

Building technique: Digital Facade and LED Lighting as a Smart System in Commercial Buildings

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Abstract:- The growing trend to enhance the built environment, through the use of technology has become alarming. Facades traditionally referred to as ‘Building front’ enhanced with colorful and dynamic outer skins through the integration of digital media tools which are also referred to as digital façade maps, particularly light emitting diode (LED) systems has become a determining factor known to enhance the economic validity and uniqueness of a commercial building. Digital façade Maps can be modified to montages of all possible kinds, reversed and torn. This digital façade maps can be drawn on a wall, constructed as Marketing strategy for advertisement, a political action meditation or formulated as a work of art. This paper focuses on digital façade maps on walls with the use of LED systems. The light emitting diode (LED) Modules which are used for outdoor façade lighting element automatically turns the building into a real landmark, attracts users, investors, tourist, government, to mention but a few. Thanks to cutting-edge facade lighting, you can illuminate architectural highlights and even design fascinating color and light effects on outer skins of the building that attract attention.

This paper aims at re-establishing the ideals of the importance of innovation in terms of LED systems and digital façade technology. The objective of this paper will highlight on specific aspects of the topic, the advantages and few disadvantages of the technology in commercial buildings from an economist view point in other to develop a precise theory.

Keywords:- Digital Technologies, Integrated Systems, Digital Façade Maps, Light Emitting Diode(LED), Commercial Buildings.

I. INTRODUCTION

Digital façade technology introduces a new form of communication platform, urban space and public perception, the intersection of media, technology, art and architecture in recent conferences under the term ‘digital façade’ (Guattari, 2011). The use of technology, arts, culture and, entertainment is the means of identifying and establishing the buildings on the worldwide map of creativity. Technological flagships, landmark buildings, festivals, activities, and a vibrant social life (Evans, 2003) will attract not only creative individuals, creative industries and investors, but also visitors whose spending activity is essential to a town or region's economic development. Although digital technologies over the previous centuries

have been the primary driver of promotions economic development (Yoo et al. 2012). The literature is nearly absent from investigating the role of digital illuminated façade in the fast economic development of the built environment. This is difficult as all fields of creative cities are profoundly affected by digital techniques and digital infrastructure, including fields such as organizational architecture (Zammuto et al. 2007), governance (Tilson et al. 2010), and strategic decision making (Sawyaradaj et al. 2013). Modern organisations are profoundly affected by digital techniques and digital infrastructure, including fields such as organizational architecture (Zammuto et al. 2007). Below is a graphical representation of a digital façade which is also known as media façade and its effects on the user’s perception of space and the urban environment.

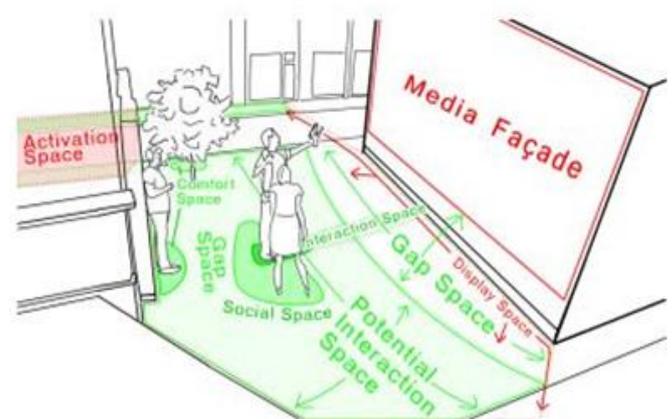


Fig 1:- Showing Media Façade Integration and the Building Structure - source: Gehring S, Wiethoff A (2014)

The term façade traditionally relates to a ‘building front’ (Merriam Webster Dictionary). With regards to the growing importance of culture for a city's economic development, the function of place branding is becoming increasingly crucial (Zukin,1995). As a result of the continuing academic discourse on the significance of place branding and marketing strategies in post-industrial societies have been created to define the uniqueness of locations in global competition for creativity (Florida,2003).

