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Abbreviations

ETICS	External Thermal Insulation Composite System
EU	European Union
GSHP	Ground Source Heat Pump
LCCA	Life Cycle Cost Analysis
MSDS	Material Safety Data Sheet
PCM	Phase Change Material
PV	Photovoltaic
PVVG	Photovoltaic Vacuum Glazing
SAHP	Solar Assisted Heat Pump
VG	Vacuum Glazing
WC	Water Closet
XPS	Expanded Polystyrene

Publishable Summary

In the course of the implementation of the SUREFIT project, there have been various passive and active building technologies that were installed and are being operated in five buildings in different European countries: Greece, Spain, Portugal, UK and Finland. These technologies aim to improve the energy efficiency of the buildings and the indoor comfort. There have been six active technologies installed, i.e. the Hybrid PV-Thermal system, the PV Vacuum glazing system, Window Heat Recovery, Solar Assisted Heat Pump (SAHP), Ground Source Heat Pump (GSHP) and the Evaporative cooler. Moreover, four passive technologies were installed, that is Prefabricated Panels for thermal insulation, the SKYTECH Pro XL membrane, Daylight louvers and PCM Passive Cooling panels.

The partners involved in the manufacturing process of the technologies and those involved in the installation and operation of the above mentioned technologies had to observe and report any important risks, constraints and difficulties of installation and operation of those technologies under real time context in the various regional conditions. The technical risks and safety issues, along with the mitigation actions are the objective of the present report and aim to ensure a good service for the post commercialisation of the technologies.

Moreover, there have been considered a) the installation and operation of the SUREFIT technologies in new buildings and b) any requirements for the application of the technologies that could lead to low carbon buildings. Finally, regional conditions including population, development, weather and other possible factors have been also commented.

1 Prefabricated panels

CJR constructed two types of prefabricated insulation panels (for the Spanish and Greek building) having silica aerogel as a core material. Both panels were aimed to be applied externally to the existing building's walls. The layers and materials of the two types of panels are shown in the following Table.

	Spain	Greece
Materials & thickness (mm)	Fiberglass Mesh (0.6)	Fiberglass Mesh (0.6)
	XPS (20)	XPS (20)
	Silica aerogel (20)	Silica aerogel (20)
	XPS (20)	Polyurethane (30)
	Fiberglass Mesh (0.6)	Fiberglass Mesh (0.6)

Table 1 Layers and materials of the two types of prefabricated panels

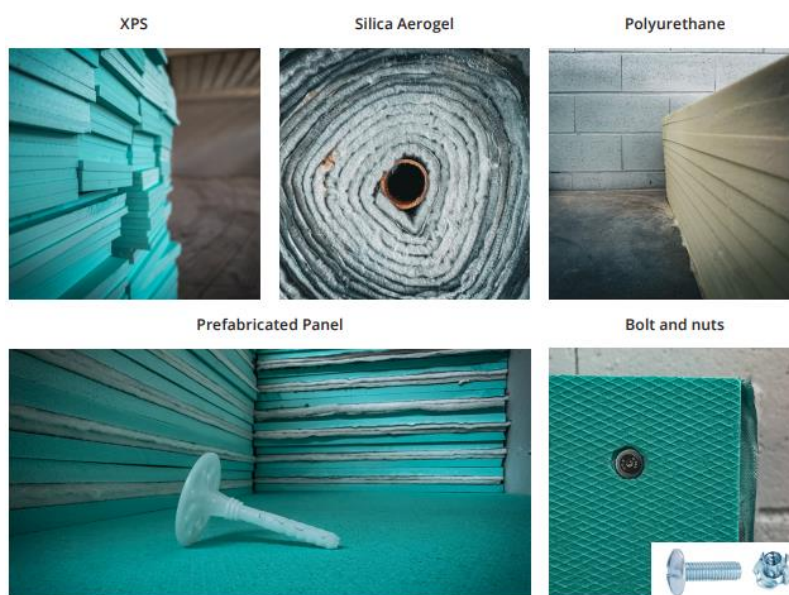


Figure 1 – Prefabricated panels by CJR

1.1 Prefabricated panels: Installation safety and operation risks

There have been identified two main risks as far as the prefabricated panels is concerned:

- A safety risk during handling of the panels due to the dust release from silica aerogel
- A general operation risk that could jeopardise the performance of the system

Mitigation actions have been also proposed.

1.1.1 Safety risk related to prefabricated panel's handling: silica aerogel release

There has been one safety risk that has been identified by both the prefabricated panels' manufacturer (CJR) as well as by the panel's installers (FSM, AMS). This risk is related to the dust that is released from the silica aerogel layer that is integrated in the panels. The dust is released during transportation, cutting, drilling and installation of the prefabricated panels.

1.1.2 Mitigation actions

The workers should wear dust mask (P100/P3 filter), eye protection and gloves during the installation works. It is advisable that the balcony doors and windows of the renovated house are closed in order not to pollute the interior of the house. It is recommended to cover the panels with membrane/fabric during transport through common areas of the building. Bio-aerogel dust is hydrophobic. Therefore, the use of soap is recommended to remove any dust from the skin. Work-wear can be washed as normal.

1.1.3 Operational risks related to the prefabricated panels: general condition of the panels

The users should promptly address any identified issues or damage to the panel. Small cracks or gaps should be repaired using compatible sealants or fillers recommended by the system manufacturer. Larger or more severe damages may require professional assistance. In addition, the users should ensure that all joints, penetrations, and gaps in the panels are properly sealed and waterproofed.

