FINAL REPORT

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ROOF AND CLIMATE

Are there lines which can draw on Europe a progressive change of the roofing parameters?

ARGUING A PROPOSAL

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Finally I would like to say thanks to my family for the opportunity to study in another country, for the sustained support and the confidence in me.

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Here I finish five years of effort, work and especially very good friendships, who I will never forget.

"Now is a time for defiance"

ABSTRACT

The roof is considered the element of house through it the majority of the heat lost are produced.

With the proper conditioning can be achieved the thermal comfort indoor. To carry out the research has been necessary to find the parameters which draw from the climate, and which can be modified regarding of it.

To carry out it as already mentioned, is necessary a previous knowledge on Europe temperatures.

With the put in practice of the roofing requirements in each country or area, and the results of comparison, it is possible to see a lineal development from North to South or vice versa of all of the parameters acting on it.

Orientation, climate, slope, winds, reflection and color, thermal analysis, ventilation, materials, insulation and cool loads have been studied accurately to argue the proposal.

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CHAPTER I -INTRODUCTION

This report will propose research of roofing types in Europe and how the choice of the roofing materials are affected by the climate avoiding losing heat by the roof in different climate conditions.

This study investigates the effect of the roofing materials, insulation, roofing slopes, and the surface color of the roof on the maximum indoor temperature of a house located in a three different climatic regions. However, the use of appropriate materials and insulation could afford significant improvement, which could be further enhanced with the use of light colors for the roof surface.

1.1. Background

First, it must also pointed, despite of the Common Market, Europe is still a patchwork quilt of separate countries with differing local and imported building materials. This has led to differing traditions of skill and habits of construction, and without a common language to facilitate pan-Europeanism in building technology. (A Green Affordable Housing, 2005).

Historically this has resulted in quite sharp architectural differences in handling weather-casting systems of sloped roofing obvious, and the demands of historic conservation keep the traditional skills and materials alive. But even in the less obvious early development of waterproof roof systems there were national differences. More recently, the advent of multi-national roofing industries and the almost universal need to conserve energy have been strong internationalizing influences, but even these have not prevailed entirely against some national prejudices and protectionist instincts.

There are, of course, climatic differences familiar to everyone, but these exists in any large land mass. What I have been delineating is the contrast in Europe, where one language and economic commonality prevails. These obstacles do not ease the task of reporting on European roofing

Is a generally held view that traditional architecture is more climatic conscious than contemporary architecture. This subject has been dealt with by a number of researchers. As a result, it is considered useful to study traditional architecture so that important lessons can be identified which can be applied in improving the current architecture (Malama & Sharples, 1997).

The present study set out to investigate traditional and contemporary housing thermal performance in Europe. It reports on measurements from temperatures average during last 10 years. It looks at a typical traditional house and analyses their thermal response to the climate. It finally compares the results of the climatic study with the results of a thermal comfort. This work is a research project which is studying the thermal performance of housing in Europe. Presented here are the initial results of the project.

Roofing is often ignored as an energy efficient component of a house, but it has a profound effect on the other systems, especially air conditioning. An efficient total roof system can lower the energy required for cooling's home by 30 percent or more. Roof is the major contributor of heat gain in buildings. Theoretical studies are available to determine heat flow through different building components. But a very few studies are available which deal with experimental investigation. High summer temperature ranging from 20-35° C in southern part of Europe necessitate cooling of buildings to provide a comfortable and workable living environment indoors. As such air conditioning is necessary in South Europe during summer months of the year. For non-conditioned residential and other types of buildings, peak temperature is reduced by using roof insulation. The use of thermal insulation to minimize solar heat gain in summer and heat loss in winter. (Suman & Srivastava, 2008).

Jean Dollfus in his *Collection of Samples of Homes* explains the relation between climate and architecture. He affirms that the main aim of the building is the research for optimal conditions of thermal comfort. According to his analysis, the constructive typology will be defined because climate regions and not for the limit region.

Roof color plays some role in attic temperature, but its role isn't nearly as significant as roof material and attic ventilation. Depending on the climate, a light or dark roof in a residential application may work in favor of, or combat, the primary conditioning needs (heating or cooling). If it interior comfort the key point to resolve, then adequate insulation in the roof or attic will have the biggest effect on thermal resistance. (Best Practices Guide to Residential Construction, 2015).

1.2. Purpose

In the beginning of the research the goal of this study was understand the causes of the decision because roofing materials choice and, for that, it would be able to drawn three areas in Europe showing them changing for climate. Finally, the report also of the last outlined, has tried to understand which parameters in addition to climate can be the main variable to choice the correct roof. Each parameter reflect on a European map depending of different factor that are acting over them.

1.3. Aim and Objectives

Against the background earlier outlined, this research project will be undertaken with the aim of carry out a statistics as to which different climate conditions are important of roofing design.

To achieve this aim, the following objectives will be pursued which include but is not limited to the following:

1. Found out which parameters influence over the roof´s construction.
2. Design Research Methodology with a diagram from the data collected.
3. Collect data on roofing materials.
4. Analyze formal statistics comparing roofing materials with climate.
5. Discuss the results and conclusions.

1.4. Scope of the Research

The scope will be limited carry out the study just in Europe, just like an only attending to European rules and conditions.

1.5. Chapter Summary

This first chapter has introduced the background of the need of understand how affect the climate around Europe in respect of the construction of the roof, taking into account the traditional roof that have already been built and applying for a new construction of them. The main aim is find the perfect roof conditions in each country with his own climatic characteristics to achieve the thermal comfort, in order to don´t have to think in air conditioning to achieve the comfort, as well as the focus of the study is not on the reduction of environmental impact through changes in product design. The aims and objectives of the research have been stated and the scope and limitations of the research given. The structure of the report has also been explained with the objectives and later it will be increased with the methodology.

The next chapter will critique the extant literature.

CHAPTER II – LITERATURE REVIEW

2.1. Overview

To develop the theme has been required to look for new data from differently fields, for what many proposals have been necessary to create solid arguments on issue. Down below are all of the literature collected, among them: main proposals, information from the website, guides, catalogues and different articles.

2.2. Analysis and Adaptation

Energy is an essential requirement for the economic development of a country. From an environmental point of view, it is extremely important to minimize energy consumption, and one potential area that requires attention is buildings. From an economic point of view as well, especially in developing countries, minimization of energy consumption in buildings is important. The domestic sector is one of the major consumers, especially in warm humid climates where people resort to active means such as air-conditioning or fans to mitigate indoor thermal discomfort. Warm humid climatic conditions generally prevail in low altitude areas between 15º north and south latitudes. They claim that such techniques would be useful in reducing the use of energy-consuming active means on most days of the year, especially when climatic conditions are not extreme. The path of the sun generally goes through high altitudes during the daytime, subjecting the roofs of dwellings to intense sunlight. Unlike vertical surfaces such as walls, the roof is exposed to the sun throughout the daytime round the year, significantly contributing to heat gain. (Jayasinghe, Attalage, & Jayawardena, 2003).

This paper has contributed to develop sunlight on the roof, it is very useful to evaluate the effect of roof orientation, roofing materials and roof surface color on indoor thermal comfort. This paper presents such a study carried out for warm humid climatic conditions.

Bansal, Grag, and Kothari (2004), in their proposal, do some experiments were performed under different conditions. A computer simulation program, based on periodic solution of the heat conduction equation, was developed to yield the time variation of the room temperature corresponding to the given meteorological parameters. As expected, the black painted enclosure recorded a maximum of 7°C higher temperature than the corresponding white painted enclosure during hours of maximum solar radiation, while during the night the two enclosures showed nearly the same temperatures. The experimentally observed temperature measurements were quite consistent with the theoretical calculations within experimental accuracies (± 2°C). The same software when used to simulate the behavior of a normal sized heavy structure, predicted 4°C to 8°C higher temperature throughout a period of 24 hours for a black colored surface than the corresponding white one. (Bansal, Grag, & Kothari, Effect of Exterior Surface colour on the Thermal Performance of Buildings, 2004).

The information about the change of temperature employing different roof color in the experiment has served to the study to differentiate a color scale among white and black, regarding of the reflectivity of the materials.

