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MINISTERY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

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Department of Architecture

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Architecture

Track: Architecture & Environment

Adaptive architecture a conceptual model building located in arid zones has a hot climate

Project: shopping center in Biskra

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<u>In front the jury</u>

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Dedication

Praise be to Allah, who helped me to complete this simple work, and my success along this course of study, these five years may be forgetting me now is just a waste of time, but I will not forget that there are who stood by my side in times of weakness and strength, the first is my dear parents Thank you for being my life, You are their colors.

And thank my dear teacher M'sellem Nour Houde who supported me and guided me in this work, I give my respect for all the members of the work, the jury professors : President Merad Yacin and the examiner BenShikha Lynda.

And I never forget that my brothers Ahmed and younger than me, as well as my sisters and their husbands, my spiritual twins Abir with Mahmoud , Sarah with Said , Lina and my dear brother's wife, Nadjet , and for my small flowers Rehab, Amen and Serine .

I thank everyone near or far away from me. My friends, my loved ones, and even the strange ones, all of them, have left a touch in my heart for five years. I know that I was the cause of so much fatigue and misery in long time but in these lines, I hope you will receive my feelings and respect. And for my friends in the way of architecture Zahra, Iman, Wahiba, Marwa and my best friend Bothaina; to everyone expensive to my heart : my family , my friends and my colleagues ;Thank you until the end in order to reach this moment.

Abstract:

Adaptive Architecture is concerned with buildings that are designed to adapt to their environments, their inhabitants and objects. The term is an attempt to incorporate what people imply when they talk about flexible, interactive, and responsive or indeed media architecture; Overall, adaptive architecture is not a well defined field of architectural investigation.

It ranges from designs for adaptive facade to eco buildings from responsive art installations to stage design and from artificial intelligence to ubiquitous computing; adaptive Architecture brings together a number of different concerns stemming from a wide variety of disciplines, spanning architecture, the Arts, Computer Science and Engineering among others. Whether buildings in this context are described as flexible, interactive or dynamic façade, they embrace the notion of Architecture being adaptive rather than being a static artifact, often with an emphasis on computer supported adaptation.

The purpose of design is to realize some kind of ideal adaption relative to the topography and situation of a site and as a consequence if design is proper then the function of space need never change and structure will never go obsolete. And of course the higher is the 'profile' of the designer the greater the tendency toward these assumptions of permanence and perfection. When the latest developments in different areas converge to create exciting new designs, experiences and lived-in buildings. It can also make the emerging field of Adaptive Architecture appear overly complex and disjointed.

Keys words:

Adaptive architecture. Adaptive façade. Interactive and responsive architecture. Dynamic façade.

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الملخص:

تهتم الهندسة المعمارية التكيفية بالمباني المصممة للتكيف مع بيئاتها وسكانها وأغراضها . المصطلح هو محاولة لدمج إلى ما يشير إليه الأشخاص عندما يتحدثون عن المرونة ، تفاعل والاستجابة وعموما عن هندسة الإعلام ،فالهندسة التكيفية ليست مجالا للتحقيق المعماري فقط .

يتراوح من تصاميم الواجهة التكيفية إلى المباني البيئية، من فن الاستجابة إلى مرحلة تصميم المنشات ومن الذكاء الاصطناعي إلى الحوسبة في كل مكان ؛تجمع العمارة التكيفية مجموعة من الاهتمامات النابعة من مجموعة مختلفة من التخصصات والأنظمة ، تمتد من العمارة ، الفن ، الحوسبة و الهندسة وغيرها .توصف المباني في هذا السياق بكونها ذات واجهات مرنة ، تفاعلية وديناميكية ، فالمهندسون أصبحوا يتبنون فكرة العمارة التي تؤدي إلى تكيف بدلا من كونها مجرد قطعة أثرية ثابتة ، مع التركيز على هذا التكيف المدعوم بالكمبيوتر.

الغرض من التصميم هو تحقيق نوع من التكيف المثالي بالنسبة إلى طبوغرافية وحالة الموقع ، ونتيجة لذلك إذا كان التصميم مناسبا فوظيفة الفضاء لن تحتاج أبدا إلى أي تغيير ،ولن تكون الهيكلة بلا معنى .

وبالطبع كلما ارتفع مظهر التصميم كلما زاد الاتجاه نحو فرضيات الكمال والديمومة ؛ عندما تتلقى احدث التطورات في مجالات مختلفة مع الخبرات المكتسبة تعمل على خلق تصاميم جديدة ومثيرة من اجل مباني حية ،ويمكن أيضا أن نجعل المجال الناشئ للهندسة التكيفية يظهر بأشكال مختلفة سواء مركبة أو مفككة .

الكلمات المفتاحية :

الهندسة المعمارية التكيفية , الواجهة التكيفية , الواجهة الديناميكية , الهندسة المعمارية التفاعلية والمتجاوبة

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CHAPTER INTRODUCTORY

The foundations of the research

Introduction

Economic transformations and commercial transactions have led to radical changes promised in various sectors, especially the economic sector, which is the basic measure of the possibility of any country, Algeria currently among the participating States to the World Trade Organization inspiring natural resources, and because of the economic policy of Algeria this year, which What aims to promote the Algerian economy and its products, which required the willingness to receive major projects, especially those related to trade, to revive the economy and preserve the architectural character of a global engineering. Economic and commercial facilities with a modern architectural character that adapts to the site, serves the consumer, helps reduce energy consumption and meets all needs thanks to an adaptive architecture.

The commercial centers are among the most vital economic public facilities, which represent the urban facade of the city. In order to make these centers operate efficiently, they need to be equipped and designed in a way that allows them to perform their function fully to adapt to their environment and meet the needs of the consumer.. Therefore desert areas are among the areas where projects are difficult to adapt to the climate, increasing energy consumption and reducing the sense of comfort for the use.

Desert areas are characterized by dry and hot climates, so it is difficult to adapt to these areas because of the difficulty of the climate and the rise of heat bikes. Therefore, public utilities in the desert areas always suffer from large consumption of energy in order to achieve the well-being of the internal areas. But it is not used in the facilities, so these areas need an architecture that deals with these facilities in a way that allows the exploitation of energy sources to achieve comfort and reduce energy consumption.

The adaptive architecture is based on a new definition of comfort that integrates the issue of dynamic architecture and occupant participation (Cole, Robinson, Brown & O'Shea, 2008). Janda (2009) argues that occupation is a major aspect of the energy performance of a building while the occupant seeks to restore a state of comfort. In this perspective, the adaptive architecture gives the occupant an active role in achieving comfort and energy performance of the building by providing opportunities for adaptation. A manifesto signed by 170 delegates in Quebec City during the 26th PLEA conference in 2009 (Demers & Potvin, 2009) argues that these passive opportunities and a freedom of choice encourage interaction between an active and responsible occupant and their built environment, and foster health, comfort and productivity. This theory aims at occupant comfort and energy saving through behavioral adaptation which, with the expectation, has much greater effects than mere acclimatization (Brager & de Dear, 1998). Indeed, several studies have shown that the range of thermal and visual comfort of an occupant increases according to the adaptation opportunities offered.

Problematic:

One of the most prominent architectural projects of economic nature today is what is known as the commercial center, which is of great importance to the engineers and specialists, which has an impact on the planning of cities and the general population distribution. Trade is the main element in the movement of architecture. Architecture is an element that evaluates the civilizations of different countries, Which Algeria is experiencing in the overall economic and trade reforms that characterize the development program that Algeria has embarked upon. It is obliged to reconsider the policies of the various development sectors, especially the commercial sector (commercial establishments and commercial centers) A big problem in Algerian cities can be asked in several questions**:**

- **How can the revitalization of the commercial area within the city under the program of urban development?**
- **How to create an urban commercial facility and give it its architectural advantages that make it an engine for urbanization of the region in line with modernity and openness?**
- **How can a commercial facility that is adaptive to climate and reduce energy consumption be developed using Adaptive architecture?**

Keywords:

Adaptive architecture – adaptive façade - shopping center

Hypotheses:

The establishment of a commercial center depends on the adaptive architecture supposed to take adaptive facade about adapt to their climate.

Goals:

• Verification of the existence of the commercial architecture in Algeria.

• Confirms that project adaptation with its environment ensures the integration of commercial project ensure an adaptive architecture in arid areas to improve comfort and minimize energy consumption with adaptive façade, and create a project depends on itself to achieve self-sufficiency and meeting the needs of the consumer

Thesis methodology:

To finish our dissertation, we will divide this work into two parts, the first of which relates to the research theme, and the second part relates to the project that we have chosen to implement in it.

1/ **The first part is divided into two parts**: the theoretical part and the applied part:

A. Theoretical part: consists of two chapters, the second chapter content of the first chapter from adaptive architecture to the adaptive façade.

B. Applied part: We selected three articles related to the subject of the research for analysis. Each article is dealt with in a different way to clarify the theme, in addition to some selected examples, in order to study how to apply their concepts by studying the techniques used in the them .

2/ the second part is divided into two parts: theoretical and applied:

A. The theoretical part: In this chapter we will talk about the commercial centers and their evolution throughout history in the world and in Algeria and its types, classification and characteristics.

The applied part: This work is divided into two phases, the conception phase in this part we analyzed examples of different commercial centers in terms of location and conception in order to extract the program used in the project , in addition to ground analysis and study of the climate of the region .The second stage is the project of concept idea and it relationship to the theme, plans, façades and perspectives.

Thesis structure:

Introduction chapter:

- Introduction
- Problematic
- Hypotheses
- Goals
- thesis methodology
- Thesis structure

Chapter 01: adaptive architecture

- Introduction
- Responsive to Adaptive – The shifting trends in Architecture
- Definition of adaptive architecture
- Types of adaptive architecture
- Adaptive architecture skins and dynamic environmental conditions
- The role of adaptive architecture in collaborate community development
- Conclusions

Chapter 02: adaptive façade

- General introductory
- Adaptive architecture with four streams
- Adaptive façades
- Conclusions and future perspectives

Chapter 03: state of art

- Analysis of articles
- Analysis of examples
- Conclusion

Chapter 04: shopping center

- Introduction
- The Definition and Typology of Shopping Centers
- Conclusions

Chapter 05: presentation of project

- Analysis of examples
- programing
- Climate region
- Field analysis
- the passage elements
- objectives
- The relationship between the project and theme
- the conceptual idea
- the project

Thesis structure progress :

theme

THEORETICAL part

Introduction chapter:

- Introduction
- Problematic
- Hypotheses
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chapter 01: adaptive architecture

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THEORETICAL part

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APPLIED PART

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CHAPTER ONE

ADAPTIVE ARCHITECTURE

I. Introduction:

There are many anachronisms relative to the contemporary situation perpetuated today in the practice of architecture and two of the most obvious are the delusions of permanence and perfection; the notion that the purpose of design is to realize some kind of ideal adaption relative to the topography and situation of a site and as a consequence if design is proper then the function of space need never change and structure will never go obsolete. And of course the higher is the 'profile' of the designer the greater the tendency toward these assumptions of permanence and perfection. The design becoming inviolate relative to the designer's prestige changing from architecture to sculpture.

In reality, we live in a world of change steadily increasing in pace and degree. A world where the works of even history's greatest and most famous architects are very routinely demolished and are lucky to survive a generation. Western society is more mobile than ever before, property value more volatile, and the structure and character of households more dynamic and complex. The environmental effects of Global Warming alone will compel a relocation of some two billion people in the coming decades. The effects of rising, and increasingly volatile, energy costs and the need for nations to reduce carbon footprints may double that number as once conventional modes of living -like conventional suburbia- become untenable and people are compelled to seriously consider the energy and carbon overheads of their daily life. Currently, real estate market bubbles are bursting all over the globe, forcing radical corrections of property value in the wake of decades of irrational finance industry practice, casting people out of their homes and compelling society to consider radical new ways of housing itself in the face of unreliable, unsafe, and increasingly unserious mortgage based systems. Social trends have steadily increased the pace of home renovations. While the market increasingly favors homes of generic aspect, homeowners are increasingly demanding customization to suit a burgeoning diversity in aesthetic taste and the structure of the family itself. The nuclear family no longer defines the model household. New household models based on the return of the extended family unit and the emergences of new non-related family groups are emerging. And technology too is having its impact, altering the architectures of domestic infrastructure systems with increase frequency while producing new trends in work and leisure activity that can radically effect the organization of the home and logistics of the household. Clearly, a contemporary trend favor a habitat of more freely adaptive architecture and nowhere is this need more acute than in the growing number of intentional communities inspired by growing social dissatisfaction with the dysfunctions of the contemporary habitat. Attrition rates for intentional communities are typically high in the industrialized world owing mostly to social issues; to unrealistic expectations, a lack of effective social skills, sociopathic behavior patterns cultivated in the mainstream habitat's anonymity, and an essential lack of cultural knowledge for what community is and how it works. In the western world especially, generations of Industrial Age development has cultivated an essential cultural sociopath rooted in the presumed inexorable logic of the Market. Traditional communities were systematically destroyed in favor of an isolated nuclear family unit identifying primarily with the macro-community of the nation-state.

Chapter one

Adaptive architecture

The culture of community must be relearned through trial and error and an incremental evolution, yet this is only possible in an environment conducive to that process. (Web1-01)

In this chapter, we will give an overview of adaptive architecture and its relation to responsive architecture. This section will be structured around the concepts of adaptive architecture from its origin and development in addition to its three types and fields of use(adaptive reuse , functionally generic architecture, and adaptive systems)in addition to Adaptive architecture skins and dynamic environmental conditions. We conclude this work by talking about the role of adaptive architecture in collaborate community development. This chapter aims to clarify the basic idea of the subject of the memory on adaptive architecture, especially that the term was used recently in the expression of a specific type of architecture with special characteristics. This work will provide the briefest details about adaptive architecture. At the end of the work, the reader can distinguish between Adaptive architecture and other architecture in addition to the reasons for creation, areas of need and use .

II. Responsive to Adaptive – The shifting trends in Architecture:

Our lives are surrounded by constantly changing forces of nature and environment. Everything is in a constant state of flux, with varying degrees of dynamism. Our lives too, are always in motion. The spaces we inhabit are constantly changing as well, although the change is slow and occurs through non-physical conditions. The physical state of the inhabitable spaces are more or less constant and not in motion (Web1-02).

A traditional building skin provides stability, regulates air pressure (fenestration) and protects the interiors from direct environmental factors (sunlight, rain and wind). Building skins are a vital component to resolve the issues of responsive architecture as they are a medium through which intelligence can be imparted to the building system to respond to an environmental stimulus. Thus key characteristic of an effective intelligent building skin is its ability to modify energy flows through the building envelope by regulation, enhancement, attenuation, rejection or entrapment (Web1-02).

The term ‘adaptation’ is commonly used in architecture in relation to the changing morphologies of the architectural artifact. These changing morphologies have been a result of timely changes and evolution of architecture as a social entity, technological product and as a practice. Through years of architectural evolution, changes have occurred in notions of how buildings are conceived and built. The architectural morphologies adapt to the time, in which they are conceived and realized. These adaptive morphologies are a resultant of changing times, social form, economic support, user needs and environmental effects. The environmental changes that occur in a given time, such as a day, can be a constant force of changes that need to occur in an architectural object, leading to local adaptations. The global climatic change, occurring over a course of time, creates forces for architectural object to change over the years, in order to survive and sustain itself. Adaptation in architecture is a long-term process that occurs with time and generations, where improvements in the technology, economic support as well as human thought-process, contribute to the adaptive response (Web1-02).

Adaptation occurs through generations, with constant improvements, feedback evaluations, and survival of the fittest, based on certain fitness criteria. Many projects dealing with adaptive architecture can be sub-categorized adaptation as interactive, dynamic, kinetic or responsive architecture (Web1-02).

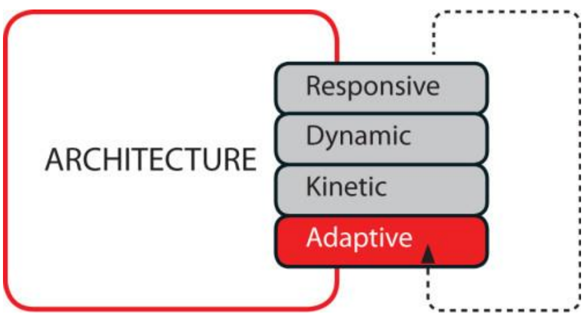


Figure 01: Relationship of adaptive architecture to responsive, dynamic and kinetic architecture Source: (rat[LAB] project adaptive[skins] carried out at AA London-Em.Tech, www.adaptiveskins.com)

An intelligent pre-programmed mechanism of response and feedback needs to be embedded in architecture, with a real-time response and improvisation, for it to be termed 'adaptive'. It is a complex phenomenon with a multi-layered non-linear process.

Buildings do not merely provide shade and protection from the external environment but have a multitude of functions to perform and a range of conditions to adapt and respond to. Architecture has transformed from being functional to intelligent, with changing requirements of time. Social environment is a constantly changing parameter and architecture needs to modulate and change with it too. Since its very origin, architecture has been evolving and developing to serve the needs of the cities and its people. In today's complex lives however, with the fluctuating parameters and conditions of the cities and changing environments, architecture needs to serve to a multitude of functions through its life cycle. Thus it is necessary that architecture responds to all the fluctuating parameters and serves the purpose of its existence. Responsiveness can be observed at various scales and in various elements of the whole system, within architectural realm (Web1-02).

The works of Diller, Scofidio (Blur), dECOI (Aegis Hypo-Surface), and NOX (the Freshwater Pavilion, NL); are all classifiable as types of responsive architecture (Diller & Scofidio 2002; Liu 2002; Lootsma and Spuybroek 1997). Each of these works monitors fluctuations within the environment and alter their form in response to these changes. The Blur project by Diller & Scofidio relies upon the responsive characteristics of a cloud to change its form while blowing in the wind. In the work of DECOI, responsiveness is enabled by a programmable facade, and a programmable audio–visual interior in the work of NOX. All of these works depend upon the abilities of computers to continuously calculate and join programmable digital models to the real world and the events that shape it(Web1-02).

Figure 02: Building envelope of Blur Building, DILLER &SCOFIDIO, and Media pavilion

Source: Swiss Expo, 2002façade of Hypo surface de COI, 2001(center) Internal spaces of Freshwater Pavilion, NOX, 2001 (Right)

Adaptation as a process has been conceived in various disciplines with similar approach and goals. This definition offers a direct translation into architectural conceptualization. We can consider the building to be a system which adapts its behavior to information acquired about its users. Information external to the building (system) could also be integrated into the process, for

Example weather data, energy prices, demands of neighboring buildings, etc. Adaptive Architecture thus has the capability to respond to a number of parameters with time. Time is an integral factor driving adaptation in architecture. Thus adaptive architecture can be said to be Responsive Architecture evolving with time (Web1-02).

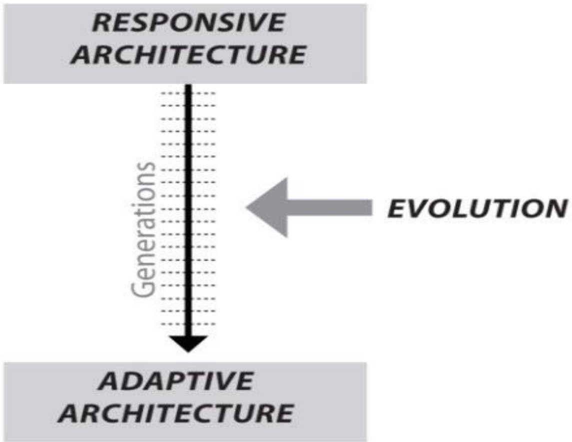


Figure 03: Evolution of responsive architecture to adaptive architecture over a period of time, through many generations

Source: *(rat[LAB] project adaptive[skins] carried out at AA London-Em.Tech. www.adaptiveskins.com)*

Figure 04: Responsive building skin designed for MASBA, Barcelona

Source: rat[LAB] – Sushant Verma & Pradeep Devadass in research adaptive[skins] carried out at AA London-Em.Tech. www.adaptiveskins.com)

III. Definition of adaptive architecture:

All Architecture is adaptable on some level, as buildings can always be adapted 'manually' in some way. Brand's 'How Buildings learn' provides an insight into the different levels of adaptation to be expected and how these apply over different time scales (Brand, 1994). The use of the term 'Adaptive Architecture' must therefore be seen in this overall context and the following delineates between adaptable and adaptive: Adaptive Architecture is concerned with buildings that are specifically designed to adapt (to their environment, to their inhabitants, to objects within them) whether this is automatically or through human intervention. This can occur on multiple levels and frequently involves digital technology (sensors, actuators, controllers, communication technologies). Taking the above context into account, this definition and associated framework is therefore an attempt to incorporate a variety of approaches, such as those labeled flexible, interactive, responsive, smart, intelligent, cooperative, media, hybrid and mixed reality architecture (Kronenburg, 2007, Bullivant, 2005, Harper, 2003, Streitz et al., 1999, Zellner, 1999, Schnädelbach et al., 2007). All the above come with their own connotations and particular areas of focus. Adaptive Architecture as it is presented here, is structured to be independent of any of these particular concerns. Before continuing with the body of the paper it is worth to set out one additional is delineation. Although the term Adaptive Architecture is often used there, design processes themselves that are computationally adaptive to data drawn from the environment, inhabitants or relevant objects are not included in the framework. Recent approaches in generative design methods and data driven architecture highlight such adaptiveness during the design process. However, these do not necessarily in themselves lead to buildings that are adaptive during their occupied life cycle. However, they certainly do present a fascinating research field in themselves (Web1-03).

IV .Types of adaptive architecture:

There are basically **three 'schools'** of adaptive architecture; **adaptive reuse, functionally generic architecture, and adaptive systems**. These further are break-down into more specific building systems and design approaches. Adaptive reuse is based on the repurposing of a 'found' structure -often a pre-existing piece of architecture that has become obsolete in its original purpose. This is most common in the context of commercial, municipal, and industrial structures with large span interiors that allow for easy retrofit or sometimes the erection of whole light independent structures within the shelter of the larger structure. Adaptive reuse also applies to vehicles and other industrial artifacts like ISO shipping containers and has been explored with everything from culvert pipe to the external fuel tanks of the Space Shuttle. Adaptive reuse also can apply to entirely new prefabricated structures and building systems which are simply employed to a purpose they were not originally designed for. This is common with light industrial and farm structures and their sometimes highly modular building systems (Web1-01).

The chief limitation of **adaptive reuse** as a strategy for adaptive architecture is that one is limited to the very providential adaptive potential of a found structure one has no control over the form of. Potential adaptability thus varies greatly, usually being greater the simpler the form of found structure and the larger its structural spans. In general, this approach is most often limited to discrete dwellings and does not suit community development unless they found structures are truly vast -like very large industrial, commercial, transportation, and municipal buildings. Early era industrial buildings, of course, are the basis of most 'loft' apartment conversion based on their large size, large spans, easy compartmentalization using built-up partition walls, and numerous windows. Few other types of buildings have been so comprehensively reusable. Modern industrial buildings, which are predominately based on steel frame and panel structures rather than masonry, are nowhere near as versatile in this respect and require radically different approaches to reuse (Web1-01).

Functionally generic architecture is based on structures intentionally designed for perpetual adaptive reuse -a level of design foresight that's rare today and typically limited to large scale commercial and industrial buildings. These are structures with no pre-determined purpose for any of their interior space -except, perhaps, in a very generalized sense relative to the environmental character of large zones of the structure. Instead, they are designed to accommodate as many uses as possible anywhere within them as necessary over time and with the aid of non-permanent retrofit that conforms to the dimensional limits of the larger structure. This concept is closely related to the notion of 'sky break' architecture where a large independent roof or enclosure structure like a dome is used as a simple weather shelter for light independent modular, and freely adaptable structures built inside it, the elimination of the burden of weatherproofing allowing these structures that lightness and adaptability. This is how Buckminster Fuller actually intended the geodesic dome to be used for housing -as opposed to the rather tricky and unreliable wooden frame dome houses we commonly see today- and it has seen more recent interpretations in such designs as Shigeru Ban's Naked House where a greenhouse like structure provided sky break shelter for a compound of traditional Japanese rooms put on boxes on casters like pieces of furniture (Web1-01).

This **functionally generic** design concept was once almost the exclusive province of commercial office building design, until in the wake of the Lofting movement a few residential developers realized the advantage of designing new buildings as ready-made loft apartment structures. We tend to think of buildings as being whole structures when, in practice, they actually tend to be organized into several primary and largely independent Elements; superstructure (which does the work of holding the building up), foundation, roof, floor/deck, ceiling, outer enclosure, partition walls, and furnishings (Web1-01).

In some vernacular architectures, superstructure, foundation, floor, and roof were the only substantial or 'permanent' elements of a structure. Everything else was temporary, moveable, and light. This strategy was adopted in modern times for the design of commercial office buildings where it was necessary to lease space on a square-foot basis and allow tenants the freedom to organize the internal layout of their workspace to suit their particular operational schemes and choices of amenities and equipment. This strategy became particularly important in the Information Age with the need to accommodate a rapidly evolving assortment of technology in the workplace. Though sometimes elaborate to the point of absurdity on the outside, office buildings are designed with simple post and beam superstructures of as large a span as practical and organized into simple floor levels. This superstructure defines the primary routing for a networked utilities infrastructure. Hanging or 'curtain' exterior wall systems and large glass windows provide the basic environmental enclosure. Everything else is non-load-bearing partitions of light framing or sometimes modular panel systems which are all considered temporary or disposable (Web1-01).