1.1.4 Mitigation actions

Address repairs promptly to prevent further deterioration, water infiltration, or potential energy losses. Follow the manufacturer's guidelines for repair materials and techniques. Check the integrity of sealant joints around windows, doors, vents, and other openings. Repair or replace damaged or deteriorated sealants promptly to maintain the system's water tightness. Consider applying a waterproofing coating or treatment to enhance the moisture resistance of the ETICS, especially in areas prone to water exposure.

2 SKYTECH Pro XL membrane

SKYTECH PRO XL by WINCO creates a closed envelope, increases wind-tightness, reflects 95% of radiation and avoids thermal bridges for a better comfort in summer as well as during winter. Thanks to its patented technology, SKYTECH PRO XL makes it possible to install a breather membrane and an insulating material at the same time while ensuring that the building remains breathable (allowing the water vapour to escape). Besides its thermal benefits and thanks to its high tear resistance and its high density (105 kg/m³), SKYTECH PRO XL alone gives a 16 dB sound reduction performance.

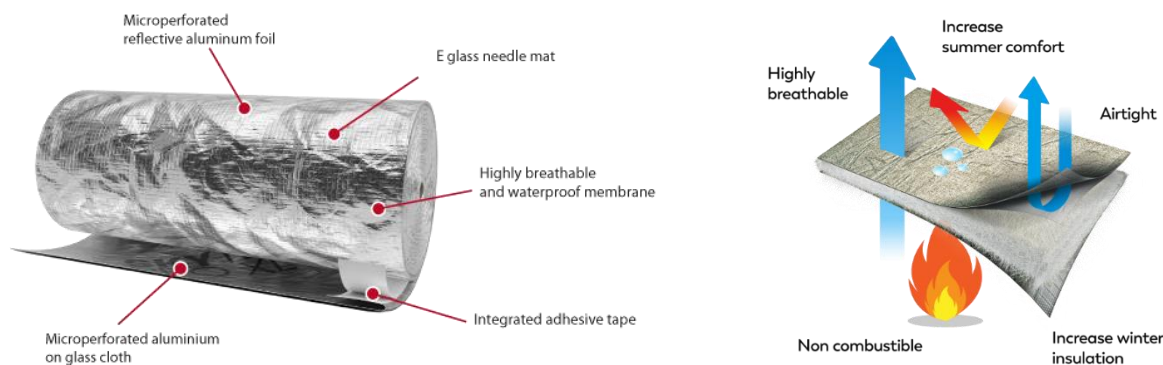


Figure 2 – SKYTECH Pro XL membrane

2.1 SKYTECH Pro XL membrane: Installation risks, difficulties and incompatibilities

There have been two technical risks related to the installation of the SKYTECH Pro XL membrane:

- a. One that is related to the obstruction of the membrane's proper operation due to inappropriate architectural features of the building.
- b. A second one related to existing irregularities of the façade

2.1.1 Technical risk related to SKYTECH Pro XL membrane: not sufficient height of the wall and restricted ventilation

This technology is mainly designed to act as a rain screen in an existing façade. In order to operate efficiently, a ventilated air gap is needed on the external side of the membrane which operates due to the stack/chimney effect. The height of the building is also important for that as the greater the thermal difference and the height of the structure, the greater the buoyancy force, and thus the stack effect. Based on these requirements, it is obvious that not all buildings are suitable for the proper operation of such a system.



Figure 3 – SKYTECH Pro XL membrane installation in a high building

This was also the case for the Greek demo site. The height of each floor is 3m approximately and moreover, the existence of balconies in every floor (Figure below) will block the air movement that is required for the proper operation of the membrane.

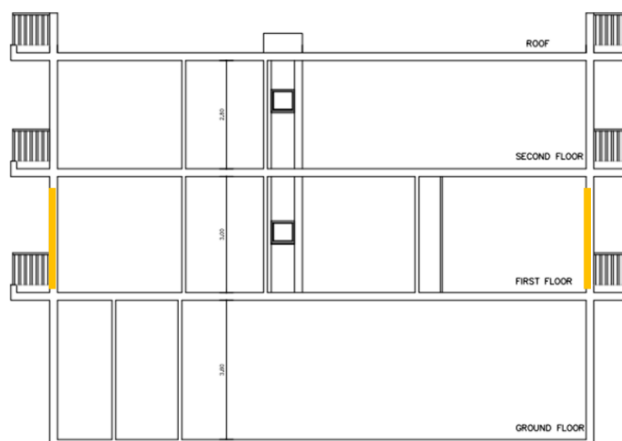


Figure 4 – Greek building design

2.1.2 Mitigation actions

N/A

2.1.3 Technical risk related to SKYTECH Pro XL membrane: difficult to adapt the irregularities of a surface

The 2cm membrane was proved to be difficult to be installed in the Spanish building due to the irregularities of the surfaces. It was complicated to fold and bend the membrane to adapt to the

irregularities of the façade, like doors or windows. In order to guarantee the existence of the air gap it has been necessary to adapt the membrane to the rafters prepared to receive the finishing boards. Adapting the membrane to the different holes and installations has been also a challenge and time-consuming activity.



Figure 5 – Spanish building: challenges during installation of the 2cm membrane

2.1.4 Mitigation actions

To use a different thickness of the membrane depending on the place of installation. A 1cm membrane would have been much easier to install.