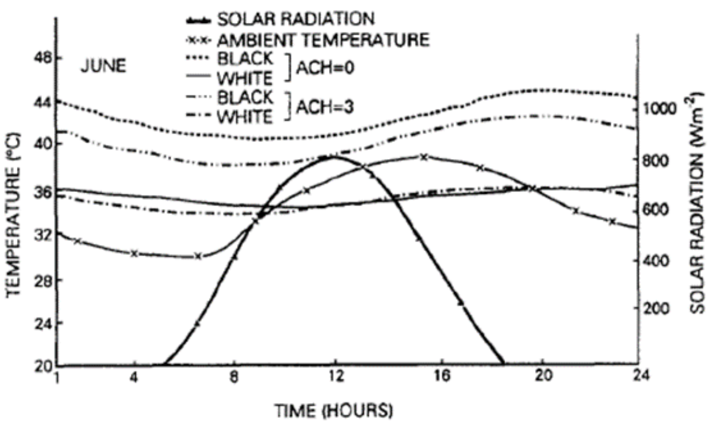

Figure 1. Computed values of room temperatures for summer conditions inside a normal sized building (4mx4mx3m). Bansal, Grag, and Kothari (2004)

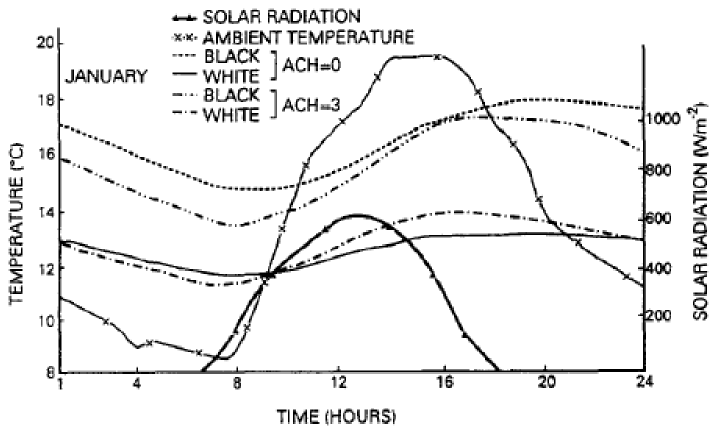

Figure 2. Computed values of room temperatures for mil winter conditions in a normal sized building (4mx4mx3m). Bansal, Grag, and Kothari (2004)

Roof color choice depends on climate and amount of sunlight. Roof color alone has effect on the overall energy balance of a well-insulated house. The attic insulation level and under-roof ventilation rate are the most important factors. (Bliss, 2015).

Roofing Type	Reduction in Peak Load	Annual Savings
Dark gray asphalt shingle (control)	—	—
White asphalt shingle	4%	17%
Terra-cotta tile	3%	13%
White S-tile	20%	32%
White flat tile	17%	34%
White galvanized steel	23%	28%

Table 1. Roofing Color and Cooling Loads. (Bliss, 2015)

In first place, the last data outlined has contributed to set the most important variable to develop the methodology, and on the other hand the annual savings regarding of the roof colors, in this way and through them attain to roofing color solution.

The quantity of the general and local thermal discomfort severities of roof reflectivity and roof greening in long-term perspective via simulation technique. Although roof top greenery performs better in achieving thermal comfort, roof reflectivity remodeling in prior recommended for improving indoor thermal comfort of metal roofed spaces in life cycle cost perspective. (Kuo-Tsang, 2009).

This once more intends to lay emphasis in roofing color affecting on reflectivity to achieve thermal comfort.

Tests at FSEC also indicate that simply switching from dark to white asphalt shingles in a cooling climate can reduce peak cooling loads by 17% and seasonal loads by

4%. The greatest savings resulted from using white metal roofing (Encyclopedia of Building and Environmental Inspection, 2014) .

The results from Website reiterate the black color for cool climates.

Roof color plays some role in attic temperature, but its role isn't nearly as significant as roof material and attic ventilation. Depending on your climate, a light or dark roof in a residential application may work in favor of, or combat, your primary conditioning needs (heating or cooling). If its interior comfort the key point to resolve, then adequate insulation in the roof or attic will have the biggest effect on thermal resistance (Best Practices Guide to Residential Construction, 2015)

Is easy to assume that if something is dark colored, it will be hotter than something that is light colored. This may be true in many cases, but one thing that should also be considered is the material. Different materials have different properties as far as how they hold, disperse, or radiate heat. Studying the combination of both color and material may be a better study than just color alone. Dark colors usually feel hotter to us, so our assumption would be that dark colored roofs would generate much hotter attics. The question revolves a lot around reflectivity, the amount of energy a material reflects, and emissivity, the amount of absorbed energy re-radiates.

A concentrated effort to reduce energy consumption in buildings has led to recent advances in the material and systems for flat roofs, used primarily in commercial construction. Selecting a roofing material that is highly reflective and emissive (cool roof) over one that is not, can reduce cooling loads by 20 percent or more. A cool roof is defined as one with a solar reflectance of at least 0,70 and an infrared emittance of at least 0,75. It claims that there is an allowance also for a cool roof that has a very reflectance, but a lower emittance. (A Green Affordable Housing, 2005).

The report published discusses the primary factors that should influence on the choice of roofing material and presents the pros and cons of the most popular flat roof assemblies. It establishes cool roof performance criteria that apply to low slope (2:12 or less) roofs on non-residential buildings.

The data collected from this study to define the slope are; sun index of reflectivity higher or equal to 70 to slopes lower than 15% and, the sun index of reflectivity 29 to highest slopes >15%.

Reflectance of Roof Materials		
Material	**Solar Reflectance (%)**	**Temperature of Roof over Air Temperature (°F)**
Bright white coating (ceramic, elastomeric) on smooth surface	80%	15°
White membrane	70%-80%	15°-25°F
White metal	60%-70%	25°-36°F
Bright white coating (ceramic, elastomeric) on rough surface	60%	36°F
Bright aluminum coating	55%	55%
Premium white shingle	35%	60°F
Generic white shingle	25%	70°F
Light brown/gray shingle;	20%	75°F
Dark red tile	18%-33%	62°-77°F
Dark shingle	8%-19%	76°-87°F
Black shingle or materials	5%	90°F

Table 2. Reflectance of Roof Materials (A Green Affordable Housing, 2005)

Material	**Roof temperature rise above air temperature (degrees F, full sun, no wind)**	**Remarks**
Bright white smooth materials	15 F	The coolest construction materials. Can be roof coating, membrane, metal, glazed tile, etc. A soiled white is warmer, about 30 F.
Rough white surface	35 F	Rough surfaces of any given material absorb more sunlight than smooth surfaces
Very light (pastel) colours	15 to 55 F	
Intense but not very light colours (green, red, blue, etc.)	79 to 83 F	Research may identify cooler colours
Medium grey	52 F	Reflectance half way between white and black
Built-Up Roof (BUR) covered with gravel	61 - 83 F	Cooler values obtained with lighter gravel
Black materials	90 F	

Table 3. Color Materials (A Green Affordable Housing, 2005)

The climate is determinant in decisions about the roofing, it means the linkage between the climate and architecture at the search for thermal comfort optimal conditions. (Mercon, 2008)

This paper claim that architectural typology is defined by climatic zones. In hot-humid areas, the characteristics of architecture are: light, well ventilated, protected in all solar radiation directions and without thermal inertia.

With everything, Mercon (2008) confirms the positioning of the building need not be necessarily perpendicular to the direction of the winds. Machado, Ribas and Oliveira (2008) affirm that the rotations 20 ° to 30 ° in relation to the prevailing summer winds are also recommended, using resources to ease crossways ventilation. This has been used to carry out to reach an orientation roofing design.

Material constructivo	λ (W / m K)	K (W / °C m^2)	Espesor (m)	ρ (Kg / m^3)	Absortancia α
Fibra natural	0,045	1,50	0,03	200	0,50
Madera	0,13	4,33	0,03	430	0,70
Teja de barro cocida	1,00	50,00	0,02	2000	0,65
Teja de amianto	0,22	36,67	0,006	1200	0,60
Teja metálica acero	50,00	8333,33	0,006	7800	0,65
Forjado de hormigón	1,316	8,77	0,15	1330	0,60
Plástico (PVC)	0,17	8,50	0,02	1390	0,05
Yeso acartonado	0,25	12,50	0,02	825	0,08

Table 4. Constructive characteristics of roofing materials. Guimaraes (2008)

The major work of W.Köppen, describes a system based on the concept that native vegetation is the best expression of climate. Thus, climates boundaries have been selected with vegetation distribution in mind. It combines average annual and monthly temperatures and precipitation, and the seasonality of precipitation. Köppen assigns generally Group C to Europe. (Wikipedia, 2015)

The information has been completed with an official weather forecast (Organización Meteorológica Mundial, 2015) focused only in Europe, for what, more exactly the temperatures have been achieved. With this temperatures has been possible draw three lines in Europe, which have divided in three areas to resolve the problem statement.

The houses of Europe are generally roofed with rain-shedding tile systems, traditionally of clay, because good clays are abundant all over Europe. However, cement has captured a share of the market in some areas during the past years. They claim that the wood shingle of North America never took hold in Europe. A large proportion of the publication focuses sheet metals, lead, zinc, aluminum and stainless steel as second category of weather-casting roofing. He maintains mostly of them are used on buildings other than houses and they can do their job successfully even at very shallow slopes. (Allen & Allen, 2014).

This proposal has helped to realize the material distribution, adding information on local materials, and others which have been rejected, due to, they are not used in dwelling roofs.

The potential environmental impact of rom air conditioner carried out for the *European Commission in support of the Energy-using Products Directive* plays a fundamental role. This paper assesses the likely market, the consequent environmental impacts and the scope for reducing the global warming impacts by the use of “best available” or “least life cycle cost” technologies. The analysis reflects the increased insulation levels of new buildings, compared to the existing stock, there is no assessment of the possible impact of provision of better shading. Spain, Italy, France and Czech Republic would be the countries with more sales than removals. (Pout & Hitchin, 2015).

The market investigation all over Europe has served to analyze which countries demand for air-condition. In this way and together with the climate dates it will be able to achieve to make a detailed analysis of the insulation regarding of climate and the temperature indoor.

