkness to danger in many aspects. Either using darkness metaphorically as a meaning of hazard, or mentally link the two together. However, realistically speaking, people have a general misunderstanding with their interpretation on darkness, it does not pose as a danger to their life. People should recognize that darkness is a natural phenomenon that was once embrace by the ancestors, and it is what should be done again in order to protect society from intense brightness. Instead of being afraid of darkness, people should welcome it.

5.2 Dark Places as an Attraction

Knowing the importance of raising people's awareness on light pollution, it is also crucial to find a method to promote destinations that are well-organized in the aspect of preserving the quality of night sky. It is a way to encourage destinations to remain the quality they are offering, and simultaneously market their night sky tourism offer. By grabbing people's attention on clear night sky destinations, they would start to appreciate a sky full of stars with little to no

disturbance from excessive light sources. This is the strategies IDA had established and later on created into an International Dark Sky Places Program back in 2001. Through this program, IDA simultaneously motivates destinations to strengthen their night sky quality protection and market the destinations by awarding them the label of Dark Sky Place through their media channels (International Dark-Sky Association, n.d.).

IDA has classified Dark Sky Places into 5 categories:

1. International Dark Sky Communities
2. International Dark Sky Parks
3. International Dark Sky Reserves
4. International Dark Sky Sanctuaries
5. Dark Sky Developments of Distinction

Destinations would have to apply and be qualified in order to get the honorable label. Throughout the application process, IDA judges the destination by examine the destinations' community support and contribution on dark sky protection. After the award is given IDA would continue to monitor the night sky quality bimonthly to ensure the destinations continue to commit to dark sky protection (International Dark-Sky Association, n.d.).

In 2015, recognizing the association's effort upon encouraging and aiding various global locations to preserve their dark sky, IDA received a National Environmental Excellence Award from the United States' National Association of Environmental Professionals, thank to its International Dark-Sky Places Program (International Dark-Sky Association, 2015). The examine process requires a great detailed of collaborations and constant follow-ups and monitoring. The efforts did not go in vain consider the number of awarded locations there are since the program began. With places across 4 continents including: 10 communities, 22 parks and nine reserve areas awarded Dark-Sky Places labelling. Majority of the locations are in North America, following by European countries and with South America, Africa and Asia having only one destination each to receive the title (International Dark-Sky Association, 2015).

Unfortunately for Switzerland, it has not yet had a location that has been approved by IDA. This is again race back to the reason given by Mr. Schuler, that Switzerland's geographical capacity is relatively smaller and more limited compare to North American countries and European countries like French and Germany (these are the countries pre-dominate the number of the Dark Sky Places). Although, this does not mean the countries stated are necessarily low in light pollution measurement. Quite the contrary, as it is shown from *Table 1* in Chapter 2.5, Switzerland's exposure to light pollution is not as critical as it is in its neighboring countries. In fact, big cities such as New York, Los Angeles, Paris and Berlin all have a severe case of light abundance. Reflecting to the observation from *Table 1*, those main cities are to be blamed for contributing to creating most of the light pollution within a country. Although Swiss big cities such as Zurich, Basel and Lucerne also have profound bright nightlife, the dominating Alpine area has prevented Switzerland to expose to light pollution to a certain degree. Having up to 65% of its geographic area covered by the Alps,

making Switzerland the second most Alpine nation (Swiss Vacations, n.d.). Having half of its landscape covered by the massive and high-altitude mountain range, Switzerland has much of its area being unexposed to brightness simply because of its uninhabitable condition. If Switzerland were a country with flat landscape, it would not have such luck as it has now to escape from the spread of population and from the light people bring with them (Schuler, L., 2017).

Had Switzerland used its advantage of clear boundary between urban areas and rural regions, the country could also develop a destination such as Dark Sky Places. Take the United States as an example, while it is one of the most light-polluted countries, at the same time the United States is also the country with most Dark-Sky Parks. In *Appendix 4*, a picture of the United States' population density is given, a similar pattern can be seen between the population density and the light polluted areas (*Appendix 5*). The near identical patterns suggested that areas with higher population density would relatively have a greater intensity in brightness. Looking into both pictures, there is an area where it is low in population density and also undisturbed by light pollution, the region is the circled area in *Appendix 6*. The circled area is the states Utah and Arizona. Both states with low in population density and light pollution measurements are the area where a large proportional numbers of Dark Sky Places are located. Utah State has used their rich natural environment as a strong suit to promote their well-preserved park. Utah state promotes its landscape features that offer the sight of Milky Way to visitors further creates a niche tourism called Astronomical/Astro Tourism (Utah Office of Tourism, n.d.).

5.3 Knight of the Night

In 2008, DSS created a label of 'Knight of the Night', unlike Dark-Sky Places with purpose of concentrated promotion on nature parks, Knight of the Night is a title organized to honor different fields of industry, including private corporates, non-profitable organization, regional tourism office, even a citizen could have the possibility of earning this title. The title of Knight of the Night practically has no limitation to whom it is awarding, instead of a region-bound award like Dark Sky Places, it is handed to anyone that has involved themselves in contributing to the act of reducing light pollution (Schuler, L., 2017).

Since the label was created by DSS, with the association's mission of spreading information and awareness on light pollution, the purpose of having the Knight of the Night title is a campaign to have an extra mean of promotion on light pollution awareness. Moreover, the title was created to demonstrate that actions and measurements are taken by individuals or organization, who are committed to the reduction of light pollution activities or projects. The receivers of the title are not necessarily given with physical rewards, like money or so. Rather, the beneficial factors of the title are the media attention as well as government's awareness on the receivers' effort on preventing light pollution. With these beneficial factors in mind, DSS further stressed that this honorable title can be received by anyone (as long as it's in Switzerland) to encourage people from different field of work to participate in this light pollution prevention/reduction act (Schuler, L., 2017).

The title was first created in 2008 because of the community of Coldrerio, in Canton Ticino, was the first ever community in Switzerland to establish environmental law on the elimination of public and private external lights during night time. Coldrerio was the first municipality in Switzerland to have all external lighting turned off from midnight and onwards. This decision was initially resisted by local electricity suppliers, as well as by companies with light advertising, who feared sales losses. In spite of the local companies voicing their displeasure to this change of regulation, the municipality stood on their ground and insisted on this change. While DSS also claims Coldrerio as their life-time honorable member, the community's title of Knight of the Night was not widely recognized, back then Knight of the Night was merely a spoken title instead of solid/physical awarding label. It was not until Canton Uri's act of preventing light emission from one of their upcoming tourism development with the canton's light monitoring project (the details of this project will be covered later in this chapter), had DSS announced their first and real "Knight of the night" with a diploma and a trophy figure (Schuler, L., 2017).

While this title is not regional-bound as it is from the Dark Sky Places label from IDA, one thing can be assured is that the title has the certainty of gaining recognition from different field, and could for sure be an approach for destinations to gain attention by offering a well-maintained and preserved night time landscape.

5.4 Gantrisch Nature Park

It is not a new strategy for a location to utilize its night time landscape as an attraction to draw tourists' attention as Utah state has done. Gantrisch Nature Park located in between the cities of Bern Fribourg and Thun is a well-preserved natural park in Switzerland. It was not until in 2012 that the Federal Office for the Environment gave the label of "Regional Natural Park of National Importance" to the nature park, with recognition to the park's well-balanced management between the three pillars of sustainability (Dark-Sky Switzerland, 2015). Soon after the nature park gained its recognition from the government, people's attention followed suit. The nature park had since then slowly but steadily developed more offers to its visitors. At the moment, majority of their visitors are day time tourists, whom mostly choose to stay overnight in the three cities nearby the park instead of choosing to stay in the accommodation available around the nature park region. This trend of tourist stay has been a constant problem poses to the nature park's tourism development (Dark Sky Switzerland, 2015).

5.4.1 Night Landscape Project

Acknowledging the problem and the need in improvement of their number of overnight stays, the Starlight in Gurnigel Project was created in 2015, and later on called the Night Landscape Project. Either names, the essence of the project is to gather groups of stargazing enthusiasts, albeit professional or amateur, everyone is welcomed to Gurnigel Pass (a plateau located in Wattenwil, is also known as one of the darkest places in Switzerland) at night time to admire the beauty Gantrisch Nature Park offers during night time (Dark Sky Switzerland, 2015). The project leader, Nicole Dahinden, believes dark sky give people a healthy and quality life, with polluted and illuminated night sky could cause restlessness and stress to people. Concerning not only the quality life of human, but also the nocturnal animals around the park that rely on the natural darkness of their surroundings,

since the nature park is label as Important Bird and Biodiversity Area (IBA). With these factors, the project leader further stressed on the importance of separating the nature park from artificial light sources and people's awareness of how captivating a clear starry night sky can be. So far, the project is held annually with the success of attracting approximately 50 stargazing enthusiasts around the world, as well as invited guests from DSS and Pro Obscurare (an electricity consumption reduction committed association) staff members to Gurnigel Pass for stargazing (Dark Sky Switzerland, 2015).

5.4.2 Pursuing UNESCO Certificate

Another strategy Gantersch Nature Park approached with the attraction of their night time landscape is to apply for an UNESCO label. This approach while certainly could gain fair amount of awareness from media, it is not the only benefits the label brings. The UNESCO certificate would bring along the attention and cooperation with the municipalities and government. However, it is easier said than done, the criteria for obtaining the label are the applicant site must have cultural and natural significant to the local heritage (Scientific America, 2013), the site must be an "irreplaceable sources of life and inspiration...our touchstones, our points of reference, our identity" (World Heritage, 2008). While Gantersch Nature Park most certainly held its natural significant to its community, what is stopping the nature park from succeeding in earning the certificate is the absence of cultural aspect importance (Schuler, L., 2017).

One of the goals the nature park has is to prolong their day time tourists' hour in staying in the park, and hopefully would result in more overnight stays. Not only do they need to strengthen their promotion on their night sky quality and the sight of stars, but also the local hospitality industry has to recognize the potential stargazing tourism package can bring to their community. This once more circles back to the importance of gaining awareness and recognition from the communities, municipalities, and government, to have their involvement and cooperation on maintaining natural site from light pollution.

5.5 Light Monitoring Project in Andermatt

One of the important trait of characters that is crucial in creating a business (regardless in which industry it is) in today's society is to have a long provision, meaning to consider in a long term to encounter issues that could rise in a sudden due to the fast-growing civilization phenomenon people are living in today. In the light monitoring project of Andermatt, the cantonal government had the provision that an upcoming tourism development project in Andermatt would serve as a potential threat to Canton Uri's well preserved natural landscape. If the control is not done properly, the environmentally well-maintained region could be slowly following the path of how the other urban areas have suffered from pollutants and wastes. Hence, the cantonal government had developed a project as a method to control the environmental threats the new tourism project would bring.

