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Abbreviations

CPR	Construction Product Regulation
hEN	harmonized European Norm
EAD	European Assessment Document
LCC	Life Cycle Cost
LCCA	Life Cycle Cost Analysis
PCM	Phase Change Materials
HP	Heat Pump
SAHP	Solar Assisted Heat Pump
AWHP	Air Water Heat Pump
O&M	Operation & Maintenance
NPV	Net Present Value
DHW	Domestic Hot Water
PVC	Polyvinyl Chloride
PVT	PhotoVoltaic/Thermal
EPS	Expanded Polystyrene
XPS	Extruded Polystyrene
EU	European Union
TRL	Technology Readiness Level
WP	Work Package
D	Deliverable
PV	PhotoVoltaic
WHR	Window Heat Recovery



Publishable summary

The aim of this document is to economically evaluate the technologies of SUREFIT project in terms of prioritizing the most cost-efficient solutions for each demonstration site, taking into account the specific characteristics of the demonstration buildings, as well as the climate conditions of the corresponding countries.

At the same time, these technologies will be compared with some similar conventional ones, in order to identify whether the SUREFIT products could be launched to the market and if they could compete other solutions already available. Four of the proposed SUREFIT technologies are already market available solutions, however new features were introduced for these technologies during the SUREFIT Project.

The economic evaluation was based on the prices and costs provided by the technology manufacturers, however, for the technologies that are still at the laboratory stage, the costs should be reduced to reflect their corresponding market price after the industrialization of the products.

A Life Cycle Cost approach was followed accompanied by the discounted Payback Period calculation, to be able to evaluate and prioritize the most cost-efficient solutions and products. At the end of the economic study, it was proved that the already available in the market SUREFIT technologies were better performing and that they could compete other conventional technologies of the market.

It was concluded that a cost reduction is needed for the lab technologies after their industrialization, so that they could be competent and affordable from the residential customers.

1 Introduction

Leading Beneficiary: AMS

Participants: CJR, ISQ, FSM, AALTO, UNNOT

Task description: Economic evaluation (AMS, M19-M48)

“The performance of the renovated buildings will be compared with data before renovation. The energy consumption and energy saving will also be analysed and the reliability of the technologies will be monitored. A life cycle cost analysis will be carried out for the technologies using a net savings methodology. The capital cost for each technology will be decided on the basis of the prototype construction and installation costs, and the energy saving costs will be calculated according to the trial and simulated heating, cooling or lighting outputs and current energy prices.”

Based on the task description, the aim of this deliverable is to investigate the economic viability of the SUREFIT technologies and to define the most cost effective solutions for each demonstration building, taking into account the existing state (energy consumptions, operating systems, insulation level etc.) of the buildings, their requirements and the corresponding climate conditions.

At the same time the SUREFIT technologies will be compared with similar conventional solutions that are already available in the market. The costs of the SUREFIT technologies will be based on the prototype construction and installation costs, however these costs should be re-evaluated when the technologies will reach a higher TRL at the end of the project and will be ready for industrialization and merchandising.

This task is correlated with the other tasks of WP8 but also with Tasks 2.2 and 2.4 where the performance of the demo buildings before and after the renovation with the SUREFIT technologies was estimated through modelling and energy simulations, whereas in Task 2.4 a first economic evaluation took place by calculating the simple payback period of the proposed technologies. In addition, important data are provided from WP4, where prototyping of the technologies took place and financial information regarding the costs of materials and devices was revealed.

In WP2 (Task 2.4), a first approach on the economic evaluation of the SUREFIT technologies was conducted by using the Simple Payback Period, considering only the inflation rates of each demonstration country and of the EU. Not all the technologies were possible to be evaluated since the energy simulations and their resulting data were available for combinations of technologies and not for each SUREFIT technology alone.

These first calculations were proved to be helpful for the initial screening and ranking of the technology alternatives, however, Simple Payback Period can oversimplify financial evaluation to the point that the best performing alternatives are not properly quantified and identified.

For this reason and to be able to provide more enlightening and comprehensive results, different ways for performing an economic evaluation of a project were examined so as to conclude to the most effective one for the Task's purpose.

In the following sections, different methods and parameters for the economic evaluation of the SUREFIT solutions will be presented, along with the methodology that was finally used to achieve the aim of this Task.

2 Life Cycle Cost Definition & Methodology

2.1 Definition of Appropriate Economic Indicators

Investment in any project is correlated with significant capital and other associated costs over the economic life cycle of the project. Especially when it comes to buildings, there are many costs that are involved, from the design and planning of a project, till the construction and the operation and maintenance of the building and of its systems.

There are numerous examples of engineering systems that have a great design and performance or accomplish the same result for the building, but have a little economic worth. In order to be able to understand which system or technology is appropriate for each building project, different economic indicators can be used. However, not all of them are capable of revealing the real economic impact of an alternative.

For example, Simple Payback Period (as well as Discounted Payback Period) and Return on Investment, are two modes of analysis that are often used in projects that do not involve major initial investments. They can provide an initial screening of the project alternatives. However, they can oversimplify the economic evaluation to the point that the most effective alternatives are not properly quantified. This is because they are not considering any benefits can occur after the payback of the project and only focus on the energy savings that result from an energy efficiency measure applied, without considering other related operating and maintenance costs.

The Payback Period is the required number of years to recover the invested capital. It is also known as the recovery, or break-even period. The Simple Payback Period does not consider the time value of money whereas, the Discounted Payback Period is providing a more completed variation of payback by considering the time value of money or cash-flows.

$$\text{Discounted Payback} = \text{Year before recovery} + \frac{\text{Unrecovered cost at start of the year}}{\text{Cashflow during the year}}$$

In general, when Payback Period concept is applied the better investment is the one with the shorter payback. In WP2 the Simple Payback Period was calculated by considering only the changes in the inflation rate of each demonstration country thus, by providing the “inflated payback period”. In this the effect of inflation was considered when calculating the annual cash flows on which the payback calculation was based.

On the other hand, methods based on the Net Present Value (NPV) can be also used to decide whether a certain investment should be made, or to compare different investment options; however, these options should have the same economic life. If their lifespan is different, then an annuity method like Life Cycle Cost (LCC) is better to be used. In this way, different alternatives with different lifetimes can be compared to determine the most effective one. In addition, NPV is strongly affected by the chosen discount rate, and this can result to unreliable conclusions.

Life Cycle Cost (LCC) or Life Cycle Cost Analysis (LCCA) is a technique for evaluating the economic performance of a project (or a building) over its entire lifetime. It is the most straight-forward and easy to understand method of economic evaluation. Especially for building projects, it

enables different options to be compared from a lifetime perspective to reduce overall costs. Life Cycle Cost Analysis can be performed on large and small buildings or on isolated building systems or components. As a result, many building owners apply the principles of life cycle cost analysis in decisions they make regarding construction, renovation activities, or improvements to a facility.

Life Cycle Cost Analysis can include all costs of a building project over its entire lifetime, including design phase, construction, operation and maintenance, replacement and renovation costs, and disposal costs after the end of the lifetime. Many times the operating and maintenance costs have greater financial impact than the investment itself. As a result, the cheapest alternative from an investment cost point of view, does not entail that it is also the most cost-efficient alternative in terms of the entire life cycle perspective.

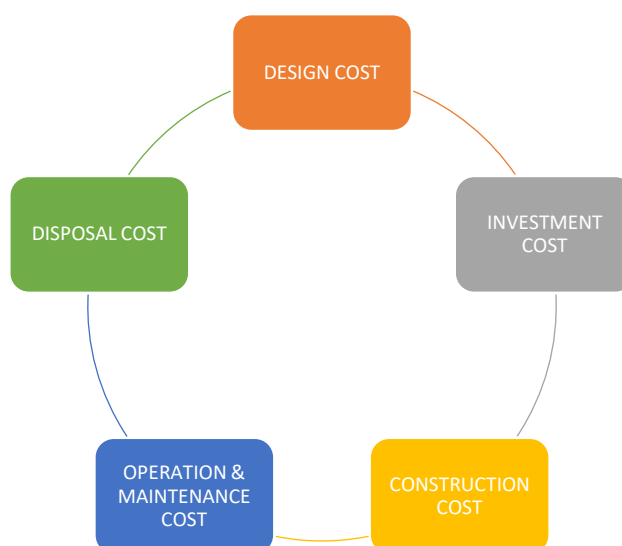


Figure 1: Costs involved in a LCC Analysis

2.2 General Parameters of LCCA Methodology

In order to perform a LCC analysis, the following steps should be followed in general:

1. Establish the objectives for the analysis;
2. Determine the criteria and parameters for the alternatives' evaluation;
3. Identify and develop the different design alternatives or different measures/solutions;
4. Gather the related cost information;
5. Develop a life cycle cost calculation for each alternative.

1/Establish the Objectives: To be successful, a LCC study must have clear objectives. LCCA can show which option will have the lowest overall cost between options that can be quantifiable in euros or generally in money. Therefore, for being able to determine the LCC, annual cash flows should be provided or calculated. That means that for example, the LCCA method could have results for an option that provides energy savings and thus, monetary savings, but cannot

evaluate options that are not reflected in energy and economic savings, as e.g. solutions that only ameliorate thermal comfort or occupant satisfaction.

2/Determine LCCA Criteria & Parameters: The two primary metrics to be used and calculated in LCCA are the life cycle costs of each alternative and their payback over a certain study life. The payback period in this case incorporates the time value of money. The parameters that will be needed to be identified for calculating the aforementioned indicators, are the period of study, the discount and inflation rate, as well as the energy prices that will be integrated in the calculations.

3/Identify the Base Case & Develop Alternative Designs: Before beginning the process of a LCC analysis the base case or baseline should be defined along with the alternatives that will be examined. The alternative that corresponds to the standard design or minimum requirements for a project usually represents the “base case.” Obviously, the alternatives that can be chosen, the comparisons that can be done and the baseline that can be assumed, can vary and can produce countless results. An infinite number of alternatives can be developed for any project.

In the case of SUREFIT Project, the baseline emerged from the assumptions conducted during the energy simulations process of WP2. Therefore, it was decided to have as a baseline the existing state of the buildings or the “as it is” state. The project team (AMS and AALTO) developed the alternatives, using their expertise and judgment in selecting relevant building and system component options. In order, to be able to evaluate each SUREFIT technology alone, and since in WP2 some different combinations of energy efficiency measures were investigated, now it was decided to calculate the effects of each measure or technology separately.

4/Gather Cost Information: Cost information can come from a variety of sources, including cost estimating consultants, suppliers, manufacturers, and designers. For each alternative, some specific costs must be collected such as construction or manufacturing costs, purchase costs of materials, auxiliary costs, installation costs, maintenance costs, replacement costs etc.

5/Perform Life Cycle Cost Calculations: For each alternative, the LCC and the Discounted Payback Period is calculated by taking into account the appropriate parameters needed for the calculations. Then, according to the results a recommendation can be made on which alternative performs better in terms of energy and cost effectiveness.

In general, when performing a LCC Analysis many assumptions are needed to be made in order to generate all the required data to produce results. These assumptions are basically related to three variables (costs, period of time and discount rate) and may affect directly or indirectly the final results. Therefore, they should be clearly stated and defined.

- ✓ The initial cost or initial investment: For the investment cost, assumptions could be made regarding the values that will be incorporated e.g. manufacturing or purchase cost of materials, assembly costs, cost of auxiliaries, installation and transportation costs etc.
- ✓ Future costs that occur after the operation of the facility: In this section the operation and maintenance costs are included, as well as residual and disposal costs. The operation costs are usually corresponding to the energy consumption of the buildings during their operation, as well as any maintenance actions required. Residual and disposal costs are more complex

concepts that are related with the remaining value of the building at the end of the LCC study period, and the disposal or not of the different components at the end of this lifetime.