Technologists have created several initiatives to identify commercial buildings and create economic profits through tourists’ attraction. Such initiatives created, include technological innovative quarters (e.g. Amsterdam, Vienna, Berlin) and the creation of technological flagships (e.g. Oslo's new Opera house) to mention but a few. Technological-innovative built environments worked as

birthplaces for fresh technological innovations or even true technological revolution at times.

These cities have been able to create an atmosphere of cooperation, specialization and innovation. The city of Copenhagen, Glasgow (shipbuilding), Berlin (electricity) amongst others (Hospers, 2003). All of these cities, paved the way for new found technological enhancement both at façade scale and in the built environment. There are some limitations expected of this study; firstly, the time to carry out the research is limited. Secondly, this paper will focus only on the digital façade technology of commercial buildings. Hence, the inadequacies of sufficient studies on this subject might create a bias for the magnitude of the research.

The main idea of this paper, however is to Showcase an economically viable façade technology and highlight the importance of innovative-technological enhancements to commercial buildings in the Built Environment. The advantages of digital façade technology enhance the visual environment and, finally, promotes and organizes local resources thereby giving the city recognition as a well-defined place in the globalized world today. However, innovation is not restricted to technology; innovation is possible in the field of organization, marketing and logistics.

Digital façades are the modern protagonists of media and architecture. who, through optical methods, come into contact with the public audience, the government spotter. They have recently opened Contemporary urban planning, architecture and media theory discourse. This highlights the interdisciplinary nature of this issue. The name conference stream indicates the interdisciplinary nature of the subject "Media Urbanism" (Tschertou, et al., 2010).

II. LITERATURE REVIEW

This section of the paper would review various literature that are critical to the selected keywords of this paper. Three major materials were selected and would be evaluated, these literatures would provide the theoretical background for the analysis of the selected case studies.

No Compromise: The Integration of Technology and Aesthetics, a journal by Dunay, Wheeler & Schubert (2013) discusses on the perceptions of integrating innovation and technology into the façade and building scale as a whole. The author emphasized on the project competition winner; the 2005 Virginia technology university team that created a 'house larger than itself'. The building was designed as a movable building with a sense of proportion and beauty. This project succeeded in reestablishing ideas of using technology not only for energy and spatial effect but also as successful marketing tool, as it attracted business investment in terms of unique materials and new found technology. Hundreds of tourists, intellectual and academic scholars, companies, business owners, manufacturers, to mention but a few were all attracted to the site. One of the

most exciting aspects of the building was its digital façade which had the ability to illuminate itself during the day and at night with use of neon electrodes. The main goal was to understand ways of building through collaborative designs and construction to improve the built environment.

The mobile Audience: Digital media and Architecture – An Observation, a book by Anke & Rieser (2011). The book was based on field research. Its principal aim was to give a critical discourse on integrating mobile technologies and LED system on the façade scale. The authors discussed on critical issues in contemporary construction and integration of mobile forms. From a variety of viewpoints which included definition of the technology, spatial understanding and through the role of the creative user. The scope of the paper is report some research goals in relation of the realization of media surfaces and, therefore, to analyse the variability of their perception and visibility related to the environmental effects, of the technologies and materials.

From 'Advertising Architecture' to 'Media Façade': Communication through Digital Display Skin, a journal by Moza & Aydogan (2012). The paper provided a critical overview of interactive architecture and reactive physical surfaces in public spaces through observation and tracks, focusing primarily on the transformation of the lived environment. Three cases on LED technology and interactive architecture by integrating this media tools and façade design were carried out. The author examined the impact of new media and digital technology by looking at transformable surfaces, the type of interactivity connectivity connected to architecture, and a new display of technologies. This paper succeeded in reestablishing ideas of the importance of digital façade maps in defining the built environment. The author stated that the façade technology known as mapping is not a neutral process, but always has been a highly selective and subjective purpose in putting building on the global map.

A. The Digital Façade Concept

The term façade traditionally relates to a 'building front' (Merriam Webster Dictionary). A digital facade as a facade in which vibrant components of communication are incorporated (Haeusler, 2009). In addition, digital façades differ in size, place, possible angles of view and factor of shape. The uniqueness of this innovation and technology gives the city an identity.

