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Comparison between Heat Conductivity of EPS (Expanded Polystyrene) and XPS (Extruded Polystyrene)

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Abstract: **The choice of insulation material plays a critical role in the heat conduction and indoor living quality. The need for elimination of mechanical appliances to reduce electrical costs and a chance to bring a change to the sustainable ways and how we choose the end product to replace them. The choice between XPS and EPS gives a comparative measure to the choice of the insulation material as we are going to compare with properties of both and the real life simulation for an overview of the numerical analysis from the two materials. The findings from the report came about from the help of simulations from Energy 2D software which is used to produce interactive results of visual Multiphysics to model all the modes of heat transfer; conduction, convection, and radiation. Due to varying average monthly temperatures, insulation materials react differently when exposed to multiple weather conditions and in this study, an average of 16 hours is used to calculate and simulate the reaction of EPS and XPS into a particular section of a wall and its immediate interior space. From the graph and tables, the outcomes are seen immediately the heat source is active and how the insulation works over time when a constant temperature is applied to a partial section of the house. To get the appropriate results for the location, average temperatures are used for each month to simulate the heat conductivity of both EPS and XPS over a period of hours to acquire data for analysis.**

Keywords: **EPS, heat conduction, indoor air quality, simulation, Thermal insulation, XPS.**

1. INTRODUCTION

Since the beginning of time, human existence has been facing extreme conditions in between the year when it was extremely hot and cold during the peak season times and being exposed to strong winter winds and high humidity causing fungus in the interior spaces among many others. To ensure the indoor living conditions are suitable for the users, the building has to protect itself from the varying outdoor conditions at all times. In the 21st century, it is not economically viable to construct stone walls which would react a meter's thickness as they use to do in the previous times because the market doesn't allow for that kind of clientele. Therefore, the cheapest and fastest way to protect our buildings is to use thermal insulation materials which would store heat inside the buildings during winter and prevent hot air into the interior spaces during summer. The process of putting up the building envelope comes in layers to reduce the amount of heat which is lost and to increase the energy efficiency of the insulating material. In doing so comes the next question on the choice of materials available in the market to insulate your building. Many variables come into place such as the cost and energy efficiency, building codes of the region and the availability of the material close by for sustainable construction. [1].

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2. LITERATURE REVIEW

In the review, we study on the Comparative assessment of insulating materials on technical, environmental and health aspects for application in building renovation to the passive house level which is based in Netherlands. Studies show that there has been an increase in the use of insulation materials over the last 30 years and has impacted the livelihood of people significantly. Studies are done on insulation materials from Mineral wool to EPS to compare the most suitable material to use. Close attention is paid to the thermal conductivity, density, water vapour diffusion resistance, resistance to fire, and the price in determining the choice of insulation viable to install on an existing building. To try to narrow down the list of all the insulation materials, we take a look at the details of EPS and XPS I the study that was done below. [2].

Material	Base materials	Thermal Conductivity (λ) [W/m·K]	Density [kg/m^3]	Fire Class NEN-EN13501	Water vapour resistance factor (μ) [-]	Price when used in R_c=3.5 cavity wall [€/m^2]
Expanded polystyrene (EPS)	Benzene, ethylene, pentane	0.032-0.045	10-80	E-F	20-100	8.60-17.35
Extruded polystyrene (XPS)	Benzene, ethylene, pentane	0.025-0.040	15-85	E-F	80-300	18.00-23.10

Fig 1. Insulation material properties. [2].

In terms of it price, EPS dominates the European market by 27% in general from other insulating materials as a whole. The upside to using it comes at the incineration process where the EPS is recycled without quality loss but due to the unavailability of large scale use in the market, the recycling costs and producers are not on demand. The main reason that the demand for high energy consumptions today is the poor insulation in our dwellings. Insulations regulations were introduced but not emphasized until recently in few areas. The thermal capacity specified nowadays is 3.5m^2·K/W for the 80-100mm thick panels.

