REPORT

Suitable GHG reduction measures for Cypriot and Greek hotel industry

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

European Climate Initiative EUKI

Suitable GHG reduction measures for Cypriot and Greek hotel industry

Structural characteristics, energy and GHG emissions performance indicators

Hotels4Climate

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OEB

The Cyprus Employers and Industrialists Federation (OEB) was founded in 1960 by 19 pioneering entrepreneurs. Today, its members are active in all sectors of the economy and employ more than 60% of the private sector's workforce. OEB is a Pancyprian, independent non-profit organization comprising of 60 of the main professional/sectoral Associations as well as hundreds of companies from the Manufacturing, Services, Commercial, Construction and Agricultural Sectors. In total, OEB has more than 15.000 Member/Enterprises.

In particular, the Energy & Environment Department of OEB was founded in 2016 and its goals are to be pioneer on the topics of energy, environment and sustainability, through actions that can improve the competitiveness of renewable energy technologies, to remove administrative or other barriers for the promotion of energy efficiency, to support Cypriot manufacturers to maintain their global position in the installation of domestic solar thermal systems, to promote clean technologies for environmental protection and the 2030 targets for circular economy and climate change, to provide education and training, to promote efficient use of energy, to provide technical advisory support on sector related issues, to promote cooperation between academia and industry in the fields of energy and environment and in the development of research and innovation.

There are many projects have been developed by the Energy & Environment Department that aim for the promotion of eco-innovation, blue energy, GHG emission reduction, etc.

OEB operates in environmentally friendly manner. Since 2017 OEB is EMAS certified as well as produces on site renewable electricity through PV net metering system.

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INSETE

INSETE is a non-profit organisation founded in early 2013, on the initiative of the Greek Tourism Confederation (SETE), by four partners with intense activity in critical areas of the Greek tourism market: SETE (principal partner), the Hellenic Hoteliers Federation (HHF), the Hellenic Association of Travel & Tourist Agencies (HATTA) and the Confederation of Entrepreneurs of Rented Rooms and Apartments (SETKE).

The mission of INSETE is to contribute with well-substantiated ideas to promoting both public and private policies that will support, modernise and improve the Greek tourism sector and any other service sector which is directly or indirectly associated with it.

Specifically, INSETE supports the Greek Tourism Confederation with:

- documented and thought out interventions in social and public dialogue (positions, proposals, etc.) aimed at promoting policies to support, modernise and improve Greek tourism.
- implementing actions to research, inform and disseminate knowledge, to develop human resources and improve and certify quality of enterprises and the skills of professionals and workers in Greek tourism.

Furthermore, the main activities of INSETE are:

- To research, safeguard and promote the position and contribution of tourism to sustainable economic, social and cultural growth and development at both a national and European level.
- To support and promote entrepreneurship (both conventional and social) in the tourism sector, and in any other service sector which is directly or indirectly associated with it.
- To enhance Human Resources development policies and tools for the tourism sector and any other service sector which is directly or indirectly associated with it.
- To provide scientific, technical or other form of documentation and support to SETE on issues relevant to its activities and operations, and to help it achieve its objectives.

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adelphi

adelphi is a leading independent think tank and public policy consultancy on climate, environment and development. Our mission is to improve global governance through research, dialogue and consultation. We offer demand-driven, tailor-made services for sustainable development, helping governments, international organizations, businesses and non-profits design strategies for addressing global challenges.

Our staff of more than 200 provides high-quality interdisciplinary research, strategic policy analysis and advice, and corporate consulting. We facilitate policy dialogue and provide training for public institutions and businesses worldwide, helping to build capacity for transformative change. Since 2001 we have successfully completed over 800 projects worldwide. Our work covers the following key areas: Climate, Energy, Resources, Green Economy, Sustainable Business, Green Finance, Peace and Security, International Cooperation and Urban Transformation.

Partnerships are key to the way we work at adelphi. By forging alliances with individuals and organizations, we help strengthen global governance and so promote transformative change, sustainable resources management and resilience. adelphi is a values-based organization with an informal culture based on excellence, trust and cooperation. Sustainability is the foundation of our internal and external conduct. Our activities are climate-neutral and we have a certified environmental-management system.

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List of abbreviations

A/C	Air Conditioning
AC	Alternating Current
AI	Artificial Intelligence
BAS	Building Automation System
BEMS	Building Energy Management System
°C	Degrees Celcius
C	Cost
CO_2	Carbon Dioxide
CO2eq	Carbon Dioxide Equivalent
DC	Direct Current
DHW	Domestic Hot Water
EE	Energy Efficiency
EU	European Union
EN	European Norm (Standard)
EPREL	European Product Registry For Energy Labelling
ESMAP	Energy Sector Management Assistance Program
EU	European Union
F-GAS	Fluorinated Gas
GHG	Greenhouse Gas
GWP	Global Warming Potential
HFCs	Hydrofluorocarbons
HFO	Hydrofluoroolefin
HVAC	Heating, Ventilation, And Air Conditioning
ICS	Integral Collector-Storage
IT	Information Technologies
KW	Kilowatt
KWH	Kilowatt- Hour
LED	Light-Emitting Diode

LOW-E	Low Emissivity
LPG	Liquefied Petroleum Gas
M-BUS	Meter Bus
ML	Machine Learning
NZEB	Nearly Zero Energy Building
PBP	Pay Back Period
PV	Photovoltaics
PVC	Polyvinyl Chloride
QR	Quick Response
RES	Renewable Energy Sources
RMB	Ren Min Bi
ROI	Return Of Investment
TV	Television
UPVC	Unplasticized Polyvinyl Chloride
VOS	Voltage Optimisation System

1. Introduction

The Hotels4Climate project partners have collaborated in order to prepare this report, which outlines the most appropriate greenhouse gas (GHG) reduction measures for Cyprus and Greece hotels based on a comprehensive assessment of their hotel industries. The measures will additionally be presented in workshops. The workshop materials will also be available online for all interested stakeholders.

This report identifies 21 measures in various categories (table 1), classified according to on three criteria:

- Investment cost.
- Energy and GHG emission savings
- Pay back period

These criteria are defined as low, medium and high, each representing a specific range and colour coding as shown in table 2.

Calculation of Pay back period or return on investment numeric is important to be calculated before any investement.

Return on Investment (ROI) is a performance measure used to evaluate the efficiency of an investment or compare the efficiency of a number of different investments. ROI tries to directly measure the amount of return on a particular investment, relative to the investment's cost. To calculate ROI, the benefit (or return) of an investment is divided by the cost of the investment. The result is expressed as a percentage or a ratio.[1]

The return on investment formula is as follows:

ROI = Current Value of Investment−Cost of Investment / Cost of Investment

Payback period in capital budgeting refers to the time required to recoup the funds expended in an investment, or to reach the break-even point. Payback period is the time required for positive project cash flow to recover negative project cash flow from the acquisition and/or development years. Payback can be calculated either from the start of a project or from the start of production.

Payback period is commonly calculated based on undiscounted cash flow, but it also can be calculated for Discounted Cash Flow with a specified minimum rate of return. The intuition behind payback period measure is that the investor prefers to recover the invested money as quickly as possible[2]

For example, a €1000 investment made at the begging of year 1 which returned €500 at the end of year 1 and year 2 respectively would have a two-year payback period. Payback period is usually expressed in years. Starting from investment year by calculating Net Cash Flow for each year: Net Cash Flow Year 1 = Cash Inflow Year 1 - Cash Outflow Year 1. Then Cumulative Cash Flow = (Net Cash Flow Year 1 + Net Cash Flow Year 2 + Net Cash Flow Year 3, etc.) Accumulate by year until Cumulative Cash Flow is a positive number: that year is the payback year´[3]

Payback period is usually expressed in years. Start by calculating Net Cash Flow for each year: Net Cash Flow Year 1 = Cash Inflow Year 1 - Cash Outflow Year 1. Then Cumulative Cash Flow = (Net Cash Flow Year 1 + Net Cash Flow Year 2 + Net Cash Flow Year 3, etc.) Accumulate by year until Cumulative Cash Flow is converted into a positive number: that year is the payback year.

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[1] Source: https://www.investopedia.com/terms/r/returnoninvestment.asp

[2] Source : https://www.e-education.psu.edu/eme460/node/682

[3] Source: https://en.wikipedia.org/wiki/Payback_period

To calculate a more exact payback period: Payback Period = Amount to be Invested/Estimated Annual Net Cash Flow. It can also be calculated using the formula:

Payback Period = $(p - n) \div p + n_y = 1 + n_y - n \div p$ (unit:years)

Table 1: Categories of measure

Green retrofitting	Building envelope improvement	HVAC Systems-applicances and refrigeration	Management / automation system	Improve lighting efficiency	Renewables	Other
Measure 1	Measures 2-6	Measures 7-10	Measures 11 & 12	Measure 13	Measures 14-15	Measures 16-24

Table 2: Classification of measures

	Low	Medium	High
Investment	<10.000 €	10.000-50.000 €	>50.000 €
Energy & GHG savings	<15%	15-35%	>35%
Payback Time	<2.5 years	2.5-7.5 years	>7.5 years

2. Presentation of suitable GHG reduction measures for Cypriot and Greek hotel industry

2.1 Planning, design, and green retrofitting / renovation

Upgrading of green retrofitting capabilities is one of the main GHG mitigation strategies the hotel industry can follow. The building sector is crucial for achieving the EU's energy and environmental goals. At the same time, better and more energy efficient buildings improve the quality of citizens' life while bringing additional benefits to the economy and the society. Therefore EU has released the Energy Performance of buildings Directive with a view to decarbonising the national building stocks by 2050, with indicative milestones for 2030, 2040 and 2050. Renovation and design strategies aim to support the sector on promoting technologies and methodologies for energy efficiency.

2.1.1 Measure 1 - Green design / retrofitting

Europe's building stock is both unique and heterogeneous in its expression of the cultural diversity and history of the continent. More than 220 million building units, representing 85% of the European Union's (EU) building stock, were built before 2001 meaning lower energy performance. As a result the energy renovation of those buildings is crucial for the reduction of energy consumption and GHG emissions.[4]

There are 87.553 tertiary buildings in Cyprus in total, including various types of buildings with offices, retail shops, dining areas, hotels, hospitals and schools. The large majority of buildings in the tertiary sector have been constructed without requirements for thermal insulation or any other energy efficiency measures. In fact, the majority (83%) of the building stock of the tertiary sector was built before the first legislation regarding energy performance requirements.

New constructed buildings (including hotels) all over Europe are obliged to follow new requirements in terms of their Environmental and/or Energy Performance with specific energy classification requirements.

Through the Energy Performance of Buildings Directive, specific measures and policies have been implemented in **Cyprus** so as to improve the EE (Energy Efficiency) of buildings and consequently reduce the GHG emissions. For example, since 2007 mandatory EE requirements were implemented for new and existing buildings which underwent major renovations. During these years, the requirements became stricter. Recently the new EE requirements that came into force on 1st July 2020, include specific requirements for hotels such as the level of insulation of the building envelope, the share of renewable energy sources (RES) in total consumption, the minimum primary consumption per square meter etc. Specificaly the new hotel buildings should consume a maximum of 220 kWh/m^2/yr and the minimum RES contribution to the primary energy consumption should be at least 9%. In addition, Category A in the Energy performance certificates for residential buildings and B+ for non-residential buildings must be achieved.

Moreover, according to the Law 31(I)/2009, it is mandatory for non-SME's, including hotels, to undergo an energy audit every 4 years

Concerning Greece the building stocks account for the 34% of total energy consumption and 65% of electrical energy consumption. In **Greece**, the minimum required energy classification of the building / building unit, is as follows:

[4] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/renovation-wave_en

a) New residential buildings, of r which the building permit is issued until 31 May 2021, must be classified at least in energy category B. The addition of a building unit (as well as the radical renovation) to these residential buildings, should be classified in the same energy category. The addition of a building unit to existing buildings should be classified in energy category B +. Existing buildings or building units that are subject to radical renovation should be classified in energy category B.

b) New residential buildings, of which the building permit is issued after 31 May 2021 must be Buildings of almost zero energy consumption therefore should be classified at least in energy category A. The addition of a building unit (as well as the radical renovation) to these buildings, should be classified in the same energy category.

c) New tertiary buildings (including hotels), of which the building permit application must be submitted by 31 December 2020, must be classified at least in energy category B. The addition of a building unit (as well as radical renovation) to these tertiary sector buildings must be classified at least in energy category B.

d) New tertiary sector buildings (including hotels), of which the building permit is applied for from 1 January 2021 onwards, must be almost zero energy buildings, therefore they must be classified at least in energy category A. The addition of a building unit (as well as the radical renovation) to these buildings, should be classified in the same energy category.

e) The new buildings (including hotels) belonging to the State or the broader public sector / administration.and are intended to be used to accommodate their services, as of 1.1.2019, must be "Nearly Zero Energy Buildings (nZEBs)" and be classified at least in energy category A. The addition of building unit (as well as the radical renovation) in these buildings, should be classified in the same energy category.

In terms of new designs and retrofitting the following parameters should be taken into consideration

- Orientation of the building
- Microclimate and vegetation
- Openings and orientation of openings (solar gains, natural ventilation and natural lighting)
- Installation of passive systems like mass wall and Trombe walls etc
- Solar protection
- Building envelope design and Um calculations
- Mechanical systems, hot water production, HVAC, mechanical ventilation
- Onsite Renewable energy systems
- Lighting efficiency
- Systems management

2.1.1.1 Area of application

Green design/retrofitting can be applied to all building areas, especially heating, cooling, ventilation, production of hot water, lighting, cooking equipment, process equipment.