Adaptive systems are building systems where whole structures are freely adaptable by virtue of easily demountable and manipulated modular components. This is the ideal form of adaptive architecture, where both the micro-scale structure of the discrete dwelling and the macro-scale structure of a whole community are freely and spontaneously evolvable at potentially the same very high rate of change if necessary. These systems are also potentially useful in the context of retrofit or in-fill structure in both the adaptive reuse and functional generic architecture contexts, providing the basis of light structures that can flesh-out the interior of other larger structures.

Such systems tend to fall into two categories; unit module systems and modular component systems. Unit module systems are based on relatively large modular units comprising one or more rooms which serve as complete prefabricated, sometimes pre-finished, structures akin to appliances that can be assembled into larger complexes, either directly or with the use of an external support superstructure. One of the best and largest examples of such architecture is Moshe Safi’s Habitat 67, built for the Montreal Expo and based on large interlocking stacked concrete modules forming a vast multi-storey complex. (Web1-01)Modular component systems are those where structures are built from relatively small size modular components, usually in some combination of frame, panel, and fixture modules all scaled for relatively easy assembly by hand and in some rare cases designed for robotic assembly. Space frame structures are the common example of this form of structure. Both of these types systems are sometimes referred to as 'plug-in architecture', though in general the term Is more appropriately applied to modular component systems based on integrated component attachment methods needing few or no tools (Web1-01) .

V. The role of adaptive architecture in collaborate community development:

Adaptive architecture offers the potential to radically alter the logistics of habitat compared to common contemporary development methods, expanding personal and social control over development and shifting things back to a mode of habitat more akin to that of pre-industrial times. It does this by reducing or eliminating the barriers of cost and time in the physical adaptation of structure and by the decoupling of the value of buildings from land, fundamentally altering the perspective of property. The wholly demountable building is an astoundingly disruptive technology when you think about it. Traditionally, the value of land has been interdependent with how it is used -how it's 'developed'- and thus interdependent with the structures put on it. This relies on the essential non-changeability of conventional architecture -on that irrational assumption of architectural permanence. This has created the very peculiar phenomenon -or cultural delusion...- of perpetual real estate appreciation, which, as we have painfully learned in the past few years in the western world, is not sustainable. The demountable building has a value independent of land because, at any time, it can be picked up and moved whole to some other location or even sold off as parts. It can also be radically altered in value and use through a reconfiguration of components. This reduces the value of land to that based purely on demand for raw space while affording the structures on it a very independent valuation based on unit component condition and re-salability. This would not automatically mean that a building must radically depreciate like an automobile or mobile home. Their depreciation is based on their engineered obsolescence -their deliberate design for irreparability. However, unlike a conventional building which has its value tied to land, it would depreciate according to the vicissitudes of market value on a discrete component basis, some parts wearing faster than others, some retaining market value relative to demand, some even appreciating. In other words, the relative value of the structure over time becomes akin to the values of furniture. You can buy the cheap and disposable stuff, buy stuff that lasts, or even buy antiques that appreciate in value.

Whether as part of primary cultures or later cultures, most people in the world for most of human history did not individually own land; either because they had no need to own it in any formal sense to use it or because ownership was limited to small ruling classes/castes. Though we often think of cities today as somehow a very recent advent of civilization, for most of history people have, out of simple necessity, lived at an urban density in a village-oriented habitat -even when that village was no more than a shared cave or a mobile collection of light huts or tents. The use of space in such early communities was subject largely to a peer-to-peer process of negotiation between immediate neighbors and often the whole community, initially in a very casual manner but increasingly formally as the nature of the built habitat became more sophisticated and the structures involved more substantial and dependent upon communal labor to create. Often community leaders, elders, or sometimes the ruling-class land owners or their assigned representatives assumed the role of mediator for these negotiations. All space was essentially 'free' for use but communities tended to create specific collective structures for protection, resource efficiency, and convenience, compelling one to participate in a negotiation for one's share of space and location in the community layout. In such an environment egalitarianism

Tended to prevail because of a very direct peer pressure for fairness and equity and a dependence on one's neighbors for building labor -if not is for survival in general. As a result, most personal dwellings tended to be consistent in basic space, form, and design, though were free for elaboration, customization, and decoration within the limits of personal labor or labor one could trade for or coax free from one's Neighbors in some way. One was always cognizant of the fact that one's rights to any particular space in a community were secondary to the needs of the community as a whole -or for that matter the will of the ruling lord or the like who might

Actually own the land and could decide at any particular time that he had better uses for it. But as a participating member of the community one was always assured that if one was compelled to move, the community would pitch-in collectively to make that move as convenient as possible and provide one with equivalence in replacement accommodations -or even some improvement as compensation for being compelled to move. And, of course, these decisions -because the labor involved could be so high- were very well deliberated and did not happen that often except where communities relied on architecture that required regular structural replacement -as in the case of buildings employing lighter organic materials (Web1-01).

Adaptive architecture compels a similarly pragmatic attitude about the disposition of the personal dwelling and the nature of property. By decoupling the value of structure from the value of land through demount ability, new -or perhaps we should say more traditional- models of property become apparent and we return to a situation where habitat becomes a social construct rather than an economic construct. In the conventional real estate market there generally exist only two options in the disposition of dwellings owing to the strict coupling of structure to land value; total ownership and total lease. One either owns ones dwelling and its land whole or own rents a dwelling owned whole by someone else. Mobile homes have created the potential third option in the form of ownership of dwelling independent of rental of space -which was actually a common situation in earlier times- but the horrendously poor quality of mobile homes and their very rapid depreciation relative to their cost and the high cost of rental space to put them on has made this a usurious option of last resort for a desperate underclass unwilling or unable to move to cities. With adaptive architecture that has a high degree of demount ability (and with that perpetual incremental maintainability like conventional buildings) one can regard a building as a portable possession akin to the furniture inside it and thus a broad spectrum of options opens up between these two ownership extremes. A commercial land owner now has options to lease space much like space in an office building without a large investment in structures or can choose to build superstructures to increase density of use without a great investment in finishing. A home owner now has many possible gradations of ownership to transition between on the way to full scale home ownership with labor cost largely eliminated by modularity and industrial production of building components a home owner can easily assemble himself. They can invest in a home incrementally, relocating as necessary to obtain more space, and choose at any time between components that are new or used/refurbished and bought on a house parts aftermarket. The scale of dwellings can freely fluctuate according to their varying use. One can add or sell off parts of a home incrementally as one's household space needs grow and shrink (Web1-01).

VII. Conclusions:

There is clearly great potential in adaptive architecture, not only in terms of collaborative community development but also in terms of discrete architecture and housing. Though most of the cultural knowledge associated with traditional community development has been lost across the Industrial Age, we see that some of the adaptive characteristics of past vernacular building technologies has been retained or rediscovered in some contemporary building systems, thanks largely to Modernists obsessions with modularity and -ironically- the dream of industrialized housing. There are definitely very important functional limitations in the contemporary technology of adaptive architecture but in many ways they far surpass older vernaculars in the ease and speed of potential evolution. Though many of the possible technologies still remain too underdeveloped for practical use, what we have at-hand today does seem suited to potentially supporting three different scales of experimentation and exploration of peer-to-peer community development. With Pavilion Architecture and Living Structures we have the possibility for very low cost community experiments at a co-habitation scale based on communal pavilion structures or repurposing a variety of commercial and industrial buildings. With Container Module systems and perhaps rudimentary purpose-built Modular Unit Architecture as well as contemporary wood Post and Beam and T-Slot structures we can explore this at a co-housing or village scale. And with purpose built Functionally Generic Architecture based on conventional commercial construction, we can, in combination again with the Living Structure approach, take this to a truly urban scale with 'micro cities' or prototype ecologies’. It would seem the only practical obstacle to such experiments is people, given that the true start of any such project is accumulating enough people with the necessary skills and freedom of mobility to attempt such projects.

Adaptive architecture is itself a science that branches into several types of contemporary architectures, which allows technology the opportunity to manifest itself through dynamic systems. Therefore, to study adaptive architecture, we must know that it contains four basic elements in order to form the concept or term of adaptive geometry; the next chapter will examine the most important element in adaptive architecture, which is adaptive façades or known as dynamic interfaces in order to complete the general concept of adaptive architecture.

CHAPTER TWO

ADAPTIVE FAÇADE

I. GENERAL INTRODUCTORY:

Humankind benefits from millennia of cultural continuity while it faces profound challenges and opportunities. Fuelled by potent new research tools and techniques the discipline of architecture is ripe with potential. New modes of practice offer models where research, design and development are seen as one, and where knowledge passes with extraordinary fluidity, as if by osmosis, from practice to academia, from teacher to pupil and from the future architect to the architect-academic. The future is now.

New roles for architectural environments are emerging that transform portions of static buildings into dynamic responsive surfaces by equipping them with near-living intelligent distributed computation systems and chemically active functions. Adaptation of architecture can be as simple as the windows, blinds and sliding screens of GERRIT RIETVELD'S Schroder house, 1924, where the first floor transforms from spaciousness to intimacy in the hands of its occupants, or it can environment is becoming responsive in terms of physical, real-time changes acting under intelligent controls.

In this chapter we will rely on the study of adaptive facade in a detailed and concise at the same time so that we will deal with the most important details so that the recipient is able to know the meaning of the adaptive facade and the difference between them and the normal architectural façades we will divide this chapter into several important addresses to facilitate the introduction of the idea of this chapter, About defining the adaptive facade and then the dynamic interface so that we will remind uh which elements Ecological footprint Often, a primary objective of the design is to reduce the ecological footprint of buildings. Approximately one third of the world's energy use takes place inside buildings, Structural placement, Movement: The adaptive mechanisms of adaptive façades are roughly dividable in two classes. One class results in changes in properties at macro scale level and one class at micro scale level. The largest part of the existing façades belongs to the macro scale category, Environmental impacts during the building's lifetime: The changes in the environment can be of different orders of time. First of all, the building's envelope is influenced by short-term fluctuations which change in order of seconds these are mostly stochastic processes, control is essential. This can be done in an extrinsic or intrinsic way. The extrinsic control systems translate feedback that results from the comparison of the current configuration and the desired state and their classment facades. At the end of the chapter the architect is able to know the characteristics of the adaptive interface and the systems used in this summary, which explains the most important details related to it.

II. ADAPTIVE ARCHITECTURE WITH FOUR STREAMS:

Architecture has always been inventive and adaptable. However, our current era is unique in its technological potential combined with societal and environmental challenges. The need to generate sustainability, developments in design techniques and technology advances are leading to the emergence of a new Adaptive Architecture.

The built environment is becoming truly responsive in terms of physical, real-time changes acting under intelligent controls. Adaptive Architecture can be characterized by four key attributes; it is Dynamic, Transformable, Bio-inspired and Intelligence.

Drawing on these themes, the Adaptive Architecture International Conference will bring together leading practitioners, researchers and industry experts who will present projects and research.

Presentations will include new types of reconfigurable architecture, and will show how adaptive strategies can extend the cultural potential of architecture, extend a building's life cycle, enhance energy efficiency and optimize resource utilization.

It will be organized into four streams:

Dynamics Façades:	**Transformable Structures:**	**Bio-inspired Materials:**	**Intelligence:**
Next generation, responsive facades will be examined and systems demonstrated that are capable of reducing energy demands, enhancing comfort and integrating energy generation into Contemporary architecture.	Methods to create building-scale structure that change their size and shape will be demonstrated. Speakers will discuss architectural solutions that adapt over different time-scales to economic Demands, weather patterns, emergencies or other factors.	Drawing on incites from the natural world, researchers are creating a new generation of adaptive materials and devices. Speakers will present state of the art research and discuss how nature Providers inspiration for design.	Speakers will address the challenges of implementing effective control where building automation Systems, user interfaces and services can interact seamlessly.

Workshop: Adaptive Architecture and Inhabitation

In addition to the four streams a separate workshop will examine the inhabitation and social motivations in the design and use of adaptive architecture.

- In this work we will shed light on the dynamic interfaces and therefore we will examine the study of the adaptive facade and areas of use (Web2-01).

III. Adaptive façades

III.1 Definition:

The definition of the term 'adaptive' is not univocal. To formulate a good substantiated definition that will be used in this thesis, some definitions in literature are examined first.

Loonen (2013), who did a lot of research and wrote papers about adaptive façades, gives the following definition: 'A climate adaptive building shell has the ability to repeatedly and reversibly change some of its functions, features or behavior over time in response to changing performance requirements and variable boundary conditions. This is done with the aim of improving overall building performance in terms of primary energy consumption while maintaining acceptable thermal and visual comfort conditions. These façades can seize the opportunity to save energy by adapting to prevailing weather conditions, and support comfort levels by immediately responding to occupants' wishes.'. (Loonen et al., 2013, p483)

Knaack (2007) supports the use of the term 'adaptive' in his work about façades as follows: 'Buildings able to adapt to changing climatic conditions are called intelligent buildings. Since the term intelligent can be misleading when used in the context of buildings or façades, we will use the term adaptive façade instead. Adaptation generally means that buildings and façades adapt to current weather conditions.' (Knaack et al., 2007) .

Kirkegaard (2011) says : « *that adaptive buildings can 'adapt their performance, in real time, to environmental changes and use less energy, offer more occupant comfort, and feature better overall space efficiency than static buildings do* ». (Kirkegaard, 2011)

Hoberman focuses with his Adaptive Building Initiative on adaptive façades and building envelopes. He promotes the use of adaptive systems in the following way: 'By controlling light levels, solar gain and thermal performance, our adaptive systems reduce energy usage, enhance comfort and increase the flexibility of the built environment' (Web 2-02).

Based on the previous, the following definition will be used in the rest of this thesis to circumscribe an 'adaptive' façade:

> 'An adaptive façade has the ability to adapt, in real time, some of its functions, features and behavior in response to changing environmental conditions, performance requirements, occupants' wishes or other boundary conditions (e.g. space efficiency). The adaption has the purpose to obtain improved overall building performance related to primary energy use (heating, cooling, ventilation and lighting) while maintaining or enhancing the comfort and increasing the flexibility during the life phase of the building.'

In literature, several alternatives for the term 'adaptive' are used by researchers and professionals (Figure 01) such as: active, advanced, dynamic, smart, intelligent, interactive, kinetic, responsive, switchable … These terms are not pure synonyms because they differ a bit in meaning (Loonen et al., 2013,p484).

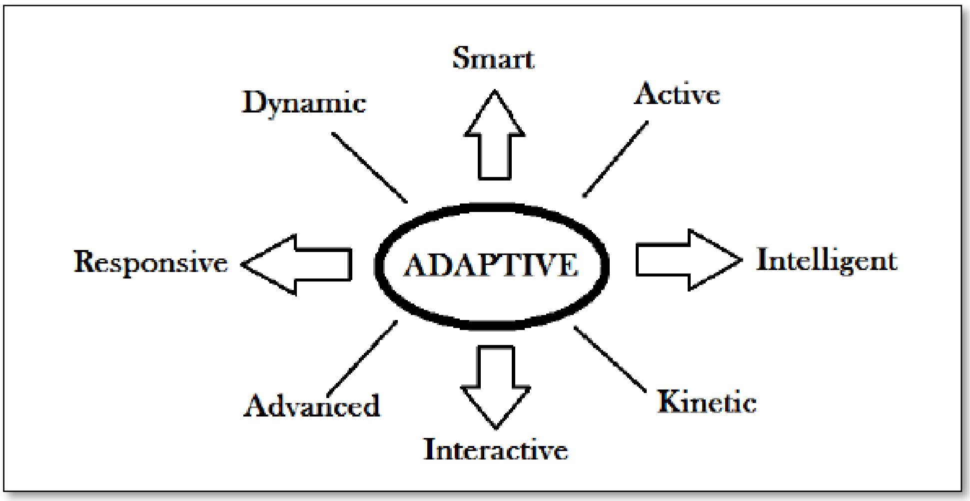


Figure 01: Alternatives for adaptive

Source: Loonen et al., 2013

'Smart' is a term that is commonly used related to materials and surfaces. The term 'smart' refers to the following basic characteristics: 'immediacy' (real-time response), 'transiency' (responsive to more than one environmental state), 'self-actuation' (internal intelligence), 'selectivity' (discrete and predictable response) and 'directness' (local response to activating events). Smart materials have the weakness that their performance is connected to a range of climatic conditions and predictable reactions. To achieve a high performance for a building, more complex systems such as smart materials in combination with sophisticated management systems are necessary(Velikov & Thun, 2013, p75).

'Intelligent' façades are characterized by a higher order of organization. They combine the environmental characteristics with information systems and expertise to get an increased performance. The key aspect of 'intelligence' in façades is to search for solutions that result in maximum comfort (air temperature, surface temperature …) while maintaining low energy consumption. The difference between 'intelligent' and 'smart' is related to the fact that in 'smart' façades the control of the system is mainly associated to material properties, which refers to internal power. This is in contrast to 'intelligent' façades that use automation and computation as controlling elements. 'Intelligent' façades involve more external power and are less limited in operational range than the 'smart' materials. A combination of both, an intelligent façade that is developed with smart materials to make it self-actuating has a lot of potential. (Velasco et al., 2015) (Velikov & Thun, 2013, p75).

'Interactive' is a term that is less used in studies about façades. However, it sometimes shows up in literature to accentuate the use of technology (sensors, micro-processors) in the façade but still in combination with human input for the initiation of response. Feedback-based systems or other automated building management systems can help the façade to optimize the energy use and to control the comfort of the occupants on the same time. (Velikov & Thun, 2013, p75)

'Responsive' is used in the same context as 'interactive' and 'adaptive'. The term is related to the interaction between the building, the inhabitant and the environment to develop adaptability. The same aspects as in 'intelligent' and 'smart' are included in the term 'responsive': real-time sensors, smart materials, automation, user override ... In addition, the 'interactive' characteristics are included in this term as well. These interactive systems can result in self-adaption of the system and make the system able to learn over time. The systems can modify their actions to the current climate and energy use (Velikov & Thun, 2013, p76).

Different mechanisms can be responsible for the regulation of the adaption to functions of the façade (Figure 2). Firstly, the humidity can be regulated by absorbing, collecting or evaporating. Secondly, the temperature can be regulated by dissipating, gaining or conserving. Thirdly, the air quality (related to the carbon dioxide level) can be regulated by filtering or exchanging. Finally, the light can be regulated by absorbing, redirecting or diffusing. The range of adaption mechanisms is quite big. A combination of the different mechanisms can make a design very complex (López et al., 2015, p27).

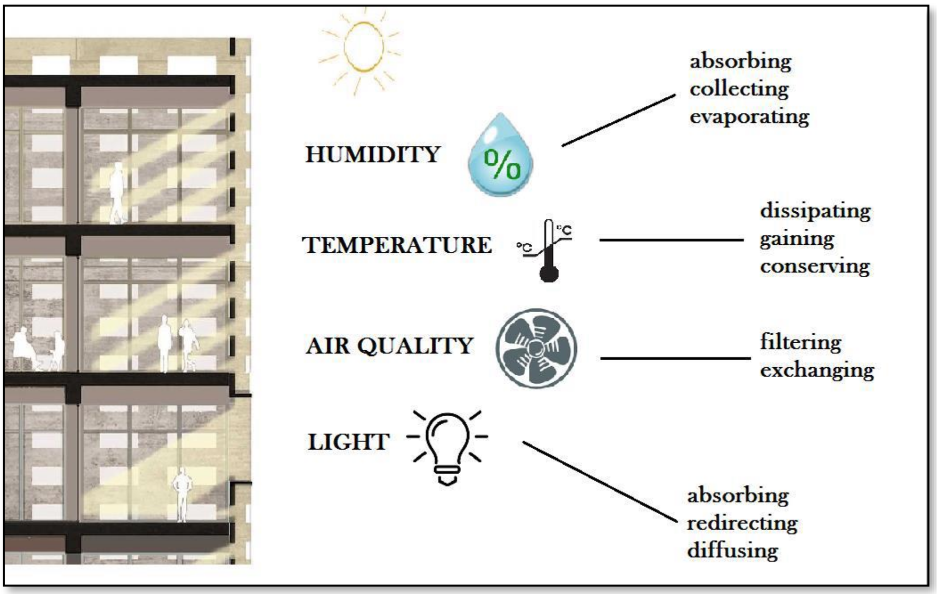


Figure 02: façade regulation mechanisms
Source: López et al., 2015

III.2. Adaptive façades:

Active systems in general have the opportunity to adapt their properties to the changing climate and the preferences of occupants. Adaptive façades improve the performance of a building by making artificial energy only necessary during peak periods (Web 2-03).

The primary objective of an adaptive façade is to reduce the ecological footprint of the building. Adaptive façades can be flexible in different ways. Not only adaptability, but also multi-ability and resolvability contribute to flexibility. The adaptability of a façade requires a good control and operation system.

III.2.1 General:

Present mid/high-rise buildings often contain a huge quantity of glass in their skins. The success of these glass skins is related to the innovative use of large aluminum frames, which make larger windows and lighter wall systems possible. Today, these lightweight panels are frequently Combined with curtain wall are systems to form the main construction elements for high buildings. Next to curtain wall systems, double façades can be used which are often foreseen of intermediate adaptive shading devices and other features. However, double façades often result in higher costs and more loss of useful space (Premier, 2015).

The curtain wall systems applied to these mid/high-rise buildings can lower the energy use and increase the internal comfort by implementing adaptive systems. To make the adaptive systems sustainable, it is important to search for solutions that are easy to manufacture, economically responsible and can adapt according to climate related changes, occupant needs or other boundary conditions (such as a changing arrangement of the surrounding buildings). Adaptive façades will automatically result in a higher initial cost, but the operational cost of the building will be lower (Kirkegaard, 2011).

However, except for many advantages, adaptive façades have some important drawbacks as well. The variety in sources that contribute to the adaptive requirements, often results in complex systems. To provide efficient energy use, they often require automatic control. This automatic control diminishes the personal control from the occupants on the internal environmental characteristics. That is the reason why 'intelligent facades' are often replaced by the term 'adaptive facades'. It is not always easy to obtain maximum comfort for the occupants (Loonen et al., 2013, p486).

In literature, the adaptive façades are also called **CABS.** CABS are only one concept of adaptive architecture. The difference with responsive, kinetic architecture is that the adaption takes specifically place at the building shell level itself and not over the whole building. The difference between CABS and active façades is that the active systems do not essentially have the purpose to influence the indoor climate. The active façades only include the introduction of dynamic aspects to the building. Examples of active façades that do not belong to the category of CABS are the media façades (Loonen et al., 2013, p486).

III.2.2 Dynamic Interfaces: Adaptive façades belong to the category of 'dynamic interfaces' (Figure 3) and are able to react in an active way with the external environment. The building envelope is no longer seen as just a shield but as a surface that can control efficiently the mass and energy balances. Dynamic buildings perform better and have a higher sustainability based on their time-based, responsive and dynamic performance.

This evolution results are today in two major solutions for dynamic interfaces on a building (Premier, 2015).

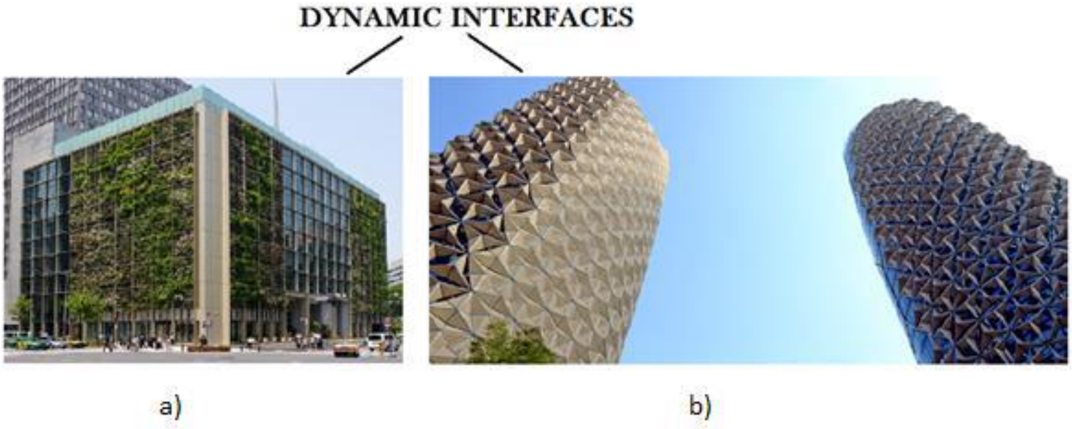


Figure03: Types of dynamic interfaces: a) green façades, b) adaptive façades

Source: Premier, 2015

The first type of dynamic interfaces is related to the integration of green into the surfaces. This principle is inspired on the natural climbing of plants on the façades and is a passive approach to save energy. These façades are also called <u>green façades</u> and can be seen as natural sunscreens. Green façades are a kind of vertical gardens. The construction leaves the conventional treatment of making a clear distinction between the natural environment and the man-made façade (Premier, 2013). The plants can be installed at different levels of the building or can grow in gardens at the base of the building (Web 2-04).

The plants improve the internal comfort by reducing the solar gain with their shadow. They form not only a sun barrier but protect the building also against wind deterioration. In addition, buildings with green façades are more sustainable by the reduced heating and cooling load because of plant evaporation (Pérez et al., 2011).

