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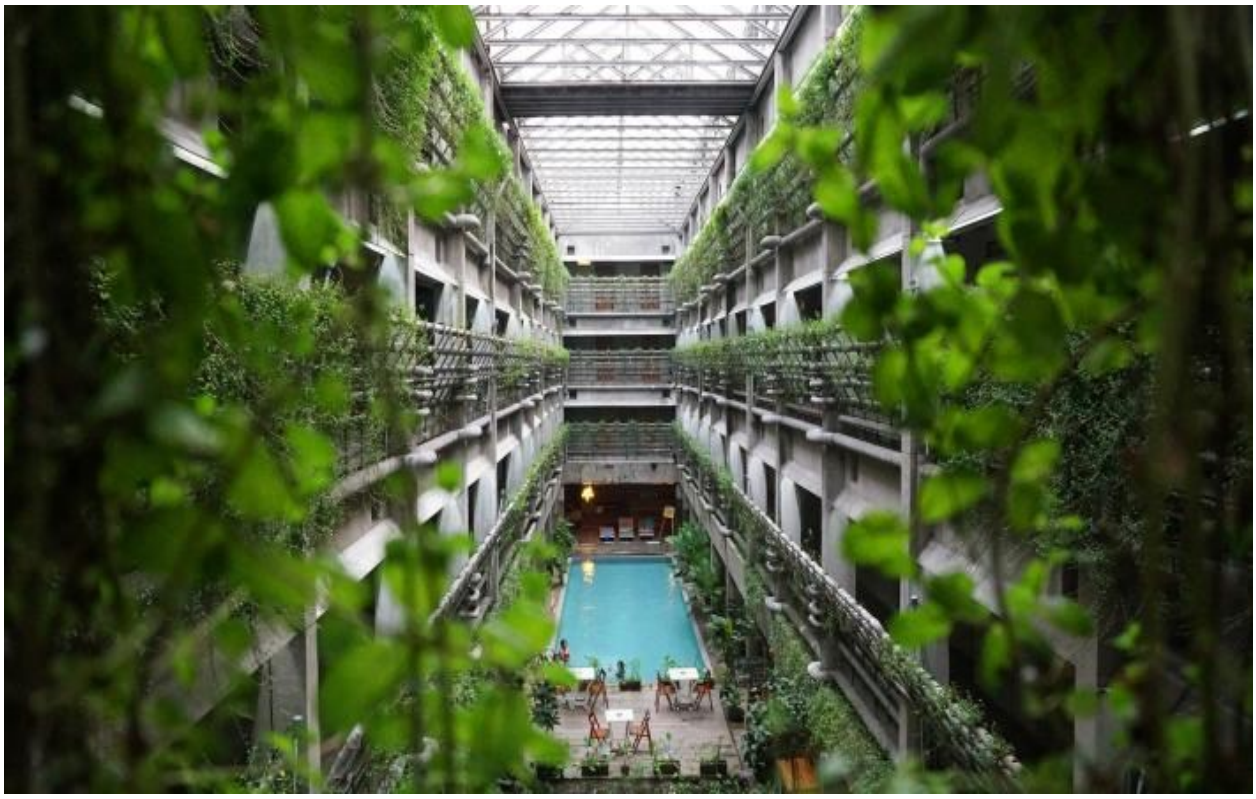
DEcarbonising the TOurism Industry Post Covid-19 Support



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Decarbonisation of European tourism entities: Sustainable energy use and policy implications

A Joint Thematic Guidebook

DEcarbonising the TOurism Industry Post Covid-19 Support (DETOCS)

Interreg Europe Programme

PROJECT ID: 01C0020

Task coordinator: Mediterranean Agronomic Institute of Chania (PP2)

Interreg Europe

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DETOCS

NOVEMBER 2025

SUMMARY

An overview of the adoption and application of sustainable energy technologies within the European tourism sector has been implemented in the framework of the Interreg Europe DETOCS (DEcarbonising the TOurism Industry Post Covid-19 Support) project. Recognising tourism as one of Europe's most energy-intensive economic activities, the report highlights the need to transition towards renewable energy sources and energy-efficient solutions to mitigate the sector's carbon footprint and align it with the European Green Deal and the 2030 Agenda for Sustainable Development. **The Joint Thematic Guidebook is a joint effort of all the organisations participating in the implementation of the Interreg Europe DETOCS project, with the task coordinated by MAICH (PP2).**

The guidebook identifies a variety of sustainable energy technologies currently in use across tourism entities besides the insulation of the building envelope and glazing. Among the most common are solar photovoltaic (PV) systems**,** solar thermalcollectors, heat pumps, LED lighting, and biomass heatingsystems**.** In the hospitality sector, these technologies are most typically applied to power lighting, heating, ventilation, air-conditioning, and water heating systems. The analysis also explores the integration of smart energy management systems (EMS), which optimise consumption patterns and enhance operational efficiency. Examples from various European destinations illustrate successful implementation and measurable reductions in energy consumption and greenhouse gas emissions.

Beyond technological solutions, the guidebook emphasises the importance of soft measures that complement technical innovations. These include energy monitoring, energy auditing, energy benchmarking, behavioural changes of tourists and employees, carbon offsetting, linking hotels with local food suppliers and the promotion of virtual tourism.The findings also address the challenges that tourism entities face in adopting sustainable energy technologies. These include high initial investment costs, regulatory complexity and seasonal variability in energy demand. By investing in these sustainable energy solutions, tourism enterprises not only lower their environmental impact but also strengthen their market position. Eco-conscious travellers increasingly prefer accommodations that

demonstrate environmental responsibility. Therefore, sustainable energy adoption enhances competitiveness, improves brand image, and contributes to long-term profitability.

Ultimately, the transition to renewable energy in tourism is not just a moral imperative but a strategic opportunity to align economic success with environmental stewardship. Overall, the present guidebookprovides evidence that sustainable energy technologies, when integrated with effective management practices and supported by enabling policies, can substantially reduce the tourism sector's dependence on fossil fuels. By fostering innovation, collaboration, and knowledge sharing among European tourism stakeholders, these technologies contribute to a more resilient, competitive, and environmentally responsible tourism industry.

Using Sustainable Energies in Tourism Enterprises

The tourism sector is one of the fastest-growing industries globally, yet it is also energy-intensive, contributing significantly to greenhouse gas emissions through accommodation, transportation, and recreational activities. As pressure mounts to decarbonise economies, tourism enterprises—such as hotels, resorts, tour operators, and tourist attractions—are increasingly exploring the adoption of sustainable energy sources. Assessing the technical, economic, and environmental feasibility of these energies is crucial to determine their potential for widespread integration in the sector.

Technical Feasibility

Advancements in renewable energy technologies have significantly enhanced their applicability to tourism enterprises. Solar photovoltaic (PV) panels, for example, are well-suited to resorts and hotels in sunny destinations, providing reliable electricity for lighting, cooling, and water heating. Similarly, small-scale wind turbines and micro-hydro systems can power remote lodges or eco-parks where grid access is limited. Energy storage systems, such as lithium-ion batteries, further improve reliability by addressing intermittency issues. Biomass and biogas technologies can also be deployed in rural or agricultural tourism enterprises, converting organic waste into usable energy. While these technologies are increasingly efficient and adaptable, technical challenges remain, including the need for skilled maintenance, system integration with existing infrastructure, and site-specific limitations such as terrain or weather patterns. Nevertheless, from a technical perspective, sustainable energy solutions are increasingly viable and scalable in diverse tourism settings.

Economic Feasibility

The economic case for sustainable energies in tourism enterprises is complex, balancing high upfront costs with long-term savings. Installing solar panels or geothermal systems requires significant initial investment, which can be a barrier for small- and medium-sized enterprises (SMEs) that dominate the tourism sector. However, declining costs of renewable technologies, combined with government incentives, subsidies, and financing mechanisms, are making adoption more accessible. Over time, operational savings from reduced fossil fuel consumption, lower electricity bills, and resilience against fluctuating energy prices enhance financial feasibility. Furthermore, adopting sustainable energy can provide a marketing advantage, as eco-conscious travellers increasingly favour businesses demonstrating environmental responsibility. For large resorts and global hotel chains, economies of scale can further improve cost-effectiveness, making the transition not only possible but strategically beneficial.

Environmental Feasibility

From an environmental standpoint, the adoption of sustainable energy in tourism enterprises is highly desirable. Renewable energy systems reduce carbon emissions, air pollution, and reliance on non-renewable resources, directly supporting global climate mitigation goals. They also minimise the ecological footprint of tourism, which is particularly important in environmentally sensitive destinations such as islands, coastal zones, and protected areas. For example, replacing diesel generators with solar or wind systems in island resorts reduces both emissions and risks of oil spills. Additionally, integrating renewables supports sustainable community development by reducing strain on local energy resources. While some renewable projects may have localised impacts—such as land use changes or visual intrusion from wind turbines—the environmental benefits far outweigh the drawbacks when projects are carefully planned. The technical, economic, and environmental feasibility of sustainable energies in tourism enterprises demonstrates strong potential for their broader adoption. Technological advancements are addressing reliability concerns, while falling costs and supportive policies are improving financial accessibility. Environmentally, the transition to sustainable energy aligns with the sector's responsibility to preserve the natural and cultural resources upon which tourism depends. Although challenges remain in terms of financing, training, and infrastructure adaptation, sustainable energies represent not just a feasible option, but a necessary pathway for the long-term viability and competitiveness of tourism enterprises.

CONTENTS

IDENTIFIED EXAMPLES IN THE PARTICIPATING REGIONS

1. HOTEL MURAT - SLOVENIA

Hotel Murat is a small-scale family-run hotel, built in 2007. The hotel offers 34 beds and a conference hall with a capacity of up to 60 people.

The hotel remains connected to the grid, yet using sustainable technologies including:

a) High-efficiency heat pump
b) LED lighting
c) Resource optimisation systems
d) Paper, cardboard, and packaging compactor
e) Building envelope insulation

The total investment in sustainable energy at Hotel Murat is estimated at 146,00 EUR of which 75% - 110,000 EUR- is covered by nonrepayable funds, while the remaining 25% (36,000 EUR) represents the hotel's own contribution. The annual savings from reduced grid electricity consumption are estimated at approximately 3,523 EUR. The payback period for the investment is around 10 years, with an expected lifetime of 15 years.

The estimated annual savings in grid electricity amount to 6,935 kWh, corresponding to an annual reduction of 2,774 kg of CO_2 emissions. The calculation is based on the latest emission factor for grid electricity, provided by the national electricity utility, which is 0.4 kg CO_2/kWh.

