FLEXIBLE SUSTAINABLE ARCHITECTURE: Major challenges between North and South

ABSTRACT: What does man need for survival? First, basic human needs, such as water and food then a shelter - the indoor created since the beginning of Humankind to protect humans from a harsh outside climate. Furthermore, since we spend most of our time indoors, that space needs to meet basic key comfort parameters, such as temperature, CO2 levels and relative humidity, keeping good daylight conditions.

The placement of buildings in different climatic regions, lead to different answers and different key comfort parameters, adaptations and implications and it is necessary to go back to basics in order to understand a design from its initial phases together with the importance of passive solutions when achieving an integrated holistic sustainable product.

One option is to consider a flexible approach like using shipping containers. A shipping container is, from its definition “a large metal box of a standard design and size used for the transport of goods by road, rail, sea, or air”. However, this thesis suggests it can be recycled into special solutions: to design temporary housing.

Flexible sustainable architecture is a challenge that can be reached by giving more having less, integrating solutions, focusing on bioclimatic approaches that adapt to different contexts, designing for shorter spans of time - temporary - without excluding the normal human tendency to be sedentary, allowing the house to become, in time, permanent.

This thesis concludes that one building solutions cannot meet habitable and sustainable parameters proposed if implemented from North to South rather, the design needs to be though and adapted from its initial phases to the place where it will belong.

KEYWORDS: Shelter; Sustainability; Shipping Containers; Climates flexible solutions; North and South; temporary

1 INTRODUCTION

Climate and extreme events “The single most pressing global issue of the current era is climate change. Politicians and policy makers may argue otherwise, but it must be clear that without addressing climate change all other issues become irrelevant. Poverty, disease, war and economy are not without consequence, but must be viewed through the less of climate change.” (Douglas 2008) What happens when the problem of losing our home strikes (North) or the namely “developed world” (South)?

Need temporary or permanent Some architects have been involved in real problems for more than 100 years and humanitarian causes are convincing a lot more to start acting. A need for shelter and for it to need to be sustainable is on today’s agenda. Those two are indispensable due to the never stopping world, its changes and constraints. More critical could be in specific situations like refugees.

Shouldn’t the solution be a comfortable space that would work temporarily and allow to be permanent also? Housing units should be answering today’s sustainable needs - Economically, Socially and Environmentally, but what about keeping architectural and human Aesthetical value? Can sustainable architecture be flexible? Moreover, can flexible be a sustainable product?

Dimension of the problem

- “The UN High Commissioner for Refugees estimates that there are 9,200,000 refugees in the world in 2004” (UNHCR United Nations High Commissioner for Refugees 2005)
- “More than 2,200,000 people die from preventable water and sanitation – related diseases each year” (United Nations Human Settlements Program 2003) Providing a shelter and basic needs such as proper sanitation and clean water is essential and it concerns supply human basic needs- the minimal.
- “47% of the World refugees are female are children (under 18) (UNHCR United Nations High Commissioner for Refugees 2004) This place, this unit, this house will most definitely shape people so young to the person they will become one day. The place needs to be a safe place where nothing bad can happen and where people – and mostly young people- need to be able to dream and be able to feel vulnerable.
- “200,000,000 people have been affected by natural disasters and hazards in the last decade”(Ahmed et al. 2011) Nature is uncontrollable and life can change drastically from one moment to another, not looking at colour, age or social status.
- “In 2003 there were 38 different protracted conflicts in the world, accounting for some 6 230 000 refugees” (UNHCR United Nations High Commissioner for Refugees 2004) Not everything referred as disasters need to mean natural causes.

1 The present essay is based on the Master Dissertation entitled “Flexible sustainable architecture: Major challenges between North and South”, supervised by the Professor Manuel Pinheiro.
The average duration of major refugee situations has increased from 9 years (1993) to 17 years (2003) (UNHCR United Nations High Commissioner for Refugees 2004) – The housing unit needs to be able to be flexible to life unpredictable situations: at the same time that is temporary yet durable, it leaves space to become permanent.

For the past years up until now -and increasing over time- due to personal or cultural issues or to the occurrence of natural disasters, the need for temporary houses has exploded. With an increase of the complexity on the interplay between individual circumstances and outside factors- out of a person’s direct control – one’s need for shelter is a primary need. The project focuses on human basic needs. A good quality design is not a luxury, but a need.