The second category is the adaptive façades. Adaptive façades have a one-way relationship with their environment and make use of artificial materials instead of plants. The most common type in this category is the sun shading systems, often in combination with smart materials and innovative technology (Premier, 2015).

It can be questioned if green façades belong to the group of adaptive façades. Vegetation can be seen as an adaptive component. Some researchers consider vegetation as a separate group because plants are purely natural screens. It is difficult to make a clear distinction between the two cases because they both are characterized by an adaptive behavior related to the changing environment.

The growing interest and evolution of dynamic façade systems as high performance solutions for buildings is related to two governing factors. First of all, the dynamic façades are more adapted to the environmental conditions and help to cope with the current environmental problems. In addition, the recently growing capabilities of computational tools and electronic devices facilitate the design and the control of dynamic systems. Planning, simulation, fabrication and control of the dynamic processes are the key factors for the construction.

The equipment related to these processes includes micro-processors, sensors and actuators (Velasco et al., 2015).

The design of dynamic interfaces is often accompanied by innovative technologies. These technologies have a higher risk factor which can result in higher investment, maintenance and failure costs. For well-informed design decisions, computational tools are indispensable. These tools can already predict the operational performance in the design stage. In addition, the performance of dynamic systems is cumulative and specific for every case, which makes it a complex job (Loonen et al., 2013, p448).

III.2.3 Ecological footprint:

Often, a primary objective of the design is to reduce the ecological footprint of buildings (Figure 4). Approximately one third of the world's energy use takes place inside buildings. The most crucial point herein is to diminish the dependency on energy intensive HVAC systems (heating, ventilation and air conditioning). The energy use of HVAC systems is directly related to the internal thermal comfort. Not only the thermal comfort, but also the relative humidity needs to be of sufficient quality to satisfy the wishes of the people in the building (Ogwezi et al., 2012).

By implementing dynamic systems in the façade, energy savings between 10-50% are possible, which lowers the ecological footprint significantly. In addition, the reduction of lighting and HVAC use can decrease the operation costs of the buildings with 10-40% (Velasco et al., 2015, p172).

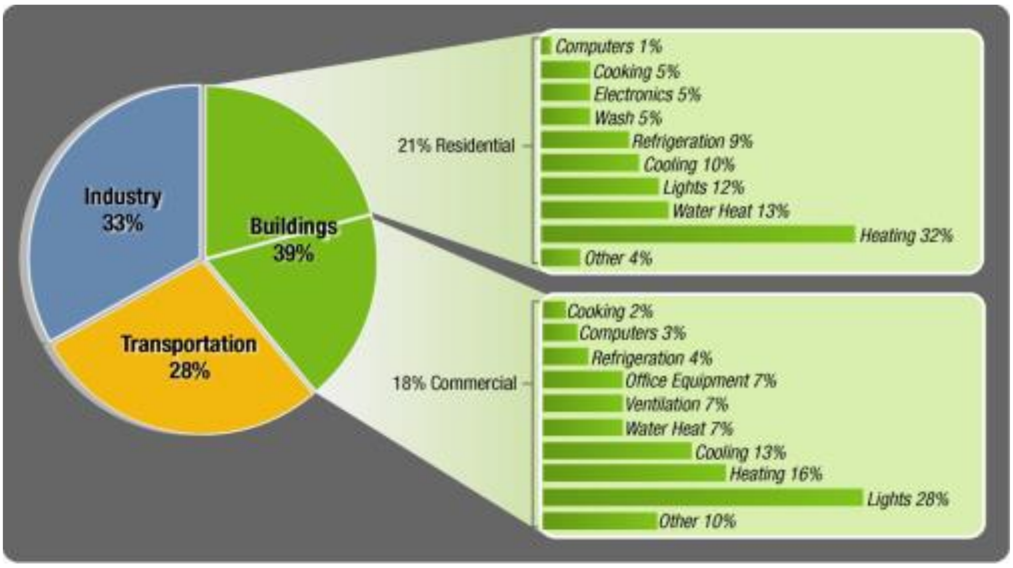


Figure 04: Ecological footprint of buildings
Source: http://newscenter.lbl.gov/2009/06/02/working-toward-the-very-low-energy-consumption-building-of-the-future/

For a long time, efforts and attention were focused on static solutions such as increased thermal insulation in the envelope of the buildings. The ultimate target, a **'Zero Energy Building'**, is

However unreachable by using only traditional design concepts. To reach this target a shift from a static to a dynamic façade is crucial. This required shift is logical considering the constant Change of the environmental conditions of a building. Dynamic façades can react continuously and pro-actively to reduce the energy demand in a significant way (Velasco et al., 2015).
From an ecological point of view, one may not forget that the adaptive behavior of the systems requires various elements that need some electricity to be able to function. Examples of such elements are actuators, power sources, processors, sensors, networks … However, the amount of energy that these elements require is mostly negligible compared to the lower energy use achieved by the adaptive behavior of the façade (Kirkegaard, 2011) (Loonen, 2010).

III.2.4 Structural placement:

A first decision in the design process of an adaptive façade is the structural placement (Figure 5).

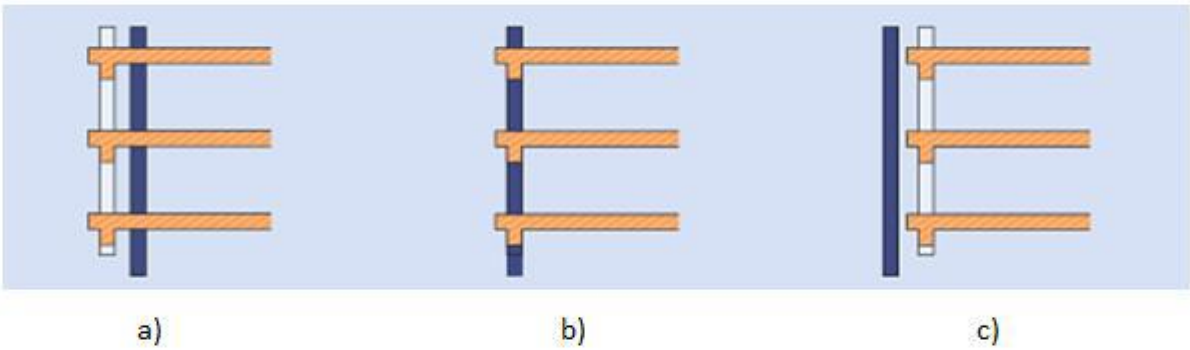


Figure 05: Position of the façade: a) in front, b) in the skin, c) behind

Source :(Sommer, 2010)

A first (most often applied) possibility is to place the system in front of the building wall or outer skin of the building, also known as the curtain wall system. On this position, the façade plays a major role in the determination of the character of the outer skin. This type is very advantageous for solar protection. However, on this position, the risk of damage is large. In addition, external placement results in greater wear and tear, which consequences a shorter lifespan and risks of malfunction of the system. Exterior placed systems will also result in higher maintenance costs. A second option is to hide the adaptive system in the double-skin systems (integrated in the primary structure). This makes the glass surface stand out more and has less impact on the visual view of the façade. When the dynamic surface is placed in the structure, dust particles cannot enter the system. Contrarily to external placed systems, no risks exist for reduced effectiveness of the operation of mechanical systems. A last possibility is to place the façade behind the primary structure. This position eliminates completely the risk of being damaged (Sommer, 2010).

III.2.5 Movement:

The adaptive mechanisms of adaptive façades are roughly dividable in two classes. One class results in changes in properties at macro scale level and one class at micro scale level. The largest part of the existing façades belongs to the macro scale category. related to mechanical

The **macro level** is movement. Macro scale changes have an impact on the configuration by moving parts resulting from sliding, expanding, creasing, rolling, inflating …

This can be done by supplemented components external to the building shell, subsystems of the Building shell itself, movement of the entire façade or the building as a whole. Except for mechanical moving, the transportation of fluids is also a possibility. This can be the flow of air, use of foam bubbles, phase change materials, transparency of water, opaque constructions … (Loonen et al., 2013, p489).

The **micro level** refers to movement that is controlled by the material properties. Micro scale changes are related to changes in thermo physical properties, transformation of energy or changes in opaque optical properties. In general, the response can be of different types: responding to surface temperature, light, incident radiation, external control signals … (Loonen et al., 2013, p489) (Velasco et al., 2015(Web 2-06).

III.2.6.Environmental impacts during the building's lifetime:

The changes in the environment can be of different orders of time. First of all, the building's envelope is influenced by short-term fluctuations which change in order of **seconds**. These are mostly stochastic processes. An example is the wind speed and wind direction. Next, changing conditions in the order of **minutes** are possible, such as cloud cover and daylight availability. Most climate adaptive façade systems are designed to lower the impact of these changes. They play with the degree of transparency to increase the comfort. Furthermore, the angular movement of the sun through the sky results in fluctuations in the air temperature. The resulting changes are In the order of magnitude of **hours**. Furthermore, diurnal changes are present as a consequence of the occupants' behavior in the building and meteorological boundary conditions. The availability of solar radiation can be efficiently adapted by using thermal storage principles. The last group of changes is the **seasonal** changes during winter, summer, spring and autumn. The different seasons have different boundary conditions, such as the altitude of the sun (Loonen et al., 2013). Figure 4-6 gives an example of the interaction of functions and the environmental changes in different orders of time. The example is based on the behavior of a west façade.

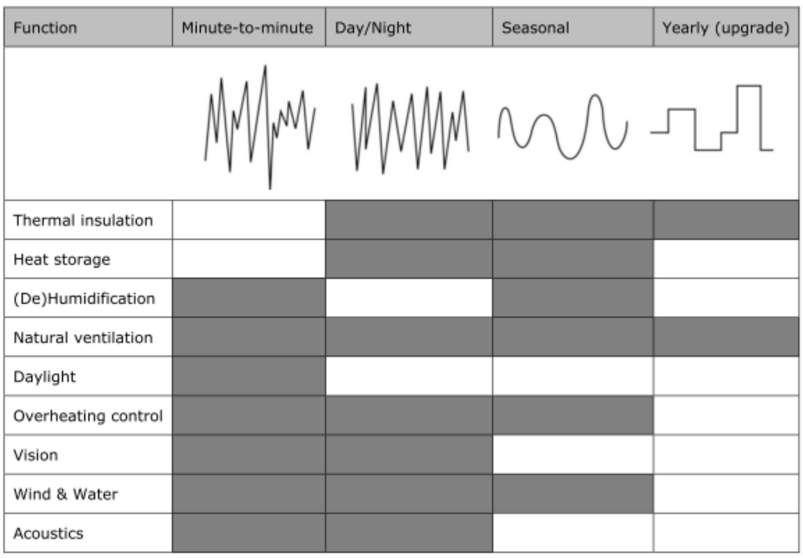


Figure 06: Level of adaption for a west façade
Source: (Van Dijk, 2009)

The figure allows drawing some important conclusions. The thermal insulation is mainly characterized by the extreme seasonal climate conditions. Summer days need low insulation but during winter, thermal insulation is important to keep the heat inside. In addition to seasonal adaption, changes in behavior during day and night can be efficient for the insulation as well. Heat storage is important during summer to be sure that the building will not overheat; this storage can be eventually cooled off during night. Heat storage does not depend on minute-to-minute changes because heat accumulation needs time. Moisture is mostly related to the seasons, due to the high relative air humidity in summer and dry air in winter. However, minute-to-minute change can be convenient if the moisture level changes due to a changing amount of people in the building. The regulation of ventilation is important on all levels. The amount of necessary ventilation depends on the season. Moreover, the amount of people will influence the daily and minute-to-minute adaption.

Daylight is related to the visible light and radiation. The influence of the sun can change from minute-to-minute. Moreover, the sun's energy can cause unwanted overheating during summertime. Overheating needs to be regulated on all time levels. Shading during daytime can be very efficient to control overheating. **Vision**, **wind** and **water** barriers and **acoustics** have no
be very efficient to control overheating. **Vision**, **wind** and **water** barriers and **acoustics** have no
clear seasonal relationship and depend only slightly on day and night cycles (Van Dijk, 2009).

III.2.7 Control:

To design a successful adaptive system, **control** is essential. This can be done in an extrinsic or intrinsic way. The **extrinsic** control systems translate feedback that results from the comparison of the current configuration and the desired state, into the required adaptation. The adjustment is based on sensors, processors and actuators. The control can be done by implementing local systems, which distribute the control over the whole building. In contrast, a centralized driven system can be used for a more global control.

Intrinsic systems do not make use of external decision making components, but are based on direct control by transforming environmental impacts. These environmental inputs, such as temperature, wind speed, solar radiation ... trigger the automatic adaption of the façade. In intrinsic systems, both actuators and sensors are combined in one step. Intrinsic systems have advantages and disadvantages compared to extrinsic systems. They do not need electricity or fuel to make the transition possible. In addition, their number of components is limited. The main disadvantage is that the tuning of the properties and variables of the system is done on a range of expected conditions. If the variations go further than expected, the system will not be able to adapt in response to the unexpected conditions.

As previously mentioned, most CABS belong to the macro scale category. These systems are mainly driven by extrinsic control types. The CABS that belong to the micro scale category are combined with an intrinsic or extrinsic control type, depending on the situation. To work really efficiently, automated systems that provide conditions of the average person need to be combined with options to meet personal preferences. However, it is difficult to integrate these systems in the building's envelope. To facilitate the working principle, it is possible to constrain the rate of change to certain boundaries (Loonen et al., 2013, p490).

III.3 Classification:

III.3.1 Proposal of a new classification system:

In the domain of adaptive façades, no general classification for adaptive façades exists. However, a clear and scientifically sustained classification model is necessary to make a more objective choice for the adaptive system. Recently, a proposal for a classification was done by Velasco et al. (2015). Their classification (Figure07) is based on the consideration of different classification systems in recent literature.

The proposed classification considers movement and control as the fundamental factors. Control factors are often not taken into account in other existing classification systems, but the type of control system is a fundamental aspect in the design and operation of dynamic façades:

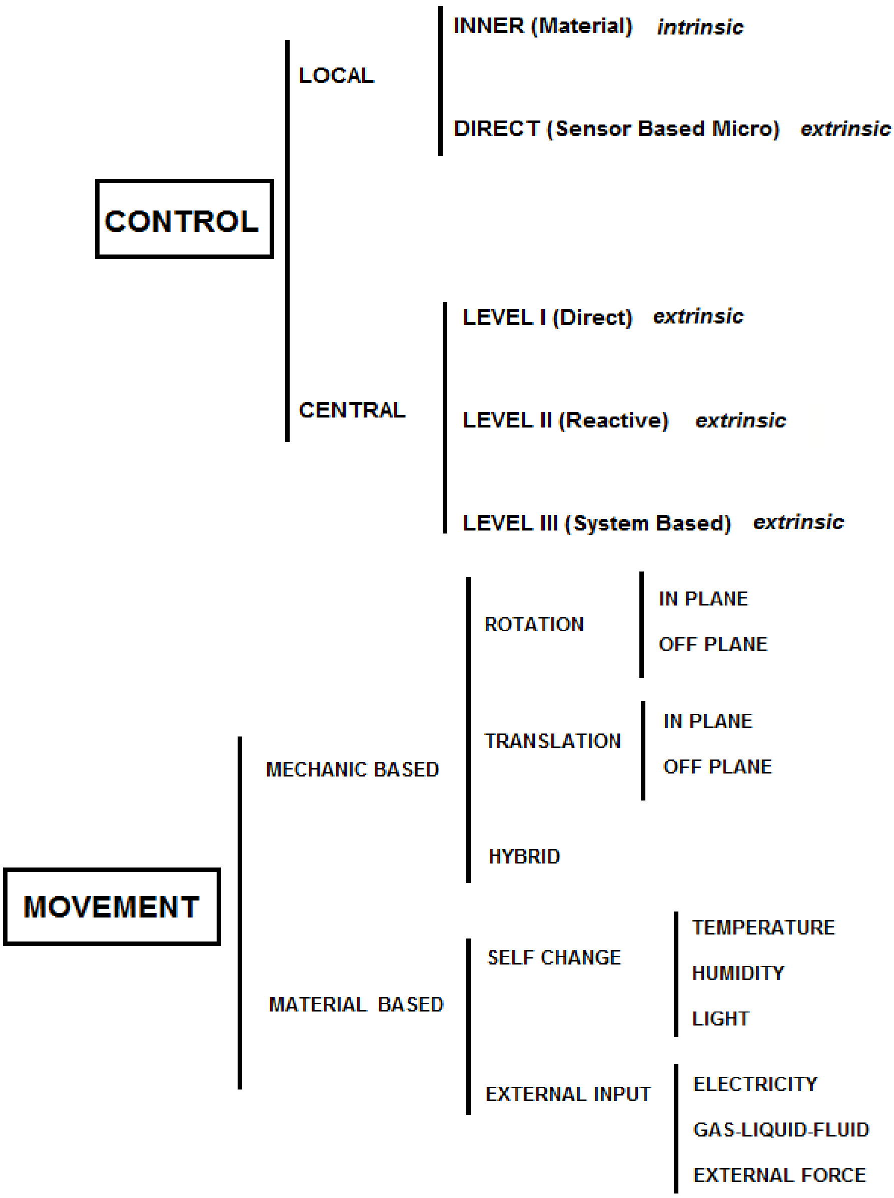


Figure07: Proposal of new classification

Source: (Velasco et al., 2015)

III.3.2 Movement:

The movement is divided into a category for mechanical movement and a category for changing material properties. As described in section '4.3.5', mechanical movement belongs to the group of changes at macro level. The mechanical based deformation can be a translation, rotation or hybrid movement. Translation and rotation can be further subdivided in 'in plane' and 'off plane' movements. The hybrid systems can mostly not be specified as being 'in plane' or 'off plane' because most transformations will act in different ways.

The material based deformation is subdivided according to the factor that causes the deformation, such as temperature, humidity or electricity. Material based deformation is characterized by changes that occur at micro level. When movement is caused by material deformation, not the connections but the components play the major role. The physical characteristics of the components will be of high importance. The first subgroup in this category is the self-changing materials. These materials are able to transform energy that is available in the environment to particular kinds of movement. The sources of energy can be related to differential humidity or temperature levels. The second subgroup is the materials that need a direct external input to make material deformation possible. This artificially controlled force can be caused by electrical current, a fluid in movement or an external source of movement. In the classification of Velasco et al., materials that react to light have no specific category where they belong to. An extra branch under the classification of self-changing materials can be light. This will make the classification system more complete.

III.3.2.1 Mechanic based deformation:

Mechanic based façades need sensors and mechanical components that can react to changes in the internal or external environment. Mechanical deformation is mostly driven by electricity, but combinations with user interaction are also possible. All physical aspects of a façade can be regulated in an adaptive way by mechanical components.

Sun shading systems are the best-known examples of mechanic based deformation in façades. They allow blocking sunlight and preventing overheating problems. In addition, they can improve exterior views as well. As previously mentioned in section '4.3.4', three types of sun shading exist, the external ones, the internal ones and the intermediate placed systems between two glazing layers. The most well-known example of sun shading types is blinds. Next to the horizontal and vertical venetian blinds, roller blinds are frequently applied as well. Furthermore, there are the awning blinds and canopies. Table 1 gives an overview of different other mechanical components that are currently used in adaptive façades and the physical function on which they have an influence.

Function	Components		
Thermal insulation	Air cavity	Vacuum	Heat Engine
Heat storage	Heat engine	Heat pipe	
(De)humidification	Ventilation	Heat engine	
Natural ventilation	Air cavity	Register	Window
Daylight	Blind	Diaphragm	Fabric
Overheating control	Sun shading	Heat pipe	
Vision	Blind	Diaphragm	Sun shading
Acoustics	Register	Vacuum	Window

Table 01: Mechanical components and their function
Source: (Van Dijk, 2009)

Blinds or other types of sun shadings and **diaphragms** can be used to regulate the daylight that enters the building. Blinds can efficiently protect against glare as well. Windows and registers help to improve the natural ventilation into the building and can contribute to an improved sound insulation. The disadvantage of the use of windows is the increased acoustic problems during opening. A better solution is a register, which can be placed above a window. It can be integrated in a window to allow natural ventilation and it does not disturb the outside view. Furthermore, making use of vacuum can be efficient to come to high insulation values in the façade. Moreover, it saves material because it is lightweight and it contributes on the same time to a better acoustic insulation of the façade. A heat engine can be used to convert thermal energy to a mechanical output. Heat engines are moreover very promising because they can influence the thermal insulation, the heat storage and the dehumidification in a room. Another mechanical system that can be applied in the façade is a heat pipe. A heat pipe transports heat to a medium (e.g. water) that needs to be heated. It can be applied in a façade to extract surplus heat and to lower the overheating problem. However, more research needs to be done about heat pipes and heat engines (Van Dijk, 2009).

III.3.2.2 Material based deformation:

Adaptive systems that belong to the category of material based deformation mostly make use of active materials. An alternative name for active materials often used in literature is 'smart' materials. Active materials can change their properties by stretching, folding or bending in reaction to an environmental stimulation. Except for their shape, smart materials can also change their color, stiffness and transparency. The changes that active materials can make are usually reversible and repeatable. The materials need to remain stable in their different configurations and during changing. These materials are capable of exchanging energy without the use of external power (López et al., 2015) (Velikov & Thun, 2013). Table 02 gives an overview of the different smart materials and the function on which they have an influence.

Function	Components			
Heat storage	Phase change materials	Thermo tropics	Light reactive materials	
(De)humidification	Humidity reactive materials	Silica gel		
Natural ventilation	Carbon dioxide reactive materials			
Daylight	Chromics (thermo/photo/electro)	Thermotropics	Vegetation	Liquid crystals/ Suspended particles
Overheating control	Chromics (thermo/electro)	Tropics (thermo/photo)	Vegetation	Phase change materials
Vision	Electrochromics	Thermotropics	Vegetation	Liquid crystals
Wind &water	Breathable fabrics		Vegetation	
Acoustics	Piezoelectrics			

Table 02: Smart materials and their function

Source: Velikov & Thun, 2013

Humidity reactive materials

A first example of active materials is humidity reactive materials**.** The most well-known example is hygroscopic materials. Hygroscopic materials can be classified under the group breathable fabrics. They possess the ability to interact in a dynamic way with the internal of Humidity and have an important impact on the thermal comfort. Their dynamic behavior results from the absorption of moisture from inside. This absorbed moisture is closed up in the fabric in a first phase. In that way, the material can prevent humid air from entering. In a second phase, the fabric pores is open and the air flows out of the building. By using hygroscopic materials, the need for air conditioning diminishes or disappears completely (Ogwezi et al., 2012).

Temperature reactive materials

A second group is the temperature reactive materials**.** A first example is the Thermo-Bimetals. These are different metal alloys that are laminated, which results in a bending deformation when the different materials are expanding at different rates during heating. The second example is the shape memory alloys that are triggered by heating above their transformation temperature, resulting in a return to their original shape. They possess a super-elastic behavior in a limited range of temperatures. Next, the shape memory polymers are well-known. Shape memory polymers are inexpensive, simple and flexible in use. They can return from a deformed state, triggered by e.g. a temperature change. Additionally there are the thermo chromic polymers or glasses that change their color due to a change in temperature. Thermo tropic materials are characterized by a change in transparency due to temperature variations. In addition, thermo tropics possess the quality to absorb thermal energy (Van Dijk, 2009).

A last example is the phase change materials. These materials can be used to store thermal energy by changing their phase due to heat absorption (mostly from solid to liquid). Phase change materials can be seen as an example of ‘artificial’ thermal mass. They can reduce peak

Loads in buildings that are built in climates with high differences in temperature during day and night. Absorbed heat can in a next step be released by night-time ventilation (Web 2-07).

Dioxide reactive materials

A third group of active materials are called the carbon dioxide reactive materials**.** These are for example the CO2 polymers (carbon dioxide polymers) that are triggered to absorb CO2 from the surrounding air (Velikov & Thun, 2013).

Light reactive materials

A last group is the light reactive materials such as photo chromic materials. These are able to absorb light due to opening of the molecule. The exposure to UV light results in a change of color. Next to photo chromic materials, phototropic materials exist as well. Phototropic materials change their transparency by exposure to light. Furthermore there are the light responsive polymers. These polymers change their shape induced by light effects. The elastomers in the polymers can contract and bend. In that way, volume changes in the gels are possible. Light-sensitive materials can control transparency and thermal gain. When applied in surface materials, they are able to gain and save energy from the environment. As already mentioned, the integration of photovoltaic cells in the moving systems can bring efficient generation of power into the façade as well as the control of the solar radiation (Velikov & Thun, 2013).

Chromomeric materials

Next to thermo chromic and photo chromic materials that change their visible appearance (color or opacity) by variations in temperature and UV illumination respectively, other chromogenic materials exist as well. The change in visible appearance can also be obtained by electrical energy (electro chromic materials). This is an example of external activation. In general, chromogenic switchable glazing can help in an efficient way to deal with the conflicting performance requirements (mitigate energy loss, unwanted energy gain and visual discomfort (glare))? Another possible type of switchable glazing to change the transparency of a glass element is to make use of liquid crystals. This system is based on the use of electricity to organize and align particles that are suspended between glass plates, which results in an increased transparency. If no electricity is present, the random organized particles block the light that tries to enter the building. Liquid crystals and suspended particle devices (classified under external activated chromic materials) more in general can control the amount of daylight and heat that passes through the window (Van Dijk, 2009).