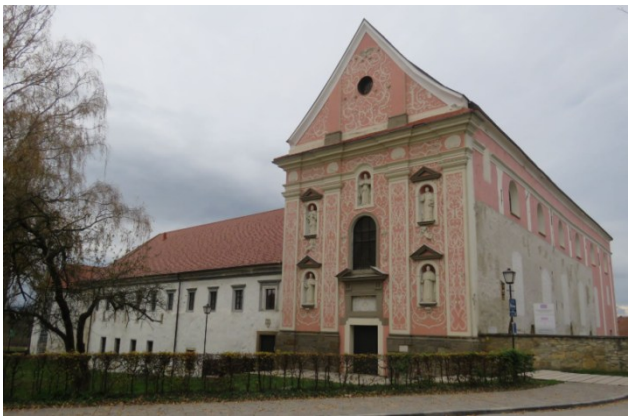
The hotel's energy renovation delivers a wide range of environmental benefits, including:

- a reduced carbon footprint,
- greater energy independence,
- a contribution to a cleaner environment, and
- improved guest comfort and quality of stay.

The transition from a fossil fuel–based heating system (natural gas) to a renewable energy solution (heat pump), combined with enhanced building efficiency, has significantly reduced CO_2 emissions, helping to mitigate climate change.

The technologies used in the renovation of Murat Hotel can be easily transferred to other tourism entities located in several EU territories.

2. DOMINICAN MONASTERY - SLOVENIA



The Dominican Monastery in Ptuj is a cultural jewel with a history spanning more than eight centuries. It was founded in 1230 by Matilda, the widow of Frederick III of Ptuj, and remained under the stewardship of the Dominicans until 1785. Today the monastery thrives as one of the city's most important cultural centres.

In recent years, the Dominican Monastery in Ptuj has introduced modern solutions that enable more efficient and sustainable energy management. The energy renovation of the monastery was subject to restrictions set by the Institute for the Protection of Cultural Heritage. In practice, this means that broader measures – such as insulating the building envelope or replacing historic windows and doors – could not be carried out. The energy solutions included:

a) High-efficiency heat pump

b) Resource consumption optimisation system

The total investment in sustainable energy is estimated at €233,000, of which 35%, or €81,000 is covered by non-repayable funds, while the remaining 65% or €152,000 represents the own contribution. Annual savings from reduced electricity consumption from the grid amount to approximately €10,000. The expected lifespan of the system is 25 years, which corresponds to the estimated payback period.

The estimated annual savings in grid electricity amount to 51,887 kWh, corresponding to an annual reduction of 20,755 kg of CO_2 emissions. The calculation is based on the latest emissions factor for grid electricity, provided by the national electricity utility, which is 0.4 kg CO_2/kWh.

The energy renovation in the Dominican Monastery in Ptuj indicatesthat even in heritage-protected buildings, modern energy solutions can be successfully implemented to reduce

costs, cut the carbon footprint and increase functionality, without compromising the building's historical value. Such energy solutions can be easily replicated in other cultural heritage buildings in EU territories.

3. MEDITERRANEAN DREAM HOTEL- GREECE

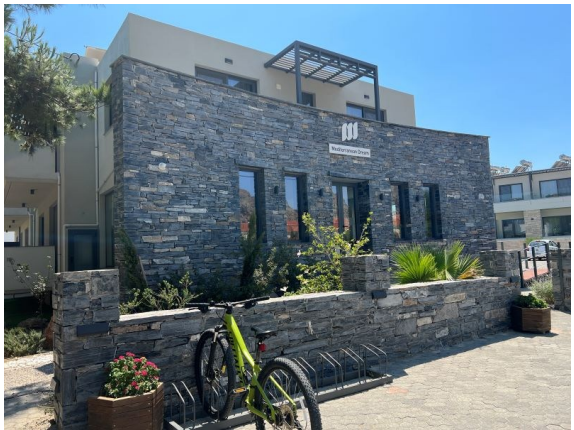
Mediterranean Dream Hotel is a small-scale boutique gem along Crete's southwest coast in the prefecture of Chania. The total covered area of the hotel is 660 m^2 while its green area is 150 m^2. It has a maximum capacityof 34 beds.

The sustainable energy technologies used in Mediterranean Dream Hotel include:

1. A solar thermal system installed on its roof terrace producing hot water,
2. A solar photovoltaic system installed on its roof terrace generating electricity,
3. Electric batteries storing excess electricity,
4. High efficiency heat pumps producing heat, cooling and hot water,
5. Insulation of the building envelope
6. LED lighting

The use of sustainable energy technologies in the hotel has several environmental benefits such as:

- Reduction of atmospheric carbon emissions,
- increased energy independence,
- increased energy security,
- contribution to a cleaner environment, and
- Improved air quality for guests.

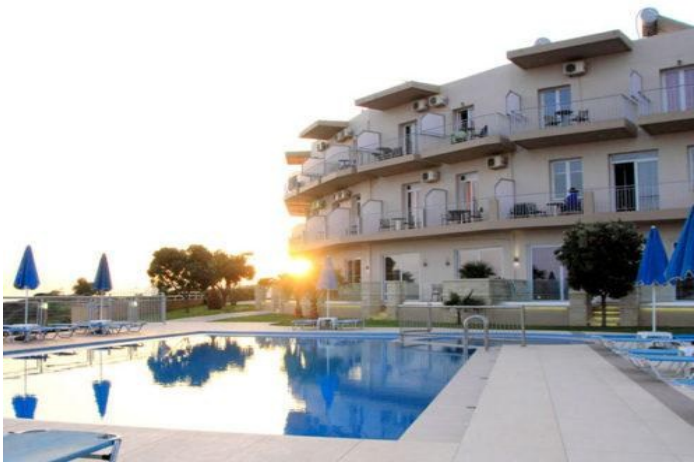


The total investments in renewable electricity generation systems are estimated at€15,450, while the total investments in renewable heat generation systems are estimated at €45,200. The annual benefit due to lower use of grid

electricity is estimated at €8,732/year. The payback period of the investment is estimated at 6.95 years.The estimated annual saving in grid electricity is 18,949 kWh_e/year while the annual decrease of CO_2 emissions due to grid-electricity saving is estimated at 7,655 $kgCO_2$/year.The operation of Mediterranean Dream Hotel in western Crete indicates that the elimination of carbon emissions in tourism entities located in the Mediterranean region is technically and economically achievable while the required energy technologies are mature, reliable and cost-efficient.The above-mentioned energy technologies can be easily replicated in other EU territories in southern Europe.

4. RENIERIS HOTEL - GREECE

Renieris hotel is a small-size family-owned hotel located in Stalos village, approximately 7 km west of the city of Chania. Its capacity is 52 beds, and its covered area is around 1,000 m^2.



At the heart of the hotel's sustainability strategy is its use of solar energy, a resource abundantly available in Crete's Mediterranean climate. The hotel uses solar thermal systems to provide hot water for guests' rooms and operational needs. This significantly reduces reliance on fossil fuels for water heating, a major source of carbon emissions in hospitality operations. In addition, photovoltaic panels are installed to generate electricity from the sun. This on-site solar electricity reduces the hotel's dependence on grid power and helps offset carbon emissions associated with conventional electricity generation. The sustainable energy technologies used in Renieris hotel include:

a) A solar thermal system installed on its roof terrace producing hot water,
b) A solar photovoltaic system installed on its roof terrace generating electricity,
c) Efficient LED bulbs for lighting,

d) The building's envelope is well insulated while it has glazed windows and doors,
e) A modern energy system is used to optimise the production and distribution of hot water.

The estimated annual saving in grid electricity is 23,750 kWh_{el}/year while the annual decrease of CO_2 emissions due to grid-electricity saving is estimated at 9,595 $kgCO_2$/year.

The total installation cost of the solar energy investments is estimated at €21,500 while the total annual economic benefit is estimated at€4,100 in savings. The payback period of the solar energy investments is estimated at 5.24 years.

The use of solar energy in Renieris hotel has significantly reduced CO_2 emissions, helping to mitigate climate change. The above-mentioned energy technologies can be easily replicated in other EU territories in southern Europe.

5. MILIA AGROTOURISM FACILITY – GREECE

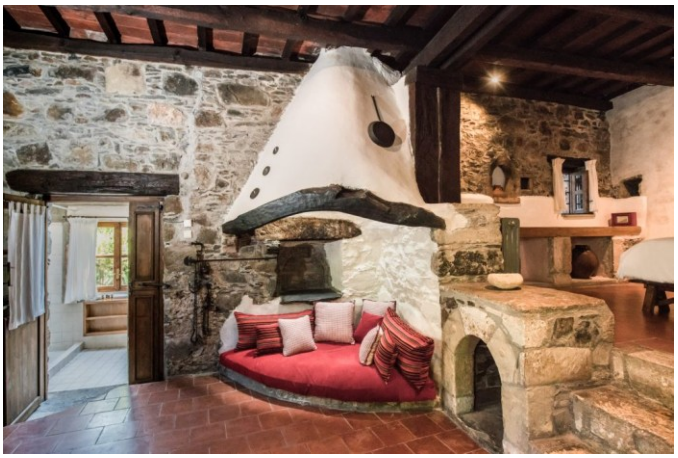
The Milia agrotourism facility is an off-grid small-scale family owned tourism entity with capacity of 41 beds. The off-grid facility operates all over the year (in winter, only onweekends) and promotes a sustainable and long-term eco-friendly traveling model characterised by:

- Self-sufficiency of energy provision through solar-PV panels for electricity and wood (collected from the nearby trees) for space heating & domestic hot water production,
- Organic food production in the farms and yards of the property and the nearby area,
- Systematic natural composting of organic material, including the leaves of trees that surround the area,
- Biological treatment of wastewater,
- Natural spring water supply towards the eco-lodge and the farm,
- Natural conditioning and zero electronic devices in the rooms,
- Zero food waste, into the food chain of the property, and

- Natural reforestation of the area by minimizing goat grazing.