The light monitoring project was initiated in 2013, when a tourism resort project was announced. With brand new hotels, second homes and resorts were planned to be built not far away from the city center of Andermatt. Although this tourism project would for sure generate a great amount of income and also create an opportunity for Andermatt in tourism industry, the

cantonal government, while being supportive of the tourism project, did not back down when it concerned to the environmental aspects that could be damaged from the project. Acknowledging that Canton Uri is one of the few regions in Switzerland that is not suffering from light pollution and the fact that on days with good weather, the Milky Way is visible to people. Therefore, the light monitoring project was created in purpose of controlling the construction and interfering when necessary if the light installation of the project does not pass their standard that were set specifically for the tourism project. It is because of this monitoring project, Canton Uri received the title of “Knight of the Night” given by DSS, the association recognized the canton’s contribution to excessive light installation prevention, and also set the project as an example to other region since the project in Canton Uri is a pioneer in the light pollution reduction field (Gisler, 2017).

The light monitoring project, as its name has suggested, monitors the light emission specifically in Andermatt and also in Hospental. To ensure the current and future tourism development do not hinder the darkness the regions have prior to once when the tourism project is done. The canton had cameras placed that snapshot pictures four times a day in different period of time. From the pictures, experts analyze the brightness during the night and examine whether the intensity of light pollution has been increased due to the tourism project or not. While the tourism project has yet been finished, the canton has already had some progress on the light emission control (Gisler, 2017). Through observing the pictures, it can be seen that the area with most light emission was from the train station which even after midnight artificial light was still switched on. Also, the local church also had its lights lighting up the outer part of the building during night as a display. Even when the sources of light abundance were found, the cantonal government was restricted by law to enforce the church and train station to renovate their lights settings. Only when the facilities are under reconstruction, the canton would then have the power to control the light implementation, it is one source of limitation that slow down the Canton’s desire to reduce light pollution. Therefore, only time can change the situation in this case, and already some improvement can be seen throughout the time lapse video of the light monitor that the local church has indeed renovated with their night time lightings and have them shut after midnight (inNET Monitoring AG Altdorf und Luzern, 2016).

On the other hand, since the tourism resort project is currently in its construction phase, Canton Uri could freely keep the construction on the track of the regulations that are set upon light installation. Ever since the ski resort project was in planning, the cantonal government had had countless discussion with the tourism project responsible company, Orascom Development Holding AG. Knowing that the private company has a large development in mind (Orascom Development, n.d.):

- Six new 4-5 star hotels
- Nearly 500 new apartments
- 30 villas
- A golf course
- One new leisure center
- New ski slopes

as well as the scale of change the project could bring to their environment, the government had interfered the construction planning multiple time whenever the project design endangered

Andermatt's natural ecosystem. Light installment policies were established to control the construction of outdoor lightings. Some fundamental outdoor lights placing regulation includes:

- All light installments must have clear purpose
- All lights have to be shielded so that the light shines only where it serves
- A direct radiation into the sky is to be avoided
- Luminaires must be shone from the top to the bottom
- Brightness intensity must be adjusted or switched off between 10 pm to 6 am

With these policies, along with specific outdoor light design requirements Canton Uri had set for the resort project, a constant adjustment on light designs needed to be proposed by Orascom Development Holding AG. Fortunately for the canton, the company's reaction to the restriction was their understanding to the canton's demands and remained cooperative to the conditions.

5.5.1 Innovative Lighting Design

Under the circumstances set by the light protection laws of Canton Uri, Orascom Development Holding AG has been in constant stress ever since their announcement of the tourism resort development in 2008. The project is already delayed in their schedule and to make the situation more difficult, the project will not be finished in the next 10 or 20 years (Gisler, 2017). It cannot be determined if the light monitoring project has hindered the tourism development or not, due to the immense nature of the tourism project. One thing for sure is the contribution the light protection laws have on light design/allocation control.



Figure 8: Chedi Andermatt Hotel at night. (Kanton Uri, 2015)

lights inside the building in between 2 glasses, with the lights only shine either upward or downward to avoid light exposure to outside. With this layout, it enables the building to be lit during night time without radiating illumination to outdoor areas and more importantly to the night sky (Gisler, 2017).

Have a glance at *Figure 8* once more, various lights can be seen near the ground, all the while the lights are pointed directly towards the floor. This is another idea of light placement the architectural team of Orascom Development Holding AG had come up to light up the field of the hotel area and at the same time averted the lights to shine to the sky. The architectural design was well-received from the cantonal government and from the further observation from

In 2013, Andermatt welcomed its first five-star hotel – Chedi Andermatt Hotel, in their tourism resort region. Being the luxury hotel pioneer is not its only uniqueness, the design of the hotel is a feature worth mentioning especially in the concept of reducing light intensity. The picture on the left is the Chedi Andermatt Hotel. Take a close look at the lighting design, it can be observed that the lights are essentially lighting up indoor space without exposing the outside of the hotel with excessive brightness. This is achieved by placing

the canton's part. It had turned out to prove the design to be effectively minimized the effect the hotel has on Andermatt's night time light emission (Gisler, 2017).

With the insistence from the cantonal government on designing an eco-friendly light planting, and the tourism development company's cooperation, the grand opening of Hotel Chedi had come true and created a win-win situation for both the destination and for the Orascom Development Holding AG. The company became the first one in opening a five-star hotel and many more future tourism developments are taking place. Andermatt managed to preserve its natural darkness and at the same time having a newly created source of income for the local business. It can be said that the tourism resort project holds a lot of potential and benefit for the future in Andermatt tourism industry.

5.5.2 Andermatt's Potential

The procedure of the tourism resort development is most definitely not a simple one. While it cannot be proven that the resort development project is late on schedule solely due to the interference from the canton's side. The government's concerns on the increase in light emission has without a doubt hindered the project's pace, by demanding the tourism development company to design a lighting model that can resolve the concern. Even with the strict supervising from the canton's involvement, the promising tourism market Andermatt have is attractive enough for Orascom Development Holding AG made the decision to continue in proceeding their tourism resort project. With the company's development plan on creating a brand new and extended package in leisure activities. Mr. Sawiris, the owner of Orascom Development Holding AG, has confidence on the tourism market potential in Andermatt, and his belief is not based on fantasy (Orascom Development, n.d.). Andermatt does possess a few appeals to both investors and tourists. For one, Andermatt is one of the few places in Switzerland where the Milky Way is still visible. Stargazing is proposed as a niche offer in Andermatt tourism office's sale and marketing plan, however, it is not the main product offer Andermatt is now focusing on. Since Andermatt is located in the heart of the Alps, the amount of snow is not as big of a problem for its ski fields as it is in other ski regions, whom rely heavily on artificial snow (Schuler, M., 2017). Winter sports include downhill skiing, cross-country skiing or freeriding, these are the typical winter activities Andermatt presents to its visitors, along with other summer activities such as golfing, hiking, climbing, and mountain biking. Most importantly, is the accessibility from various destination to Andermatt. The roadways go over and through the Gotthard remain amongst the most important trans-alpine routes to this day. Also, along the trip the visitors can enjoy a sweeping view of the Urseren Valley and a spectacular panorama of over 600 Alp summits (Schuler, M., 2017).

The cooperation between Orascom Development Holding AG and Canton Uri proves that there can be a successful case of tourism development compromising with the requests of preventing excessive light emission with special artificial lighting design. Despite the fact that with adjusting and moderating light exposure is a difficult and time-consuming process, it is crucial for tourism development project to be able to modify when it is posing a potential threat to the destination's environment. This has turned out to be a successful case also thanks to Canton Uri's strong insistence on putting their environmental preservation into priority instead

of focusing on the financial potential the resort project could bring or simply dismissing the possible hazards that come with tourism project.

5.6 Canton's Involvement in Law Establishing

Knowing the importance of government's involvement from Andermatt's tourism resort project, it is also important to explore how other cantons are taking actions to prevent light pollution from spreading into natural darkness. With various means of channel, such as FOEN and DSS, endorsing the message of avoiding unnecessary light emission, gradually, more and more cantons started to establish laws on outdoor light installment. Canton Uri also takes its light monitoring project as a model and present the details of the project to canton representatives who also notice the significance of light abundance prevention (Gisler, 2017). It is certainly a good sign that many cantons are beginning to be involved in the act of reducing light pollution, it surely posed a difference than it was a decade ago when only the community of Coldrerio had first regard the endangerment light pollution produce and set regulation with the intention to reduce light abundance (Schuler, L., 2017).

Currently, the cantons that had already authorized notice on avoiding unnecessary light emission includes Canton Aargau, Bern, Basel, Schaffhausen, Solothurn, St. Gallen, Ticino, Uri, and Zurich. All these cantons have based their outdoor light installment policies on SIA Norm 491, with some cantons additionally prohibits the use of sky beamers. Considering sky beamers are powerful spotlights that beam directly into the sky, producing both great amount of light exposure to the sky and waste in unnecessarily energy consumptions (FOEN, 2016). For instance, in Canton Bern, the cantonal government had set the restriction on sky beamer for advertising on events since 2012 (Kanton Bern, n.d.).

To know the perspective of the sky beamer display companies, two private companies are contacted, one based in Zurich whereas the other is based in Courroux, Canton Jura. Unfortunately, only the company in Courroux, SBK-Laser, had responded to the interview request. The representative of SBK-Laser Mr. Sébastien Kottelat answered that, working in the field of laser light performance, he expressed his point of view on how he does not see laser light show have a strong link to light pollution, because the thin concentrated laser lights do not light up the sky (Kottelat, 2017). However, the fact that light pollution is not simply about the brightness in dark sky, it also concerns the discomfort artificial light can do to human and animals' eye was either ignored or unknown to Mr. Kottelat. It can be seen that the different responses sky beamer has created, while it might not be primarily caused by the difference in regulations, but to a certain degree the lack of law enforcement contributes to people's insufficient interest and concern to light pollution.

Although it is appraisable to see that in recent years many municipals stepped up to take action in enforcing regulations on outdoor light installing to reduce unnecessary light emission, it is unfortunate to know that light pollution (although growing in attention) is not the priority of concern to the local authorities.

5.7 Performance and Displays

Since sky beamer is mentioned, let's talk about performance and displays with the use of artificial lights. Like mentioned before, light effects can be used as a complementary factor to use lights as a source of display, for example, during night time lights are switched on beaming to tourist attraction (i.e. castle or, cathedrals). With lights pointing at the buildings, it not only allows people to visit the sites during night time, but also with lights on it shows another astonishing side of the building that cannot be visible in day time. Sometimes light can be the main focus of a show, seeing artificial light brightly shine in dark sky can easily create a wow factor similar to fireworks. To some extents, it is true that light effects do enhance tourist's experience during night time, and it has the potential of becoming a main attraction of a destination's night life. However, is it justifiable for tourism industry to abuse the use of artificial lights and endanger the quality of night sky darkness? This is a critical issue that should be looked into.

5.7.1 Christmas Market and Fairs

One of the early concept of this research paper is to find out if tourism facilities or events have produced light emission that eventually add on to the brightness level at night. A particular event came into mind was Christmas Markets. Christmas Markets, traditionally are organized in numerous cities and towns from the beginning of December till the 25th or end of December. In Switzerland, with over 100 Christmas Markets hold yearly, it can be easily imagined the immense amount of light emission Christmas decorations create as they are being switched on all at once over a month. Much as the Christmas Markets, fairs also bring their share amount of light emission to the environment when one is being held. As mentioned in *Chapter 3*, fairs such as Basel Fair has bear its cultural, economic and touristy importance to the locals. One cannot deny the value a fair could add to a destination, with addition to the use of lights, besides the fact that it could prolong the time of the event in a day, but also heighten visitors' experience. Having extravagant light decoration is not only a way to create another emotion to visitors, but also a method to prolong the opening hour of an event per day.