3 Hybrid PV-Thermal system

SOLIMPEKS manufactures the Hybrid PV-Thermal (PV/T) solar collectors to achieve both hot water and power generation from the sun as a clean and free energy source. As a combination of solar PV and solar thermal in a single unit, the system is capable of delivering twice as much renewable energy in the same rooftop footprint as standard solar, therefore also delivering twice as much carbon displacement.

3.1 Hybrid PV-Thermal system: safety and installation risks

There have been identified two types of risks as far as the Hybrid PV-Thermal system is concerned:

- a. Some general safety risks
- b. A technical risk/challenge related to the size of the storage tank

3.1.1 General safety risks related to the Hybrid PV-Thermal system

Electricity generation of PV-Thermal modules cannot be switched off, so special precautions should be taken to ensure that power-carrying parts are either inaccessible or cannot be touched during assembly, use and maintenance. PV-Thermal modules are current limiters that require an unusual approach to designing fault protection systems because backups generally do not respond under short-circuit conditions. PV-Thermal systems contain DC cabling that few installers are familiar with. The installation of PV-Thermal systems includes a unique combination of hazards – electric shock hazard, risk of falling and difficulties in handling the material at the same time. All these dangers are encountered, of course, on construction sites, but rarely all at once. While roofers are used to minimizing crash hazards and avoiding injuries due to problems with manual handling, they are not necessarily familiar with the risk of electric shock. Similarly, electricians are familiar with electric hazards, but are not used to dealing with large objects at high altitudes.

3.1.2 Mitigation actions

The users and installers should be aware of the requirements of the Regulation on Electricity at Work. Certified electricians are required for the installation.

3.1.3 Technical challenge related to the dimensions of PV-Thermal storage tank

The storage tanks provided with the installation are quite big, so there is an issue to install them in tiny houses due to the lack of space.

3.1.4 Mitigation actions

This challenge was faced in the Greek and Spanish demo cases. In the Greek demo building, the tank was installed on the ground floor after demolishing an existing WC.



Figure 6 – Greek building: demolishing of WC to install the storage tank

In the Spanish pilot, two of the tanks have been installed outdoors and the third one has had to be reduced in capacity to be installed indoors. The outdoor installation requires the construction of a shelter to protect the equipment from the weather.



Figure 7 – Spanish building: outdoor installation of the storage tank and auxiliaries

4 PV Vacuum glazing unit

The structure of vacuum glazing window is commercially mature, and it is similar to the double glazed unit, however the cavity indicates no gas, but vacuum. Vacuum acquires significantly more effective insulation levels compared to any gas. In addition, greater performance in terms of acoustics and sound reduction accompany the VG windows. The PV component on the window is integrated in the form of thin-elastic-films. PVVG exhibits three different components:

- the self-cleaning coated glass,
- the vacuum-filled layer and finally,
- a thin film PV glass with additional grass cover.

The system is thinner than 30 mm and presents lower U-value than $2.5 \text{ W/m}^2\text{K}$. The thin film will bear solar shading coefficient of 0.45 and solar heat gain coefficient of 0.39, while light transmittance is 70%.

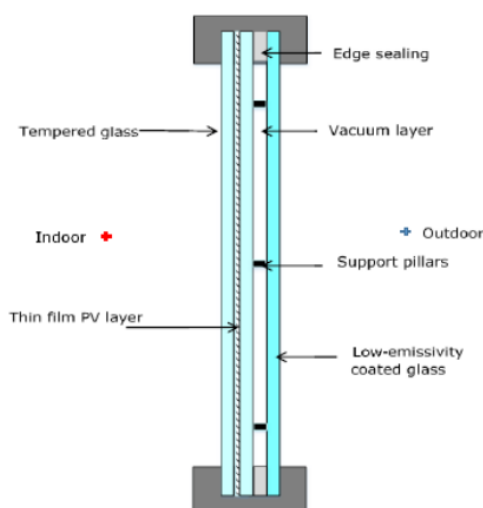


Figure 8 – Schematic of PV Vacuum glazing unit



Figure 9 – Photos of the PV Vacuum glazing systems

4.1 PV Vacuum glazing unit: technical and safety risks

There have been identified two types of risks as far as the PV Vacuum glazing unit is concerned:

- a. Technical risks related to the installation of the system
- b. A safety risk related to the weight of the system

4.1.1 Technical difficulties related to the installation of PV Vacuum glazing unit

The installation of PV Vacuum Glazing requires the replacement of existing window frames. This structural alteration results in additional costs and requires careful planning to ensure the structural and aesthetic integrity of the buildings. The electrical cables need adjusting to fit with window frames, which needs additional design on the fitting process.



Figure 10 – Photos of the PV Vacuum glazing system integrated in the frames – Spanish demo

4.1.2 Mitigation actions

Close collaboration with supplier is necessary to ensure that the new window frames seamlessly integrated with the existing design.

4.1.3 Safety risk related to the weight of the PV Vacuum glazing units

The PV Vacuum Glazing is heavier than traditional double glazing. The transportation, moving and installation needs additional protection and safety equipment. In general, safety handles and equipment cloth wear is required before installation.

