

24/7 Temporality and Post-Industrial Chronobiology

As the most private, most vulnerable state common to all, sleep is crucially dependent on society in order to be sustained.¹

— Jonathan Crary in *24/7: Late Capitalism and the Ends of Sleep*

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INTRODUCTION

The new post-industrial cities incubate a 24/7 lifestyle which creates a great disconnect with our body's circadian pacemaker that controls many physiological and metabolic functions, including sleep. The lifestyle of service sector jobs, increasingly including overnight-shift work combined with the ability and desire to be in constant communication between different time zones across the globe, places a great strain on human body's natural inclination to maintain its circadian rhythm. Efforts on massive scales in cities such as Songdo International Business District (SIBD)² in South Korea and Sino-Singapore Tianjin Eco-city³ in China to make the greenest possible cities through integration of open green spaces, bike lanes, and recycling programs fail to consider their residents' chronobiology. In a work environment that operates across time zones, the temporality of our built environment is no longer in sync with the solar cycle as those of the farmers and factory workers in the pre-Edison era; in new open cities, chronobiology of the cities is guided by the human sleep cycle that is under constant attack by our 24/7 culture.

This paper explores the uncertainties and contradictions found in relationships between contemporary cities and their inhabitant's sleep patterns through considering light. I examine the recent finding in medicine on the impact of electric and natural light on human circadian rhythms along with the historical development of electric light in industrial cities. I then reflect upon the 24/7 non-stop activities that fuel the post-industrial cities and their sleepless phenomena. Finally, I will speculate how new theories of human health along with advancements in lighting technology could shape an architectural response to the problem. How could the design of buildings and cities actively protect their inhabitants' sleep and well-being?

THE IMPACT OF LIGHT UPON SLEEP

The idea that the brain was central to sleep was developed over the last two hundred years and has recently been proven scientifically. For centuries, explain neuroscientists Steven Lockley and Russell Foster, “sleep was regarded as simple suspension of activity, a passive state of unconsciousness”, but this thinking has since been proven wrong. Early in the 19th century, experiments on birds by Luigi Rolando and later by Jean Pierre Flourens showed that a permanent sleepiness was induced in birds after removal of their cerebral hemispheres. In 1918, Romanian psychologist Constantin von Economo, examining deceased patients with damaged brains, proposed that different areas of the brain regulate sleep and wakefulness.⁴

Charles Czeisler at Division of Sleep Medicine at Harvard Medical School claims that light affects the human circadian rhythm, the internal clock that regulates all living beings’ 24-hour cycle, more powerfully than any drug. In addition to our sight, human eyes have non-visual purposes of regulating our body functions, including sleep. Photosensitive retinal ganglion responses to light, including the circadian rhythm. When the retina is struck by artificial light between dusk and dawn, sleep-promoting neurons are inhibited and melatonin, which induces sleep, is suppressed, and as a result interferes with sleep. The hours of sleep has been decreasing in inverse proportion to the amount of electric light used. Between 1950 and 2000 in the UK, the cost of light production fell six fold, while light consumption per capita increased by four times. With increase in light consumption comes a rise in sleep deficiency.⁵

Night shift workers are particularly vulnerable to the health hazards of disrupted sleep patterns. The World Health Organization’s International Agency on Cancer has added night-shift work to its list of known carcinogen.⁶ When night-shift workers are awake overnight, they are exposing themselves to light when the circadian clock is anticipating darkness. This disruption is further aggravated as these worker’s schedules change every few days and their bodies must re-adapt each time.⁷ Night-shift workers have a much greater risk of accidents, injuries, and long-term diseases. Many high profile accidents occurred at night: Exxon Valdez (midnight), Chernobyl (1:30am), and Three Mile Island (4am).⁸

While the effect of sleep deprivation on well-being has not been understood medically until recently, sleep deprivation has been used as a form of torture and punishment. Perhaps the most well-known architectural device of surveillance, Jeremy Bentham’s panopticon, also utilized lighting. Prisoners in solitary cells were bathed in light, with no shadow in which to hide, in constant vigilance under a guard’s single eye in the center. Inside this opaque building is complete transparency in which privacy is stripped away through constant light and surveillance.⁹ We now know that sleep deprivation causes neurobiological impairment, including deterioration in reaction time and cognitive abilities.¹⁰ Inhabitants of over-illuminated post-industrial cities may be putting themselves through slow deterioration with sleep deprivation in their own offices and homes.