Other smart materials and techniques

More smart materials exist such as electro active polymers and piezoelectric materials. Electro active polymers change their shape by stimulation through electricity. They are often used in actuators and sensors. Piezoelectric materials are able to transform electrical energy into mechanical energy and vice versa. They are often applied in façades to convert the elastic energy from acoustic vibrations into electricity. In that way, they contribute to the reduction of the amplitude of the acoustic vibrations (Van Dijk, 2009).

A recent, very promising approach for the domain of adaptive architecture is *4D-printing*. This principle adds the extra dimension of time to 3D-printed structures, which turns into printed structures that can adapt themselves. Moreover the behavior can be controlled in a predictable way by subjecting the structure to thermal and mechanical forces.

The next future step is to make hybrid materials by the union of different materials with different features, resulting in multi-material printing that can support multiple functionalities (López et al., 2015).

III.3.2.3 Overview existing applications:

Figure 8 gives, based on the case studies in the appendix (see Appendix A), the amount of applications that use a certain type of movement. Most recent applications use principles that are based on mechanic based movement. The most popular category is the principle of movement based on off plane rotation. A second popular group is the hybrid deformation. The groups of in plane rotation and off plane translation are less popular in existing applications. However, the existing mechanical applications can further be improved. Also the further development of material based deformation forms an interesting subject.

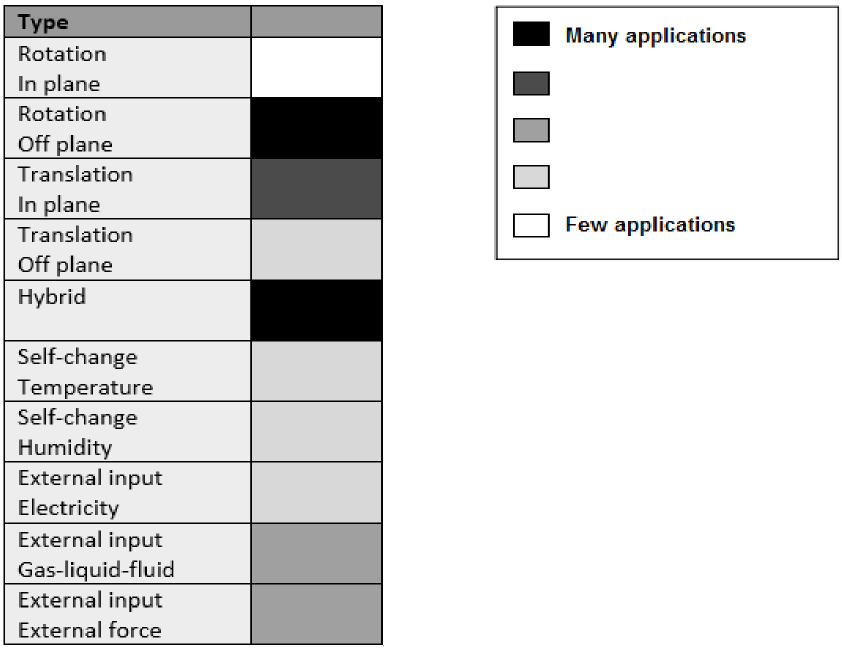


Figure 08: Overview movement of existing systems

Source: (Loonen et al., 2013

Nowadays, the largest part of the existing adaptive façades is specific solutions for an individual case. These individual cases are interesting because they form the basis for further developments. In the future, adaptive façades should be developed on a more regular base. This makes large-scale production of the materials and components possible. More standardization for application of adaptive façades in mid/high-rise buildings with high budgets, may result in cost-effective solutions (Loonen et al., 2013, p491).

III.3.3 Control:

The second important factor, next to movement is the control factor. Two important groups are distinguished here: Local and Central control. Local control implies that each actuator is autonomous and linked to an exclusive sensor-control system. The local control can be embedded in the **i***nner* material that reacts against external conditions.

This is a type of intrinsic control. However, a *direct* local control system is also possible when the component is controlled by an external system (extrinsic control). This can be done by a sensor, microprocessor or actuator that is related to one component. When different components are grouped together as a central controlled system, they do not belong to the local but to the central category. In central control systems, the actuators or group of actuators are linked to one single control system. It always implies that a number of components is linked to a central processor. Depending on the complexity of the processes a further sub categorization is possible. If no external inputs (sensors) are needed and the system is a pure pre-programmed unit, a *direct* system is created. When sensors can influence the behavior, a more deterministic system is created based on Boolean expressions. This makes the complexity of the system larger and is called a *reactive* control system. In a last step, even more complexity is added to the control system by using multi-deterministic and stochastic processes to solve complex problems. This last group is called a **system based** central control (Velasco et al., 2015).

III.3.4 Relevant physics:

In addition to the classification system from Velasco et al. (Figure 9) that classifies systems according to movement and control, the relevant physics to which the façade is optimized can specify the type of adaptive system in more detail. The building façade influences physical interactions between the indoor zones and the outdoor environment. To classify the façades in accordance with the physical interactions on which they have an influence, four general domains can be distinguished. These domains are: Thermal, Optical, Air flow and Electrical.

Adaptive façades that have an impact on the thermal domain cause changes in the energy balance of the building by conduction, convection, radiation and storage of thermal energy. The optical domain is related to the visual perception of the occupants that changes due to transformation of the transparency of the surfaces of the building shell. Air flow is related to a flow near the boundary of the façade or effects of wind direction and wind speed. The electrical domain refers mostly to the conversion of energy into electricity. However, the electricity that is needed for the adaptive behavior is also related to this domain (Loonen, 2010).

Most of the adaptive applications influence more than one domain. The overlap between the different domains results in interaction and can be efficiently visualized in a Venn-diagram (Figure 9). Overlap between the four different basic domains results in a total of 15 different possible combinations.

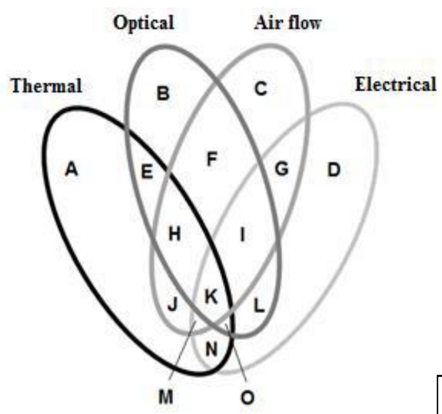


Figure09: The four physical domains and overlap zones

Source: *(*Loonen, 2010*)*

The thermal domain is present in almost all existing systems due to the fact that the thermal environment is constantly changing. Optical effects play also very often a role in the systems, because mostly controlled day lighting is part of the CABS strategy (Loonen et al., 2013, p493).
Studies (Loonen, 2010) show that most adaptive façades can be classified in zone E, which is the thermo-optical overlap zone. The second popular combination is the thermo-optical domain in combination with air flow (represented by zone H) or in combination with electricity (zone O). In one third of the cases the air flow domain is present in the strategy as well. According to the studies of Loonen (2010), the electrical domain is more or less present in one fourth of the cases. This is mostly related to the use of photovoltaic to gain energy (Loonen, 2010).
(Figure10) gives an overview of the different physical domains that are involved in the adaptive systems studied in Appendix A. The thermal domain makes almost always part of the adaptive structure. The *red and orange zones* show the areas with a lot of existing applications. *The blue zones* are the areas with an intermediate amount of applications. *The green areas* indicate zones with a few existing examples. *The white areas* are not really interesting because most adaptive systems have automatically an influence on the thermal comfort in some way (direct or indirect). The same zones and indexes as in Figure 9 are used.

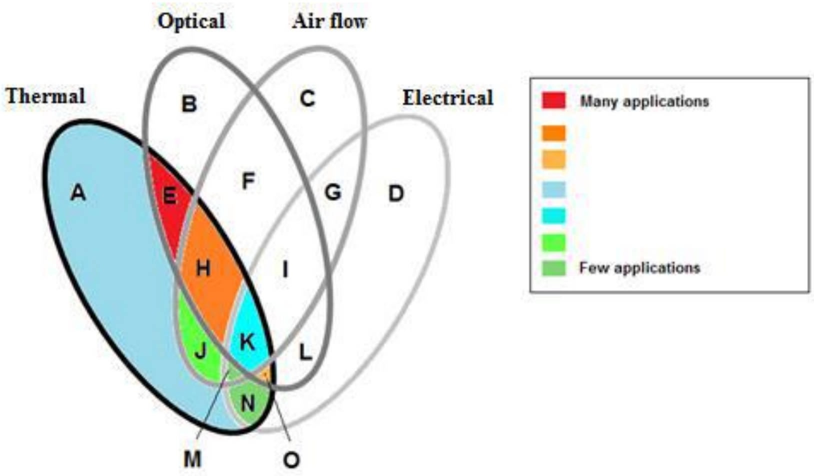


Figure10: Overview distribution of applications

Source: (Loonen, 2010)

IV. Conclusions and future perspectives:

For a long time, the attention and efforts of building designers were focused on optimizing the thermal insulation of envelopes. Further upgrade of these envelopes is necessary to increase the energy efficiency. This upgrade requires a shift from static to dynamic systems. In the future, the building's envelope will actively regulate the flow of heat, light, air and water from outdoor to indoor and vice versa by acting as an interface that continuously and actively adapts to changing conditions (Perino & Serra, 2015).

The low-technological examples of adaptive façades have the current trend to become more high-technological and complex. However, simple constructions for adaptive façade elements can still be very efficient and effective to obtain 'zero energy' houses. High-rise buildings require often more technological and mechanized actuation and sensor systems. Systems equipped with new per formative materials, sensors, actuators and computerized intelligence increase in popularity to control functionalities such as light, air flow, sound transmission, thermal transfer and interior humidity quality. In addition, biological models are increasing in popularity and form the inspiration for simple efficient adaptive façades (Kolarevic & Parlac, 2015) (Velikov & Thun, 2013).

Adaptive systems that have a movement principle that is mechanic based offer a lot of opportunities for efficient control of energy use. Future systems could combine mechanic and material based principles to create new concepts. The most applications that currently exist in the category of mechanical deformation are based on an off plane rotation principle or hybrid deformation. Hybrid movement is most interesting because it offers a wide range of possibilities.

A combination of possibilities for human adjustment and control of the systems with the avoidance of user override requires feedback systems. Extrinsic control of the systems is promising because this type of operation control is most effective to combine automated strategies with personal control.

The areas of adaptive systems are numerous in architecture, especially as they rely heavily on the mechanics of movement and therefore the energy saving which is mainly the source of renewable energy. The consumption is large in large buildings with wide range of movement and comprehensive use of the user. Therefore, adaptive systems are the ideal solution for such projects, such as commercial centers, etc.

1. Article presentation:

Title: The sustainability of adaptive envelopes: developments of kinetic architecture

Author: Marta Barozzi1*1, Julian Lienhard2, Alessandra Zanelli3 and Carol Monticelli

N° of pages: 10

Search for it: Politecnico di Milano, Architecture, Built Environment and Construction Engineering Department (ABC), Campus Leonardo, via Bonardi 9, 20133 Milano, Italy

Source: Procedia Engineering 155 (2016) 275 – 284

Net site / Google scolaire: http://www.sciencedirect.com/science/article/pii/S1877705816321701;

Accessed on: 14 /12/2017

Keywords: adaptability, responsive architecture, kinetic architecture

The article objective:

The purpose of the research is the collection of relevant constructed examples to describe a state of the art adaptive façade system and also understand their environment performance

Method of categorizing shading systems based both their function in the building hierarchy (roof or envelopes) and their movement characteristics

Article analysis

Article	Author	questioning	problematic
The sustainability of adaptive envelopes: developments of kinetic architecture (The sustainability of adaptive envelopes: developments of kinetic architecture)	**Marta Barozzi et al. / Procedia Engineering 155 (2016) 275 – 284**	How to use adaptive shading systems about to help reduce the energy demand of buildings?	Envelope building is the primary subsystem through which external conditions and environmental changes can be adjusted so that the problem is the acquisition of the building envelope is of great importance in the development of new approaches to solutions of construction

3. The case study:

The case study is facade of adaptive shading systems (Choose different examples to illustrate these systems and describe the techniques of these interfaces such as : Garden by the Bay, Singapore , ThyssenKrupp headquarter, Essen , Al-Bahr Tower in Abu Dhabi , Thematic Pavilion Yeosu Expo 2012 , IBA-Soft house in Hamburg , Architectural installation “Bloom”, Los Angeles , Hygro skin Pavilion)

4. Research methodology: This divided work has two parts: first part contains information necessary to define adaptive shading, and the second part works on the analysis of examples to clarify the basic principles of adaptive shading and their envelope in selected examples.

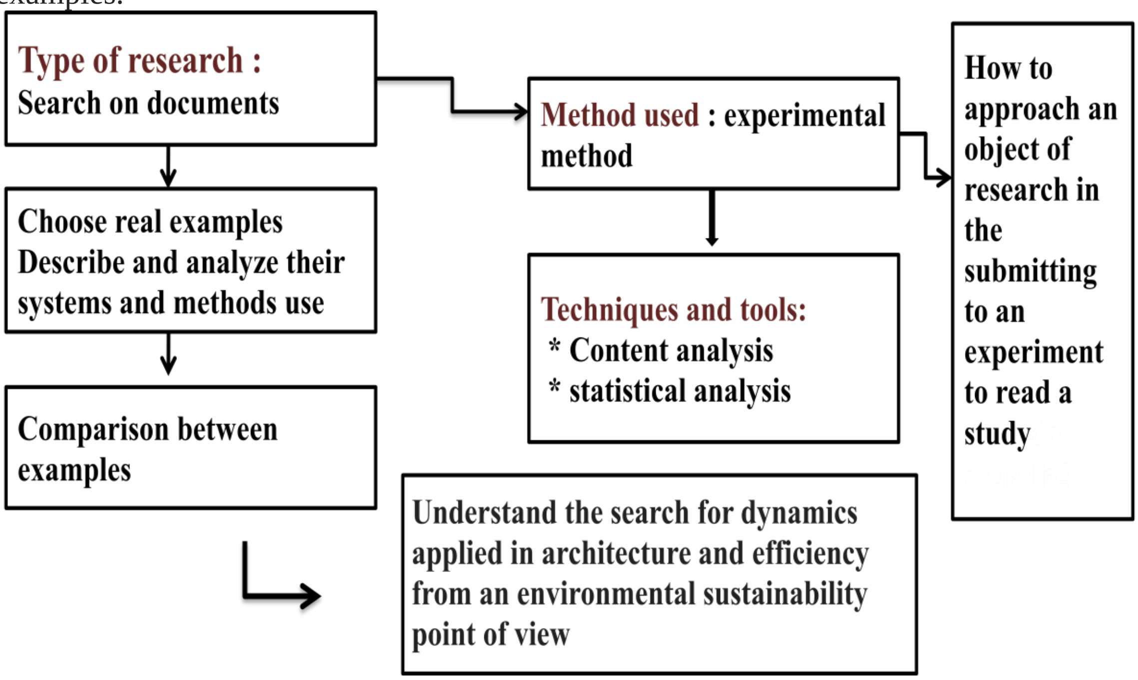


Fig.01: Schema illustrating the methodology used in analyzing this article (author)

4.1 Statistical analysis:

The author chooses real examples to study their strategies and principles of adaptive shading systems like the 2 figs.

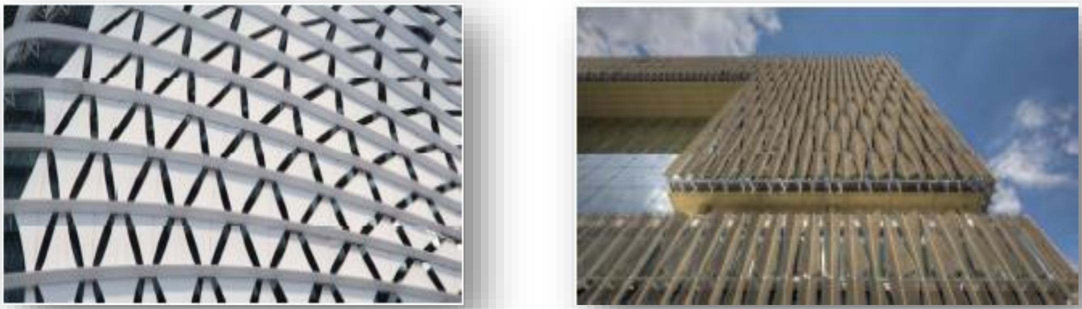


Fig.2: Garden by the Bay, Singapore (Serge Ferrari S.A.S); B: ThyssenKrupp headquarter, Essen (photo by Günter Wet)

4.2 Content Analysis:

He studies possible different patterns of adaptive facade system (kinetic facade) and classified different examples by their systems

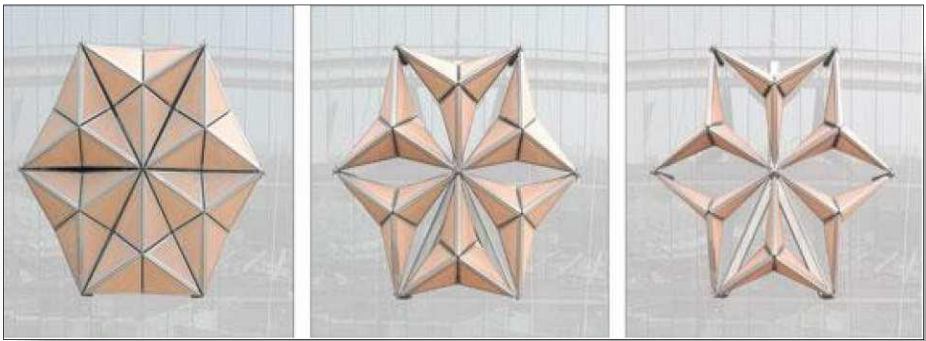


Fig.3: B Different possible configurations of the Al-Bahr façade system (Alotaibi, 2015)

Fig. 4.: Al-Bahr Tower in Abu Dhabi (Attia, 2015)

5. Results:

Despite the advantages offered by internal shading systems, exterior shading elements currently seem to be the most effective option for avoiding undesirable heat gains. So far, they are the most applied solution in case of reactive facades, especially with regard to high-rise buildings. From the analysis of previously

In the cases illustrated, it is obvious that externally applied adaptive facade systems are often used as a pretext for designing innovative and unique dynamic façades, thus becoming architectural landmarks more than energy saving systems.

Table 1. List of case studies and design approaches

Kinematic systems	Externally applied	Internally applied	Integrated in the façade
Institut du Monde Arabe, Paris (1987)			X
Simons Center for Geometry and Physics, SCGP, Stony Brook University (2010)		X	
Thyssenkrupp quartier, Q1 Office Building, Essen (2011)	X		
Al-Bahr tower, Abu Dhabi (2012)	X		
Garden by the Bay, Singapore (2012)	X		
Campus City of Justice, Madrid (2012)		X	
Elastic kinetic systems	**Externally applied**	**Internally applied**	**Integrated in the façade**
Flectofin® (2011)	X		
Thematic Pavilion EXPO 2012, Yeosu (2012)			X
Bloom, Los Angeles (2012)	X		X
IBA Soft House, Hamburg (2013)	X		
Hygroskin, Orléans de la Source (2013)			X

6. Conclusion:

The classification of adaptive envelopes does not lead to any viable scientific or practical conclusions. For the moment, there is no common agreement for the evaluation of adaptive facades. Literature dealing scientifically with the shading of facades is rare and in the best case focused on individual projects. In general terms, it is still necessary to define what these systems are. As mentioned above, recent architectural tendencies lead to increasingly complex geometries that lead to a revolution in the design of the hierarchy of building systems; the strict differentiation between the roof and the facade can often not be made. For this reason, terms like skin or skin are becoming more and more common.

1. Article presentation:

Title: **Adaptive Façades for Architecture:** Energy and lighting potential of movable insulation panels

Author: CEDRIC DU MONTIER[1], ANDRE POTVIN[1], CLAUDE MH DEMERS[1]

N° of pages: 07

Search for it: Groupe de recherche en ambiances physiques (GRAP), University Laval, Quebec City, Canada

Source: PLEA2013 - 29th Conference, Sustainable Architecture for a Renewable Future, Munich, Germany 10-12 September 2013

Net site / Google scolaire :https://www.researchgate.net/publication/267268114;

Accessed on: 10/05/2018

Keywords: movable insulation, shading, energy consumption, lighting ambiance, adaptive architecture

The article objective:

This research contributes to the exploration of adaptive façades, in regard of movable elements and their effects on ambiances. The outcomes do not provide specific optimization of energy and lighting performances of the devices. They rather aim to show the potential of movable devices and the compatibility between energy and lighting goals.

Article analysis

Article	Author	questioning
Adaptive Façades for Architecture: Energy and lighting potential of movable insulation panels	**CEDRIC DU MONTIER[1], ANDRE POTVIN[1], CLAUDE MH DEMERS[1]**	Is it possible to considered the potential of movable insulation panels as an effective adaptive strategy for responding to occupants needs and to changing climatic conditions. ?

Problematic:

Transparency of the envelope can be considered essential from a sustainable architecture standpoint, for its energy benefits as well as for its basophilic features. However, in Nordic climates, windows are responsible for great thermal losses when not exposed to solar radiation. This incompatibility is an important challenge for designers working toward an environmental approach for architecture. Movable insulation panels (MIP) can address this challenge. Movable insulation or night insulation comprises covering windows when they do not insure solar gains, mainly by night time, by heavy cloud covers or depending on solar orientation, and when exterior views are not needed.

3. The case study:

The space that is studied is an enclosed office measuring 3 meters wide by 7 meters long and by 2,85 meters high, with a south oriented window, in Quebec City.

a.
b.
c.

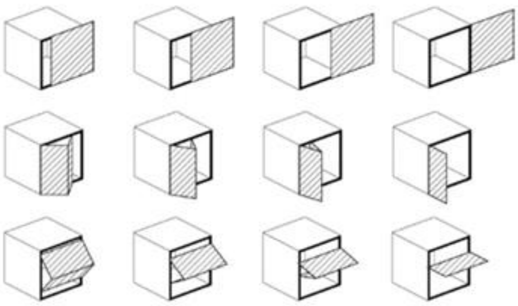


Fig.5: (left) simulation model with use of MIPs and (right) reference case model

The objective of this sample to study: Analysis of an enclosed room offers an independent assessment of the impact of one panel for one opening. The window of the model covers nearly the entire surface of the exterior wall with dimensions of 3 meters wide by 2, 75 meters high. Transparency/façade ratio of 100% is said to be the case. Since there is only one exterior wall, all other surfaces are considered as having adiabatic thermal transfers.

4. Research methodology: This research proposes to combine energy and lighting analysis in the assessment of MIP's shading and light reflecting properties as well as thermal insulation properties. It analyses three types of MIPs and compares their impacts on energy consumption and luminance level, and classifies different daily manipulation scenarios based on the panels' positions and on the ratio between energy saving and lighting control potentials.