4.1.4 Mitigation actions

N/A

5 Window Heat Recovery unit

Window Heat Recovery systems are heat exchangers coupled to building windows frames that enable to exchange heat between exhausted and supplied air during the building ventilation. Heat pipes have two main parts, the cold side (condenser) and the hot side (evaporator), where heat is transferred from evaporator to condenser. One axial fan is installed on the supply air side and another at the exhaust air outlet. The Window Heat Recovery system works in all four seasons, for example, in winter, its purpose is to recover heat from exhausted air to the supplied fresh air, and in summer, the exhausted air cools the supplied air. The detailed design configuration has dimensions of 1125mm length, 220mm width and 90mm height. Louvers with filters are installed in the indoor side, with two supply fans and two exhaust fans installed in the outdoor side. Moreover, only a power button and a ventilation rate adjust button is shown on the indoor surface. This design is for aesthetic view with slim, simple outlook, as well as minimum the noise level to maximum of 35dB.



Figure 11 – Photos and schematic of the Window Heat Recovery unit

5.1 Window Heat Recovery unit: technical risks

Three main technical risks have been identified regarding the installation and operation of the Window Heat Recovery:

- The need to replace the existing window frames in a building
- The ventilation hole that has to be drilled on the wall
- The operating noise of the system is higher than expected



5.1.1 Technical difficulties related to the installation of Window Heat Recovery Unit

The installation of Window Heat Recovery requires the replacement of existing window frames. This structural alteration adds additional costs and requires careful planning to ensure the structural and aesthetic integrity of the buildings. The connection process of the electrical wires needs to be designed before the installation to maintain the aesthetic outlook.

5.1.2 Mitigation actions

Close collaboration with supplier is necessary to ensure that the new window frames seamlessly integrated with the existing design.

5.1.3 Technical risk related to the ventilation hole of the Window Heat Recovery unit

The Window Heat Recovery units, as they are designed, open a non-controlled ventilation hole on the wall that needs to be considered for further installations.

5.1.4 Mitigation actions

Enhance the design of the unit to avoid non-controlled infiltrations.

5.1.5 Technical risk related to the operation noise of the Window Heat Recovery unit

The Window Heat Recovery units are noisier than expected.

5.1.6 Mitigation actions

Enhance the design of the unit to avoid noise.

6 Daylight louvers

SUREFIT is researching a louver shutter system in which the slats that make up the shutters are specifically designed for each orientation and geographic location. The aim is to reduce the entry of infrared radiation into the interior of the building, reflecting visible light into the interior. This achieves a reduction in cooling demand without a loss of interior brightness.

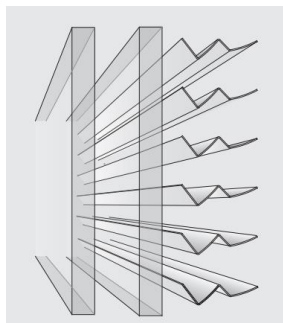


Figure 12 –Daylight louvers RETROLux 20 mm used in Spain and Finland

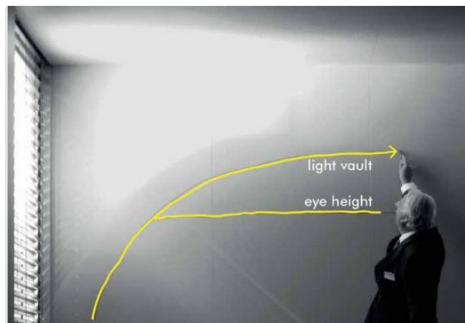


Figure 13 –Daylight louvers

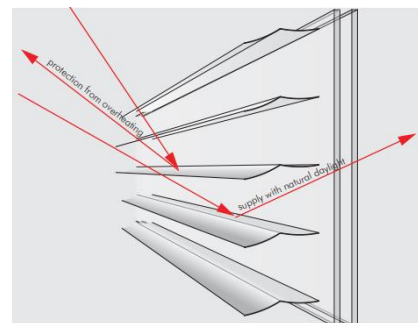


Figure 14 –Daylight louvers RETROLux 80 mm used in Finland

6.1 Daylight louvers: technical installation risk and operational challenges

There have been identified two types of risks regarding the Daylight louvers:

- a. Technical risk/challenge related to the installation of the system
- b. An operational risk/challenge

6.1.1 Technical challenge related to the installation of the Daylight louvers

The louvers are designed to be installed either outside or inside the glazing. However, in Finland louvers are typically installed between the glazing which may lead to some difficulties during installation mainly due to the fitting of the mechanism.

6.1.2 Mitigation actions

The installers should ensure there's enough space between the windows for the mechanism and also be prepared to modify the window framing for passing through the cables etc.

6.1.3 Operational challenges related to the Daylight louvers

Due to installation between the glazing, the louvers in the Finnish pilot have their mechanism entirely between the windows, which means that to operate the louver, the tenant needs to

open the inner window first. Fortunately, the position of the daylight louvers doesn't need to be changed that often but when it does, this brings some inconvenience to the tenant.

6.1.4 Mitigation actions

In future installations, fitting of the mechanism should be thought of better. A possibility could be to bring the control cable outside the window by modifying the window framing but drilling a simple hole would not have been sufficient in the case of the Finnish building.

7 PCM Passive Cooling Panels

Phase Change Materials (PCM's) are simply chemical solutions, capable of storing and releasing thermal energy during the process of melting & freezing. During this process they can both store and release large amounts of energy in the form of either heating or cooling. In simple terms, PCM's can be seen to act like a thermal battery.



Figure 15 – PCM operation



Figure 16 – Schematic of PCM

7.1 PCM Passive Cooling Panels: Safety installation and operation risks

There is a number of safety risks that have been reported by PCM regarding the PCM Passive Cooling panels that refer to the installation and operation and are presented below.