SOCIAL PRESSURES AGAINST SLEEP & DARKNESS

Despite scientific findings that show how detrimental sleep deprivation is to wellness and safety, social pressure against sleep remains omnipresent in post-industrial society. With long working hours, abilities to communicate across time zones, 24/7 access to online shopping, and flexibility of remote offices, sleep is a low priority of productive, hardworking citizens. To admit the need for sleep is

a weakness, Jonathan Crary observes, conceding that humans have limitations: “Sleep is an irrational and intolerable affirmation that there might be limits to the compatibility of living beings with the allegedly irresistible forces of modernization....within the globalist neoliberal paradigm, sleeping is for losers.”¹¹

Historical associations of light with truth and goodness and darkness with evil and danger further complicate sleep advocacy. In the book *At Day's Close: Night in the Times Past*, historian Roger Ekirch says night is associated with suspicion and insecurity because it robs our vision, “the most treasured of human senses”.¹² People judge another’s character through vision - posture, facial expression, even clothing. When sight is taken away, suspicion and fear result.¹³ This fear of darkness persists in human culture. In the early 1600s, nighttime was associated with the descent of noxious vapors from the sky.¹⁴ Night was thought a cause of sickness and contagion because, as is true today, illness symptoms get worse at night.

Conversely, light is revered in Christianity as the source of eternal light.¹⁵ Werner Oechslin observes that architecture has affirmed the symbolic validity of eternal light more than other art forms. For example, the vault in a church is where the divine light is held and symbolized. In the Chapel of Visitation at Vallinotto, domes on three levels were lit indirectly by light flooding through hidden windows to “render visible the heavenly hierarchy”.¹⁶ Besides religious and mythical significance, illumination was associated with cleanliness and safety. In mid eighteenth century European cities, public illumination became a symbol of progress and was seen, as is today, as a safeguard against crime.¹⁷ Such positive associations with light add challenges to advocating for reduced illumination.

LIGHTING IN PRE-INDUSTRIAL AND INDUSTRIAL CITIES

In the pre-industrial era, human sleep patterns were much more tightly in synch with lunar and solar cycles. In traditional farmhouses of Iceland, windows were very small and few. Farmers slept longer during its dark winters that had only several hours of sunlight each day, and slept less during the summer months when the sun never or barely set. They slept when the sun was down, and worked outside as long as the sun let them see and kept them awake.

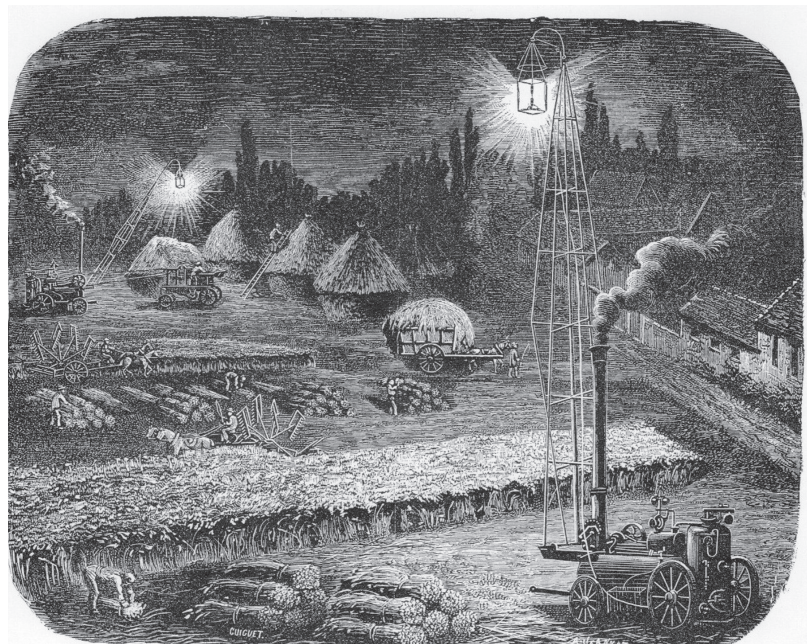


Figure 1: Woodblock print *Harvesting by Electric Light* (1882) *La lumière électrique* by E.M. Alglave and J. Boulard.

Generator mounted on portable steam engine supplies electricity for the arc lamp hanging from a tall mast.