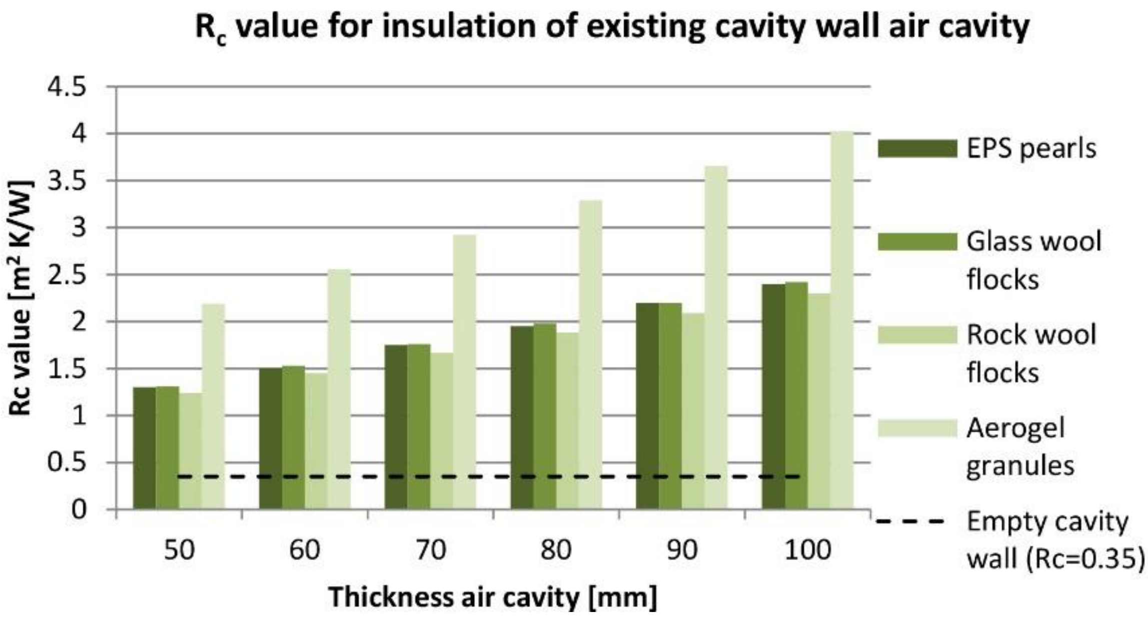

Fig 2. Comparing R-value and thicknesses. [2].

This table illustrates the difference of having an empty cavity wall in comparison to other insulation materials and their annual heat flow through the wall to measure the energy that is lost over a period of time. We can measure its life cycle cost and its effectiveness to be able to choose the most suitable material for the region of installing the insulation materials. In choosing the best insulation material, it can be said that there is no such thing because it depends on the specifics of application. In terms of environmentally friendly materials, some materials work better than others preferably with materials that have end–of-life options .e.g. recycling or reuse much more advised. There is no doubt that the thesis selects EPS and Mineral wool as its best insulation materials for passive house renovations due to its high saving on costs and the ability to cope with the ever changing standards.

3. INSULATION MATERIALS

3.1 EPS (Expanded polystyrene)"

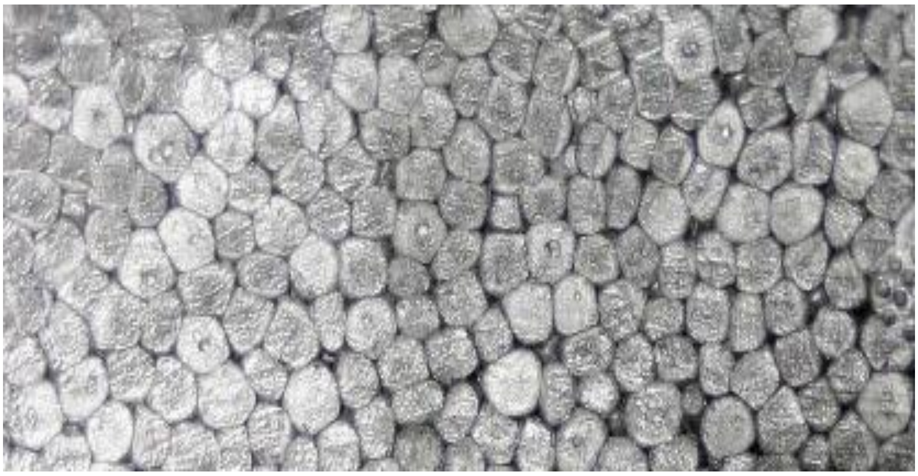

Fig 3. Expanded polystyrene

The expanded polystyrene or in short (EPS), the system was first adopted in by. Expanded polystyrene is a familiar material used in our daily lives for example when unboxing a new television set the polystyrene acts as a shock absorber to protect it from damage during transportation.