The key sustainable energy technologies used in the Milia facility include:

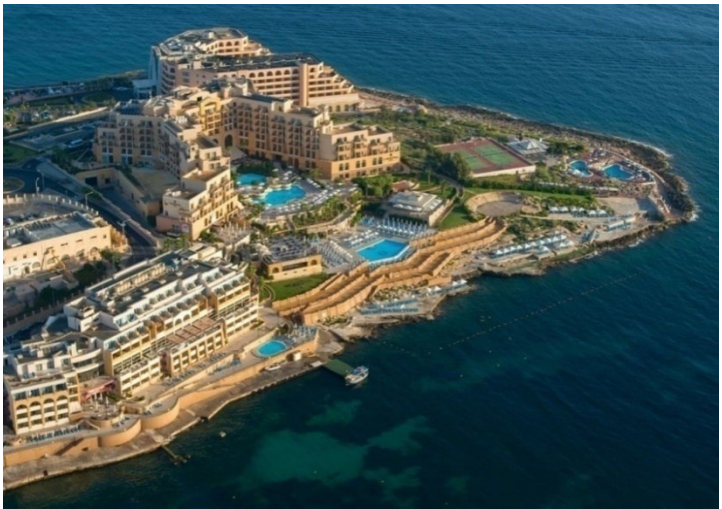
a) A solar photovoltaic system,
b) An electric battery system,
c) A solid biomass burning system providing hot water and space heating to the rooms.



The estimated annual saving in grid electricity is 54,000 kWh/year while the annual decrease of CO_2 emissions due to grid-electricity saving is estimated at 23,760 kgCO_2/year. The Milia agrotourism facility indicates that the use of locally available renewable energy sources can eliminate the carbon emissions during the operation of small-scale hotel entities in the Mediterranean region. The technologies used in the Milia facility can be easily replicated in other tourism entities located in areas with plenty of solar energy and biomass resources.

6. CORINTHIA HOTEL - MALTA

Corinthia Hotel St. George's Bay originally opened in 1995. It is a tranquil coastal resort with sea views. There are 250 beautiful rooms, five swimming pools and a private rocky beach.



The hotel operates a full Building Management System (BMS) for all energy systems. Projects are being implemented to convert all the fossil fuel boilers to heat pump water heaters and replace all chillers by high efficiency seawater cooled chillers for air conditioning. Moreover, all lighting will be converted to the latest LED technology, and a new occupancy and intelligent control systems will be added to the BMS. The total budget is €5 million. Moreover, the hotel has invested in a rooftop solar photovoltaic system of 126 kWp capacity.

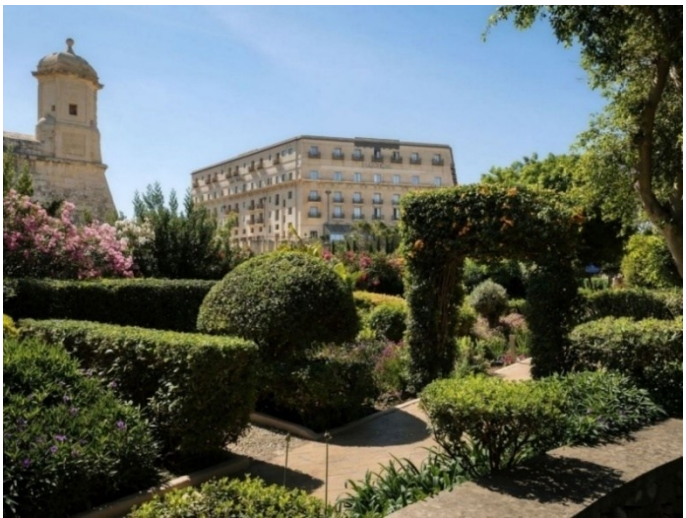
The total investment of €5 million is expected to yield an annual saving of €139,000 from electrical consumption and €61,000 from the elimination of diesel oil, bringing the total savings to €200,000/year. Therefore, the payback period of the investment would be around 25 years – except for the photovoltaic system, which has a payback period of 5 years. The sustainable energy investments are fully financed by the hotel. The long payback period for some measures do not hinder the hotel from investing in sustainable energy, because the tourism market is demanding more sustainable operations regardless of the immediate payback period. Indirect benefits such as improved revenues from higher numbers of visitors, will holistically offset the investment in a short time.

Following the planned investment of €5 million in the next 5 years, the estimated annual saving in grid electricity is estimated to amount to 30%, while fossil fuel usage in the hotel will be eliminated. The reduction in carbon dioxide emissions due to shifting from diesel oil to heat pump water heaters will amount to 270 tonnes CO_2/year, while the estimated total CO_2 emissions reduction due to electricity savings will amount to 524 tonnes CO_2/year, bringing the overall savings to 794 tonnes CO_2/year.

The energy renovation in Corinthia Hotel St. George's Bayindicates that the use of several sustainable technologies in large-scale hotels in the Mediterranean basin can substantially reduce their energy-related carbon emissions. The use of the solar photovoltaic system in regions with high solar irradiance, like Malta, isvery profitable. The energy technologies in the hotel can be easily transferred to other hotels across Europe.

7. THE PHOENICIA HOTEL - MALTA

The Phoenicia Malta Hotelis a five-star hotel located at the entrance to Valletta, proudly standing on a site rich in Maltese heritage. The total covered area of the hotel is 30,350 m^2, while its green area is 15,350 m^2. The capacity of



the hotel is 264 beds. The sustainable energy systems used in the hotel include:a BMS, which monitors and controls all key operations, including site-specific controls for air conditioners in every bedroom; double-glazing and insulation of roofs against heat and sound; new air-conditioners with full control throughfresh air mechanical ventilation using inverter-driven systems; and water heating using modular LPG (Liquefied Petroleum Gas) boilers with direct control. Additionally, all pumps are inverter-driven and fully controlled via the BMS, all new cold rooms are used for preservation of food and energy saving, and the hotel's cooling system for outdoor pools uses evaporative cooling systems.

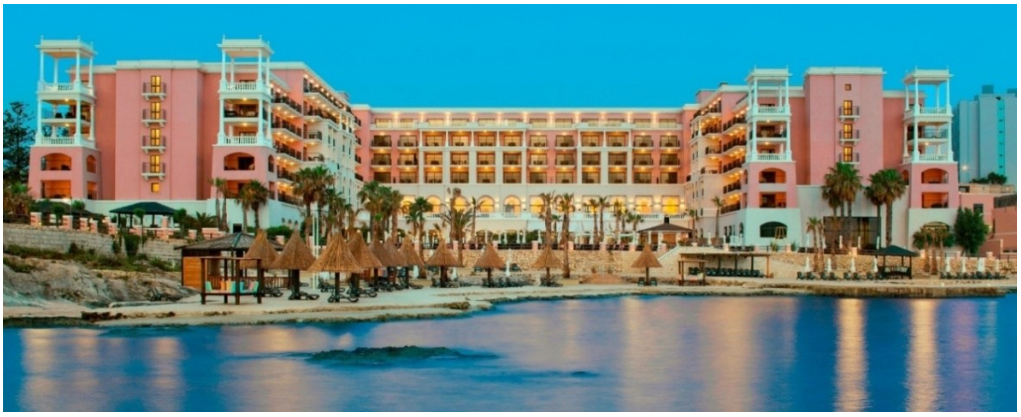
The 2024 total annual energy consumption in the hotel is 1,920,000 kWh/year, with electricity accounting for 1,286,400 kWh_{el}/year (67%) and heat for 633,600 kWh_{th}/year (33%). The hotel's turnover and gross profit have grown more rapidly than electricity demand, demonstrating improved energy efficiency per euro of revenue generated (lower energy intensity). Consequently, the investment has resulted in a net-positive outcome by stabilising consumption despite the expansion of guest facilities.The energy investments implemented in 2015 have consistently delivered clear environmental gains alongside economic returns. The replacement of diesel boilers with modular LPG systems has reduced particulate emissions and improved local air quality, supporting both guest comfort and compliance with modern EU standards The total investment cost of the sustainable energy systems is estimated at around € 1,000,000. These energy investments have been financed by own capital (100%). The average cost saving is estimated at approximately €125,000/year. The payback period is estimated at around six years.The use of sustainable energy systems in the Phoenicia Malta Hotelindicates that the use of several sustainable technologies in large-scale hotels in the Mediterranean basin can be financed by own capital while they substantially reduce their energy-related carbon emissions. The energy technologies in the hotel can be easily transferred to other EU hotels.

8. THE WESTIN DRAGONARA RESORT - MALTA

Standing apart on a natural peninsula fringed by the sea, the Westin Dragonara Resort brings warm-hearted, luxurious Mediterranean living to a vibrant, historic island. The total covered area of the hotel is 74,000 m^2, while its green area is circa 7,000 m^2. The built-up

area amounts to 38,800 m^2 of air-conditioned space and 4,459 m^2 of outdoor pools. The hotel's capacity is 413 rooms (625 beds).

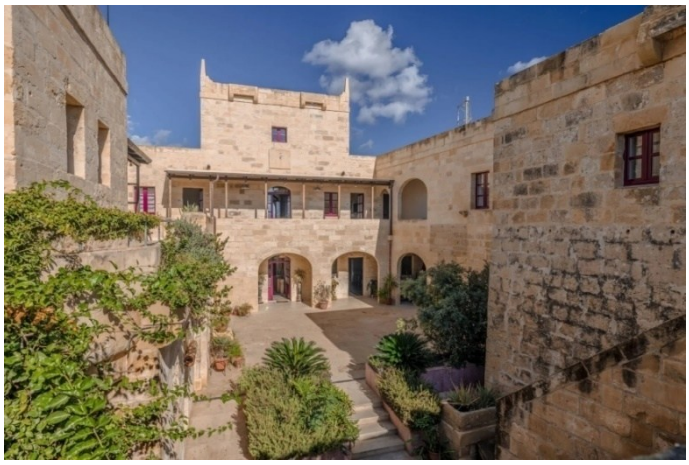
The hotel's energy systems are designed to maximise efficiency and sustainability through anintegrated approach. Heat pumps play a central role by transferring ambient heat from the air or ground to provide heating and cooling. In winter, they supply hot water with significantly lower electricity consumption compared to conventional boilers. During the summer months, they operate in reverse to provide cooling. Solar technologies further enhance efficiency. Solar panels (photovoltaic) generate renewableelectricity, reducing dependence on the national grid and lowering carbon emissions. Meanwhile, solar thermal collectors are dedicated to water heating, particularly for the guestsuite pools. All systems and guest rooms are centrally monitored and controlled through a BuildingManagement System (BMS). By combining heat pumps, solar power, solar collectors, and a sophisticated BMS, the hotel achieves a sustainable, efficient, and well-managed energy ecosystem that supports both environmental goals and cost control. The hotel has also invested in a 330kWp solar photovoltaics system generating circa 500,000 kWh/year, as well as solar heating. Furthermore, there is a large green roof with a total area of 1,985 m^2.



Over the last five years, the hotel's investment can be summarised as follows: Solar collectors for plunge pools were €107,720, and a heat pump for the main pool amounted to €254,097. The sustainable energy investments have been financed by own capital (100%). The payback period is estimated at 5 years.