Effect of Expanded Polystyrene and Fiberglass thermal insulation on roof has been studied with a view to reduce heat gain and improve thermal performance. The experiment were conducted by treating one roof with thermal insulation while the other was kept untreated. Indoor and outdoor air temperature, roof and ceiling temperature and relative humidity in terms of dry bulb and wet bulb temperature were recorded during peak summer period. They found that indoor environment of untreated room was in the discomfort range during the most of the hours whereas indoor temperature of room treated was within comfortable range with a ceiling fan providing wind speed around 9m/s.

Table 1: Computed properties of untreated and treated roof section				
Roof section	U – Value (W/m²K)	Decrement factor (λ)	R - value (m²K/W)	Time lag (Φ) hour
Untreated section	4.87	0.457	0.076	1.5
Treated with Fiberglass	0.58	0.016	1.470	7.9
Treated with EPS	0.51	0.010	1.710	8.8

Table 5Computed properties of untreated and treated roof section

It have approached to the study that the use of thermal insulation can minimize solar heat gain in summer and heat loss in winter through roof. (Suman & Srivastava, 2008)

Distribution of the regional wind regimes in terms of full-load hours have been adapted to establish roofing slopes regarding regional wind regimes. (University of Strathtclyde Engineering, 2009)

The information collected has been used to make a prior distribution of Europe among three areas with three different slopes: higher, low and steepest slopes.

In materials section, roof-covering materials shall be studied to apply and install in accordance with the provisions of requirements for roof coverings, where is analyzed each material (Asphalt singles, valley lining material, concrete roof tile, clay and concrete tile, metal roof coverings, slate shingle head lap and wood shingle and shake installation) (Oregon Structural. Speciality Code, 2004).

Between the different section of the publication, Roof Drainage, Performance Requirements, Fire Classification, Materials and Requirements for roof coverings. In the study have been used the last two, materials and requirements for roof coverings. With them together with data from slope, whose requirements depend of material, it has been possible get a distribution of the materials in Europe.

COMPONENT	INSTALLATION REQUIREMENT
1. Roof slope	Asphalt shingles shall only be used on roof slopes of two units vertical in 12 units horizontal (2:12) or greater. For roof slopes from two units vertical in 12 units horizontal (2:12) up to four units vertical in 12 units horizontal (4:12), double underlayment application is required in accordance with Section 1507.2.8.

Table 6. Asphalt shingle application. (Oregon Structural. Speciality Code, 2004)

GENERAL — CLAY OR CONCRETE ROOF TILE			
Maximum basic wind speed (mph)	Mean roof height (feet)	Roof slope up to < 3:12	Roof slope 3:12 and over
85	0-60	One fastener per tile. Flat tile without vertical laps, two fasteners per tile.	Two fasteners per tile. Only one fastener on slopes of 7:12 and less for tiles with installed weight exceeding 7.5 lbs./sq. ft. having a width no greater than 16 inches.
100	0-40		
100	> 40-60	The head of all tiles shall be nailed. The nose of all eave tiles shall be fastened with approved clips. All rake tiles shall be nailed with two nails. The nose of all ridge, hip and rake tiles shall be set in a bead of roofer's mastic.	
110	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.	
120	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.	
130	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.	
All	> 60	The fastening system shall resist the wind forces in Section 1609.7.2.	

Table 7. Clay and concrete tile attachment (Oregon Structural. Speciality Code, 2004)

Maximum basic wind speed (mph)	Mean roof height (feet)	Roof slope up to < 5:12	Roof slope 5:12 < 12:12	Roof slope 12:12 and over
85	0-60	Fasteners are not required. Tiles with installed weight less than 9 lbs/sq. ft. require a minimum of one fastener per tile.	One fastener per tile every other row. All perimeter tiles require one fastener. Tiles with installed weight less than 9 lbs/sq. ft. require a minimum of one fastener per tile.	One fastener required for every tile. Tiles with installed weight less than 9 lbs/sq. ft. require a minimum of one fastener per tile.
100	0-40			
100	> 40-60	The head of all tiles shall be nailed. The nose of all eave tiles shall be fastened with approved clips. All rake tiles shall be nailed with two nails. The nose of all ridge, hip and rake tiles shall be set in a bead of roofer's mastic.		
110	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.		
120	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.		
130	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.		
All	> 60	The fastening system shall resist the wind forces in Section 1609.7.2.		

Table 8. Clay or concrete roof tile with projecting anchor lugs (Oregon Structural. Speciality Code, 2004)

Maximum basic wind speed (mph)	Mean roof height (feet)	All roof slopes
85	0-60	One fastener per tile.
100	0-40	One fastener per tile.
100	> 40-60	The head of all tiles shall be nailed. The nose of all eave tiles shall be fastened with approved clips. All rake tiles shall be nailed with two nails. The nose of all ridge, hip and rake tiles shall be set in a bead of roofer's mastic.
110	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.
120	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.
130	0-60	The fastening system shall resist the wind forces in Section 1609.7.2.
All	> 60	The fastening system shall resist the wind forces in Section 1609.7.2.

Table 9 Interlocking clay or concrete roof tile with projecting anchor lugs. (Oregon Structural. Speciality Code, 2004)

SLOPE	HEADLAP (Inches)
4:12 < slope < 8:12	4
8:12 < slope < 20:12	3
slope ≥ 20:12	2

For SI: 1 inch = 25.4 mm.

Table 10Slate shingle (Oregon Structural. Speciality Code, 2004)

Davies (2013), in his guide to roof construction, stablishes roof pitch in the UK for a traditional house, which will be 40°-50° but at the extreme can go up to 70°. Part of the choice of pitch is down to the architect.

As well as the visual appearance, the choice of roof pitch is influenced by the materials to be used and the resulting overlap required if roof tiles are used. An example is proposed; thatched roofs are often 45° or more whilst a slate tile roof can be much flatter at say a 35° pitch if desired. In areas of high snow all then the roof pitch can be much greater, to allow the snow to fall off the roof rather than settle and build up on the roof. Roofs with pitches of 10°-20° are often called low pitched roofs and special considerations need to be made, particularly on the overlap between tiles to avoid water being blown into the roof by the wind. (Davies, 2013)

It proposes different material used for the outer layer of pitched roofs, just as, once more, it helps to understand that in cold climates the slopes will be highest than in warm climates. One point that Davies attaches is the concept of the high slope taking in account the height of roof due to the snow.

Light colored roofs in warm climates and dark colored roofs in cold climates are most compatible with the particular climate's primary type of conditioning (cooling or heating). The higher the solar reflective value, the more efficient the product is in reflecting sunlight and heat away from the building and reducing roof temperature. This is particularly important in warm areas where peak load is a concern. In warm and sunny climates, highly emissive roof products can help reduce the cooling load on the building by releasing the remaining heat absorbed from the sun. On the other hand, there is also evidence that low emissivity may benefit those buildings located in colder climates by retaining heat and reducing the heating load.

A poorly constructed attic or roof assembly can lead to excessive energy losses, ice dams, mold, rot, and lots of unnecessary homeowner angst. In a cold climate, the primary purpose of ventilation is to maintain a cold roof temperature to avoid ice dams created by melting snow and to vent any moisture that moves from the conditional living space to the attic. In a hot climate, the primary purpose of ventilation is to expel solar-heated hot air from the attic or roof to reduce the building's cooling load and to relieve the strain on air-conditioning systems. In mixed climates, ventilation serves either role, depending on the season.

For best results, provide between 50% and 75% of the ventilation space at the eaves; a 60/40 split is a good sweet spot. (Lstiburek, 2011)

Apart of the information about the location and final area of the ventilation, this proposal continue with the information about the color and reflection, differencing among warm and cold climates.

The optimization of the indoor climate is the most important and long recognized role of the architect. In contrast, although not entirely neglectful of climatic considerations, urban planners have, until comparatively recently, only rarely considered climatic among the several constraints upon urban design. (Chandler, 1976).

Thus, the modification exercised by the local orography upon the regional climate are of fundamental importance and have to be carefully considered, for substantial differences in radiation receipts and losses, temperature. (Geiger et al. 1969)

This paper involves air environment from another angle, the air above cities is infused with solid, liquid and gaseous pollutants; temperatures are generally higher in cities than in their rural surrounds; it provide relative humidities, which are most frequently lower though absolute humidities can sometimes be higher in urban than in rural areas; precipitation tends to be enhanced within or the lee of cities; visibilities are poorer and radiation receipts are also lowered by the pollution. Until this point the differences of climate among urban and rural areas have been not considered.

Wise's Effect studies the influence of the slope of the roof of the highest building influenced by the speed wind which affect on the lower level, this study is carried out through some tests. These tests may include wind tunnel tests, where the slope of the highest building was tested with three numbers. Of this study it can affirm the relation between the slope and wind speed on the lower level. With lean angles among 24º and 45º wind force is set to increase. (Apcarian, Walter, & Lassig, 2004).

Here is established that winds higher to 5 m/s will impact negatively to the people's comfort.