Expanded polystyrene insulation or EPS insulation is manufactured using a mould to contain small foam beads. Heat or steam is then applied to the mould, which causes the small beads to expand and fuse together. This manufacturing process does not form a closed cell insulation as there can often be voids between each of the beads where they are not touching one another.

3.2 XPS (Extruded Polystyrene):

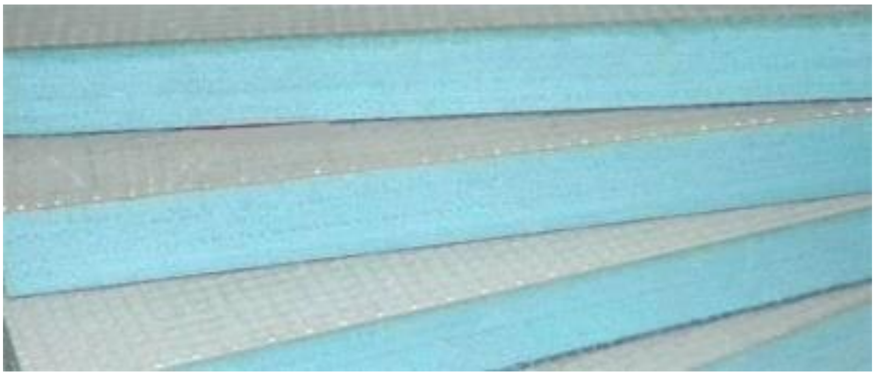

Fig 4. Extruded Polystyrene

Extruded Polystyrene (XPS) is a high performance, water resistant and lightweight board of thermal insulation recommended for use under concrete slabs, green roofs, edge beams, cavity walls, external walls and cool rooms. XPS has a high compressive strength and is available in shiplap or square edge.

Extruded polystyrene insulation or XPS Insulation is manufactured through an extrusion process. This manufacturing process involves melting together the plastic resin and other ingredients. The liquid formed is then continuously extruded through a die and expands during the cooling process. This produces a closed cell rigid insulation. [3].

4. PHYSICAL PROPERTIES

Definition of R-value. : A measure of resistance to the flow of heat through a given thickness of a material (such as insulation) with higher numbers indicating better insulating properties.

EPS – Physical Properties of Common Types Used in Building Envelopes				
Classification:	Type I	Type II	Type VIII	Type IX
Density (pcf)	1.0	1.5	1.25	2.0
Comp. Res. (psi)	10	15	13	25
R-value (@ 75 degrees F.)	3.85	4.17	3.92	4.35

XPS – Physical Properties of Common Types Used in Building Envelopes					
Classification:	Type IV	Type V	Type VI	Type VII	Type X
Density (pcf)	1.6	3.0	1.8	2.2	1.3
Comp. Res. (psi)	25	100	40	60	15
R-value (@ 75 degrees F.)	5.0	5.0	5.0	5.0	5.0

Fig 5. Physical properties of the insulation. [4].

4.1 ADVANTAGES AND DISADVANTAGES OF EPS AND XPS

Advantages

1. Recyclable products that assist with LEED points.
2. Won't support mould or mildew growth.
3. Long-term, stable R-value.
4. Can be placed below grade.
5. Can be utilized for inverted assemblies (over membrane).

Disadvantages

1. Exposure to sun will deteriorate the product.
2. Solvents/solvent-based materials cause irreversible damage.
3. Elevated temperatures (above 250 degrees F.) will "melt" polystyrene.
4. Incompatible with certain thermoplastics, polystyrene insulations are known to draw plasticizers out of thermoplastic membranes, causing permanent degradation.
5. Polystyrene is flammable, requiring proper placement in any assembly. [4].

4.2 WATER ABSORPTION

The bond in between the beads of EPS allow for water permeability because they are not close to each other as compared to XPS. Water is a good conductor of heat which will lead to a lower performance. The effect of water is largely seen in climates experiencing freezing and thawing which causes water to freeze and melt in turn leading to breakage of the bonds in between the beads.

4.3 THERMAL CONDUCTIVITY

The thermal conductivity of XPS begins at lower than the thermal conductivity of EPS. This is because air is a good conductor of heat. The air inside the spaces of the EPS conducts heat and to reduce the effect, a higher density is required to the conduction effect. This means that, if the beads are more, the voids become smaller. [5].