However, the idea of doubting the necessity of the extreme use of light in Christmas Markets and fairs was quickly denied. Stated by Mr. Schuler, "the government does not necessarily control or supervise the use of light in such events, because this type of events is normally organized to last for a short period of time. Therefore, it is not much of a concern to us and to the government." (Schuler, L., 2017). On top of the fact that there is a lack of interference on authorities' side, there is a further indulgence on the hour of light consumption, that in the period from the 1st Advent to the 6th of January, home Christmas decoration could be switched on until 1 in the morning, unlike the usual time restriction that starts at 10pm (DSS, 2016). Despite knowing the fact that at a year's end and in January is the period of time with the highest level of light pollution, there is no proof, or lack thereof, to say that Christmas and New Year celebration is the direct cause to the immense intensity of brightness. The negligence of controlling the use of light in the sense of celebratory events could really bring a toll to the degree of light pollution in the future. Consider the events have the stability of being organized annually, their negative impacts on adding light pollution ought to be taken more seriously.

To debate on the use of light during festive time is a conflict between tradition and modern pollution issue. “My colleague once tried to switch off all the streetlights (except ones at crossroad) in his community, and let the population rely all on the decoration from the private houses and Christmas market.” Mr. Schuler confessed. This extreme and possibly controversial approach had actually brought an unexpected result. It turned out that having the Christmas decorations from the private household and markets alone are sufficient to light up the whole community, and the residents were not aware of this massive change in the use of their night time facility. The reason this approach was initiated was because in the said community, traditionally the Christmas decorating started in mid-November. To take care of both the tradition and the environment, by not disappointing the residents and keeping the brightness level at bay, switching off the streetlights and keeping the light decoration were a risky but proved to be an effective move. When questioned about the legal issue of going to the extent of switching off streetlights, with the aim to experiment on the effect of Christmas decorations have on light pollution. Mr. Schuler explained that a community is actually not legally bound to have their streetlights lit. There is no regulation on how a community have to utilize their streetlights, only that the streetlights placed at crossroads must be switched on. However, this is not a knowledge known by many, and the pattern of lighting up street lamps are dominantly controlled by the reliance people have on brightness at night. Fortunately for the community, the lack of regulation has for once comes in aid to grant them the liberty of keeping their tradition of early celebration and simultaneously preventing the celebration to further polluting the darkness (Schuler, L., 2017).

5.7.2 Lighting up Buildings

Often during night time, streetlights are not the only outdoor lights that are being switched on. Exterior lights also include the lights that are being used to light up buildings. Thanks to the lights that beam up towards buildings, many of the buildings remain visible to people even at night time. While the sole purpose to light up a building was to guide people towards the building, nowadays it too has become a way to highlight the feature of an architect. Driving through cities and towns in Switzerland, one can see that a lot of churches are lit by spotlights as a display of their location as well as the architectural design. The spotlights certainly served the purpose of attracting attention, however in this situation, the attention is not necessarily a positive one. The spotlights have bluntly directed their light beams toward the buildings, from bottom to top. Although it does highlight the architectural features of the building, many of the lights have unfortunately also seep to the sky. This is the scenario Kurt Wirth, a board member of DSS, had encountered even he was passing through a construction site of a church, Wirth is also the creator of the (Ein-)Leuchtendes Modell. The purpose of creating this model is to highlight the distinction different light settings could produce. The model does not introduce any new concepts but simply demonstrate the light setting under the SIA Norm 491's effect contrasting to the common light effects people often encounter in a municipal (Schuler, L., 2017).

In this model, a miniature is built that recreates a church and its surrounding as if it would be built in real municipal. This miniature features a church, roads, private households right across the church, streetlights along the streets, tree-illumination-lights, and church-illumination-lights. As the picture shown on the right. The light poles in this miniature are actual lights that can be switched on and off, and the light settings can be altered with the brightness and the lamp color emitted. The positions of the lamps are fixed, and the light beaming directions remain unchanged. The settings are arranged as such in the purpose to truly prove that with different lighting systems, it would create a complete different light exposure when in totally darkness. One of the major concerns a usual light setting has is the tree-illumination-lights. Tree-illumination-lights are placed on the ground circling around a tree, the problem with these lights is that the lights are built with the intention of lighting up trees. However, most of the light source seeps through the tree and is also lighting up straight toward the sky. Since one of the two different light setting involved is based on the recommendation of SIA Norm 491, as the recommendation had suggested to *eliminate unnecessary light planting*, the model has completely shut off the tree-illumination-lights when demonstrating the SIA Norm 491 version of illumination setting. The most prominent difference between the two settings, other than the absence of tree-illumination-lights, is the cold church-illumination-light from the normal version, to SIA Norm 491's version with warm temperature light. With a vary in color, the level of brightness can be differentiated without difficulty. The illustration of the two light settings is shown in the picture to the left. The left-hand side is the typical light setting, whereas the one on the right is the setting under SIA Norm 491 recommendation (Schuler, L., 2017).



Figure 9: A photo of the miniature. (DSS, n.d.)

The (Ein-)Leuchtendes Modell does not just simply display how under an organized light system a significant difference can be seen with the less bizarre light emission and glare, the model also shows that the less in light intensity has a direct impact on the ecosystem. To break down, the cold color lights that are typically used as the spotlight to

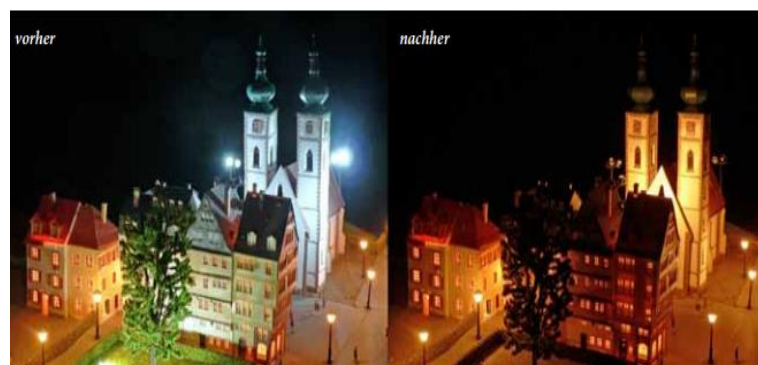


Figure 10: Demonstration of the two light settings in darkness. (DSS, 2016)

shine directly to the church buildings. Aside from the birds that got distracted and confused similar to the example from 911 Tribute of Lights Monument, sometimes there are bats that habitat in side churches would also be disturbed by the cold temperature and harsh light source. By changing the light bulbs to a warmer color decrease the intensity of brightness significantly. Wild animals are not the only victim this demonstration has identified. Humans also turned out

be to one of the victims in the recreation this model had suggested under the commonly installed lighting system. In this case, tree-illumination-light is the troublemaker. As previously mentioned, tree-illumination-light poses a major problem in night time in a municipal because of its non-shielded design that does not essentially hold any significance on creating visibility to residents, it is served more as a decoration. When tree-illumination-lights are switched on, the lights have unintentionally beamed toward the sky and also into private households, ultimately creating sky glow, light trespassing and disruption to the sleeping pattern of residents inside the households. The complete cancellation on having tree illumination light are additional benefits of having the SIA standardized lighting system.

DSS is demonstrating this model to different communities and municipalities governments who are interested to the issue of light pollution. The purpose of having this model demonstrated to different people is to tackle the problem light pollution has in Switzerland, not the severe brightness level Switzerland has but the lack of attention people paid in this field of pollution.

5.8 Is LED the Best Choice?

LED light being the newest technology that offers a long-lasting life and no sodium emission and many other advancements among other types of light bulbs, is now replacing HPS to be used on streetlights. The primary reasons of HPS light bulbs being replaced are first the environmental harmful substance such as mercury HPS releases when it is lit. Secondly, while HPS already has a decent length of usage, LED lights provide an even longer hour of usage. Looking upon all the advantages LED lights have; many communities had started to use LED light on their streetlights. However, Mr. Schuler from DSS addressed that while it is true that LED lights hold those advantages of energy and source material saving, but what is being omitted is the fact that the light LED produced is not as environmentally friendly as people think it is. As it was mentioned in *chapter 2.3.4*, LED lights typically produce blue close to whiteish

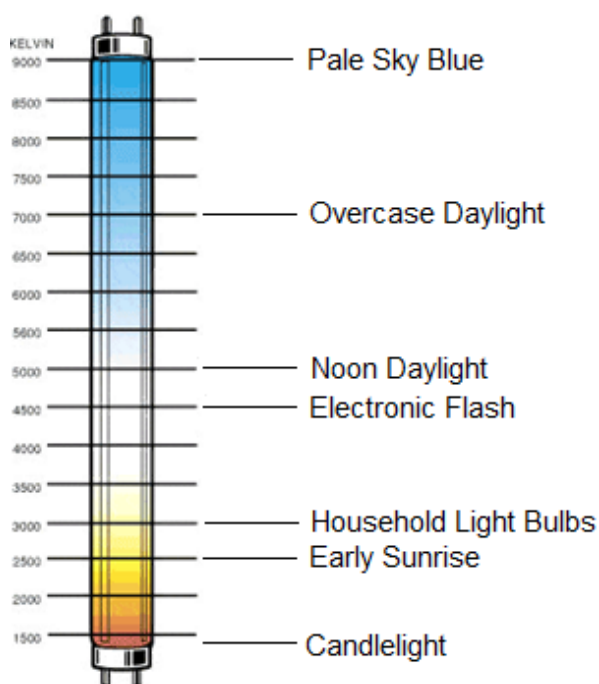


Figure 11: Illustration of color temperature.
(McCauley Electrical Service, 2015)

light beam. While now in the market, there are LED lights with color temperature varies from 2600k to 7000k (McCauley Electrical Service, 2015). Referencing the color temperature to *Figure 11* on top, LED lights produce brightness levels range from equivalent to HPS light's orange glow to as bright as daylight. LED lights can still be seen as the better choice as it provides more option and variety of brightness level. However, the warm light temperature LED lights produce is not its natural design. With today's technology, the color of LED lights was achieved to be alterable and the design behind it is fairly simple as well. LED lights naturally emit blue-white light, no matter how dimmed the light is already adjusted the color temperature does not change, the spectrum LED lights beam out would still present in cold color. The warm

temperature LED lights that are now on the market, the LED lights being filtered by a colored cover to change to color of the light emitted. This method while served its purpose, the drawback is that the energy used to produce the higher-energy-consuming blue light is still consumed but to create the less-energy exhausting orange warm light (Schuler, L., 2017).

Furthermore, as it is known from the literature review, centuries ago people relied on moonlight to shine their paths in darkness. It was not until the further development of artificial light implemented into many aspect of human life, had streetlights slowly replacing the natural light from full moon to today's full moon moonlight being dimmer than streetlight. In terms of Kelvin Color Temperature, a full moon has in average approximately 4000k, color temperature being close to a cold color and is about the same recommended color temperature as IDA has suggested. With the traditionally used HPS light bulbs as the choice of lamp for streetlights, the lamps' natural emitted color having ranged between 3000 to 4000k is compatible to moonlight. Whereas LED lights' natural blue light is considerably closer to the color of daylight.