"Generally, roof color plays some role in attic temperature, but its role isn't nearly as significant as roof material and attic ventilation". A cooler attic or roof means there is a bigger temperature difference across the insulation, which results in faster heat loss. Therefore, in residential applications, dark colored roofs may be better for northern climates. This concept has contributed to the research to divide among cool and heat roof, in other words black and white. (Energy Options Explained (EOE), 2015).

"Roof Colors"*, Energy Options Explained* (2015) finds the insulation associates with the reflection (light-colors), because only the suitable thickness will have the biggest effect on thermal resistance. With this information it has been able to achieve the correct insulation distribution.

Attic temperatures can vary as much as 20 to 40 degrees F (-6ºC to 4,5ºC) which in turn can reduce energy consumption by 20%, (Builders, Dealers, DIY and Framers, 2014).

The study of this corporation ensures that radiant absorptivity of the shingle is a predominant factor indicating peak roof sheathing temperatures. Besides of data collected of roofing colors from the website, it provides the results with a study in which changing black and white shingles on the same roof, it made with panels under them, the temperature of the attic in a sunny day the black-shingled roofs were 10ºF to 15ºF warmer than the identical white-shingled. However, during the evening, the black-shingled roofs also tended to lose heat faster than white. In obtaining equilibrium with ambient outdoor temperature, both, generally experienced similar nighttime temperature profiles.

The information of Findlay Roofing Website affirms that roof ventilation is more important than shingle color if you are concerned about keeping roof and attic temperatures low in the summer. This approach, roof ventilation can be achieved through the combined use of ridge vents, soffit vents and other features. “Roof ventilation combined with attic insulation is the recipe for a cool house in the summer” (Findlay Roofing, 2015).

In this way to develop the ventilation in European roofing it has taken in account the insulation regarding of the altitude. This article has helped to reach an agreement about to distribution the ventilation, then divide it in two parts, in warm and cold climates.

More attic ventilation is good, roof vents are for warmer climates, roof vents remove warm air during the winter This are some topics which the author take into account to keep attic fresh with circulating air and to reduce moisture levels. (Pickett, 2015).

The same at the previous case, this proposal has helped to understand the ventilation importance in the attics behavior.

An indication of the BASIX classification for their roof tiles, which is split into ratings of light, medium or dark, depending on the tile’s solar reflectivity. Out of 22 concrete tile colors, only one was classified as light and four as medium. For terracotta tiles, out of the 17 choices none were light and only five were rated medium. “The part color plays here is that a dark roof in certain climates may mean that compliance would recommend a slightly higher R-value for their insulation, but it is not massive factor “. (Jewell, 2014).

The recently appointed sustainability guide “Your Home” states that light colored roofs are estimated to reflect up to 70 per cent more than a dark roof. However, research the RTAA commissioned, found that light colored tiles yielded energy savings between 25-36 per cent compared to dark colored tiles.

Heating season and two primary purposes of attic ventilation, removing moisture and ice dam prevention, are treated in this website. As outdoor temperature drops we add heat and add moisture to our homes. In the winter, home acts like a giant smoke stack: cold air comes in through the basement and rises through the house into the attic. (Energy Smart Home Performance, 2015)

Moisture in the attic is drawn to cold surfaces just as it's drawn to your windows. When those surfaces get wet, they rot and mold ensues. The "theory" behind attic ventilation is to give that moisture a place to escape before it causes mold, mildew, rot, or other problems. The ventilation reduces peak attic temperatures by less than 10 degrees and changing from dark roof color to light color can have 6-7 times greater impact.

The good ventilation can significantly reduce the temperatures in the houses. Simpler and cost effective options like roof ventilators need to be explored for the settlements about minimize energy consumption, depending on passive cooling principles in addition to cool roofs. (Thermal Comfort, 2015).

Even though the need for space cooling has increased and growing incomes and aspiration have resulted in air conditioners replacing fans in most of the middle class houses, the article has provided for the research the needless to use air condition in cool climates.

2.3. Chapter Summary

This chapter has contributed to develop and lay the foundations to argue the proposal. The main sources of inspiration for this research can be collected in a group of twenty seven, within which there are two main proposals – Thermal Comfort and Architectural Typology in Hot Climates and Roof orientation, roofing materials and roof surface solour: their influence on indoor thermal comfort in war humid climates. The rest of them are literature which help to extend each integrated topic. Due to this paper is formed by the intervention of different parameters, has been necessary and very useful the integration of the little paragraphs deriving from internet websites.

CHAPTER III - METHODOLOGY

3.1. Methodology Scheme

This chapter describes the Methods adopted and why were they employed to written this paper. The methodology has been divided in two parts. In the first the expectations of connection between climate and roofing design are showed on a diagram. This is the principal part of the research, because to develop this paper the search it must focuses in the parameters which have been investigated.

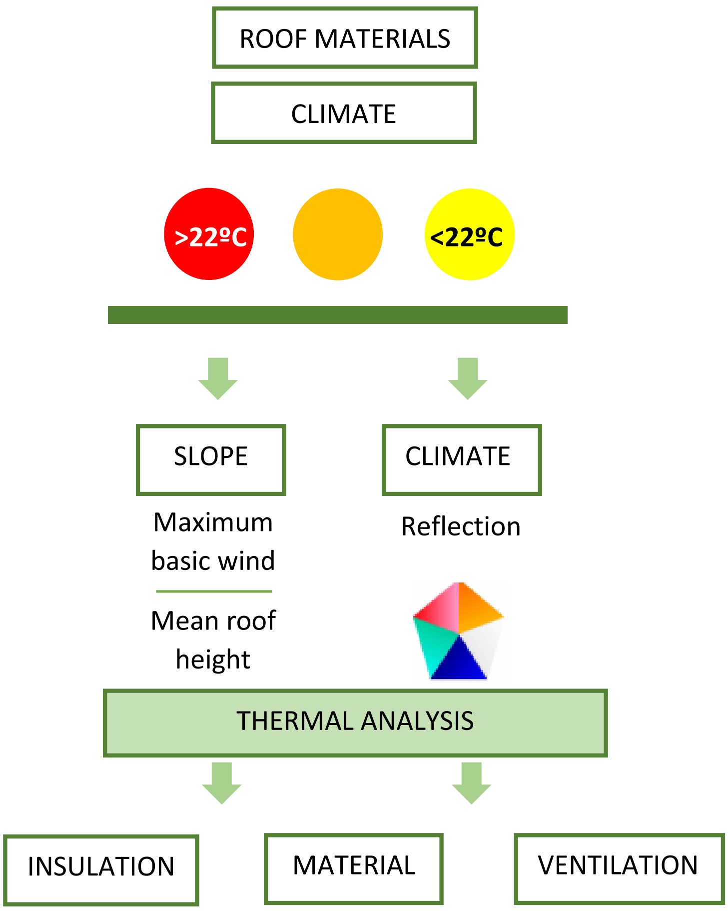

Figure 3 Expectations connection between climate and roofing design

3.2. Climate as a Source

Climate is the most important factor to choice houses building systems. The parameters which are acting in each region will distinguish different air temperature conditions, radiation, relative humidity and air movement.

This parameters in combination define climatic areas. The work treating differently among three regions. This work has used W. Köppen methodology. Within W. Köppen classification, the research specifics Mediterranean climate with temperatures amongst -3/>22°C (dry climate), Oceanic climate with temperatures amongst -7/<22°C (wet climate), and finally Continental climate with temperatures lower -10°C in winter and higher 10°C in warm months (cold climate). 22ºC has been chosen like a point to develop from it, because it is considered the perfect temperature to get thermal comfort.

3.3. Chapter Summary

The climate is determinant in decisions about the roofing, considering that the parameters which act in every situation will do each region has different conditions of air temperature, radiation, relative humidity and air movement, which will be studied with samples in laboratory. These parameters will determine combinations climatic zones.

The three different areas have been established by the W. Köppen method collecting meteorological information for time wide enough, in addition adopting as a criterion the relationship between climate and vegetation.

Climate will be studied through V.Köppen classification and minimum and maximum temperatures for sufficiently long time, just like the future hypothesis.

The three different areas have been established by the obtaining of the average values. These average values* have been got with gathering weather information classification and minimum and maximum temperature over a sufficiently long time period , as with the analysis and study about kinds of climate, specially Mediterranean, Oceanic and Continental. Beside the previously mentioned the W. Köppen method has been decisive in the data meteorological information collected, in addition adopting as a criterion the relationship between climate and vegetation.

*To study the local climate must be analyzed weather elements: air temperature, relative humidity, solar radiation, air movement and rainfall. There are factors that it can influence in these elements: the geographical latitude, the altitude, the orientation of relief with respect to the incidence of solar radiation or the prevailing winds, ocean currents and continental, distance to ocean or sea.

In warm and damp regions the air movement is the main element to achieve comfort. As a result, perfect location to comfort will be those which, even though they are outside the prevailing wind direction, will be located in areas exposed to air current.

CHAPTER IV – DATA ANALYSIS

4.1. Data Presentation

On the other hand, the proposed method of data analysis to support the proposition is to connect roof design parameters to climatic variables. The data collected will be based on treating 7 topics differently, which will be able to capture on graphs variations that influence wind, maximum and minimum temperature, use of insulation and slope values dependent on climate, just like insulation, roofing color. Figure 1 shows expectations connection between climate and roofing design, the rest of Figures 4,5,6,7 show roofing design and climate found from literature.