**Understand importance of flexibility and low cost** To overcome a need to be flexible and adapt to change, it is my belief that architecture should redraw inspiration from history – portable and movable solutions, easily erected shelters and buildings that are built according to their context.- as an example for understanding and studying the human’s most basic needs. This idea can open windows towards helping people without a home. “It is the obligation of architects to provide dignified housing for the poorest communities, yet few architects have shown an interest in making such building the heart of their practice. Ethically it is appalling that architects remain uninterested in and out of touch with building for the most vulnerable and impoverished people. [...] Can an architect coming out of one of the world’s excellent architecture schools create a good shelter on that budget (250 dollars)? Will it be decent, culturally appropriate, durable and safe? Will it be aesthetically pleasing, environmentally responsible and ethically made?” (Ahmed et al. 2011)

The proposal concerns the study of comfortable spaces satisfying the basic need for the ordinary human beings that still allows improvements and upgrades – following the idea “add as you grow”. Nevertheless, those needs ought to be studied in more than one context to verify how much the design would stand as flexible and still sustainable. The following section will discuss concepts from sustainability, to flexibility, climate and their specifications, comfort, human basic needs , etc. and in order to understand the feasibility of the concept and its integration on today’s world available solutions.

### 2.1 SUSTAINABILITY AND FLEXIBILITY

“While the motivation to live sustainably dates back to ancient times, its vocabulary is but three decades old.” (Thiele, 2013) Even during vernacular architecture, there were attempts of sustainable practice -as it is referred in “Arquitectura sustentável em Angola [Manual de boas práticas]” - when constructive techniques are the product of years of knowledge being transferred from generation to generation.

“A practice (...) is not sustainable if it undermines the social, economic, or environmental conditions of its own viability”. (Thiele, 2013) The expression “green architecture” and the word “sustainability” have constantly been used in the last decades. It was defined in the report “Our Common Future” known as the “Brundtland Report” from 1987. This report do among other things conclude that a; “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. (World Commission on Environment and Development 1987) Nevertheless, sustainability extends moral concern not only across expanses of time, but also across geographic space. To practice sustainability is to move beyond the national, political, economical, ideological, racial, ethnic, and gender borders and cleavages that fragment and divide us” (Thiele 2013) To live in a sustainable way is to live in an holistic way, where the different parts of equation are balanced.“To truly be effective, sustainable architecture must go beyond checklists and material choices. Architecture needs a cohesive and holistic sustainable philosophy, a driving force behind the design and construction of buildings. Architecture needs sustainable aesthetic philosophy.” (Douglass 2008)

“Human beings are flexible creatures. We move about at will, manipulate objects and operate in a wide range of environments.” (Kronenburg, 2007) Not too long ago, during evolution, human survival as species was due to the man capacity of changing, adapting and moving. Man and shelter would shape each other. Changes in a cave’s shape, for example, could happen and additions of other chambers could be done on the simplest caves – added to one side or the other, above or below and behind the main space, adapting to the existing needs. “A simple cave could be enlarged, changed in shape, have another chamber added to it behind, to one side, above or below, linked by ramp, stair or doorway, and then another chamber beyond that, and yet another, perhaps, in a different direction, or branching off from one of the new chambers” (Kahn & Easton 1973) Even though man has, is most places and cultures, lived a sedentary life, flexibility may be raising as priority in human development. Economic, social and technological changes, based on the cheap and fast transportations and the wide web, are encouraging, if not even forcing, a new form of a nomadic life and existence. Is nomadic the new sedentary way of living? “Flexible architecture adapts to new uses; responds to change rather than rejects it.” (Kronenburg, 2007). Architecture is kinetic instead of being steady. Almost like a creature that...
never sleeps, it moves, it changes. Flexible architecture is form and shape that is innovation, multi
disciplinary and it is on the edge of nowadays-contemporary matters and questions.
To overcome a need to be flexible and adapt to change, it is my belief that architecture should draw
inspiration from history – tents, primitive shelters, caravans, portable and movable solutions and
nomads. In order to understand and study the human’s most basic needs and the adaption to specific
conditions such as climatic or natural human growth.
NOMADS AND SEDENTARS Nomadic life, or more precisely nomads, is a good example of economy of
space, lightness of materials and efficiency in solutions. The Australian architect Glenn Murcutt is an
example of this “going back to basics”, through his designs that relate and focus on basic human needs
together with the character of place. His buildings, erected on the most amazing and difficult contexts
and climates, count on the use of materials easily produced, his close attention to the movement of the
sun, moon and seasons. He is able to exemplify a dwelling in its simplest forms.