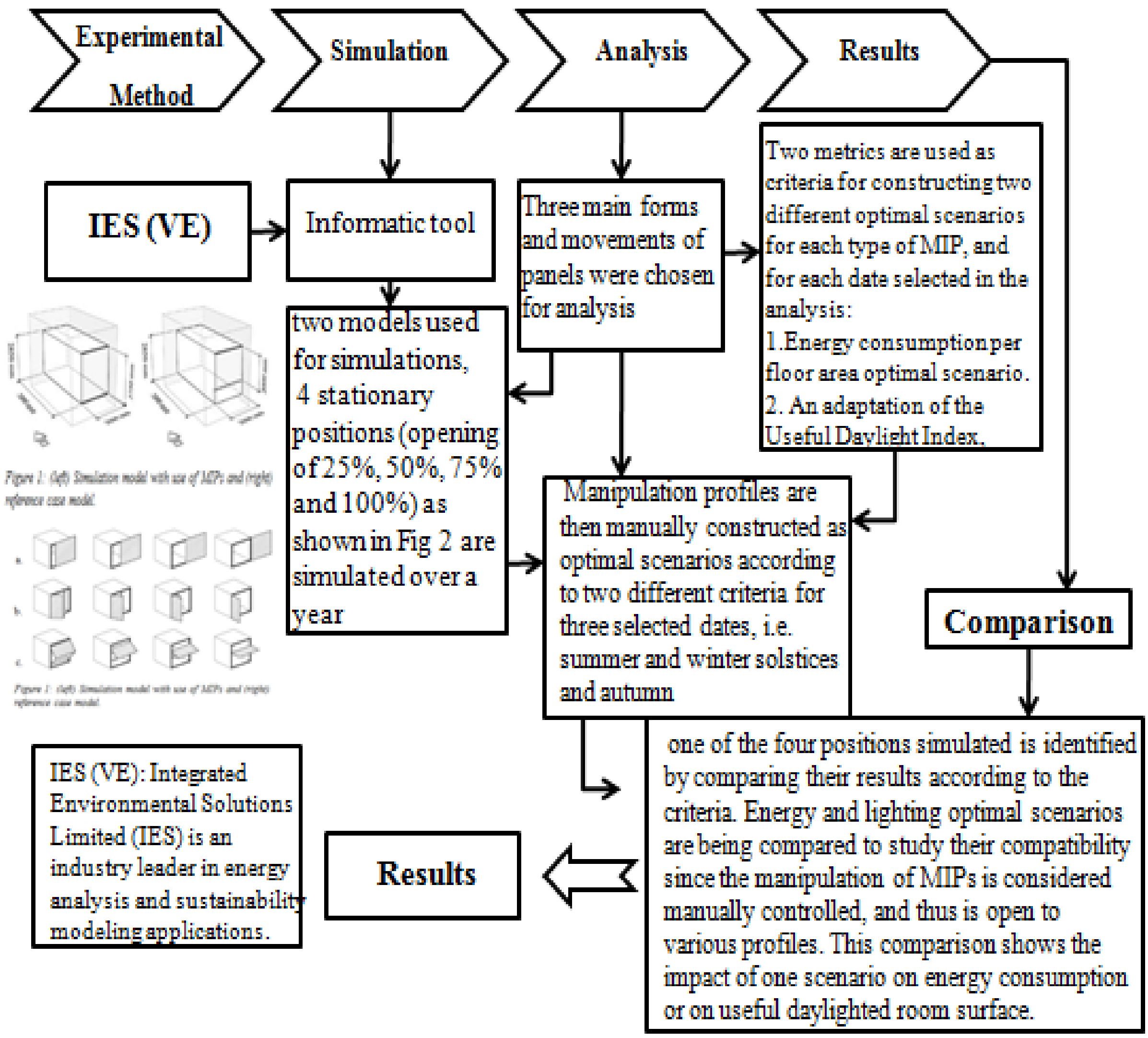
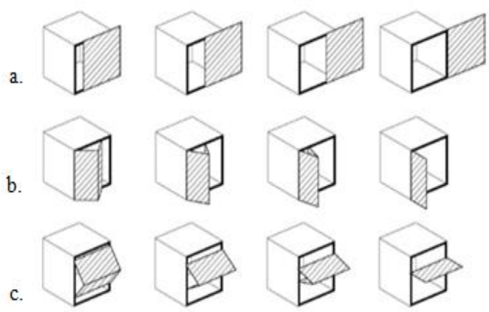


Fig.06: Schema illustrating the methodology used in analyzing this article (author)



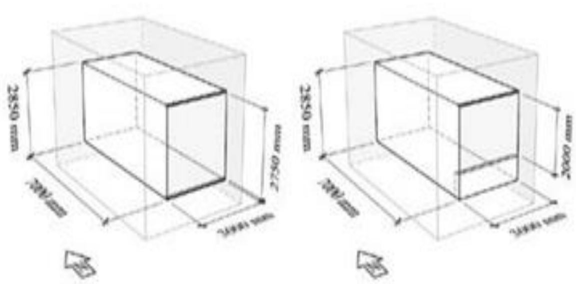


Fig.5: (left) simulation model with use of MIPs and (right) reference case model

Fig.7 :(left) simulation model with use of MIPs and (right) reference case model

5. Results:

For identical climate conditions, optimal scenarios for all types of MIPs are generally similar from an opening percentage standpoint, but result in very different energy and lighting performances. Fig. 5 shows the results for the vertical folding panel on summer solstice. Thermal and lighting incompatible needs are clearly shown, though not as much as for the sliding MIP [7]. Indeed, an opening of 100% is suggested for the lighting optimal scenario throughout most of the day to allow a maximum light penetration while openings of 25% to 75% are identified in the energy optimal scenario form 10AM to insure shading and to avoid too much solar gains.

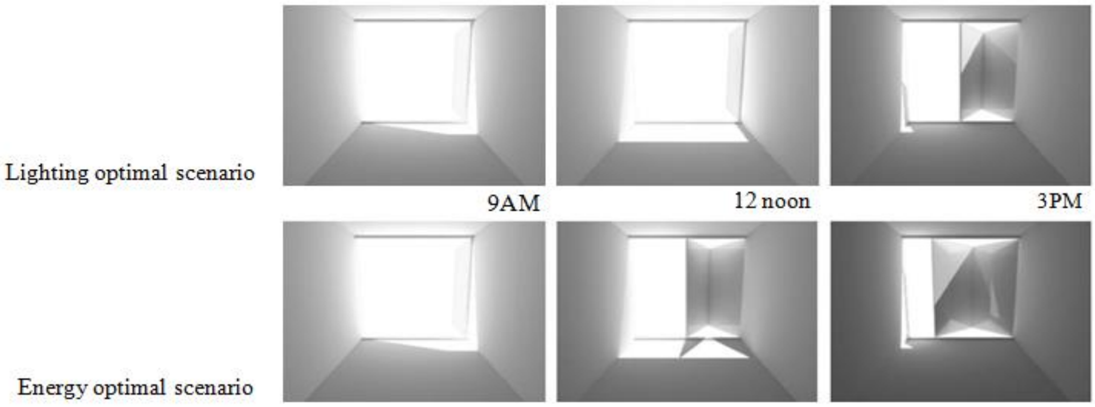


Fig.8: interior renderings for the vertical flooding panel optimal scenarios

Both energy and lighting scenarios results, for each typical day, are plotted on a single graph (Fig. 4) where the top section indicates energy consumption and the bottom section, the adapted useful daylight index, and where the dotted lines show the results of the reference case. The top gray icons illustrate the different positions of the MIP identified for the lighting scenario while the bottom black icons illustrate the positions for the energy scenario. The same shades then refer to the lines on the graph; gray for the lighting scenario and black for the energy scenario. The zone created in between the lines represents the impact of one scenario over the energy or lighting performance. For example, at 10AM on summer solstice (Fig. 4), an opening of 100% compared to one of 50% results in a slight increase of energy consumption, still lower than the reference case, but also results in a much more important and desirable increase of the lighting performance.

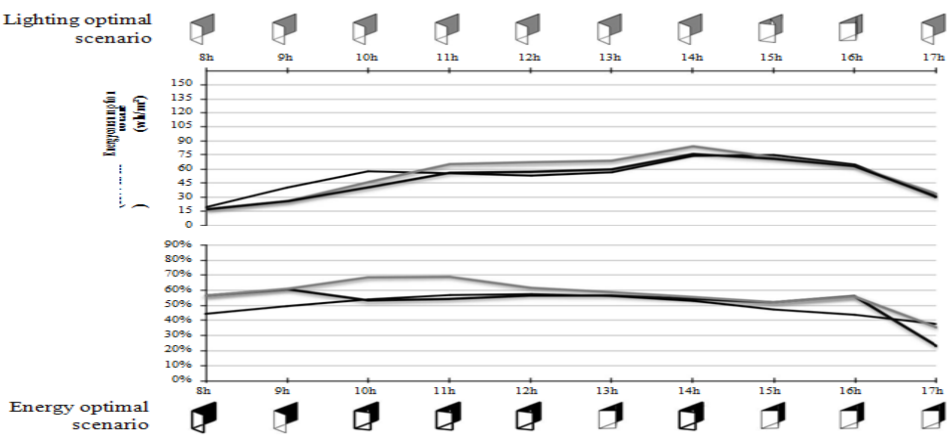


Fig.9: Optimal scenarios results for the vertical folding panel on summer solstice

The graph (Fig. 5) also clearly demonstrates the potential for the use of MIP during wintertime. As previously mentioned, December scenarios considerably benefit from shading on both energy and lighting accounts and from the reduction of thermal losses by nighttime. As for autumn and summer scenarios, the vast majority shows improvement on only one aspect. For example, in the case of sliding and vertical folding MIPs, autumn energy optimal scenarios propose energy savings resulting from shading, but also a decrease of lighting performance compared with the reference case. Summer scenarios show generally the worse performances. Comparing MIP types**, the vertical folding panel** presents the best overall performance. From an energy standpoint, its scenarios are most of the time characterized with the best energy performance in world.

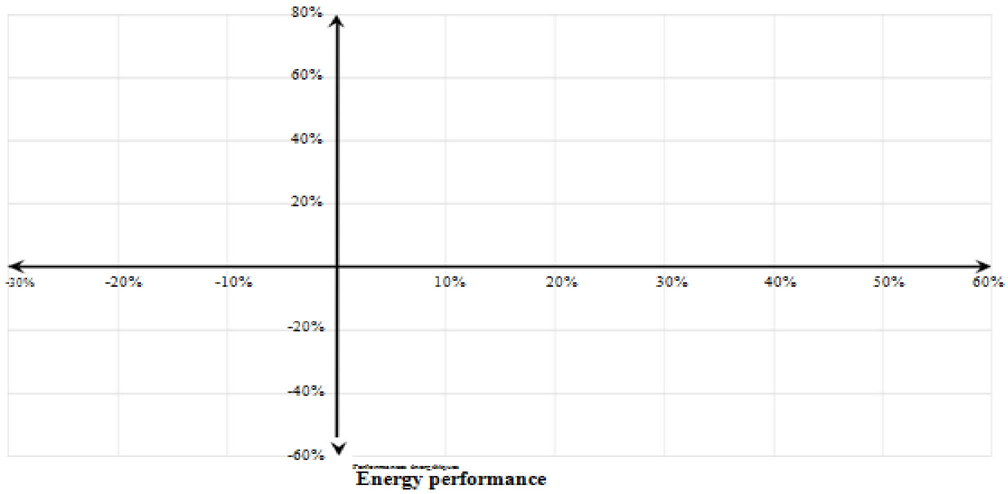


Fig.10: Optimal scenarios energy and lighting performance for all three types of MIPs

6. Conclusion:

The goals of this exploratory research were to demonstrate energy and lighting impacts of a daily use of three types of MIPs as shading and movable insulation devices on energy consumption and on luminance control. The research demonstrates a clear potential for the use of MIPs, as well as introducing such devices as an effective adaptive strategy.

Among all types of MIPs studied, the vertical folding panel presents the best compromise between energy and lighting performances. Better performances were expected for the horizontal folding panel, but still are higher than the sliding panel's performance. It is interesting to note that implementation for vertical panels, regarding ice and snow loads, would be less complex than for horizontal panels. The vertical folding panel also yields the best compatibility index and control freedom index on average for the three seasonal days, slightly higher than the horizontal folding panel. These indexes are used to assess the potential of MIPs as an adaptive strategy.

1. Article presentation:

Title: **Active materials for adaptive architectural envelopes based on plant adaptation principles**

Author: Marlen´ Lopez´[a,*], Ramon´ Rubio[a], Santiago Mart´ın[a], Ben Croxford[b] and Richard Jackson[c]

N° of pages: 12

Search for it: Department of Construction and Manufacturing Engineering. University of Oviedo, IDEASCAD Research Group. C/ Pedro Puig Adam. Room 6.1.19. Campus de Viesques, 33203 Gijon, Spain. Tel.: +34 656 181913; E-mail: arqmarlenlopez@gmail.com.

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Accessed on: 10/05/2018

Keywords: Active materials, adaptive architecture, biomimetics, energy efficiency, plants.

The article objective:

This research aim to propose the relationship that can be developed between active materials and environmental issues in order to propose innovative and low-tech design strategies to achieve living envelopes according to plant adaptation principles.

the objective of this research is to transfer this biological mechanism into a new system for architectural envelopes capable of adapting to the same issues in order to be more efficient and less energy demanding. Therefore humidity, temperature, carbon dioxide and light, are the environmental issues selected in this research.

Article	Author	questioning
Active materials for adaptive architectural envelopes based on plant adaptation principles	Marlen Lopez, Ramon Rubio,Santiago Mart´ın ,Ben Croxford and Richard Jackson	Is it possible to investigate the application of biomimetics to the development of adaptive architectural envelopes according to plant adaptation strategies?

Problematic: Cities are part of the climate change problem, but they are also a key part of the solution. Nowadays cities consume the larger part of global energy and are therefore major contributors of greenhouse gas emissions. Moreover, cities have key competencies to act on climate change through their responsibilities over urban sectors such as buildings. So much so that latterly the European Union has been developing a large number of funding buildings efficiency programs for research and innovation trying to problem-solve these issues, such as the Horizon 2020 frame-work. Some of these programs focus on building retrofitting, or the installation of energy efficient technologies, especially on facades. Facades have an important role in the regulation and control of energy waste, since they act as intermediary filters between external environmental conditions and inside users and functional requirements.

3. The case study:

Some plants were selected from different regions with different climates as research specimens. Some issues were selected for experimentation with such intentions as (fig seeds, arid regions of the Mediterranean climate, wood, Crucifera leaves, dentata leaf,); therefore humidity, temperature, carbon dioxide and light, are the environmental issues selected in this research.

4. Research methodology:

This work is organized in two main sections. In the first one, motivations for application to biomimetic principles from plants to architecture are explained, as well as concepts such as adaptation and why plant adaptation principles are the basis of this research. The second section is related to how to convert these inspirational mechanisms of plants into technical implementations for adaptive architectural envelopes. A selection of possible active materials is proposed, according to the environmental issues defined: humidity, temperature, carbon dioxide and light. Finally some ideas about possible manufacturing tools are described.

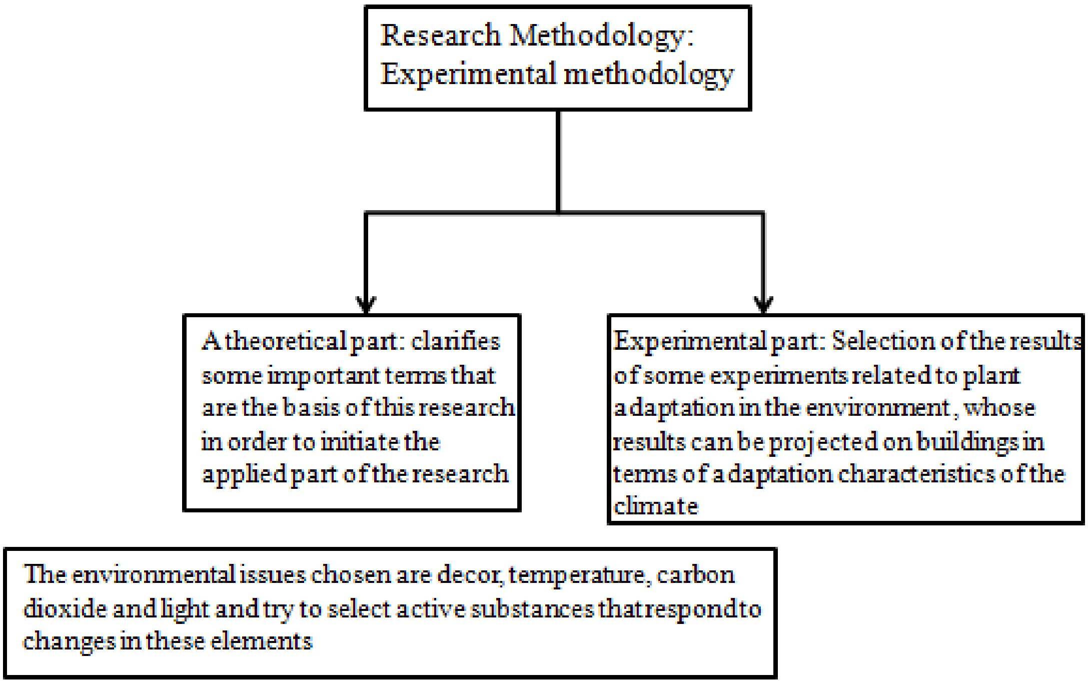


Fig.11: Schema illustrating the methodology used in analyzing this article (author)

5. Experimental part:

<u>* Stoma: related</u> to botany, is that it is a pore, found in the epidermis of leaves used to control gas exchange. The pore is bordered by a pair of specialized parenchyma cells known as guard cells that are responsible for regulating the size of the opening. Guard cells perceive and process environmental and endogenous stimuli such as light, humidity, carbon dioxide, temperature, drought, and plant hormones to trigger cellular responses resulting in stomatal opening or closure.

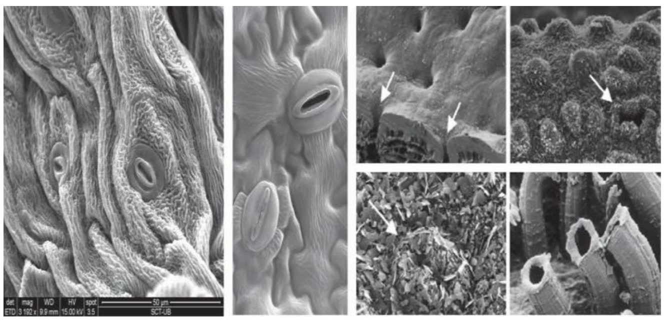
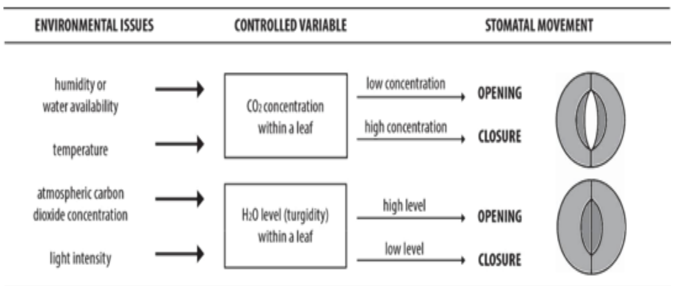


Fig.12: From left to right: stomata on **Crucifera** leaves; stomata valve movements on a *Lavandula dentata* leaf; different morphologies of sunken stomata, waxes, hair Structure or chimneys to reduce the evaporation of water.

Fig.13. Diagram of showing the mechanism of stomata movement.

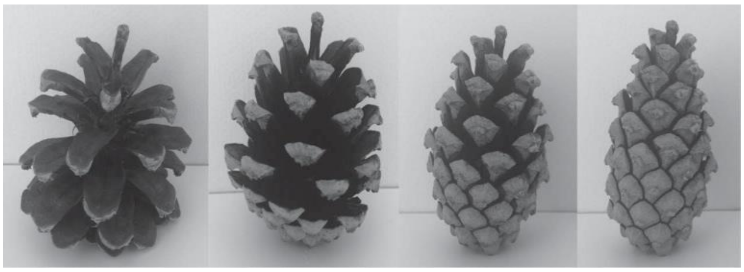


Control of stomata movements depends on the controlled variable within the leaf and the external inputs (Fig. 9). Controlled variables are dioxide concentration and the water level (turgidity). External inputs are humidity or water availability, temperature, atmospheric carbon dioxide concentration and light intensity.

***Active materials:** After defining biological inspiration how can we materialize this mechanism into a technical implementation? This research tries to work out a system capable of growing or shrinking in size or changing in shape to adapt to deferent environmental issues, through the ingrained properties of the material they are made of, without the need for external energy or complex mechanical parts. We study the possibilities of fabrication of responsive systems, where multiple materials can react to the environment and deform over time, such as mechanisms that transform into a predetermined shape, changing property and function after fabrication through deformation of active materials capable to stretching, folding or bending, depending on environmental stimulus. However, traditional materials such as ceramics, metals or glasses are industrially produced to satisfy the demands of the building sector, so they are homogeneous and uniform in composition, and isotropic, having identical or very similar properties in all directions (Menges, 2012). Thus, conventional materials and manufacturing processes only provide inert solutions, static results or complex high-tech equipment to achieve kinematic systems; On the other hand, a wide range of smart materials has emerged in recent years. Smart materials have properties that react to changes in their environment. The main research directions are based on shape memory alloys (SMA), shape memory polymers (SMP), piezoelectric materials, magnetostrictive materials, electrostrictive materials and electro active polymers.

1. Humidity reactive materials: Hydro gel: smart gel based on an insoluble network of polymer chains that swell up when water is added, making an expanded mass. Hydro gels are highly absorbent, they can store large amounts of water, and they also possess a degree of flexibility very similar to natural tissue, due to their significant water content.

Fig.14. Experiments of opening and closing movements in conifer cones due to humidity level changes.



2. Temperature reactive materials:

-Thermo-Bimetal: sheets of deferring metal alloys laminated together. When two metals which, when heated, expand at deferent rates and they are joined together, the structure that they form will bend as the metals fight each other into contortions and these could provide a useful embedded structural response . **Shape memory alloys:** smart metals capable of recalling their original shapes. Once deformed, heating them above their transformation temperature will trigger them to return to their original shape.

Shape memory polymers: smart polymers capable to return from a deformed state, temporary shape, to their original or permanent shape, induced by an external stimulus, in this case a temperature change.

Thermo chromic polymers, inks or glasses: thermo chromium is the property of substances to change color due to a change in temperature. These materials alter their color in reaction to temperature changes.

Heat sensitive plastics: plastics capable to expand induced by thermal changes (Fig.15). Combinations of two plastics of deferring coefficients of thermal expansion involve heat sensitive actuation.

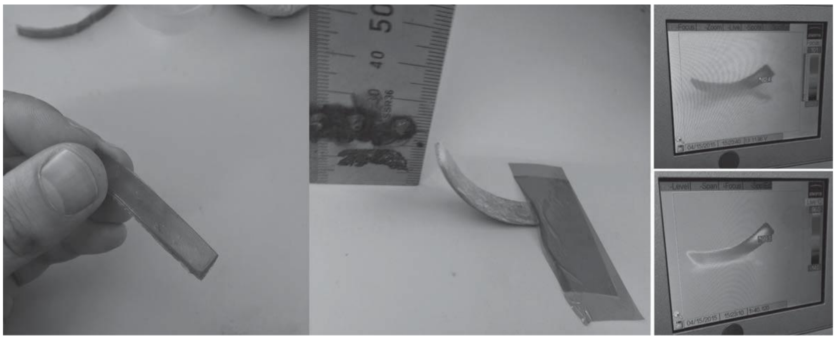


Fig.15. Experiments of heat sensitive Plastic in the UCL Healthcare Biomagnetics Laboratories (The Royal Institution of Great Britain) where an infrared camera is used to Capture the heat distribution triggered through The temperature changes.

3. Light reactive materials:

Photo chromic dyes, Light responsive polymers…etch

Among others the technical implementation for adaptive architectural envelopes we are looking into. Consequently, materials with special properties to be manipulated and used in additive manufacturing will be selected (fig. 12).

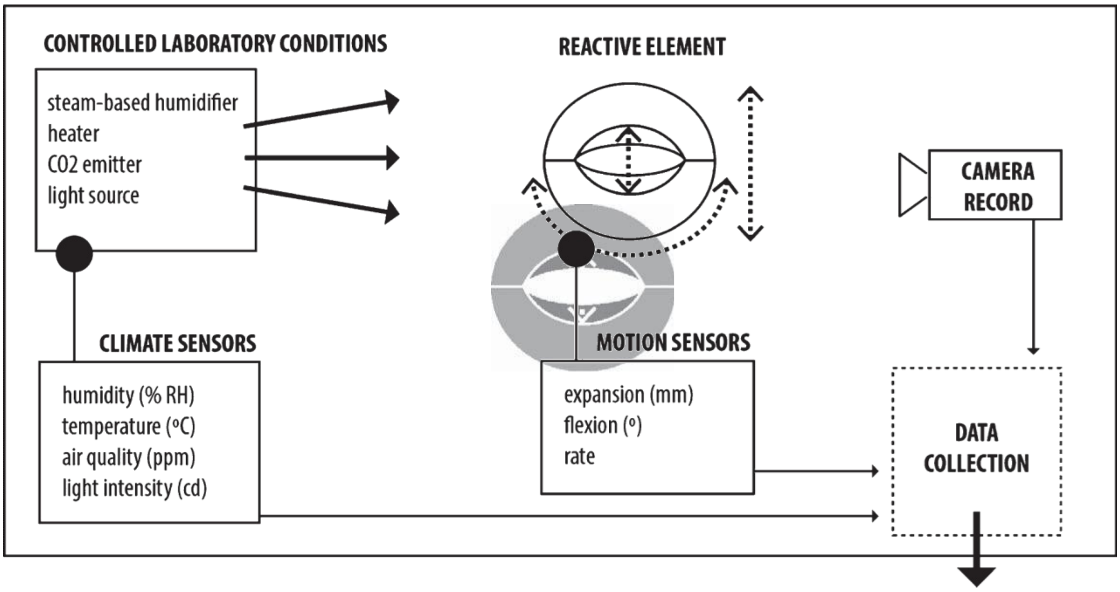


Fig.16. Scheme idea of the testing scenario, a homogeneous climate chamber with controlled laboratory conditions to verify different motions.

Using the same shape element as a starting point, we will control the values of the environmental parameters to observe the response range and behavior of deferent materials. These tests should show dimensional changes on element surface (i.e. opening, closing, expansion, fold and other transformations) caused by varying environmental issues, and thus, demonstrate the material capacity to rapidly respond to changes in temperature, humidity, carbon dioxide or light. Through these experiments we try to explore the interrelationships between active materials research and its response to external stimuli (humidity, temperature, carbon dioxide and light) seeking meaningful ways to bridge between the natural inspiration, stoma, and the technical implementation, adaptive architectural envelope.

6. Results:

We concluded that during this experiment, the leafs must continuously adjust the apertures of its stomata as conditions. Depending on the factor affecting the heat, humidity and carbon dioxide, the movement of the stomata depends on the influencing environment in order to meet their basic needs smoothly. Therefore, this phenomenon is considered a key to understand the principles of adaptation solutions and transferring them into artificial systems for adaptive architectural envelopes.