- ✓ Residual value: It is the value of the product, component or building/building system at the end of the study period for which the LCC is executed.
- ✓ The costs of disposal: The costs of disposal may be tricky because depending on the type of the materials, these can be recycled or reused, they could be relocated or sold and also could be disposed. Each one of these actions could have a different cost and a different procedure that also depends on the country of disposal.
- ✓ The study period to be considered: The study period is the period of time to be considered for the calculation of the LCC and depends on the lifetime of the project (in this case the building) and the life span of the different technological solutions. Usually, the study period ranges from 20 to 40 years depending on the owner's preferences, the overall life of the facility etc.
- ✓ The discount rate or interest rate: The discount rate is used to discount all costs to their net present value and can have a great impact on the results. The assumptions here can involve the consideration or not of the inflation rate (real discount rate excludes the rate of inflation whereas nominal discount rate includes the rate of inflation) and/or the consideration of a discount rate that will be appropriate, according to the nature of the project under examination.

In general, LCCA calculations include planned maintenance in the form of replacement costs of equipment and systems. For example, if the time frame of a study is 30 years and a component of a mechanical system (e.g., a heat pump) needs to be replaced every 10 years, then the life cycle costs need to include the cost of that replacement at year 10, year 20, and year 30.

Not all costs are relevant to all projects. The costs and expenses that are going to be included in each project depend on the nature of the project and the experience and assumptions of the developer/project team that will allow to produce a realistic LCC comparison of the different alternatives.

The common unit that is used to express each life cycle stage is euros per square meter of usable floor area per year (€/m²/yr).

3 SUREFIT Project's LCCA Methodology

3.1 Initial steps for the Establishment of the Methodology

In the framework of the SUREFIT Project, five demonstration buildings were selected to be renovated with the innovative SUREFIT technologies listed below:

1. Bio-aerogel insulation, manufactured by UNNOT
2. Skytech insulating breathing membrane provided by WINCO
3. PV Vacuum Glazing windows produced by UNNOT
4. Phase Change Material (PCM) layer provided by PCM Products
5. Window Heat Recovery system manufactured by UNNOT
6. PhotoVoltaic /Thermal Panels (PVT) manufactured by SOLIMPECS
7. Solar Assisted Heat Pump (SAHP) produced by UNNOT
8. Ground Source Heat Pump (GSHP) produced by UNNOT
9. DayLight Louvers provided by KOESTER
10. Prefabricated Panels with silica aerogel manufactured by CJR

The five demonstration buildings are located in five different countries:

- Greece
- Spain
- UK
- Portugal
- Finland



Figure 2: Demo sites from left to right, Greece, UK, and Portugal



Figure 3: Demo sites from left to right, Spain and Finland

By the aid of a simulation software named IDA-ICE, a dynamic simulation model was generated for each building representing its existing state (pre-renovation state). Then, different combinations of the SUREFIT technologies were applied to each building model, to calculate the energy savings resulting from each energy measure. The combinations of technologies were selected in such way so as to succeed a reduction in the purchased and primary energy consumption, and a reduction of the CO₂ emissions by 60% (one of the targets of SUREFIT Project).

The initial screening of the technologies from a financial point of view, was already carried out in the framework of Task 2.4 and some basic conclusions were derived for some of the SUREFIT technologies alone based on the specific renovation packages/combinations that were defined in terms of achieving the aforementioned targets. Therefore, not all the technologies were possible to be evaluated at that stage due to the fact that the energy simulations were conducted for combinations of technologies and not for each technology alone.

In addition, the Finnish building was excluded from the calculations as no SUREFIT technologies except for the daylight louvers, would be applied on that building.

More detailed information about the energy simulations that took place, the assumptions that were made and the first results from the energy saving and the economical point of view can be found in deliverables D2.2 “Results of Dynamic Simulation of Building Energy Demand” and D2.4 “Results of Socioeconomic Investigation”.

The following scheme from D2.2 indicates the combinations of measures examined during WP2 in Task 2.2:

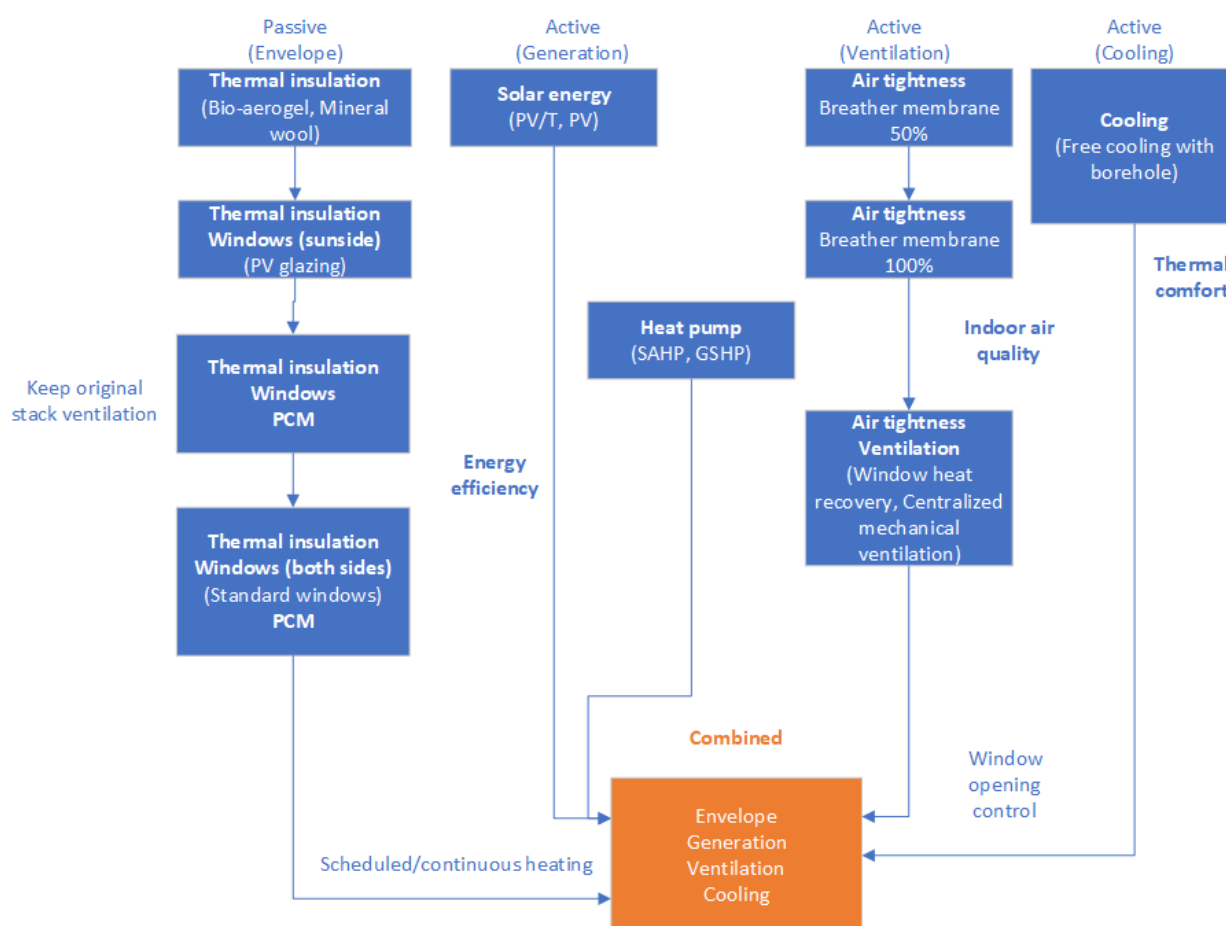


Figure 4: Scheme from Deliverable 2.2 indicating the retrofit packages

According to the above diagram the retrofit packages or combinations that were simulated were:

1. The bio-aerogel insulation alone
2. Bio-aerogel insulation + PV Vacuum windows
3. Bio-aerogel insulation + PV vacuum windows + PCM (PASSIVE renovation package)
4. Insulating membrane (50% airtightness improvement)
5. Insulating membrane (100% airtightness improvement)
6. Insulating membrane (100% airtightness improvement) + Window HR system (ACTIVE renovation package)
7. PV/T system
8. SAHP

As it appears, only four of the ten SUREFIT technologies were simulated alone, therefore in order to be able to economically evaluate all of them it would be needed to obtain energy saving results for each one of the technologies alone, in order to define the exact impact of each technology in each demonstration building.

In addition, some technologies could not be possible to be simulated due to the specialized and detailed design that should be conducted for each demo case. These technologies were the daylight louvers and the prefabricated panels. For the prefabricated panels, a calculation that considered the silica aerogel insulation alone took place, in order to simulate the impact of such an insulator at the different demonstration buildings.

3.2 Additional Energy Simulations & Individual Evaluation of SUREFIT Technologies

To reveal single SUREFIT technology's impact on energy consumption and CO₂ emissions, each SUREFIT renovation technology was integrated into and simulated separately in the demo building models, except the Finnish apartment building. The specific properties of the renovation technologies applied in the different demo building models are shown in *Table 1*. In all additional simulation cases, space heating is continuously available between September and May. The heating set point is 20 °C.

Table 1. Properties of SUREFIT technologies.

SUREFIT renovation technology	Properties
1. Bio-aerogel insulation	Thermal conductivity [W/mK]: 0.024, Density [kg/m ³]: 43, Specific heat [J/kgK]: 2260, Thickness of thermal insulation panel [mm]: 50
2. PV vacuum window	Solar heat gain coefficient (SHGC): 0.42, Solar transmittance: 0.3, Visible transmittance: 0.65, U-value of glazing [W/m ² K]: 0.6, Efficiency of electricity generation [%]: 3.5, Window area [m ²]: UK: 12.8, Greece: 11.2, Spain: 19.6, Portugal: 1.1
3. PCM	Layer density (solid) [kg/m ³]: 1100, Layer specific heat (solid) [J/kgK]: 2300, Layer heat conductivity (solid) [W/mK]: 0.22, Layer specific heat (liquid) [J/kgK]: 2300, Layer heat

	conductivity (liquid) [W/mK]: 0.22, Specific heat during reversing [J/kgK]: 300
4. Insulating breath membrane	Thermal conductivity [W/mK]: 0.029, Density [kg/m ³]: 96.15, Specific heat [J/kgK]: 2260, Thickness of insulating breath membrane [m]: 0.026, Airtightness (50% improvement) at 50 Pa [ACH]: UK: 8.1, Greece: 3.4, Spain: 3.4, Portugal: 3.4, Airtightness (100% improvement) at 50 Pa [ACH]: UK: 0.14, Greece: 0.07, Spain: 0.11, Portugal: 0.15
5. Window HR system	Air flow rate [L/sm ²]: 0.6, Pressure rise by supply and return fan [Pa]: 15, Heat recovery efficiency: 0.76
6. PVT system	Electricity generation efficiency: 20%, Conversion factor of solar thermal: 0.47, Loss coefficient a_1 [W/m ² K]: 6.18, Loss coefficient a_2 [W/m ² K]: 0.0001
7. SAHP	Total heating capacity [kW]: 11, COP: 4, Dimensions of each solar collector panel [m]: 2.1×0.81, Panel number: 4, Conversion factor η_0 : 0.7, Loss coefficient a_1 [W/m ² K]: 4, Loss coefficient a_2 [W/m ² K]: 0.005

In addition, Aalto research team also made a comparison between SUREFIT technologies and corresponding conventional technologies already available in the market by conducting some extra calculations or simulations. *Table 2* shows the SUREFIT technologies, their corresponding typical conventional technologies for comparison, and also their properties.

Table 2. Properties of SUREFIT technologies and their corresponding typical technologies.