7.1.1 Safety Risks related to the PCM Passive Cooling Panels

The following safety risks related to the PCM Passive Cooling panels' installation and operation have been identified:

1. Ceiling panels might drop if the fitting is not properly installed
2. Leakage of the container content
3. Fire risk
4. Manual damage by workers/owners
5. Dust/dirt build up

7.1.2 Mitigation actions

The mitigation actions per safety risk are presented below:

- Inspections before installation
- Annual checks of the filling port
- EU standard fire testing carried out and certification is obtained
- Label clearly highlighting the contained solution and MSDS close by
- Regular cleaning like any exposed component

8 Solar assisted heat pump and Ground source heat pump

The concept of solar assisted heat pump (SAHP) is the same as a traditional heat pump. The main difference is the using of a thermodynamic solar panel as evaporator, which permits extraction of heat from environment and the absorbed solar radiation in the solar panel.

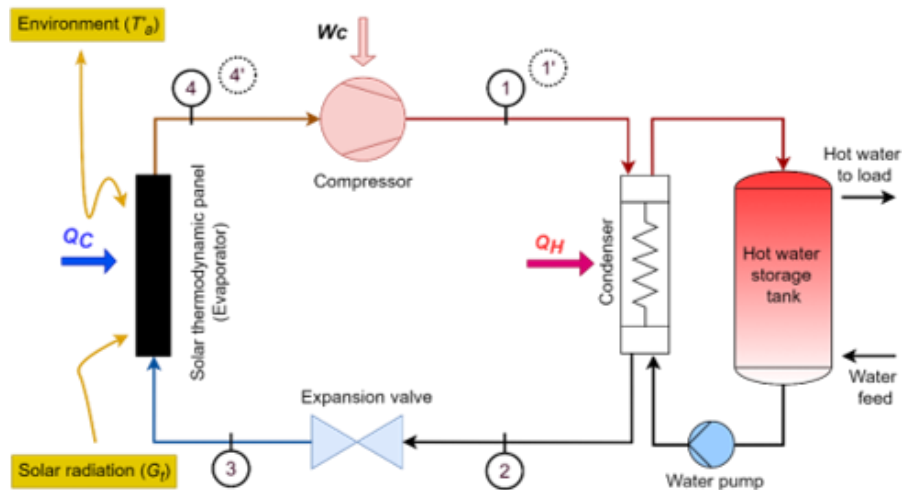


Figure 17 – Schematic of Solar Assisted Heat pump

The Ground source heat pump system harnesses heat stored in the shallow ground for heating and cooling. Surface geothermal is more efficient and sustainable than conventional systems, as the ground serves as a constant source of thermal energy.



Figure 18 – Construction works at the UK demo building for the installation of the Ground Source heat pump



Figure 19 – Installation of the Solar assisted heat pump and the Ground source heat pump at the UK demo building

8.1 Solar assisted heat pump and ground source heat pump: technical difficulties related to the necessary accessories needed

The main risk that has been identified for the two types of the heat pump (SAHP and GSHP) is related to the effort and accessories required for the installation. The installation of solar assisted heat pump and ground source heat pump requires specific design on the electrical wires, water and refrigerant pipes, and control. Those accessories need additional costs and require careful planning to ensure the structural and integrity of the buildings.

8.2 Mitigation actions

Close collaboration with supplier is necessary to ensure that all connections (water, refrigerant and electrical) seamlessly integrated with the building requirement.

9 Evaporative cooler

Air-conditioning systems consume substantial amounts of energy with an accompanied peak demands on the electricity supply infrastructure contributing to a large proportion of carbon dioxide emissions. Evaporative cooling is a highly energy efficient alternative where applicable. Dew point cooling could decrease the air temperature close to the dew point without moisture increase, so it maximises the cooling capability of the dry air, but most of the dew point cooling heat exchanger is complicated and not easy to make and also costly and not suitable for large airflow.

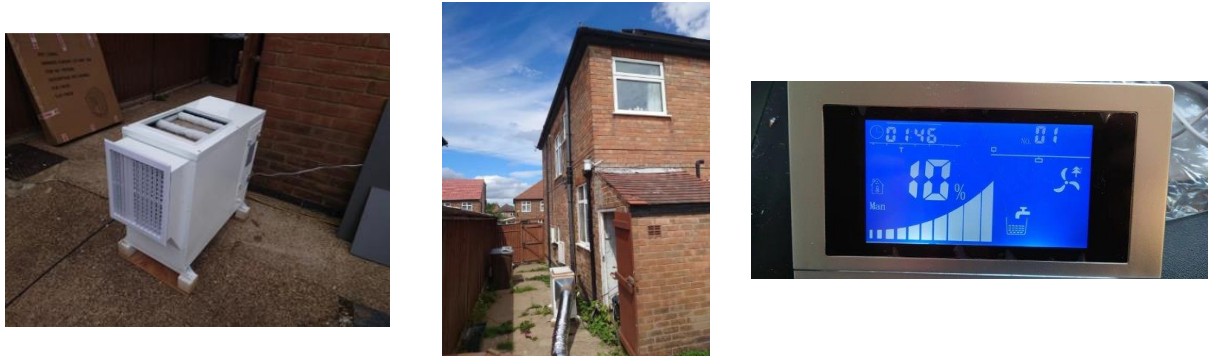


Figure 20 – Evaporative cooler - Installation at the UK demo building

9.1 Evaporative cooler: technical difficulty

The installation of evaporative cooling needs careful design on the connection between the cooling machine with the air duct and water pipes.