9. THE MULBERRIES WELLBEING CHATEAU GUESTHOUSE - MALTA

Long-term sustainability is rooted in every aspect of the Mulberries Wellbeing Château operation, from the initial property design to the hospitality offering. The total built-up area of the small-scale hotel is 1,000 m^2, while its green area is circa 2,700 m^2. The hotel's capacity is 19 beds.



The guesthouse incorporates passive and active energy principles and practices. To counter local buildings' reliance on conventional, electric cooling systems that generate global warming emissions, Mulberries boasts features that drastically reduce heat gains in a passive manner. It is joined by high efficiency, double-glazed external apertures. The white-washed roofs reflect and minimise the effects of direct sun heat in the summer and contain a thermal insulation layer used in refrigeration systems to ensure optimal thermal performance. Moreover, heat recovery from the computer servers is fed into the indoor pool for pre-heating.

Over the last five years, the hotel's investment in solar heating including solar collectors, calorifiers, pumps and controllers is estimated at €35,000. Annual savings from electricity use is estimated at €5,735 while the payback period of the investments being 6 years. The sustainable energy investments have been financed by 72% own capital and a €10,000 grant (28%) from a European Commission energy initiative.The use of solar thermal energy in the Mulberries Wellbeing Château Guesthouse indicates that solar thermal energy can substitute fossil fuels in heat generation, reducing the carbon footprint of the hotel. The solar thermal energy systems used in this hotel can be easily transferred to other European hotels located in regions with abundant solar irradiance.

10. KUORTANE OLYMPIC TRAINING CENTER - FINLAND

The Kuortane Olympic Training Center is a versatile sports training centre, an official training centre for elite sports (Finnish Olympic Committee) and a centre for wellness and leisure, located on the shores of Lake Kuortane in the region of South Ostrobothnia, Finland. Accommodation is available in hotel rooms, apartments and cottages. The Kuortane Olympic Center has nearly 1,000 beds in summer and 850 beds all year round.

The centre's energy system is anchored by geothermal heating, which supplies 99% of its heating needs. Over 3,000 solar photovoltaic panels contribute 15% of annual electricity demand. The remaining energy demand is covered by grid electricity.The remaining energy demand is covered by grid electricity. Building automation, LED lighting with motion sensors, and HVAC (Heating, Ventilation and Air Conditioning)optimisation further enhance energy efficiency.

Over the past five years, a total of approximately €4 to €5 million has been invested in renewable power generation systems. Renewable heat generation systems account for approximately €3.5 million. These systems have led to annual savings of €500,000.Most of the financing for the energy investments at the Kuortane Olympic Training Center (75%) was covered by lease financing. In addition, 15% was covered by public subsidies and 10% by self-financing. The payback period of the geothermal heating system has been estimated at around 15 years. The payback period for the solar power plant is estimated at 6.9 years.

At the Kuortane Olympic Training Center, the implemented energy systems are expected to save around 2,800 megawatt-hours of energy annually while the reduction of CO_2 emissions is estimated at 1,500 tonnes per year.

The use of several sustainable energy systems in the Kuortane Olympic Training Center indicates that geothermal heating, solar photovoltaic panels and other sustainable energy systems can be used in tourism entities. These energy systems can be easily transferred in other EU hotels located in regions with geothermal energy resources and low solar irradiance.

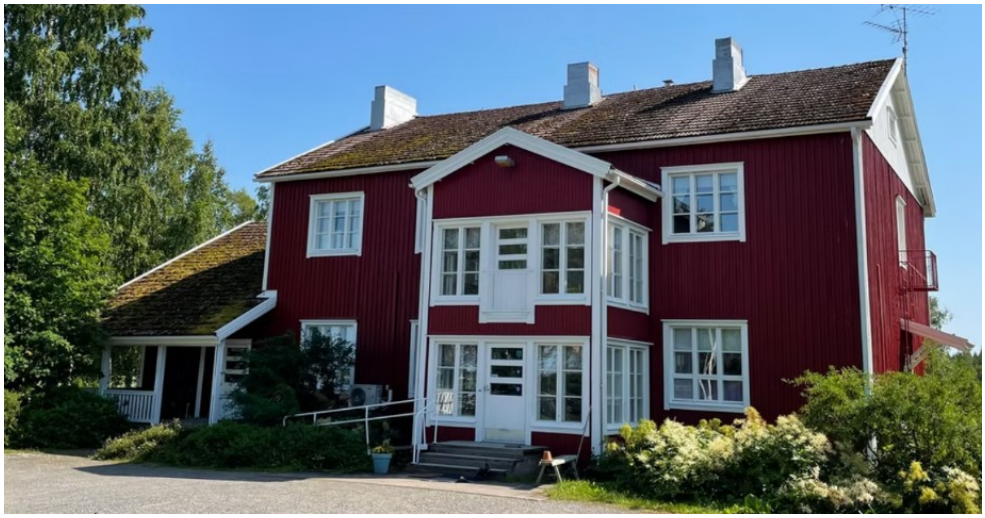
11. HOTEL OPINTOLA B&B – FINLAND

Opintola B&B is a cosy accommodation located in Norinkylä, Teuva, in the rural heart of South Ostrobothnia. Opintola B&B is housed in a beautifully renovated former elementary school building, offering a peaceful setting ideal for relaxation. Land area is 7,000 m² and the built-up area is 500 m^2 while its capacity is at 23 beds.

The Opintola B&B energy system is based on an air-to-water heat pump and room-specific air source heat pumps. Heat pumps have reduced oil consumption to one third (from 9,000 litres to 3,000 litres). Outdoor lighting is controlled by a twilight switch to optimise energy use. Electrical equipment has been gradually replaced with more energy-efficient models as needed, while LED lighting is also used. The annual use of fossil fuels has decreased by approximately 6,000 litres, which corresponds to a reduction of around 15 tonnes of CO_2 emissions per year.

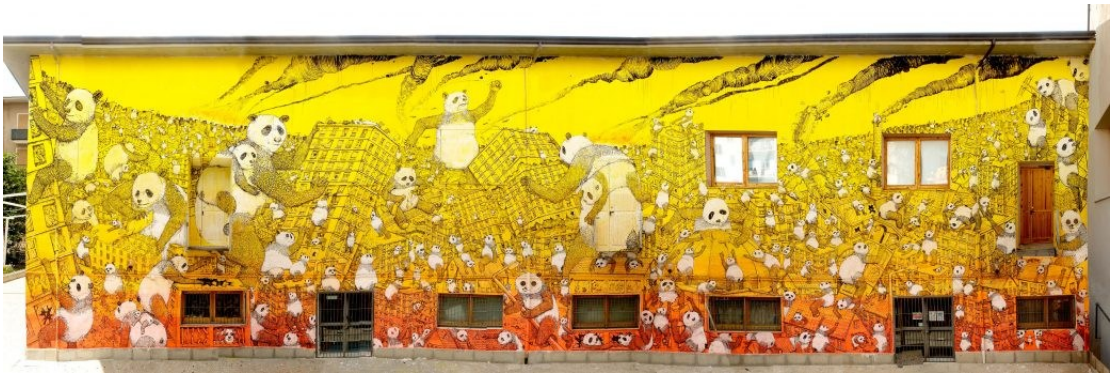
Over the past five years, a total of approximately €32,000 has been invested in renewable power generation systems. The annual benefit resulting from reduced fossil fuel use has averaged €2,500 over the past five years. This is based on an annual saving of 5,000 kWh in energy consumption and replacing oil with electricity. The payback period of the energy investments is estimated at 12.8 years. Most of the financing for the energy investments at Opintola B&B, (62.5%) was covered by a bank loan. In addition, 37.5% was by self-financing and once the investment has been completed, a 20% subsidy on the tax-free price (€3,000) of the investment was achieved.

The use of several sustainable energy systems in Hotel Opintola B&Bindicates that high efficiency heat pumps and other sustainable energy systems can be used in tourism entities. These energy systems can be easily transferred in hotels located in other regions.



12. CINEMA ALPHAVILLE - ITALY

Cinema Alphaville is located in the heart of Campobasso, within the historic building of the former ONMI on Via Muricchio. The venue covers an area of approximately 300 m² on the ground floor, divided into a foyer, a cinema hall with 80-90 seats, offices, and service areas. Today, it represents the only municipally owned cinema/theatre space actively operating in the city centre. Since its founding, Cinema Alphaville has served as a vital cultural hub for the city, offering an alternative and high-quality film programme.



The sustainable energy systems used in Cinema Alphaville include: a) a well-insulated buildingenvelope, b) arenewable energy photovoltaic system at 10 KW, c) athermal heat pump, and d) a LED lighting system.

Before the interventions, the Alphaville building had an energy rating of class C. Following the implementation of the improvement measures, the building achieved an A2 energy rating. A total annual saving of 125 MWh of non-renewable energy was achieved. The estimated reduction of CO_2 emissions was at 57,125 kgCO_2 per year.

The total investment for the energy and functional renovation of the Alphaville Cinema amounted to €257,112.15, of which €198,822.93 was allocated to construction works. The interventions led to a reduction in operating costs of approximately €6,700 per year. The overall investment was largely funded through the National Recovery and Resilience Plan (PNRR) under the public notice “Call for proposals to promote eco-efficiency and reduce energy consumption in public and private theatres and cinemas,” with a contribution of €200,000. The simple payback period for the energy efficiency measures was estimated at 8.5 years.

The use of several sustainable energy systems in Cinema Alphavilleindicates that several sustainable energy systems can be used in cultural buildings achieving financial support from public funding. These energy systems can be easily transferred in EU cultural buildings and hotels located in other regions.

13. THEATRE AND RESTAURANT KOEPOORT- THE NETHERLANDS

The City Theatre of Middelburg (Stadsschouwburg) was built in the late 1960s and has undergone several renovations since. During the most recent renovation, the Koepoort restaurant was added to the building, named after and offering a view of the historic Koepoort gate. The theatre seats 530 guests and hosts a variety of performances including cabaret, musicals, music, and small-scale arts.

The theatre is equipped with 64 rooftop solar-PV panels, two heat pumps, a battery of 68 kW and 32 vertical solar panels installed on the façade. During the renovation in 2018, a mechanical ventilation system with heat recovery was installed. In addition, the theatre replaced almost all lighting into LED and replaced all windows with isolating glass. In 2024, a gas boiler was replaced by two electrical boilers, both of which were 42 kW.