According to the level and type of activity. Based on those demands, the following functions' are defined for the architectural envelope, as an adaptive interface between environmental issues and internal comfort:

- Absorbing, collecting or evaporating to regulate humidity
- Dissipating, gaining or conserving to regulate temperature
- Filtering or exchanging to regulate carbon dioxide (air quality)
- Reflecting, absorbing, redirecting or defusing to regulate light

Once these individual experiments have been made and tested, the next step towards the final prototypes is the union of deferent materials with deferent features to manage hybrid materials, that is materials or active composites which can embody multiple functionalities. The materials needed for fabrication of humidity reactive systems may be deferent from the materials used in temperature reactive mechanisms. Therefore, techniques of multi-material printing are needed to be embedded into a single 3D system or structure to control several environmental issues simultaneously, and thus implemented in the multi-adaptive architectural envelope.

6. Conclusion:

The research focuses on the relationship that can be developed between active materials and environmental issues in order to propose innovative and low-tech design strategies to achieve living envelopes according to stomata movements in plants, as a result of the application of biomimetics in architecture. Environmental issues selected are humidity, temperature, carbon dioxide and light and we try to select active materials that respond to changes in these elements. Some of these active materials include: heat sensitive plastics, wood or carbon dioxide responsive polymers, with capabilities such as programmable actuation, sensing, self-transformation and workable in 3D printer technologies. The next step in the research is the development of several experiments with single active materials in simple geometries by 3D printing to elaborate laboratory tests in a climate-box in order to demonstrate dimensional changes on surface elements caused by varying environmental issues; to carry out experiments in active material elements with behaviors as actuators for innovative and low-tech design strategies, and subsequently to achieve hybrid materials or active composites which can embody multiple functionalities.

CHAPTER THREE

ANALYSIS EXAMPLES OF ADAPTIVE FAÇADE

1. Kiefer Technic Showroom:

Name	**Kiefer Technic Showroom**
Location	**Bad Gleichenberg, Austria**
Architect(s)	**Ernst Giselbrecht and Partner**
Year(s) of construction	**2006-2007**
Building Function	**Office building and exhibition space**
Awards	**Austrian Architecture Award 2008**
Façade type	**Curtain wall**
Presence	**All façades (not the minor sides)**
Function	**Thermal (solar control)**
Climate zone	**Moderate**
Classification	**Movement: Mechanic based - Hybrid (folding)** **Control: Local - Direct**

General concept :

The Kiefer Technic Showroom in Austria has a dynamic façade foreseen of sunscreens that can open and close according to changing environmental conditions. When fully opened, a lot of ay light can enter as the exterior wall of the building is fully transparent.

Adaptive system

The façade of the showroom is an easy but very efficient curtain wall system. The frame exists of Aluminum mullions and transoms. The sunscreen system is made of perforated aluminum panels. These shutters are electronically controlled.

Building physics and energy

The façade allows controlling the solar gain by opening or closing the sunscreens. The electronically control of the system makes it possible to allow adaptation of the structure by the users according to Their individual requirements to optimize the internal climate.(reference :web A-01,Web A-02)

Figure 1: Kiefer Technic Showroom

Figure 2: Detail of the façade

2. Media-ICT Building:

Name	**Media-ICT Building**
Location	**Barcelona, Spain**
Architect(s)	**Enric Ruiz Geli, Cloud9 Architecture**
Designer(s)	**Vector Foiltec**
Year(s) of construction	**2010**
Building Function	**Building for science and technology companies, lobby for public exhibitions, workshops and events**
Awards	**Best building in the world (WAF 2011)**
Façade type	**Curtain wall**
Presence	**South-west façade**
Function	**Air flow (air control), Optical (lighting), Thermal (shading system)**
Climate zone	**Moderate**
Classification	**Movement: Material based - External Input (Fluid)** **Control: Central - Reactive**

General concept

The Media-ICT building, designed by architect Enric Ruiz Geli in cooperation with Cloud architecture, is situated in 22@, an experimental district. The South-West façade of this building in Barcelona is made out of plastic panels capable of transformation. The façade has a net-like steel structure which makes it able to integrate the public spaces to the building.

Adaptive system

The envelope of the building is a temperature-controlled skin that is capable of inflating and deflating. This system can be classified as a material based deformation principle triggered by an external input, more specific fluid. The inflatable segments have a triangular shape, inspired by nature. The membrane of the segments is fluorine based plastic (ETFE: Ethylene tetra Fluor ethylene). The segments are encased in a frame.

The air chambers of the segments are centrally controlled by solar-powered sensors. The sensors are responsible for the contracting and inflating of the cushions according to the sunlight by differing the air pressures inside.

The reaction of the sensors is based on the continuous calculation of the environmental changes (e.g. cloud cover). The system is not able to react quickly to the changing environmental conditions but needs on average about one hour to react.

Building physics and energy

The ETFE-membrane acts as a sunscreen and filters heat and UV-rays by inflating. The inflating chambers block the solar rays and create cooling shade. In winter, the solar rays are soaked up by the opening of the membrane to maximize the transmission of light and heat to the interior. Next to the adaptive façade, the building is equipped with a photovoltaic roof, rainwater recycling system and district cooling as well. Al these measures contribute to an almost net zero building, the carbon emissions are reduced by 95%.In addition, the skin is anti-adherent and needs little cleaning.

Figure 3: Media ICT-building

Figure 4: Air cushions

Figure 5: Detail of the inflating cushions

References:

(Velasco et al., 2015)
(Web A-3)

4. The Abu Dhabi Investment Council New Headquarters:

Name	Al-Bahr Towers
Location	Abu Dhabi, UAE
Architect(s)	Aedas Architects, Abdulmajid Karanouh (Diar Consult)
Engineer(s)	Arup
Construction company	Al-Futtaim Carillion
Year(s) of construction	2009-2012
Building Function	Office building
Awards	CTBUH 'Innovation' award 2012, Tall Building Innovation Award 2012
Façade type	Curtain wall
Presence	South, west and east façade
Function	Thermal (solar control), Optical (daylight control, glare)
Climate zone	Subtropical
Classification	Movement: Mechanic based - Hybrid Control: Central - Reactive/(Direct)

General situation:

The architectural firm AEDAS designed in 2008 the concept for the Abu Dhabi Investment Council Towers. The design for the towers was driven by the integration of environment, tradition and technology. The strength of the concept of AEDAS is the combination of inspiration from the past with looking forward into the future. Each tower is basically a curved cylindrical glass tower. The two towers are 150 m tall and the fluid form is inspired on a honeycomb. The building is located in a desert on the north shore of the island. The weather in the United Arab Emirates is characterized by intense heat and glare, requiring an innovative solution to create a comfortable indoor environment.

Adaptive system

The automated shading system is a curtain wall system. The screen of the façade is placed on an independent frame, two meter in front of the exterior of the building by applying the unitized method. Each unit of the screen exists of six triangular frames. The frames unfold through a centrally positioned actuator and piston. The cladding of the façade is placed on the south, west and east side. The north face of the building is only exposed to direct solar rays for a short time before and after working hours, which makes shading unnecessary. The geometric pattern (a triangular structure) for the design of the façade was based on the Islamic traditional Mashrabiya. The components of the system open and close as a reaction to the movement of the sun during the day and changing incidence angles during the different days of the year. In the night, the pattern is folded, which makes the exterior visible. In the morning, when direct sunlight is present, the pattern closes at the east-side and moves with the sun around the building during the day. The folding system is an example of a movement system that is a 'Hybrid In Plane Translation/Out-of-Plane Rotation System'. The dynamic movement of the panels recalls the opening and closing of flowers. The façade consists of semi-transparent umbrella-like PTFE (poly tetra flour ethylene, a Teflon-coated woven fiberglass membrane) panels, which form the movable components that react to the position of the sun by stretching. These panels are extremely durable and weather resistant. The fluid aerodynamic geometry of the panels helps to withstand the wind pressures effectively. In addition, the color of the panels fits perfectly with the color of the surrounding sand of the desert.

The panels allow the sunlight to enter but block on the same time the strongest rays. This is in order to prevent heat and glare gain in the building.

The frame for the cladding is made out of steel. Each tower comprises 1000 individual shading devices that are controlled by the 'Building Management System'. The actuation of the panels, based on parametric and algorithmic modeling, is done by control software in this management system. The mechanism of a unit is driven by an electric screw-jack actuator that is positioned centrally and uses a low amount of energy. The linear is actuator responses to a pre-programmed calculated sequence which results in the opening and closing of the panel one time each day. In addition, the façade system includes some sensors which react to overcast conditions and high winds. These sensors will open the units in dangerous situations and provide live feedback to light, wind and rain. The Building Management System allows also manual intervention in emergency cases or for maintenance.

Building physics and energy

The system results in a huge increase of the use of alternative energy. It improves the comfort and light in the spaces. It reduces the entering of solar radiation in the building by 50%, which lowers the need for cooling. On the same time, the need for artificial lighting is reduced. The folding principle reduces solar glare combined with a better visibility by avoiding the distortion by internal blinds or the use of dark tinted glass. In addition, the towers are very high. This makes it possible to introduce a dynamic façade over a large area, which is more cost efficient. Moreover, the shading makes it possible to select more selective glass finishing for the façade that is behind the screen. More naturally tinted glass can reduce the need for artificial light by providing better views and fewer glares.

For the design, an integrated building model was used to view the project at any given time. This model creates the opportunity to facilitate performance optimization. Moreover, it ensures proper coordination of the building elements. In addition, the overall form of the towers was optimized to complement the shading system as well. The towers are based on a circular plan that becomes narrower at the base and the top and broader around the intermediate floors.

Figure 6: Abu Dhabi investment council

a) b) c)

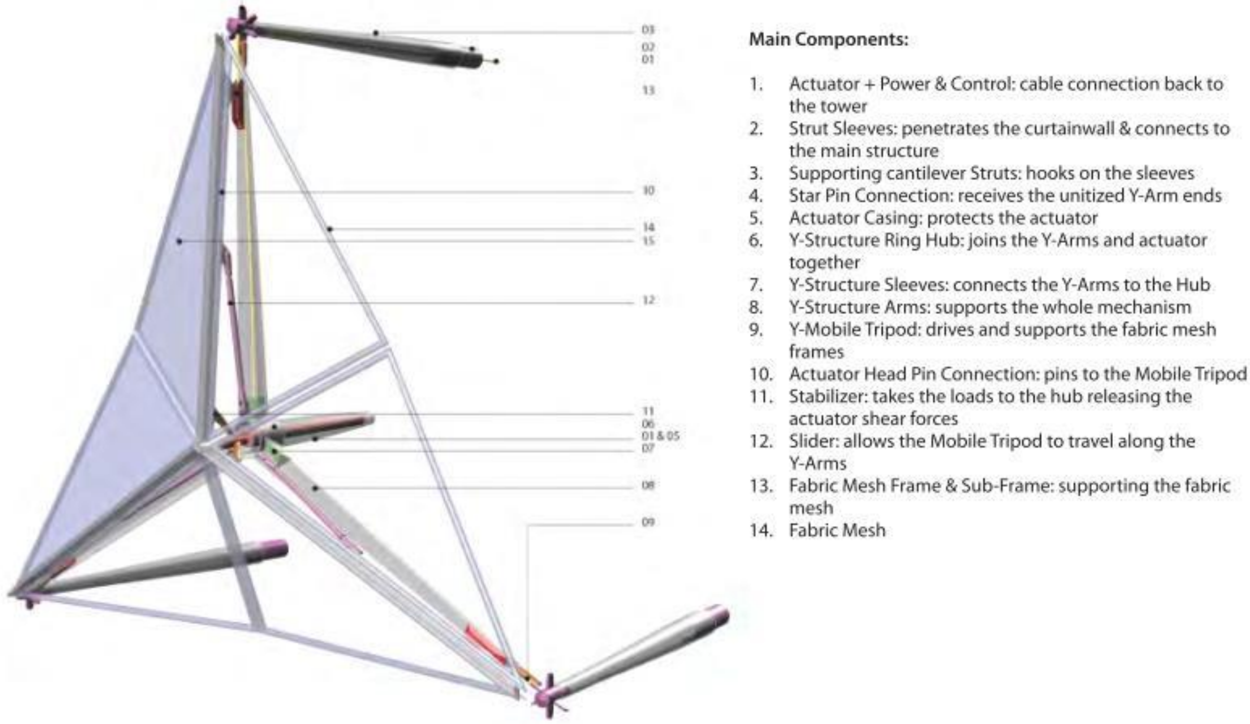
Figure 7: Unit in: a) closed position, b) opening position, c) opened position

a) b)

Figure 8: Shading system Investment council Abu Dhabi (Karanouh & Kerber, 2015)

Figure 9: Inside view of the curtain wall system (Karanouh & Kerber, 2015)

Figure 10: Construct detail (leaflet CTBUH Innovation Award, 2012)



References:
(Premier, 2015)
(Karanouh & Kerber, 2015)
(Web A-04; Web A-05; Web A-06)

4. Thematic Pavilion:

Name	Thematic Pavilion
Location	Yeosu, South Korea
Architect(s)	SOMA
Engineer(s)	Knippers Helbig Advanced Engineering
Year(s) of construction	2012
Building Function	Multimedia exhibition, space for innovations in research and technology
Award	Open international competition 2009
Façade type	Curtain wall
Function	Thermal (solar control)
Climate zone	Subtropical
Classification	Movement: Material based - External Input (External Force) Control: Central - Direct

General concept:

This fish-like pavilion was built for the EXPO 2012 in Yeosu, South Korea along a new promenade in the former industrial harbor basin. The theme of the Expo was 'The Living Ocean and Coast'. The architects of SOMA (from Austria) had the intention to create a landmark that harmonizes with its urban and natural context. The shape and design of the building create the experience of an ocean as an endless surface with a certain depth.

Adaptive system:

The inspiration for the kinetic façade is based on the application of biological moving mechanisms in architecture (biomimetics). The façade has moveable lamellas that can control the entering of light in the building. The lamellas are individually controlled, and can open and close in succession which allows the creation of wave-like patterns over the length of the building. The lamellas are made out of glass fiber reinforced polymer. The material properties of the lamellas are the basis for the kinetic movement of the lamellas.

Building physics and energy:

The façade of the building is foreseen of LEDs at the inner side of the lamellas. When the lamellas are in open position, the LEDs can illuminate the adjacent lamella. The size of the illuminated surface depends on the length of the lamella. The longer lamellas have a wider opening angle which results in a larger illuminated surface. The lamellas allow the control of solar energy. The system makes also use of renewable energy because the power for the operation of the moving lamellas is supplied by solar panels on the roof.

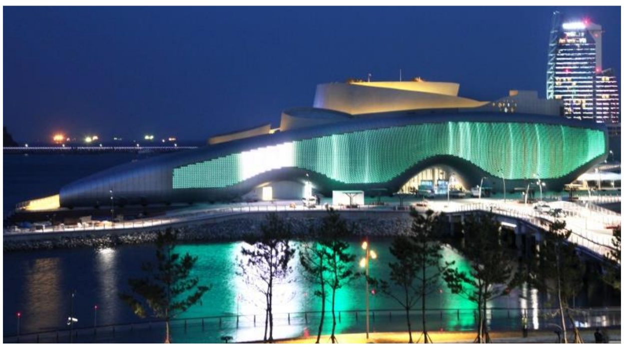


Figure 11: The kinetic light façade

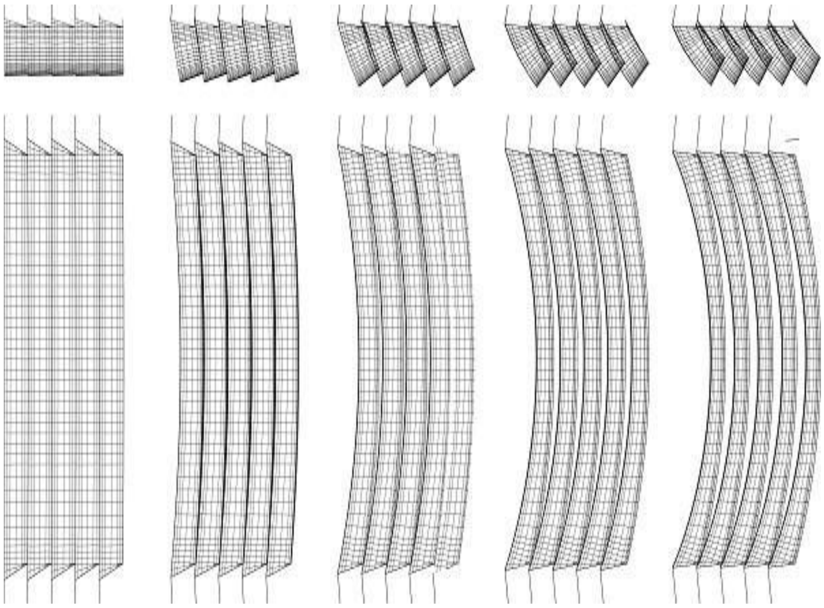


Figure 12: Movement of the lamellas

Figure 13: Opening of the lamellas

Figure 14: Lamellas in the façade

References:

(Velasco et al., 2015)

(Web A-07)

5. CJ Research Centre’s Kinetic Folding Façade:

Name	CJ Research Centre
Location	Seoul, South Korea
Architect(s)	Yazdani Studio
Engineer(s	Matt Williams
Year(s) of construction	2011-2012
Building Function	Research and Development Centre
Façade type	Curtain wall
Presence	All façades
Function Climate	Thermal (solar control), Optical (glare, daylight) Subtropical
zone Classification	Movement: Mechanic based - Hybrid Control: Local - Direct

General concept

The CJ Research Centre in Seoul consists of three tear drop shaped towers. The towers have a glass atrium that allows the entering of a lot of solar radiation in the interior environment. The large quantity of glass stimulates the design of an adaptive shade system to make the energy use of the building more efficient.

Adaptive system

The kinetic façade system is made out of accordion folded window shading covers. The moving system exists of the automatically opening and closing of the metal steel strips. The strips are installed on scissor actuators. The opening system is inspired by an umbrella. To allow the bottom and top portions of the foldable system to move independently, two separate linear actuators are used.

Building physics and energy

The responsive façade adapts to changing solar radiation and user input. The system is able to maximize solar control. The façade allows proper natural light levels while reducing overheating and glare on the same time.

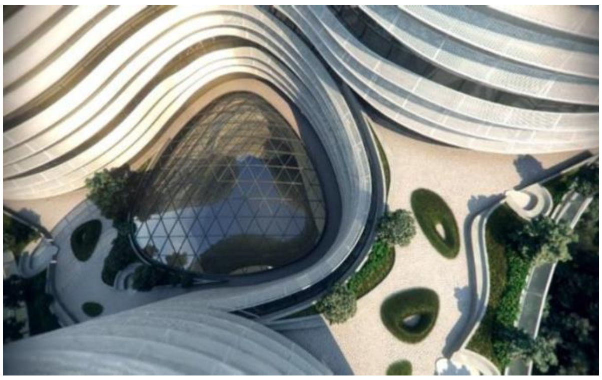


Figure 15: CJ R&D centre

Figure 16: Top view of the research centre

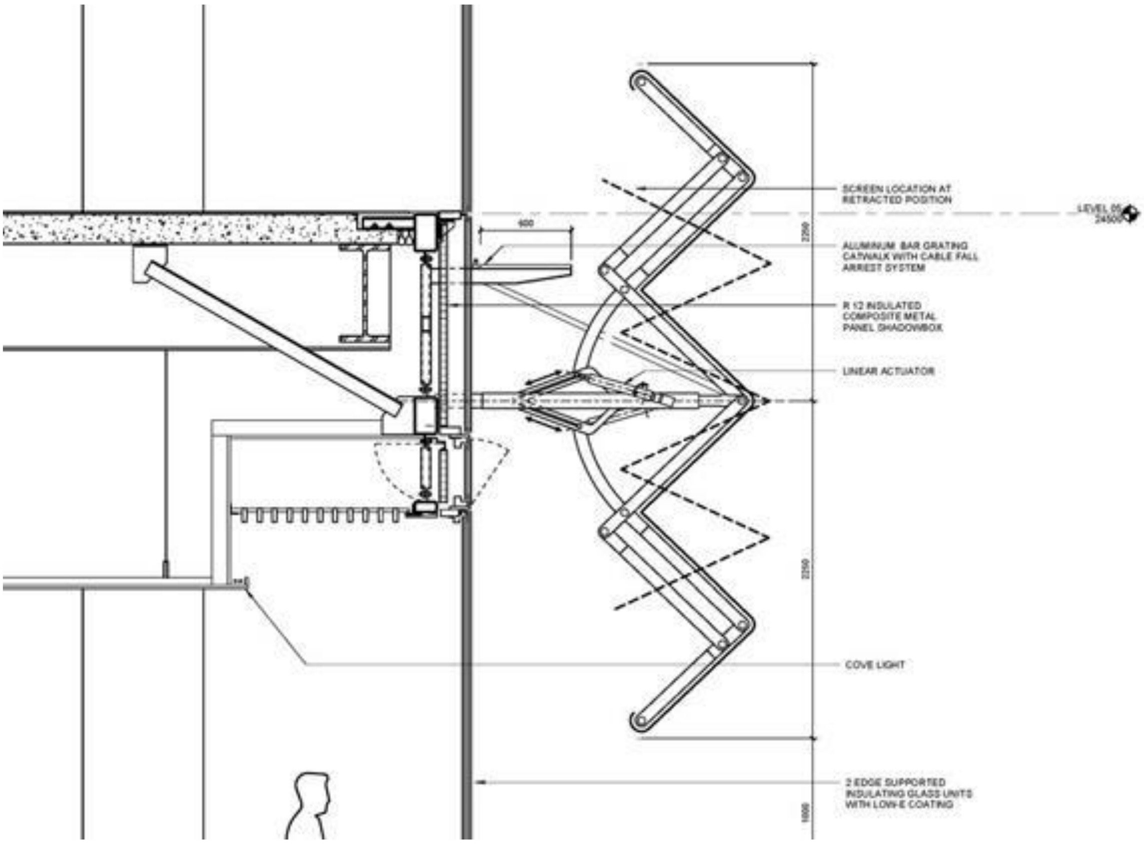


Figure 17: Folding system with scissors

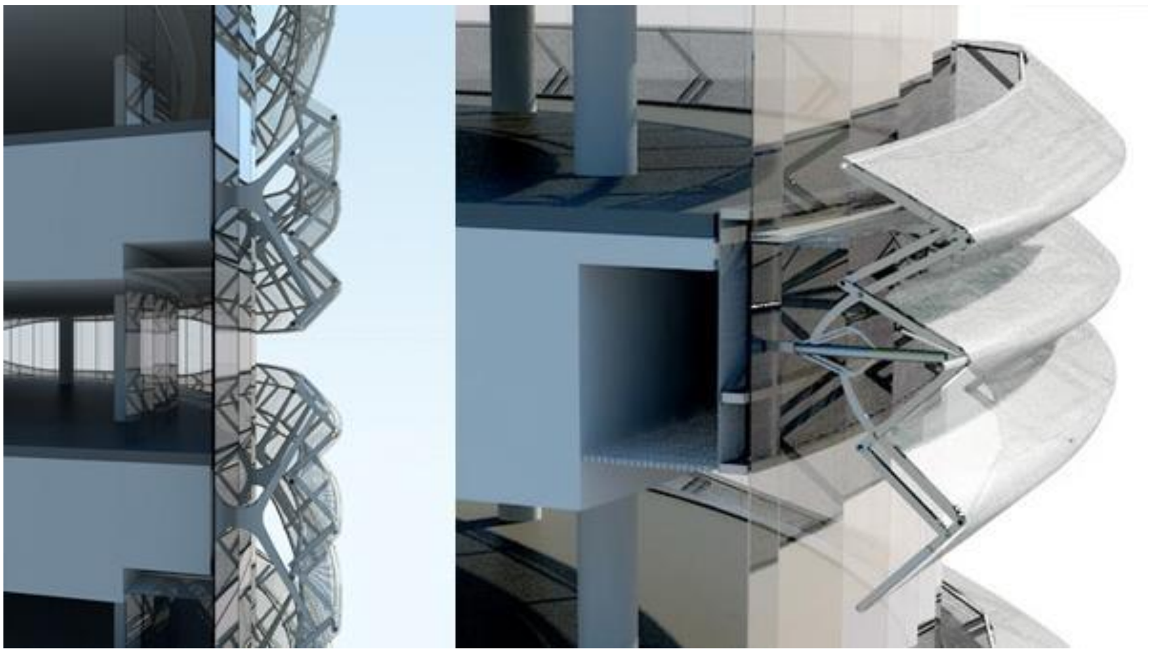


Figure 18: Kinetic folding façade

References:

(Web A-08; Web A-09)

General conclusion:

After analyzing the articles related to adaptive architecture and adaptive façades, we concluded that there is no limit to the number of articles related to this context. Each article examines a different aspect of adaptive architecture using different means to prove its efficiency compared to others. It is necessary to refer to adaptive façade, For them, it is achieve the highest proportion of natural lighting, ventilation and the most important less energy consumption by installing them in proportion to the project guidance and climate data in addition to the state of the environmental. In order to know the mechanisms of the work of these façades we approached the study of different examples gave us an overview of the dynamic of these interfaces. They are varied according to location, function, and design. It can be said that this conglomeration has gained adaptive architecture widely spread globally, allowing it to living buildings from adapting to the environmental.