Since they are embedded in the hosting building architecture, digital façades may have arbitrary 3-dimensional (3D) form variables as opposed to located government displays. (Gehring et al, 2013). In contrast to incorporating light-emitting elements into a building's architecture, Scheible and Ojala turned arbitrary objects into digital façades in urban settings, using a project or mobile device to communicate with the projection. (Scheible, & Ojala, 2009).

When developing digital content, the form factor or shape of a digital façade is a critical problem. A digital façade is a core part of the urban space, its context and physical environment affect the perception and experience of content (Schoch, 2006). Below is a table showing different façade integration with Light emitting diode systems.

Although digital technologies over the previous centuries have been the primary driver of promotions economic development (Yoo et al. 2012), The literature is nearly absent from investigating their role in the fast economic development of the built environment.

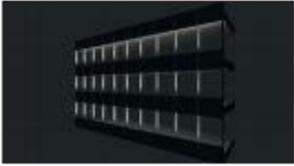
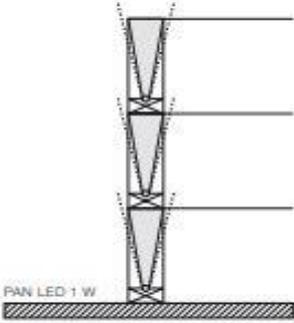
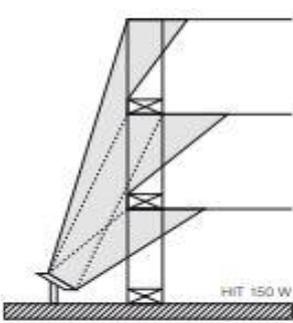
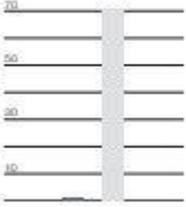
Two methods – a direct comparison	Detail of façade Integrated lighting	Detail of façade Direct illumination
SURFACE	6 window elements	6 window elements
LUMINAIRES	12 PAN LED spots asymmetric	1 HIT 150 W wide-angle
VISUALISATION		
TYPE OF LIGHTING		
OUTPUT AND LUMINAIRE	PAN LED ~1.2 W at 350 mA In this application thanks to current reduction: PAN LED ~0.32 W / lighting point Total output across six elements: PAN LED 6 luminaires 3.84 W max.	HIT ~150 Watt In this application: HIT ~150 W / lighting point Total output across six elements: HIT 1 luminaire 150 W max.
EFFICIENCY OF CONTROL GEAR	85 %	93 %
OUTPUT INCL. CONTROL GEAR	4.41 W per unit (6 off)	161 W per unit (6 off)
WINDOW ELEMENTS	2,691 elements – 448 units	2,691 elements – 448 units
TOTAL OUTPUT	1.98 kW	72 kW
OUTPUT COMPARISON <small>Output figures in kW</small>		

Table1:- Showing Façade integration with LED systems - source: Zumtobel (2013).

This is difficult as all fields of creative cities are profoundly affected by digital techniques and digital infrastructure, including fields such as organizational architecture (Zammuto et al. 2007), governance (Tilson et al. 2010), and strategic decision making (Sawyaradaj et al. 2013).

B. The Integration of Digital Façade Technology and LED System

In reaction to the industrial decrease and economic stress of this era, city branding as a discipline was created quite soon in the 1970s. About a decade later, the governments of Margaret Thatcher and Donald Reagan

introduced more entrepreneurial and business-friendly methods that, combined with economic cutbacks on the cultural industry and accelerated globalization, left towns with no choice but to turn to self-promotion (Zukin, 2014). Post-industrial sectors have created policies such as urban marketing and place-branding to reinvent and encourage their identity at global level in order to develop themselves as a 'must-see' destination (Vanolo, 2008).

The 'economy of experience' is a main component in this process. Pine and Gilmore (1999) invented the word to define a fresh atmosphere that provides the residents and visitors of a town with a multitude of cultural experiences as a strategy to increase economic revenue (Walmsley, 2011). However, it is not always evident to what extent branding methods are genuine or sustainable in the long run (Evans, 2003).