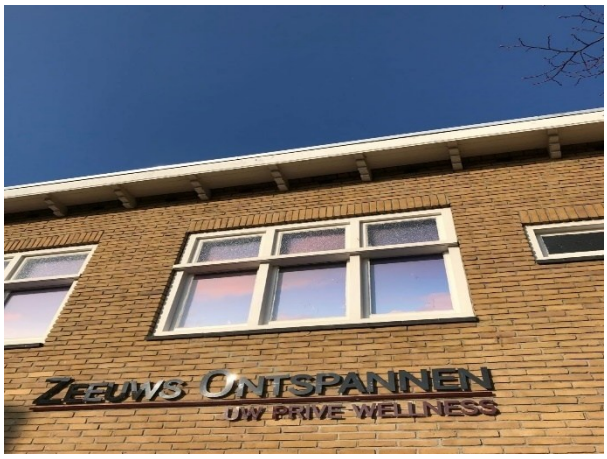
The estimated annual reduction of fossil fuel-generated electricity was 20.2 MWh, while the annual CO_2 reduction amounted to 8.2 tCO_2/year.

The battery, the heat pumps and the vertical solar panels are partly funded by an Interreg A project (50 %) and co-funded by the municipality of Middelburg.

The use of several sustainable energy systems in the theatre and restaurant/B&B Koepoort indicates that several sustainable energy systems can be used in cultural buildings achieving financial support from public funding. These energy systems can be easily transferred in EU cultural buildings and hotels located in other regions.

14. ZEEUWSONTSPANNEN – THE NETHERLANDS

ZeeuwsOntspannen is a private wellness centre located in the city centre of Middelburg (Zeeland), catering to small groups of 2 to 4 people. The centre also offers two luxurious wellness suites, providing a complete space for relaxation suitable for both day and overnight stays.



Deliberate choices were made to implement sustainable and innovative systems that reduce energy consumption while ensuring a comfortable stay. Solar photovoltaic panels generate a significant portion of the required electricity, lowering energy costs and limiting CO_2 emissions. In addition, a hybrid add-on connects the existing heating system to a hybrid heat pump.

At the heart of these installations is an Energy Management System (EMS), which optimally coordinates all appliances and building systems. Unlike traditional systems that operate in simple on/off modes, the EMS enables refined, intelligent control for maximum efficiency. This technology connects the existing heating system to a hybrid heat pump.

The annual saving in grid electricity is estimated at 5,000 kWh/year while the annual saving in gas is estimated at 2,000 m³. The annual decrease of CO_2 emissions due to fossil fuels and grid electricity saving is estimated at 6.2 tonnes CO_2/year.

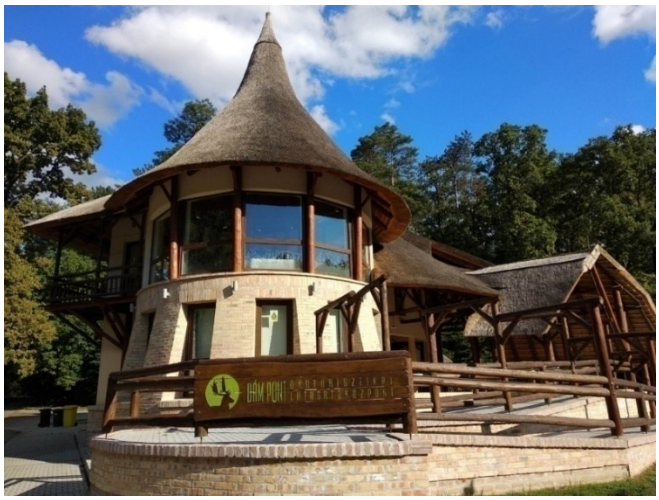
The total annual economic benefit of the energy investments in five years was estimated at €18,000. The sustainable energy investments were supported by own capital and a bank loan.

The use of several sustainable energy systems in the Wellness and B&B ZeeuwsOntspannenindicates that several sustainable energy systems can be used in tourism entities without financial support from public funding. These energy systems can be easily transferred in EU hotels located in other regions.

15. DÁMPONT ECO-TOURISM VISITOR CENTRE - HUNGARY

The DámPont Eco-tourism Visitor Centre, located near Miklósvár Park Forest and Miklósvár Lake and close to the GyulajZrt. Tamási game park, has been welcoming guests since 2020. Constructed from natural materials, the building blends seamlessly with its surroundings. As an eco-tourism centre, it aims to promote awareness of the local natural heritage,

helping new generations to better understand the region's flora and fauna. The built-up area of the centre is 460 m², and it receives around 5,000 visitors annually.



DámPont employs carefully selected, environmentally friendly energy systems with a strong emphasis on efficiency and sustainability. LED lighting is used throughout the building, while restrooms are equipped with motion-sensor lights, ensuring illumination only when needed. Heating is provided by a wood gasification boiler system, an efficient and sustainable solution that reduces reliance on fossil fuels by using locally sourced renewable biomass. The centre also utilises a solar thermal system with an installed capacity of 35 kW.

The development was carried out within the framework of the project entitled "*Sustainable Ecotourism Development of the Town of Tamási*", with 100% funding coverage. The construction cost of the Visitor Centre amounted to approximately €520,000 (HUF 208 million). Annual GHG emissions for the eco-centre are low, estimated at 1.38 tCO_2/year. The total annual financial benefit from reduced grid electricity and fossil fuel consumption is estimated at around €15,500/year.

The use of several sustainable energy systems in DámPont Eco-tourism Visitor Centreindicates that several sustainable energy systems supported by public funding can be used in non-profit tourism entities. These energy systems can be easily transferred in other non-profit tourism organizations located in other EU regions.

16. JANKOVICH KURIA HOTEL - HUNGARY

The Jankovich Kuriahotel is housed in the 18th-century Jankovich Manor, located in the heart of the country, in the centre of the old village of Rácalmás in a park filled with ancient trees. The hotel opened its doors in 2007 with 25 rooms and a Korean restaurant. The capacity of the hotel is 88 guests.

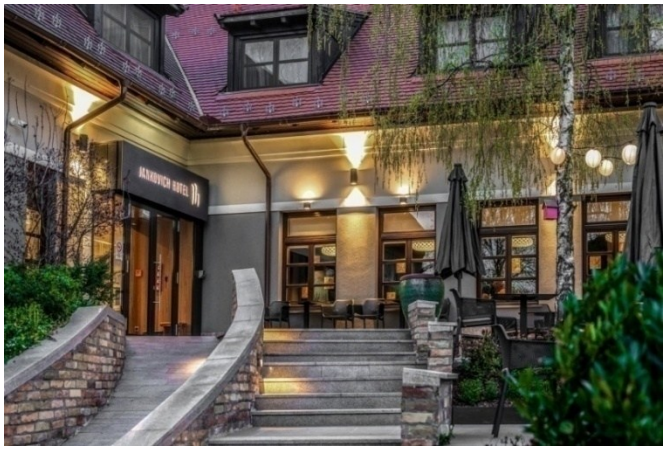
The environmentally friendly energy systems in the hotel include:

a) solar collectors (20 m²) installed on the roof in 2016, with all communal area lighting being energy-efficient and equipped with automatic sensors;

b) solar panels (50 kWp) installed in addition to the solar collectors; and

c) modern kitchen equipment introduced during the kitchen modernisation, which is less energy-intensive than the previous appliances.

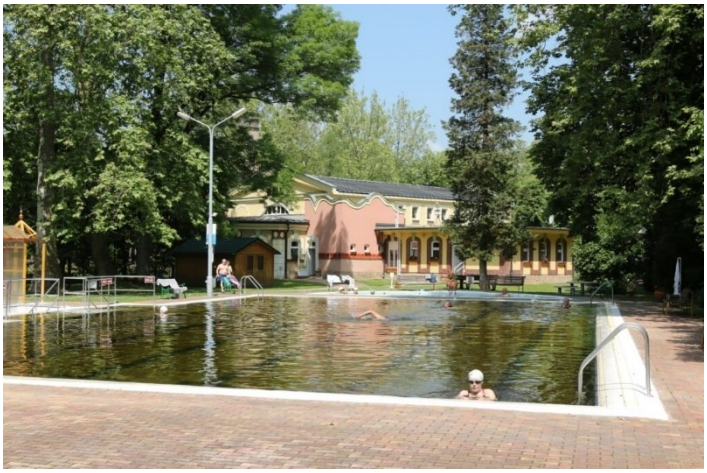
The hotel's energy sources include electricity, piped natural gas, and solar energy. Compared to previous years, electricity consumption was reduced by 15% in 2024, resulting in annual savings of 57,516 kWh. Fossil fuel consumption decreased by 1.12 t/year (tonnes/year), leading to a total annual reduction in CO_2 emissions of 5.38 t/year from both grid electricity and fossil fuel savings.Total investments in renewable power generation systems amounted to €31,646 while the total investments in renewable heat generation systems were €5,823. The total annual benefit due to lower use of grid electricity and fossil fuels was €11,200/year. The payback period of the investments was 3.3 years. The sustainable energy investments were realised by using own capital at 95% and a bank loan at 5%.



The use of the above-mentioned sustainable energy systems in Jankovich Kuria hotelindicates that solar energy systems can be used for heat and power generation in EU hotels without public subsidies. These solar energy systems can be easily transferred in other hotels located in other EU regions.

17. NAGYATÁD THERMAL SPA - HUNGARY

The Nagyatád Thermal and Medical Spawelcomes those seeking relaxation and healing all year round with its therapeutic thermal water and various medical treatments. The spa islocated in a nature reserve park. The indoor area features therapeutic pools with temperatures of 34, 38, and 42 degrees Celsius, while separate rooms offer baths. The built-up area is 3,955 m^2 while the spa complex accepts 18,072 visitors per year.



The buildings (spa, cultural centre, tourist centre) continue to receive their electricity primarily from the national grid. This is supplemented by a solar-PV panel system in all three buildings(15.40 kWp, 20.35 kWp, and 50.05 kWp, respectively), which was installed primarily to cover the energy needs of the heat pumps. A solar thermal system is also used for hot water production. Heating energy and hot water for domestic useare provided entirely by a heat pump system. The installed power of the solar photovoltaic system is 85.8 kWpwhile the installed heat power of the solar thermal collectors is 530.3 kW_{th}.