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With industrialization, however, work after dusk was made possible. Paintings of mills and machines operating late into the night, such as Sir Richard Arkwright's cotton mills, begin to appear in this time period.¹⁸ An 1882 woodblock print depicts harvesting by electric light. As Roger Ekirch notes, "No previous time in Western history experienced such a sustained assault upon the nocturnal realm as did the period from 1730 to 1830....growing numbers after dark ventured outdoors in search of pleasure and profit."¹⁹

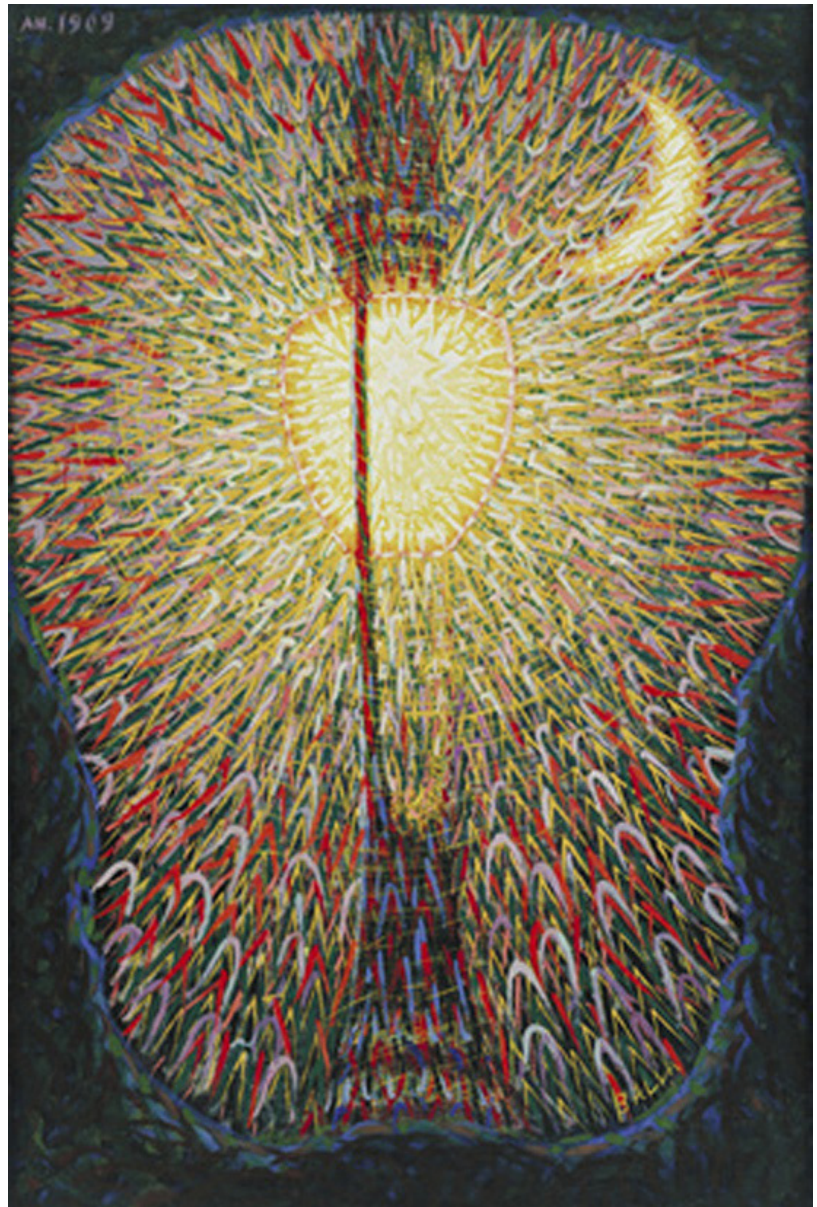
Artificial illumination of city streets came about relatively recently. In 16th Century Paris, those walking the streets after dark were required to carry a lantern, or they risked getting arrested. By the end of the 17th century, a state-run lighting system with candles was installed. As hired torchbearers who stood at street intersections often served as police informants, lanterns came to represent law and order.²⁰

In the 19th century, street lighting took on a new quality as lantern smashing became a common revolutionary act against the government in cities such as Vienna and Paris.²¹ The shift from oil to gas light impacted the scale at which streets could be illuminated. There is one word, according to the German historian of cultural studies Wolfgang Schivelbusch, that describes the changes in perception of gas lighting from oil lamp: distance. Whereas candle and oil lamps were intimate forms of light only bright enough to illuminate a small area, the brightness of a gas lamp was able to light a vast area by comparison. Moreover, the fuel came from a distance gas-works, and the flame could be adjusted from a distance with a switch, not by trimming of the wick at the light's presence.²² Street lights could now be controlled in mass, and the light source was so bright that it was blinding to view it directly. It is also around this time from the late 18th to early 19th centuries that the wealthy leisure class began to assemble at night in pleasure gardens, masquerades, gaming and theaters.²³