Situation before: *The hotels' construction was not taking green design and sustainability into consideration. Consequently, the majority of the hotels lack of energy efficient design resulting in high energy consumption.*

Situation after implementation: *Energy efficiency is calculated during the design phase, so it is easier to implement energy efficient measures during the construction phase. In addition, the EU decision for nZEB buildings is now already in force for all member states, therefore new buildings are expected to perform better. Energy certification ranks at higher levels between A+ And A buildings.*

2.1.1.2 Assessment of Measure 1 - Green design / retrofitting

HIGH **Investment**	The design phase is critical for decisions as they are related to the entire life cycle of the building. Minimum energy performance requirements, site specific design, high quality materials, and smart monitoring all require additional investments, however, they can reduce operating costs throughout the life cycle of the building.
HIGH **Energy & GHG savings**	This measure has both high energy and GHG emissions saving potential in the long term.
Payback Time	Green design or retrofitting is an especially important measure if the hotelier is the owner of the building as it can reduce operating costs, therefore payback period is within buildings life span. Usually payback period is between 6-25 years.

2.2 Building envelope improvements

The performance aspects of a hotel building in terms of the building envelope include the thermal capacity, insulation, passive heating, thermal bridges and insulation characteristics. These are therefore the key elements of the building envelope that should be improved in order to provide energy efficiency benefits and GHG emissions reductions. The interventions below are typically more difficult and expensive to implement but they have a quite high and long-lasting effect on improving energy efficiency and simultaneously on reducing the total energy cost.

2.2.1 Measure 2 – Shading installation

Shading is especially important in warm climates as they protect the buildings from solar irradiation, preventing the increase of the internal temperature of the building. . Shading systems can have a major impact on the buildings energy requirements, as lower operation time and reduced load of the cooling systems can be achieved. There are various shadings options, with the most common being:

- Fixed shading (horizontal and vertical);
- External shading with removable shutter;
- External shading with removable rolling blind (translucent); and
- External shading with removable rolling blind (opaque).
- Linen covering / curtains, usually called as black outs.
- Awnings that could prevent the panoramic view from being blocked in hotels while still shading windows.

2.2.1.1 Area of application

Shading can be applied to any hotel windows with high sunlight gains.

Situation before: *In many hotels, openings were often not protected with shading for aesthetic reasons. Lobbies, restaurants, and rooms in many cases were gaining heat from sunlight in favour of guests enjoying panoramic views, which resulted in higher use of A/C and cooling.*

Situation after implementation: *By applying shading sun gains are more controlled, resulting in reduced needs of cooling.*

2.2.1.2 Assessment of Measure 2 - Shading installation

MEDIUM **investment**	Investment depends on the openings that should be sun protected and the technology used. For example, fixed outdoor shading can be a high-value investment and indoor shading with blinds and curtains can be a lower-value investment. Specifically, for a fixed outdoor shading the investment cost can be 120 €/m², while the cost for a movable outdoor shading can be around 220€/m². For indoor shading, such as roller blinds, the cost can be around 25 €/m².
HIGH **Energy & GHG savings**	The energy and GHG emission saving can be significant, especially in warm climates. Under normal operation, evaluating the effects of sun-shading shows that flexible shading has a greater impact than fixed shading. When combined with an economic analysis, the results can vary. For example, in high-rise residential buildings, the difference in energy saving rate between fixed and flexible shading is not considerably high (0.05%~1.35%), but the fixed shading is more cost effective than flexible shading. The effectiveness is also

	dependent on the type of building, the surrounding geography and location. For all types of buildings including hotels, whose load comes mainly from the occupant and equipment loads, the energy-saving effects of such technology may not be obvious. External shading should be considered by the architect during the design process so the form of the building can be combined with external shading in a way to achieve an ideal energy-saving result.
Payback Time	The payback period for this measure can be considered moderate. For indoor shading installations such as curtains and rolling blinds, the payback period can be very low. For outdoor automatic shading which opens and closes based on sun irradiation, the payback period can be up to 10 years because of the expensive technology.

2.2.2 Measure 3 - Energy efficiency frames and double-glazed windows

There is a wide range of materials, styles, colours and solutions regarding energy efficient frames and glazing for windows. Typically, the frame material is made of aluminium, polyvinyl chloride (PVC), or sometimes wood. Thermal insulation frames, called “thermal break”, are currently on the market . A thermal break is a continuous material between the inside and outside window frames that acts as a barrier, reducing the flow of thermal energy (heat). The most energy efficient type of glass for double and triple glazing is low emissivity (low-E) glass. Low-E glass has a microscopically thin coating of metal oxide on one of the internal glass surfaces. This coating reflects heat back into the home but at the same time still allows the light from outside to enter .

The energy performance of a window depends on how well these materials can prevent heat from passing through, as well as how much sunlight travels through the glass and how little air can leak around the window.

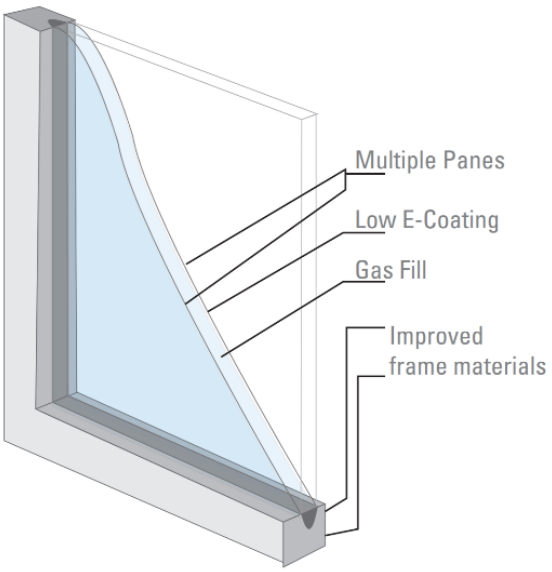

Figure 1: Elevation of a double glazed window[5]

[5] Source of picture : Enery Star - https://www.energystar.gov/sites/default/files/asset/document/HeatingCoolingGuide%20FINAL_9-4-09_0.pdf

Energy efficient windows are made of two or three glass panes sealed in a single unit, surrounded by a frame made from Unplasticized Polyvinyl Chloride (uPVC), wood, or another material.

- **double-glazed windows** have two sheets of glass with a gap in between, usually about 16mm;
- **triple-glazed windows** have three sheets of glass, and two gaps. This can make them better at insulating than many double-glazed windows and that is why it is recommended;
- The gaps between the glass panes are filled with air, or an inert gas such as argon. The air or gas is completely sealed.

Figure 2: Thermograph picture of a building[6]

2.2.2.1 Area of application

All windows in a hotel property could be optimised by this measure.

Situation before: *In most hotels, window glazing is single, as hoteliers typically make investments in facilities and aesthetics. However, the energy losses are significant as single glazing cannot provide sufficient insulation to the building envelope.*

Situation after implementation: *Lower heating and cooling needs, as well as improved thermal insulation for the building.*

2.2.2.2 Assessment of Measure 3 - Energy efficiency frames and double-glazed windows

HIGH	The required investment is usually high, depending on the number of window panes and frames that need to be replaced. For a typical double-glazed window with thermal break, the investment cost is approximately 220€/m²,

[6] Source : https://ec.europa.eu/info/news/new-energy-performance-buildings-directive-kicks-2020-mar-09_en

investment	while for a typical double-glazed and low-e window with thermal break, the investment cost is approximately 240€/m². As regards a typical triple-glazed window with thermal break, the investment cost is approximately 300€/m².
HIGH **Energy & GHG savings**	The energy and GHG emission savings' potential can vary depending on the type and characteristics of the frame and glass. In fact, the actual energy savings from the replacement of a window with a double-glazed and aluminum frame with a thermal break can be up to 7%. Apart from energy savings, double-glazed windows offer sound insulation and reduction of thermal bridges. The upgrade from double-glazed windows to triple-glazed windows does not achieve significant energy savings. However, in this case, the investment cost will be considerably high.
Payback Time	The payback period is more than ten years, however, the installation of double-glazed windows is necessary in order to achieve thermal and sound insulation. The payback period seems long, mainly due to the high capital expenditure. However, in the long run, it can offer significant savings as the lifespan of the windows is similar to the lifespan of the building.

2.2.3 Measure 4 - Thermal insulation of the building envelope

Thermal insulation is considered to be one of the most cost-effective measures in the energy efficiency of buildings. The thermal insulation refers to the application of a thermal insulating material on the outside or inside surface of vertical or horizontal walls of a building.

Thermal insulation acts as a "protective layer" for the building, which reduces heat transfer to and from the interior. Thermal insulation reduces the heat loss to the outside during the winter months, while the heat flow in the building is reduced during the summer months. In addition to the energy and cost savings that can be achieved, thermal insulation contributes significantly to the improvement of thermal comfort conditions as well as to the treatment of humidity problems inside the building.

The greatest heat loss in a building usually comes from the roof of the building. For this reason, roof insulation is considered to be as one of the most economical and efficient measures in the field of energy efficiency of buildings. By only insulating the roof of the building, the percentage of the total estimated energy savings amounts to about 40% per year, as the needs for space heating and cooling are significantly reduced. Undoubtedly, a priority for implementing energy efficiency measures for an existing building is the thermal insulation of the roof.

For the selection of the most efficient envelope thermal insulation, a number of factors must be taken into consideration , such as the existing waterproofing situation of the building, the climatic zone of its location and its use and of course the variety of the specialized thermal insulation materials available.

2.2.3.1 Area of application

Thermal insulation can be installed on all vertical or horizontal walls of a hotel. The insulation can be installed internally or externally of the walls.

Situation before: *The majority of the buildings were constructed without any thermal insulation.*

Situation after implementation: *Thermal insulation contributes to the energy and cost savings, improving at the same time the thermal comfort conditions inside the building*

2.2.3.2 Assessment of Measure 4 - Thermal insulation of the building envelope

MEDIUM - HIGH **investment**	The investment cost depends on the area (m^2) of vertical and horizontal structural elements of the building where thermal insulation will be installed. It also depends on the type of thermal insulation materials that will be used. Approximately, the investment cost for the installation of roof and wall thermal insulation is 40€/m^2 and 55€/m^2, respectively.
MEDIUM **Energy & GHG savings**	The energy saving potential for heating and cooling can be up to 40% with the installation of roof thermal insulation and up to 5% with the installation of wall thermal insulation. The exact amount of savings depends on the type and width of the thermal insulation material, as well as the fuel used for heating and cooling inside the building.
Payback Time	The payback period for the installation of wall thermal insulation is more than ten years while the payback period for the installation of roof thermal insulation is around 3-4 years. This difference is attributed to the higher investment cost and the lower energy saving potential of the wall thermal insulation. The installation of roof thermal insulation is more important than the wall thermal insulation because heat losses are much higher from the roof compared to the walls.

2.2.4 Measure 5 - Green façade and green roof

A “green façade” refers to a vertical structure where climbing or hanging plants are directly or indirectly supported to grow up or down the structure. Green façades and green roofs can be characterized as nature based solutions, which can be broadly defined as actions addressing challenges through the protection and restoration of natural processes and ecosystems. The growing medium of these plants is ground-based for climbing plants and plant-trough-based for hanging plants.

“Green roof” refers to vegetated landscapes that are installed on a roof surface in a loose-laid or modular format. Green roofs may be further classified as extensive, semi-intensive or intensive depending on the depth of the substrate installed and the type of planted vegetation.

A green roof could reduce annual building energy consumption by enhancing the roof insulation properties. In addition to this related to the reduction in the heat increase during the summer months and heat loss from the building in winter, a green roof can play a vital role helping internal temperatures to stay stable year round by adding thermal mass. Nichaou et al. (2001) determined how a green roof with different degrees of existing insulation could improve buildings energy consumption. In this study, they compared two buildings in Athens with similar insulation properties but one with a green roof. The internal temperatures of these buildings were recorded for three days in July. Without a green roof, the internal air temperature was higher than 30 ◦C for 68% of the period; while on the other hand, with a green roof, the internal air temperature was higher than 30 ◦C for 15% of the period.. [7]

[7] Nichaou et al., 2001, Nichaou, A., Papakonstantinou, K., Santamouris, M., Tsangrassoulis, A., Mihalakakou, G., 2001. Analysis of the green roof thermal properties and investigation of its energy performance, Energy and Buildings, 33 (7), 719-729 Pisameteo database.

"Green wall" refers to a vertical structure that is normally fitted with modular, pre-planted panels containg wall-bound vegetation. Vertical green protects a building against the heat of the sun in the summer, keeping it cooler. In the winter, the vegetation can protect the building from wind and reduce heat loss via convection along the facade and the air pocket between the vegetation and the building. A stationary air pocket of 5 cm between vegetation and a building is comparable to a heat transfer coefficient of 2.9 W/m^2K which can be compared to a window with thermal break. Thicker layers of air do not improve the insulation significantly, as convection loss due to the stack effect increases. This could be fixed by compartmentalising the vertical growth using, for instance, the supporting structure.[8]

The terms "green roof" or "living roof" is used to describe a roof, terrace or veranda of a building that is entirely or partially covered with vegetation. This vegetation is planted in a layer of soil, which can be placed over waterproof membrane or on top of additional layers, such as a root barrier and a drainage/irrigation system. "Green roofs" or planted roofs are categorized internationally into two main types, i.e. The extensive type, where the total surface of the roof is covered and the semi- intensive type, where other construction elements might be included. Green roofs also act as insulation, and protect the roof(s) against heat and water. The creation of a green roof and terraces is one of the most environmentally friendly solutions for achieving significant energy savings, while at the same time providing an aesthetic upgrade of the accommodation.