SUREFIT renovation technology	Corresponding typical technology
Bio-aerogel insulation: Thermal conductivity: 0.024 W/m ² K	White Polystyrene Board (EPS): Thermal conductivity: 0.042 W/m ² K
Insulating breathing membrane: Thermal conductivity: 0.029 W/m ² K	White Polystyrene Board (EPS): Thermal conductivity: 0.042 W/m ² K
Prefabricated panel (silica aerogel): Thermal conductivity: 0.015 W/m ² K	White Polystyrene Board (EPS): Thermal conductivity: 0.042 W/m ² K
PV vacuum window: U-value: 0.6 W/m ² K, Solar heat gain coefficient: 0.42, Electricity generation efficiency: 3.50%	Triple glazing window: U-value: 0.6 W/m ² K, Solar heat gain coefficient: 0.49; Commercial PV panel: Efficiency: 20%
PVT panel: Electricity generation efficiency: 20%, Conversion factor of solar thermal: 0.47, Loss coefficient a_1 : 6.18 W/m ² K, Loss coefficient a_2 : 0.0001 W/m ² K	Commercial PV panel: Efficiency: 20%; Commercially available flat-plate solar collector: Conversion factor of solar thermal: 0.719, Loss coefficient a_1 : 1.45 W/m ² K, Loss coefficient a_2 : 0.0051 W/m ² K
SAHP: Main parameters at the rated condition: total heating capacity: 11 kW, COP: 4; Number of connected solar thermodynamic panels: 4; Water tank capacity: 420 L	Air to water heat pump (AWHP): Reference COP at rated conditions: 3.62

The comparisons were implemented to answer the following questions for each SUREFIT technology:

- 1) How much thickness of EPS insulation is required to reach the same insulation level achieved with bio-aerogel (5 cm)?
- 2) How much thickness of EPS insulation is required to reach the same insulation level achieved with insulating breath membrane (2.6 cm)?
- 3) How much thickness of EPS insulation is required to reach the same insulation level achieved with silica aerogel (5 cm)?
- 4) What kind of window and how many areas of typical PV panel are required to reach the same energy saving potential achieved with PV vacuum windows?
- 5) How many areas of typical PV panel and solar thermal collector are required to reach the same energy saving potential achieved with PVT system?
- 6) How much heating capacity of a typical AWHP is required to reach the same energy saving potential achieved with SAHP?

The first three questions were answered by calculation based on the following equation, while the remaining questions were solved based on building level simulations.

$$d_{EPS} = \lambda_{EPS} \times \left(\frac{1}{U_1} - \frac{1}{U_0} \right) \times 100$$

Where d_{EPS} represents the required thickness of EPS insulation (cm), λ_{EPS} is thermal conductivity (W/m²K) of EPS insulation, U_1 and U_0 are the U-value (W/m²K) of building envelopes after and before renovation with SUREFIT insulating technologies.

For being able to compare the SUREFIT technologies with the conventional ones mentioned above, the costs of these conventional technologies in each demonstration country should be also defined, based on the current market prices.

3.3 SUREFIT's LCCA Methodology

To establish the LCC methodology for the economic evaluation of the SUREFIT technologies, the variables that would be involved in the calculations, were defined.

Firstly, the energy consumptions and productions of the buildings were identified for each different demo case from the additional energy simulations as were described in the previous chapter of this report.

These energy consumptions (and productions if any) calculated before and after the installation of the SUREFIT technologies were then transformed into economic savings, so that they could be later expressed in cash flows (see figure 5).

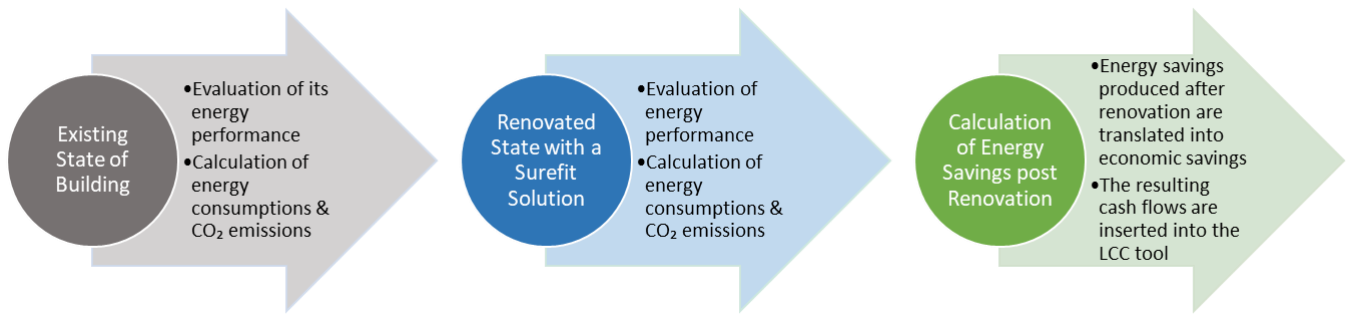


Figure 5: Diagrammatic description of the process followed

Another important variable is the reference period that will be considered for the life cycle study. This was also linked with the lifespan of the different SUREFIT technologies. Usually, the study periods that are utilized in building projects are between 20 to 40 years.

At the same time, the different costs and expenses that will occur at different times in the lifetime of a project, cannot be directly compared, therefore they must be discounted to their present value. The discount rate that will be used should be also carefully selected. The real discount rate is related to the real interest rate which is derived from equations that link the nominal interest rate and the inflation rate.

Real interest rate depends on market rate R and on inflation rate R_i :

$$R_R = \frac{R - R_i}{1 + R_i}$$

The discount rate depends on real interest rate R_R and on year of the considered costs (p). In the year ($T_0 + p$) the discount rate will be:

$$R_{\text{disc}} = \left(\frac{1}{1 + R_R} \right)^p$$

For the two aforementioned variables (study period and discount rate) a sensitivity analysis was conducted where, different values were taken into account (different study periods and different discount rates that were influenced by the changes in the interest and inflation rates of the last years) in order to reduce the risk of getting unreliable results.

Initially, different periods of study were selected and results were obtained for 20 years, 30 years and 40 years of study. Then, by considering the fact that the different technologies have different lifespans, an average number of years (30 years) was considered that could better represent all the cases. However, the maintenance costs that were considered included any replacements or heavier maintenance would be needed to take place during these 30 years, at the end of life of each one of the technologies.

Table 3: Interest and inflation rates of the four demo countries in different periods of time during 2023

Country	Financial Indicators					
	January '23		May '23		December '23	
	Interest Rate	Inflation Rate	Interest Rate	Inflation Rate	Interest Rate	Inflation Rate
UK	3.5%	10.4%	4.25%	8.7%	5.25%	4%
Greece	3%	7%	3.75%	4.6%	4.5%	3.5%
Spain	3%	5.9%	3.75%	3.3%	3.25%	3.4%
Portugal	2.5%	8.4%	3.75%	5.7%	6.9%	2.5%

From the sensitivity analysis that was conducted the following conclusions were derived:

- As the study period gets longer the LCC is getting higher;
- As the real interest rate R_R (linked with the discount rate) becomes higher and turns from negative to positive values, the LCC becomes lower, which is quite reasonable, since the inflation rate becomes lower and the products' prices are going down.

Some examples of what is described above are depicted in diagrams 1 and 2 which are referring to the Greek demonstration building.

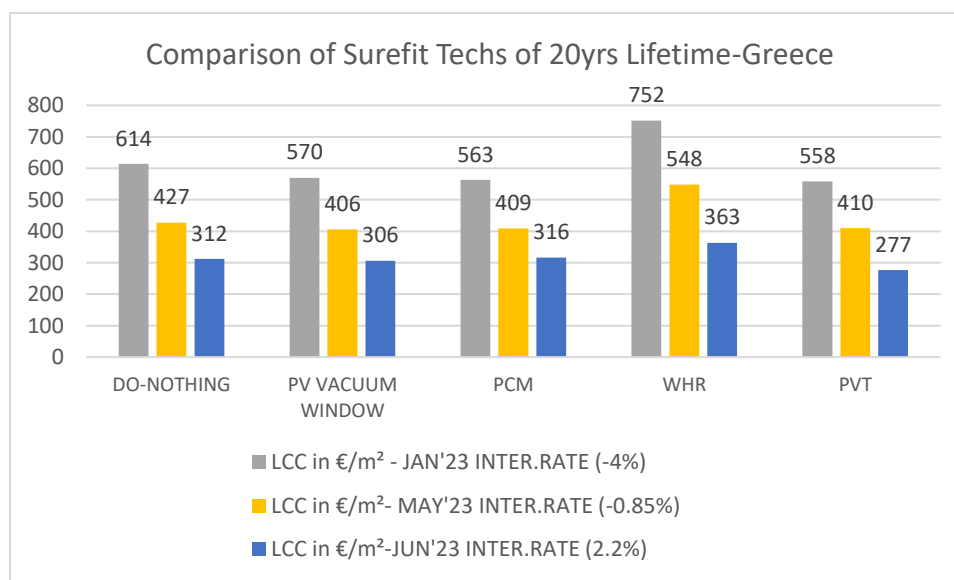


Diagram 1: Comparison of SUREFIT technologies with shorter lifespan (20 yrs.) for the Greek demo site & for different interest rates

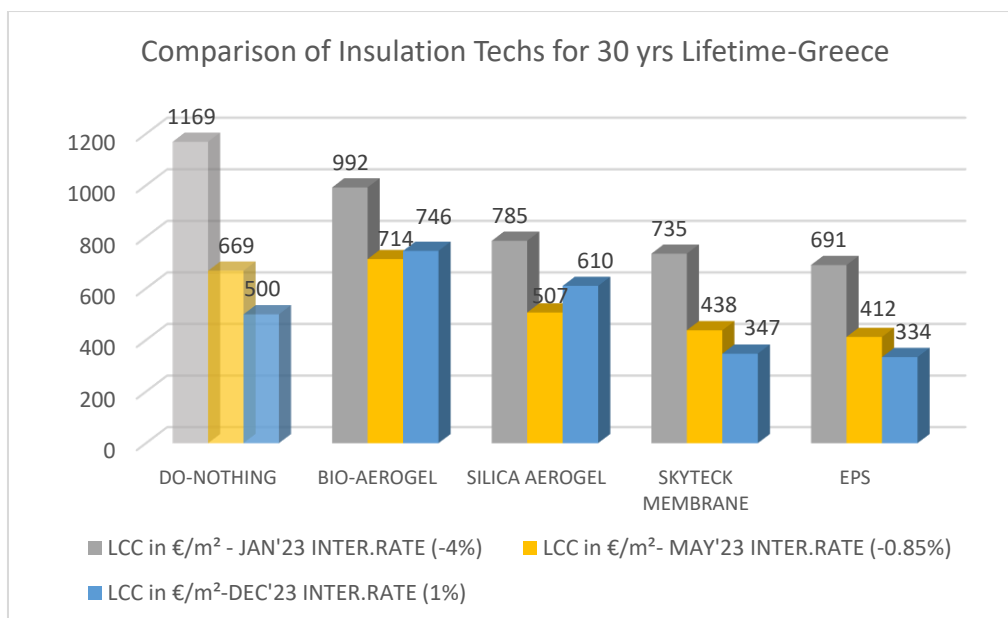


Diagram 2: Comparison of insulation technologies and 30yrs.period of study for the Greek demo and for different interest rates

3.3.1 Costs Considered in the SUREFIT LCC study

The **initial or investment costs** that were considered in the LCC analysis, were basically provided by the technology manufacturers and providers. As investment costs were in fact considered the manufacturing and installation costs for each technology and more specifically:

- the manufacturing costs of the SUREFIT technologies, that include the purchase costs of materials and any other costs for the assembly of the products,
- the costs of auxiliary materials or devices for the proper operation of the SUREFIT technologies,
- the installation costs that will be needed in terms of additional materials and additional labour.