6 Discussion and Recommendation

This chapter discusses the findings and relates them to the information gained in the literature review. Moreover, recommendations will be given on how Switzerland and Swiss tourism industry could face the problem of light pollution

6.1 Discussion

The purpose of this research paper is to find out how light pollution has changed today's society and more specifically in the tourism industry in Switzerland. To what extent should the tourism industry take some responsibilities of causing light pollution furthermore, what changes should the industry made with their products and services to reduce emission of unnecessary light source. In this section, the highlights from both findings and research part will be given to address to the research questions. Then a cross reference will be taken in place to evaluate the knowledge gained from this paper.

6.1.1 Findings

Firstly, the findings reveal that light pollution in Switzerland is still a relatively new topic that needs to be taken care of seriously. Although some efforts are made in order to reduce the excessive use of artificial lights, it is yet not a commonly discussed practice. The awareness people have in general on the critical impacts light pollution has on the environment is fairly limited. Even if some have the issue in mind, a general association is made to the waste in energy rather than the damage light abundance has on the ecosystem. In recent year, Switzerland has a greater population which more people are informed about the issue of light pollution, thanks to non-profit organizations like DSS's devotion on spreading the information. Local municipalities also have their fair share of contribution on informing residents on the importance of avoiding needless use of exterior light as well as establishing regulations on the construction guidelines of implementing outdoor lights. There are a whole lot of channels that promote the issue of light pollution, such as IDA's Dark Sky Places, and Ganstrich Nature Park's Night Landscape stargazing gathering, however, it is currently still a niche topic that only attracts a certain target group. When it really should be a subject of concern to everyone. An important method of promoting the act of reducing light pollution, other than to simply spread information about it, is to show the difference one's effort could make when an act of reducing light pollution is taken in place. Seeing the differences one can make could be an incentive to encourage people to join the party of fighting against light pollution. DSS has made itself as a model on showing the difference one can make when people undertake actions. Through the title of "Knight of the Night", DSS reported to people that light pollution is a threat to ecosystem, and authorities are making efforts to take the issue under control. With the addition of (Ein-)Leuchtendes Modell, it demonstrates the variation of results different light settings can have to night time. Perhaps, what is needed to be done is not simply telling people the problems light pollution brings, but the possibility of solving this source of pollution human had made does exist. To let people know it is not a just wishful thinking to succeed in protecting the environment from artificial light emission.

Thus far, light pollution does not seem to be a well-acknowledged issue that has been taken seriously to have certain impacts to tourism industry. Meaning, the existence light pollution is

known but the extra-step of reducing it is often not taken, not only in tourism industry but in many other fields. Switzerland, as a tourism developed country have most of their tourism facilities installed (including streetlights). Even if the municipality of a destination had newly established regulations on new standard of implementing outdoor lights. It could be politically challenging to enforce changes, unless a remodeling is taken in place. To lessen the willingness and possibility in upgrading light facilities into an eco-friendly design, the process of adjusting consist of a great deal of expense as well as management effort, that without a proper planning from authorities' side, it would be close to impossible. Fortunately for Switzerland's ecosystem, a successful case in Canton Uri happened that light control was issued strongly by the government and resulted in the brightness level in the region remained the same before and after a tourism project was launched. In the developing process of this tourism project, the cantonal government's interference on the light designs involved in the tourism development project are constantly altered to have a most light sustainable design. Special designs and techniques are used to reduce the exposure of light into the sky. However, the case was successful in avoiding light exposure only because it was still in a phase when adjustment could still be made. While the canton realized the local church and train station also have emitted intense lumination after their opening hour, the canton could not force changes to be made since a construction is not in process.

Due to the recent emerge of light pollution in the past decades, on top of how light pollution is not largely talked over, it does not have much power to change the development of tourism industry in Switzerland. Take fairs as an example, the light emission a single fair could produce is quite tremendous. Normally, the light decorations used in a fair, for example on a roller coaster ride, consists bundles of small individual light bulbs placed around the frame of the facility. There are no intentions of shielding the light exposure caused by the light bulbs, since the purpose of having them placed in the first place is to have them shine brightly as a display at night time. The additional problem on missing in control of light emission in the cases of events and fairs is the indulgence from government's side, justifying the excessive use of light decoration as a temporary use is not a proper and legit response one should have let along the authorities. Allowing the extravagant lights being displayed by saying it is a temporary event, but omitted the fact that these events typically are organized every year. Not to mention events like fairs and Christmas Market hold a certain degree of cultural influence, so far, emitting large quantity of brightness seems to be part of the culture that has been reflected by organizing events. On top of government's indulgence on wasteful light sources in an event, people overlooking the effect light abundance has on their life is perhaps the second major cause of light pollution beside the actual use of light. There are also successful cases of where the threats of light pollution a newly developing tourism project make compromises to alter and prolong the project design to avoid extra light pollution the tourism project could produce. When the tourism resort project by Orascom Development Holding AG was announced in Andermatt, the light pollution the tourism project could potentially bring along with pushed Canton Uri to step in to supervise the process of construction design to ensure the tourism project would not hinder the night sky quality Andermatt had preserved.

Also, the lack of control on the use of light poses a critical threat to the future development on reducing light pollution in Switzerland. While some cantons' acknowledgement on light

pollution, and later on the prosecution on installing environmentally-friendly lights are certainly some progress from the authorities' side. It is still not as effective as it would be if a federal prosecution is enacted. With only a few cantons out of 26 have authorized the recommendations from FOEN on equipping outdoor lights as their construction standard. The lack of unified regulation could create double standards within one country. From the findings, it is known that Canton Bern had prohibited sky beamer technology to be used at outdoor area due to its high intensity of the light beamed could display itself as a source of light pollution. Nevertheless, sky beamer shows can still be seen outside of Canton Bern. In cantons that do not share similar regulation, sky beamer is defined as a non-threatening to dark sky. From the example of the use of sky beamer, the loop hole of only having cantonal law can be observed. Only having certain cantons setting restrictions (not only just about reducing the abundance use in outdoor lights) on environmental protections in general, it would create a vicious cycle of the law breaker to transfer their location to a place where lawfully the restriction is not applied. Light pollution being an environmental crisis, ought to be taken care of on a national scale rather than a regional extent, since it is the environmental of the population that is exposed to this pollution and everyone has their responsibility in causing the ecosystem it is today. Regulations on avoiding excessive use of light should be established as federal regulation, other than having a few regions putting effort on reducing light pollution while others still use lights excessively without much caution.

Last but not least, so far in the paper, there are many cases where lights are used as an asset to add more effect to a tourist offer (spotlighting a building, Christmas decoration), same cannot be said to its polar. A tourism offer on a place with total darkness is rarely on the market, at least in Switzerland. There are IDA's promotion on International Dark Sky Places, that had later on led Utah States to enter the niche market of Astro Tourism. Switzerland, although lack in the large geographic advantage, does have a relatively tamed light emission compare to the United States, meaning Astro Tourism could have a potential market in Switzerland. While Ganstrish Nature Park has in recent years started to promote more of their natural clearness of a night sky the park has, to generate more overnight stays and simultaneously advertise the beauty darkness can have in the night. At the moment, providing clear night sky is more of a niche offer a destination has specifically to attract niche target groups such as stargaze enthusiasts or astronomy research groups. With cautious care and marketing, dark sky can one day be a main attraction than a supplementary offer it is today. Further detail would be given in as recommendation the next subchapter.

6.1.2 Reflect on Research

Coming to the second part of this section, the research proposes that, light pollution is not an environmental problem that could be solved in a flick of a time. Ironically, the literal action of flicking off lights is an actual solution. What make the solution an unachievable one and the challenges of reducing light pollution are, identical to what the finding suggested, the government and people's omission and reliance on light source. Most of the light pollution in a country is generated from their major cities, such as Milan, Madrid, Berlin and Paris are all measured to be exposed under a high intensity of brightness. Typically, big cities hold a dense and large amount of popularity, with more people living within a close area, the density of outdoor lights (mostly streetlights or LED signs from stores) would also grow proportionally.

Without proper control on the light implementation, light emission from the urban area could spread its way into the more rural area, consequentially even the region with natural darkness could not escape from the artificial brightness. Intense artificial brightness is not just the problem of the loss of stars visible in the night sky, it is also a problem of causing discomfort to people and animals when the light source is too harsh, distracting or directly glare to naked eyes. These are generally caused by the poor design of light (mostly streetlights) that is not properly shielded from exposing toward sky and private household, and lighting to places that is not necessary. Since it is known from the finding that the quantity of streetlights does not proportionally lessen the frequency of crime, the installation layout should primary be concerned with the visibility streetlight can produce in the dark rather than the phycological comfort light source provides to people.

Society's development does not come in aid to lessen the emission of light, in reality artificial light sources have gained more and more importance throughout the history. From many decades ago, when streetlights were not required on the night with full moon to light up the path, to present time where moonlight cannot compete with the LED board fully blasting its brightness, artificial lights have only grown in its significance. In today's society, time only serves as a factor of letting the use of light to grow, instead of growing in progress on reducing excessive consumption of light. Take the case in Surrein as an example, after literally a life time of streetlight-free environment, the village had welcomed its first implementation of streetlight in 2016. During the decision process, the issue of light pollution was brought out as a defense against installing streetlight, some residents recognized having streetlights installed would mean the end of darkness at night. In spite of the concern, the arrangement of planting light was still set after the majority of Surrein residents voted in favor of it. As the lights had been planted, most of the residents were pleased and felt safe with their new facilities. Furthermore, the comforting sides for the environment are the up-to-date technology used on the lamps and the well-operated light system implemented along with the installation. While it can be said that streetlight is a necessity, it is also essential to install with proper technique to avoid or minimize the damage streetlight planting could bring along. Once more, it is a misinterpretation people often have that dark areas are more dangerous than lit regions. It is important to balance between the demand of outdoor lightings and the protection against light pollution. Although without doubt many of the areas on this global are covered in abundant brightness during night time, it would be unpractical and unnecessary to have all the outdoor lights to be shut off to solve the problem of light pollution, or to the extreme extent of not installing light poles at all.

The most effective solutions to reduce light pollution would be to maintain the quality of light to make sure the light source is properly shielded and equipped with eco-friendly lamps. Since majority of the light pollution comes from the light emission from streetlights, it is crucial to ensure this public facility is maintained with eco-friendly light setting to avoid emission toward the sky, private household or directly to people's eyes. With suffice shielding, Full Cutoff or Cutoff shielding, light source would only be directed downward, with the light bulb being covered to avoid brightness escape and seep into the sky. Furthermore, with more concentrated light beaming, it could avoid causing glare or light trespassing as well. Complementing light shielding, the type of light bulb being used is another method to diminish

excessive light emission. Present commonly used light bulbs on streetlights are High Pressure Sodium lights (HPS), this type of light generates warm color light that is neutral to human eye, unlike the intense blue light Light Emitting Diode (LED) generally emits. It is one of the advantages to use HPS on streetlights, along with its long-lasting life. However, with newly developed technology, LED light now offers blue light reduced model as well as warmer temperature color. It further on holds the benefits of even longer durability than HPS, not to mention the eco-friendly emission it has unlike the sodium releasing technology HPS is. Nowadays, an increase growth in number of municipality decide to alter their streetlight light bulb in to LED technology. However, the findings have shown a different conclusion about LED light implementation on streetlight. While in the findings, it agrees with the significant advantage LED lights have against HPS light bulbs, the problem of LED lights stand on the color temperature the light emits. A typical LED light produces blue light that can be equivalent to daylight brightness. Unlike having HPS' color temperature similar to moonlight, LED is a much more light-pollution-emitting device. Even with a filter placed to change the color temperature, energy is only wasted to create the effect a HPS light could produce without any modification. It can be concluded that, in the aspect of energy and material saving LED lights would be a better choice, but in the point of view on avoiding light pollution, the neutral warm colored HPS lights is a more suitable option.