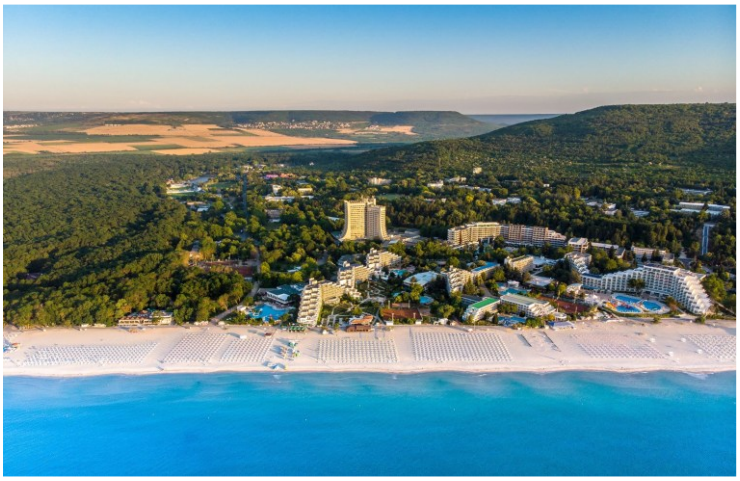
The annual saving in grid electricity was at 2,766 kWh/year while the annual saving in fossil fuels was 36.34 t/year. The annual decrease of CO_2 emissions due to fossil fuels and grid electricity saving were at 337.62 t/year.

The total investments in renewable power generation systems were €494,441 while the total investments in renewable heat generation systems were €410,525. The annual benefit due to lower use of fossil fuels was €23,177/year. The payback period of the investments was 23 years. The sustainable energy investments were realised with the use of own capital at 53% and the support of public subsidies at 47%.

The use of the above-mentioned sustainable energy systems in Nagyatád Thermal Spa complexindicates that public subsidies can facilitate the promotion of sustainable energy systems in European tourism entities. The above-mentioned sustainable energy systems can be easily transferred in other tourism facilities located in other EU regions.

18. SEASIDE RESORT ALBENA - BULGARIA

Albena SA is the largest hotel company in Bulgaria. The company owns three resorts on the Bulgarian Black Sea coast: Albena Holiday Village, Primorsko Holiday Village, and Byalata Laguna Holiday Village. The total surface area of the Albena resort is approximately 700,000 m², with a built-up area of around 120,000 m². Green spaces – such as lawns, parks, and natural zones – cover more than 182,000 m², creating a balance between urbanised and natural environments. The resort provides 12,909 beds distributed across multiple hotels of different categories.

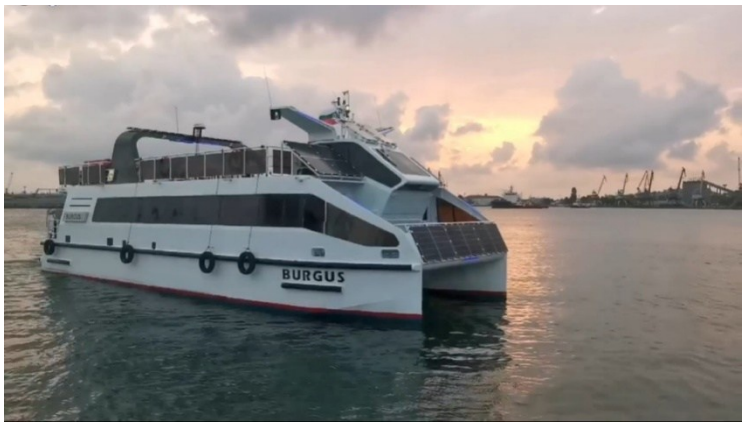


Albena Resort utilises a mix of conventional and renewable energy sources, with increasing emphasis on sustainability in recent years. Over 50% of the energy consumed annually is generated on-site using renewable energy sources. Several hotels and facilities have installed solar thermal panels for hot water production, reducing reliance on electric or gas boilers. In addition, solar photovoltaic systems (1.5 MWp) are being expanded gradually to cover parts of the resort's electricity demand. A 1 MW peak power biogas cogeneration plant was built, which annually produces over 8,000 MWh of clean electricity and another 8,000 MWh of clean heat, using silage corn as raw material. Energy consumption is managed through a centralised building management system (BMS) that monitors heating, cooling, lighting, and occupancy in realtime.

The annual energy savings at the hotel are estimated at 8,000,000 kWh/year, resulting in a reduction of approximately 3,464 tCO_2/year from both fossil fuel and grid electricity savings. Albena SA has invested around €7,311,474 in renewable electricity and heat production installations, including solar energy and biogas systems. The total annual financial benefit from reduced use of grid electricity and fossil fuels is estimated at €1,431,520, with an expected payback period of 5.1 years.

These investments were primarily financed through Albena SA's own capital, without the use of bank loans or public subsidies. The deployment of multiple sustainable energy systems at Seaside Resort Albena demonstrates that large tourism enterprises can successfully implement several renewable energy investments without relying on public support.

19. CATAMARAN BOAT "BURGUS" - BULGARIA



The solar-powered tourist catamaran "Burgus" is a sustainable tourism initiative developed by the Municipality of Burgas under the project "The Power of Water," financed through the Operational Programme Regions in Growth 2014–2020. With a capacity of 100 passengers, the catamaran represents an innovative product promoting eco-friendly maritime tourism in the Black Sea. "Burgus" is a 20-meter-long, 7.8-meter-wide aluminium hybrid vessel featuring both open and enclosed decks.

The catamaran is primarily powered by a 40 kW IVECO Marine Diesel generator, which provides propulsion and backup energy. To reduce emissions, a 4.4 kWp photovoltaic system was installed in 2021, consisting of 10 Longi 370 Wp modules and 4 Victron Energy 175 Wp modules. This system powers essential onboard loads, including navigation equipment, lighting, and communication systems. Over three years, it produced 9 MWh of

electricity, replacing approximately 2,250 litres of diesel fuel. Additionally, the vessel uses LED lighting, which consumes up to 70% less electricity than conventional systems.

The annual saving in grid electricity is estimated at around 3,000 kWh/year while the annual savings in fossil fuels is at around 750 litres diesel. The annual reduction in CO_2 emissions is estimated at 1.299 tonnes.

The total investment in the solar photovoltaic system is approximately €20,000 while the total annual benefit is estimated at €1,500 per year. The payback period is estimated at approximately 13 years. The solar energy investment was mostly financed by EU structural funds.

The use of a solar photovoltaic system in the small-scale tourist vessel in Burgas indicates that solar energy can cover part of the energy needs in small-scale tourism vessels while the above-mentioned technology can be replicated in similar vessels in EU regions, particularly in Mediterranean region.

LIST OF SUSTAINABLE ENERGY TECHNOLOGIES USED IN THE ABOVE-MENTIONED TOURISM FACILITIES

The following sustainable energy technologies were used in the above-mentioned hotels and tourism facilities:

1. Energy Saving Achieved with Insulation of the Building Envelope
2. Solar Photovoltaic Systems
3. Solar Thermal Systems for Hot Water Production
4. High-Efficiency Heat Pumps
5. Geothermal Heat Pumps
6. Solid Biomass Burning Systems for Hot Water Production
7. Energy Management Systems

8. LED Lighting Systems
9. Modern and Energy-Efficient HVAC (Heating, Ventilation, and Air Conditioning) Systems
10. SeawaterChillers
11. Electric Batteries
12. Heat and Power Cogeneration Systems Using Biogas
13. Wood Gasification Boiler Systems for Heat Generation
14. Green Roofs
15. Waste Heat Recovery and Reuse

2. LESSONS LEARNT FROM THE HOTELS AND OTHER TOURISM ENTITIES STUDIED

The lessons learnt from the study of the above-mentioned hotels and tourist entities can be summarised as follows:

1. Several sustainable energy technologies can be used in tourism-related enterprises in European regions, reducing their carbon footprint and their environmental impacts.
2. Solar photovoltaic systems, solar thermal systems and high-efficiency heat pumps are the most popular sustainable energy systems used in tourism-related enterprises in European regions.

3. Sustainable energy investments in tourism-related enterprises are financially supported and subsidised by national and EU funds.
4. The sustainable energy investments in tourism-related enterprises are mainly financed by own capital, bank loans and public subsidies.
5. In most cases, the payback period of the energy investments is attractive.
6. Involvement of energy-saving companies or energy cooperatives in the realisation of the energy investments in tourism entities is not noticed.
7. The aim of the tourism-related enterprises studied in the current survey is the reduction of the fossil fuels used and their carbon emissions. The majority of them did not try to eliminate all their carbon emissions to achieve carbon neutrality.
8. Most of the identified sustainable energy technologies in tourism-related enterprises can be replicated in other European regions. These energy technologies include: a) energy-saving technologies, b) technologies using locally available renewable energy sources, and c) high-efficiency energy technologies.

3. SOFT MEASURES FOR HOTELS' DECARBONISATION

Soft measures – which are not related with energy investments – facilitate the clean energy transition in hotels achieving their optimum way towards carbon neutrality. These soft

measures include: a) energy monitoring, b) energy auditing, c) energy benchmarking, d) behavioural changes of the guests and the staff, and e) offset of carbon emissions.

The role of energy monitoring in the decarbonisation of hotels

One of the most impactful strategies to achieve decarbonisation is the systematic monitoring of energy consumption, enabling hoteliers to understand, manage, and ultimately reduce their carbon footprint. Energy monitoring refers to the continuous collection, measurement, and analysis of energy usage data within a facility. In hotels, this process involves tracking the consumption of electricity, gas, water heating systems, and sometimes renewable energy outputs. The purpose is not just to measure but to translate raw data into actionable insights that support carbon reduction strategies. Energy monitoring plays a critical role in hotel decarbonisation for several reasons, including baseline establishment. To reduce emissions, hotels must first know their starting point.

Sustainability commitments require year-on-year verification. Energy monitoring provides auditable data, proving that interventions (e.g., LED retrofits, solar photovoltaic installation) are delivering the expected emission reductions. Energy monitoring is not simply a technical add-on; it is the strategic backbone of hotel decarbonisation. By providing accurate, real-time insight into how, when, and where energy is used, hotels can target interventions that yield measurable carbon reductions, operational savings, and competitive advantages.

The role of energy audits in the elimination of carbon emissions in hotels

One of the most effective strategies in the clean energy transition of hotels is the energy audit, a systematic process of evaluating a building's energy use to identify opportunities for improvement. Energy auditing serves as a diagnostic tool to pinpoint inefficiencies, recommend cost-effective measures, and create a roadmap toward carbon-neutral operations. In the context of hotels, energy audits play a pivotal role in both reducing operational costs and minimising the carbon footprint, ultimately contributing to the elimination of emissions over the long term. An energy audit is a systematic inspection, analysis, and evaluation of energy flows in a building, process, or system, with the objective of understanding energy consumption patterns and identifying opportunities for improvement.