CHAPTER FOUR

SHOPPING CENTER

I. Introduction

Trade-related architecture has developed with the growth and concentration of trade. The use of these spaces by the city dweller has changed, at the same time as the architecture that houses them. The design of the commercial architecture questions the way in which recent commercial equipment has been inscribed in the city as a creator of specific environmental environments and particularly the nature of the spatial boundaries between these different and delicate environments of the city.

The commercial zones offer spaces with a very strong main function: to group together all the shops in unique places and to offer a wide choice of products to favor the act of consumption.

This chapter deals with the basic theoretical questions surrounding shopping centers as a kind of introduction into the world of shopping centers. As Apply and Benjamin (1994) remarked too, the literature on shopping centers and the related theoretical schools follow the activities of practicing professionals, rather than opening up new perspectives. This is probably one of the reasons, why there is no stable theoretical system to precisely describe the world of shopping centers. In accordance with this, very frequently even the most widely used concepts and terms are not clearly defined or are given new and new meanings every time they are used. Accordingly, this subchapter pays attention to clarifying such basic concepts as the definition and types of shopping centers in world and in Algeria.

II. The origin and evolution of commercial spaces throughout history: (MEKID et al, 2017).

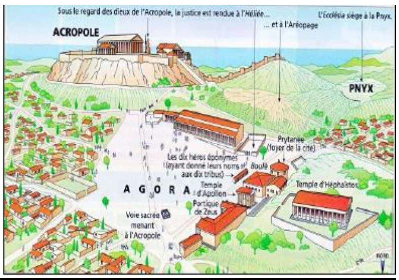
The period of antiquity	The middle age period	The Renaissance period
<u>The Greek Agora:</u> It is the first urban form, The Greek agora was a collective place of political, commercial, temporary or permanent sales market exchange  **Fig.e 1 : L'agora grecque** **Source : (blog.crdpversailles fr/notre paris romain).**	**<u>The market halls:</u>** The hall, which in France has been the selling point for food items since the Middle Ages, is a ventilated, well-built shelter with a basilica plan. built entirely of wood (in Aragon, Milly, etc.) or partly in stone (in Dives) and, from the 19th century, in metal frame. Sometimes it forms the ground floor of a municipal building. The major trading cities of the West had specialized halls for different products: cloth, canvas, leather, wheat, meat, wine, etc. halls  _**Fig.3: Beaumont-du-Gâtinais.** **Source: (.free.fr/halles/bh77beaumont02.jpg).**	**<u>The passages:</u>** Appeared at the beginning of the 19th century, the covered passageway innovates in its architectural form and social role, it is a small private road that connects two roads, in the form of street, covered courtyard or a succession of porches. Dedicated to pedestrians, surrounded by shops and surmounted by a glass roof that protects are from bad weather. The wooden galleries of the Pala is-Royal, created in 1786, are considered as the prototype of this passages.6 between 1860 and 1880; the passage takes on a monumental dimension and is transformed into a place of public walk in fashion  **Fig.5: Passage of Choiseul** **Source (assagechoiseuil.canalblog.com).**
<u>The Roman Forum:</u> It was not just simple flat spaces, surrounded by closed power buildings in the square. These are places intimately linked to civil and social life and it was the meeting place of merchants	**<u>The fair:</u>** The fairs have been in medieval Europe, they are large markets with fixed durations in the same year-round place, middle-age fairs are developing in cities located on The major European fairs are those of Bruges, Antwerp, Ypres in the Netherlands; Sturbridge in England; Cologne, Frankfurt am Main, Leipzig, Germany; Milan, Venice in Italy.	**<u>Department stores:</u>** In the second half of the 19th century, European metropolises saw the appearance of department stores and moved to the city center. Between 1855 and the First World War, the department stores developed together with the major fairs and the Universal Exhibitions, which serve as models in terms of architecture and presentation of articles, they were laboratories of architectural innovations,

 **Fig.2: Forum view from Capitol Source (www.rome-passion.comforum-romain.html).**	 **Fig.4: Fair in Ghent Belgium Source :(fr.wikipedia.org/wiki/FichierUne_foire_A_Gand_au_Moyen-Age.jpg#file).** **<u>Bazaars :</u>** Refers to a market or group of businesses where goods and services are available for sale and purchase. In Arabic it is The souk, this space exists since the first civilizations in the form of spaces of exchange, it is the medieval version of the agora in the Islamic countries it is generally located near mosques in the center of the agglomeration.	Thanks in particular to their metallic and glass structure, in France it was also thanks to the big changes launched by Baron Haussmann. The best known are: Louvre Stores "1855", the cheap "1862", galleries Lafayette "1895". Pygmalion is the first department store built in Paris in 1793  **<u>Fig.6:</u> Le bon marché Source (http://sabf.fr/hist/arti/sabf193.php).**
The modern period:	**The contemporary period:**	
<u>1 Supermarkets:</u> In 1958 the first supermarket was built under the Express Marché banner, it offers for sale self-service goods, this sales system has upset the habits of French consumers, in 1959 there were only 1,663 supermarkets in France, i.e. 0.2% of the French commercial park.	**<u>Shopping and leisure centers:</u>** At the end of the 20th century, ubiquitous equipment was created, bringing together a multitude of activities (commerce, leisure, administration, service). Attractiveness corresponding to new trends in shopping centers.	
<u>Hypermarkets:</u> They appeared in the United States in the 1960s to reinforce the "Open Space" approach, located on the outskirts with very large sales areas and huge "no parking no business"		

Table 01: The origin and evolution of commercial spaces throughout history
Source: author

III. The Definition and Typology of Shopping Centers:

Parallel with the emergence and development of shopping centers, professional associations and the scientific circles started to pay attention to them. Thus, as a first step, their definition became the center of attention. Before we enter deep in the presentation of the shopping center literature, I see it necessary to clarify and fix some of these basic concepts. Therefore, some definitions used by the practicing industry and the scientific circles will be presented in the followings. There are many classifications in use for defining shopping center typologies. I will touch upon the most important ones (Reikli, 2012).

III.1 The Definition of Shopping Centers:

As mentioned earlier, there are still many imperfections in the use of concepts from the field of shopping centers, the most frequent being the different interpretation, the different meanings given to the same notions and the variety of their definitions. This is the case of the definition of the shopping center as well. Therefore, only a few of the most widely known definitions will be presented. (Reikli, 2012).

Firstly, I'll present the definitions formulated by the industry's two most recognized organizations, namely the International Council of Shopping Centers and Urban Land Institute.

- According to the International Council of Shopping Centers (ICSC, 2004, p.1.), the shopping center is

« *a group of retail and other commercial establishments that is planned, developed, owned and managed as a single property, with on-site parking provided. The center's size and orientation are generally determined by the market characteristics of the trade area served by the center. The three main physical configurations of shopping centers are malls, open-air centers, and hybrid centers.* **»**

The constant development and progress of the industry and concepts are also reflected in the fact, that in 1999 they've only distinguished between two main categories of shopping centers: the closed malls and the open-air strip centers.

- According to the Urban Land Institute's (ULI, in. Kramer et al, 2008, p.4.) 1947 general definition, the **shopping center** is « *a group of architecturally unified commercial establishments built on a site that is planned, developed, owned, and managed as an operating unit related by its location, size, and type of shops to the trade area that it serves. The unit provides on-site parking in definite relationship to the types and total size of the stores.* **»**

III.2 Shopping Center Types:

One of the classical shopping center typologies, is the six-type one developed by *Dawson* (1983, in. Sikos T. et al, 2004), which distinguishes between the following shopping center types:

- 1. *General-purpose stand-alone shopping centers*
    - Community
    - Neighborhood
    - Regional

- 2. *General-purpose centers in traditional trade areas, renovated centers*
    - Infill
    - Extension
    - Developed as Part of a City Center Restoration
- 3. Multi-use centers
- 4. Ancillary centers
- 5. Specialized centers
- 6. Focused centers

The most important characteristics of these center types, for instance total area, number of storey's, control of tenant composition, optimal site etc., are summarized in Table 1.
Another classical classification is prepared by Guy (1994, in. Sikos T. et al, 2004), which distinguishes between the following six types, according to their appearances: (1) focused center or neighborhood center, (2) retail park, (3) shopping mall, (4) regional shopping center, (5) factory outlet center and (6) specialized centers. The specific characteristic of the latter two types is that they do not have a so-called anchor tenant. It is worth to take a look at the following table, which contains the possible geographical occurrences of these different types.

III.3 The classification of shopping centers:

The classification of shopping centers is done according to two fundamental criteria, it's are Location and size.

1/ Accor ding to the location:

The urban shopping centers:

They are located in the heart of the cities, their surface varies from 5 000 to 20 000 m ², and bring together twenty stores and services: sometimes they take the form of a gallery in which the shops are arranged along a covered street; their parking is underground. The major role of these centers is to structure or reinforce an urban pole. (Carol Maillard, 2007, p10)

Peripheral shopping centers:

They are in the periphery, their sales areas range from 40,000 to 100,000 m².
Well equipped, they offer almost all the services of a city center: the supermarket, specialty stores, services, restaurants and cinemas. They have one additional major benefit is the large outdoor parking area easily accessible. (Carol Maillard, 2007, p10)

2/ according the size:

Community shopping centers:

They have a GLA * area of a minimum of 5,000 m2 and / or a minimum of 20 Shops or services. Their customer radius is at neighborhood scale

Large shopping centers:

Their minimum GLA area is 20,000 m2 and / or a total of at least 40 stores and services. Their customer base is city-wide.

Regional shopping centers:

Their GLA area is over 40,000 m2 and / or at least 80 shops and services.

Their customer base is regional.

Super regional shopping centers:

These shopping centers have a GLA surface greater than 80000 m2 and / or

Host at least 150 stores and services. Their customer departments are scaled National. (Carol Maillard, 2007, p10)

Table 02: The frequency of occurrence of the different shopping center types :

Type of shopping center	City Center	Edge of the city center	Other retail areas	Other city areas	Residential area	City outskirts
Stand-alone store		X		X	X	X
Focused center			X		X	X
Retail park				X		X
Shopping mall	X			X		X
Regional center				X		X
Specialized center	X	X		X		
Transit outlet center				X		X

Table02: the frequent occurrence of the given type of shopping center in the market places.
Source: Sikos T. et al (2004)

Table 03: Characteristics of shopping centers according to Dawson's typology:

Characteristics	Strip	Community	Neighborhood	Regional	Super-regional	Infill	Extension	City Center Restoring	Multi-use	Ancillary	Specialized	Focused
Total area (sq.m)	1,500	5,000	20,000	50,000	100,000	2,500	15,000	40,000	40,000	3,000	6,000	10,000
Number of storeys	Only one	Usually only one	Usually only one	One or more	Usually only one	Usually only one	Usually more	Several	Several	Usually only one	One or more	Usually only one
Open-air/ closed	Open-air	Usually open-air	Both	Usually closed	Closed	Usually open-air	Usually closed	Closed	Usually closed	Both	Both	Both
On-site center management	No	No	Sometimes	Mostly	Yes	No	Sometimes	Yes	Yes	Sometimes	Sometimes	Sometimes
Association of tenants	No	Mostly	Mostly	Yes	Yes	No	Mostly	Yes	Mostly	No	Mostly	Rarely
Possibility for the settling of independent retailers	Yes	Some	Little	No	No	Yes	Some	Little	Little	Yes	Some	Little
Anchor tenant	No	Supermarket	Mixed store	Department store	Department store	No	Variable	Department store	Department store	No	Often no	Big company
Control of the tenant composition	Weak	Weak	Medium	Significant	Significant	Weak	Medium	Significant	Significant	No	Significant	Significant
Optimal site	Near a regional center	Local road network intersection	City road network intersection	City road network and intercity highway intersection	Within the conurbation between cities	Highest-prestige retail neighbor hood	Near city center restoration	Traditional city center	New settlement	Big office building	High-earning neighborhoo d	City road network intersection
Significance as growth pole	No	No	Limited	Some	Some	No	No	Significant	Significant	No	Limited	Limited

Table 03: Characteristics of shopping centers
Source: Dawson (1983) id. Sikos et al. (2004), p. 116.

III.4 the Algerian typology of commercial spaces:

Small sales areas:	The average sales area:
Traditional stores "Hanoute": These are sales areas of a surface less than 100 m2, their essential activity is the sale, mainly dedicated to sell products a first priority. Occupy the ground floor of most residential buildings. Their designs is done under no commercial pretext.  Figure 07: store in Bouira Source : (MEKID and al,2017)	**The Superettes** It is a self-serve food space with an area of between 120m² and 400m², they are beginning to replace traditional food stores, their design and construction follow commercial concepts.  **Figure 09**: Supermarket Madala in Bejaia. Source: (MEKID and all, 2017).
The Kiosks: These are prefabricated spaces, generally found in the urban environment, with a reduced surface area (less than 12m2). Constructed with lightweight materials "aluminum, plywood", are either fixed or mobile.  Figure 08 : Kiosk Bejaia Source : (MEKID and al,2017)	**The Markets:** These are the most popular commercial places in Algeria. They occupy public squares, streets, or even the urban wasteland divided into open and covered markets, daily or weekly, and do not follow any commercial principle. Until recent years, the state has established procedures for the establishment and construction of these spaces.  **Figure 10**: On Bab El Oued Algiers. Source (e-monsite.com/marche-de-bab-el- wadi-interior-jpg.jpg).

The major sales areas:

Supermarkets:

These are self-service retail spaces. Their surface area does not exceed 2,500 square meters, in Algeria these areas are generally confused with hypermarkets, we have not found examples that are strictly speaking supermarkets.

Figure 11: Supermarket –cheraga
Source (http://www.bledco.com).

Hypermarkets:

Are self-service retail spaces, appeared in Algeria thanks to the brand of Carrefour which opened January 16, 2006, the first hypermarket in Algeria Belouizdad, they offer a wide choice of products either food or non-food.

Figure 13: Hypermarket-ARDIS-Mohammedia-Algiers.
Source (http://www.algerie-focus.com/wp-content / uploads / 2013/07 / ardis.jpg).

Shopping centers :

Commercial spaces that contain a large number of stores, are located in urban areas, they have their own parking, and their surface is 5000 m2 minimum.

Figure 12: The-Mall coupole- Constantine .Source (http://www.pikasso.com/im g / fe_news / la-dome-constantine.jpg).

Shopping and leisure centers

The "Malls" : It is a multifunctional space that includes shops, restaurants and leisure activities, it is the new trends of shopping centers that serve to become poles of attractiveness for their radius of influence, the first center of this type of shopping center. 'Espace is the shopping and leisure center of Bâb Ezzouar

Figure 14: Park mall-Setif.
Source : (MEKID and al,2017)

Table 04: The Algerian typology of commercial spaces
Source: author

IV. Conclusion:

By analyzing the typology and the origin of the commercial spaces and the genealogy of their architectures we note that since always, each building is cut off from its external environment and seeks to magnify the customers. The technical exploits are used to divert the users and various scenes allow animating them. But today the design style of commercial spaces seems to be breaking with this approach; commercial spaces have begun to integrate into their environments. In this perspective, the commercial architecture should integrate with its surrounding landscape, to obtain a virtually non-existent envelope. The research should not be limited to a simple treatment of the facades and its surroundings.

CHAPTER FIVE

Analytical chapter

I.2 General Syntheses:

Park Mall Setif	Bab Azzouar	Vulcano Buono	Olympia 66
➢ A multidirectional traffic system, the user within this center may not use the same paths during his journey. ➢ Insufficient internal signage affecting the circulation and valuation of activities located away from the main entrance and main rooms. It should be noted that for the entrances at the disposal of the center, no entry has a signage sign including the center plans. Yet at the level of regulation, it is well indicated that	➢ An interior configuration reinforces the commercial function: clarity, cleanliness, straight aisles, qualitative treatment of the main entrance ...; ➢ A central channel playing a real social role, a main function of passage concentrating the flow of people in the center, ➢ A well organized and functional interior	➢ The architectural design of Volcano gave it a great dimension insofar as the design idea was an architectural volcano adjacent to a natural volcano, thus connecting nature and architecture ➢ Vulcano distinguished itself from other projects because it canceled the idea of exterior facades and created interior facades that were more pleasant than the usual facades. ➢ The superior vision of the project gives a look at the complementary relationship between architecture and naturalness, it is a green space along the project with a volcano crater representing more open internal facades. And the closure on the outside ➢ interior spaces clad in a beautiful natural stone with a warm color that cadences and characterize the annular path of the shopping arcade.	➢ The Olympia project has a unique design inspired by the local culture and has given a unique mountain in a dense urban fabric. ➢ The diversity of spatial and functional organization has led to the diversity of spaces in terms of form and number, ➢ Fun to visit internally in Olympia is unique: the shape of a carp gives curves that create a unique ride ➢ The shopping center depends on the renewable energy generated by the main source is the sun ... The solar panels are distributed at the roof, which must always be exposed to the sun

Table01: the synthesis for the analysis of four examples
Source: author

II. Programming:

II.1 the extraction of programs through the comparison of the examples:

Program proposed	Park Mall Setif	Bab Azzouar	Vulcano Buono	Olympia66
✓	Park car	Park car	Park car	Park car
✓	shop	shop	shop	shop
✓	restaurant and cafeteria	restaurant and cafeteria	restaurant and cafeteria	restaurant and cafeteria
✓	Cinema 7d	Cinema 7d	Cinema 7d	Cinema 7d
✓	Pharmacy	Pharmacy	Pharmacy	Pharmacy
✓	Banks	Banks	/	/
✓	Hypermarkt	Hypermarkt	Hypermarkt	Hypermarkt
✓	Service	Service	Service	Service
✓	cheek areas and Bowling	cheek areas and Bowling	cheek areas and Bowling	cheek areas and Bowling
✓	leisure	leisure	leisure	leisure
✓	administration	administration	administration	administration
✓	/	finesse center	finesse center	/
	Offices	/	/	/
	Hotel	/	Hotel	/
✓	conference room	conference room	conference room	/
✓	Ice rink	/	/	Ice rink
✓	rest areas	rest areas	rest areas	rest areas
✓	Atrium	Atrium	Atrium	Atrium
✓	/	Gym	Gym	/
	/	/	Sauna	/
	swimming pool	/	swimming pool	/
	/	/	Bar	/
	/	/	/	Garden Terrace
✓	Halls	Halls	Halls	Halls
	/	luxury apartments	luxury apartments	/

Table02: program proposed through the comparison of the examples
Source : Author

II.2 program proposed by Muhammadiyah:

Sector	Space	Area
Daily Trade sector	Clothes	250
	Looks	50
	The shoes	100
	Jewelry	50
	Toys	50
	House ware	50
	Perfumes	40
	Cosmetics	40
	Electronic devices	70
	Furnishing	70
	Phones	70
	Automatic	70
	machine tools	70
	Traditional tools	300
	Great market	50
	Sale of antique	25
	Flowers	25
	Tobacco	25
	Video tech	25
	Take photo	25
	Office services	25
	Newspapers	25
	Suite offer	25
	Baking	25
	Sell coffee	25
	Sell tea	25
	Chocolate factory	30
	Berber	50
	The ratio	44.5%
Culture and Liseur Sector	Cafeteria	50
	Pizzeria	100
	Internet café	50
	Candy	40
	Sundae	40
	Fast food	50
	Algerian restaurant	250
	French restaurant	250
	Agora	100
	Multi-activity hall	100
	Hall preparation	200
	The ratio	26.8%

Sector	Space	Area
Service sector	Office security and surveillance	20
	Information desk	25
	Air treatment center	25
	Devices maintenance	25
	Quantification and alarm	/
	Medical service	25
	Service elevators	20
	Warehouse	25
	Water processor	25
	The ratio	3.4%
Management Sector	Office guidance	70
	Secretary	25
	Director office	40
	The ratio	2.6%

Table03: program proposed by Muhammadiyah
Source: memory master, 2012

II.3 Final program:

sector	space	N°	A (m²)	sector	space	N°	A(m²)
Daily trade sector	-Hypermarket:			**Entertainment sector**	cafeteria	2	50
	General foodstuffs	1	100		restaurants	2	200
	Vegetables and fruits	1	100		internet cafe	1	100
	Meat and fish				game hall	1	100
	Milk and dairy	1	100		baking	1	50
	products	1	100		gymnasium for men	1	100
	Flour and cereals				center of finesse and	1	150
	Cleaning materials	1	50		massage for men		
		1	50		a steam bath for men	1	100
					gymnasium for women	1	100
					center of finesse and	1	150
					massage for women		
					a steam bath for	1	100
					women		
					conference room	1	300
					showroom	1	300
					cinema 7D	1	100
Trade sector	Men's dresses	3	30	**Social Service Sector**	Clinic	1	50
	Women's dresses	3	30		Pharmacy	1	50
	Kids clothes	1	25		Incubation	2	50
	Babes clothes	1	25		Prayer hall	1	50
	Men shoes	2	25		Office lost objects	-	50
	Women shoes	2	50		Bank	1	300
	Kids shoes	1	30		Postal distributor	1	100
	Toys	1	25		Cleaning service	-	-
	Traditional clothes	1	50		Travel agency	1	100
	Furniture	1	120				
	Jewelry	1	30				
	Gifts and perfumes	2	25				
	Cosmetics	1	30				
	Bags and caps	3	25				
	Wristwatch and	2	25				
	glasses						
	Electronically tools	2	30				
	House ware	1	100				
	Phones	1	30				
	Automatic media	1	50				
	Antiques	1	30				
	Men barber	1	25				
	Women barber	1	25				
	School tools	1	100				
	Library	1	80				
	Reading room	1	50				
	Sport clothes	2	30				
	Sports shoes	1	50				
	Sport tools	1	100				
	Cosmetics	1	30				

sector	space	N°	A (m²)
Administration	Manager's office	1	40
	Secretariat	1	25
	Accounting office	1	30
	Meeting room	1	80
	Archives	1	30
	Shops coordination and purchase office	1	30
Technical service sector	Office of security and surveillance	-	50
	Information office	-	50
	Device maintenance	-	50
	Storage	-	100
	Refrigeration rooms	-	100
	Car park	-	-
	W.C	-	-

Table04 : final program
Source : Author

III. climate of region :

Biskra has a desert climate. During the year, there is virtually no rainfall. The Köppen-Geiger climate classification is BWh. The average temperature in Biskra is 21.8 ° C. The rainfall here averages 141 mm.

1. Situation:

Biskra, called the "Queen of Zibans", is a city located 470 KM southeast of Algiers. County town of Wilaya with an area of 21,671 Km

2. Average temperatures and precipitation:

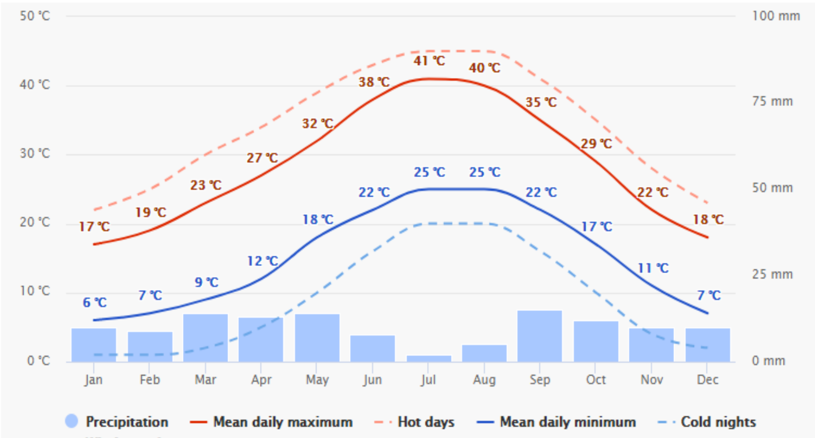


Figure01: the average temperatures and precipitation
Source: www.meteoblue.com

The "mean daily maximum" (solid red line) shows the maximum temperature of an average day for every month for Biskra. Likewise, "mean daily minimum" (solid blue line) shows the average minimum temperature. Hot days and cold nights (dashed red and blue lines) show the average of the hottest day and coldest night of each month of the last 30 years. For vacation planning, you can expect the mean temperatures, and be prepared for hotter and colder days. Wind speeds are not displayed per default, but can be enabled at the bottom of the graph.

The precipitation chart is useful to plan for seasonal effects such as monsoon climate in India or wet season in Africa. Monthly precipitations above 150mm are mostly wet, below 30mm mostly dry. Note: Simulated precipitation amounts in tropical regions and complex terrain tend to be lower than local measurements.

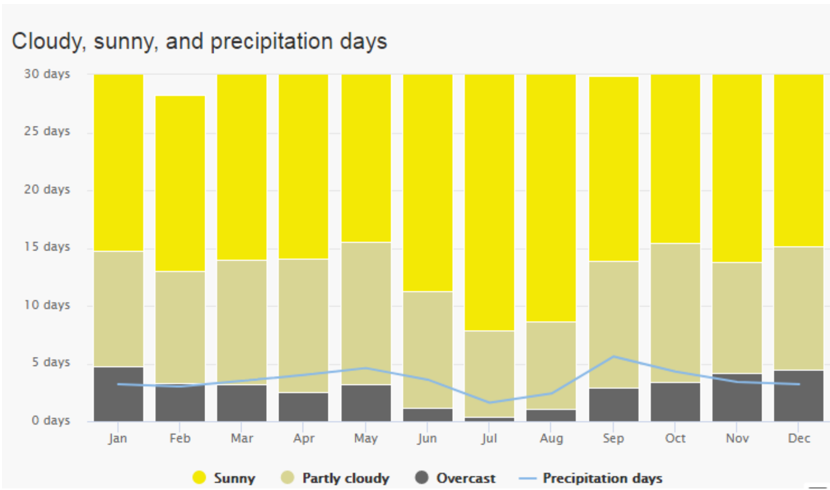


Figure02: graph of the monthly sunny and precipitation days
Source: www.meteoblue.com

He graph shows the monthly number of sunny, partly cloudy, overcast and precipitation days. Days with less than 20% cloud cover are considered as sunny, with 20-80% cloud cover as partly cloudy and with more than 80% as overcast. While Reykjavík on Iceland has mostly cloudy days, sossusvlei in the Namib Desert is one of the sunniest places on earth.
Note: In tropical climates like in Malaysia or Indonesia the number of precipitation days may be overestimated by a factor up to 2.