Many people associate light pollution with waste in energy consumption and losing the starry night, however, that is not the whole picture. Indeed, more than half of the world population has no longer the luxury to even have a glimpse at a single star at night. Additionally, a large quantity of energy is lost often due to the existence of unnecessary light source and poorly constructed lamps. Artificial light source actually has threatened the co-habitant of humans on this planet, the wild animals. Wild animals, unlikely humans do not have the technology and historical developments to help them in survival, frequently, wild animals rely on their instinct to survive. Unfortunately for the wild animals, their instincts that had been built up for centuries have been disturbed in a short and rapid time by the fast-developing advancement humans are creating. As light pollution is not an environmental crisis a century ago, artificial light source is still a fairly new and unfamiliar concept for the wild animals to grasp, let alone to adjust their natural habit to the change of society. More often than not, artificial light source does not provide the same function to wild animals as it does to human, in fact the use of artificial light is not a function rather than a disturbance to the animals. For nocturnal animals, the disturbance is obvious that the night used to be dark and suitable for them to be active in this period of time. However, the then dark night is illuminated by streetlights, store signs and LED boards. Other than the nocturnal animals, migratory birds and sea turtles are also the victims of light pollution. Both migratory birds and sea turtle are distracted by the man made light source that pose a threat to their life and death. Migratory birds often have to travel overnight to reach their destination on season. Frequently, the birds are distracted by the light and fly toward or circle around the light source, in some case, the lights are reflected to buildings' windows and cause the birds to crash into the wall. As for sea turtle, the danger started when they are born on beaches. Coastlines are one of the most popular locations in tourism industry, therefore many tourism facilities are built along the coastline, most prominently at the beach. Facilities such as streetlight, roads, traffic light and hotels are built. While the facilities are built

for tourists to enjoy their time at the beach, the nature site is also where the sea turtle lays eggs. Hatched baby sea turtles rely on the moonlight reflected on the ocean to navigate their way towards to ocean. However, with lights from streetlights and hotels the baby sea turtle crawl to the wrong direction. Sadly, these are not the only species that are affected by artificial lights, and it is the responsibility of the human is prevent light to disturb animals' life in the future. While human has the ability to adapt to the modern changes quite effortlessly, it does not mean the wild animals can do the same.

Switzerland, as it was evaluated in the literature review, has a lower in percentage of brightness exposed population comparing to the countries nearby. In general, Switzerland does not have as much population and geographic area that are in contact with extreme brightness as the compared countries. In contrast to the countries listed in *Table 1*, most of the countries struggle to break out of the light polluted population with level of brightness over 3000 mCd/m², Switzerland has managed to have 0 percentage of population expose to that degree of harsh brightness. One might think that, Switzerland has achieved to have a relatively low figure in light pollution, the regulation must have a great contribution to the control in light emission. In fact, as it is known from the finding results, the country has not yet had a fully applied regulation to restrict outdoor light emission. While there is a regulation controlling outdoor lights to be switched off from 10pm to 6am, other than this there are no valid regulations that are established to control the construction of light installment. A mere list of recommendations based on the SIA Norm 491 is given as a governmental approved light installation standard for construction companies to use as a guideline. If Switzerland has already preserved its environment from high intensity of light emission, what would it be like if a fully developed law and regulation is authorized, it is a great potential Swiss government has yet to explore. Switzerland is now in the progressing phase with more and more cantons joining the act of fighting light pollution (enforcing SIA Norm 491 as standard construction requirement), as well as more publicities of informing the issue of light pollution. Even with the efforts from NGOs and cantonal governments, it would proof to be more effective with more engagements from the federal government. To have a firmer background in reducing light pollution in a national dimension.

6.1.3 Cross Referencing

After gathering the knowledge from both the findings and the research, comes to answering the research question and some unexpected results.

One of the research question is: *Are the DMO/Municipalities aware of how much light pollution is produced?* From the findings and the research, it is found that the difficult part with countering light pollution is not just finding a solution, it is the part where notifying people about the critical condition humans had made with the invention of artificial lights. Throughout writing the whole paper, the lack of government's interference and short in people's acknowledgement on light pollution issue had been addressed multiple times, it only emphasized the necessity to correct these deficient. To improve the light-polluted society we are living under right now, other than the local authorities, the municipalities, or the DMOs, citizens also have to be informed and aware of the situation and why should light pollution be studied closely. Looking into Switzerland, light pollution mildly speaking is not in a very critical condition compare to

many other developed, most importantly tourism developed countries. Even under less alerted situation by comparison to other European countries, FOEN had addressed light pollution as an issue that is under supervised by listing out recommendations on how to prevent emitting unnecessary light source in 2013. Thanks to FOEN's suggestion and publication, the problem of light pollution had gained its recognition by many. The recommendations are mostly adopted by cantons and municipalities as a standardized outdoor light construction law. Seeing how there are 9 cantons (stated in *chapter 5.6*) are implementing the FOEN recommendation into their cantonal laws, the awareness would grow in time. However, it must be said that at this rate, Switzerland would need a long time before all the 26 cantons recognize the importance of reducing light pollution. Upon examine this research question, an issue found is the deficient in people's knowledge on light pollution. The cause of deficiency is people's reliance on light source during night time, often the light source is no longer emitted for navigation purposes. As addressed before, people's understanding on the concern of light pollution is valuable, make it an essential step to approach a future with less light pollution.

Coming to the next question: *Are they (DMO/municipalities) willing to compensate the pollution by sacrificing light display?* There are cases where tourism facilities have a direct cause to light pollution. For example, hotel lights at the beach that misdirect sea turtles toward land instead of ocean. From the literature review, we know that usually, to resolve the causes of excessive light emission, it is normally not by regulating the facilities to be completely shut down, but to change the light displays into a more eco-friendly setting instead. Once again, in Switzerland there is no federal regulation on a standardized light installation. The federal government only encourages and suggests cantons and private construction companies to implement the according the SIA Norm 491 guideline. Therefore, a lighting system alternation is not enforced unless the located canton demands so. External light setups that typically induces light pollution are the one that are not covered fully to prevent upward beaming, or ones that are planted in places deemed unnecessary.

Tourism facility such as outdoor building spotlight is one type of outdoor light setting that creates direct, unshielded beam light towards the dark sky, as *Figure 12* illustrates. In *Figure 12* note how the towers' surfaces are completely lit while the nearby buildings are dimmed in the background. The lit builds are the infamous attractions in Zurich, Grossmünster and Fraumünster. Two of the top sites in Zurich city are clearly in view during. While it does provide a magnificent view that give the tourists another atmosphere that daylight could not create, what is omitted is the fact that the light not only beams at the building but the sky too is lit. The necessity of having building spotlights is debatable, it is truly a useful tool in tourism industry to not only prolong the time a tourism attraction could be offered in one day, it also



Figure 12: Zurich at night. (Zurich Tourism, n.d.)

creates another impression when the attraction is displayed at night. As mentioned before, it is unpractical to have the municipality to switch off all the outdoor lights altogether, the approach is more likely to have the light setting changed or adjusted. Just like the (Ein-)Leuchtendes Model discussed in the findings *chapter 5.7.2*. With this approach, DMO/municipalities are not necessarily sacrificing the light display per say, but making compromising changes in the meantime keep the light installations.

Last of all: *What are some actions that are taken to reduce light pollution?* As answered in the previous question, by reducing light pollution, many authorities do so by modifying the facilities' setting. It can be to change the time range of the illumination time. Such as the case from 911 Tribute in Lights, where the light beams had influenced the night vision of birds and attracted them toward the beams. By preventing birds being confused and trapped in the lights, the project team of Tribute in Lights decided to turn off the lights every 20 minutes, also there were volunteers that carefully observe if there were any birds disturbed by the light display. It is the solution Tribute in Lights' project team given that allows this memorial event to be kept as a new annual and cultural development. Another approach is to change the shielding design of the light setting. From the light monitoring project taken in place in Andermatt, it is an example of how the municipality of Andermatt and Cantonal government of Uri recognized the threat a in progressing tourism resort development posed to their naturally dark environment. The cantonal government then demanded the tourism project team that if they would like to start a tourism and leisure project, the team would have to design light installment that would not increase the brightness level Andermatt had. The tourism project developing company, Orascom Development Holding AG, recognized the potential Andermatt tourism market had yet been fully developed, chose to agree to the cantonal government's insistence instead of backing off from the project development. After the approval from both Canton Uri and Orascom Development Holding AG, a special light design (mentioned in *chapter 5.5.1*) was introduced and the first 5-star luxury hotel in Andermatt had its grand opening in 2013. From both the findings and literature reviews, there are real life examples of how tourism products are modified to reduce the impacts they have on provoking light pollution. Both source of information proves on the point that tourism industry can and is willing to make changes to ensure on diminishing light abundance, and further provide the actions that had already been taken from the tourism companies' side.

6.2 Recommendation

Given the knowledge gained by the literature review and expert interviews, some recommendations were developed which are believed to give a source of direction on how Switzerland can reduce light pollution in the field of tourism industry. Furthermore, what tourism market potential does Switzerland hold if diminishing light pollution had shown its progress.

6.2.1 Solid Regulations

One of the major problems of light pollution existing in Switzerland is the close to non-existence of regulation on light installment control. Consider that all the light infrastructures have been installed, if a decision on changing light setting into a more light-emission-neutral setting is made, it would be an extra expense for the parties involved to do the modifying and maintaining. Due to this reason, many authorities do not recognize the need of reducing the abundant light

emission from the streetlights. Also, as addressed multiple times in this paper, light pollution is generally ignored by population. The damages light pollution brings out is not as pronounced as other means of pollution, there is no immediate health concern light pollution would bring to people. These are the reason why light construction control often escaped from the eye of authorities, not just in Switzerland but many other regions as well. As long as there is no obligation for a community or construction company to follow through, no individuals would spend the effort on light pollution prevention. Therefore, it is strongly suggested by the author of this paper, to establish legit regulations based on the SIA Norm 491, to enforce municipalities and construction companies to design and install every sort of exterior lights under the standards. With a legal establishment on the control of light installing, it would not only prevent further polluting on the night darkness, but also place the law in a national basis. Modify the recommendation on avoiding the use of excessive light into a federal law, instead of only having a few cantons acknowledging this national and even global scale of environmental issue.