9.2 Mitigation actions

Close collaboration with building engineers and electrical technician for specific design requirement.



10 General installation risks

Besides the risks on installation and operation for each technology that were previously described, there have been identified some general risks and challenges that are related with the renovation and construction activities. These activities are presented in the following paragraphs.

10.1 Existing hydraulic and electrical network

The existing hydraulic and electrical network are inadequate to support the new technologies.

10.2 Mitigation actions

A complete rehabilitation of these networks is necessary, adding complexity and time to the project. This requires hiring specialized professionals and carefully coordinating installation activities.

10.3 Comprehensive planning

The challenges faced, such as the shortage of specialized workforce, underestimation of the required materials, and lack of preparation to deal with the attitude of tenants, highlight the importance of comprehensive planning before the project commences.

10.4 Mitigation actions

This includes a detailed analysis of labor needs, accurate estimates of materials, and considerations for potential obstacles that may arise during project execution.

10.5 Flexibility and resilience

The ability to deal with unforeseen circumstances and adapt to changes is crucial for project success. Material delivery delays and difficulties related to installations in properties occupied by tenants underscore the need for the team's flexibility and resilience to overcome these challenges and maintain project progress.

10.6 Mitigation actions

N/A

11 Installation of the SUREFIT technologies in new buildings

In the previous paragraphs were reported the installation and operation risks, obstacles and safety issues of the SUREFIT technologies in five renovated buildings. Most of the identified risks will also stand for the installation and operation of technologies in a new building. However, for some of the technologies, i.e. the Hybrid PV-Thermal, the PV Vacuum glazing unit, the Window heat recovery unit and the Daylight louvers, some of the risks will not materialise in a new building and these cases are briefly mentioned below.

11.1 Hybrid PV-Thermal system

As previously reported, the big size of the storage tank requires adequate space in the building. In the Greek demo building in particular, this required the demolition of a small WC which posed disturbance to the occupants, added significant installation time as well as cost for the constructor. In the case of a new building under construction, the space required for the storage tank should be taken into account during the design phase, therefore such additional works and risks will be avoided.

11.2 PV Vacuum glazing unit and Window heat recovery unit

As previously reported, one main technical risk/challenge for the installation of the PV Vacuum glazing unit and the Window Heat Recovery unit is that they both require replacement of the existing window frame which results in additional works, time and cost. In the case of a new building, this parameter will be taken into account during the design phase of the frames and such a risk/challenge will be avoided.

11.3 Daylight louvers

In the case that the daylight louvers have to be installed between the existing window panes of a building, there exists the technical challenge that the installers should ensure there's enough space between the windows for the mechanism and also be prepared to modify the window framing for passing through the cables etc. Obviously, this challenge will not materialise for a new building under construction, because the window unit with integrated daylight louvers will have been designed beforehand and by taken into account all the above-mentioned parameters.

12 Effect of regional conditions on installation & operation of SUREFIT technologies

According to the Task 8.3 description, in this report should be also considered regional conditions including population, development, weather and other possible factors. In the following paragraphs are briefly commented aspects related to the development level of a society in the uptake of retrofitting technologies and innovations as well as the climate conditions' effect on the SUREFIT technologies.

12.1 Development level of a society

One important factor that should be taken into account when the uptake of buildings' retrofitting technologies is examined, is the energy poverty, which affected more than 9% of the European population in 2022 and 2023 (1, 2 and 3). Energy poverty is defined in the 2023 Social Climate Fund regulation and the revised Energy Efficiency Directive as 'a household's lack of access to essential energy services that provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing social policy and other relevant policies, caused by a combination of factors, including but not limited to non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes' (2). For the population living under the energy poverty condition, it is doubtful that they could adopt any retrofitting technologies themselves, unless supporting measures, such as subsidies, will apply.

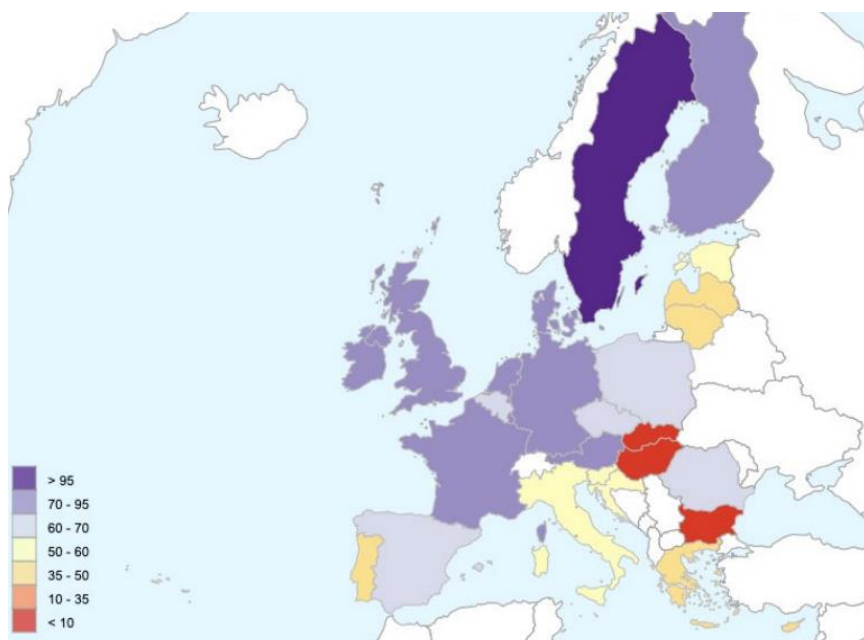


Figure 21 – Domestic energy poverty index scores (Source: EDEPI, 2022)

But even for the population currently above the energy poverty level, there exist a number of barriers that may prohibit the uptake of the traditional and the new innovative retrofitting solutions. These barriers are the limited financial support from the state, a long payback period of the retrofitting technologies, lack of awareness of the building owners but also of the professionals in the building sector about new and innovative retrofitting solutions etc.