Streetlights that stay on all night all year long is a relatively new phenomenon. Between the end of seventeenth to the end of the nineteenth century, public lighting was tied to the natural cycles of the moon and stars. In 1860 Leipzig, for example, gas lighting was turned down on moonlit nights.²⁴ In 1870's and 1880s, several European cities installed electric arc-lights in the streets. Predecessor to filament bulbs, arc lights cast a light that had a spectrum similar to that of daylight. The eye saw arc-light with retinal cones as it sees daylight, while gaslight was seen with retinal rods.²⁵ Arc lights were even brighter than gas light that, like the sun, it could not be looked at directly and had to be placed high above the street. Despite its high performance, the arc light towers proved to be more about monumentality than efficiency. In 1888, the city of Detroit installed 122 arc light towers, each 153 feet tall. They were, however, taken down within thirty years and replaced by street scale lampposts that lit individual streets.²⁶

MODERNISM AND LIGHT

Modernist architecture associated light - both natural and artificial - with a progressive technological stance. Illumination was seen as an effective means to counter impurity.²⁷ Italian Futurism was a movement celebrating the technological triumph of humanity over nature, and its members championed electric light. In 1909, Futurist painter Giacomo Balla painted *Street Lamp*, which depicted sharp red, yellow, and green rays of light overshadowing the quarter moon in the background. The same year, Tomasso Marinetti published his manifesto 'Let's Kill the Moonlight'.²⁸ In this second manifesto of Futurism, he attacked the



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Figure 2: *Street Light* by Giacomo Balla (1909). The Museum of Modern Art.

moonlight as the symbolism of the past and proclaimed that moon be replaced with electric light bulbs.²⁹ In 1914, Paul Scheerbart published *Glasarchitektur*, in which he called for floodlights in all parks and towers.³⁰ Moonlight, the natural source of illumination, was now seen as obsolete.

Between 1880 and 1920, electricity began to reach modern homes in urban areas, first in the kitchens and corridors, followed by the living rooms.³¹ Contrary to gas, electricity was, with its pure and odorless properties, regarded as beneficial to health. The field of medicine has been fascinated by the use of electricity for health since the end of eighteenth century, as evidenced by electrotherapy, electric bath, and galvanization of farming soil as a form of fertilizer.³² This healthy perception associated with electric light continued to persist through Modernist architecture, in which brightness and whiteness are associated with health. Le Corbusier in *Toward an Architecture* condemned 19th century architecture for being an incubator of tuberculosis and advocated machines for living filled with light and air. In the final chapter, he opposed the “healthy” modern

workspace to the unhealthy private house, and related the disease of the streets to the disease of the house.³³

Despite their advocacy for healthy bodies, many Modernists including Le Corbusier, Reyner Banham points out in “Edison, Missing Pioneer”, failed to recognize what happens at night to the buildings bathed in daylight. Until the advent of mass-produced light bulbs around 1890, nighttime darkness rendered buildings invisible. With electric light illuminating the interior, buildings made largely of glass became visible at night as during the day.³⁴ Contemporary sleep science studies show that exposure to light at the waking hours of the day enhances alertness and performance, but at night, it can not only disrupt sleep patterns but also negatively impact alertness and mood.³⁵ Although the Modernists repeatedly associated daylight with health, the impact of light exposure at night has largely been ignored. The Case Study Homes, as seen in photographs of Julius Shulman, were frequently depicted with healthy human figures. The often-published photograph of the Stahl House by Pierre Koenig is fully bathed in electric light at night, overlooking an endless illuminated grid of Los Angeles in the background. Even though the Case Study Homes were designed to create good living conditions for post-war families, illumination in the cities was regarded with excitement, not concern for sleeplessness.