5. METHODOLOGY OF STUDY

Based upon the average temperatures of the year through each month in the city of Famagusta, the simulation has produced the results with their graphs and tables respectively. The density of the EPS and XPS that was used to test their heat conductivity was 15 kg/m3 so as to produce comparative results as per their effectiveness in thickness. Their properties change as follows:

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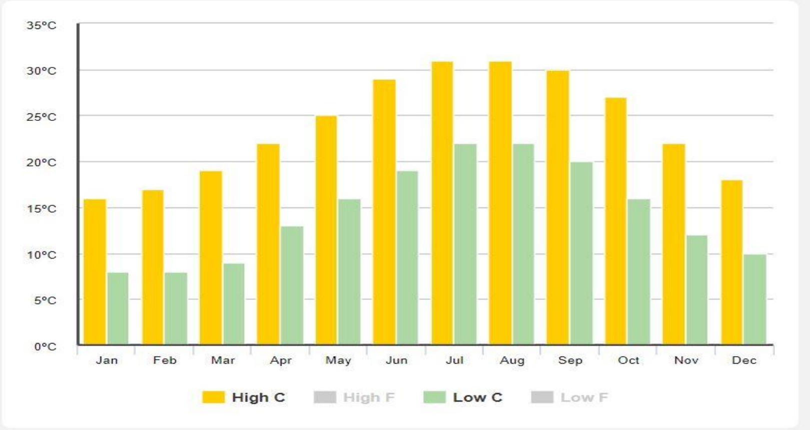
EPS thermal conductivity = 0.034 W/(m.°C)

XPS thermal conductivity = 0.033 W/(m.°C)

EPS specific heat = 1300 (J/kg °C)

XPS specific heat = 1500 (J/kg °C)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High °C	16	17	19	22	25	29	31	31	30	27	22	18
High °F	61	63	66	72	77	84	88	88	86	81	72	64
Low °C	8	8	9	13	16	19	22	22	20	16	12	10
Low °F	46	46	48	55	61	66	72	72	68	61	54	50

Fig 6. Average monthly temperature. [6]

6. FINDINGS

The simulation starts by applying a heat source from the exterior of the wall with a constant temperature for an estimate of 12 hours for each month of the year in the location described. The chosen temperatures are as per the averages that were recorded on average for each month as shown on fig 7. Four different temperature readings are put in place between the exterior, sheathing, insulation, wall and the interior space to gauge the variations in radiations from the sun on that particular section of wall. On the first month, 16°C is recorded to be the highest temperature on average and when applied, the insulation materials react in the same manner by blocking the heat from penetrating through. That interior space is assumed not to have any cooling or heating mechanisms so as to judge the immediate response to the radiations and their behaviour.

Month: January 16°C

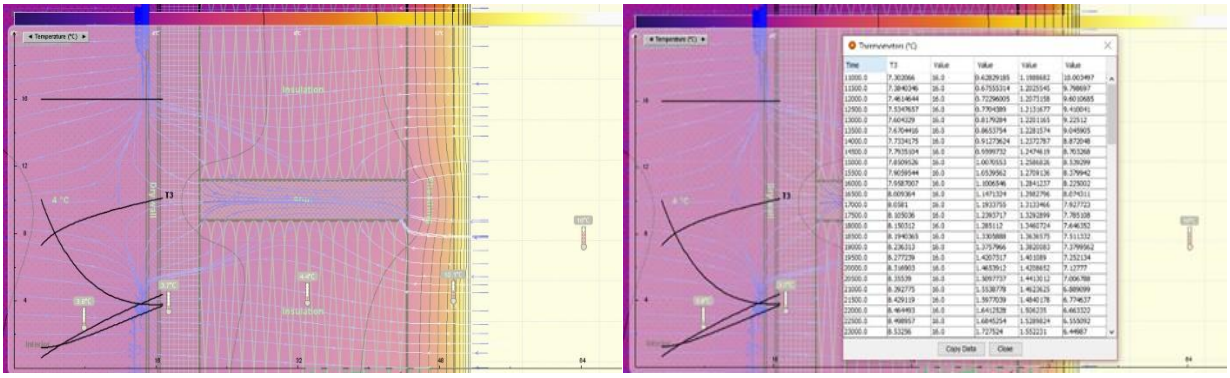


Fig 7. Graph and table of EPS 16°C. [7].