Flexible buildings are intended to respond to changing situations in their use, operation and location”
(Kronenburg, 2007). The possibilities with a flexible building are immeasurable and endless. For
example, a house designed to allow and propose changing occasions to its inhabitants. Flexible
buildings can evolve from a reality to another and accommodate new purposes and needs, such as for
example, if a building, designed for a specific number of people –for example one or two- needs to
suddenly give an answer and allocate five more. Maybe it is a building that fits individual needs in the
present moment, a “now”, but that allows investment, adaption and change along diverse phases of a
human life. Flexible is the architecture that adapts to change and that moves, transforms, is flexible and
interacts, as an organism always alive. A possibility of architecture, that depends not only on its own
form, but also in the shifting arrangements of its neighbouring environment. These temporary houses
withdraw inspiration from other examples from the past, such as caravans , trains, boats and other
movable structures, in order to investigate how structures designed to be in constant motion, work.
Flexible sustainability departures from the other fields within sustainability - referred before- in the way it
is social, economic, aesthetic and technical sustainability. Furthermore, it adds the qualities of something
that adapts to change, a building that results for cheap but comfortable solutions, a building that
accommodates various purposes, and that evolves and is shaped by its users.
It is not static, more, it is movable, and it is flexible, it is a sustainable product.

2.2 NORTH Vs. SOUTH: THE CLIMATES
In classical Roman religion a genius loci was the protective spirit of a place. “In classical times, it means
not so much the place itself as the guardian divinity of that place. In the eighteenth century the Latin
phrase was usually translated as ‘the genius of a place’, meaning its influence. "We now use the current
version to describe the atmosphere to a place, the quality of its environment.” (Jivén & Larkham, 2003)
Described in the book Nightlands, by the Norwegian architect and phenomenologist Christian Norberg-
Schulz , the genius loci – “A sense of place” - enlightens and relates to more than geographic place: it
includes the site, - it is the physical context but also the social and cultural context. It is a realm in its
general idea. Despite globalization, a design and building, has to have the ability to be general and
international, but regional and answer of local conditions: “ A manifestation of the environment in which it
is placed.”. (Norberg-Schulz 1996) “Global inequity, and the tension between industrialised countries
(‘The North’) and less economically developed countries (‘The South’), have been defining factors in the
evolution of international environmental policy, including the UN Framework Convention on Climate
Change (UNFCCC) and its Kyoto Protocol”. (Boydell 2008) North and South Hemispheres, different sun
path, how to place the house facing North or South. There is more solar radiation when closer to the
Equator line than there is further – as seen bellow in the quote relating to a local north VS south- Europe.
Europe can be used as a smaller scale comparison to the expression North vs South :“The climatic
zones in Europe range from the Mediterranean in the South to the Arctic in the North. While there is still
snow in Lapland, Sicily might already suffer from summer heat. And while it’s raining again on the
Shetland Islands, Andalusia is going through just another dry spell”. As it is generally hotter in the South,
insulation must be good but not necessary as thick as in the North. Also triple glazing is not required in
most cases.” (ISOVER 2007b)

2.3 INTEGRATED HOLISTIC APPROACH TO SUSTAINABILITY
It is possible to establish a balance between what is built and the climate where it is placed, as Manuel
Correia Guedes (DATA) refers “through the use of a number of strategies – referred and bioclimatic or of
passive design”. The focus areas concerning environmental sustainability are all about creating high
thermal comfort (experienced temperature, heating and cooling) visual comfort (light and shading), high
air quality (fresh air, removal of pollution, surplus heat etc.) and architectural quality. All these
circumstances are affected by the passive qualities of the building, which deals with qualities regarding
geometry, design and choice of materials and affect the light, temperature and air in the building. (Andersen et al. 2009)

INTEGRATED DESIGN BUILDING By working with an the Integrated Design Process, energy consumption, indoor environment, functional aspects, architecture and design can be merged. “The Integrated Design Process is a synthesis of the pedagogical method (PBL), the students’ personal learning efforts, and the professional learning components from architecture and selected components from engineering” (Knudstrup 2004) This method is divided into five phases. The phases are not to be followed chronologically, but more iterative by jumping back and forth in-between them, which enables on going evaluation and thereby ensuring a possibility for optimizing the project.

MIXED METHODS Mixed methods in social research is also crucial - reason to be referred briefly below.

The conflict between the quantitative and the qualitative, expressed in Alan Bryman’s theory brings qualitative and quantitative conclusions together, allows an insight that cannot be reached in other way. A fusion of these two approaches may help clarify each one, while understanding both. Architecture is about combining engineering of construction with aesthetics.

INTEGRATED ENERGY DESIGN “In a Integrated Energy Design process focuses firstly on achieving as much comfort as possible through the passive qualities, (second circle of the chart). Subsequently, focus will be on supplementing with as few but efficient active qualities as possible in terms of installations, adjustments and other technical systems (Inner circle of the chart)” (Andersen et al. 2009) “Sustainable design is passive first,” says Duncan Phillips of RWDI. “If we have to introduce a system to solve something, it’s because we haven’t solved it passively.”