It poses as a problem when regulations are not unified and created double standards. In the research process of finding out how sky beamer performance is affected by the restriction of light pollution, both cantonal regulation and sky beam performance company are looked into. Indeed, there is a contradiction on how sky beamer is viewed in respective to its light pollution emission.

From the literature research, it is known that Hong Kong has a daily laser light show that is not only the world's longest sky laser beam performance, it is also one of the top night life attraction to do in the region. However, the sky beam show is a partial origin that caused Hong Kong to be the most light-polluted region in the world, to make the matter worse, Hong Kong government does not have policy against the excessive light used in the region. In comparison to the law establishments in Switzerland, as known from the findings, although many cantons had started to establish law enforcements on light pollution, only a few had specifically mentioned the restriction of the use of sky beamer.

Therefore, the author would strongly suggest to the federal government of environmental office of Switzerland to establish a legal standard on how outdoor lights should be installed to produce the least amount of light pollution today's technology is allowed. With the law establishment, all the municipalities would together prevent the growth of light pollution in the future and protect the environment together as a nation not just as a community. Not to mention that the law enforcement would have the municipal government and construction companies' awareness on the issue of excessive light emission.

6.2.2 Transparent Planning

For this recommendation, it is a combination of gaining awareness and taking action in decreasing the emission of artificial light. By the meaning of transparent planning is to have the process of construction shown to authorities and public. A project design should be shown to authorities or experts and have them examine whether the project design would bring additional light pollution to the community the project is taken in place or not. If any flaws are found in the design, the examiner parties would have to enforced the project team to modify

the model until it is deemed as safe for the environment. Once the project has its approval, the development team should then podcast their project to public. To show people what efforts are given in the planning phase, how the planning has shown contribution to reducing light pollution and how others can also attain the same accomplishment. The benefits of transparent planning are that once it has passed the examination, it safes the extra steps for any alternations, if the implementation was already properly installed at the first place. Furthermore, well-informed public would also be more aware of the present and upcoming projects concerning light emission, knowing what is being done as an action of reducing light pollution.

As known from the findings, the light monitoring project in Andermatt is a great success and a leading example of how light pollution can be prevented, instead of changing a built infrastructure when it has already been generating light pollutants. Although the light monitoring project is indeed a worth-praising achievement in Switzerland's milestone of light pollution prevention, the project is known limited by the municipalities that are interested in the topic of light pollution prevention and the local residents of Andermatt. What this project is lacking, is the attention it should have had from more population. The light monitoring project had involved many different parties including, the cantonal government, tourism project team, destination management organization, private construction company, and the locals. While the involved parties are all well-notified about the monitoring project's purpose and results, the communication end at the region of Uri. Although the project leader of light monitoring did present their work to different municipalities, the project still does not have the recognition it deserves. The locals of Andermatt are all briefed with the tourism project and extra light emission prevention project. Since those are two massive projects that would bring additional income to them without the worries of damaging their environment, the two complementary projects are well-received by the local. If only the project had been marketed outside of Uri, would it have been appreciated by a greater population.

The transparency of planning also applies to informing related industry. The light monitoring project is a unique case study for the tourism industry in Switzerland. Since it is the first time where a cantonal government had stepped into the process of a tourism project development with the concern of light pollution in mind. Not only should municipal governments be informed of the success of this case study, tourism development companies ought to know the difference lighting system can create if it is appropriately designed and follow through with the example Orascom Development Holding AG had provided. However, the current situation is that the light monitoring project is not well-spread enough that has gained the attention from tourism industry. If only the information is widely publicized, could tourism industry be informed and act in accordance to reduce the excessive light emission this industry has induced.

6.2.3 Astro Tourism

As far as it is known, Switzerland's geographic characteristics although is smaller than its neighboring countries, the nation has preserved much of its region in darkness thanks to the Alps dominating the country's landscape. Switzerland has a clear boundary of urban areas and rural region that gives the country an opportunity to development different offers of tourism packages based on different fields. Very much like the geographic feature in Utah, U.S.A, where the light pollution intensity is distinguishable from the severe brightness from its nearby

states. Utah State has a part of its area, where it still has its darkness protected, making the state one of the regions with most Dark Sky Places located. The state tourism office utilized the region's special offer of dark sky as an attraction and further developed its tourism offer with a niche tourism called Astro Tourism. With the successful promotion case from Utah State on Astro Tourism, the author believes that in Switzerland there is also a potential market to welcome Astro Tourism.

In Switzerland, as it is covered, has proportionally less area that is exposed to light than countries being compared in *chapter 2.5*. Using this advantage as a strength to develop Astro Tourism can create a new potential to Switzerland's by now a well-developed tourism industry and make the country once again attractive to old and new comers. Gantrisch Nature Park already has events that gather stargazing enthusiasts to visit the natural site darkness can offer. The event attracts visitors from nearby countries, whose countries are not able to provide the starry site anymore. The fact that foreign visitors are coming into the nature park for stargazing proves that starry sky as an attractive offer that has the power to lure international tourists to the scenery's destination. Starry sky scenery came into aid for the park's nearby region's overnight stays, since the only time to observe the stars is at night time, the visitors have not much choice but to stay. The stargazing event in Gantrisch Nature Park was a success that the newly established event, has become a yearly activity. The success of the nature park proves that stargazing can be an appealing touristy offer, that not only lure most visitors to the destination, but more importantly overnight guests.

The drawback of Astro Tourism is its target group. Stargazing has a specific group of interest, explicitly astronomy researchers or scientists. It is a market that has yet been developed into a more popular offer. It could become a problem once Astro Tourism is growth its population, the current visitor (researcher, star enthusiasts and scientist) and the potential new customers might create conflicts to the tourism experience. One crucial factor Astro Tourism provides is the undisturbed nature the destination has. If Astro Tourism were to become an emerging tourism offer, tourism facilities would have to be provided to suffice the demand from the visitors. Basic facilities such as transport system and accommodation could all bring damage to the previously undisturbed nature to a certain extent. Rules and regulations should be set with persistence and clarification to prevent visitors harm the environment. It could happen that the strict restrains would diminish a positive experience. It would be a difficult task to balance the control and freedom tourists should be given, to protect the environment at the same time provide a memorable experience to guests. On the other hand, the existing visitors are mostly the professionals that stargaze to make scientific observation or people who do the activity as a habit. Although physically being in presence under a starry night is preferable for them, the sudden appearance of tourists, that come for entertaining reasons, could be an unappealing scenario for the current visitors. Furthermore, outdoor platform (i.e. Gantrisch Nature Park) is not the only place the professionals could go to for stargazing, there is always observatory research center that have the observation condition and facilities ready for operation. The current target group could slowly drift away from the stargazing fields, either switch to another destination with similar offer or to an observatory research center.

Developing an Astro Tourism in Switzerland has its benefits, as mentioned, generating more overnight stay at nearby region, make darkness appealing to a greater population, and it is a market the country's neighbors had yet developed. The challenging part is to find an approach to balance between the old and new visitors' expectation and at the same time have the environmental protected. This niche tourism has a great potential to bring awareness on light pollution prevention from people and is also a physical example shown to people of how beautiful darkness can be.

6.2.4 Darkness Experience Campaign

The fact that human's eye is able to adjust in darkness should be more widely known, it was not until recent years that scientists have proven human's ability to see in dark. However, the chance of a person to be expose to complete darkness is rare, let alone being in darkness long enough for the eyes to adjust to it. With the lack of common experience people can have to let their eyes be accustom to darkness, it is hard to prove this biological reaction human has. Additionally, causing it difficult to convince people to lessen their reliance on lights. One of the reason light pollution has not gained much attention as other environmental crisis is because of its intangible impacts. Associations like DSS has committed in a great deal of their effort on conducting research results to have the scientific proofs on the effects of light pollution. However, the research is usually published in stream of media that is specifically designed for audience that are working in the field of either environmental protection or electricity consumption, the spread of information halted at a greater population.

This recommendation is specifically addressed to DSS, as the association is the most well-knowledge organization in Switzerland on the matter of light pollution and is a well-respected among the field, DSS have the credibility to promote issues on the subject. At present, DSS already have a tangible model that demonstrates the effects of different lighting can do to night sky with the (Ein-)Leuchtendes Modell. The model does not bring out a ground-breaking finding on the issue of light abundance, but simply informing the audience a mere change in light setting can be helpful to today's excessive brightness condition. The (Ein-)Leuchtendes Modell turns out to be a great step to make a research finding more tangible to people. The problem again lies on the limited witnesses to the demonstration and the lack of interaction people can actually be involved in. Therefore, the author proposes to have a darkness room placed in crowded area, such as Zurich Main Station, to let people experience what it is like to be in total darkness and have their eyes adjust to a dark environment.

The idea behind this proposal is to help people to recognize the reliance on light can be lessen, and only without light abundance could people see the beauty of darkness. The concept of this idea is that a temporary cabin is built at a location where has people passing by frequently and the location must be exposed to brightness both at day and night time. A suggested location is Zurich Main Station, since the location fit into those criteria and the station is not unfamiliar with being chosen as the location for a couple of marketing campaigns to taken in place. The cabin would be designed to completely block out the light from outside, once people go inside the cabin nothing but darkness will be seen. However, darkness is not the only thing in presence, dimmed small light bulbs could be placed on the ceiling representing stars, and the walls could be drawn with mountains and different landscape. These small details are not

meant to be discovered by human eye at first glance in the darkness. It is a process of self-discovery, to have people's own eyes adjust to the darkness without the help of illumination. Only when their eyes are adjusted to a degree then they would find out the detailed layout inside the cabin. The author believes that without an interactive and tangible experience provided to people, it is hard for one to imagine the differences a world without light could be to present time's brightly lit society. Hopefully, throughout this experiment it can be a method to cut off their dependence on artificial light sources.

7 Conclusion

After extensive research into the topic it has become apparent to the author that light pollution prevention and reduction is a yet developed field of work in Switzerland. As addressed, it is partially due to the little to non-involvement from the federal's side and public's low awareness. Light pollution crisis is an issue that ought to be taken care of because it is an intangible environmental pollution that with people's ignorance would one day grow to its maximum capacity unbeknown to the public. So far, the general public's attention on environmental crisis is on air or water pollution, light pollution is left aside and even being encouraged to increase due to a growth in outdoor light planting.