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However, the margins from which they block the radiations varying by a difference of 2.4°C over time with the XPS having an upper hand due to its higher thermal conductivity. Although the density of both the two material is equal at 15kg/m^3, XPS has its particles much closer to each other thereby making it harder for heat to pass through due to its bond.

In February, Famagusta receives an average of 17°C. The finding from the simulation show a slight temperature by 0.01°C for each on the interior indicating that a degree change within a few hours within a day has minimal impact on the effectiveness of the insulation without forgetting that EPS still has a higher conductivity rate meaning it allows more heat to pass through as compared to XPS for the temperatures that have been experienced so far.

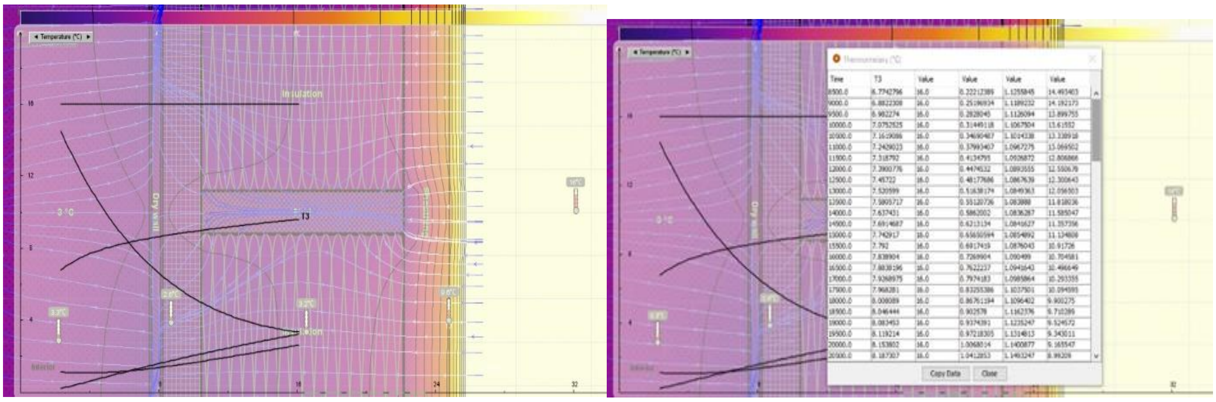

Fig 8. Graph and table of XPS 16°C. [7].

Over a period of 12 months, the averages note that the temperatures from the interior space of both the two insulation materials remain the same with a slight increase by every degree as was mentioned.

Month: May 25°C

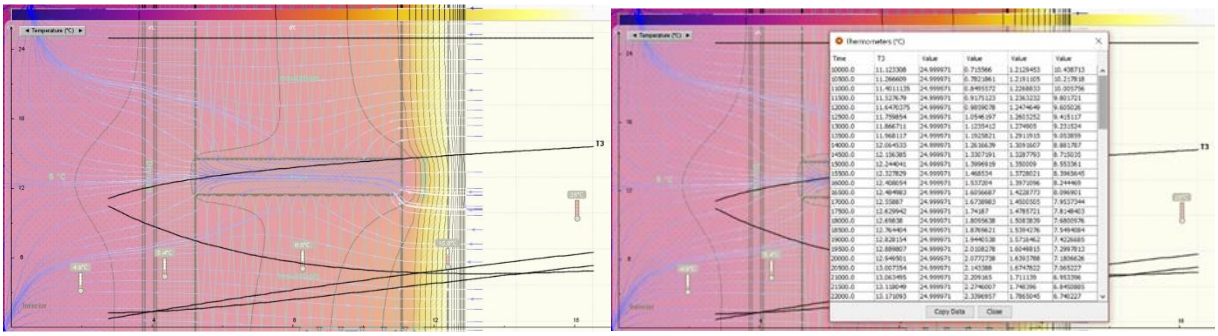

Fig 9. Graph and table of EPS 25°C. [7].