To date, there has been a shortage of digital façades growth and prototyping instruments. Also, due to the characteristics of digital façades, the existing toolkit is tailored to a particular setting and to the physical and technical characteristics of the digital façade. They represent the façade, its surroundings and the real hardware used in the environment in a simplified way. (Gehring et al, 2013).

C. Designing a Digital Façade

The façade's location, its scale and the techniques used have an effect on the user's experience of the discontinued material. There are some key challenges when designing applications for digital facades (Dalsgaard & Halskov, 2010). There is a description of how Touch Projector is applied to enable multiple users to interact with the digital façade simultaneously via live video on mobile devices. Because of the lack of suitable testing and prototyping tools, their initial implementation on the target façade was poor in real-world circumstances for variable viewing distances and altering lighting and weather conditions.

To fix these problems, they required to conduct extra design revisions (Boring et al, 2011). Digital facades

prototyping is a critical component of the design process and the absence of generalized instruments makes it difficult to reproduce facilities in a controlled environment (Bohmer et al, 2011). Bohmer et al also created a specialized virtual simulator tailored to the specific façade to incorporate their content into a 3D test model. A miniature hardware toolkit named Light box for reproduce the façade's hardware setup to simulate and test the user's mobile device interplay and the digital façade's hardware interfaces (Wiethoff & Blockner, 2011).

It was reported that reproducing a small-scale setup may be appropriate for prototyping the hardware interplay, but it runs the risk of missing significant variables such as model visibility. Possible viewing angles may vary from the real-world counterpart, and it is difficult to fully reproduce the installation technology and circumstances on site (Wiethoff & Gehring, 2012). The absence of prototyping and testing equipment for controlled environments and the huge discrepancies between the controlled laboratory environment and the real on-site circumstances make the design method more complicated and significant in the design process (Bohmer et al, 2011).

D. Digital Façade in the Built Environment

For a start, some examples of technological innovative cities that used digital façade system as a branding tool to promote its economy are:

- *The city of Copenhagen, Denmark:* Confederation of Danish industry headquarters. Dating back in history, the excellent economic achievements of the city of Copenhagen is dependent on two main factors; Clear digital façade marketing strategy and the effective collaboration between the government, commerce and education (Hospers,2003). **fig 2** below is a pictorial representation of the building. The renewed exterior consists of a large digital illuminated façade with a sea of visuals swirling into and around one of the busiest junctions in the city (Harman, 2013). The building attracts hundreds of tourist, technology inquisitive minds, businesses investors interested in the LED technology, to mention but a few.



Fig 2:- Façade LED maze of close and the urban space - source: Hospers et al. (2003).

- *The Cheonan in South Korea:* Dynamic media/digital facade illuminates South Korea, Cheonan is now home to one of the world's largest media façades, situated on the shopping mall of the Galleria in city center. With more than 22,000 LED lighting points, dynamic light shows wrap the structure in a shimmering skin developed by luminaire manufacturer Zumtobel, the high-power LED spotlights are designed to fuse into the façade (ephragave, 2011). **fig 3** below is a pictorial representation of the south Korea digital façade building.



Fig 3:- South Korea façade with LED (light emitting diode) - source: (Ephragave, 2011).

In Asia, for consumption, individuals are not just visiting shopping malls. Shopping centers such as the Galleria at the city center are also a place for social interaction in the Far East (berkel,2011).

- *GFRP façade (Swissbau 2007):* The GFRP building is located in Basel, Switzerland whose 9meter stairway tower digital façade is composed of both glass and

composite. This building is known to attract large scale business, tourist, intelligent minds amongst others to the city. Its continuous expanses of glass are united by almost invisible, high insulation joints that make use of technology known as composite glazing.

Fig 4 below is a pictorial representation of the Swiss composite LED glazing façade.



Fig 4:- The Swiss composite LED (light emitting diode) glazing façade - source : *Swissbau et al. (2007)*

The large expanses of digital glazing in this demo façade are possible because the new technology combines and harnesses the strengths of both glass and composite. Innovative digital Facade Technology using Glass and Composite. The two materials work together properly due to their identical linear expansion that forms a load bearing component which is used to achieve slender façade profiles (Moor, 2006).