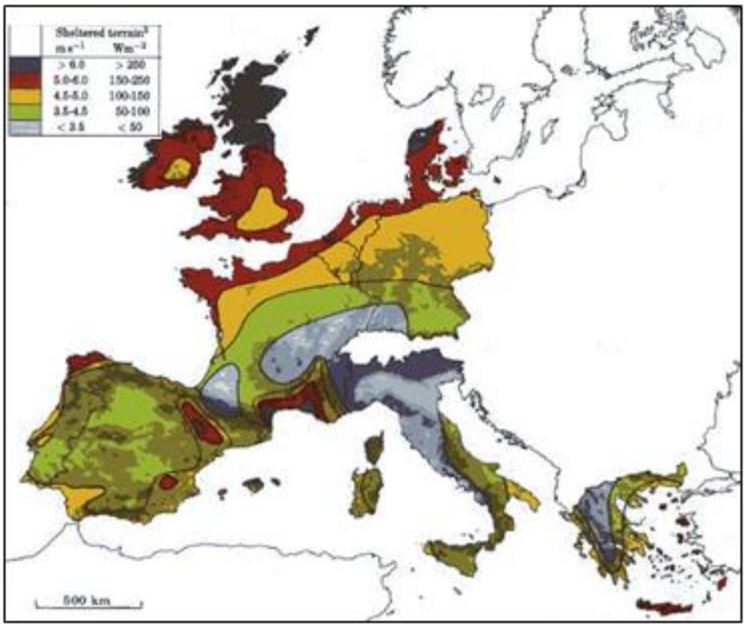

Figure 4 . Observing the spatial distribution of the regional wind regimes in terms of full-load hours . Source: University of Strathclyde Engineering ESRU(2009)

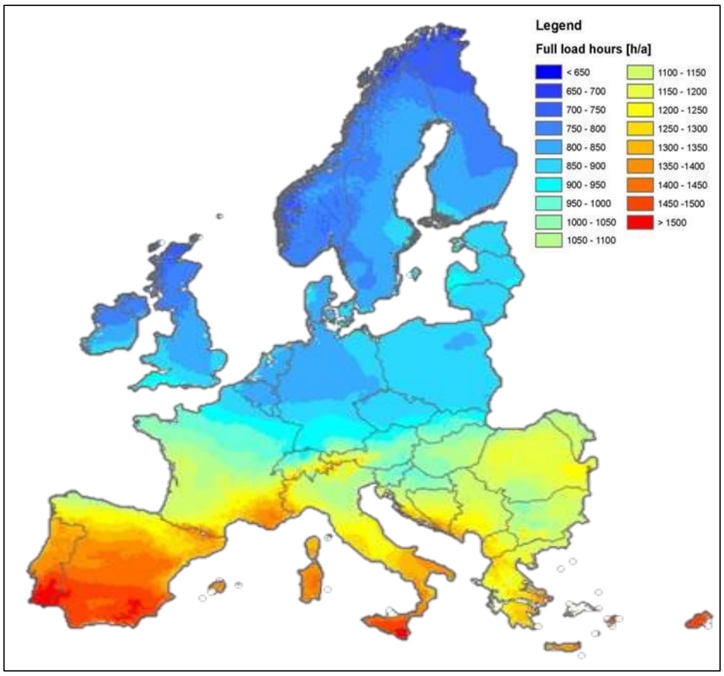

Figure 5 Annual full load hours of optimally inclined PV modules. Source: (Held 2011) based on data from Suri et al. (2007) and a performance ratio of 0.75

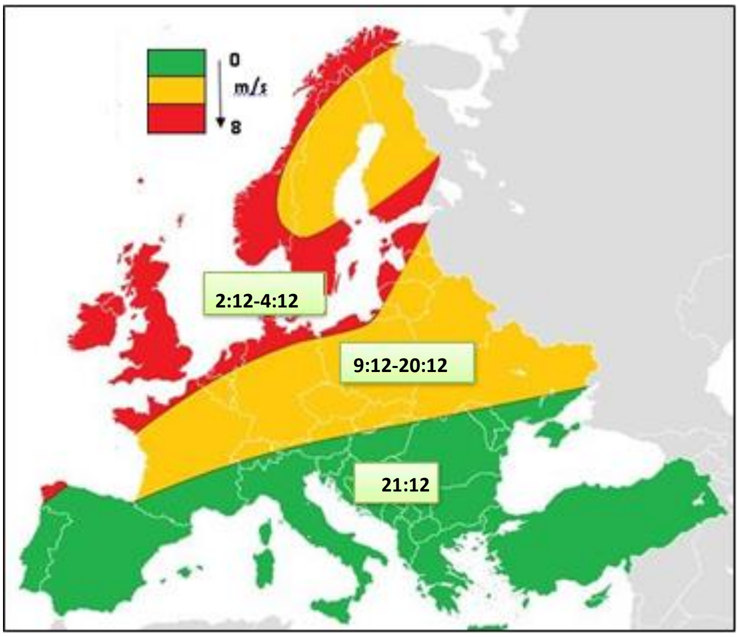

Figure 6 Adapting roofing slopes regarding regional wind regimes.Source: University of Strathtclyde Engineering ESRU.

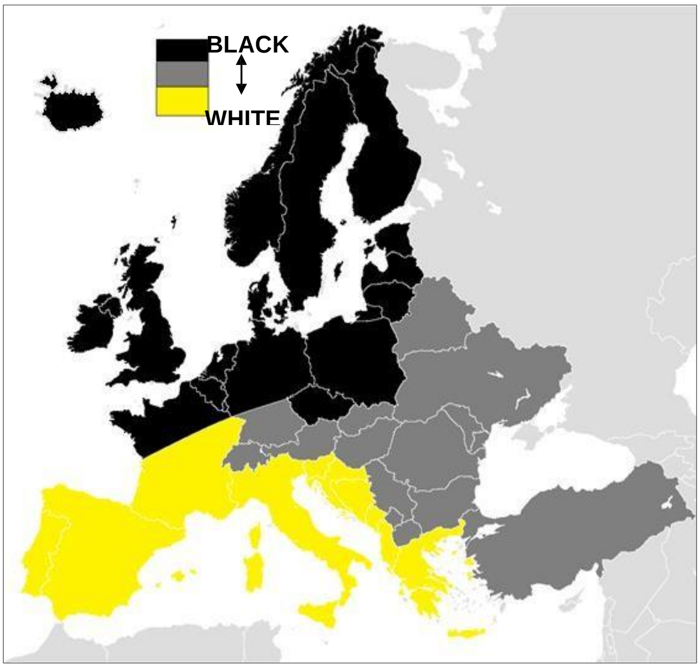

Figure 7 Adapting roofing slopes regarding regional wind regimes. Source: University of Strathtclyde Engineering ESRU.

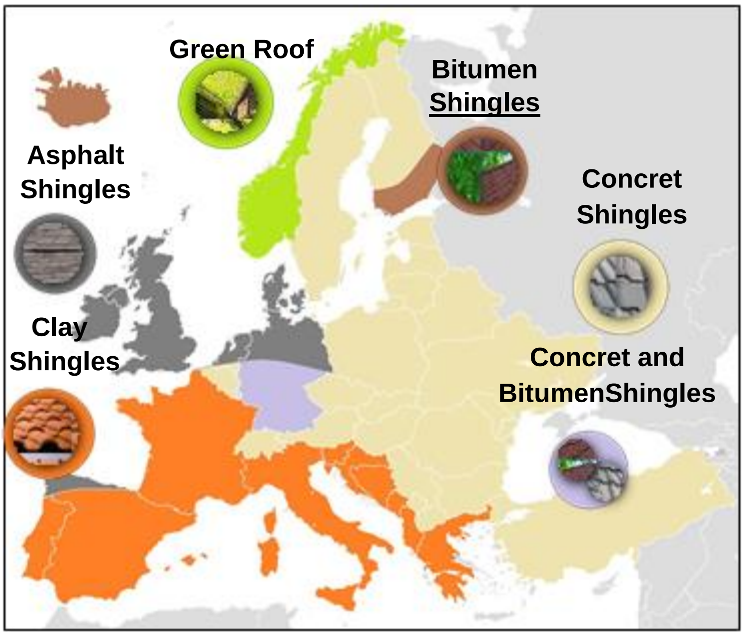

Figure 8 Figure 4. Roofing Materials in Europe. Source: Roof coverings and best practices(2012)