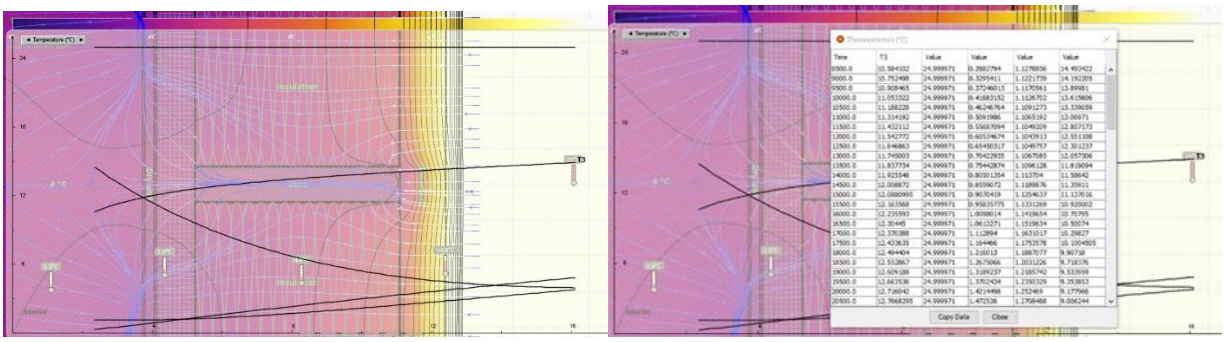

Fig 10. Graph and table of XPS 25°C. [7].

The sheathing which is placed just adjacent to the insulation is not affected what so ever by the insulation therefore the effect of both the two insulation materials is not accounted for in the temperature readings. The direct exposure to the solar radiation determines its temperature and the type of material that is used therein. Therefor the result remains the

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same for the two insulations' interior but the sheathing itself seems to have a rise of 1°C for every rise of 2°C in the exterior temperature from the sun's radiations. Moving on to the temperature readings of the insulation materials themselves, the readings show that for EPS, it manages to pass through 0.11°C for every rise in 1°C in the outdoor temperature while XPS only allows 0.03°C for the same outdoor temperature. This exhibits the effectiveness of XPS when installed on the exterior walls of a building as compared to the EPS. Temperature changes on the outdoors barely affects the insulations capacity of both insulation sheets but the durability of EPS on wet and dry climates can be questioned with a slight yellowish colour and hardening during freezing and thawing processes.

Month: December 18°C

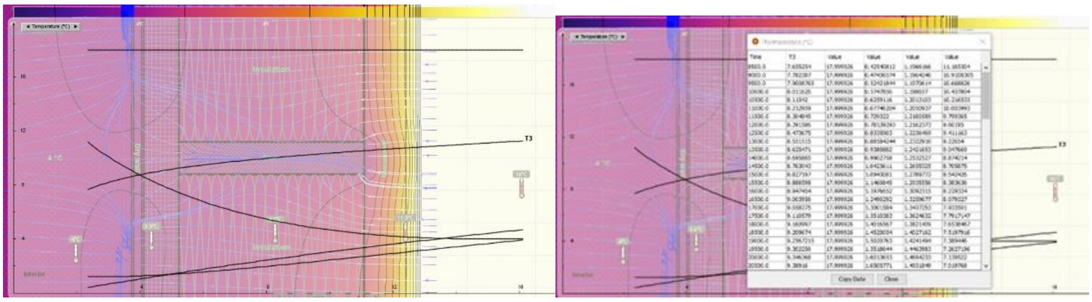

Fig 11. Graph and table of EPS 18°C. [7].

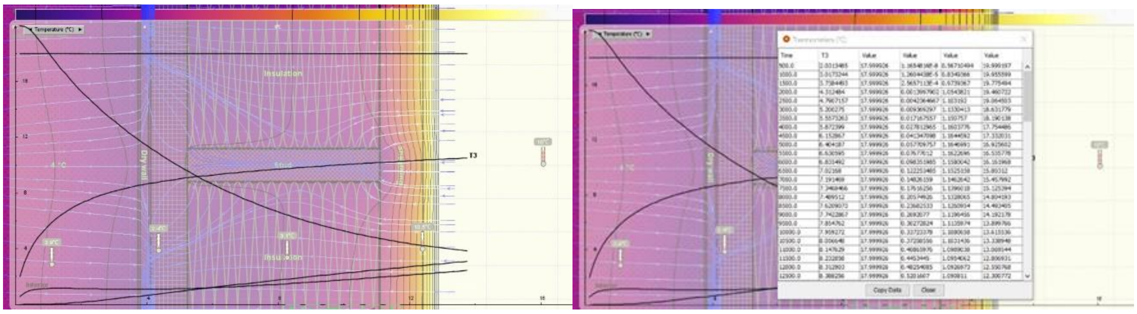

Fig 12. Graph and table of XPS 18°C. [7].