2.4 SHIPPING CONTAINERS: FROM USE TO REUSE

There are several reasons why containers are a reasonable and realistic choice skeleton for housing purposes. The author Jure Kotnik describes the reasons why shipping containers are more than interesting but logical choices: “Containers have many characteristics that make them convenient for use in architecture. They are prefabricated, mass-produced, cheap and mobile. Because they are compatible with practically every transport system, they are easily accessible all around the world. They are strong and resistant, while also being durable and stackable. They are modular, recyclable, and reusable.” (Kotnik 2008). “Since the majority of the world’s goods are manufactured in the Far East and shipped to the West, Western countries import far more containers than they export. It costs approximately $900 to ship back an empty container to where it came from, which means that it is usually easier to buy a new container in the country of origin rather than ship them back from the Western countries”. (Kotnik, 2008).

“Also, construction projects with containers typically use no groundwork excavation processes, are quick to set up and complete, and generate less waste than traditional construction projects”. (Kotnik, 2008).

“Human beings are flexible creatures. We move about at will, manipulate objects and operate in a wide range of environments” (Kronenburg, 2007)

2.5. HUMAN BASIC NEEDS

“BACK TO BASICS” The basic is forgotten, what is really needed is hidden and human beings are constantly being blinded by what is desired and superfluous. What happened when instead of choosing to live with less, someone is put into a situation where there is nothing to be done, where money doesn’t exist, where everyone is equal? “Scientists are to outline dramatic evidence that global warming threatens the planet in a new and unexpected way – by triggering earthquakes, tsunamis, avalanches and volcanic eruptions.” (McKie, 2009) “Water is essential for life, health and human dignity” (Red Cross, Red Crescent Movement, & NGOs, 2013) “Human rights are rights inherent to all human beings, whatever our nationality, place of residence, sex, national or ethnic origin, colour, religion, language, or any other status. We are all equally entitled to our human rights without discrimination. These rights are all interrelated, interdependent and indivisible.” (United Nations Human Rights, n.d.)

ABRAHAM MASLOW – HUMAN NEEDS: The two lowest levels of the pyramid (The first level, at the bottom of the pyramid, consists of our short-term basic needs, also known as physiological needs: food, water, warmth, sex. The second level consists of longer-term safety needs: security, order, stability.) are important to the physical survival of the organism. Then, once we have our basic physical and safety needs sorted, we feel more ready to share ourselves with others and accomplish things in the world.

Most people can readily identify with these common levels of motivation. (Barry, 2010)

2.6 INDOOR CLIMATE AND AIR QUALITY

“ In industrialized countries about 90% of the time is spent indoors. The ambient parameters affecting indoor thermal comfort are air temperature and humidity, air velocity, and radiant heat exchange within an enclosure. In assessing the thermal environment, one needs to consider all ambient parameters, the insulating properties of the occupants’ clothing, and the activity level of the occupants by means of heat balance models of the human body. Apart from thermal parameters, air quality (measured and
perceived) is also of importance for well-being and health in indoor environments."

Daylight and ventilation by windows are inseparably connected to indoor climate. Indoor climate encompasses all the elements: temperature, humidity, lighting, air quality, ventilation and noise levels in the habitable structure. Buildings provide shelter, warmth, shade and security; but they often deprive us of fresh air, natural light and ventilation. Although we spend our time indoors, we are still “outdoor animals”. The forces, which have selected the genes of contemporary man, are found in the plains, forests and mountains, not in centrally heated bedrooms or ergonomically designed workplaces. We have adapted to the life indoor, but our gene code is still defined for outdoor life. Sick building syndrome, winter depressions, asthma, allergies, etc. are symptoms linked to the quality of the indoor environment as regards our biological needs. It is imperative that buildings and spaces where we spend much of our time are designed with those needs in mind; going back to nature, with natural ventilation and natural lighting." (Velux Group, 2010) "It is all about the sun; without solar radiation there will be no light, no wind, no heat, no life. And the solar radiation reaching the ground is far larger than the energy needed. Solar energy is often viewed as a set of niche applications with a useful, but limited potential. "(Perez, 2009)

"IAQ is about what we breathe. IEQ, more comprehensively, is about what we breathe, see, hear, and feel inside a building. IAQ is part of indoor environmental quality (IEQ), which includes IAQ as well as other physical and psychological aspects of life indoors (e.g., lighting, visual quality, acoustics, and thermal comfort). (KMC Controls, 2014) “For each location the lowest primary energy demand is achieved by the building with light from the windows. The energy demand of the building without windows is approx. 5 times higher than the one with windows, when using electrical light to reach the same light levels. Windows are low energy light sources (Wargocki et al., 2002). "The air humidity usually only has a small influence on the human perception of the air quality, and therefore the recommended interval for the relative air humidity is also relatively large and is between 30-70 %. “(Andersen et al., 2009). "To eliminate most complaints, total indoor carbon dioxide should be reduced to a difference of less than 600 ppm above outdoor levels. NIOSH considers that indoor air concentrations of carbon dioxide that exceed 1,000 ppm are a marker suggesting inadequate ventilation.” (NIOSH, 2013)

3. ONE DESIGN AND FOUR CLIMATES: CASE STUDY 1

The point of departure is the idea of thinking globally, while the point of departure is the reflection upon how thinking in order to study some different conditions, the project was applied, studied and calculated in 4 different climatic zones — Arid, Tropical, Cold (Temperate) and Mediterranean, considered as the extremes that need to be taken in consideration. Those 4 climates are exemplified by 4 countries: Saudi Arabia, Malaysia, Denmark and Portugal, respectively.