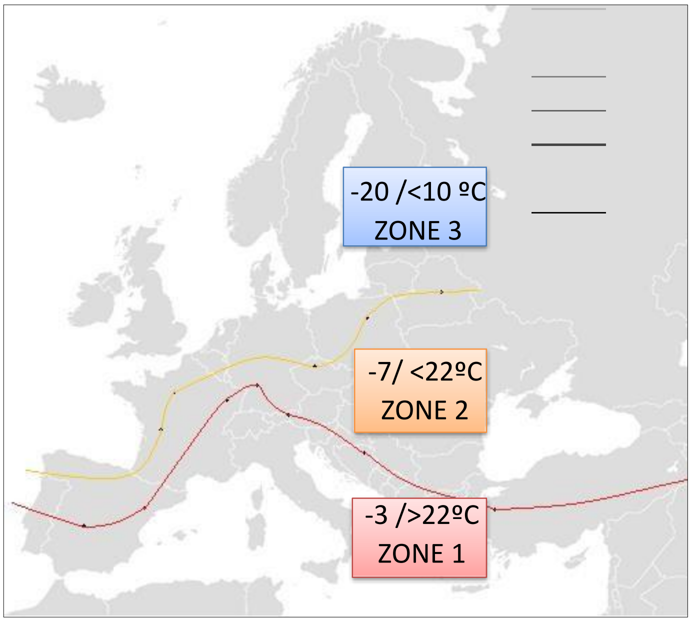

Figure 9 Minimum and máximum temperaturas in Europe. Source. (Organización Meteorológica Mundial, 2015), (Köppen, 2015)

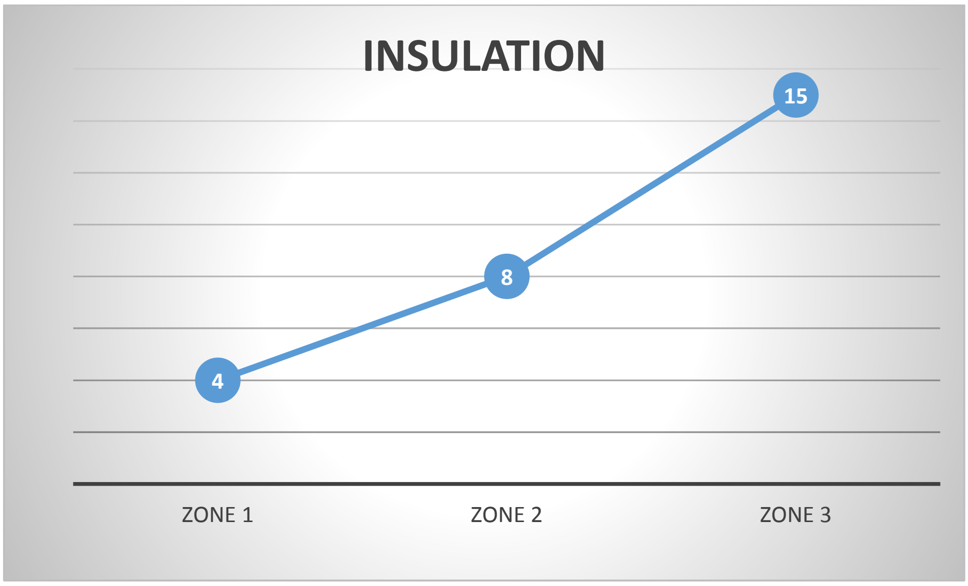

Figure 10.

4.2. Chapter Summary

The results from an intensive research have been developed in this chapter. All of them has been presented on European maps, with a one aim. This aim has been to show how all the parameter and variables, deriving from the changing climate, vary leaving three clearly different areas from North to South.

Arguing each topic and comparing the results obtained has been possible to achieve the first idea on the distribution and change. Knowing that all factors change at the same time in the lines before mentioned, is possible to suggest the perfect conditions for a roof and attic work according with the specific influences upon them, in other words, standardised proprieties.

CHAPTER V- DISCUSSION OF RESULTS

5.1. Topics of the research

Maria Guimares (2008), in her strong proposal suggests roofing material, roofing color and orientation like the most important factor indicating peak roof sheathing temperatures. Against her proposal the article from the *Norbord* (2014), ensures that radiant absorptivity of the shingle is predominant factor indicating it. Giovani (2008), however mentioned that the effect of external color on room air temperature depends on various other parameters also, particularly the heat resistance and heat capacity of the building (construction). It was observed that for low U value building with high thermal capacity, the effect of external color is not so significant as for a low thermal resistance and low heat capacity building. Finally Marcus Pickett (2015) in his article agree with good roof ventilation can increase energy efficiency during the summer, but sun exposure and insulation are considered by the author like a two variables exponentially more important to overall energy efficiency than ventilation. In the guide "Best Practices Guide to Residential Construction", *Federal Emergency Management Agency* (2009) is completed the idea of the roof color plays some role in attic temperature, but its role isn't nearly as significant as roof material and attic ventilation. Depending on each climate, a light or dark roof in a residential application may work in favor of, or combat, your primary conditioning needs (heating or cooling). If its interior comfort the key point to resolve, then adequate insulation in the roof or attic will have the biggest effect on thermal resistance.

The las outlined was useful for starts the methodology research, finally the research was focused in reflection as an important aspect to consider. From this target point positioned in roofing color and its corresponding thermal analysis together the rests of the factors.

Most of authors attach importance to the ventilation, in this research it has not been specially considered until the last research which has been found about. Currently, the opportunity to contain ventilation like an important variable would be studied to future researches.

5.2. Orientation

Jayasinghe, Attalage and Jayawardena (2003) in his article consider seriously the importance of the orientation of roof acting simultaneously with the roofing materials and colors.
Machado, Ribas and Oliveira (2008), with their intervention in the proposal of Maria Guimaraes (2008) “Thermal Comfort and Architectural Typology in Hot-Humid Climates”, dare to take one more step and they propose the rotations, 20 ° to 30°, in relation to the prevailing summer winds, using resource to ease crossways ventilation. Conversely, from the experiment carried out by Suman and Srivastava (2008) about insulated roof for energy saving and thermal comfort could be conclude that the orientation of roof make a neutral effect relating to roof. They assert that is a negligible effect.

Anyway in this research has not been considered the roofing orientation, because in when the wind direction is not coincident with the best solar orientation, ventilation must be prioritized due to ease of elements are used to shade against to drive the winds. Thus, in the first idea to develop the methodology was not took it in account. Priority has been given to attic ventilation.

5.5. Reflection. Color

Givoni and Hoffman (1994), have carried out some experiments with different roof colors. The experimental measurements reported for two colors, namely white and grey, showed a difference of 3°C in the room air temperature when measured only 0,1m below the ceiling, while it remained only 1°C when measured 1,2m above the floor. The temperatures, as expected, were higher for grey colored enclosure.

Independently of the different studies and experiments performed, all of the authors, even Bansal, Grag, and Kothari (2004), all their results agree on the idea of the change of the indoor temperature when the color roof is altered, approximately the number would be 7ºC.

With the last result it has been able to do a pre-selection between cool climates and heated, in such a way, divide Europe in black roof where the temperature are lower, in our map between -20º to 10ºC, and white roof where are higher, where the temperature is between -3º-22ºC. In the area of the middle with temperatures among -7º to 22ºC the roof color defined is grey.

In the magazine A green Affordable Housing (2005), a cool roof is defined as one with a solar reflectance of at least 0,70 and an infrared emittance of at least 0,75. Regarding of sunlight intensity will be select roofing type. The shortage has been completed with the pick of datum of annual full load hours of optimally inclined PV modules in Europe (Held, 2011). Consequently if it looked the Table the materials with reflectance of roof materials at least 0,70 are white coating, ceramic, also metal and elastomeric. The last two have not been considered like a typically material used to residential buildings. Finally the South of Europe with warm climate will be built with Clay tiles which fulfil requirements successfuly.

Material	Solar Reflectance (%)	Temperature of Roof over Air Temperature (°F)
Bright white coating (ceramic, elastomeric) on smooth surface	80%	15°
White membrane	70%-80%	15°-25°F
White metal	60%-70%	25°-36°F

Table 1. Reflectance of Roof Materials (A Green Affordable Housing, 2005)

As adaption to the study can be affirmed that since the “single-ply” classification includes both light and dark colored materials, products that are highly reflective it should be select also for heat island reduction and energy savings purposes.

Maria Guimaraes (2008), in the main proposal used to carry out the research, supplies a table with a list of materials commonly employed in the contemporary architecture, and their characteristics among them, the reflection, *figure 7*. This characteristics table has been useful to present where necessary black and white roof is, but has been more profitable to decide and to discuss about the materials issue around Europe. That will be discussed subsequently.

In the report of *Energy Options Explained* (2015) it has wanted to explain the basic physics behind light and colors; dark colors absorb more of the light spectrum, while lighter colors reflect more of it, but the visible light that is absorbed doesn’t just disappear into a material, it usually converts to infrared. The information here is not focuses just in color, but it is focused studying the combination of both, color and material to achieve thermal comfort.

In addition to the already presented “Builder, Delers, DIY and Framers” *Norbord* (2014), conclude with a concept which has been not contemplated before which determines the black color in cooler climates to help to melt winter snow.

As already stated, this concept has been casted aside of any consideration for the research.*Table 3.*

Material	Roof temperature rise above air temperature (degrees F, full sun, no wind)	Remarks
Bright white smooth materials	15 F	The coolest construction materials. Can be roof coating, membrane, metal, glazed tile, etc. A soiled white is warmer, about 30 F.
Rough white surface	35 F	Rough surfaces of any given material absorb more sunlight than smooth surfaces
Very light (pastel) colours	15 to 55 F	
Intense but not very light colours (green, red, blue, etc.)	79 to 83 F	Research may identify cooler colours
Medium grey	52 F	Reflectance half way between white and black
Built-Up Roof (BUR) covered with gravel	61 - 83 F	Cooler values obtained with lighter gravel
Black materials	90 F	

Builders, Dealers, DIY and Framers, (2014) claims that effect of external surface color on the room temperature inside a building will depend on other parameters:

- Rate of air ventilation in the building

- Direct solar radiation gain into the building

These two effects have essentially been addressed in this study.