Research has show that the use of vegetation on and around buildings can improve thermal comfort, mitigate the Urban Heat Island Effect (UHI), reduce operational energy needs in buildings, increase the liveability of the built environment (Energy Sector Management Assistance Program/ ESMAP 2020a), as well as improve air quality and rainwater management (Alexandri and Jones 2008).

2.2.4.1 Area of application

A green façade can be applied in all types of vertical walls.

Roof insulation (green roofs) can be applied to all roofs that meet the following basic parameters:

- The load structure must be able to withstand the additional load of the garden.
- The building structure should be protected from the penetration of plant roots.
- The plants selected should be able to grow in the special conditions prevailing on the roofs.
- The way of irrigation and drainage of excess water and rainwater must be ensured.
- The surface must be protected from wind.

8 https://www.urbangreenbluegrids.com/measures/green-facades/

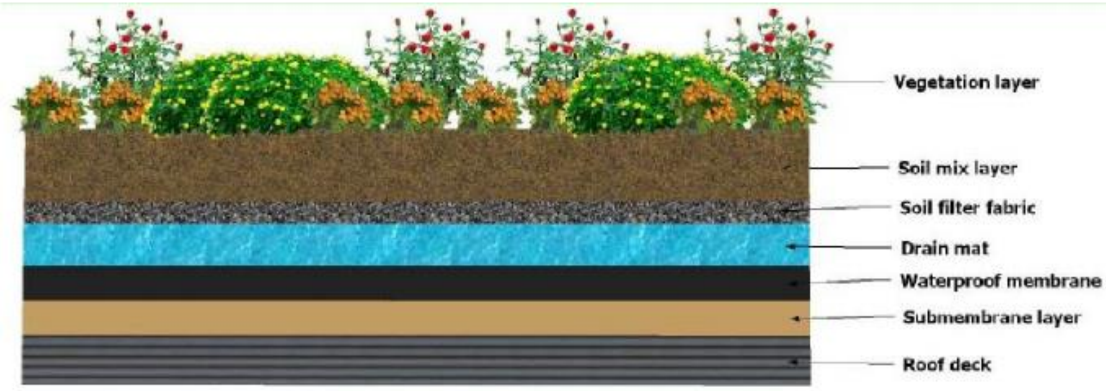

Figure 3:Typical cross section through a green roof [9]

Situation before: *Most of the hotel terraces are made of concrete without any vegetation.*

Situation after implementation: *Green roofs and green façades increase energy efficiency and aesthetics. They can also improve local biodiversity and the building/green areas ratio.*

2.2.4.2. Assessment of Measure 5 - Green façade and green roof

LOW TO MEDIUM **investment**	Investment according to application design and size of the vertical façade.
HIGH **Energy & GHG savings**	The creation of a "green roof" not only increases the Energy Efficiency of the building, but has also many benefits for its inhabitants and the environment, too[10]. • Extends the life of the building's waterproofing up to 40 years, because it protects it from exposure to extreme temperature differences. • Enhances thermal insulation, (saves up to 2 litters of heating oil/m^2, thus reducing GHG emissions by 5 kgCO2eq/m^2) – energy reduction can reach up to 50% in the summer period in warm climates (25% for heating and 75% for cooling). • Reduces the abrupt flow of rainwater. The result is that 10-50% of the water, instead of ending up in the sewers, returns to its natural cycle. • Filters and improves the city air. It retains suspended particles and dust and makes the microclimate in cities healthier. • Absorbs, instead of reflecting, noise and solar radiation, mitigating the phenomenon of "urban heat island". • Offers recreation area for the residents of the building. • Recyclable and recycled materials can be used for its construction. When considering installing a "green roof", you should consult with your building engineers, before you go ahead with the instalment. • Sound reduction provided by the protective layers of the planted roof

[9] Source of picture: 2013, **Nastaran Shishegar,** University of Wisconsin–Madison, Green roofs: Enhancing energy and enviromental performance of buildings, https://www.researchgate.net/publication/271206483_GREEN_ROOFS_ENHANCING_ENERGY_AND_ENVIRONMENTAL_PERFORMANCE_OF_BUILDINGS

[10] Source : Hotels4Climate, training material

	• Positive psychological impact due to users' feeling of relaxation.Development of microcultivation within the urban fabric, reducing the consumer environmental footprint and the users' sense of self-sufficiency in food resources.
Payback Time	The payback time is estimated between 6-8 years.[11]

2.2.5 Measure 6 - Heat rejection films

The installation of sunscreens/films on the windows, are usually recommended for those with south, east and west orientation. These films prevent excessive sunlight to enter the building and consequently, the indoor temperature is not increased. It should also be taken into account that these films can likewise reduce light levels.

Window films are available in a large scale of patterns and grades, each with a different level of performance.

2.2.5.1 Area of application

All windows that are exposed to excessive sunlight, especially in lobbies and restaurants with south, east, and west orientation.

Situation before: *This measure is not often used in many hotels and as result extra unnecessary heat penetrates through the windows creating an unpleasant indoor atmospheret.*

Situation after implementation: *This measure controls the heat gains from the sun that can be obtained through the windows and therefore the cooling needs are decreased.*

2.2.5.2 Assessment of Measure 6 - Heat rejection films

LOW **investment**	Depending on the size of the windows to be covered, but in general, this measure is considered to have a low investment cost.
MEDIUM **Energy & GHG savings**	Reduction of up to 60% solar energy coming through the windows – which can be very effective in rooms or areas having high solar gains.

[11] Source : https://www.gsa.gov/

Payback Time	The payback period of this investment is below 5 years.

2.3 HVAC Systems- appliances and refrigeration

If the central air conditioning unit is more than 12 years old, replacing it with an efficient certified model could reduce your cooling costs by 30%. HVAC systems are very important for hotels as energy for cooling, heating and ventilation could represent up to 50% of total energy consumption. Heat pumps, energy labelling of appliances (many hotels are using split units) as well as refrigeration will be presented in the following section.

2.3.1 Measure 7 - Heat pumps

Air-to-water heat pumps transfer the low temperature heat of the environment to high temperature heat for hot water application. The advantage of these systems is that the transfer needs less energy than the production of heat. So a heat pump can transfer 1 kWh of electricity into 4 kWh of heating energy. The efficiency of heat pumps is stated by the coefficient of performance (COP). The COP is the ratio of produced heat and consumed electricity. So a COP of 4 means that with 1 kWh of electricity 4 kWh of heating energy can be produced. The higher the COP the more efficient is the heat pump. Heat pumps can replace electrical heating rods. They can save up to 75% of electrical energy. If the water is heated by another fuel other than electricity the installation of a heat pump is usually not economically feasible.

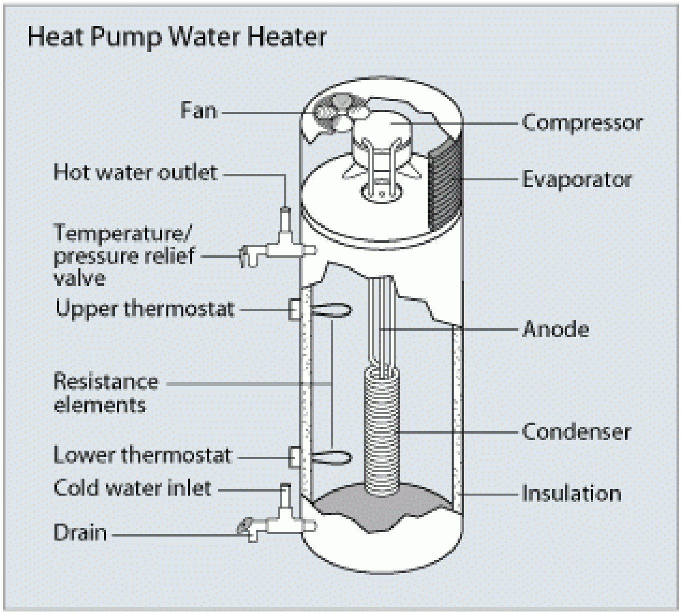

Figure 4: Heat pump water hear parts[12]

2.3.1.1 Area of application

Hot water production for various areas and facilities around the hotel.

Situation before: *Hotel uses diesel or liquefied petroleum gas (LPG) boilers for water heating.*

Situation after implementation: *Heat pump replaces the diesel burners with low efficiency.*

[12] Source of picture: https://www.energy.gov/energysaver/water-heating/heat-pump-water-heaters

2.3.1.2 Assessment of Measure 7 - Heat pumps

MEDIUM investment	Depending on the energy needs and the number of heat pumps the investment can be considered medium. The investment cost for the installation of a high energy efficiency AC split unit is about 600€/unit. For a heat pump, the investment cost is around 15.000 €/100kW (This cost only applies to the outdoor unit)
HIGH **Energy & GHG savings**	A heat pump is an efficient cooling and heating system. A heat pump absorbs heat energy from the outdoor air and transfers it to the indoor air. When in cooling mode a heat pump and an air conditioner are functionally identical, absorbing heat from the indoor air and releasing it through the outdoor unit. Therefore it is a very efficient solution, especially when replacing an oi-fired boiler. The energy saving for space heating that can be achieved by replacing an oil-fired boiler with a high energy efficiency heat pump can be up to 80%, while the cost savings can be up to 60%, depending on the fuel used.
Payback Time	The payback time depends on the efficiency of the heat pump and the technology that is replaced. Usually, the payback time is up to five years but this must be calculated by a proper techno-economic analysis from the hotel's technical team and energy professionals. Indicatively the payback period can range between 5-8 years.

2.3.2 Measure 8 - Energy labelling

Energy labels is considered to be as one of the most important tools, since it enables consumers to have a better understanding and compare the energy efficiency of appliances, leading them to more energy-sustainable and cost-effective markets.

Essentially, the energy label indicates that a product is graded on an A+++ to G scale depending on its energy consumption, with the A+++ class representing a product with a high energy efficiency rating. Today, there are 14 categories of products that have energy labelling, while most of them concern not only household appliances (refrigerators, washing machines, dryers, televisions, lamps) but also equipment such as solid fuel boilers, water heaters, air conditioners, etc.

It is noted that the energy label is mandatory for all products sold in the European Union (EU), for which an energy labelling requirement (Regulation (EU) 2017/1369) applies. Energy labels must be placed in a visible place at sale points, even in distance selling markets.

Over the last few years there has been tremendous progress in terms of energy efficiency of products, resulting in more and more products being classified in the categories A +, A ++ and A +++. In this context, the EU has decided to upgrade the classification of the energy label, implementing a simpler and more consumer-friendly scale from A to G in 2021.

The new energy label will be applied from March 1, 2021 and will concern products such as dishwashers, washing machines, washer-dryers, refrigerators and electronic screens (TVs). From September 1, 2021, the new energy label will also be applied to light bulbs.

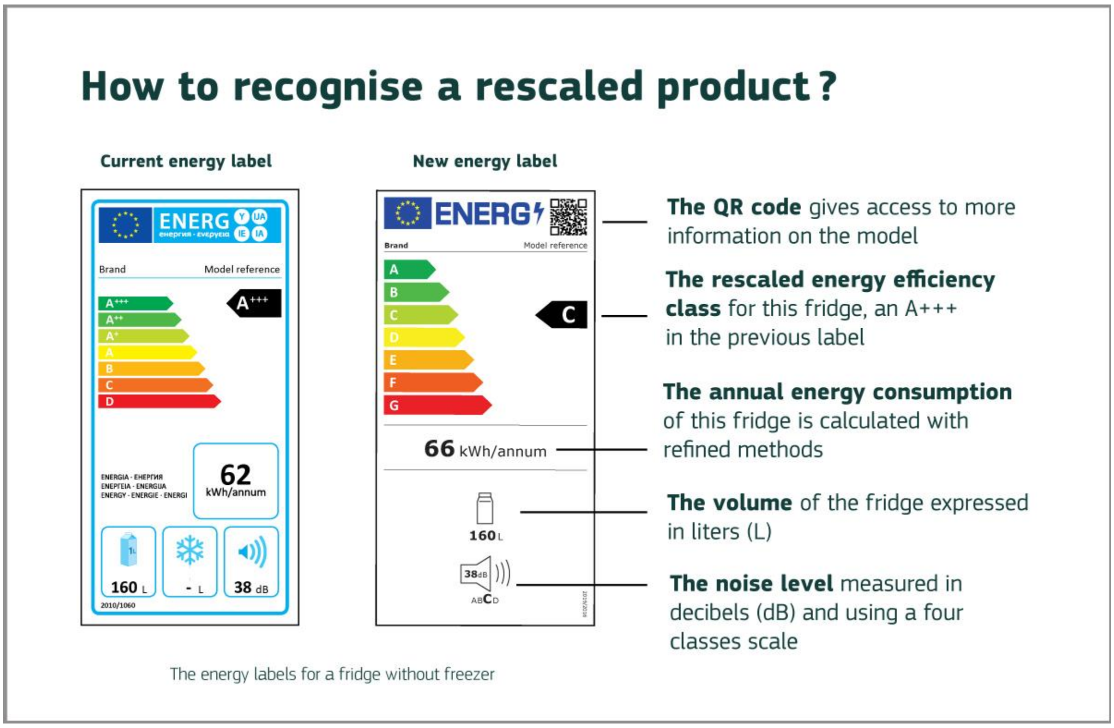

Figure 5: Comparison of current and new energy label[13]

- The new labels will contain a simpler scale (A to G) and it will be easier to compare the energy efficiency among different products.
- The EU energy label is language neutral, essential as there are 24 official languages within the EU internal market.
- By scanning a Quick Response (QR) code on the upper right corner, consumers will have access to more detailed product information on the European Product Registry for Energy Labelling, called EPREL. This database will be accessible to the public at the end of 2020. The EPREL database will help national market surveillance authorities to verify that the products comply with requirements on energy efficiency and that the information on the label is correct.[14]
- The new labels can also feature icons that show information like product capacity or dimensions, noise level or water consumption, providing at a glance useful information to the consumers.