As a discussion, the results that have been produced from the Energy 2D program show a clear cut indication from its numerical analysis and presentation to give us an understanding of the difference between these insulating materials. It is essential that we understand we understand the layer of temperature difference that can be caused by the insulation materials that we choose to install onto our buildings and how heat conduction works through it. As heat is transferred from the sun towards the building, the first obstacle it encounters in this case is the sheathing material and works its way to the interior through the insulation material. In between these materials, temperature fluctuates and reduces significantly before it reaches the interior spaces to create an indoor air quality.

Due to the fact that XPS has close compacted cells, it makes it harder for heat or cold air to pass through because of the tight bond of the materials whereas for EPS, air space between the beads allows the intrusion of water leading to lower productivity as compared to XPS and the chance of formation of mould on the surface becomes inevitable in winter periods causing deterioration of the insulation material and shortening the lifespan. Changes in seasons doesn't affect the productivity of the insulating material because they work effectively and at the same rate when different temperatures are applied to them. Cold winter winds and warm summer winds have the same proportion of temperature change on the interior of the building. this consistency in results shows that indoor spaces can be kept cooler during summer when a cooling mechanism is used in the interior with losing it to the exterior and warm air doesn't penetrate through the walls to increase the indoor temperature and vice versa.

It is also import to note that sheathing material or the cladding elements that are used on the facades of buildings can affect the functionality of the insulating material by the amount of heat they can manage to allow to pass through them before reaching the insulation. Shading elements and double skin facades are another way to control the heat and shade for the buildings when needed so as to reinforce the building in its interior air quality. Therefore, we can say that from the findings, XPS is much more effective in its ability to resist heat absorption and because of its economic viability, it makes sense to instable because its R value is higher, cheaper to purchase per m^2, thinner insulating sheets which lead to a less bulky building.

7. CONCLUSION

Apart from the fact that the two insulating materials have different properties, comparison between the effectivity and feasibility plays a role in their choices in building construction. As compared to the XPS, EPS is relatively cheaper per unit measure for installation but it comes with its downsides of how permeable it is when exposed to rain/moisture due to its density and how the R-value is affected under the same conditions.

Why do we really need to insulate our buildings and what are the consequences of our actions towards its negligence. It is imperative that we understand the importance of keeping our interior spaces cool in summer and warm in winter for the wellbeing of the building and the people who live in it to serve in main purpose. We cannot imagine ourselves freezing inside our homes and places of rest yet they are our habitats. Knowing what is necessary for the user is indispensable to cater for their needs and this would also impact on the budget of putting up a structure. The choice of material heavily.

Many cases are experienced of poorly insulated building and how that has affected the health and livelihood of its inhabitants. Many buildings in Famagusta are poorly protected causing high electricity consumptions during high and low temperatures. This has also caused the growth of moulds in wet spaces in winter because heating inside the building is not well preserved and cannot reach the toilets. This leads to poor health of the people using the building due to the mould and inability to spend enough on heating and cooling. Governing bodies are solely responsible to maintain rules and regulations and keep up with the ever changing technology for the better to ensure that buildings that are brought up meet the necessary criteria for people to live in. once regulations are put in place, the smallest of deviations would matter to buildings in overall and significant changes are to be noticed just by the choice of material or in some cases not adhering to the rules of building.

REFERENCES

[1] Wiki/Polystyrene. Polystyrene, [Online]. Available: https://en.wikipedia.org/wiki/Polystyrene Johnson, T. (2017, April 2). What is EPS? - Expanded Polystyrene, [Online]. Available: thoughtco.com/

[2] Melchert Duijve (2012), Master thesis report: Comparative assessment of insulating materials on technical, environmental and health aspects for application in building renovation to the Passive house level.

[3] Wiki/Polystyrene. Polystyrene, [Online]. Available: https://en.wikipedia.org/wiki/Polystyrene

[4] Building smarter facility management, [online]. Available: https://www.buildings.com/article-details/articleid/8498/title/insulation-eps-and-xps

[5] Epsindustry. (2012). Physical Properties, [Online]. Available: http://www.epsindustry.org/packaging/physical-properties

[6] Annual Average temperatures (2017), [Online]. Available: http://www.holiday-weather.com/famagusta/averages/

[7] Energy2D software, Interactive Heat Transfer Simulations for Everyone