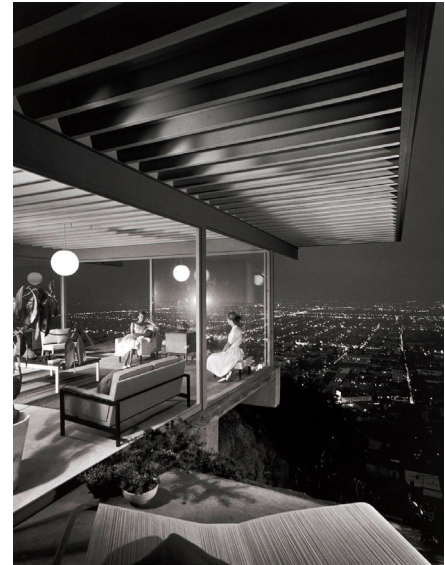
LIGHT POLLUTION IN CONTEMPORARY CITIES

Aside from the negative impact of over-illuminated cities on sleep, groups of different interests have advocated for darker cities for varying reasons. The Dark Sky movement is a recent action by groups of people who fight against skies that are polluted by light. Light pollution is an unwanted consequence of outdoor lighting. Astronomers whose studies of the sky and the stars were interfered with due to excessive light at night founded many of the organizations that fight light pollution, including the International Dark Sky Association, the oldest in the dark-sky movement. These organizations promote preservation and protection of night skies across the globe. According to IDSA, 22% of all energy generated in the U.S. is used for lighting, with 8% of that used for public outdoor lighting.³⁶

Advocates for dark skies are not limited to astronomers. Ecologists Travis Longcore and Catherine Rich make a distinction between astrological light pollution and ecological light pollution, which are negative impacts of electric light on ecosystems and organisms. Diurnal animals and birds rely on light to migrate, mate, and hatch according to the natural sunlight cycle. Artificially lit beaches with not enough shadows are causing sea turtle hatchlings to become disoriented, and nocturnal migrating birds have become entrapped in artificially lit zones.³⁷ If these impacts on animals provide any indication of what night-time light exposure does to humans, our health is at risk and needs to be protected from light exposure at wrong times of the day.

POST-INDUSTRIAL WORK CONDITIONS AND SOCIAL IMPLICATIONS OF LIGHT

If sleep disruption inside a trans-Atlantic Boeing 747 is an unintended byproduct of globalization, an example of a space that actively and deliberately disrupts sleep patterns is migrant workers’ factory housing like that at Foxconn and Huawei Technologies. Both of these factories are in Shenzhen, China, a city that grew out of a small village as a special economic zone for manufacturing. In the dormitories, day shift and night shift workers are housed in the same bedrooms. As a result, they regularly disrupt each other’s sleep.³⁸ Along with excessive overtime hours, isolation from families, and repressive working conditions, lack of



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Figure 3: Stahl House by Pierre Koenig, Los Angeles (1959). Photography by Julius Shulman.



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sleep contributed to many of them committing suicide. In 2010 alone, eighteen young migrant workers attempted suicide at Foxconn.³⁹

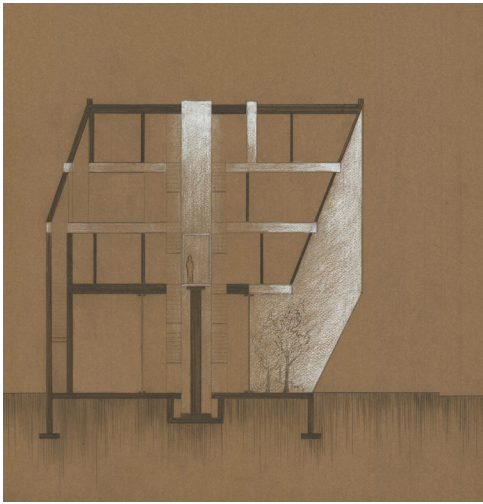
As with other forms of infrastructure, the quality of light in post-industrial cities is distributed unevenly across social classes. While wealthier cities may invest in design of finely tuned lighting master plans for aesthetic identity and improved appearance, cities with less wealth may use light purely for safety. As this paper has demonstrated, the quality of light also impacts wellbeing. Low-paid factory workers in such places as Foxconn are exposed to excessive amounts of light at wrong times of the day while the executives may be in offices with finely tuned lighting system that are less disruptive to their circadian rhythm. Groups such as Social Light Movement (SLM) argue that “intelligent and creative lighting is a fundamental right [more] than a privilege of wealth or status”.⁴⁰ The design of cities must integrate distribution of healthy lighting across social and economic classes and education of the public about the impacts of light.