2.3.2.1 Area of application

Situation before: *Usually hotels are buying various appliances based on cost.*

Situation after implementation: *Hotels should check the energy label of the product before proceeding with its purchase. Purchasing more energy efficient products contributes significantly to energy savings and consequently to reducing energy bills.*

[13] Source: https://ec.europa.eu/info/news/focus-new-generation-eu-energy-labels-2020-aug-13_en

[14] Source : https://ec.europa.eu/info/news/focus-new-generation-eu-energy-labels-2020-aug-13_en

2.3.2.2 Assessment of Measure 8 - Energy labelling

LOW TO MEDIUM **investment**	The cost varies depending on the number of appliances that are replaced.
HIGH **Energy & GHG savings**	By replacing low energy efficiency appliances with high energy efficiency ones, can lead to significant energy and GHG emission savings (e.g. The replacement of 100 TV units (B class) with A+++ TVs can reduce energy by 10.000 kWh per year if those are used on a typical operation.
Payback Time	By reading the energy label you can easily check and compare the energy consumption products. The payback period for purchasing higher energy-efficiency appliances is medium. For example, the replacement of minibars with low energy ones has a payback period of 10 years.

2.3.3 Measure 9 - Energy saving in refrigeration

Energy saving in refrigeration is critical for the hotel industry because represents an important part of the process equipment consumption. Ice machines, refrigeration, water coolers, walk in coolers and freezers, vending machines, mini bars are used in various locations. Energy consumption and the use of greenhouse gases are the main carbon contributors.

Energy consumption management

- Energy management for refrigerators should include the following sub measures
- Insulation improvements
- Defrost control
- High efficiency fans and compressor
- Lighting
- Central system technologies
- E-Cube temperature
- Interchanger to reduce purge water losses in ice machines

GHG emissions management

F-gas management is critical in order to control greenhouse gases (F-gases), including hydrofluorocarbons (HFCs). The EU has introduced the following strategy[15]:

- **Limiting the total amount** of the most important F-gases that can be sold in the EU from 2015 onwards and with gradual steps reach to one-fifth of 2014 sales by 2030. This will be the driver force towards more climate-friendly technologies;
- **Banning the use** of F-gases in many new types of equipment where less harmful alternatives would be widely available, such as fridges in homes or supermarkets, air conditioning or foams and aerosols;

[15] Source: https://ec.europa.eu/clima/policies/f-gas/legislation_en

- **Preventing emissions** of F-gases from existing equipment by requiring regular inspections , proper servicing and gas replacement at the end of the equipment's life**.**

Hotels should manage the F-gases they aplly by trying to focus to the following five strategies

(i) Reducing the demand/use of appliances and consequently the production of refrigerants by decreasing leaks through better management practices.

(ii) Replacing refrigerants with friendly alternatives for all the new installations[16]. The alternatives include:

- Natural refrigerants such as Carbon dioxide (R-744), Ammonia (R-717), Propane (R-290) etc.
- HFCs with lower GWP (Global warming potential), such as R32
- Hydrofluoroolefins (HFOs)
- HFC-HFO blends.

Another alternative is ammonia. Ammonia (R717), a refrigerant commonly used in many types of refrigeration system and which is not an F-gas, is not considered to be an alternative in split air conditioning systems for toxicity reasons[17].

(iii) By increasing the cooling efficiency of appliances, the use of refrigerants is also reduced

Regarding energy efficiency, the principle used in this assessment is that a “suitable” alternative must ensure that the system using the alternative refrigerant can be at least as energy efficient as the conventional, F-gas based refrigerants on the market. Equipment with alternatives must also comply with the efficiency standards of the Eco-design Directive, ensuring that the positive climate impact of indirect emissions is also guaranteed.20 To give an example, R134a (HFC) and R513A (HFC mixture) are not considered to be suitable alternatives due to their low cooling capacity and a lack of efficiency for comfort cooling in appliances. Ecodesign requirements continue to improve as technologies are involving. In this way, Ecodesign requirements have an impact on the charge amount needed, with higher efficiencies typically needing more refrigerant. Since A3 refrigerants (see risk classification above) are more limited in potential refrigerant charge size than existing standards, their scope regarding energy efficiency improvements continues to be more limited unless existing obstacles can be effectively treated .

Safety aspects, especially in regards to handling and waste, should be also discussed.

(v) Ensuring recovery, reclaiming/recycling, and destruction of refrigerants at end of their life cycle.

2.3.3.1 Area of application

All the areas refrigerants can be used are used are kitchens, stores, rooms (mini bars), bars.

Situation before: *Hotels are using many refrigerants in various locations with high GHG equivalent.*

Situation after implementation: *By replacing refrigerants with low GHG alternatives a high reduction of CO_2 emissions can be achieved. This way, energy efficiency can be additionally achieved.*

[16] Source https://ec.europa.eu/clima/policies/f-gas/alternatives_en

[17] Source : Report from the commission, the availability of refrigerants for new split air conditioning systems that can replace fluorinated greenhouse gases or result in a lower climate impact, COM 6637/30-9-2020 https://ec.europa.eu/clima/sites/clima/files/news/docs/c_2020_6637_en.pdf

2.3.3.2 Assessment of Measure 9 - Energy saving in refrigeration

MEDIUM to HIGH **investment**	Depending on the number of appliances that need to be replaced.
HIGH **Energy & GHG savings**	According to energy studies conducted by Hotels4Climate, the process equipment has a high percentage in the total energy consumption. The use of alternative F-gases in new equipment like R32 or R290 can reduce refrigerant GHG emissions significantly. For systems with a cooling capacity below 7 KW R-290 provides good energy efficiency and moderate price. For systems >7KW R32 is preferable. [18]
Payback Time	The payback period of this measure is mainly climate change related issue so there is no direct energy reduction.

2.3.4 Measure 10 – Heat recovery

Waste heat minimisation and energy recovery are two of the most effective ways to reduce energy costs and greenhouse gas emissions. Reducing heat loss not only decreases energy and maintenance costs, but can also minimise air pollutant emissions and improve the productivity of furnaces, ovens and boilers as well[19].

Heat recovery in central air conditioning units

The compressor in air conditioning units will process a large number of waste heat (produced by the condenser and the motor of the compressor) which is emitted into the atmosphere. Heat recovery technology can make use of the waste heat to get hot water, providing it to the hotel and have a better undersanding of the importance of heat wastage and its utilization or use.. Also, heat recovery technology, used in such as water-cooled units, can reduce the thermal load of original condenser and increase the heat exchange efficiency. If applied to air-cooled units, you can achieve some water-based, and the units possess the characteristics of high efficient of water-cooled units. Both the water-cooled units and the air-cooled units can cut down the load, reduce the risk of failure and prolong their life spam after the reconstruction.

Drain Water Heat Recovery

Valuable energy in hotels is literally going down the drain with every shower taken. The process of temperature regulation is inefficient: The cold water comes directly from the mains as the hot water comes from a heating device. During the shower, the shower tap mixes a large volume of hot water with the cold water to reach the ideal water temperature for the user. A water heat recovery device installed under a shower tray or a bathtub can recover

[18] C(2020) 6637 final - The availability of refrigerants for new split air conditioning systems that can replace fluorinated greenhouse gases or result in a lower climate impact

[19] https://www.csemag.com/articles/using-energy-recovery-systems-to-increase-building-efficiency/

energy from the warm water heading down the drain. The heat is transferred to the cold water mains before arriving to the shower tap mixer. The cold water reaches the mixer tap that has already been preheated thus requiring less hot water to reach the ideal temperature.

Heat Pipe Technology

Hotel heating and air conditioning systems are a significant source of energy loss due to this process being enacted on a large scale and variable from room to room. Heat pipes are thermal transfer devices capable of transferring heat and energy several hundred times faster than conventional methods. By using this type of technology can recover up to 70% of the heat energy. There are many types of heat pipe devices, and they are all designed to be compact and require minimal intervention.

Steam Energy Recovery

Steam has played a major role in energy production since the industrial revolution, and nowdays energy recovery from steam produced in hotel kitchens is becoming more and more widespread in hotels and restaurants. Steam forming in the washing chamber flows into the steam recovery unit placed at the back of the dishwasher. A ventilator pushes it into contact with water pre-loaded in the machine and circulated through an auxiliary hydraulic pump. The water falls as rain, heated as it comes into contact with the steam below, managing to reach up to30% energy savings.

Energy recovery technology is attracting an increasing amount of investment and the global energy recovery devices market is estimated to witness a considerable growth for the forecast period 2015 to 2025. There is great opportunity for hotels to take advantage of the established and emerging technology as well , helping them meet their sustainable development goals and move closer to eradicating waste energy resulting from their operation.[20]

2.3.4.1 Area of application

Situation before:*Many hotels are not using heat recovery technologies, however there are some hotels that use heat recovery from the chiller, in order to produce hot water.*

Situation after implementation: *Heat recovery systems reinforce energy savings as energy is not lost.*

2.3.4.2 Assessment of Measure 10 - Heat recovery

MEDIUM **Investment**	The investment cost for the installation of a heat recovery system for DHW production is about 2.000 - 4.000 €/100kW.
HIGH **Energy & GHG savings**	In general, hotels that combine the main DHW heating system with heat recovery from the chiller, had significantly lower energy consumption per guest-night for DHW. Heat recovery technology recovers the waste heat discharged into the atmosphere during the operation of the chiller in cooling mode and as a result, "free" production of hot water is achieved. A typical heat recovery system can cover up to 20% of the hotel's needs for DHW.

[20] https://www.tourismdashboard.org/talking-point-four-ways-hotels-can-recover-and-re-use-waste-energy/

Payback time	The payback period for such investment is considered low, as it can be around 3-4 years.

2.4 Management / automation systems

Intelligent building automation can reduce the energy consumption of buildings by up to 30%. The hotel building could be provided with an energy monitoring system that is able to report the overall energy consumption of the building. An energy monitoring system can be installed in order to separately measure and report the energy consumption for heating, cooling, lighting,domestic hot water or for any other high energy-intensive area of a hotel.

A metering strategy is essential to ensure accurate measurement of a building's energy use. This is also important in buildings with supplies of heating, cooling and domestic hot water from a central source as the 2018 Energy Efficiency Directive[21] requires consumption data to be provided to energy consumers. It is important to ensure that the meters are installed properly, with due attention to calibration and placement, as well as to the way that the data will be obtained and analyzed by the technical team of the hotel.

2.4.1 Measure 11 – Building / energy management system (BMS/EMS)

Automation and control systems are very important for the energy management of a building. A building management system (BMS), otherwise known as a building automation system (BAS), is a computer-based system that controls and monitors the building's mechanical and electrical equipment. The primary function of this BMS is the control of the HVAC systems (Heating, ventilation, and air conditioning systems of a building). It is also used to monitor the pumps' operation and the water level of the water tanks. In general, a BMS provides technical staff real-time information on the building's energy use (temperature, operation hours, etc.) using networked sensors connected to the building utility meter. The user-friendly interface allows technical staff to analyze hotel energy data very easily without the need for significant training... It is important to mention that the EU legislation requires the following:

"Member States shall lay down the necessary requirements in order to ensure that, where technically and economically feasible, non-residential buildings with effective rated capacity for heating (Art.14)/air-conditioning (Art.15) systems or systems for combined space heating/airconditioning and ventilation of over 290kW being equipped with building automation and control systems by 2025." "The building automation and control systems shall be capable of: (a) continuously monitoring, logging, analysing and allowing for adjusting energy usage; (b) benchmarking the building's energy efficiency, detecting losses in efficiency of technical building systems, and informing the person responsible for the facilities or technical building management about opportunities for energy efficiency improvement; (c) allowing communication with connected technical building systems and other appliances inside the building, and being interoperable with technical building systems across different types of proprietary technologies, devices and manufacturers."[22]

2.4.1.1 Area of application

BMS can be installed in all building's mechanical and electrical equipment

Situation before: *Many hotels are not using monitoring systems like BMS. Data collection in the hotel sector in very difficult especially in smaller sized properties*

Situation after implementation: *Connected building management systems (BMS) will help hotels to reduce their energy bills and GHG by optimizing consumption across guest rooms, restaurants, and other areas. They can also offer to technical managers a set of very simple and useful control tools.*

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[21] Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency - https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2018.328.01.0210.01.ENG

[22] BACS compliance verification checklist, European Building Automation Controls Association https://www.eubac.org/cms/upload/downloads/BACS_COMPLIANCE_VERIFICATION_CHECKLIST_Combined_Draft.pdf

2.4.1.2 Assessment of Measure 11 - Building / energy management system (BMS/EMS)

MEDIUM **investment**	A BMS is considered a medium-size investment and it depends on the number of sensors and the complexity of controls. Therefore, the investment cost for the installation of a BMS can vary between 10.000€ - 40.000 €
HIGH **Energy & GHG savings**	Compared with multiple separate control systems, a BMS offers centralised control, greater flexibility, increased interaction and feedback. Replacing separate control systems with a BMS can provide a cost-effective energy saving opportunity, while delivering a range of other benefits such as diagnosis of possible system failures, customer satisfaction, etc. The US Department of Energy and other researchers have shown that a BMS can potentially deliver 17 to 30% energy cost savings compared to typical buildings without a BMS.
Payback time	Based on the high energy cost savings that can be achieved, the payback period for installing BMS is medium ranging between 5-8 years.