Energy audits typically follow three levels:

a) Preliminary Energy Audit,
b) General Energy Audit, and

c) Detailed Energy Audit.

Energy auditing stands as one of the most powerful tools available to hotels seeking to eliminate carbon emissions. By identifying inefficiencies, enabling renewable integration, and providing a structured pathway toward sustainability, energy audits offer both environmental and financial rewards**.**

The role of energy benchmarking in the decarbonisation of hotels

Energy benchmarking is the process of measuring a building's energy use, normalising it for variables such as size, climate, and occupancy, and comparing it with:

a) Historical performance (internal benchmarking).
b) Industry peers (external benchmarking).
c) Recognised performance standards (standard-based benchmarking).
d) Energy benchmarking as a cornerstone of hotel decarbonisation.

By contextualizing these figures, hotels can understand how efficient they are relative to themselves over time and to similar properties in comparable markets. Energy benchmarking is a cornerstone of hotel decarbonisation. By measuring, normalising, and comparing performance, it provides the insight necessary to identify inefficiencies, priorities, and interventions, and also to verify progress towards carbon reduction goals. For hotels, benchmarking offers a strategic advantage: *it not only drives environmental performance but also improves profitability, enhances brand reputation, and ensures compliance with evolving regulations*.

The role of behavioural changes of tourists and employees in the decarbonisation of hotels

Behavioural changes from both tourists (guests) and employees represent a powerful, but often underestimated lever for reducing carbon footprints. Technical upgrades in hotels such as solar photovoltaic panels, LED lighting, and efficient HVAC systems are essential, but they require capital investment and time to implement. Human behaviour, by contrast, can change rapidly and often at low cost.

Low-carbon practices for tourists include: a) energy-conscious use of amenities,b) water conservation, c) food-related choices, d) mobility choices, and e) waste minimisation.Hotels can facilitate these changes by making sustainable choices more convenient than unsustainable ones.

Employees interact with hotel systems daily—housekeeping, kitchen, maintenance, and front desk operations all influence energy and resource use. Staff can either uphold sustainability standards or undermine them through neglect or outdated habits.

Behaviour change is most impactful when tourists and employees reinforce each other's actions. Behavioural changes, when supported by infrastructure, policy, and culture, can produce rapid, low-cost emissions reductions while also fostering a deeper sense of shared responsibility. Tourists' decisions—whether to take a shorter shower, switch off a light, or choose a vegetarian meal—aggregate into significant carbon savings. Employees' diligence in efficient housekeeping, energy management, and guest engagement ensures that sustainability goals are met consistently.

The role of carbon offsetting in the decarbonisation of hotels

Among various sustainability strategies, carbon offsetting has emerged as a pivotal tool for mitigating greenhouse gas emissions. In particular, hotels running energy-intensive operationsare turning to carbon offsetting as a pathway to environmental responsibility. Carbon offsetting can be realised in two markets: the voluntary and compliance markets. The voluntary market allows companies, organisations, or individuals to purchase carbon credits on their own initiative, usually to demonstrate climate responsibility, enhance reputation, or meet internal sustainability goals. Participation is optional, and standards vary across certifiers. In contrast, the compliance market is regulated by governments under schemes like the EU Emissions Trading System or the Kyoto Protocol. Here, companies must offset emissions to meet legally binding caps, and only credits from approved projects are valid. Thus, compliance offsets are mandatory and strictly regulated, while voluntary offsets are flexible and market-driven.Carbon offsetting is the process of compensating for emissions by funding projects that reduce or remove carbon dioxide (CO_2) or other greenhouse gases elsewhere. Common offsetting projects include reforestation**,** renewable energy development**,** methane capture**,** and energy efficiency improvements in developing regions. The idea is simple: while some emissions are currently unavoidable, hotels and other businesses can neutralise their environmental impact by investing in these projects. However, it is not a silver bullet**.** The hospitality industry must resist the temptation of easy solutions and commit to deeper, systemic changes in operations, infrastructure, and culture.

According to several studies, carbon emissions in tourism facilities vary in the range of 20-60 kgCO_2 per night spent (p.n.s.). The cost of carbon offsetting in the voluntary market falls in the range €3-6 per tonne of CO_2 with average prices in the beginning of 2025 at

€4.10/tCO_2. Therefore, the current cost of carbon offsetting in tourism facilities in the voluntary market is rather, low falling in the range of €0.07-0.20/p.n.s.

4. KEY CHALLENGES IN HOTELS' DECARBONISATION

Decarbonising Europe's hotel sector is essential to meet EU climate targets and to future-proof an industry exposed to rising regulation, volatile energy markets and shifting guest expectations. Yet hotels, historic buildings, and high-service operations face a set of interconnected barriers: regulatory complexity and compliance cost; access to finance; the technical limits of aging building stock; skills and operational capacity gaps; energy-system constraints; and the difficulty of reducing emissions related to food, supply chainsand travel.

Regulatory complexity and rising compliance costs

European policy is moving fast: the revised Energy Performance of Buildings Directive (EPBD) and related EU measures push for a decarbonised building stock and tighter energy-performance rules for 2030–2050. While these rules set a clear direction, they create short-term compliance burdens for hotels (especially small operators) that must upgrade heating, cooling, insulation and building management systems to meet new minimum performance standards. The EPBD creates obligations that are necessary but costly and administratively complex for many properties.

Access to finance and investment gaps

Decarbonisation requires heavy capital investment (building fabric, heat pumps, installation of renewable energy systems, batteries, electrification of kitchens and laundry). Europe-wide analyses show a massive funding gap to meet building decarbonisation targets, and industry observers estimate that public and private capital flows are currently insufficient to cover the needed investments. Smaller hotel owners often lack balance-sheet capacity or bankable project pipelines, making it hard to attract low-cost capital or use energy-performance contracting. Without de-risking instruments, grants and tailored financing, many hotels will postpone upgrades.

Building stock, heritage constraints and technical barriers

Hotels occupy a wide range of buildings: modern purpose-built properties, converted historic structures, and seasonal facilities. Older and listed buildings present special barriers — insulation, façade works or window replacement may be restricted for heritage reasons; cavity insulation may be technically infeasible; and integrating heat pumps or district heating requires building-level alterations. Even where technical options exist, retrofits must be staged around occupancy cycles and guest comfort. Sector guidance and roadmaps exist, but real-world implementation is technically complex and costly.

Skills, know-how and operational capacity gaps

Decarbonisation is not only about hardware — it requires trained staff, energy managers, procurement teamsand maintenance capability. Many hotels, particularly SMEs, lack in-house sustainability expertise to design, procure and operate low-carbon systems optimally. Operations must adapt to realise projected energy savings. Industry surveys indicate that while large chains invest in sustainability teams and targets, many independent hotels prioritise cash-flow and short-term operational issues. Even financed retrofits can underperform without the staff capacity to operate systems efficiently; training and access to trusted technical advisory services are essential.

Energy supply, grid constraints and seasonality

Electrification (e.g., heat pumps, induction cooking, EV chargers) is central to decarbonisation, but it increases electricity demand. Local grid capacity and the timing of upgrades are variable across Europe; in some destinations upgrades to distribution infrastructure are needed before hotels can electrify fully. Additionally, seasonality in tourism (i.e., peak summer demand in some regions, winter peaks in others) complicates

load management and the economic case for storage and demand-response.Regional disparities in renewable electricity supply also affect the carbon intensity of electrification.

Emissions related to food systems and supply chains

A significant share of hotel emissions lies outside direct energy use — notably food, purchased goods, waste and guest travel. This makes measurement and mitigation challenging. Sector workstreams show large potential gains from transforming hotel food systems butthey also reveal the complexity of coordinating suppliers, changing guest expectations and tracking embodied emissions. Practically hotels that focus only on onsite energy risk missing major, achievable emissions reductions in procurement and operations.

Guest expectations, transparency and greenwashing risk

Consumers increasingly demand sustainable stays, but new EU rules on environmental claims tighten how hotels can advertise carbon-neutrality and sustainability claims. Accurate measurement, independent certification and transparent communication are increasingly necessary to avoid reputational risk. Smaller operators may struggle to meet the documentation burden or to choose credible standards.

Split incentives and fragmented ownership models

Many properties are owned by investors and operated under franchise/management agreements. Owners may not capture the full operational savings from energy upgrades (which are accrued on operators), creating a classic split-incentive problem that prevents necessary investments. Contractual misalignment between owners and operators is a major behavioural challenge.

Decarbonising Europe's hotels is achievable, but it depends on addressing a complex set of interconnected challenges, including financing, skills, building-level technical issues, grid readiness, and supply-chain emissions. Policy certainty, targeted financing, capacity building, and sector-wide collaboration are the levers most likely to drive widespread progress. Taking early action—such as prioritising low-regret measures and combining financial support with expert guidance—can reduce costs, lower risks, and enhance the sector's resilience as regulations tighten and guest expectations evolve.

5. KEY ENABLERS IN HOTELS' DECARBONISATION

While the challenges in thedecarbonisation of hotels are substantial, a growing set of *key enablers*—technological, regulatory, financial and organisational—are making decarbonisation more viable and attractive.

Supportive Policy Frameworks and Regulatory Alignment

One of the strongest enablers of hotel decarbonisation is the increasingly clear direction provided by European sustainability policies. The EU's climate framework, including the European Green Deal, the Energy Efficiency Directive (EED) and the Energy Performance of Buildings Directive (EPBD), creates a roadmap for energy-efficient buildings, renewable energy adoption and carbon reduction. For hotels, these policies act as both a compliance signal and an investment motivator.

Meanwhile, national governments are rolling out building standards, renovation targets, and incentives such as tax credits, rebates and grants for energy-efficient equipment. This policy clarity reduces uncertainty and helps hotel owners justify long-term investments in decarbonisation measures that may otherwise appear too costly. Crucially, regulatory alignment across countries ensures that hotel chains operating in multiple EU markets can build consistent strategies, rather than navigating competing frameworks.

Expanding Financial Mechanisms for Sustainable Upgrades

Decarbonisation requires upfront capital, especially in older buildings needing retrofits. Europe is seeing rapid growth in financing mechanisms designed to support energy transitions:

Green loans and sustainability-linked loans

Banks increasingly offer financing tied to energy performance improvements or certified green building standards. Interest rates or repayment terms improve when hotels demonstrate verified reductions in carbon emissions.

EU and national grants

Programmes targeting heat pumps, solar photovoltaics, building insulation, electrification of kitchens, and sustainable mobility infrastructure (e.g., EV chargers) reduce financial barriers.