INSIDE WRAPPING - INSULATION UNIT The insulation need was studied and analysed according to the architectural parameters – related to how much free space the inside would have after adding inside walls- and the impact resulting on adding specific thickness of plywood and insulation inside. This process of dimensioning and designing the inside “wrapping” elements needed a very balanced compromise between engineering and architecture and resulted on the use of an insulation + wood unit of 100 mm - for walls and roof. Those 100 mm of “extra wall” represent 85 mm of Rockwool insulation + 15 mm of plywood.

Table 1- Results for the thermal resistance of the container wall before when it is only a steel wall, and after when the inside unit is added. (Own table based on results when carrying Bsim simulations)

<table>
<thead>
<tr>
<th></th>
<th>External wall A (Only steel)</th>
<th>External wall B (Steel+ inside unit)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dist d (m)</td>
<td>λ (W/mK)</td>
</tr>
<tr>
<td>Plywood</td>
<td>-</td>
<td>0,13</td>
</tr>
<tr>
<td>Insulation (rockwool)</td>
<td>-</td>
<td>0,0150</td>
</tr>
<tr>
<td>Steel</td>
<td>0,0018</td>
<td>54</td>
</tr>
<tr>
<td>Resistance, out</td>
<td>-</td>
<td>0,04</td>
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<tr>
<td>Σ</td>
<td>0,0018</td>
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<tr>
<td>Uwall= 1/ Σ R</td>
<td></td>
<td>5,88 W/ m²K</td>
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</tbody>
</table>

THE BOARD For the final design, as explained before, plywood was the material decided upon, for all the inside walls, roof and floor, covering the space in all directions: x, y and z.
PLANS AND OPENINGS

The plans are flexible and they are a result of a division between wet areas of the house and dry. (Figure) The wet area of the house is related to the place where sink or shower is and for that reason the kitchen and bathroom. The furniture is movable, flexible and adaptable, relating to the rest of the design and concept. The plans are clean of unnecessary additional things. The only physical division in scale one and two is the wall to the bathroom, so that the plan does not seem even smaller for those living there.

Table 2 - 24H (Above) Average calculations (Below) Bsim results for steel container with inside basic unit

<table>
<thead>
<tr>
<th></th>
<th>Rel. Moisture (%)</th>
<th>CO2 (ppm)</th>
<th>Hours &gt; 20°C</th>
<th>Hours &gt; 24°C</th>
<th>Hours &gt; 26°C</th>
<th>Hours &lt; 20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portugal</td>
<td>59,4</td>
<td>950,8</td>
<td>67,5 %</td>
<td>45,2 %</td>
<td>34,3 %</td>
<td>32,5 %</td>
</tr>
<tr>
<td>Malaysia</td>
<td>45,5</td>
<td>992,8</td>
<td>100%</td>
<td>100%</td>
<td>99,9 %</td>
<td>0,0 %</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>22</td>
<td>954</td>
<td>93,8 %</td>
<td>89,9 %</td>
<td>76,9 %</td>
<td>6,2 %</td>
</tr>
<tr>
<td>Denmark</td>
<td>70,9</td>
<td>943,8</td>
<td>29,6 %</td>
<td>11,1 %</td>
<td>5,6 %</td>
<td>70,4 %</td>
</tr>
</tbody>
</table>

OUTSIDE EXPRESSION INTEGRATED WITH INSIDE: OPENINGS AND SHADING, SECOND SKIN

Sean Godsell is one of the architects that the project redraws inspiration from. The listing, wooden elements placed all around the building close to each other, provides an architecture expression to it together with the function of shading from the Australian hot sun. In the project “ temporary houses”, the listing on the entrances and shading devices denotes where the “widen” passages or elements are. It breaks the bareness of the façade and creates a rhythm that accompanies the visitor along his tour around the house.

4 THE INTERVENTION SOLUTION

4.1 CLIMATE ADAPTED DESIGN: THE MIX OF ADJUSTMENTS

After trying to get one design to be only partly adapted to the climate - same window area, position and type; same insulation inside, etc- it is clear it doesn’t work to only party depend on passive solutions or work bioclimatic “half way”. The design hits a dead-end, due to the fact that. Some adjustments such as number of openings and their area and type of walls, shading devices used need to be taken in consideration and some specific changes need to take place in the initial design. What could change in a design that would influence the final result and improve the values achieved before? (see 4.2. Case 1).