2.4.2 Measure 12 - KNX systems

A building automation system (BAS) is an intelligent system that uses both software and hardware to connect security, lighting, HVAC, and other systems on a single platform. This form of automation is imperative when it comes to providing with tools and information regarding the building's operational performance, as well as improving the comfort and safety of the occupants. KNX is an automation that handles lighting, shading, heating, ventilation and conditioning.

KNX is an open standard (see EN 50090, ISO/IEC 14543) for commercial and domestic building automation. KNX devices can handle lighting, blinds and shutters, HVAC, security systems, energy management, audio video, white goods, displays, remote control, etc. KNX evolved from three earlier standards; the European Home Systems Protocol (EHS), BatiBUS, and the European Installation Bus (EIB or Instabus). It can use twisted pair (in a tree, line or star topology), powerline, RF, or IP links . On this network, the devices form distributed applications and tight interaction is possible. This is implemented via interworking models with standardised data point types and objects, modelling logical device channels.[23]

KNX makes it possible to reduce your energy consumption used for light, shading, heating, ventilation and air conditioning at the same level of comfort. KNX meets the requirements of the top Energy Performance Class for building automation as per EN 15232. KNX is ideally suited to fulfilling the tightened energy consumption requirements for buildings allowing up to 50 % energy savings.

In all operational areas of the hotel, a system can be applied in various scenarios, as required in order to provide comfort and relaxation. For example, KNX is ideal for guest rooms as the system knows when the tenant is in the room. Some typical applications of KNX are the following areas:

- Lighting control applications
- Blind and solar control

[23] https://en.wikipedia.org/wiki/KNX_(standard)

- Window control / natural ventilation
- Field control of HVAC
- Lighting control applications
- Blind and solar control
- Window control / natural ventilation
- Field control of HVAC
- Underfloor heating control
- Metering and energy management
- Security applications
- Monitoring systems
- AV control and interfacing
- Smart home automation systems
- Touch screen control & visualisation packages
- IP connectivity & remote access systems
- Interfaces with many third party systems
- Many other forms of control & automation
- OpenTherm
- Smart metering

In terms of energy management, there are KNX devices covering many different elements of energy management. These include, but are not limited to:

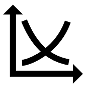
- Peak demand monitoring
- Current detection
- Network monitoring
- Load shedding
- Meters
- Energy pulse counting
- Data logging
- Visualisation
- Sensors and actuators
- Controllers and data processing

2.4.2.1 Area of application

Situation before: *Hotels do not often control lighting or other areas with smart systems in terms of energy control. Only a limited number of hotels are willing to install KNX systems for lighting scenarios and controls.*

Situation after implementation: *Hotels can control energy use more efficiently in various ways as regards lighting, temperature etc.*

2.4.2.2 Assessment of Measure 12 - KNX systems

MEDIUM  **investment**	The amount required for such investment can be characterized as medium and depends on the features installed. Usually, typical installations include lighting control and dimming.
MEDIUM  **Energy & GHG savings**	In terms of energy saving, lighting is considered to be an important energy-consuming sector within a hotel. Up to 10% of the total energy used within a typical hotel could be contributed to the lighting load. Therefore lighting control is critical and energy savings for lighting can reach up to 10%.
 **Payback time**	The KNX system can achieve significant energy savings in lighting consumption and therefore the payback period of this investment is considered to be medium from 5-10 years.

2.5 Lighting efficiency

Lighting is of great importance to hotels because it is directly linked with their design and style. When the use of lighting is efficient its contribution to total energy consumption is not more than 7% of the total energy in use.

2.5.1 Measure 13 - Improve lighting efficiency

Lighting is vital for hotels because it is directly linked with their design and style. Before the widespread use of LED (light-emitting diode) technology (about 10 years ago) energy consumption for lighting accounted for more than 25% of a hotel's total electricity consumption and up to 10% of the total expenditure for energy. At that time, most of the energy intensive uses, such as DHW (domestic hot water) and heating, were mostly based on other energy sources, such as fossil fuels. Today, lighting accounts for less than 10% of a hotel's total electricity consumption, although the use of electricity has increased its share in the total energy mix. The following measures can reduce the energy consumption for lighting between 10% to 80% depending on the percentage of LED lights already installed in your accommodation:

- Replace incandescent or halogen bulbs and T12 fluorescent tubes with newer type LED lamps and T5 tubes; savings in electricity consumption from lighting could reach 70%.
- Install lighting controls connected to high end centralized systems, such as BMS or KNX47.
- Install light, motion sensors and timers in appropriate locations.
- Install occupancy sensors or a master light switch in every guest room.
- Install a magnetic or key-card power switch in every room.

LEDs work like solar panels in reverse, converting electrons to photons instead of the other way around. They use 90 percent less energy than incandescent bulbs to perform the same amount of light, and half as much as compact fluorescents, without toxic mercury. More than that an LED bulb will last much longer than any other type.

Equally, LED technology can deliver many more lumens per watt than the other two, therefore it is far more energy efficient compared to them.

Types of lamps

Buying a light bulb today involves a lot more than just looking at watts:

- Brightness/Light output: Lumens measure the amount of light a lamp produces. The more lumens, the brighter the light. The first question to ask is whether the light is meant only to be used for reading or does it need to be bright enough to light up an entire room?
- Colour temperature: Do you prefer daylight colour or a yellowish light? For the latter, choose 2700K, or "warm white", lamps. For your office, choose a "cold white" lamp in excess of 4000K.

- Lifetime: The lifetime of a lamp is the number of hours it will operate before “burning out”. Lamps that are constantly on will fail sooner, and those that are rarely used will last longer. The longer the lamp’s life, the less often you will have to buy a new one

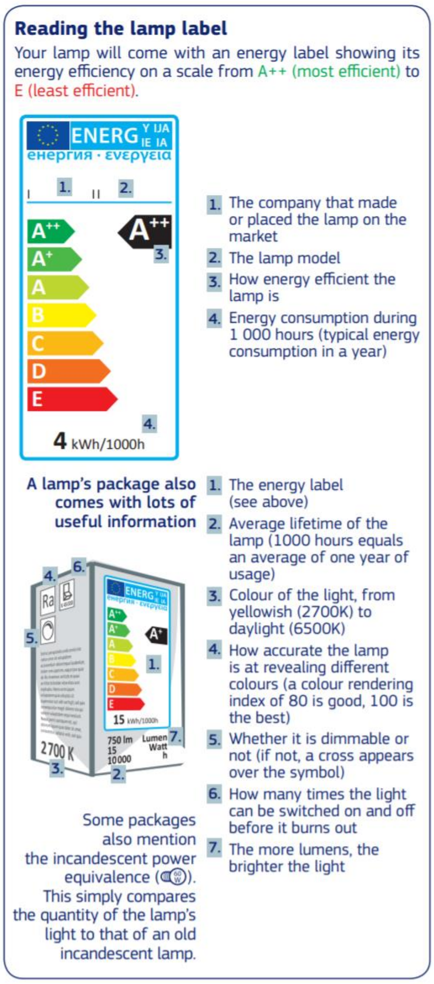


Figure 6: Reading the lamp label[24]

Daylighting

- Good lighting design includes consideration of daylighting, the admission of natural light.
- Window design can ensure high levels of daylighting, having the ability to control sunlight/natural light admission and of course less energy use.

2.5.1.1 Area of application

All hotel’s areas, especially areas where lighting is controlled by guests.

Situation before: *Before the spread of LED technology, almost all hotels used conventional lighting (halogen, incandescent) and as a result, energy consumption for lighting was reaching 15-20%*

[24] Figure source : EU – A consumer guide to energy efficiency lighting https://ec.europa.eu/info/sites/info/files/consumer_guide_to_energy_efficient_lighting.pdf

Situation after implementation: The replacement of the conventional lighting (halogen, Incandescent) with LED technology,*the energy consumption for lighting can be between 3%-5%.*

2.5.1.2 Assessment of Measure 13 - Improve lighting efficiency

MEDIUM **investment**	The investment required can be characterized as medium and depends on the number of lighting bulbs replaced. The predominant technology used nowadays is LED.
HIGH TO MEDIUM **Energy & GHG savings**	The energy and GHG emissions savings depend on the existing situation of a hotel. Old-style incandescent (including halogen) bulbs are highly inefficient, consuming most of the energy they use as wasted heat. When changing to LED, the savings in electricity consumption that can be achieved for lighting could reach 70%.
Payback time	The payback period for the installation of LED technology can be around 1 year.

2.6 Install Renewable Energy Sources (RES) on site

European Union aims to become he world’s first climate-neutral continent by 2050 and energy transition to Renewable energy sources will play a crucial role . The use of renewable energy has many potential benefits, including the reduction of greenhouse gas emissions, the diversification of energy supplies and the reduced dependance on fossil fuel markets (especially , oil and gas). The development of renewable energy sources may also stimulate employment in the EU, through the job creation onin new ‘green’ technologies.[25]

In 2019, renewable energy represented 19.7 % of energy consumed in the EU-27, only 0.3 % short of the 2020 target of 20 %.

- Renewable energy sources include the following
- Photovoltaics – Solar energy
- Wind turbines – Wind energy
- Hydro energy
- Tidal energy
- Geothermal energy
- Biomass energy

2.6.1 Measure 14 – Install Photovoltaics (PV) on site

PV is a mature, commercially available renewable energy technology. The arrays convert sunlight to electricity without producing air pollution or greenhouse gases (GHG). They require very little maintenance, make no noise, and can be mounted on various types of buildings and structures. PV direct current (DC) electric power can be conditioned into grid-quality alternating current (AC) electric power using an inverter, or be used to charge batteries. Most PV installations are grid-connected (net metering) and therefore, very few use batteries.

2.6.1.1 Area of application

The following installations are the ones recommended for the hotles to apply :

- Install PV systems to produce electrical energy on site; and
- Install autonomous PV systems connected to the swimming pool pumps. These pumps need to operate more intensively during daytime.

In order to successfully implement an on-site PV project, teams must make numerous decisions during the planning process. Each project is affected by a large number of factors, such as:

- Availability of useable roof space or ground space for PV arrays solar resource;
- Providing incentives for installing renewable energy facilities (net metering or grid prices); and
- Different policies, rules, and procedures that can be applied to any possible project location , regulations, land use restrictions etc.

In Cyprus, there are 3 available support schemes that can be exploited by the hotels which are the net-metering, net-billing and autonomous PV systems. The size of the PV system under the net-metering and net-billing scheme should not exceed 10 kW and 10 MW, respectively. Regarding the autonomous PV systems, there is no limit on their installed capacity. Although these schemes can be very beneficial for the hotels, they cannot be used on the desired extent mainly due to roof space limitation that prohibit the installation of large PV systems.

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[25] https://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics

Situation before: *Hotels do not invest in RES on site due to various limitations such as space.*

Situation after implementation: *Installing RES on site, such as PV, is a great measure to reduce GHG emissions and energy costs.*

2.6.1.2 Assessment of Measure 14 - Install Photovoltaics (PV) on site

HIGH **investment**	The investment required can be characterized as high. However, the cost of PV panels has been reduced and various incentives provided by the government, improve the profitability and Return of Investment (ROI) of the project. The typical cost for a PV system is 1.300 €/kW.
HIGH **Energy & GHG savings**	The energy saving potential is high. The energy production per kW of installed PV system is about 1.600 kWh/kW. The GHG emission saving potential is also very high as electricity production by RES has no emissions.
Payback time	Depending on the electricity cost the payback time is usually 5-6 years when PV is applied under the net-metering and net-billing schemes. The IRR is around 16%.

2.6.2 Measure 15 – Install solar water heaters and solar thermal systems

Domestic Hot Water (DHW) production has a large percentage on the total energy consumption of a hotel, accounting for about 20%.. Hot water is necessary in various applications in a hotel such as showers, laundry, washing machines and dishwhashers, spa etc.The production of hot water requires a large amount of energy.. However, through the proper design and implementation of available technological solutions and systems, almost zero energy consumption for DWH production can be achieved. Solar water heater is among the most efficient way to covert solar energy to thermal energy.

The solar water heater is an energetic solar thermal hot water system. It is widely used in countries with high rates of sunshine, for example in the Mediterranean countries and, of course, in Cyprus and Greece pioneering in solar water heaters since the 1970s. The solar water heater is the simplest and best known solar appliance.