As far as the payback period and the SUREFIT technologies is concerned, from the LCCA that was performed in Task 8.1 – *Economic evaluation* and is reported in D8.1, it was resulted that the SUREFIT technologies already in the market, i.e. the Hybrid PV-Thermal system by SOLIMPEKS and the SKYTECH Pro XL membrane by WINCO have competitive prices. The PCM Passive Cooling panels and the Daylight louvers that are also in the market were not analyzed in the framework of T8.1, however it can be considered that they have also competitive prices. For the rest of the technologies (SAHP, GSHP, PV Vacuum glazing window, Window Heat recovery unit, and prefabricated panels) that are currently not in an industrial-scale production, the future market prices should be competitive to similar technologies already available in the market, in order to be attractive for the customers.

12.2 Climate conditions

The study of the SUREFIT technologies that has been implemented until now, did not show any clear result of how the climate conditions can affect the efficiency of the technologies. The main reason for this is that the primary energy consumption and CO₂ emissions are depending on many other parameters apart from the climate. As an indicative example to support this statement, a comparison of the primary energy consumption of the Hybrid PV-Thermal system, the PV Vacuum glazing window and the SAHP in Greece, Spain and UK is going to be presented.

As shown in the following Table, the Hybrid PV-Thermal system in Greece and Spain reduces the primary energy consumption by two times compared to the UK, which could be attributed to the sunlight intensity of the two Mediterranean countries. However, by comparing the energy consumption of PV Vacuum window, it is shown that the Spain and UK have similar and quite low reduction. The reason behind these performances is that the efficiency of this system is also related to the orientation of the windows, the degree of exposure to the sunlight and also to the surface of the window glass. Furthermore, the primary energy consumption of the SAHP appears to be two times worse in Greece compared to the UK, and the reason for this is that it depends on the country's electricity primary energy conversion factor, as this technology increases the electricity consumption.

Country	Primary Energy consumed in kWh/m ² /year (per technology, when applied alone)			
	Original Case	PV-THERMAL	PV Vacuum Window	SAHP
GR	152.8	128.5	136.4	136.2
Reduction	-	16%	11%	11%
SP	181.3	145.3	177.1	125.3



Reduction	-	20%	2%	31%
UK	285.5	259.9	277.3	225.0
Reduction	-	9%	3%	21%

Table 2 Primary energy consumption simulated by AALTO for the three technologies: Hybrid PV-Thermal, PV Vacuum window and SAHP in Greece, Spain and UK.

Thus, the results obtained so far for the application of the SUREFIT technologies in different countries cannot drive to any concrete conclusion about the effect of the climate in the efficiency of the systems. It can be considered that, in principle the SUREFIT technologies can be applicable to all climate conditions, as long as the necessary energy studies will prove a positive impact of each technology to the building under study.

13 Application of the SUREFIT technologies in low carbon buildings

The application of combinations of the various SUREFIT technologies has been realised in five buildings around Europe and it is currently under evaluation monitoring. However, during the design process of the SUREFIT renovations, AALTO University conducted a number of simulation studies in order to estimate the reduction of the purchased and primary energy as well as the reduction of CO₂ emissions. In every examined retrofitting scenario, the reduction of the aforementioned parameters was found to lie between 45% up to 75%, and the annual CO₂ emission after the renovation was estimated between 7.2 and 14.3Kg/m². These results prove that the SUREFIT technologies will result in a significant reduction in CO₂ emissions of a building in different regions of Europe. Therefore, there have not been identified any specific application requirements towards the target of low carbon buildings.

More information about the reduction in purchase and primary energy demand as well as for the reduction of CO₂ emissions are briefly presented in the following paragraphs.

It should be mentioned that in the Finnish building, from the available SUREFIT technologies only the daylight louvers have been installed and therefore this use case is not presented.

13.1 Greek demo case

The following Table summarises the renovation scenario for the Greek demo site that was simulated by AALTO University. The installation of the technologies on the 1st floor of the building has been considered.

Combination of the SUREFIT technologies simulated for the Greek demo site
Hybrid PV-Thermal
PV Vacuum glazing on the south windows of the 1 st floor
PVC frame double glazed commercial windows in the north façade of the 1 st floor
Breathable membrane (ceiling of the ground floor)
Prefabricated panels on the south and north façade

Table 3 Combination of the SUREFIT technologies simulated for the Greek demo site

The simulation results showed a significant reduction of 61-62% in the purchased and primary energy and the CO₂ emissions.

GREECE	Original	Final combination (ceiling insulation, 50% airtightness improvement)
Purchased energy (kWh/m ²)	120.9	46.4
Reduction (%)	-	62%
Primary energy (kWh/m ²)	143.5	55.6
Reduction (%)	-	61%
CO ₂ Emissions (kg/m ²)	36.6	14.3
Reduction (%)	-	61%

Table 4 Theoretical calculation of the purchased energy, primary energy and CO₂ emissions reduction after the SUREFIT renovations in the Greek building

13.2 Spanish demo case

The following Table summarises the technologies for the Spanish demo site that have been used in three simulation scenarios by AALTO University.