- *Adelaide rundle lantern in Australia:* The Rundle Lantern is a spectacular and thrilling development that attracts both residents and tourists as Adelaide's fresh cultural canvas. Attached to the Rundle Street U-Park of the Adelaide City Council at the junction of Rundle and Pulteney Street, the Rundle Lantern includes nearly 40% of the construction (Ben, 2008) **fig 5** below is a pictorial representation of the Adelaide rundle lantern LED (light emitting diode) glazing façade.



Fig 5:- source: Ben et al. (2008) the South Korea façade LED lights up the urban space

The nine-story lantern includes an area of 1,066 square meters and consists of 748 square panels activated by a scheme of LED (light emitting diode). The Lantern works for unique activities every night from dusk to midnight, and later (Stewart,2008).

➤ *Beijing digital façade:* Creating a façade that reflects digital technology graphically may seem unusual, but with the Digital Beijing Building, Studio Pei-Zhu, based in Beijing, has achieved so in several respects. The northern and southern sides depict barcodes in this 57m-high structure that provided communication and data facilities during the 2008 Beijing Olympics (Baan,2013). **fig 6** below is a pictorial representation of the Beijing digital LED (light emitting diode) glazing façade.



Fig 6:- Picture of the Beijing digital façade - source: Baan, (2013)

The western and eastern façades, meanwhile, reproduce the appearance of an integrated circuit board. When vertical grooves take a diagonal jog in those façades before straightening out again, they look like wiring routing on a circuit board (Baan,2013).

➤ *Germany Klubhaus st. pauli digital façade in hamburg:* The project was granted the MAB 16 Biennial Award for Media Architecture 2016. The building is located by the right in the core of Hamburg's renowned

Reeperbahn. In this busy entertainment district, 5,000 m², the Klubhaus has become a fresh attraction to tourist, entrepreneurs, business owners, manufacturers, to mention but a few. Its media façade is a distinctive approach to media architecture's progressively appropriate phenomenon (Akyol, 2011).

Fig 7 below is a pictorial representation of the *Klubhaus st. pauli digital façade* with light emitting diode.



Fig 7:- Germany Klubhaus st. pauli digital façade - source: kamps et al. (2011)

The concept of architectural design, media layer and basic media content were simultaneously developed, understanding the façade as part of the identity of the building. The displayed content is divided into three sections: artistic material, branding and self-promotion of the resident cultural and leisure facilities.

The "core visuals" are a set of artistic video animations designed to form an integral part of the identity of the building. The economic viability of this project is evident due to its attractions of users, business investment, academic interests, tourists, to mention but a few to the site (Kamps, 2011). Other examples include: In Australia, there's the new Munday Wall, an enormous eight-by-nine-meter mural featuring an indigenous painting reproduced onto glass. Also, the Harlem Hospital in New York is another great example, with its full-colour building façade made of glass panels in the colors and styles of 1930s Harlem art and culture amongst others.

III. RESEARCH METHODOLOGY

The main method of data collection used is the use of existing materials, available existing journals, books, research publications and other research papers that talk about LED technology in the built environment, economic development and digital façade technology (Data Collection, 2010). The main method of data analysis used is the qualitative analysis whereby the use of thematic analysis and descriptive statistical analysis will guide the whole procedure (Data Analysis, 2010). A quasi-experimental research design will be used to examine patterns of aesthetic response. An existing process, environmental colour mapping, will be augmented with digital technology and used to isolate, identify and manipulate the independent variable and for preparation of visual stimuli. The main research questions focused on whether changes in aesthetic response are associated with variations in façade colour; and whether changes in judgements about building size, congruity and preference are associated with differences in façade design while integrating LED system.

Throughout this conceptual approach, the analysis would deal with digital facade design and LED systems throughout common typology such as plan commercial spaces in public areas. this report will also be point out the limitation

s and challenges faced by such technology, the advantages to the urban environment and their recommendations in terms of attracting growth to the built environment, strictly from the study taken. During the course of the research, I found out that many studies published between 1995- 2000 were somewhat relevant, they were omitted from this review because they lacked important details and because they included conditions that could no longer be considered typical. Although, the data collected was generated by numerous case studies, literature reviews, relevant journals, to mention but a few. Only articles with sufficient information on integrated LED systems and Façade design were included to determine what was calculated or manipulated and in which there were no apparent inconsistencies in the nature of the study.