Solar water heating systems include storage tanks and solar collectors. There are two types of solar water heating systems: the active, which has circulating pumps and controls; and the passive, which does not.[26]

Most solar water heaters require a well-insulated storage tank. Solar storage tanks have an additional outlet and inlet connected to and from the collector. In two-tank systems, the solar water heater preheats water before it enters the conventional water heater. In one-tank systems, the back-up heater is combined with the solar storage in one tank.

[26] https://www.energy.gov/energysaver/heat-and-cool/water-heating

Three types of solar collectors are used for such applications:

- **Flat-plate collector**: Glazed flat-plate collectors are insulated, weatherproofed boxes that contain a dark absorber plate under one or more glass or plastic (polymer) covers. Unglazed flat-plate collectors – are typically used for solar pool heating -- have a dark absorber plate, made of metal or polymer, without a cover or enclosure.
- **Integral collector-storage systems**: Also known as ICS or batch processing systems, they dispose one or more black tanks or tubes in an insulated, glazed box. First, cold water passes through the solar collector, which preheats the water. The water then continues on to the conventional backup water heater, providing a reliable source of hot water. They should only be installed in mild-freeze climates because the outdoor pipes could freeze at extremely low temperatures.
- **Evacuated-tube solar collectors**: They feature parallel rows of transparent glass tubes. Each tube contains an outer glass tube and metal absorber tube attached to a fin. The fin's coating absorbs solar energy but inhibits radiative heat loss.

2.6.2.1 Area of application

Solar thermal systems are installed on the hotel's roof for the production of hot water, supporting the existing heating system. Solar thermal systems can cover a large part of the hotel's need for hot water..

Situation before: *Many hotels have already been using flat-plate solar collectors for the production of hot water.*These systems are installed on the roof of the hotel to support the oil-fired boiler, which is usually the main heating system.

Situation after implementation: *For hotels not using solar heaters this should be the first energy investment to be implemented due to high ROI, energy and carbon savings.*

2.6.2.2 Assessment of Measure 15 - Install solar water heaters and solar thermal systems

MEDIUM **investment**	A techno-economic analysis can support the decision on the number and the size of solar thermal collectors that need to be installed. Based on the available roof space, a typical hotel normally installs around 80 (appr 160 m^2 solar thermal collectors). The investment cost for the installation of solar collectors only, can be around 250 €/collector or 125 €/m^2. In the case of installation of pipelines, hot water storage tank and circulation pumps, the investment cost can reach up to 400 €/collector.
HIGH **Energy & GHG savings**	Hotels that combine the main DHW heating system with solar thermal panels have significantly lower energy consumption per guest-night for DHW. The energy saving for DHW production that can be achieved is between 30-40%.
Payback time	In Cyprus and Greece, due to the high solar irradiation and solar potential, solar collectors can be very efficient, with their payback period estimated at 3 to 5 years. Solar thermal collectors have a lifespan of around 25 years.

2.7 Other measures

2.7.1 Measure 16 - Voltage optimization system

Voltage optimization is a transformer-based technology that stabilizes and optimizes the incoming current grid voltage to return. This technology is crucial in islands or areas where the electricity is not stable. The basic principle of this technology is, supplying an optimized voltage level more suitable to the actual electrical device in order for it to perform its task more efficiently and in accordance with limits of European harmonized voltage while basic design is a low loss series connected transformer designed to optimize a whole site or individual loads to target the most optimized loads (overvoltage).

2.7.1.1 Area of application

The voltage optimization can be installed to the electricity system of the hotel.

Situation before: *In many areas the normal electrical current waveform is not stable due to harmonics,leading to high energy demands and costs. Mainly large scale properties have installed Voltage optimization systems. Especially in areas where the electric grid the problem unstable electricity is critical.*

Situation after implementation: *The system will stabilize electricity harmonics and reduce energy costs. For hotels the cost should be >0.97.*

2.7.1.2 Assessment of Measure 16 - Voltage optimization system

MEDIUM **investment**	Medium size investment, ranging between 100-130 €/Kva.
HIGH **Energy & GHG savings**	Voltage optimisation aims to reduce the voltage received by electrical equipment to improve operating efficiency as well as reduce energy costs and power demand. It can improve power quality by filtering harmonic and transient voltages as well as balancing phase voltages. This has a great energy and emission saving potential as kWh consumption is controlled and reduced. The savings depend on the load dynamics. Significant reductions in CO_2 emissions can be achieved as consumption is normally directly associated with kW/h consumption. Other indirect savings potentials are the reduced maintenance costs and less damages to equipment. This investment can reduce the electricity consumption approximately by 8-10%
Payback time	The payback period ranges between 4-6 years.

2.7.2 Measure 17 Soft mobility - E-mobility (E-bikes, E-cars)

Nowadays, soft mobility is considered to be the third most frequently used mode of transport for everyday uses. It includes all modes of transportation such as cycling, walking, roller-skating etc. that can be achieved by using your own steam . Soft mobility can be described as an environmentally-friendly mode of transportation, including the electromobility, like electric cars/bikes. Soft mobility is on the rise and presents multiple benefits with the most important being the improvement of physical health and the reduction of GHG emissions.

2.7.2.1 Area of application

Promote soft mobility to hotel's guests and personel

Situation before: *Soft mobility is not promoted by hotels*

Situation after implementation: *Soft mobility measures will allow guest to explore the destination.* Soft mobility is on the rise, especially in downtown areas, and has numerous advantages: it saves time, often money, and obviously reduces overall environmental impact.

2.7.2.2 Assessment of Measure 17 - Soft mobility - E-mobility (E-bikes, E-cars)

MEDIUM **investment**	Medium size investment depending on the number of bikes.
LOW **Energy & GHG savings**	High energy and carbon saving as e-bikes can replace conventional means of transportation.
Payback time	The payback time for e-mobility is very low.

2.7.3 Measure 18 - Water saving devices

When water is heated, energy is lost at a higher rate than when water runs at high flows. Therefore water saving devices can play a significant role on water and energy reduction in hotels. Those devices can be easily installed at low cost. The list below present the water devices that are widely available in the market.

- Low flow showers
- Shower timers
- Shower flow restrictors
- Low flow toilets
- Dual flush converters
- Tank bags
- Faucet aerators
- Motion sensor faucets
- Rainwater tanks
- Greywater diverters

- Rainfall shutoff devices (for outdoor irrigation)
- Soaker hoses (for outdoor irrigation).

2.7.3.1 Area of application

Rooms, kitchens, washrooms, back of house.

Situation before: *Water flow is not controlled in many hotels.*

Situation after implementation: *The requirements of various standards (such as Travelife, Green Key etc) are as follows: The water flow in basins must be no more than 5 litres per minute. – The water flow in showers must be no more than 10 litres per minute. – Toilets must not use more than 6.5 litres per flush. – Urinals must not use more than 2 litres per flush.*

2.7.3.2 Assessment of Measure 18 - Water saving devices

LOW **investment**	Aerator cost 1€-5€ per device, the cost depends on how many devices should be installed in the hotel.
HIGH **Energy & GHG savings**	Using water and especially hot water consumes energy. The installation of water devices can have high energy and GHG savings. The following example support this investment: By installing shower flow controllers in a “typical” 100-room hotel to reduce the maximum output of its guestroom showerheads from 15 L/min to 10 L/min could: reduce the hotel’s water consumption by 2,700 m^3 /year and up tp 9,800 kg of CO_2/year. [27]
Payback time	The payback period is less than a year.

2.7.4 Measure 19 - Energy sensors, occupied sensors and timers

Occupancy and vacancy sensors are devices that detect when a space is unoccupied and therefore automatically turn OFF (or dim) the lights, thus saving energy. The device may also turn the lights ON automatically upon detecting the presence of people, providing convenience and a potential security aid. [28]

Timers allow pre-based schedules for lighting on various machines . Manuals and automatic timers are also available on the market .

[27] Travelife calculation

[28] Source : https://www.lightsearch.com/resources/lightguides/sensors.html

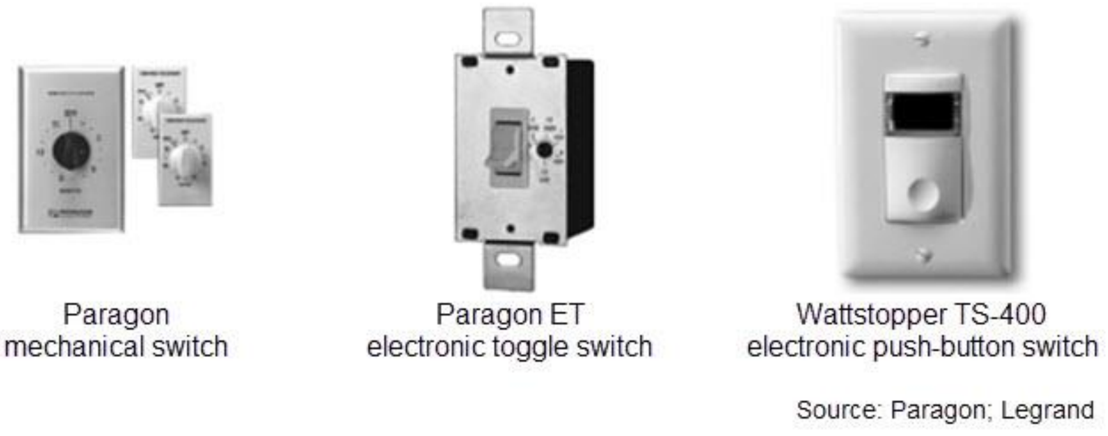

Figure 7: Three types of timer switches[29]

2.7.4.1 Area of application

Rooms, washrooms, back of house areas.

Situation before: *Many hotels do not use occupied dimining sensor in order to control energy use*

Situation after implementation: *Occupied sensors will allow hotels to better control the way guests use energy by automatically shutting off light and adjusting temperatures of rooms.*

2.7.4.2 Assessment of Measure 19 - Energy sensors, occupied sensors and timers

HIGH **investment**	Sensor costs are low and can be easily be installed.
LOW **Energy & GHG savings**	High return on Investment. According to the Lawrence Berkeley National Laboratory, occupancy-based strategies can produce average lighting energy savings of 24%.[30]
Payback time	The payback time is considered very low as sensors can achieve high energy savings (0.4-2 years)

29 Source :Legrand

30 Source : https://ouc.bizenergyadvisor.com/article/lighting-controls

2.7.5 Measure 20 - Smart metering

Smart metering data is starting to become available to final consumers in many markets. Smart meters will allow users to receive real time data and evaluate them as well as they can provide much more information when compared with traditional meters, allowing consumers to be well informed about their consumption. This feature makes decision-making simplier making it easy to reach a more efficient consumption.

While smart meters and, most importantly, the data generated by them *(load curves*) can act as facilitators to achieve higher levels of energy efficiency, developing an intelligence layer converting energy metering into easily understandable terms is of critical importance. Artificial Intelligence *(AI)* and Machine Learning *(ML)* techniques are already available and enable the creation of new highly tailored energy services.[31]

Greece is expecting to start installing smart meters by 2022. In Cyprus the project to install smart meters in all electricity meters is planned to be completed by 2027 according to Cypriot energy regulatory authority.

2.7.5.1 Area of application

Situation before: *Most of the hotels are not using smart metering or real time metering (new technology).*

Situation after implementation: *Smart meters accurately monitor what energy the hotel uses, when, and how whilst real time metering will* provide the hotel management with the necessary information in order to better comprehend how energy is being used.This will allow changes and improvements before the bills. As a result energy and costs can be saved.

2.7.5.2 Assessment of Measure 20 - Smart metering

LOW **investment**	Depending on the number of meters required for the property.
MEDIUM **Energy & GHG savings**	Energy reductions can be achieved as real time monitoring can increase energy efficiency.
Payback time	The payback time is very quick, however this measure is consider as indirect.

[31] Source : https://watt-is.com/smarts-meters-as-enablers-of-energy-efficiency/

2.8 Departmental measures

2.8.1 Measure 21 – Departmental good practices

The following is a list of measures addressing to the various hotel operating departments that can be implemented by all hotel businesses at no cost and create significant environmental, energy and financial benefits.

Guest rooms

- Ensure that all electrical appliances are switched off when rooms are not in use
- Set specific temperature limits for rooms when guest arrives (i.e. 24º C)
- Set a towel and linen program and train effectively the housekeeping department
- Set guidelines to guests

Laundry

- Ensure to operate laundry and driers in full load
- Try to use laundry out of pick loads
- Install separate meter for laundry in order to evaluate consumptions and cost
- Ensure that laundry area is sufficiently naturally ventilated in order to reduce A/C requirements
- Try to wash in lower temperatures (post Covid) if this is possible
- When wash is finished make sure that the machines have been completely deactivated .

Restaurants / Bars

- Ensure switching off all machinery when bars and restaurants do not work .
- Ensure switching off lights, A/C and all unnecessary electrical appliances when bars and restaurants do not work .