“Any design decision should be justified in at least two ways”. (Baumann, 2010) It is important to integrate the process and the design, allowing the decisions taken to be as complete as possible. Opening a window will influence not only positively, when it allows more daylight an ventilation, but also negatively when it contributes to the raise of temperatures – through solar radiation on the glass façade. “Shading, orientation of windows and openings are of major importance for the total energy balance of the buildings. Comparison of building codes and valuation or selection of best practices is rather complicated.” (International Energy Agency, 2008)

There are five important things and main focus : Optimal building orientation : Reduce large glazed facades towards east, south and west for a Northern hemisphere, Ensure daylight availability for lighting and efficient solar shading, Location of rooms with high internal heat gains or demand for low
temperature towards orientations with small solar gains; Reduce all internal heat gains (anthropogenic loads, equipment, artificial lighting); Zoning of the building according to patterns of use and internal loads; Location of areas with high internal heat loads, such as server and printing rooms in separate rooms; Apply external solar shading; Make use of a daylight control system to minimize the heat load from the artificial lighting (Andersen et al., 2009)

A. ORIENTATION / LOCATION Orientation of the design first, depending on wind direction and speed and mostly depending on the optimization related to the sun. That "best" or optimized orientation is achieved concerning wind and sun using considerations and diagrams, which can be seen in annex. East/West is the best orientation for a building representing an elongated form.

B. INSULATION For calculation proposes and to study more directly the influence of the insulation materials, insulation and common materials such as brick, concrete and cement are used on the software. In the case of using metallic sheets on the roof- and since it is a material that allows heat and cold to pass through easily- it is necessary to add other solutions, such as the use of fake roof or lining under the sheets. The air circulation between the two roofs refreshes the space bellow the ceiling. In cold climates, that space can be covered with insulation so that heat is not lost. Palm leaves can be put on top of the roof between the concave shapes. If possible, the concave shapes should be orientated contradictory to the dominant wind direction. Roof can also be covered with green solutions due to its good thermal results and low cost. (images)

C. OPENINGS For the calculations it is important to reflect upon three things: location (positioning), area and number of windows. “An window can frame a view, bathe a wall with light, orient a building user to the exterior landscape, express thickness of the wall” (Baumann, 2010), allow ventilation or just a feeling of not being suffocated inside. The placement, size and design of the openings will be essential for the total air change and for the airflows in the building. “North-facing windows create a significant energy problem in temperate and cold climates and should be minimized” (Randall, 2006) Randall confirms the general rule that energy performance will be optimized as long as the main facade – the facade with the greatest solar-oriented window area – is oriented to within 45° of the midday sun. “Brown and DeKay, […] define the limits more closely, stating that if the facade is within 30° of south the fall-off in solar performance will be less than 10%”. (Huw, 2012) “Windows alone, however, do not provide satisfactory daylighting of deep spaces due to poor penetration and distribution of the illumination within the space; this can result in glare and local overheating. Skylighting in combination with properly designed windows can effectively illuminate deep interior spaces and offers opportunities for natural ventilation.” (Hampton, 2008)

D. SHADING DEVICES Solar shading must be chosen as an external solution, since this type of shading is the most effective solution. Many technical solutions are available. Figure x shows four different solutions. Illustration a. shows an automated solution where blinds run up behind the facade cladding when not in use. In the illustrations b. and c. solutions with fixed overhangs above the windows are shown. In such cases it is essential to make a careful calculation, that happens when the sun drops below the shading device causing direct radiation into the house. In illustration c. louvers fixed on rails are seen. These can manually be run in front of the windows when needed. At the house in Illustration d. it is planned to grow deciduous vegetation (not yet planted in this photo) over the rooftop, which, during the summer will provide shade on the windows around the terrace, but during the winter will allow the sun to come into the house.

Figure 2 - External shading. (Left to right: a., b., c. d.)

Solar shading is used for screening the direct sunlight, in order to either reduce the heat load or to avoid glare from the windows. External solar shading is most efficient in terms of reducing heat radiation, as the rays of the sun will not pass through the windows. Internal solar shading has limited effect as heat screenings, but work well as glare screenings. (Andersen et al., 2009)

"Shading and sun screening are just as important as the window itself for good daylighting performance. Pleated blinds and
Venetian blinds can be used for adjusting the amount of daylight entering the spaces and reducing window luminance to control glare. The venetian blind can also be used to redirect the light into the room. The most efficient shading solution to prevent direct solar radiation into the building by utilizing external shading. Examples of external shading are roller shutters and awning blinds. A dark grey screen will reduce the illumination and luminance levels significantly to a level where the risk of glare can be avoided. ” (Velux Group, 2010) Solar shading improves both the U-value and g-value of window systems and can be controlled dynamically for optimal performance.