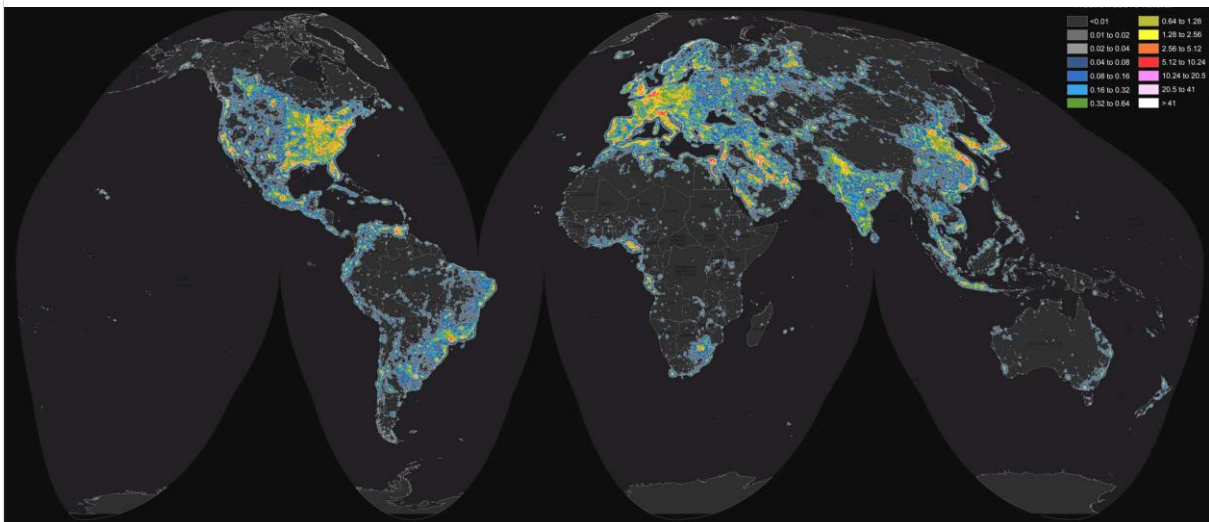
Tourism industry is among the public groups that has been paying scant attention to the topic of light pollution. There are examples of how some tourism facilities are adjusted when modifications are demanded by authorities due to the light hazard the infrastructure would produce. Additionally, some other gradual involvements cantonal governments are starting to attain. These are all recent developments that have yet gained great popularity from the public. As it is marked countless time in this paper, public recognition is one of the crucial starting point of reducing light pollution. With Switzerland's present awareness on excessive use of light, it would take some time for the country to have the majority of population well-educated in the matter of light abundance. Therefore, here is where the author's recommendations come into aid. The given recommendations are the combination of gathering the federal government and people's attention while simultaneously promoting the natural darkness as a beautiful phenomenon that people have yet explore.

Appendices

Appendix 2: Birds trapped in Tribute in Light. (Daily Mail, 2015)



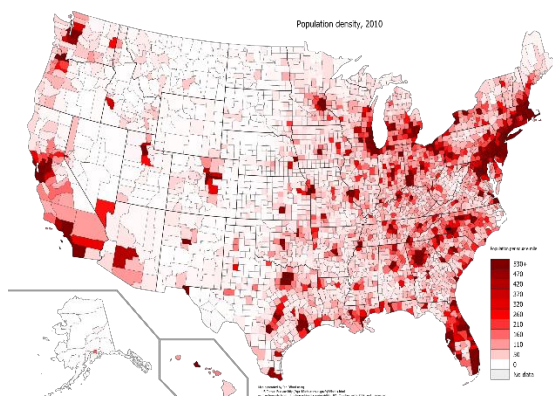
Appendix 1: Light Glow on world map. (Falchi, 2016)



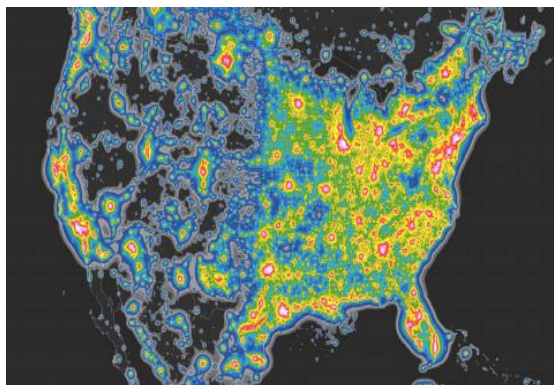
Appendix 3: Brightness Level Measurement. (Falchi, F. et al, 2016)

Ratio to natural brightness	Artificial brightness ($\mu\text{cd}/\text{m}^2$)	Approximate total brightness (mcd/m^2)	Color
<0.01	<1.74	<0.176	Black
0.01-0.02	1.74-3.48	0.176-0.177	Dark gray
0.02-0.04	3.48-6.96	0.177-0.181	Gray
0.04-0.08	6.96-13.9	0.181-0.188	Dark blue
0.08-0.16	13.9-27.8	0.188-0.202	Blue
0.16-0.32	27.8-55.7	0.202-0.230	Light blue
0.32-0.64	55.7-111	0.230-0.285	Dark green
0.64-1.28	111-223	0.285-0.397	Green
1.28-2.56	223-445	0.397-0.619	Yellow
2.56-5.12	445-890	0.619-1.065	Orange
5.12-10.2	890-1780	1.07-1.96	Red
10.2-20.5	1780-3560	1.96-3.74	Magenta
20.5-41	3560-7130	3.74-7.30	Pink
>41	>7130	>7.30	White

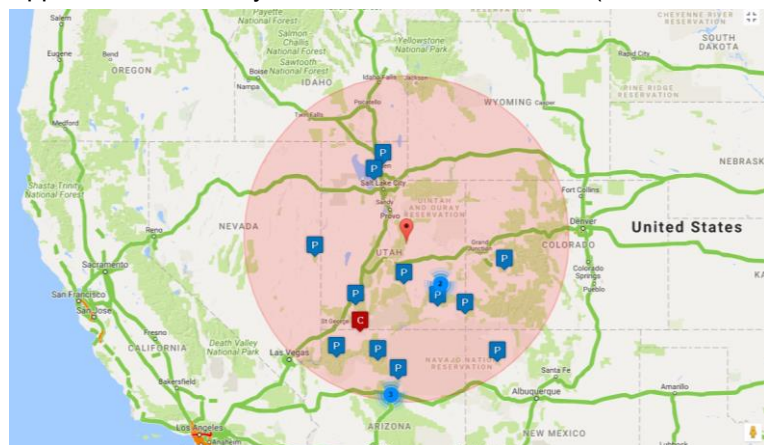
Appendix 4: Popularity Density in U.S.A. (Handleman Post, 2015)



Appendix 5: Light Glow in U.S.A. (Falchi, F. et al, 2016)



Appendix 6: Dark Sky Places around Utah State. (International Dark-Sky Association, n.d.)



Interview with Dark-Sky Switzerland

Interviewee: Lukas Schuler

Interviewer: Yung-Hsin (Emily) Hsiao

Date: March 30, 2017

1. *How does Dark-Sky Switzerland (DSS) function?*
 - DSS spreads the information inform people on the issue of light pollution.
 - They would also interfere with construction site to monitor their light installation.
 - Raise people's awareness on light pollution
2. *What is the situation in Switzerland? Compare to other countries are people more aware of light pollution?*
 - Yes, people are much more informed about light pollution than they were ten years ago. (Light pollution was already an issue in the 1980s, in the canary island it even traces back to the 70s, therefore the growth in awareness was not because of the student burst of light pollution)
 - However, compare to our neighboring countries (France, Germany), Switzerland is not as progressive? As they are. In both countries, they already have dark sky place, however Switzerland has the disadvantage of being smaller geographically.
3. *How is Dark Sky Place qualified?*
 - IDA Lable: examine what kind of light is being installed, is it warm LED light? Does the light reflect towards the sky?
 - UNESCO: examine the sky clearness, also take the cultural heritage of the sight as a consideration as well.
4. *Are there any laws set on the matter of light pollution and specifically on tourism industry?*
 - According the sia.ch SN 586 491, it is a set of principle that needs to be followed, and it is approved by the government.
 - Usually fairs, Christmas market have not much light restriction because it is usually a short-term event.
5. *How is Christmas market affect light pollution?*
 - During the Christmas season, there is a longer hour for light usage, and generally January is the month with highest light pollution.
6. *How is light pollution measured?*
 - With equipment like, Sky Quality Meter (SQM), note the weather condition is also crucial in the measuring process. i.e. humidity, temperature, air pressure, foggy or not, etc.)
7. *Are there any places in Switzerland that is famous for stargazing?*
 - Nature parc Gautrisch: part of the BLN community where it is an environmental protected area
8. *What are the methods to reduce light pollution?*
 - There are some strategies to control the display of light i.e. Gradually reduce the brightness as the night goes on, or only light up the road when there is a car or people passing by (this method is implemented in Chur)

Interviewee: Lukas Schuler

Interviewer: Yung-Hsin (Emily) Hsiao

Date: July 02, 2017

1. Why is this title created? Is it in the aim to raise awareness of light pollution in different places?
The title has been created to demonstrate that actions or measures are taken by persons (individuals) or organizations (community, association, SME, NPO), who are pioneering in the reduction of light pollution. So it is less bound to places, more to the actions taken or projects done. Of course we'd like to raise the awareness and provide good examples what has been successful.
2. How are places qualified for this title?
It is organisation or people bound. So a measure has to lead to a reduction of light pollution (unnecessary emissions), has to be an advantage to the living nature near-by (biosphere) and support Dark-Sky Switzerland in its mission. Location of the winner is irrelevant, as long as it is in Switzerland. Our plan is to provide the price every two years or more often, as soon as more projects are done, that are honorable.
3. Does the title provide advantages to the receivers?
There is no money provided, but the honor is accompanied by some media attention and it can help to resist political forces that would like to withdraw taken measures against light pollution.
4. By far who has received the title and why?
In 2008, Dark-Sky Switzerland announced the community of Coldrerio, TI as honorable member for lifetime with Dark-Sky Switzerland, because this community pioneered the extinction of public and private external light during nighttime by an environmental law. Those days, the "knight of the night" was only mentioned. In 2015, the idea of the "Knight of the Night" as a real price was reborn in an internal workshop in the mountains. With some delay for preparations, in 2016 the 20 year existence of Dark-Sky Switzerland as association was celebrated and for that occasion, the first real "Knight of the night" as a Diploma and Figure was given to the Environmental Office of Canton Uri for the monitoring of light pollution of the whole village Andermatt caused by the construction of the new resort (Hotel Chedi) by the investor Samih Sawiris.
5. Is the title equivalent to the Dark Sky Place from International Dark-Sky Association?
No, it has not much in common. The Dark Sky Place is region and darkness-bound. It's goal is to enhance and further guarantee the darkness in a region and raise the awareness for the natural darkness. The "Knight of the night" could also be provided to a citizen of a bright place who has been able to extinct the light during nighttime in a large area (just as an example).
I actually was one week on holiday in canton Uri and I took the Sky Quality Meter with me. I measured one night when the conditions weren't too bad (and no visible moon), a value of $21.74 \pm 0.04 \text{ mag/arcsec}^2$ read. Such a value would never be reached close to a city. At full moon, you would expect something like 16.

Interviewee: Lukas Schuler

Interviewer: Yung-Hsin (Emily) Hsiao

Date: July 21, 2017

I just have some more questions regarding the (Ein-)Leuchtendes Modell that is mentioned in the Lichtblick 2016.

As I had asked my friend to briefly translate the flyer, what my understanding on the section is that it is related to the outdoor lighting on church buildings.

I send you a picture (not for publication) that better explains how the model looks like.

The author of the Modell ist Kurt Wirth.

It is made of regular railway model houses and trees etc. The model LED lamps have different color temperature (from 3000 to 8000 Kelvin) and demonstrate the impact of light towards human sleep and nature (e.g. bats living in the church tower).

On the side, power switches are installed for different on/off light situations:

public street lamps (the lantern posts and car light) houses (internal lamps, and church internal and kiosk) tree illumination (very aggressiv uplights at the bottom of the tree) church illumination cold light (on large posts) church illumination warm light (from roof-top of houses to front of church)

With this one can select scenarios to explain different light situations and its impact.