The conclusions which have been adapted to the study are based on the concept that external surface color of a building envelope has been shown to have appreciable effect on the thermal behavior of a building measured in terms of the room temperature.

5.3. Materials

The study of Jayasinghe, Attalage and Jayawardena (2003), compares the effect of aligning the ridge of a double-pitched roof in the east west or north-south direction, using different roof covering materials such as cement fibre sheets and clay tiles,

using different insulation materials such as aluminum foil and polystyrene, and having a light or a dark colored roof surface.
Between the final conclusions the statements below have provided sufficient data, to affirm on roof covering material, the performance of clay tiles is marginally better than that of cement fibre sheets, and that the light color roof surfaces (white) can achieve indoor thermal conditions comparable to those of the insulation materials.

Mariana Guimaraes (2008), with her study provides parameters of the contemporary materials, in this case, cover materials, which are the most used in the cotemporary architecture. With the level of tile's absorption supplied and the incidence of the solar radiation will be possible to classify and then produce a new European map. It will be able to live up to the requirements for thermal comfort. The materials with the highest absorption, in other words with lower reflectivity, will be destined to countries with the low radiation and in the opposite case to intense radiations countries. These materials are asphalt, bitumen and concrete tiles. They are a fine-grained, foliated, homogeneous metamorphic rocks, and as such, is naturally resistant to moisture intrusion untreated. This means frost and freezing will not damage slate roofing. Slate roofing has many other advantages too.

The weakness of the last paper is founded in the shortage of materials that she describes, because of it is only possible and applicable to the research the propriety of the clay tiles with an absorbency of 0.65. The last valor described is totally agree with the reflection of the data from "Roofing Materials for Flat Roofs", *A green Affordable Housing* (2005), which determine for a cool roof a solar reflectance of at least 0,70. From this relationship is able to reach the first conclusion that clay tiles will be the properly material to warm climates with a high level of sunny light reflection.

"Roof Assemblies and Rooftop Structures", *Federal Emergency Management Agency* (2007), give some conclusions on asphalt and slate tiles what have helped to distribute them only on cool and very wet climates. The next lines describe features taken in account.

-Shingles in general have a high emissivity but low reflectivity.

-White shingles only reflect up to 30% of the light that hits them. With any reflective surface, the reflectivity is reduced when the surface becomes dusty, dirty, or covered.

Dark red tile	18%-33%	62°-77°F
Dark shingle	8%-19%	76°-87°F
Black shingle or materials	5%	90°F

Making again a comparison Guimares (2008) and "Roofing Materials for Flat Roofs", *A green Affordable Housing* (2005), dark colors in the third area delimited, with black color, the area number 2 will have a reflectance between 30 and 70%.

-Lighter colored shingles can last longer than dark shingles. This is because they absorb less light, and therefore aren't prone to as much expansion and contraction as dark shingles are, causing less wear and tear.

-Lighter colored shingles will however show their age, stains, and imperfections more noticeably than dark shingles.

-Many studies show that black shingles reach temperatures 20-40 degrees higher than white shingles. However, attic temperatures will rise by only as much as 10 degrees Fahrenheit. Still, in a cooling application this 10 degree difference is of some worth when considering the temperature difference across a thermal boundary. The smaller the difference, the slower the heat loss.

5.4. Economic Requirement

The first point it is thought to keep the temperature inside home, is controlling the temperature with air conditioning but it could assume a reis in the final costs of the bills electricity. Through the good realization of the roof it could decrease to 20%. That is the way that is exposed in the article "Roofing Materials for Flat Roofs", *A Green Affordable Housing* (2005), and by Chandler (1976), furthermore the study done by Bliss (2015), determines a 17%.

5.6. Insulation

Pout and Hitchin (2015) describe the results of surveys conducted in 12 mixed-mode buildings. The survey focus on areas indoor environmental performance, including thermal comfort and air quality. The data shows that only 11% of the 370 buildings, most of which have conventional air-conditioning systems, are meeting the intent of the thermal comfort standards to achieve 80 satisfaction in the buildings.

As is in the last outlined, this paper has contributed data for the research on insulation and where is necessary as his thickness.

The weaknesses which has been found in this study is the focus on the use of insulation through the air conditioning datum, thus, it has been necessary to continue contrasting datum, it has been strengthened using an approach developed by Suman and Srivastava (2008), with it and their simulation in their experiment will be able to collect more precise statistics.

The results of the simulation of Suman and Srivastava (2008) have been useful to adapt the data to achieve a classification on the thickness insulation in Europe. High summer temperatures 40°C necessitate cooling of buildings to provide a comfortable and workable living environment indoors. As such air conditioning is necessary.

With a scale established of insulation thickness between the minimum 400mm to 1200mm. The assignment of it will regard the attic temperature and the difference of temperature between both spaces, indoor and attic indoor. To avoid heat lost, it will have to able to entail both, cool as heat roof, independently of the temperature. The warmest area has the minimum insulation, growing to 1200mm till the third part, the cold area.

5.7. Slope

Davies (2013), in his guide to roof construction, stablishes roof pitch in the UK for a traditional house, which will be 40°-50° but at the extreme can go up to 70°, roof can be much flatter at say a 35° pitch if desired. In areas of high snow all then the roof pitch can be much greater, to allow the snow to fall off the roof rather than settle and build up on the roof. Roofs with pitches of 10°-20° are often called low pitched roofs and special considerations need to be made, particularly on the overlap between tiles to avoid water being blown into the roof by the wind.

The data collected from A Green Affordable Housing, (2005) define the slope; sun index of reflectivity higher or equal to 70 to slopes lower than 15% and, the sun index of reflectivity 29 to highest slopes >15%.

Chandler (1976) suggest three topics differing in scale, they are regional climate, determined by synoptic factor; the modifying effects of the local orography and the self- induced modifications of the buildings. Such differences are particularly important in high latitudes and high altitudes where major differences can accrue from relatively small changes in slope and aspect and these differences need to be carefully considered along with other criteria in deciding such matters as land use zoning for residential, commercial and industrial user.

The authors consider wind speed as a factor to human comfort, but the research is not focus in it. The research has combined wind and slope, but not for goal of human comfort on the lower level (on the street), but also it adapts wind speed to achieve the suitable roofing construction and lay down a scale with for each winds conditions. To do so, it has entirely exploited the meteorological data of wind from Agency European of Meteorology (AEMET, 2015), and it has been contrasted with another website (Organization Meteorological Mundial, 2015) (University of Strathclyde Engineering ESRU, 2009). Thus it can establish de next parameters:

<table>
<tr><th>m/s</th><th colspan="2">SLOPE</th></tr>
<tr><td>3,5-4,5</td><td>30%</td><td>Low</td></tr>
<tr><td>4,5-5,0</td><td>30-50%</td><td rowspan="2">Higher</td></tr>
<tr><td>5,0-6,0</td><td>50-70%</td></tr>
<tr><td>>6,0</td><td>80%</td><td>Steepest</td></tr>
</table>

Table 11. Slopes Scheme, Source; The author 2015)

Despite of the last outlined, to check the wind force of Europe has been necessary to collect data from other threshold, like for sample: wind load of wind energy. Is huge suitable compare datum from countries which can benefit of the wind speed. (FEMA, 2015). It means that will have to provide their roof of appropriate slope.

Another reason underlying to secure proper slope to get the good conditions in attic regarding of climate is working for reduce the heat island effect (Energy Options Explained (EOE), 2015), it means low slope roofs tend to be best, as they have a high reflectivity, with a high emissivity and will orient heat directly upward rather than at an angle.

From the assembly of Oregon Structural it has been used the exact numbers corresponding to the requirement to the roof installation. The maximum basic wind speed and the roof height have been two factor to take in account. Thus, with data winds and the slope suggested by the Specialty Code, it has reached a final conclusion of the slope European distribution. The roof height data have been disregarded in this research.

Held in his article “Roofing Materials for Flat Roofs” makes quickly subsection to suggest for a cool roof applying a low slope, this slope is 2:12 or less. In its sole discretion he claims a solar reflectance index higher or minimum than 78 is properly to low slopes (<15%), in another hand whether it is 29, it will be designate to higher slopes.

If it takes in account the last outlined with all of parameters acting on a properly roof slope installation, involving reflection, wind, and low slopes to avoid heat islands effect and also it keeps the pitch suggested by Davies, in “Guide to roof Construction”, which will be minimum slope 40-50 º C in UK, this is agree with the rest of the feedbacks for highest slopes in addition with the black roof (high level of absorbency), and to refer again to the information collected of the assembly, then it will decide and it could verify the perfect system, which will be a slope of the 2:12 for asphalt shingles, or where appropriate, concrete tiles regarding basics maximum winds of 100 mph. This condition would be appropriate for the north Europe, in other words, for the 3th part limited by the minimum and maximum temperature.