E. COMPACT / DENSITY Complicated designs increase the energy demand compared to plain, compact building styles. Compact design is most favourable.

F. GEOTHERMIC/EVAPORATIVE Free cooling is a process where like, passive cooling, there is no extra energy needed to run the cooling process but instead the cooling capacity of cool outdoor air, groundwater, seawater, water from lakes etc. can be utilised directly. “ Passive cooling, here the outdoor air is being used as a refrigerant typically in combination with natural ventilation. Capacity can be increased through the use of night time cooling in combination with exposed thermal mass or to utilize buried channels, where the heat capacity of the surrounding earth will contribute to cool the incoming air during summertime and temperate the incoming air during winter time. Another cost effective and energy efficient form of passive cooling is to use cool materials on the building envelope. Cool materials (paints, tiles, shingles etc.) can reject solar heat remaining cooler under the sun. This is due to their two main properties high solar reflectance and high infrared remittance. At building scale the use of cool materials results in lower energy consumption for cooling, improved thermal comfort and lower carbon footprint. These effects are far more important if the building is poorly or not insulated”. (Andersen et al. 2009) The BRE document Environmental Site Layout Planning: Solar Access, Microclimate and Passive Cooling in Urban Areas (2000, pp37–43) provides references to research which confirms our intuition that bodies of water will provide a source of cooling. The larger the body of water the better is the rule. A lake might provide a reduction in air temperature in its vicinity of up to 2°C. Green spaces in cities do not merely provide an environment for recreation but bring beneficial cooling for a considerable distance, 150m or more into the urban fabric according to Baruch Givoni in Climate Considerations in Building and Urban Design (1998, pp308–310)

G. EXTRA CONSIDERATIONS: Materials, colour, inside organisation, urban planning /organisation

4.2 CLIMATE ADAPTED DESIGN: CASE STUDY 2

As far as designing and proposing one solution for all the climates and everywhere around the world, it is easy to see why it did not work. In order to get a deeper understanding and more detailed results, together with a stronger “on one hand, …on the other” comparisons, in this section, not 4 climates are studied but only 2: Hot dry and Cold. It could be argued that it is too little and it will not be detailed enough, but this was mostly to have an idea how the initial – case 1- solution wasn’t appropriate and also the fact that it is for some reason that people haven’t just created a working example using shipping container- it is harder than initially it seems.

A. ORIENTATION AND LOCATION In hot climates, building in a depression implies relatively lower air temperatures. When building on a slope, the leeward side is preferable, as long as the orientation is acceptable. In both cases, warm breezes would be minimized. Besides this, using a container that poses as an elongated shape, clearly unidirectional, and in order to avoid West/East sun – more difficult to control, the axis of the container should be East/West. It did not make sense to use Bsim to prove that this orientation would be the best so; calculations and results are not shown for North/South axis. The model in Bsim starts already in its best-optimized orientation given by Autodesk Ecotec, rotated 85°.

B. INSULATION More insulation in less swing tem and colder, and more thermal mass – bigger heat capacity when there are big temperature swings. For this section, first of all the model was used only with steel (unfortunately the software does not always give good results when using so thin layers of materials , such as the metal). Since steel is a material with very big transmission losses and gains, in Denmark – due to the cold climate temperatures when the simulation is done only with the steel container are very low (93.20% bellow comfortable 20°C).

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**Figure 4** - Transmission values for container in. Riyadh, Saudi Arabia (Left) Only steel material.(Right) Steel container with 2 cm insulation on walls . The red colour represents the inside and it is clear the temperatures are a lot more balanced due to the insulation.
The best solution for Denmark, and considering that heavier materials – such as brick, concrete, etc. are being used, the solution relies mostly on a lot of insulation that blocks the heat to go leave the building, while in Saudi Arabia, there is very little insulation that helps balancing the values and the difference of temperatures, but the walls and structures relay on construction with high heat capacity-good thermal mass.

C and D. OPENINGS AND SHADING It is important to take into consideration the fact that in Saudi Arabia, the sky is mostly clear and for that reason the sun rays are stronger and too much daylight reflects on glare problems, so windows should be positioned higher and be smaller. On the other hand, less windows will increase the need for electrical power for artificial lighting. How much is enough and how much is too much?