Kitchen

- Ensure that temperatures in the refrigerators are set properly
- Ensure that all evaporator surfaces are free from ice (ice machines, fridges)
- Use the correct machinery depending on the amount of guests
- Use ultrasonic humidification rather than steam
- Train all kitchen employees
- Install a data logger system for monitoring and recording temperature (and humidity) levels on a 24/7 basis. A temperature logger is an electronic device capable of storing a large number of measurements from one or more sensor inputs at predetermined frequencies. Some systems can even transmit the measurements wirelessly to a central device, eliminating the need for costly wiring installations. Measurement data can be analysed later or in real-time. Such systems can work autonomously or be a part of an integrated Building Management System (BMS).
- Install an opening alarm on every freezer / fridge door. A door alarm device is basically a sensor, generating an audible signal every time the door of freezer or fridge stays open for more than a predefined period. It can be an autonomous system or be part of a BMS. Some systems are capable of sending an alarm message to a mobile device, such as a phone. This is extremely important, from both hygienic and energy wastage perspective, in case of a door is accidentally left open at the end of a working day.
- Install PVC strip curtains on every freezer / fridge door or other openings to highly air-conditioned areas, such as chemical or dry food stores. They reduce energy consumption by minimising thermal losses. They are low cost and easy to install.
- Prefer high-energy efficiency electric devices (B or higher) when replacing or upgrading kitchen or restaurant equipment; a higher initial price is often quickly offset by lower running costs

Conference rooms

- Ensure switching off lights, A/C and all unnecessary electrical appliances when conference rooms are closed .

- Set specific temperature levels such as 24oC

Gym and spa management

- Use facilities by appointment in order to reduce energy load when not in use. This also increases guest satisfaction.
- Install buttons and controls on various gym equipment, as well as on the Jacuzzi, in order to allow guests turning them on and off as they wish instead of having them on all-day long.
- Install occupancy sensors to avoid energy wastage from having lights, air conditioning and other equipment on when nobody is using these facilities.

Office and information technologies (IT)

- Look for high energy efficiency ratings when purchasing new IT equipment, such as printers, monitors, photocopiers, etc.
- Install occupancy sensors to avoid energy wastage from leaving lights, air conditioning and other equipment on after working hours.
- Use cloud for storage and work with cloud tools in order to reduce the need of hardware and servers.

Lobby and reception

Take advantage of natural light as much as possible and avoid having all interior lighting powered on during the day. In collaboration with the technical department a zoning system can be applied to all lights, thus it can be easily determined which lights should be kept on or off under any given conditions.

- Limit lighting to an acceptable (safety) minimum during the night shift.
- Promote the hotel’s environmental program to guests and make suggestions on how they can take part in their efforts to reduce energy consumption and GHG emissions. You can appoint a member of the staff as a "green" ambassador to communicate such issues to guests (you can also create a "green" team to further increase employee engagement).
- Set the temperature of the A/C (Air Conditioning) units in the server and telecommunication room at 26°C.
- When purchasing new IT equipment, investigate low energy alternatives (a higher cost price is often quickly offset by lower running costs).

Technical department

- Monitor, record and analyze energy consumption data; if possible install additional meters (for electricity, liquid or solid fuels and water) in appropriate locations in order to obtain information about the consumption patterns of specific equipment, a hotel area or use (e.g. a freezer, a pumping station or the air conditioning system). This is a valuable tool for assessing the efficiency of an equipment and the payback period of an upgrade before making any relevant suggestions to the hotel management.
- Check for high peaks in your instant demand for electric power that might affect your billing; try to reduce such peaks by not operating high intensity systems simultaneously, if possible.
- At least once every two years, perform an energy audit to map energy usage patterns and identify any significant changes in major users
- Monitor and regulate the operation of critical equipment, such as the HVAC system, the domestic hot water (DHW) boilers, the fire protection system, the swimming pool filtering system or the wastewater treatment facility, as per the manufacturer/installer’s guidelines. Such installations are very energy consuming too.
- If you have additional boilers only turn them on when the capacity of operating boiler(s) is insufficient. Turn these boilers mode off when not in use and overnight.
- Give solar thermal and heat recovery priority from the chiller.
- Respond to all reports of faulty or damaged equipment at the earliest possible time.

Preventative maintenance

- Perform all necessary preventative maintenance according to the level of technical expertise of the department's staff members (from just cleaning the filters of the HVAC system or repairing a pump, to adjusting the λ factor of a gas burner in order to improve combustion quality). A well-maintained system operates more smoothly and can save up to 10% of its annual operating costs. Its life expectancy is also increased.
- When more specialized skills are required, seek external support and request evidence that all manufacturer/installer's requirements have been fulfilled.
- Keep detailed and updated service logs for all equipment; this will provide the necessary information to better assess the overall running cost of each piece of equipment.
- Label control and power switches.
- Provide clear guidelines to staff from other departments on how to use certain equipment.
- Divide lighting into zones (where applicable); It will be easier to switch on only the lights needed at any given moment.
- Clean lighting covers regularly in order to maintain their luminosity.
- Install motion sensors to control lighting in areas with a low frequency of visitors (such as public restrooms or staff changing room)
- Install daylight sensors to control lighting in exterior areas.
- Install automatic timers to control lighting or other electrical equipment in areas with specific requirements (e.g. underwater swimming pool lights, ventilation fan in a storage).
- Check if all external doors and window frames close properly and make any necessary adjustments (at least twice per year in year-round hotels and before the opening in seasonal hotels).
- If centrally controlled, adjust the A/C's thermostats at a temperature of 20-22°C for the winter season and 24-26°C for the summer period.

2.8.1.1 Area of application

Various hotel areas

Situation before: *Many hotels are not investing in human attitudes and soft measures.*

Situation after implementation: *Well-trained employees when implementing specific measures can help the hotels to save energy and reduce GHG emissions.*

2.8.1.2 Assessment of Measure 21 - Departmental good practices

LOW **Investment**	Soft measures with low cost that can be applied from all hotels. It is crucial to have procedures in place for all departments related to energy management issues.
HIGH **Energy & GHG savings**	Soft measures and human attitudes may have significant effects on energy savings.
Payback time	The specific measures cannot be associated with depreciation investment logic and thus payback period cannot be accurately calculated.

2.9 Awareness raising and behavioral measures

2.9.1 Measure 22 - Employees training

Employees have to be aware of the progress the hotel management is making in relation to its energy reduction targets and sustainability efforts in general. Trainings can help employees to understand energy and GHG targets as well as their contribution to each department, as the results of the above can benefit not only the environmental but also the local community.

2.9.1.1 Area of application

All departments.

Situation before: *Many hotels are not investing in trainings specifically for energy efficiency.*

Situation after implementation*: Trained staff has a better insight and understanding of energy issues and can also create the appropriate conditions so as to reduce energy consumption.*

2.9.1.2 Assessment of Measure 22 - Employees training

LOW **Investment**	Training is a low cost investment
MEDIUM **Energy & GHG savings**	With the necessary skills -relevant to each organization and job description- to perform at their best and meet management's expectations. Thus, it is necessary to include a simple, concise narrative about the hotel's energy strategy and goals in the basic staff training. Thereafter, additional training sessions, focused on the specific role and position of each employee, can be offered.
Payback time	Staff training may bring significant energy savings, yet the exact financial illustration of this measure is not possible.

2.9.2 Measure 23 – Waste management

Almost every waste management step generates greenhouse gas (GHG) emissions, hence it is importand to design appropriate manamement methods and reduce the amount of waste disposed. In Europe, we currently use 16 tonnes of material per person per year, of which 6 tonnes become waste. EU aims to reduce the amount of waste produced, maximize recycling and re-use and phasing out landfilling.

Hotels have great opportunities on waste management especially through recycling. Hotels should efficiently train all their employees on recycling techniques and food waste management. A key principle is to move waste management up the 'waste hierarchy' (according to which, waste prevention is the most favourable option, followed by preparing for reuse, recycling and other methods of recovery, and waste disposal is least favourable) as well as to to follow the principles of a circular economy. The basic principles of a circular economy are to maintain the resource value in the economic cycle for as long as possible and also to prevent and reduce the negative impacts of the explotation of primary resources.

2.9.2.1 Area of application

Situation before: *In some cases hotels are not recycling effectively.*

Situation after implementation: *Effective recycling can benefit the environment and the hotel also.*

2.9.2.2 Assessment of Measure 23 - Waste management

LOW **investment**	The installation of recycling bins around a hotel is a cheap investment.
LOW **Energy & GHG savings**	- Reuse and Recycle Cardboard Boxes: Save almost 4 tons of CO_2 for every ton of corrugated cardboard boxes kept from entering the landfill. - Recycle Plastic Film: Avoid the upstream energy necessary to produce one ton of new product saves about 2 tons of CO_2 annually. - Recycle Paper: The amount of energy and materials it takes to make a ton of office paper is reduced by 4.3 tons of CO_2 when recycling paper.[32]
Payback time	The waste management measure is directly associated with the reduction of carbon dioxide emissions and it is not possible to be illustrated with financial terms

2.9.3 Measure 24 - Beach cleaning and volunteering

Each hotel should undertake and promote voluntary environmental activities through various ways of raising awareness and engaging both guests and personnel.

A beach cleaing is an essential volunteer activity that helps to increase sustainability awareness, colloboration as well as team building. Team building and volunteering are critical for implementing sustainability actions such as energy and GHG emissions reductions.

In order to organize a beach cleanup the following steps should be followed

1. Choose a beach in need of a cleanup or the beach in front of the hotel
2. Set up a schedule and make an open invitation for employees and guests
3. Organize the beach cleaning and check the results.
4. Take pictures and post the results giving kudos to the team.

Cleaning a beach is essentially a volunteer activity among concerned citizens that takes place **on a regula basis** along **various** coastlines around the world. People pick up garbage off the beach in order to transform the seashore into a a nicer and safer place for everyone. Cleaning the beach also improves the coastal and ocean ecosystem by making sure that none of the trash kills the marine life or is too toxic to disrupt the marine life cycle.

[32] https://www.stopwaste.org/at-work/reduce-and-reuse/recycling-business-waste/recycling-and-climate-protection

2.9.3.1 Area of application

All departments. Guests, visitors and personnel can participate in this activity.

2.9.3.2 Assessment of Measure 24 - Beach cleaning and volunteering

LOW **investment**	Beach cleaning has a low or zero investment cost.
LOW **Energy & GHG savings**	Strenghthening environmental awareness of the hotels' staff and guests, their encouragement to participate in the environmental activities organized by the hotel as well as the adoption of daily habits contribute to the protection of the environment as well as reinforces the relationships between hotels' staff and guests. .It is necessary to include the hotel's energy and environmental strategy in the basic staff training. Thereafter, additional training sessions, focused on the specific role and position of each employee, can be offered.
Payback time	Coastal cleaning activities are connected with the employee awareness and cannot be depicted with financial terms.

3. Conclusions

Among the measures presented, provided that a hotel has not yet proceeded to replace the light bulbs with LED, it should directly proceed to this investment as it has the most immediate repayment period while simultaneously creating appropriate conditions for further investments as the results are directly visible to the owners. RES (Renewable energy systems) are also cost effective however there are restrictions related to space and aesthetics. What is more, something that must always be taken into account is seasonality since some investments have a higher payment rate. A Measure of great importance comprises the correct initial design of the hotel, including orientation, the enhancement of the night ventilation, the exploitation of thermal capacity etc.

During the operation of the hotels, the departments should operate following specific rules and procedures based on the efficient operation. Finally, actions intended to improve energy and environmental behavior can play an important role in creating a sustainable hotel.

The table on the next page summarizes the overall interventions described above.

Table 3: Summary table of measures

Measure	Investment	Energy & GHG savings	Payback Time
Measure 1 - Green design / retrofitting	The design phase is critical for decisions as they are related to the entire life cycle of the building. Minimum energy performance requirements, site specific design, high quality materials, and smart monitoring all require additional investments, however, they can reduce operating costs throughout the life cycle of the building.	This measure has both high energy and GHG emissions saving potential in the long term.	Green design or retrofitting is an especially important measure if the hotelier is the owner of the building as it can reduce operating costs, therefore payback period is within buildings life span. Usually payback period is between 6-25 years.
Measure 2 - Shading installation	Investment depends on the openings that should be sun protected and the technology used. For example, fixed outdoor shading can be a high-value investment and indoor shading with blinds and curtains can be a lower-value investment. Specifically, for a fixed outdoor shading the investment cost can be 120 €/m^2, while the cost for a movable outdoor shading can be around 220€/m^2. For indoor shading, such as roller blinds, the cost can be around 25 €/m^2.	The energy and GHG emission saving can be significant, especially in warm climates. Under normal operation, evaluating the effects of sun-shading shows that flexible shading has a greater impact than fixed shading. When combined with an economic analysis, the results can vary. For example, in high-rise residential buildings, the difference in energy saving rate between fixed and flexible shading is not considerably high (0.05%~1.35%), but the fixed shading is more cost effective than flexible shading. The effectiveness is also dependent on the type of building, the surrounding geography and location. For all types of buildings including hotels, whose load comes mainly from the occupant and equipment loads, the energy-saving effects of such technology may not be obvious. External shading should be considered by the architect during the design process so the form	The payback period for this measure can be considered moderate. For indoor shading installations such as curtains and rolling blinds, the payback period can be very low. For outdoor automatic shading which opens and closes based on sun irradiation, the payback period can be up to 10 years because of the expensi The payback period for this measure can be considered moderate. For indoor shading installations such as curtains and rolling blinds, the payback period can be very low. For outdoor automatic shading which opens and closes based on sun irradiation, the payback period can be up to 10 years because of the expensive technology.