Papers were also selected based on whether they provided sufficient information on the result to assess whether the building was a good or bad marketing strategy by attracting tourist, foreign investors, government, to mention but a few. The research focus was based on topics under a particular commercial typology, which included the digital façade and LED on commercial buildings in the 21st century built environment. Furthermore, the secondary focus was on a particular Digital façade systems integrated with LED lighting which has energy saving properties. This is due to the growing concern of ensuring a sustainable environment.

IV. FINDINGS AND DISCUSSION

The study showed that core visuals of digital façade in commercial buildings which are a set of artistic video animations, forms an integral part the building identity and is a determining factor known to enhance the economic validity and uniqueness of a commercial building. In the course of the research I studied three major journals relating to enhanced façade technology, LED systems and digital technology in the building scale. All of which, aimed at reestablishing ideas of using technology not only for energy and spatial effect but also as successful marketing tool and the conclusion from the findings and results were all positive. Hence, the importance of the study. The integration of digital façade & LED systems in commercial buildings attracted business investment in terms of unique materials and new found technology.

Furthermore, Clear LED integration & digital façade is a building marketing strategy that is proven to be viable in both developed and developing nations. The concept of architectural design, media layer and basic media content when simultaneously developed play an important role in acknowledging the façade as an integral part of the commercial building identity. Creating a façade that reflects digital technology graphically may seem unusual but a proper integration of technology and aesthetics creates a building that is not only economically viable but also enhances the environment.

In the attempt to enhance visual communication, it was also proposed to use cost-effective methods throughout lighting scale attenuation. It is also possible to use external elements mounted on the structure of the building to act as informative media projections.

Digital façade which are also called media façades are a prominent example of the catalyst for urban space growth. In this research, I reflect the idea of transforming a building's surface into a digital display on a large scale. It was noted that, contact is needed at a distance because of their enormous size and so they have a high level of visibility. Also, based in a very diverse urban environment with rapidly changing circumstances, this technology is a ground breaking approach to put the urban environment and city on the global map.

Finally, the study showed that cutting-edge facade lighting, can illuminate architectural highlights and when enhanced with fascinating color and light effects on outer skins of the commercial building, it will inevitably attract attention.

V. CONCLUSION

This study examined digital façade in the Built Environment and included constructive elements, design, space and organization of Landmarks. it is important to note that facades play a very important role in putting a technological-intelligent built environments on the map in the globalized world today and this has been proven to be a viable branding strategy for the economic development of the city or region. These facades offer day lighting, connection to the outdoors, corporate image and thinner envelopes for more 'lettable' gross floor area, it generally is a major part of the urban area which attracts factors the improve the economy.

One of the major challenges of this technology to the built environment which I encountered during this research, is the issue of "light pollution" which has emerged, causing a wide-ranging discussion on how to preserve the dark, 'un-blind' night sky. This subject is certainly strongly related to the theme of carbon dioxide and energy waste and its effect on the environment. The well thought-out question here is, whether from this point of view digital façades can be justified.

Digital façade offers environmental benefits, including illuminating the city scape, creating an environment for technological output for information, it is a good concept for marketing and branding of the city and the commercial building in general, digital façade design embedded with energy saving LED system is an approach to conserve energy for a more sustainable environment. In the study, it also serves as photovoltaic source in the building. The digital façade also acts as a shading blocking direct solar heat, so the thickness of the integrated system on the façade acts as a façade element which not only shields the building envelope, it also, acts as an indirect LED illuminance to the interior space. Hence, the perceptivity of the interior space to users heightens with regards to the resulting aesthetic effect. The first step in ensuring innovative façade designs are put in place is through the involvement of policy makers who create laws that ensure buildings offer the right kind of brand in line with what the place is trying to sell. This ensures controlled design that creates a harmony between buildings and surrounding environments while paying attention to society's needs all the while being economically viable.

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