Table 3 - Shading devices and influence on temperature (Left) Saudi Arabia (Right) Denmark

<table>
<thead>
<tr>
<th>Shading device</th>
<th>Out &quot;Comfort range&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No shading</td>
</tr>
<tr>
<td>Hours &gt; 26 °C</td>
<td>61,9 %</td>
</tr>
<tr>
<td>Hours &lt; 20 °C</td>
<td>20,0 %</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E. COMPACT SHAPE / DENSITY In hot climates the P/A ratio should be kept to a minimum. This would cause minimum heat gain. Plan form for enhancing ventilation is not a compelling proposition as breezes are often quite warm. In cold climates too the P/A ratio should be minimal. This ensures minimum heat loss. Heat gain can often be achieved by solariums etc. In hot dry climates S/V ratio should be as low as possible as this would minimize heat gain; In cold dry climates also S/V ratios should be as low as possible to minimize heat losses heat. (Andersen et al. 2009)

5 ANALYSIS AND DISCUSSION OF RESULTS
There were two cases presented. On the first, the intention to answer the slogan “Think globally, acting locally” showed that, as already expected, the idea of creating something to be suited everywhere and to be mass produced as one product, it is difficult due to the differences between contexts and consequently their needs. On the other hand, the case 2 would propose a mix of different adjustments and study some of them more into detail. Those adjustments were thought as major elements that influence a design and its response as a sustainable product.

CASE 1 VS CASE 2 It is clear that a solution that covers all cases ends up by not covering any. By building globally in all senses of the word, then locally it does not adapt or work. The case 1 leads to an dead end and therefore, case 2 is studied in order to achieve a better understanding of the influence of different parameters and end up with better simulations and better results in each case. It is not good to
design one element according to what fits better another place, because building elements, materials and type of construction depend on the region. For example, if a window in a cold place allows the sun to go in and for that room to be heated it is a good thing, nevertheless the same window placed in a hot area will make the room overheat too much to a degree that is unbearable. This same rule of not “copying and pasting solutions” also applies to walls, roofs and floor construction and their insulation thickness, etc. As an example, a solution that works okay in the Danish climate was set to be studied for the hot dry represented by Saudi Arabia and the results are

The example two does not include as many things as the first, but it does include the transport to the site, so it gets more expensive. Nevertheless, the price is very low when considered that the core, the structure – container- is included in the money estimate.

<table>
<thead>
<tr>
<th>Sustainability Area</th>
<th>Social</th>
<th>Economic</th>
<th>Aesthetic</th>
<th>Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holistic design: Flexible Sustainability</td>
<td>Temporary house/shelter; Private vs Public spaces; Community part of reconstruction process; equality; Human basic needs; traditional building techniques; temporary to permanent</td>
<td>Recycled materials; 7+1 weeks to construct and erect; long lasting materials, disassemble pieces; passive (free) approaches; add as you grow</td>
<td>Comfortable magic box; multi functionary space; unfold-able, adaptive and extensive inside and outside solutions;</td>
<td>Thermal comfort; passive approaches; back to basics; think globally while acting locally</td>
</tr>
</tbody>
</table>

Unfortunately, It is difficult to express all points of view and refer to all the different elements related to this thesis once it is a very broad term – “sustainability” and field. Moreover, even in the elements considered for the thesis, it is essential to try to detail some questions – in order to show some level of understanding and deepness but also to keep it general to allow more fields to be studied and later studies to be hold. This thesis is written as a point of departure of some pre researched elements and it keeps out a lot of information gathered and reached, in order to be a possible work to be used for other and myself to be developed and continued at another time. It is a too short paper for the information that the author wanted to shared and for the work done on the subject. It intends to be a contribution to knowledge rather than a concluded piece of work. For the solutions proposed, they would of course influence other aspects such as acoustics and humidity – choice of materials – and for that reason the materials are also put aside and kept open only suggested. Can we think globally whole acting locally? Can design be Standard for everyone and everywhere? How does place and location influence a design? How important are passive solutions? Can we go back to basics when designing with less? Can a container – existing in our daily life and barely noticed as more than a dark box- be used as more than a trend, rather a potential modular solution that competes in cost with traditional solutions, respecting temporary housing?

POTENTIAL DEVELOPMENTS: When describing the Danish weather, the wind direction and the season are fundamental – the weather simply changes according to the prevailing wind direction. What is more, it is often windy in Denmark and calm situations are rare. The wind power industry and sailors enjoy this state of affairs while sunbathers and cyclists feel somewhat more dubious. At all events, the wind is a key factor of daily life in Denmark. (Cappelen & Jorgensen, 1999). Wind mills and turbines could be considered for Denmark, while for Saudi Arabia, it would rely on solar collectors and solar cells and potentiality on the hot sun. Due to lack of wind, inspiration can be redrawn in boats and how those direction the wind to ventilate the inside – nowadays with the use of specific tents as a very basic and cheap solution- but also architectural inspirations such as Gleen Murcutt organic shapes- making the building potentiality for its environment and site conditions.

BIBLIOGRAPHY