The size of the model is 80 times 60 cm. The container box is 80cm high, since the bottom is already 15cm and the church is not very tiny. Transportation needs a car.

Our topics that usually are demonstrated are therefore: Distraction of nature (bats, birds) because of cold church lights distraction of human sleep by the uplights, tree lights esthetics: how architecture profits by better and more accurate warm lights energy saving: how less light can be more profitable to nature and economy

I hope this is okay.

Interviewee: Lukas Schuler

Interviewer: Yung-Hsin (Emily) Hsiao

Date: July 28, 2017

1. *What is your recent project?*

Recently my measurements on moonlight brightness has been published and the result shows that a full moon moonlight has more or less 4000k, equivalent to an orange HPS lamps. While an unfiltered blue light LED is 2 to 3 times more in kelvin measurement.

2. *So which light would be a better choice for installing on a streetlight?*

HPS would be a more suitable choice of lamp to be installed in a streetlight. LED has been installed in more and more places because it saves more money in long-term and project more brightly than HPS. However, HPS installation is more environmentally friendly, with the warmer light color it provides, HPS creates much less disturbance to wild animals than the LED lights.

3. *But isn't there a new technology with LED lights changing its color to warm temperature.*

Yes, but the method is used to change the color temperature is to simply add a colored filter underneath the light source to change the blue-whiteish color to a warmer one. This method while reaches its purpose, but the energy consumption is greater when blue-light is emitted, if a filter is added to create a less energy consuming color, it would be a waste in use of energy if not to use an originally warm color.

4. *Throughout my research, I found out that no federal law is a major problem that cause no pronouncing progress in Switzerland's light pollution issue. Would you agree to that?*

Yes, I would say so. The regulatory control of light installment is non-existent in Switzerland. Although the environmental office did provide the recommendations, as long as it is not an obligation to follow the recommendation no one would take it seriously. To let the politicians understand the importance of controlling light emission, I would have to lay out the negative impacts light pollution brings, but the impacts are not as prominent and fast-showing as for instance air pollution. This is one of the reasons light pollution is often ignored by authorities and also people.

5. *Speaking of people, it is also a problem with lack of awareness. What do you think of it?*

There are two reasons why people are not aware.

- The effect is not obvious, we might have adopted to a bright lifestyle mentally but biologically we still need darkness to be fully rested.
- Another reason is that the negative impacts are not as obvious as other pollution, there is no physical impacts like how people cough when the air is polluted

6. *The first idea of writing this paper is aimed to know more about light pollution and Christmas Markets, what do you think the relationship is between the both of them?*

Statistically speaking, January is actually the most light-polluted period of time, but the data recorded only shown it as that because there simply are more snow than there is in December, and the snow is a very reflective surface that when even a well-covered light shine on snow, the snow will reflect all the light back upwards to the sky. As for Christmas Market, it is true that it generates a large amount of light emission, but there is no legal bind that control the use of light. My colleague once tried to switch off all the streetlight (except ones at crossroad) in his community, and let the population rely all on the decoration from the private houses and Christmas market. It turned out the community was still well-lit even if the Christmas decorations were the only lights that were on.

7. *How was he allowed to do so?*

He decided to do this because in his community, traditionally they start the Christmas decorating around middle of November, but with this tradition the light emission would increase. So, he decided to take the chance with trying to turn off the streetlight. By law, there are no obligation for a municipality to have streetlights turned on. There is no regulation on how many streetlights there should be within meters or how bright, how long streetlight setting should be. People, even politicians often don't know about this, and they just want to have their street lit at night.

8. *I saw from one of your flyer, it said that the frequency of crime has no relation to the quantity of light, how so?*

Many people think that with more lights they feel safer from danger, but there is no data proving that there is more crime in darker areas. This misleading common thinking is just making people want to have more light in their night life. It is also why there are more streetlights than it used to be, even though the many streetlights are not needed. I also was trying to evaluate if dark area has more traffic accidents. And it turns out that there are actually more car accidents in dark area, but there are also more dark areas compare to lit areas so this also prove be to a misinterpretation people have that darkness means danger.

9. *Comparing to other European countries, Switzerland has actually quite an impressive preservation on light polluted area. Why so?*

That is because Alpine region taken over half of the landscape in Switzerland and many parts of the region have no resident. If Switzerland is a country with flat landscape, the light pollution situation would just be as bad as other countries.

Expert Interview with Canton Uri – Personal Interview

Interviewee: Roman Gisler

Interviewer: Yung-Hsin (Emily) Hsiao

Date: May 22, 2017

1. Why was the light monitoring project initiated?

- The light monitoring started in 2013, and was initiated because of a tourism project that is taken place in Andermatt. The tourism project is that hotels, resorts, second homes are being built in an open, vacant area in Andermatt. The canton government has the provision that this tourism project would bring light pollution to Andermatt. Therefore, the light monitoring project had begun.

2. What is the light monitoring project about?

- The light monitoring project, as its name has suggested, monitors the light emission specifically in Andermatt and also in Hospental. To ensure the recent and future development do not affect the darkness in the night the places has back when the project was planned.
- Data of brightness during the night are collected 4 times a day. The data are further calculated and analyzed to examine the light pollution situation in Andermatt.
- Some regulations are set to control the construction, to make sure the light installment does not bring negative impacts to the dark sky.
- Although the canton has regulation on the control of light installment, the policies are only applied to the renovation or new construction projects. They could not control the existing building on the light installment, only when the building is under taking a renovation, then they could apply the policies to them.

3. Does the canton regulate policies to control light emission?

- Yes, there are policies as it was mentioned before. And the policies are similar to the SIA Norm
- The policies are quite new compare to other means of pollutions' regulation, because there is no issues on light pollution until the recent years.

4. How did the canton earn the title "Knight if the Night"?

- The canton had earned the title because of its contribution and effort that are being made in the matter of light pollution.

5. Before the light monitoring project, is light pollution a problem already in Andermatt?

- No, light pollution is not a problem, the purpose of the light monitoring project is mainly to prevent the start of light pollution before it is even started in Andermatt.
- The canton has the provision of the tourism project being a cause of light pollution if a certain control was not issued.

6. Are the locals involved in this project? What are their reaction to the project?

- Yes, there are some publicities informing the residents of this project, and they had appreciated the project development. Although most of the residents are actually keen on the tourism project, that is going to bring financial resources to the locals, they also acknowledge the importance of keeping the night dark.

7. What is the Federal Government's involvement in the light monitoring project?

- At the beginning of the project, the government has helped with data collecting,

however, no financial support was given.

8. *Are there any other cantons in contact with Uri to learn from the light monitoring projects?*

- Yes, some presentations are shown to cantons about our project, if the cantons want to learn more about the project, they probably are in contact with the company that is helping us collecting the data.

9. *Are there any conflicts between the canton and the representatives of the tourism project?*

- Yes, there are some arguments and discussions of course. However, most of the time the tourism project agrees to the standard the canton has issued.

10. *What is the brightness of dark night during Christmas season?*

- We did not specifically look into Christmas time. There are some decorations but we don't restrict on the decorations. There was a case where someone complained about a private household's decoration being too bright and a federal trial was held. The final verdict was that the decoration is not a problem, only if the light is shut off after 1 in the morning.

11. *What are your future plans?*

- When the tourism resort finished, it depends on the development to see if the monitoring is still necessary. However, the project is estimated that it won't be finished in another ten or twenty years.

Expert Interview with Andermatt Tourism Office - Email

Interviewee: Miriam Schuler

Interviewer: Yung-Hsin (Emily) Hsiao

Date: June 12, 2017

1. *What is the long-term vision of Canton Uri, does it involve selling stargazing activities as an attraction?*
It is definitely a selling point, which we mention in sales and advertising combined with product such as snow shoeing or others. But so far there is no activities or attractions plant with the only focus on stargazing in Andermatt Holiday Region.
2. *What is the main attraction of the canton as a destination?*
William Tell, Myth Gotthard, Gotthard Base Tunnel, Cable cars, landscape from the lake to the glaciers, Alpine passes combined with touring, traditions, Alpine life, hiking, biking, snow sports.
3. *What are some benefits the title "Knight of the Night" brings to the canton?*
Media attention is always good. It give focus on our unattached nature and it attracts the right people who love rather great nature then stage attractions.
4. *After receiving the title, had Canton Uri gained more recognition from tourists?*
(Can't be measured)
5. *Around how many percentage of tourists visit Canton Uri for stargazing?*
?
6. *Why is Andermatt chosen as the destination for the Tourism Resort Project?*
Andermatt offers visitors a great many activities to enjoy throughout the year. Andermatt is located in the heart of the Alps and enjoys excellent snowfall, making it very snow secure. Winter sports include downhill skiing, cross-country skiing or freeriding, and summer activities include golfing, hiking, climbing, bicycling or mountain biking. The roadways over and through the Gotthard remain amongst the most important trans-alpine routes to this day, and they ensure the excellent accessibility to Andermatt, the charming historic village at the foot of the Gemsstock. From the peak of this mountain one enjoys a sweeping view of the Urseren Valley and a spectacular panorama of over 600 Alp summits.
7. *What are the locals' reactions to the resort project?*
The locals have been involved from the beginning. They support the project understanding this is a unique chance for the development of tourism and economy in the valley.
8. *What are the vision and mission of the Tourism Resort project?*
The Andermatt Swiss Alps project is developing the charming mountain village of Andermatt into a unique year-round destination. It offers an attractive mix of hotels, apartment buildings and chalets – a wide range of living and lifestyle opportunities.
9. *The project seems to be taking longer time than it was originally planned, is it due to the interference of the light monitoring project?*
Andermatt Swiss Alps is an immense project transforming Andermatt and bringing it on the map of attractive tourism destinations. There is no fixed timeline. But it happens that complex projects as Andermatt Swiss Alps need some time.
10. *How does Andermatt still remain as an attractive location for the Tourism Resort Project's*

investors when other destinations might not have as strict light monitoring taken in place?
Andermatt has several unique advantages as described.

Expert Interview with SBK-Laser - Email

Interviewee: Sébastien Kottelat

Interviewer: Yung-Hsin (Emily) Hsiao

Date: May 30th, 2017

My name is Emily, I am a student from HTW Chur. As it is my last year of study, I am currently writing a thesis topic about light pollution involved tourism industry. So, I am contacting your company in the aim of finding out some restriction your company has to follow while having an outdoor laser light show and general awareness of light pollution in your business. Thank You

About light pollution and laser light shows, I can't really see a strong link between the two, mainly because laser light is and stay extremely focused, so don't « spread » itself in the sky, clouds etc, like conventional lighting.

Also, it is not common that the laser beams are directed in the sky, they are always horizontally directed and terminated on a solid structure (buildings, walls, mountain etc)

Furthermore, a laser show like I do, usually doesn't last very long (around 15 min), and the effects are very varied.

About restrictions, for long laser beams directed in the sky, in addition to the standard country's related installation announcement required for all laser installations (Sound Levels and Laser Ordinance, SLO) it's better to inform Skyguide and local airports if any, eventually Rega, and coordinate with them especially if the beams will be inside an air corridor.

I hope this helps. Let me know if you need other informations

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