Transport costs for the transportation of products or of the technologies to the installation sites, were not considered, as it was decided to compare similar cases for the technologies, and the transportation cost could differentiate a lot the final result, since it would be different for each demonstration site, whereas in some cases, customs clearance would be also needed to be counted in for countries outside of the EU (UK, Turkey).

Table 4: Costs and data considered for the calculation of the passive technologies' investment costs

Type of Technology	Thickness	Capacity	Country	Manufacturing or Purchase cost (with VAT 20%) (€/m2)	Auxiliaries (€/m2)	Installation cost (€/m2)	Life Span	Total (€/m2)
1. Bio-aerogel	10mm	—	UK	55.80	20.9	58.5	30yrs	135.20
			PT			13		89.7
			GR			22		98.7
			SP			—		—
			FI			—		—
2. Silica Aerogel	10mm	—	UK	16.8	20.9	58.5	30yrs	96.2
			PT			13		50.7
			GR			22		59.7
			SP			16		53.7
			FI			—		—
3. Breathable membrane (Skytech)	26mm	—	Same for all countries	24	0.37	14	50yrs	38.37
4. PCM panels	32mm	—	Same for all countries	96	—	10	25yrs	106
5. PV vacuum windows	24mm	—	UK	703.8	—	22.6	20yrs	
			PT			247/unit		
			GR			95		
			SP			24		
			FI			—		

Table 5: Costs and data considered for the calculation of the active technologies' investment costs

Type of Technology	Capacity	Country	Manufacturing or Purchase cost (with VAT 20% or 5% for SAHP) (€/unit)	Auxiliaries (€/unit)	Installation cost (€/unit)	Maintenance	Life Span	Total (€/unit)
6. Window Heat Recovery	—	UK	704.1	9 €/m	459	~10 €/unit annually- > 1,4% of manufacturing cost	20yrs	1214.94
		PT			247			1002.94
		GR			95			850.94
		SP			459			1214.94
		FI		Assumed that every edge of the unit requires sealant = 5,76m x 9 €/m = 51,84€	—			—
7. PVT Panels	—	Same for all countries	420	366	140	70€/h x 2hours assumed=140€/yr-- > 1,35-1,45% of the investment cost= between Groups 1 & 2	20yrs	926
8. SAHP	3kW	See the different values next	4075	3277.5	750	180€/yr--> about 2% of the investment cost - Group 2	15yrs	8102.5
	5kW		6520					10547.5
	7kW		8966					12993.5
	11kW		12377					16404.5
9. GSHP	1,3kW	Same for all countries	2360.4	3277.5	8600	180€/yr	25yrs	14237.9
	4kW		7262.3					19139.8
	6kW		10893.4					22770.9
	7kW		12709					24586.5

Other important variables that are counted in during the LCC calculations are the **energy costs** such as the electricity cost, or the oil and natural gas costs at which residential customers purchase the energy, as well as the price at which the electricity produced from the photovoltaics

is sold to the electrical grid. These prices are different for each country and depend on the inflation rate of the countries and on the energy mixture of each country.

Table 6: Energy prices considered for each demonstration country – for the electricity sold to the grid no tax was applied

Country	Energy prices (with VAT)			
	Electricity	Heating oil	Natural gas	Electricity sold to grid
UK	0.35 €/kWh	-	0.09€/kWh	0.19 €/kWh – tax free
Greece	0.1346 €/kWh	0.127 €/kWh	-	0.087€/kWh – tax free
Spain	0.1469 €/kWh	-	0.08€/kWh	0.1€/kWh
Portugal	0.1461 €/kWh		0.1078 €/kWh	0.06 €/kWh

The energy consumptions (purchased energy) that were calculated for each demo building before and after its renovation with a SUREFIT technology, were transformed to primary energy consumptions according to the primary energy conversion factors of each country (table 7). Then, the primary energy consumptions in kWh were converted to euros by multiplying them with the energy costs (€/kWh) of each country, so as to produce the needed for the LCC cash-flows.

Table 7: Primary energy conversion factors for each demonstration country

Primary energy factors (kWh/kWh)	Finland	Spain	Greece	UK	Portugal
Natural gas	1	1.195	1.05	1.13	1
Diesel	1		1.1		1
Electricity	1.2	2.368	2.9	1.501	1.49
LPG			1.05		
Biomass		1.113	1		
District heating from Power Plant Stations	0.5		0.7		
District heating from Renewable energy sources			0.5		

Finally, annual **maintenance costs** were considered depending on the nature of each technology and on the information provided by the manufacturers. For example, the insulating technologies have no maintenance costs according to their manufacturers.

As a general remark, the methodology followed for the LCC analysis as well as the parameters that were involved, was also very much affected by the type, quantity and quality of the provided by the manufacturer's information.

The general methodology that was followed is indicated in the diagram below. Briefly, the basic characteristics of the SUREFIT technologies were introduced into the simulation software IDA-ICE to produce the energy consumptions results of the buildings. Then, the obtained results for each demonstration building, were combined with the data related to the costs for the

manufacturing and installation of the technologies, as well as with the energy prices of the demonstration countries, so as to produce the needed for the LCC calculation, savings and O & M cash flows.

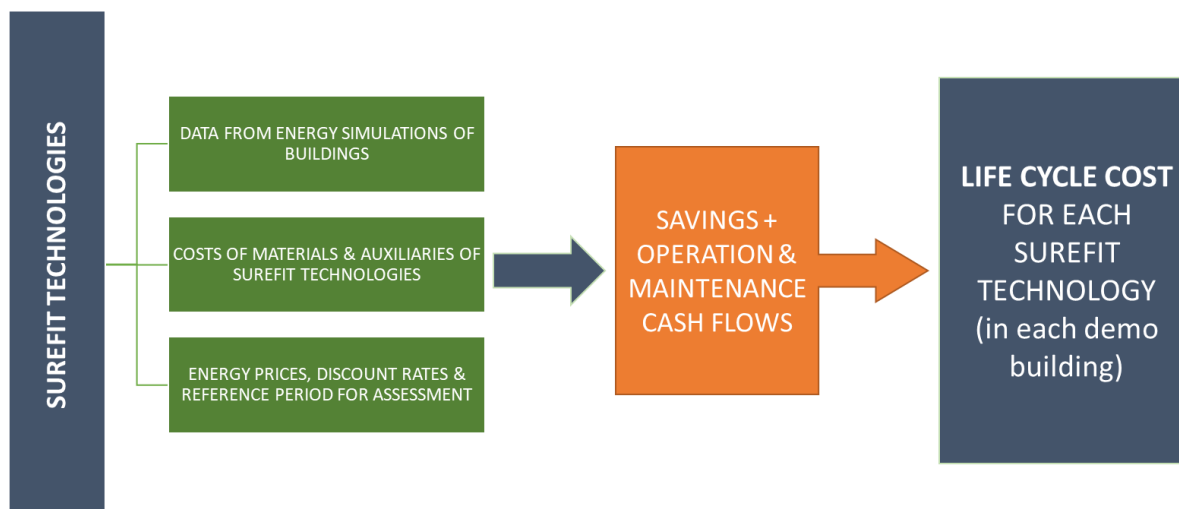


Figure 6: Brief diagrammatic description of the process that was followed to calculate the LCC of the different technologies

All the parameters and data that were gathered during Task 8.1, were introduced in an excel spreadsheet that was based in different freely offered at the web tools, calculating life cycle costs.

3.3.2 LCC tool

The excel tool that was created for the SUREFIT's LCC calculation was based on the previous calculation excels that were developed during Task 2.4 and on a variety of other LCC excel spreadsheets published on the web.

The basic input that is needed in this excel tool, is:

- the floor area in sq. meters of the building under consideration;
- the study period in years for which the LCC will be conducted;
- the interest and the inflation rate which will provide the real discount rate;
- any annual income from electricity production;
- the energy prices of the energy sources that are utilized in each building for heating, cooling, DHW, equipment and auxiliaries;
- the energy consumptions (primary energy) for heating, cooling, DHW, equipment and auxiliaries;
- the PV production or electricity production (if any);
- the construction cost, where the investment cost and the installation costs are included;
- the maintenance costs, which are considered as a percentage of the construction cost.

The different costs have been introduced in the excel tool after incorporating the corresponding VAT depending on the country and the product.

The energy produced from renewables is considered in the energy balance as a positive contribution to the energy consumption, and the revenues from the renewables have been subtracted from the energy costs.

The LCC tool is composed by 6 tabs; the first 3 tabs are receiving the input values, and the last 3 tabs correspond to the results and the calculation tables.

3.3.3 Life Cycle cost calculation

The equation that was used for the calculation of the LCC value is based on the Net Present Value (NPV), and reflects the sum of the discounted costs, of revenue streams, and residual value during the phases of the selected study period of the life cycle.

The basic NPV equation is as follows:

$$X_{NPV} = \sum_{n=1}^p \frac{C_n}{(1+d)^n}$$

Where,

- C_n : cost occurred in year n ;
- d : real discount rate per annum;
- n : number of years between the base date and the occurrence of the cost;
- p : study period (40 years).

With the net present value calculated for each alternative, comparisons are simple because units are consistent. The best option is usually the alternative with the lowest life cycle cost or lowest net present value. However, since the LCC analysis is often related with some degree of uncertainty depending on the assumptions made, the results should be weighted qualitatively too and not only quantitative. If for example, two alternatives have small differences in the overall life cycle cost, then they should be considered as equal, and also count in other parameters too for the selection of the best option, like the user's comfort, or the environmental impact etc.

The basic formula of the LCC is as follows:

$$LCC = C + PV_{RECURRING} - PV_{RESIDUAL-VALUE}$$

Where:

LCC is the life cycle cost

C is the Year 0 construction cost

$PV_{RECURRING}$ is the present value of all recurring costs (utilities, operation, maintenance, replacements, service, etc.)



$PV_{\text{RESIDUAL-VALUE}}$ is the present value of the residual value at the end of the study life (in many financial guides it is recommended to assume that residual value is zero for simplicity reasons).

4 Results of the Economic evaluation of SUREFIT technologies

The SUREFIT technologies already presented in other deliverables (D2.5, D2.2, D2.4 and deliverables of WP4) are quite different between them and are covering different needs of a building. Bio-aerogel and prefabricated panel (with silica aerogel integrated inside) are fulfilling the need for thermal insulation, whereas the breathable WINCO membrane can be used for either insulation purposes, or as a rain screen and for air tightness improvement. PV vacuum windows are improving the energy performance of the windows while producing small amounts of electrical energy. PVTs on the other hand are used for the production of DHW and of electrical energy, whereas some remaining thermal energy can be used as a supplementary source for the space heating of the building.

Most of these technologies were simulated via IDA-ICE (AALTO) to result to the specific impact that each one of them could bring to the existing demonstration buildings, whereas others were not possible to be simulated due to their specific characteristics which needed a more detailed design and sizing for each specific building (light louvers, GSHP). Also, it was observed that some of the SUREFIT technologies, when applied to small residential buildings like the examined ones, can mostly have an impact and amelioration in the well-being and the thermal or visual comfort of the occupants, and less effect in the energy consumption of the building.

The same was also done, for the conventional technologies that were also applied as renovation measures in the IDA-ICE building models, so as to compare the SUREFIT technologies with other, already available in the market and common technologies for heating, cooling and insulating.

The basic assumption considered for the economic evaluation and comparison of the different SUREFIT technologies with the corresponding conventional ones, was for the conventional ones to produce the same energy consumptions or to have the same energy performance as the one occurred when the SUREFIT products were applied to the buildings.

Basic Assumptions for the SUREFIT LCCA:

The study period was 30 yrs.

The maintenance was calculated according to the lifespan of each technology and for the technologies that have a smaller lifetime than the 30yrs, a replacement/repair cost or a higher maintenance cost was counted in at the year of their potential end of life. The maintenance costs were determined as a percentage of the initial investment cost per year.