Combination of the SUREFIT technologies simulated for the Spanish demo site
Hybrid PV-Thermal
PV Vacuum glazing on all windows except the unheated basement
Breathable membrane on external walls and the roof
PCM panels in one bedroom
Window Heat Recovery (6 units)
Daylight louvers on all windows except the unheated basement
Smart controls
Prefabricated panels

Table 5 Combination of the SUREFIT technologies simulated for the Spanish demo site

The three scenarios have been the following:

- **Combined, 2 insulated:** Planned installation

- **Combined, 3 insulated:** Planned installation, but thermal insulation extended to all participating apartments
- **Combined, 3 insulated, 60%:** Extended insulation, with thicker insulation layer and larger PV-THERMAL array to reach the 60% target
- *Spanish demo building, final case – 3 apartments out of 4 included in calculations.

The simulation results showed a significant reduction of 45-61% in the purchased and primary energy and the CO₂ emissions.

SPAIN	Original	Combined, * 2 insulated	Combined, 3 insulated	Combined, 3 insulated, 60%
Purchased energy (kWh/m ²)	129	69.5	59.7	50.4
Reduction (%)		46.1 %	53.7 %	60.9 %
Primary energy (kWh/m ²)	146.5	80.1	69.5	59.2
Reduction (%)		45.3 %	52.5 %	59.6 %
CO ₂ Emissions (kg/m ²)	25.5	13.7	11.8	9.9
Reduction (%)		46.2 %	53.9 %	61.1 %

Table 6 Theoretical calculation of the purchased energy, primary energy and CO₂ emissions reduction after the SUREFIT renovations in the Spanish building

13.3 Portuguese demo case

The following Table summarises the technologies for the Portuguese demo site that have been used in the simulation scenario by AALTO University.

Combination of the SUREFIT technologies simulated for the Portuguese demo site
PV Vacuum glazing
Window Heat Recovery
Daylight louvers
Smart controls
Solar assisted heat pump

Table 7 Combination of the SUREFIT technologies simulated for the Portuguese demo site

The simulation results showed a high reduction of 74-75% in the purchased and primary energy and the CO₂ emissions.

PORTUGAL	Original	Final Combination (without insulation)
Purchased energy (kWh/m ²)	115.4	28.4
Reduction (%)	-	75%
Primary energy (kWh/m ²)	163.0	42.3
Reduction (%)	-	74%
CO ₂ Emissions (kg/m ²)	28.3	7.2
Reduction (%)	-	75%

Table 8 Theoretical calculation of the purchased energy, primary energy and CO₂ emissions reduction after the SUREFIT renovations in the Portuguese building

13.4 UK demo case

The following Table summarises the technologies for the UK demo site that have been used in the simulation scenario by AALTO University.

Combination of the SUREFIT technologies simulated for the UK demo site
PV systems
Bio aerogel insulation panel
PV Vacuum glazing
Evaporative cooler
Window Heat Recovery
Solar assisted heat pump
Smart controls
Ground source heat pump

Table 9 Combination of the SUREFIT technologies simulated for the UK demo site

The simulation results showed a high reduction of 62-71% in the purchased and primary energy and the CO₂ emissions.



UK	Original	Final combination
Purchased energy (kWh/m ²)	206.8	60.8
Reduction (%)	-	71%
Primary energy (kWh/m ²)	242.7	91.2
Reduction (%)	-	62%
CO ₂ Emissions (kg/m ²)	42.7	14.0
Reduction (%)	-	67%

Table 10 Theoretical calculation of the purchased energy, primary energy and CO₂ emissions reduction after the SUREFIT renovations in the UK building

Conclusions

The partners involved in the manufacturing, installation and operation of the SUREFIT retrofitting solutions, reported the main installation and operation risks of those technologies and where possible, mitigation actions were proposed. It is worth to mention that there have not been observed any crucial risks and unmanageable obstacles in the examined technologies that could put the installation and operation of the systems at stake or pose major safety danger. Nevertheless, there is still room for improvements of some of the examined technologies.

During the installation and operation of the SUREFIT technologies in new buildings under construction, similar risks are expected to be arisen as in the case of the retrofitted buildings that have been studied in the SUREFIT project. However, for some of the technologies such as the PV-Vacuum glazing and Window Heat recovery for which replacement of the existing window frames were needed during their installation, the installation works will be less demanding when these will be applied in a new building. The same applies for the space that is needed for the storage tank of the Hybrid PV-Thermal system, which is going to be pre considered and designed during the application in a new building under construction.

The results obtained so far for the application of the SUREFIT technologies in different countries cannot drive to any concrete conclusion about the effect of the climate in the efficiency of the systems. It can be considered that, in principle the SUREFIT technologies can be applicable to all climate conditions, as long as the necessary energy studies will prove a positive impact of each technology to the building under study.

Finally, the installation of the SUREFIT technologies in different buildings resulted in every case to a significant reduction of the energy consumption and the CO₂ emissions. In every examined retrofitting scenario, the reduction of the aforementioned parameters was found to lie between 45% up to 75%, and the annual CO₂ emission after the renovation was estimated between 7.2 and 14.3Kg/m².



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