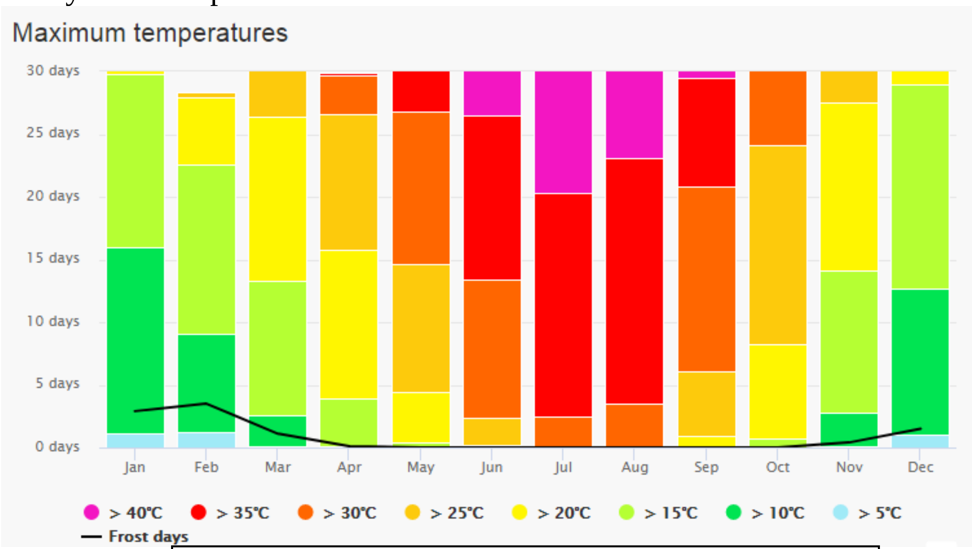


Figure03: diagram of the temperature for Biskra
Source: www.meteoblue.com

The maximum temperature diagram for Biskra displays how many days per month reach certain temperatures. Dubai, one of the hottest cities on earth, has almost none days below 40°C in July. You can also see the cold winters in Moscow with a few days that do not even reach -10°C as daily maximum.

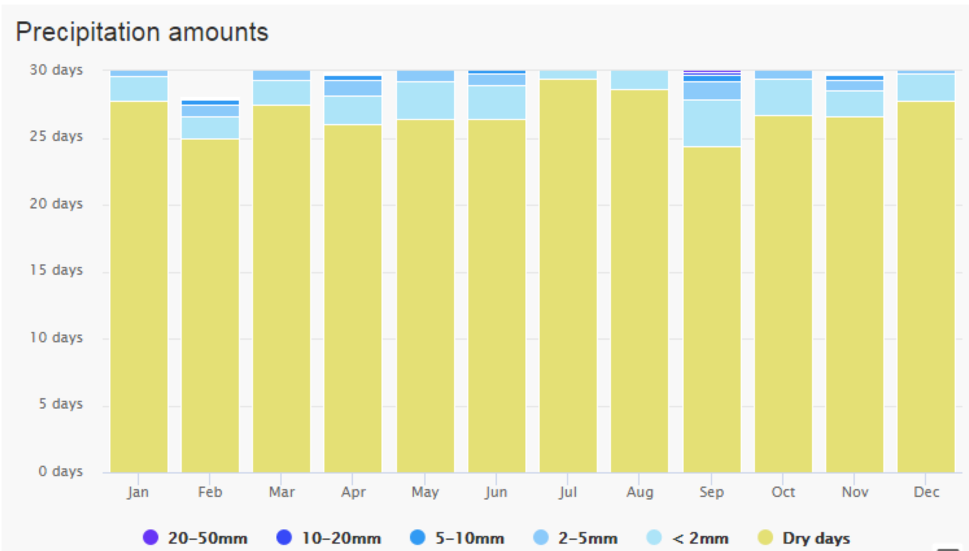


Figure04: diagram of the precipitation amounts for Biskra
Source: www.meteoblue.com

He precipitation diagram for Biskra shows on how many days per month, certain precipitation amounts are reached. In tropical and monsoon climates, the amounts may be underestimated.

4. The winds:

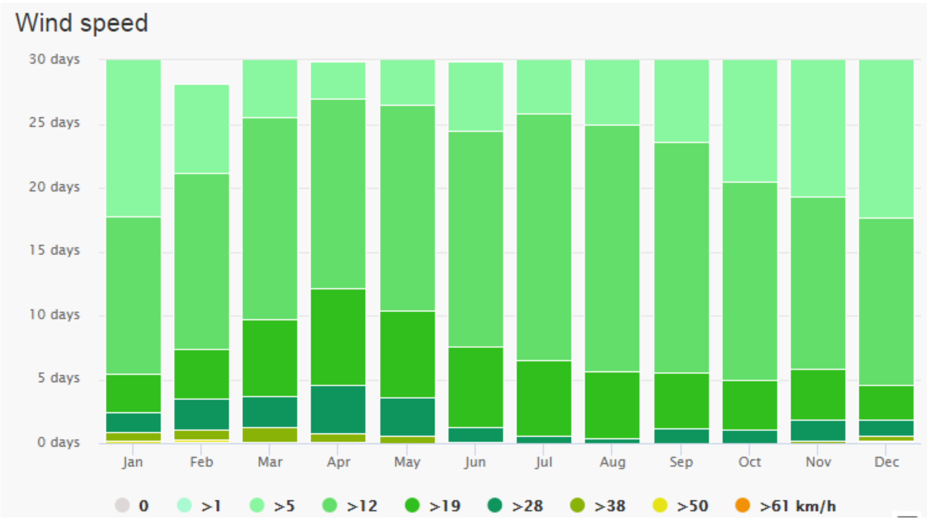
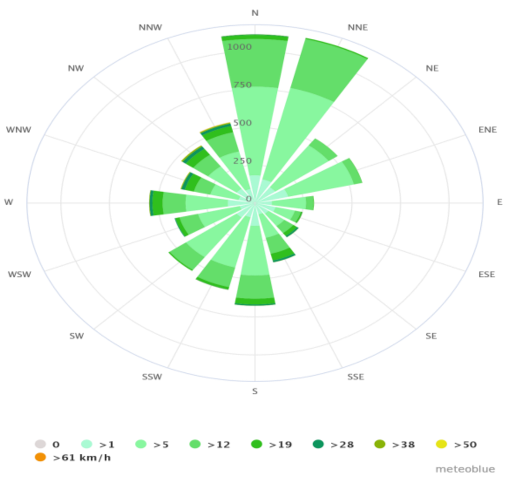


Figure05: diagram wind speed for Biskra
Source: www.meteoblue.com

The diagram for Biskra shows the days per month, during which the wind reaches a certain speed. An interesting example is the Tibetan Plateau, where the monsoon creates steady strong winds from December to April, and calm winds from June to October.
Wind speed units can be changed in the preferences (top right).



The wind rose for Biskra shows how many hours per year the wind blows from the indicated direction. Example SW: Wind is blowing from South-West (SW) to North-East (NE). Cape Horn, the southernmost land point of South America, has a characteristic strong west-wind, which makes crossings from East to West very difficult especially for sailing boats.

Figure06: the wind rose for Biskra
Source: www.meteoblue.com

5. Conclusions:

Biskra has a desert climate, therefore, heat and wind are among the most important indicators to be studied and detailed in all seasons. It is important to know these climatic data for use in architectural designs to better adapt to climate.

Source: http//; www.meteoblue.com

IV. Field analysis:

IV.1 the reason for the choice of ground:

The presence of terrain in the urban fabric and thus will be an important attraction in the urban environment
The intensity and diversity of commercial activities support the presence of the project in their environment
Good accessibility thanks to several mechanistic roads and railways
Near the ground of some permanent and temporary markets

Figure07: situation of the ground
Source: Google earth 2017

2. Situation:

The ground is located in the city of Biskra in the Hay Mujahedeen district near the old train station

Figure08: situation of the ground
Source: PDEAU BISKRA2015

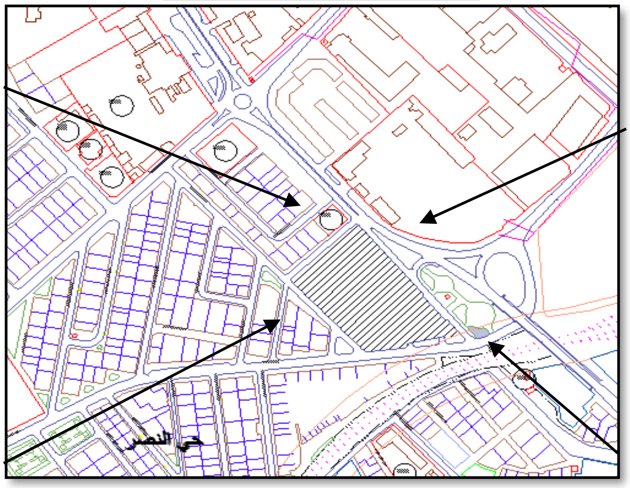
3. Limits of ground:

Souk Alfalah

Palm Clinc

habitats

habitats

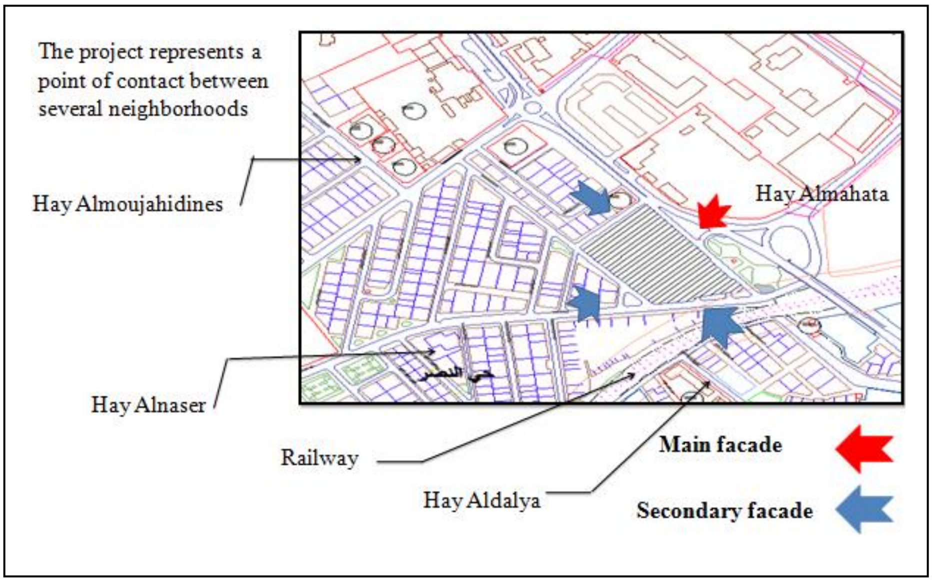


Factory of traditional industries

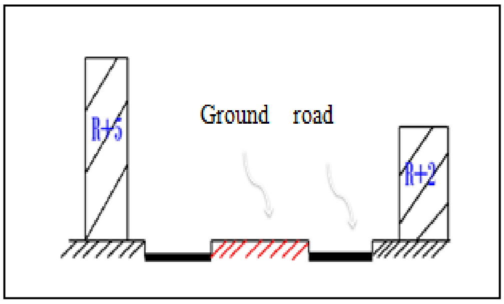
Financial Control of Biskra

4. The visual field relationship with the city:

The project overlooks four facades and there is a main and the other breast of an urban fabric in great density.

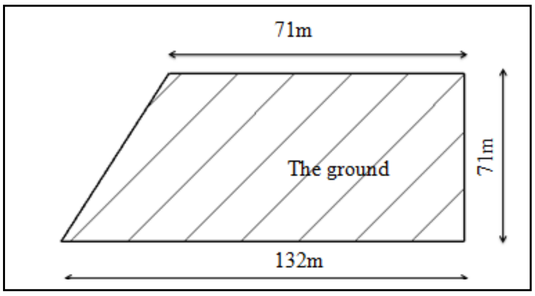


The ground is flat... Surrounded by buildings of varying heights up to (R + 5)



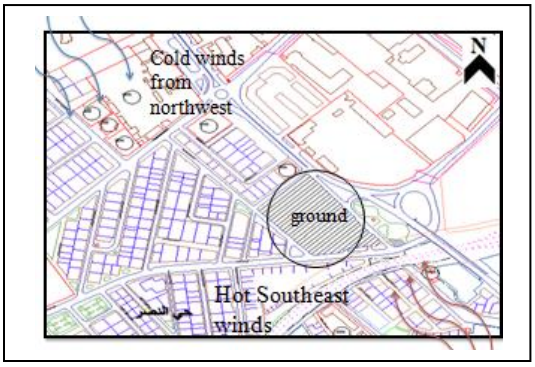
5. Ground area:

The shape of terrain is rectangular; the ground area is 8100m²
Surface is sufficient for a project that includes a parking on the basement. The project also takes the horizontal form of elevations to emerge in their urban environment



6. Bioclimatic analysis of the site:

The Terrain is exposed to two types of wind: hot on southeast in the summer and cold northwest in the winter
We must therefore take care of the facades exposed to the wind



The ground is located in an urban environment and is therefore partially protected by the surrounding buildings The terrain is located in a dense urban center, so it is protected from sunlight during the morning, especially in winter and part of the terrain is not exposed to the sun in the evening

7. Climate site data:

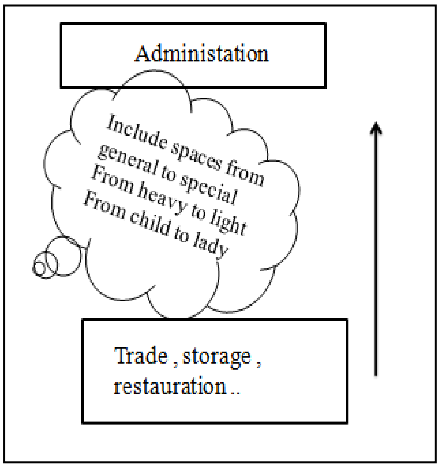
Biskra has a desert climate. During the year, there is virtually no rainfall. The Köppen-Geiger climate classification is BWh. The average temperature in Biskra is 21.8 ° C. The average in this year is 141 mm

Données	Valeur
Température moyenne annuelle:	23.1°C
Température maximale moyenne annuelle:	28.9°C
Température minimale moyenne annuelle:	17.0°C
Humidité moyenne annuelle:	41.2%
Précipitation totale annuelle:	49.25 mm
Visibilité moyenne annuelle:	9.6 Km
Vitesse moyenne annuelle du vent (Km/h):	13.8 km/h

8. Synthesis:

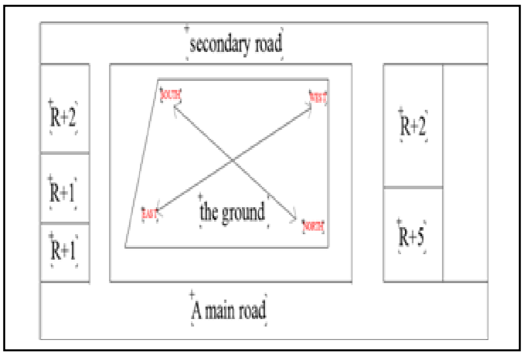
- ❖ Good accessibility and their ease is a strong element in the success of the project because the land represents the point of contact between several neighborhoods such as: Hay Al-Nasr. Hay Al Mujahedeen, and Hay al Mahatta ...
- ❖ The presence of ground in the urban fabric contains several public equipments and therefore the influx of residents to these equipments, especially the temporary market located in the old station, giving the project a clear mentality

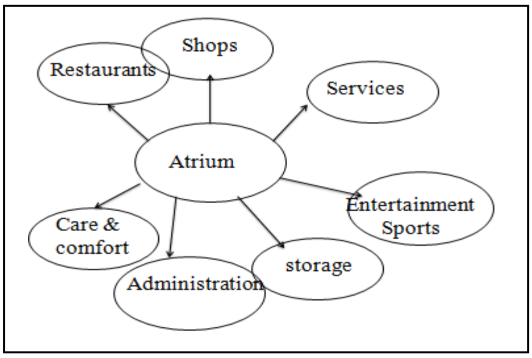
V. The passage elements:



From the analysis of examples:

- Hierarchy of space:
  - From general to special
  - From heavy to light
  - From child to lady
- project flexibility
- Hierarchy of function
- Continuity between the environment and the project
- Project monumentality in the urban fabric
- From the analysis of field, we conclude that :
- The urban environment with different heights of five levels will work on the project monumentality the directionality of the project to verticality. **Project more then (R+5)**





VI. The goals:

- Change the traditional mode of design of shopping centers in Algeria
- Improve user comfort
- Improve the environmental awareness of the citizen
- Reduce the environmental impact in the project and the use of renewable energy
- Adaptation in environment
- Improve the mood (natural lighting in the space)

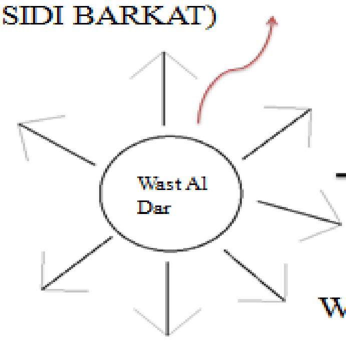
VII. Relationship between the project and the theme:

The commercial centers are among the most vital economic public facilities, which represent the urban facade of the city. In order to make these centers operate efficiently, they need to be equipped and designed, in a way that allows them to perform their function fully to adapt to their environment and meet the needs of the consumer... Therefore desert areas are among the areas where projects are difficult to adapt to the climate, increasing energy consumption and reducing the sense of comfort for the use .The adaptive architecture is based on a new definition of comfort that integrates the issue of dynamic architecture and occupant participation argues that occupation is a major aspect of the energy performance of a building while the occupant seeks to restore a state of comfort. In this perspective, the adaptive architecture gives the occupant an active role in achieving comfort and energy performance of the building by providing opportunities for adaptation. Argues that these passive opportunities and a freedom of choice they give encourage interaction between an active and responsible occupant and their built environment, and foster health, comfort and productivity. This theory aims at occupant comfort and energy saving through behavioral adaptation which, with the expectation, has much greater effects than mere acclimatization. Indeed several studies have shown that the range of thermal and visual comfort of an occupant increases according to the adaptation opportunities offered.

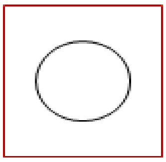
I. The conceptual idea:

We will choose the old Biskra as the first nucleus in the conception of the project idea

we use the principle of (wast El Dar) as a traditional architecture and then develop this idea
we chose (wast Al Dar) for their spatial organization and the distribution of spaces there is a center and (BAB ALDHARB, BAB ALFATH, ALMSID, RAS ALKARIA MAJNICH, KADACHA AND SIDI BARKAT)



We

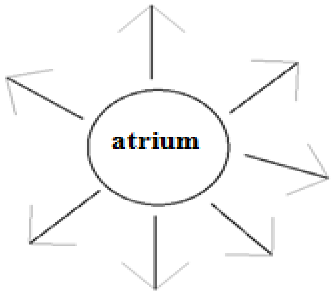


Center - based distribution

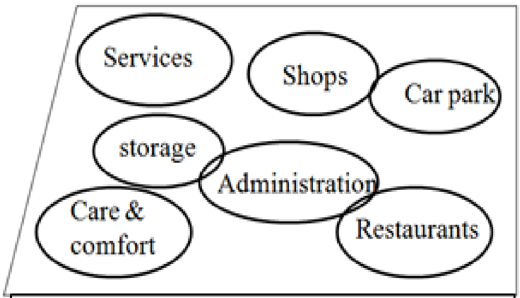
Drop the idea on the project

We distribute the different sectors of the commercial center through the center to different spaces: trade, storage, entertainment, parking, management and services, etc.

Distribution element

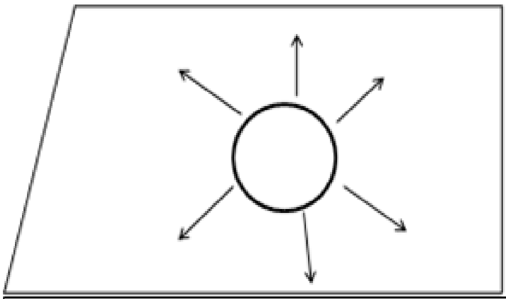


Step 01:



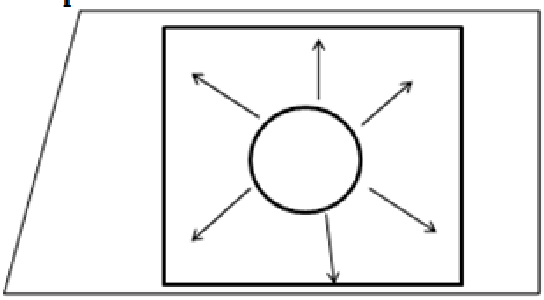
distribution of zonings according to their needs

Step 02:



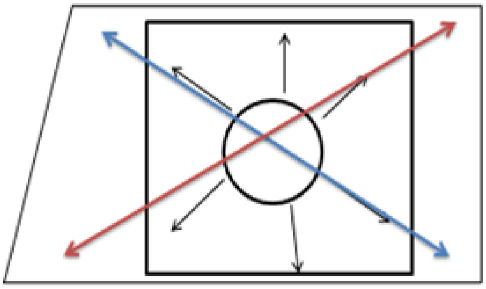
Representing the center in a circle in the middle of the field

Step 03:



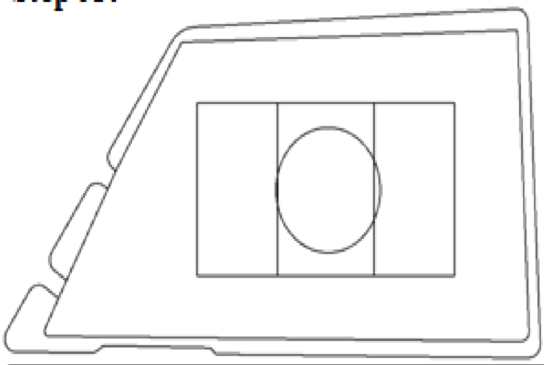
The distribution is rectangular so that the distribution is different from one side to the other

Step 04:



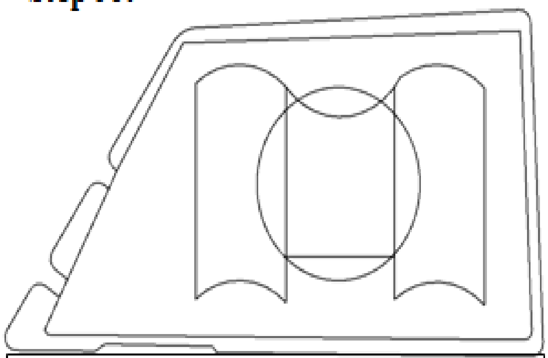
Define routing hubs to know how to manage facades in advance

Step 05:



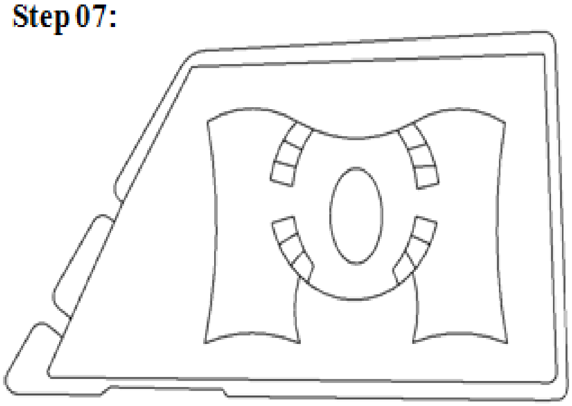
projection of the desired shape in the field with real dimensions

Step 06:



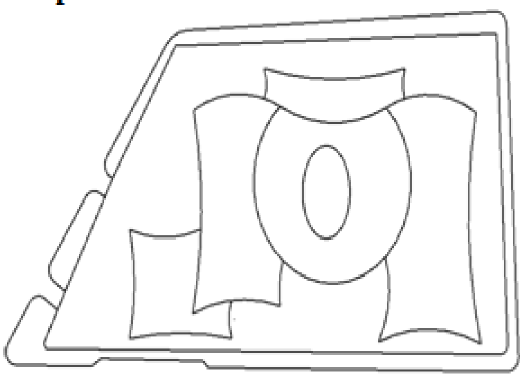
Bend sharp corners to break a more flexible movement

Step 07:



We have shape with best flexible movement and similarity

Step 08:



Change sizes and volumes to break the overall similarity

THE PROJECT

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