Table 8: Maintenance costs considered for the different SUREFIT technologies

TECHNOLOGY	ACTIVITY	SHARE OF INVESTMENT COSTS	UNIT
Bio-aerogel	Maintenance	0	EUR/a
Silica aerogel	Maintenance	0	EUR/a
Prefabricated panel	Maintenance	0.18 %	EUR/a

Breathable Membrane (Skytech)	Maintenance	0 %	EUR/a
PCM panels	Maintenance	0%	EUR/a
Window Heat Recovery	Cleaning and maintenance	1.4 %	EUR/a
PV Vacuum Windows	Cleaning & Maintenance	0.6 %	EUR/a
PVT panels	Maintenance	1.35-1.45%	EUR/a
SAHP	Maintenance	2 %	EUR/a
GSHP	Maintenance	2 %	EUR/a

Residual values represent the value of a product or system at the end of the period of study. As there are no structured or relevant data for the residual values of the SUREFIT technologies, since they are new and in a laboratory phase, the residual values could be based on the straight-line method of depreciation. In this case where the study period is 30 years, the active technologies, or the technologies that include active components, have a lower lifetime than the study period, and thus these technologies are reinvested, and the remaining residual value is deducted after the observation period.

Disposal cost is the cost for dismantling, disposing, recycling, reusing etc. a product or component when it reaches the end of its lifetime. Depending on the item to be disposed, many different costs could interfere that make the calculation of this cost more complex. E.g. if a product need special treatment because it contains hazardous substances, then a fee may be needed for its disposal. Or if the item could be sold for usage in another project or building then a revenue could be considered. Therefore, when it comes to disposal cost, different parameters would be needed to be considered:

- Income and expenses associated with materials' disposal are dependent on whether the materials are demolished, recycled, relocated, or sold.
- Disposal costs also depend on the type of the materials (e.g. hazardous) and the treatment they need after their removal, as well as on the area (region regulations etc.) where they will be disposed.
- Different regulations and policies, as well as different costs and fees may be applied in each country for the disposal process of the different materials.

Considering all these facts, disposal costs were not considered in the LCC calculation, as they would complicate a lot the process. Moreover, since the examined period for the LCC calculation will be shorter than the lifespan of the entire building, this cost is not needed to be counted in.

In addition, for many of the SUREFIT technologies, it was assumed that the owner will not discard them at the end of their lifetime, but he will continue to use them with appropriate maintenance

and components replacement. This was assumed because it is a general practice for the majority of the residential owners, since for the technologies that are assessed in the SUREFIT project, it is difficult or expensive to directly replace them or discard them.

After calculating the Life Cycle Cost, the discounted Payback Period was also determined based on the cash flows already produced for the LCC. Therefore, the SUREFIT technologies were assessed by both these indicators.

For all the demonstration buildings, the same SUREFIT and conventional technologies were examined.

4.1 UK Demonstration Building

UK, during the previous months of the project, had a quite high inflation rate which had a direct impact in the products' prices. During the year 2023, the inflation rate changed many times, with great fluctuations. In order to avoid any misleading results, these inflation and interest rate fluctuations were used in the definition of the discount rate of the LCC calculation, in terms of conducting a sensitivity analysis. This procedure was used to eliminate the risk of uncertainty. The latest values that were used for the inflation and interest rates are those corresponding to December 2023, when the inflation rate became lower than the interest rate, after almost one year of really high values.

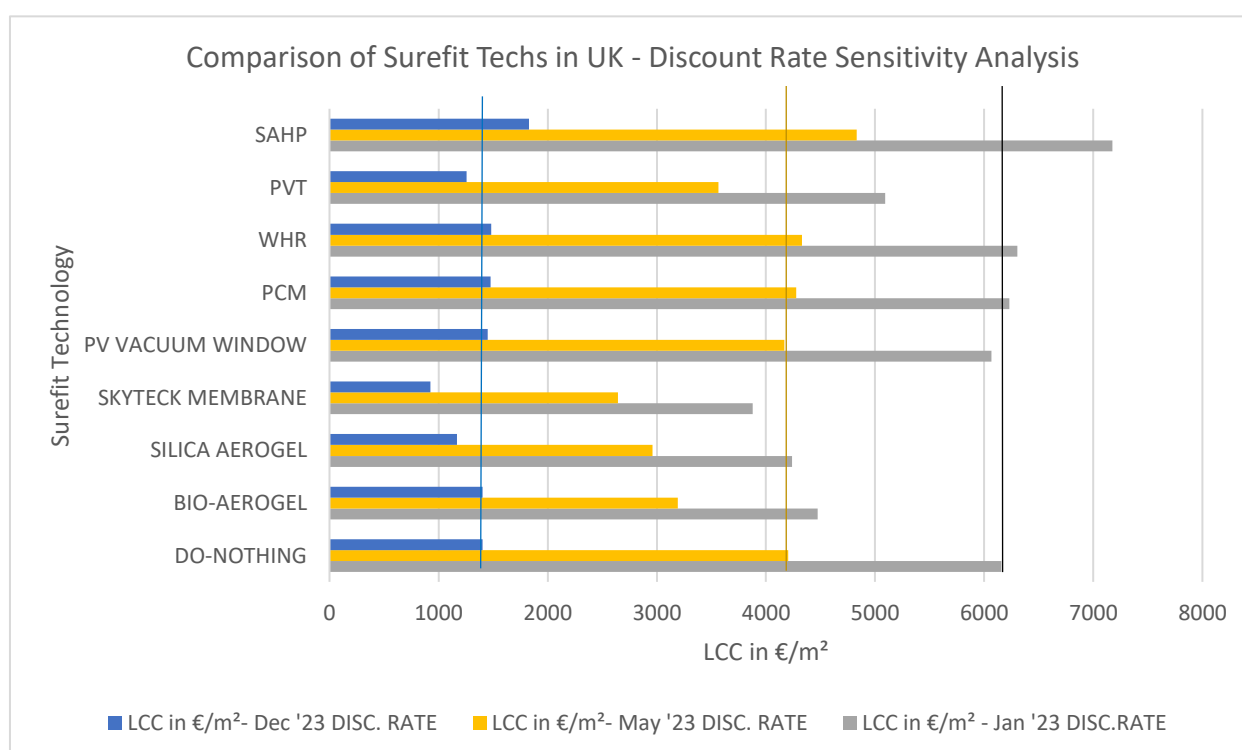


Diagram 3: Sensitivity analysis with variation in the discount rate (interest & inflation rate fluctuations) for the different SUREFIT technologies

From the diagram above, it is concluded that bioaerogel, silica aerogel, Skytech membrane and PVT panels are cost efficient technologies from a LCC point of view, regardless the fluctuations

in the discount rate. On the other hand, SAHP, Window Heat Recovery (WHR) and PCM do not seem to be economically viable, whatever the discount rate is.

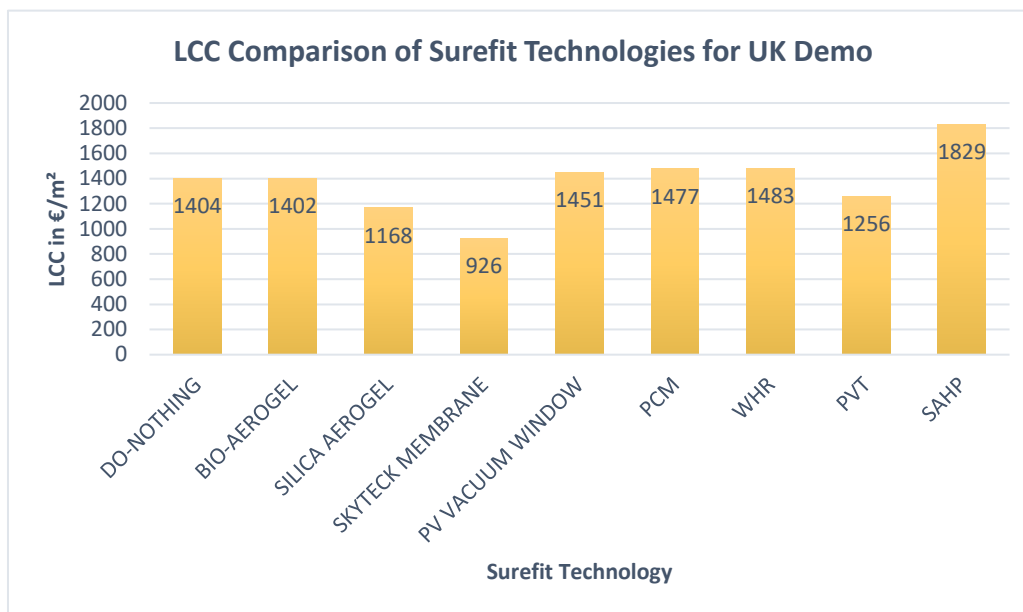


Diagram 4: LCC comparison of SUREFIT Technologies for UK demo building

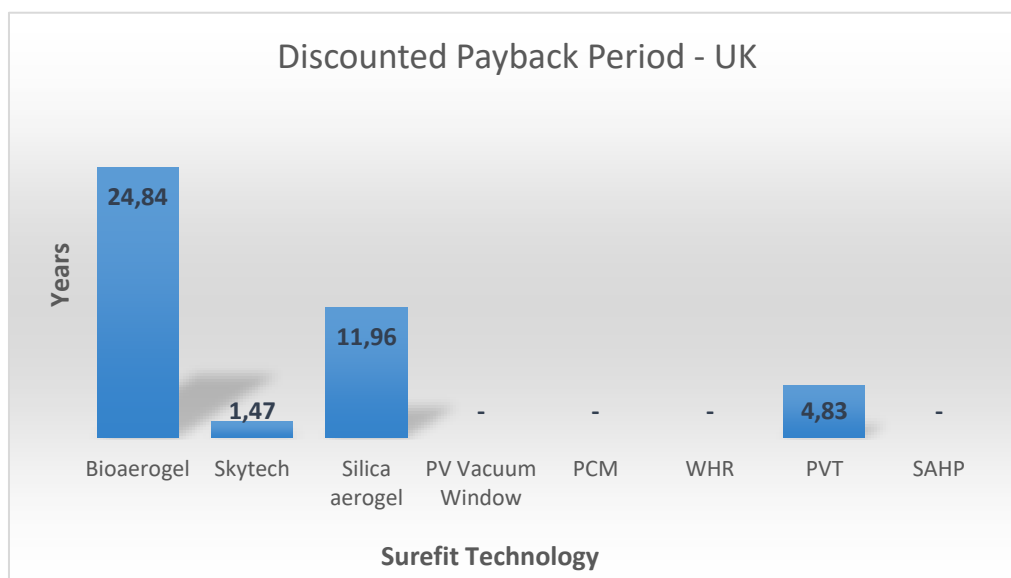


Diagram 5: Discounted Payback Period of the SUREFIT Technologies for UK demo building

Diagram 4 indicates the LCC of the different SUREFIT technologies for the UK demonstration building, for a study period of 30 years, interest (5,25%) and inflation (4%) rates of December 2023 and the energy prices of December 2023 – January 2024. As was also revealed from the sensitivity analysis, the best performing technologies by an economic point of view are Skytech membrane, PVT panels and silica aerogel. This is illustrated in both the diagrams 4 and 5 above.

Another conclusion that is derived from the energy and economic assessment of the examined SUREFIT technologies, is that SAHP and WHR are producing no energy or economic savings since the electricity consumption of the building is increased in these two cases and this is translated as bigger expenses, since the electricity price in UK is greater than that of the natural gas.

The dash symbol that is depicted in diagram 5 indicates that there are no payback periods, as there are no savings from the application of the technology.