THE DIRECTION OF ARCHITECTURE FOR HEALTH AND WELL-BEING

Health in Modern architecture was associated with daytime and sunshine. Even though we spend a third our lives sleeping, architecture overwhelmingly prioritizes the waking hours. Reyner Banham points out that, while Eric Mendelsohn and Frank Lloyd Wright approached electric light with enthusiasm, Corbusier’s “intellectual reference for light is limited to the sun and the candle” despite his celebration of machines.⁴¹ In addition to advocating for use of daylight in buildings, the era of 24/7 temporality calls for further investigation into the role of electric light in architecture at nighttime.

Le Corbusier called for homes to become more like the offices and factories in which they worked - machines flooded with sunlight. Today, the distinction between places of work and sleep is fast diminishing. All-glass facades in urban condominiums allow street illumination to enter the space of sleep. Residential and commercial building skins are often designed with similar considerations for light infiltration. When spaces are designed to be occupied at different times of the day - for work during the day and for sleep and rest during the night - should the building envelope not be treated differently? Or, when people work around

Figure 4: Factory production line at Foxconn.
Disconnected from the solar cycle for half day or longer. www.china.org.cn.



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the clock, do buildings increasingly become designed generically, as if their occupants are no longer in sync with the solar and lunar cycles?

As a way to explore alternatives for spaces of sleep, students in the author's second year studio in the Bachelor of Architecture program at Virginia Tech were given a prompt to design an Institute for Sleep in New York City, the "city that never sleeps". They were charged to design a building in which neuroscientists could conduct research on sleep and provide spaces for research participants to sleep with or without access to daylight in private rooms. There were projects that proposed some form of indirect access to daylight through windows, skylights, or floors while not disrupting the participants' sleep through bright lights. On the street facade of one proposed design, windows were cut within the thickness of the floor joists so that the reflected indirect light could infiltrate the rooms through the floors, not the walls or the ceiling. These windows were not about views but are a connection between the interior and the level and quality of light outside. Another proposal elevated the sleep rooms to the top, on the 4th and 5th floors, farthest away from the noises and light of the streets while keeping the researchers' offices and public reading rooms on the lower floors. The sleep rooms had no access to natural light or view, and the corridors that lead to the sleep rooms had narrow slits of windows that allowed people to adjust from the brightness of the street to the dark rooms for sleep.

These hypothetical projects provoked questions about how people may be fed light through the buildings they inhabit. How could building apertures be designed with more thought for their impact on sleep? Are spaces for sleep in post-industrial cities designed differently than the Modernist homes in relationships to natural light during the day and electric light from the city streets at night? And how do the sleep spaces look, smell, and feel to touch? Without reverting to nostalgia of pre-industrial farmhouses, how could buildings in cities be designed to protect its inhabitants' sleep while staying connected to the light-dark cycles of the earth?

In addition to the design of building massing and exterior envelopes, there is evidence that shows some use of interior and exterior electric lighting for (and against) wellness. Photosensitive retinal ganglion cells responsible for regulating our circadian clock are most receptive to short-wavelength blue and blue-green light, which means this spectrum stimulates the brain to keep it awake. Solid state white light (LED) is typically rich in blue light, so exposure to LEDs is

Figure 5: Institute for Sleep project model and drawing by Corey Crist, student at Virginia Tech School of Architecture + Design (2014).

ENDNOTES

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generally more disruptive to circadian rhythm, melatonin secretion and sleep than incandescent. Color composition of solid state light fixtures could comprise multiple color LEDs which means it can be easily controlled not only in intensity but also in color spectrum. To reduce adverse effects of stimulating light on the eyes, blue spectrum could be changed to red or orange spectrum at night in order to prepare for sleep, and reversed during the day.⁴² Such manipulation of the artificial light to be more like daylight may become advantageous in order to sustain health.

Distinctions between spaces of sleep and spaces of work in post-industrial cities are becoming increasingly undermined as a result of working around the clock. Citizens make their homes into offices, feeding their eyes with light from lamps and LCD screens late into the night to communicate with cross-Atlantic counterparts who are just waking up as their own bodies are signaling them to go to sleep. For hotels to attract business from global business travelers, 24/7 business centers in hotels have become a necessity. Both public and private spaces are being shaped by the human desire to be active and be communicating non-stop. This drive must be balanced by active protection of necessary sleep and integration of lighting control design. In the post-industrial era, new knowledge on sleep science and chronobiology, coupled with attention to delivery of natural and electric light, hold potentials to bring about a new kind of comfort for human wellness.