Measure	Investment	Energy & GHG savings	Payback Time
		of the building can be combined with external shading in a way to achieve an ideal energy-saving result.	
Measure 3 - Energy efficiency frames and double-glazed windows	The required investment is usually high, depending on the number of window panes and frames that need to be replaced. For a typical double-glazed window with thermal break, the investment cost is approximately 220€/m², while for a typical double-glazed and low-e window with thermal break, the investment cost is approximately 240€/m². As regards a typical triple-glazed window with thermal break, the investment cost is approximately 300€/m².	The energy and GHG emission savings' potential can vary depending on the type and characteristics of the frame and glass. In fact, the actual energy savings from the replacement of a window with a double-glazed and aluminum frame with a thermal break can be up to 7%. Apart from energy savings, double-glazed windows offer sound insulation and reduction of thermal bridges. The upgrade from double-glazed windows to triple-glazed windows does not achieve significant energy savings. However, in this case, the investment cost will be considerably high.	The payback period is more than ten years, however, the installation of double-glazed windows is necessary in order to achieve thermal and sound insulation. The payback period seems long, mainly due to the high capital expenditure. However, in the long run, it can offer significant savings as the lifespan of the windows is similar to the lifespan of the building.
Measure 4 - Thermal insulation of the building envelope	The investment cost depends on the area (m²) of vertical and horizontal structural elements of the building where thermal insulation will be installed. It also depends on the type of thermal insulation materials that will be used. Approximately, the investment cost for the installation of roof and wall thermal insulation is 40€/m² and 55€/m², respectively.	The energy saving potential for heating and cooling can be up to 40% with the installation of roof thermal insulation and up to 5% with the installation of wall thermal insulation. The exact amount of savings depends on the type and width of the thermal insulation material, as well as the fuel used for heating and cooling inside the building.	The payback period for the installation of wall thermal insulation is more than ten years while the payback period for the installation of roof thermal insulation is around 3-4 years. This difference is attributed to the higher investment cost and the lower energy saving potential of the wall thermal insulation. The installation of roof thermal insulation is more important than the wall thermal insulation because heat losses are much higher from the roof compared to the walls.

Measure	Investment	Energy & GHG savings	Payback Time
Measure 5 - Green façade and green roof	Investment according to application design and size of the vertical façade.	The creation of a "green roof" not only increases the Energy Efficiency of the building, but has also many benefits for its inhabitants and the environment, too. • Extends the life of the building's waterproofing up to 40 years, because it protects it from exposure to extreme temperature differences. • Enhances thermal insulation, (saves up to 2 litters of heating oil/m^2, thus reducing GHG emissions by 5 kgCO2eq/m^2) – energy reduction can reach up to 50% in the summer period in warm climates (25% for heating and 75% for cooling). • Reduces the abrupt flow of rainwater. The result is that 10-50% of the water, instead of ending up in the sewers, returns to its natural cycle. • Filters and improves the city air. It retains suspended particles and dust and makes the microclimate in cities healthier. • Absorbs, instead of reflecting, noise and solar radiation, mitigating the phenomenon of "urban heat island". • Offers recreation area for the residents of the building. • Recyclable and recycled materials can be used for its construction. When considering installing a "green roof", you should consult	The payback time is estimated between 6-8 years

Measure	Investment	Energy & GHG savings	Payback Time
		with your building engineers, before you go ahead with the instalment. • Sound reduction provided by the protective layers of the planted roof • Positive psychological impact due to users' feeling of relaxation.Development of microcultivation within the urban fabric, reducing the consumer environmental footprint and the users' sense of self-sufficiency in food resources.	
Measure 6 - Heat rejection films	Depending on the size of the windows to be covered, but in general, this measure is considered to have a low investment cost.	Reduction of up to 60% solar energy coming through the windows – which can be very effective in rooms or areas having high solar gains.	The payback period of this investment is below 5 years.
Measure 7 - Heat pumps	Depending on the energy needs and the number of heat pumps the investment can be considered medium. The investment cost for the installation of a high energy efficiency AC split unit is about 600€/unit. For a heat pump, the investment cost is around 15.000 €/100kW (This cost only applies to the outdoor unit)	A heat pump is an efficient cooling and heating system. A heat pump absorbs heat energy from the outdoor air and transfers it to the indoor air. When in cooling mode a heat pump and an air conditioner are functionally identical, absorbing heat from the indoor air and releasing it through the outdoor unit. Therefore it is a very efficient solution, especially when replacing an oi-fired boiler. The energy saving for space heating that can be achieved by replacing an oil-fired boiler with a high energy efficiency heat pump can be up to 80%, while the cost savings can be up to 60%, depending on the fuel used.	The payback time depends on the efficiency of the heat pump and the technology that is replaced. Usually, the payback time is up to five years but this must be calculated by a proper techno-economic analysis from the hotel's technical team and energy professionals. Indicatively the payback period can range between 5-8 years.
Measure 8 - Energy	The cost varies depending on the number	By replacing low energy efficiency appliances	By reading the energy label you can

Measure	Investment	Energy & GHG savings	Payback Time
labelling	of appliances that are replaced.	with high energy efficiency ones, can lead to significant energy and GHG emission savings (e.g. The replacement of 100 TV units (B class) with A+++ TVs can reduce energy by 10.000 kWh per year if those are used on a typical operation.	easily check and compare the energy consumption products. The payback period for purchasing higher energy-efficiency appliances is medium. For example, the replacement of minibars with low energy ones has a payback period of 10 years
Measure 9 - Energy saving in refrigeration	Depending on the number of appliances that need to be replaced.	According to energy studies conducted by Hotels4Climate, the process equipment has a high percentage in the total energy consumption. The use of alternative F-gases in new equipment like R32 or R290 can reduce refrigerant GHG emissions significantly. For systems with a cooling capacity below 7 KW R-290 provides good energy efficiency and moderate price. For systems >7KW R32 is preferable.	The payback period of this measure is mainly climate change related issue so there is no direct energy reduction.
Measure 10 - Heat recovery	The investment cost for the installation of a heat recovery system for DHW production is about 2.000 - 4.000 €/100kW.	In general, hotels that combine the main DHW heating system with heat recovery from the chiller, had significantly lower energy consumption per guest-night for DHW. Heat recovery technology recovers the waste heat discharged into the atmosphere during the operation of the chiller in cooling mode and as a result, “free” production of hot water is achieved. A typical heat recovery system can cover up to 20% of the hotel’s needs for DHW.	The payback period for such investment is considered low, as it can be around 3-4 years.

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Measure 11 - Building / energy management system (BMS/EMS)	A BMS is considered a medium-size investment and it depends on the number of sensors and the complexity of controls. Therefore, the investment cost for the installation of a BMS can vary between 10.000€ - 40.000 €	Compared with multiple separate control systems, a BMS offers centralised control, greater flexibility, increased interaction and feedback. Replacing separate control systems with a BMS can provide a cost-effective energy saving opportunity, while delivering a range of other benefits such as diagnosis of possible system failures, customer satisfaction, etc. The US Department of Energy and other researchers have shown that a BMS can potentially deliver 17 to 30% energy cost savings compared to typical buildings without a BMS.	Based on the high energy cost savings that can be achieved, the payback period for installing BMS is medium ranging between 5-8 years.
Measure 12 - KNX systems	The amount required for such investment can be characterized as medium and depends on the features installed. Usually, typical installations include lighting control and dimming.	In terms of energy saving, lighting is considered to be an important energy-consuming sector within a hotel. Up to 10% of the total energy used within a typical hotel could be contributed to the lighting load. Therefore lighting control is critical and energy savings for lighting can reach up to 10%.	The KNX system can achieve significant energy savings in lighting consumption and therefore the payback period of this investment is considered to be medium from 5-10 years.
Measure 13 - Improve lighting efficiency	The investment required can be characterized as medium and depends on the number of lighting bulbs replaced. The predominant technology used nowadays is LED.	The energy and GHG emissions savings depend on the existing situation of a hotel. Old-style incandescent (including halogen) bulbs are highly inefficient, consuming most of the energy they use as wasted heat. When changing to LED, the savings in electricity consumption that can be achieved for lighting could reach 70%.	The payback period for the installation of LED technology can be around 1 year.
Measure 14 - Install Photovoltaics (PV)	The investment required can be characterized as high. However, the cost	The energy saving potential is high. The energy production per kW of installed PV	Depending on the electricity cost the payback time is usually 5-6 years when

Measure	Investment	Energy & GHG savings	Payback Time
on site	of PV panels has been reduced and various incentives provided by the government, improve the profitability and Return of Investment (ROI) of the project. The typical cost for a PV system is 1.300 €/kW.	system is about 1.600 kWh/kW. The GHG emission saving potential is also very high as electricity production by RES has no emissions.	PV is applied under the net-metering and net-billing schemes. The IRR is around 16%.
Measure 15 - Install solar water heaters and solar thermal systems	A techno-economic analysis can support the decision on the number and the size of solar thermal collectors that need to be installed. Based on the available roof space, a typical hotel normally installs around 80 (appr 160 m^2 solar thermal collectors). The investment cost for the installation of solar collectors only, can be around 250 €/collector or 125 €/m^2. In the case of installation of pipelines, hot water storage tank and circulation pumps, the investment cost can reach up to 400 €/collector.	Hotels that combine the main DHW heating system with solar thermal panels have significantly lower energy consumption per guest-night for DHW. The energy saving for DHW production that can be achieved is between 30-40%.	In Cyprus and Greece, due to the high solar irradiation and solar potential, solar collectors can be very efficient, with their payback period estimated at 2 to 5 years. Solar thermal collectors have a lifespan of around 25 years.
Measure 16 - Voltage optimization system	Medium size investment, ranging between 100-130 €/Kva.	Voltage optimisation aims to reduce the voltage received by electrical equipment to improve operating efficiency as well as reduce energy costs and power demand. It can improve power quality by filtering harmonic and transient voltages as well as balancing phase voltages. This has a great energy and emission saving potential as kWh consumption is controlled and reduced. The savings depend on the load dynamics. Significant reductions in CO_2 emissions can be achieved as consumption is normally directly associated	The payback period ranges between 4-6 years.

Measure	Investment	Energy & GHG savings	Payback Time
		with kW/h consumption. Other indirect savings potentials are the reduced maintenance costs and less damages to equipment. This investment can reduce the electricity consumption approximately by 8-10%	
Measure 17 - Soft mobility - E-mobility (E-bikes, E-cars)	Medium size investment depending on the number of bikes.	High energy and carbon saving as e-bikes can replace conventional means of transportation.	The payback time for e-mobility is very low.
Measure 18 - Water saving devices	Aerator cost 1€-5€ per device, the cost depends on how many devices should be installed in the hotel.	Using water and especially hot water consumes energy. The installation of water devices can have high energy and GHG savings. The following example support this investment: By installing shower flow controllers in a “typical” 100-room hotel to reduce the maximum output of its guestroom showerheads from 15 L/min to 10 L/min could: reduce the hotel’s water consumption by 2,700 m^3 /year and up tp 9,800 kg of CO_2/year.	The payback period is less than a year.
Measure 19 - Energy sensors, occupied sensors and timers	Sensor costs are low and can be easily be installed.	High return on Investment. According to the Lawrence Berkeley National Laboratory, occupancy-based strategies can produce average lighting energy savings of 24%.	The payback time is considered very low as sensors can achieve high energy savings (0.4-2 years)
Measure 20 - Smart metering	Depending on the number of meters required for the property	Energy reductions can be achieved as real time monitoring can increase energy efficiency.	The payback time is very quick, however this measure is consider as indirect.
Measure 21 - Departmental good	Soft measures with low cost that can be applied from all hotels. It is crucial to have	Soft measures and human attitudes may have significant effects on energy savings.	The specific measures cannot be associated with depreciation investment

Measure	Investment	Energy & GHG savings	Payback Time
practices	procedures in place for all departments related to energy management issues.		logic and thus payback period cannot be accurately calculated.
Measure 22 - Employees training	Training is a low cost investment	With the necessary skills -relevant to each organization and job description- to perform at their best and meet management's expectations. Thus, it is necessary to include a simple, concise narrative about the hotel's energy strategy and goals in the basic staff training. Thereafter, additional training sessions, focused on the specific role and position of each employee, can be offered.	Staff training may bring significant energy savings, yet the exact financial illustration of this measure is not possible.
Measure 23 - Waste management	The installation of recycling bins around a hotel is a cheap investment.	- Reuse and Recycle Cardboard Boxes: Save almost 4 tons of CO_2 for every ton of corrugated cardboard boxes kept from entering the landfill. - Recycle Plastic Film: Avoid the upstream energy necessary to produce one ton of new product saves about 2 tons of CO_2 annually. - Recycle Paper: The amount of energy and materials it takes to make a ton of office paper is reduced by 4.3 tons of CO_2 when recycling paper.	The waste management measure is directly associated with the reduction of carbon dioxide emissions and it is not possible to be illustrated with financial terms
Measure 24 - Beach cleaning and volunteering.	Beach cleaning has a low or zero investment cost.	Strenghthening environmental awareness of the hotels' staff and guests, their encouragement to participate in the environmental activities organized by the hotel as well as the adoption of daily habits contribute to the protection of the environment as well as reinforces the relationships between	Coastal cleaning activities are connected with the employee awareness and cannot be depicted with financial terms.

Measure	Investment	Energy & GHG savings	Payback Time
		hotels' staff and guests. .It is necessary to include the hotel's energy and environmental strategy in the basic staff training. Thereafter, additional training sessions, focused on the specific role and position of each employee, can be offered.	