4.2 Greek Demonstration Building

The Greek demonstration building has also been simulated for a renovation with CJR's prefabricated panels. Therefore, for this case, as well as for the Spanish one, except for the evaluation with the bio-aerogel and silica aerogel, an extra assessment was conducted for applying the prefabricated panels with the following layers:

Table 9: Layers of materials and thicknesses of the prefabricated panels produced for the Greek building

Layers/materials of Prefabricated Panel for Greece	Thickness
PU	30mm
Silica Aerogel	20mm
XPS	20mm

In this case, when the prefabricated panel was applied it was assumed that the building would have the same energy consumption as in the case of the application of the simple silica aerogel. Besides the materials and thicknesses of the prefabricated panels were selected in such a way, so that their resulted U value would bring the same result as that of the silica aerogel when applied upon the existing walls.

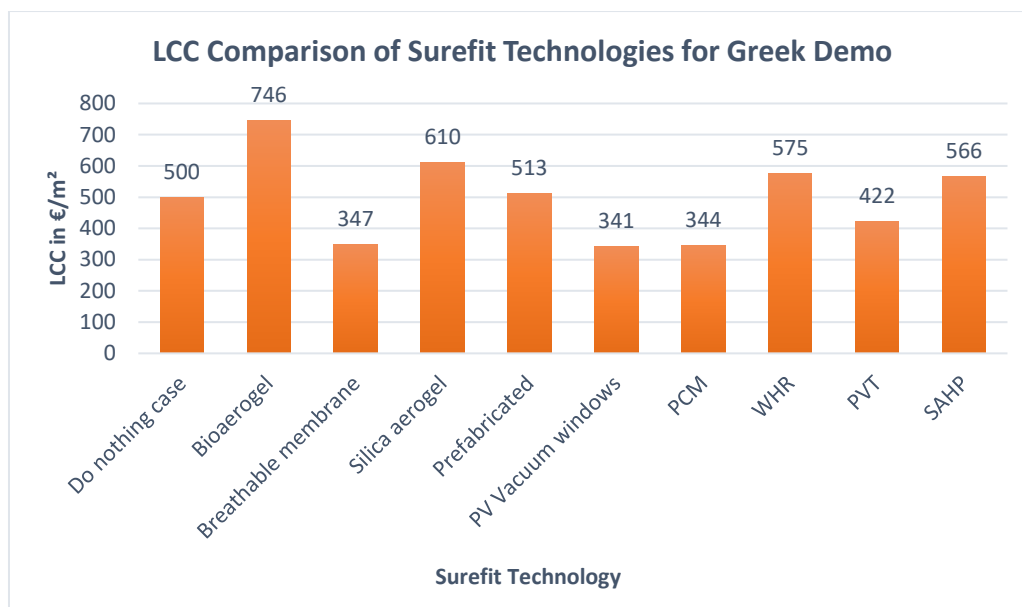


Diagram 6: LCC comparison of SUREFIT Technologies for Greek demo building

Regarding the Greek building it is observed that the bio-aerogel, the silica and the prefabricated panel, have a higher LCC value than the existing – do nothing case – and only the breathable membrane has a “positive” result. This could be mainly explained by the fact that the area that was simulated for the installation of insulation is quite large, and this in relation to the high initial costs of these technologies contributes to the non-cost-efficient results. On the other hand, breathable membrane, PV vacuum windows, PCM and PVT panels seem to have an acceptable economic performance. As a matter of fact, it is worth noting that PCM technology which as it will be indicated below, is a technology that does not reflect its effectiveness in the energy or economic savings, in this specific building, due to its different roof structure (flat roof), it acts as an additional thermal insulation layer for the roof.

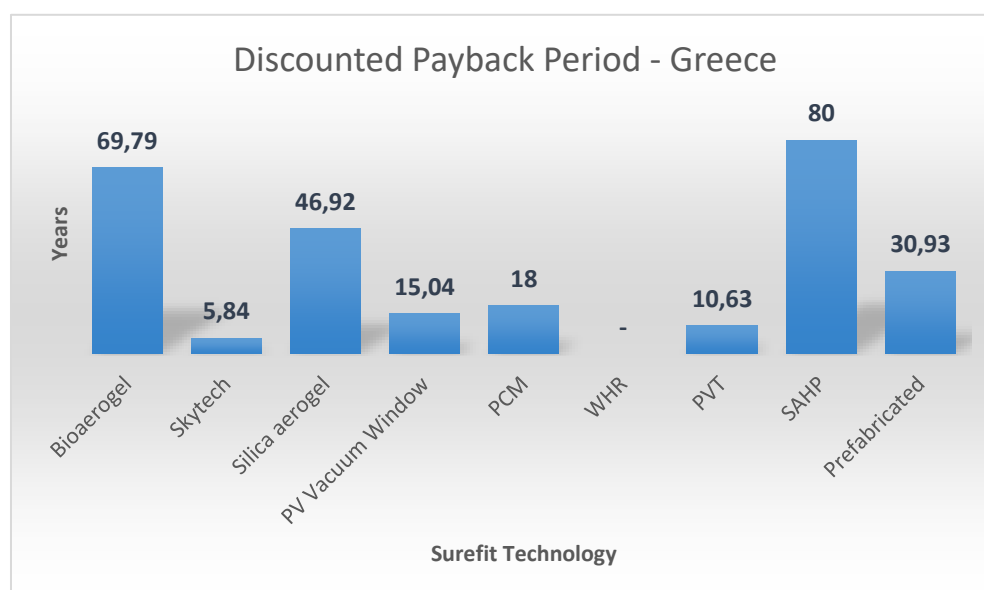


Diagram 7: Discounted Payback Period of the SUREFIT Technologies for Greek demo building

As for the discounted Payback Period, only Skytech membrane and PVT panels have a low recovery period, which lies within the limit of 10 years, usually set as a target for this kind of projects.

WHR has again no Payback period, as no savings are produced, whereas SAHP and bio aerogel present the bigger periods of recovery.

4.3 Spanish Demonstration Building

As in the case of the Greek demonstration building, an evaluation took place for the renovation with CJR's prefabricated panels. The prefabricated panel that was constructed for the Spanish building was only consisted of XPS and silica aerogel with the following layers:

Table 10: Layers of materials and thicknesses of the prefabricated panels produced for the Spanish building

Layers/materials of Prefabricated Panel for Greece	Thickness
XPS	20mm
Silica Aerogel	20mm
XPS	20mm

As it is illustrated in the following diagram, the bio aerogel and the silica aerogel have again a LCC greater than that of the "do nothing case". For this building the technologies that seem to have a positive economic impact are the Skytech membrane, the PV vacuum windows, the PVT panels and the prefabricated panels. However, the PV vacuum windows and the prefabricated panels have a Life Cycle cost which is similar with that of the "do nothing" case. Therefore, no observable economic savings seem to be produced by those two technologies, but an amelioration in the occupants' wellbeing and in their indoor comfort will definitely occur by their application in the building.

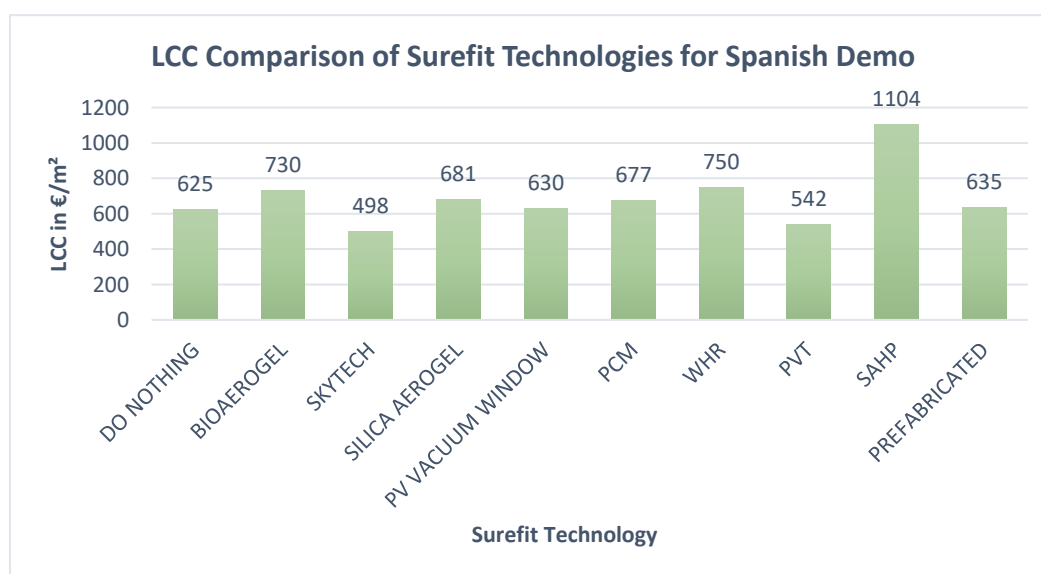


Diagram 8: LCC comparison of SUREFIT Technologies for Spanish demo building

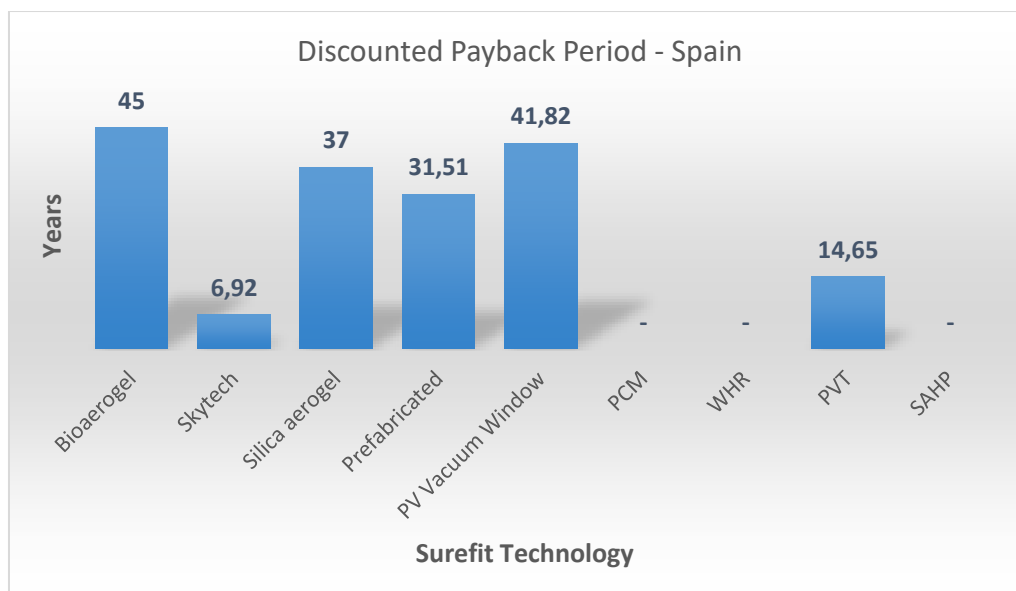


Diagram 9: Discounted Payback Period of the SUREFIT Technologies for the Spanish building

In diagram 9, it is worth noting that the only technology that has an acceptable Payback Period within the limit of the 10 years, is the Skytech membrane. This indicates the fact that was previously described in this report, that the Payback period indicator can oversimplify an economic evaluation and produce misleading results, if it is used as the only tool of economic assessment.

In addition, SAHP increases the use of electric energy and reduces the use of natural gas, and this has a negative impact as the price of electricity in Spain is greater than that of natural gas and therefore no economic savings are produced. This is also linked with the really high value of the primary energy conversion factor of Spain for the electricity (2.37).

4.4 Portuguese Demonstration Building

This building has the particularity that it is heated exclusively by electric heaters and therefore any reductions succeeded in the energy consumptions, will concern the electrical energy. As electricity is related with higher primary energy conversion factors for almost all countries (compared to oil or natural gas) and is related to higher purchase prices, this is also translated to also higher expenses for the building.

In this demonstration building, it was decided to also test the prefabricated panel (the one produced for the Spanish case) for its economic performance, as it was observed that the insulating measures were performing better from an economic point of view.