This procedure has been carried out during whole process on the rest of the areas to achieve the correctly roof slope in each case.

In Roof Assemblies and Roof Structures, the author mentions other parameter to take in account in roof construction, for example the IRC, IRC addresses roof covering requirements in several areas. Fire resistance is covered in Section R902 and insulation is addressed in Section R906, but the majority of the requirements are presented in Section R903 and R904, which address weather protection and materials, respectively. Requirements for individual roof covering systems (e.g., asphalt shingles, clay or concrete tile, etc.) are listed in Section R905. In spite of the importance of these conditions, it have not been took into consideration for the research. This factor is considered very changing factor regarding of the European region where it is investigated, in turn, with their own building technical code.

In the same guide, the last one, are provided the characteristics of some materials to roof covering, among them asphalt, metal, slate and clay shingles.

5.8. Climate

W.Köppen (2015), establishes an average monthly temperature above 10°C in their warmest months, and an average monthly temperature above -3°C in their coldest months. This includes areas from coastal Norway south to southern France. Dry summer or Mediterranean climates where summers are hot and dry, and in winter have moderate temperatures and changeable, in this threshold will be South Europe, except areas of northern Spain and Portugal, these areas would be oceanic.

The Oceanic climate usually occur on the western sides of continents. Summers are cool due to cool ocean currents, but winters are milder than other climates, but usually very cloudy. (Denmark, France, UK).

The last one in relation with Europe, continental climate. This climate have an average temperature above 10°C in their warmest months, and a coldest month average below -3°C. In warmest month the temperature is above 22°C , with at least four months averaging above 10°C. Coldest month averaging above -38°C.

Regarding of the three climatic areas stablished with Köppen Methodology, it has been able to develop the ventilation in Europe.

The reason for what Chandler (1976) considers the climate as a neglect point has been partly the relative youthfulness of the science of urban climatology, and partly the relatively weak communication links that presently exist between climatology and planning. Each element of climate, airflow, air chemistry, temperatures, humidities, precipitation visibility and so on will differ in urban as compared with rural areas. Due to the antique of this paper, the neglect of climate has not been dealt as a consideration, but includes the principal variable of the methodology chosen.

5.9. Ventilation

Together with the three areas divide, it can claim that the three must have ventilation, the one main point that the vent should be placed as far to the outside edge of the soffit as possible. Otherwise, warm air next to the heated siding can rise, enter the vent, melt snow, and cause ice dams. This is especially a concern on cold-climate homes with deep eaves. It is the one king that will be emphasized on the ventilation roof choice.

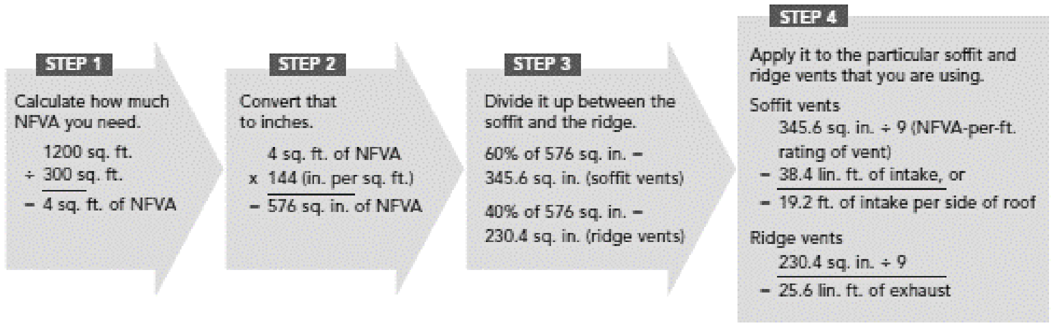

Figure 11.Ventilations Size (Pickett, 2015)

The first issue in which Pickett (2015) considers attic ventilation just a good option, he means that insufficient ventilation can lead to moisture problems during the winter and decreased energy efficiency during the winter and decreased energy efficiency during the summer. This has been one more reason consequently attic ventilation has been considered in whole Europe. He self describes it like an undisputed. Taking in account that Roof vents create an additional roof penetration, essentially where leaks can occur.

The problem named in "The other piece of the question", *Energy Smart Home Performance*, (2015) may be occurring if it knew that the moisture is coming from the house, then could be thought why it spend money ventilating the attic. The money would be better spent stopping valuable moisture and heat from getting to the attic in the first place. For example, in the cooling season stack effect reverses, any leaks between the home and the attic push superheated attic air down into the house.

This question has achieve to think in the importance of the ventilation prevailing on the other factors. Coat in cold climates.

5.9.1. Ventilation in warm climates

"Does Color Roof affect your Home's Temperature", *Findlay Roofing* (2015), affirms that it don't need to worry about the heating effects of shingle colors. The roof ventilation provides cooling for the shingles while the insulation blocks the remaining attic heat from transferring into the home.

In turn, also in a hot climate, Joseph Lstiburek (2011), provides exactly values about the size of the ventilation in attic, they are between 50% and 75% of the ventilation space at the eaves; a 60/40 split is a good sweet spot. Marcus Picket in his publication says that is need a ratio of 1:300, where for every 300 square feet of ceiling space, it needs 1 square foot of attic ventilation, then the entire vent opening doesn't count as vented space. Consequently in the area number "1", *figure 9*, delimited with temperatures between 3ªC and higher than 22ºC the main aim of the ventilation will be avoid the getting warm in attic through air refreshing. Marcus Pickett says that in warmer climates it doesn't need worry about condensation, in these climates, hot attic space are eliminated by installing a thermal barrier along the roof line, instead of the attic floor.

As a result, in the majority of attics in Mediterranean Climate the insulation will be positioned on the attic floor to prevent the heat gain in summer, and, in turn, avoiding in the wrong way, the useless and waste use of air conditioning. This is the reason because of it has been chosen as a best construction condition for this climate.

5.9.2. Ventilation in cool climates

Meanwhile, preventing moisture damage is a much greater benefit and applies to colder climates more than warmer ones. In fact, the colder the climate, the more likely it is that the home will be benefit from attic ventilation. In order to install an unvented roofing system in colder climates, is will need highly rated, rigid insulation to prevent condensation on roof sheeting.

5.10. Chapter Summary

The Literature variety has given the possibility of arguing each concept from different points of view. With analysis, data collection and combining them, have been possible to reach an agreement on the possibility to keep the temperature indoor, making use of properly techniques, materials and external factors intervening.

CHAPTER VI – CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The aim of this thesis was to defend the following proposition:

> *The main "feebleness" against heat lost is the roof. The best way to avoid it and consequently achieve thermal comfort indoor is with the properly roofing work. The form to achieve it is knowing the variables acting on the roof, with which, their performance, could be improved depending how they behave and how their characteristics vary regarding of the climate.*

The questions arising from this statement were:

Question # 1: Are there parameters influencing over the roofs construction?

Question # 2: May climatology condition be used to good design of roof, thereby the lost heat of roof?

Question # 3: Is there region limits that constrains the division, and can they follow gradually characteristics scale?

The approach this problem, a literature review was conducted. The literature review focused on the parameters of slope, wind, thermal analysis, ventilation, materials, insulation, orientation and cold loads which condition the bearing of roof, the size of them, the peak, and the rest of dimensions and materials involucrate. Independent was studied literature of climate, as a principal point to develop of the report.

The method to defend the proposition was arguing and comparing. List of data was collected, extracting maximum and minimum temperatures on Europe three divisions were made, equipping each one with the correct benchmarks.

The results were discussed in regard to the critic data from the different authors, guides and specialist books.
Despite discussed shortcomings, it was found that the results were reliable enough to argue the proposition.

The questions arising from the research aim can be answered as followed:

Question # 1: Are there parameters influencing over the roofs construction?

Yes, there are parameters influencing over the roofs construction, in fact the main components are ventilation and roofing color.

Question # 2: May climatology condition be used to good design of roof, thereby avoid the lost heat of roof?

Yes, the climate condition the existence or absence of some roofing elements, thereby how the size and thickness or the form of them.

Question # 3: Is there boundaries that constrains areas and can they follow gradually characteristics scale?

Yes, there are three boundaries. FIGURE which follow values gradually, for sample, insulation will be thickest in the north that in the south, regarding of color, scale of color will be black in the north to white in the south (grey in the middle), slope will be steeper in the North than in the south areas, and in this way each factor.

Accordingly, the proposition has been defended.

The main "feebleness" against heat lost is the roof. The best way to avoid it and consequently achieve thermal comfort indoor is with the properly roofing work. The form to achieve it is knowing the variables acting on the roof, with which, their performance, could be improved depending how they behave and how their characteristics vary regarding of the climate.

6.2. Recommendations

Keeping temperature constitutes a complex system of the different variables intervening. Developing of the technology and new systems to get a good work of the roofing is a work in progress, it does impossible to set a “perfect” system, which for the next years continues with the same performance that right now.

European roofing materials have been pursued by the traditional technics till nowadays. It means that there has not had a previous study in each country to carry out them. That is not to say that there wasn't a previous idea about. The man has thought always in his comfort and the correct way to achieve it.

If the research continues in a future maybe would be appropriate investigate in new materials which could have enough capacity to resist the change climate without the need of turn to regard the rest of the components.

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