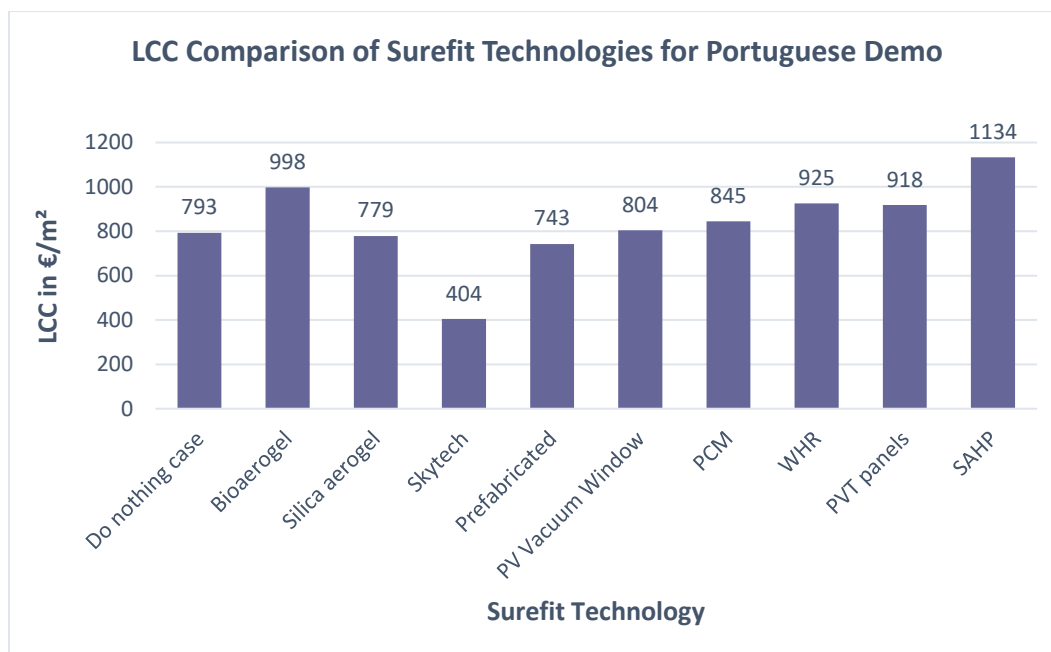


Diagram 10: LCC comparison of SUREFIT Technologies for the Portuguese demo building

Silica aerogel, Skytech membrane and prefabricated panels have lower LCC value than the “do nothing” case, however, the most cost efficient technology is again Skytech membrane. All the other technologies are presented as non-cost effective. Therefore, only the passive technologies (insulation) seem to be effective on this demo building.

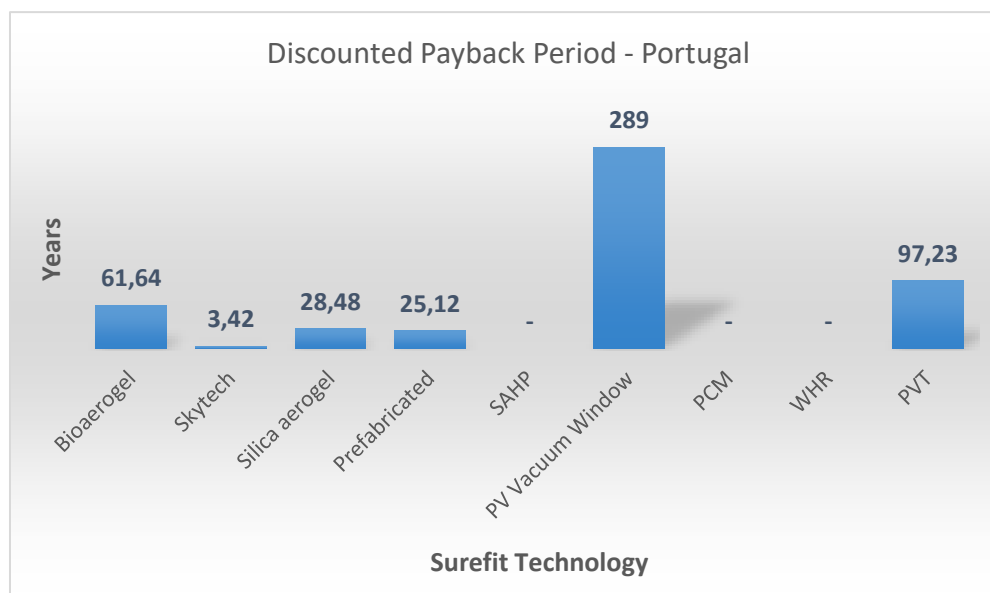


Diagram 11: Discounted Payback Period for the Portuguese demo building

From the diagram above, it is again concluded that Payback Period as an indicator cannot reveal the effectiveness of a measure. That is why it is preferred to use it in combination with other economic indicators. The only technology that pays off within the limit of 10 years is the Skytech membrane. The two measures that follow are the silica aerogel and the prefabricated panel, but

their payback period exceeds the 10 years. The obvious reason for that is that even though these three insulating technologies produce almost the same energy savings and thus economic savings, their investment cost is much greater than that of the breathable membrane.

As a conclusion from the LCC study of all the four demos, in the following map, a prioritization of the most cost-efficient technologies for each demonstration building is depicted.

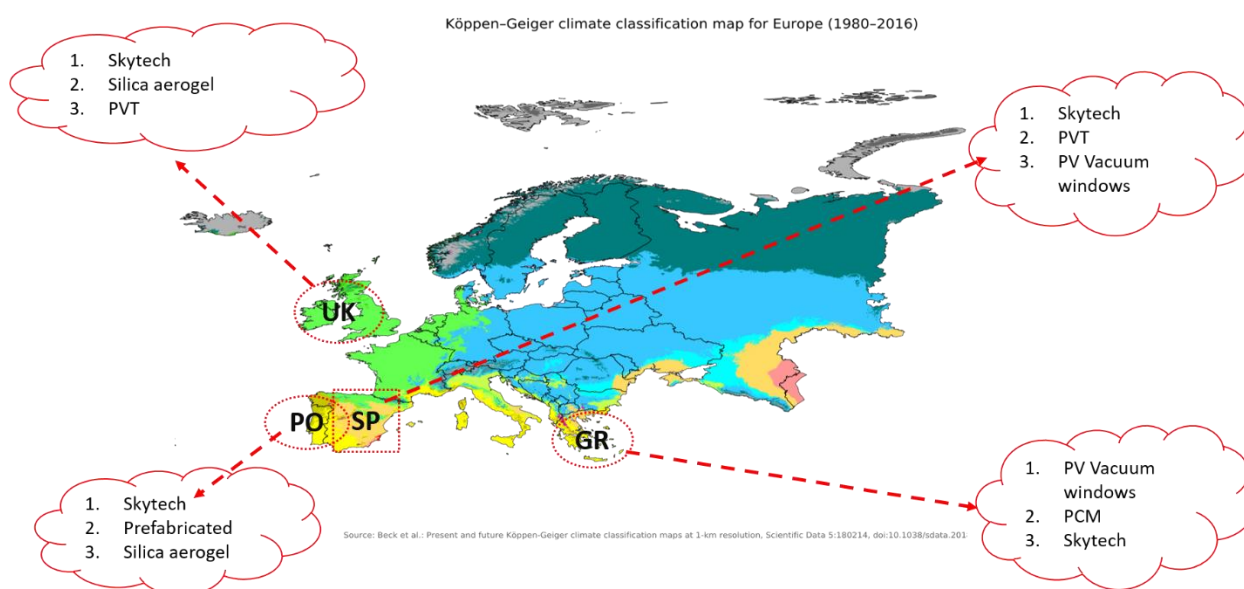


Figure 7: Prioritization of SUREFIT technologies for each demonstration country

5 Comparison of SUREFIT Technologies with Conventional ones

In order to be able to understand how the technologies examined in the SUREFIT project could be compared and compete with other already available in the market conventional technologies, a market research has been conducted to first point out with which common alternatives the SUREFIT technologies could be compared.

Then, a methodology was followed that was based on the already conducted energy simulations and economic study. Some additional assumptions and energy simulations¹ were also conducted where needed. This methodology assisted in the definition of specific products in the market (type of window, type of PV panel, type of heat pump etc.), the characteristics of which could be used for the comparison with the SUREFIT products.

The technologies or products that were selected to be compared with the SUREFIT ones were the following:

- EPS (Expanded Polystyrene) insulation that would be installed as a conventional ETIC system.
- PVC (Polyvinyl Chloride) windows with triple glazing (to reach the U value of 0.6 W/m²K which is the U value of the PV vacuum windows) in combination with simple monocrystalline PV panels, to simulate the PV Vacuum windows.
- Simple monocrystalline PV modules with 20% efficiency in combination with flat plate selective solar collectors, to simulate the PVT system.
- The SAHP was decided to be compared with a common type of Air Water Heat Pump of 3.62 COP value.

Ground Source Heat Pump is a more complicated technology that requires additional and more costly preparatory works, some space in the perimeter of the building to install the thermal pipes into the ground, and some drilling machines and works that could not be represented by a simple AWHP. The ideal would be to compare this system with a conventional ground source heat pump, however, to do that, additional and complicated studies would be needed for each demo site. In addition, this technology, for all the aforementioned reasons, was only installed in the UK demo.

The baseline for the comparison with the conventional products, was to obtain the same energy consumption results as those obtained when the corresponding SUREFIT technologies were

¹ AALTO simulations – see chapter 3.2 of this report for more details

applied to the buildings. The results for each country and each different building are indicated in the following diagrams.

5.1 UK Demonstration Building

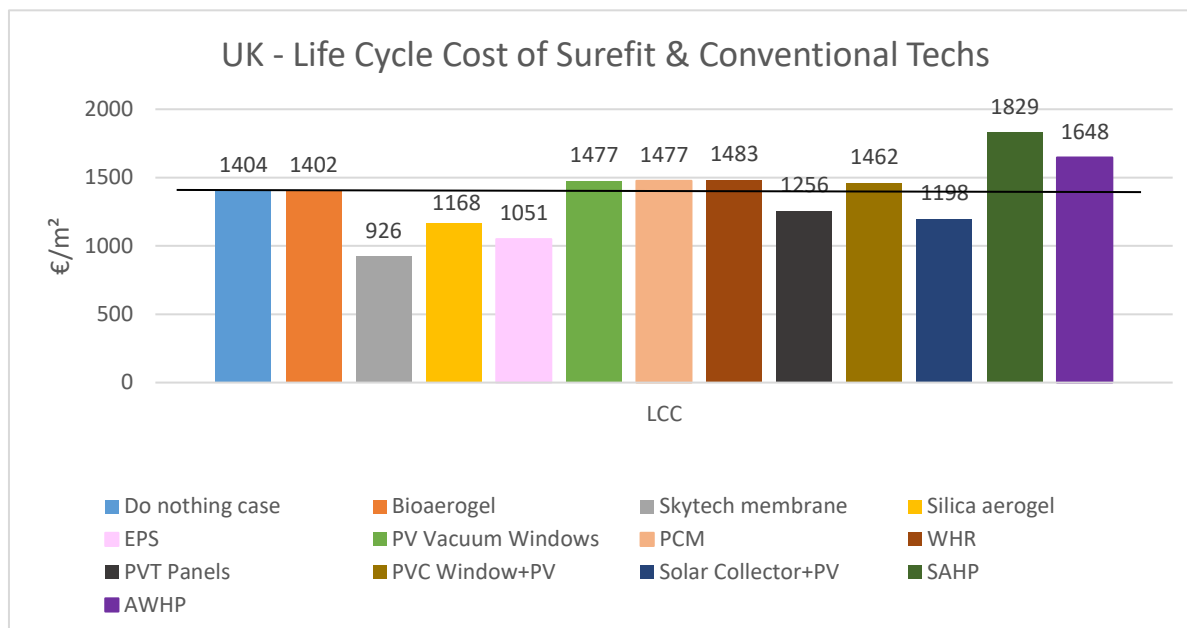


Diagram 12: Comparison of LCCs of the SUREFIT Technologies with Conventional Ones – UK

For UK building, the most cost effective are proved to be Skytech membrane, silica aerogel, EPS, PVT panels and the combination of solar collectors with PV modules. In fact, it is illustrated that PVT is a technology that can compete other similar and common in the market technologies.

5.2 Greek Demonstration Building

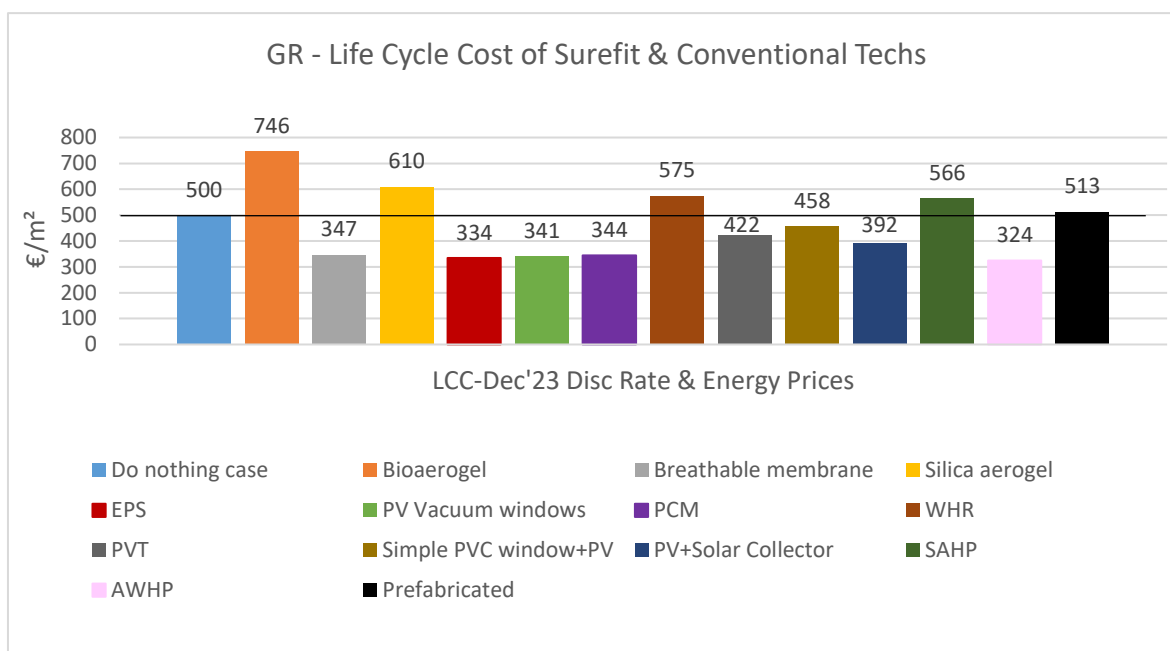


Diagram 13: Comparison of LCCs of the SUREFIT Technologies with Conventional Ones – GR

For the Greek building, almost all the assessed technologies seem to have a good economic performance. The only non-cost effective solutions are the bio aerogel and silica aerogel which are quite expensive and then, WHR and the SAHP which increase the consumption of the electricity which also in the case of Greece costs more than the heating oil.

In this case, it is indicated that PV vacuum windows are more cost effective than the corresponding combination of “Simple triple glazed PVC windows + PV panels”.

5.3 Spanish Demonstration Building

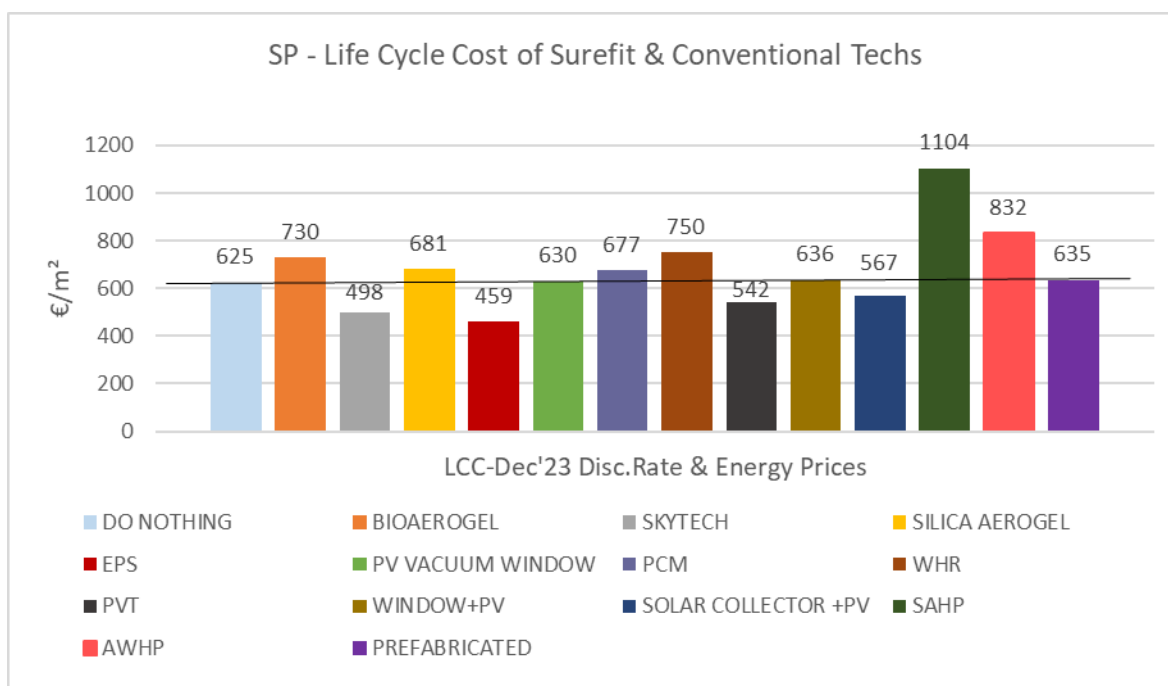


Diagram 14: Comparison of LCCs of the SUREFIT Technologies with Conventional Ones – SP

For the Spanish building, Skytech, EPS and prefabricated panel along with PVT panels and the combination of solar collector with common PVs are the best solutions from an economic point of view.

5.4 Portuguese Demonstration Building

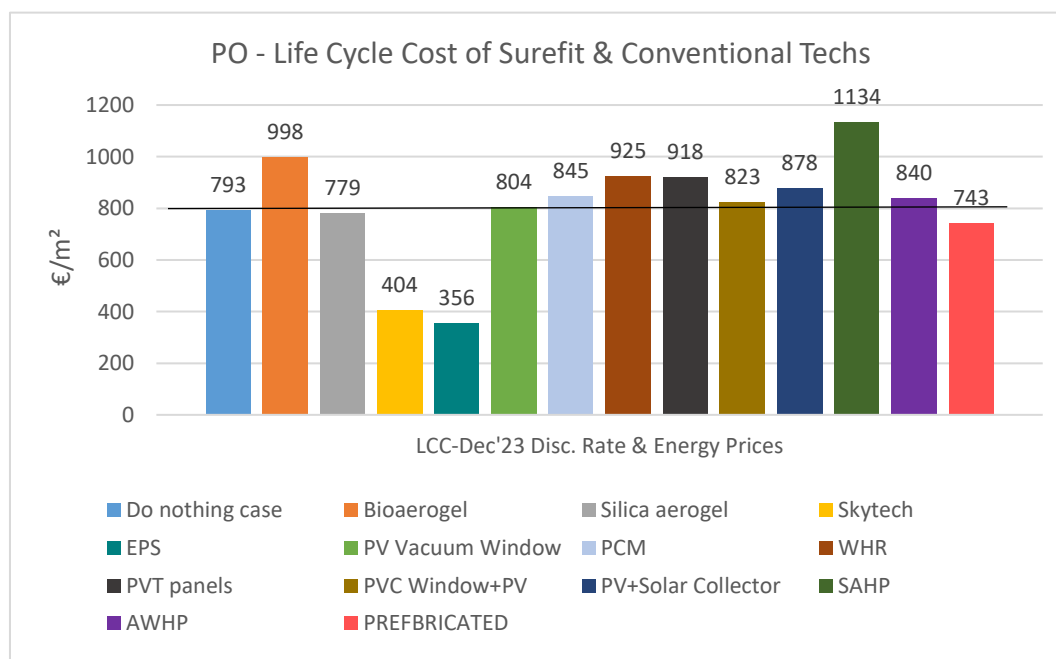


Diagram 15: Comparison of LCCs of the SUREFIT Technologies with Conventional Ones – PO



For the Portuguese demo site the only cost effective energy measures are the insulating measures. That is, the silica aerogel, the Skytech membrane, the EPS and the prefabricated panel. This indicates that for buildings like the demo one, the most important measure is to reduce the heating and cooling needs and this can be succeeded by the use of thermal insulation. All the other solutions that are active solutions, cannot reduce the energy needs but only the energy consumptions.

6 Conclusions

The most important conclusions that can be obtained from the economic evaluation study are as follows:

- The insulating materials (except for bio-aerogel which is quite expensive) seem to have a better economic impact to all the demo sites.
- It is observed that an active system alone like e.g. a heat pump or a PV/PVT system, cannot provide the required reduction in the energy consumption of a building if it is not accompanied by a reduction in the energy needs for heating and cooling.
- For Mediterranean countries the reduction in cooling needs is crucial, especially during the last decade. In Greece, the cooling loads for most of the buildings are higher than the heating loads.
- Window heat recovery proves to be non-cost efficient for all the demos. WHR system is a mechanical ventilation measure which leads to increased energy consumption (therefore no energy savings), consisting of electricity consumption by fans. It could ameliorate the indoor air quality and be effective for humidity issues inside the house.
- The effect of the light louvers cannot be quantified and cannot be demonstrated through the energy consumption of residential buildings, where the area of openings is limited. An amelioration in the thermal and visual comfort of the occupants can be expected from this type of technology. Additionally, the daylight louvers prevent overheating through the window glazing. They reflect at least 70% of the radiant energy transmitting through the glass. This is very effective in summer periods. Therefore, it might not be cost effective in the small houses because of the lack of active cooling, however if there is active cooling, then a reduction in the energy consumption for cooling will be achieved, especially in case of larger windows.

Besides preventing overheating of buildings in summer, the technology also improves the natural daylighting. This reduces the energy consumption for electric lighting.

- PCM panels act mostly like a passive cooling method and their effect cannot be reflected in the energy savings. This technology also depends on the roof structure of the building. As it was demonstrated in the Greek case, PCM seems to have better energy results and thus better economic results, when the roof on which it is applied is flat and not a pitched roof.
- PV Vacuum Windows and PVT system have similar results when compared with combinations of conventional solutions. This means that they could compete well in the market with other relevant solutions.
- Skytech and PVT panels have the best economic performance in almost all the buildings. This could be also explained by the fact, that these two products are already commercially available and therefore, their prices are market prices and should be cost efficient in order to compete other similar solutions of the market.

As a general remark many of the examined SUREFIT technologies, seem to be economically non-viable and this is due to their high initial investment cost. Therefore, efforts should be made from



the technology providers, to minimise the costs especially of the laboratory technologies in order to make them more competitive and affordable in relation to other similar conventional technologies.

As a final comment, it is worth mentioning that the methods that were followed for the economic study, as well as the results produced, are directly related to the quality and quantity of information provided by the manufacturers and the technology providers of the SUREFIT Project. The results presented above are affected not only from the characteristics and geometry of each building, but also from the climate in each country and the prevailing inflation and energy prices, which have also an impact in the products' purchase prices and investment costs.



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