Energy Performance Contracting (EPC)

With EPC models, energy service companies finance and install equipment and are repaid through the energy savings achieved. This is particularly valuable for independent hotels without access to large capital budgets.

Hotel chain investment strategies

Large hotel groups are setting internal carbon budgets, sustainability funds or group-wide plans dedicated to decarbonisation. Their scale allows aggregation of projects, lowering costs and spreading innovations across brands. The growing maturity of green finance is a transformative enabler because it allows hotels to act proactively, rather than waiting for mandatory regulations to force investment.

Advances in Clean Technology and Building Retrofits

Technological progress is accelerating the decarbonisation potential of hotels across Europe.

High-efficiency heating and cooling

Heat pumps, variable refrigerant flow (VRF) systems, heat recovery ventilation and high-performance chillers can cut energy consumption dramatically. Many technologies now deliver adequate performance even in colder climates, making them suitable for the majority of European hotels.

Building management systems (BMS) and digital monitoring

Smart controls allow hotels to optimise heating, cooling, lighting and ventilation in real time based on occupancy. Savings of 15–30% are common, simply through better system optimisation. Increasingly accessible IoT devices make these solutions affordable for smaller properties.

Onsite installation of renewable energy systems and energy storage

Solar PV, solar thermal, battery storage and, increasingly, biogas or geothermal solutions help hotels reduce dependence on fossil-fuelled grids. The falling cost of renewable energies significantly improves return on investment.

Low-carbon retrofitting solutions

Innovations such as thin internal insulation, high-performance glazing and prefabricated façade panels facilitate upgrades in historic or complex buildings. These technologies reduce disruption, which is crucial for hotels that cannot close for long periods, and make heritage properties viable candidates for deep renovation. Technology is central, but without skilled operation, hotels cannot fully realise its potential.

Supply-Chain Transformation and Low-Carbon Procurement

Hotels' emissions extend far beyond their buildings—food, beverages, amenities, laundry, linens, construction materials and guest transport represent a significant share of carbon emissions. A major enabler of decarbonisation is the availability of more sustainable products and suppliers, as discussed below:

Sustainable food sourcing

European hotels increasingly access suppliers offering plant-forward menus, regenerative agriculture products, low-waste procurement systems and regional sourcing, all of which reduce upstream emissions.

Green procurement standards

Certification schemes and procurement guidelines make it easier to identify low-carbon cleaning products, toiletries, linens, and maintenance materials.

Circular economy partnerships

Collaboration with recyclers, linen rental companies, waste-to-energy providers and refurbishment specialists enables resource efficiency and emissions reduction across a hotel's operations.

Workforce Skills Development and Operational Culture Change

Human capability is one of the most overlooked yet most powerful enablers. Even the best technologies underperform without skilled staff who can operate equipment efficiently or implement low-carbon practices. Key developments enabling decarbonisation include:

Training programmes and certifications

Hospitality schools, industry associations and sustainability networks now provide training on energy management, waste reduction, food sustainability and ESG reporting.

Internal sustainability teams

Large hotel groups have dedicated sustainability departments or "green champions" coordinating initiatives across properties.

Operational practices

Behavioural changes—such as optimised housekeeping schedules, laundry reduction programmes, waste sorting, HVAC optimisation and menu redesign—can save substantial energy and emissions at low or no cost.

Employee engagement

A culture where employees understand and support sustainability goals creates long-term improvements and fosters innovation at the property level.

Digitalisation, Data Platforms and Better Carbon Accounting

Accurate data is essential for target setting, financing, and reporting. Digital solutions are making decarbonisation simpler and more transparent.

Carbon measurement platforms

Hotels can now easily track energy consumption, waste, water use and supply-chain emissions through software solutions designed for hospitality.

Benchmarking tools

Peer comparisons incentivize improvement and help identify best practices. Some hotel networks provide portfolio analysis tools that highlight the highest-impact opportunities.

Tourism Sector Collaboration and Industry Networks

Industry-wide coalitions play a central enabling role:

- Hotel associations share guidance, case studies and procurement resources.
- Global sustainability alliances provide frameworks and tools for emissions calculations, supply-chain engagement and reduction roadmaps.
- Destination-level initiatives (e.g., city tourism boards or regional green tourism programmes) coordinate decarbonisation efforts among hotels, restaurants, transport providers and attractions.

Collective action helps smaller hotels overcome barriers by giving them access to knowledge and supplier networks normally available only to large chains.

Europe's hotel sector faces a complex decarbonisation journey, but the enabling landscape is expanding quickly. Supportive regulation, accessible finance, advanced technology, greener supply chains, skilled personnel, data solutions and strong industry collaboration are all accelerating the transition. Together, these enablers not only reduce carbon emissions but also strengthen hotels' resilience to rising energy costs, regulatory pressure and shifting customer expectations. The European hotel industry is now positioned to transform itself into a more sustainable, competitive and future-proof sector—provided that operators continue to leverage these enablers and embed sustainability into long-term investment and operational strategies.

6. LIMITATIONS AND RISKS IN HOTELS' DECARBONISATION

Hotels operate in diverse building types, under varied regulatory regimes, and with business models heavily dependent on guest satisfaction and adaptable service delivery. While numerous enablers support decarbonisation, a range of limitations and risks complicate the transition. These are financial, technical, operational, regulatory, reputational, and market-related in nature.

Financial Limitations and Investment Risks

<u>High upfront costs</u>

Decarbonisation requires capital-intensive interventions: deep building retrofits, renewable-energy installations, high-efficiency HVAC systems, and digital monitoring technologies. Many hotels operate on tight margins and have limited cash reserves, especially independent hotels and family-owned properties. These properties struggle to justify long-payback investments, even when long-term savings are promising.

<u>Uncertain return of investment</u>

Energy savings can vary because of fluctuating energy prices, occupancy patterns, climate variations, and technology performance. This uncertainty discourages investors and hotel owners who need predictable cash flows.

Limited access to financing

Smaller hotels often lack the creditworthiness or collateral needed to access green loans or sustainability-linked finance. Even when public incentives exist, administrative complexity or eligibility requirements may limit uptake.

Risk of stranded assets

If a hotel invests in equipment that becomes non-compliant with future regulations or quickly outdated due to rapid technological change, the asset may lose value before the end of its expected lifetime.

Technical Limitations and Building-Specific Constraints

Heritage and historic buildings

A large portion of Europe's hotel stock consists of historic or listed buildings where structural modifications are restricted. External insulation, window replacement, installation of heat pumps, or rooftop solar panels may require special permissions or be technically unfeasible.

Complex energy demands

Hotels have unique energy-use profiles such as 24-hour operations, high domestic hot water demand, restaurants, spas, pools, laundry facilities, and large communal areas. This complexity limits the applicability of some standard commercial-building solutions.

Space constraints

Older buildings often cannot accommodate new mechanical rooms, air-source heat pumps, battery storage, or large HVAC retrofits. Urban hotels may lack roof space for solar-PV panels or external units.

Technology integration challenges

Introducing new into old infrastructure can cause compatibility issues, operational disruptions, or performance failures if not engineered correctly.

Operational Risks and Capacity Limitations

Lack of technical expertise

Many hotels lack in-house engineering or sustainability expertise. Without proper installation, commissioning, and ongoing optimisation, decarbonisation technologies may underperform or fail outright.

Maintenance risks

More advanced systems—such as high-efficiency boilers, smart controls, or renewable assets—require specialised maintenance. Hotels in remote or seasonal regions may struggle to access skilled technicians, increasing downtime and operational risks.

Disruption to guest experience

Energy retrofits may require partial closures, noise, dust, or temporary disruptions to heating or cooling. Poorly timed upgrades can affect occupancy rates and reputation. Hotels must balance sustainability actions with revenue protection.

Behavioural limitations

Even with modern systems installed, energy waste can persist if:

- staff are not trained properly,
- guest behaviours (e.g., long showers, leaving windows open) counteract efficiency measures.

Operational culture change is often slower than technological adoption.

Regulatory and Administrative Risks

Complex regulatory landscape

European hotels must navigate a mix of EU directives, national building codes, municipal requirements, and tourism regulations. This fragmentation creates uncertainties around timelines, disclosure requirements, and minimum performance standards.

Risk of regulatory tightening

Hotels might invest based on current rules, only to face stricter future standards requiring additional spending. This is particularly relevant for emissions reporting, building performance requirements, and environmental claims regulations.

Permitting delays

Retrofitting older buildings, installing heat pumps, or integrating solar panels often requires local approvals. Lengthy permitting processes can delay projects and increase costs.

Supply-Chain Limitations and Dependency Risks

Limited availability of low-carbon materials

Some key materials—such as high-efficiency glazing, low-carbon concrete, or specialised HVAC components—are still in short supply or carry premium prices, increasing project costs and lead times.

Global supply-chain volatility

Disruptions can slow the delivery of essential equipment. Hotels operate on fixed renovation windows, so delays may force deferrals of entire projects.

Market Risks and Customer Behaviour Constraints

Cost sensitivities

Hotels may need to pass some decarbonisation costs on to guests. In competitive markets, higher prices can reduce occupancy and revenue, especially for midscale and budget hotels.

Uncertain consumer demand

While many travellers say they value sustainability, not all are willing to pay more for sustainable stays or to make changes to their behaviours. This limits the commercial incentive for hotels to invest aggressively.

Reputational risks

If guests perceive sustainability initiatives as service reductions—such as reduced cleaning, limited air conditioning, or smaller menus—hotels may face negative reviews, even if changes align with decarbonisation goals.

EnergySystem and Infrastructure Risks

Grid capacity constraints

Electrification (heat pumps, EV chargers, induction cooking) increases electricity demand. In some regions, however, grid infrastructure is insufficient.

Dependence on national energy mixes

Hotels in countries with more carbon-intensive grids may find that electrification does not immediately reduce emissions to expected levels, complicating climate-target reporting.

Energy price volatility

Energy markets remain unstable. Even as efficiency improves, hotels remain exposed to volatility in electricity prices, which can undermine the expected financial savings from decarbonisation.

Decarbonising the European hotel sector is both essential and inevitable, but the journey is constrained by a range of limitations and risks. Financial, technical, operational, regulatory, and market limitations can slow progress or lead to suboptimal outcomes. For hotels, the key to navigating these risks lies in long-term planning, robust feasibility assessments, cross-sector collaboration and investment in skills and data systems. For policymakers and industry associations, streamlining regulations, improving access to finance, and building strong support networks are essential to ensure that decarbonisation is both achievable and commercially sustainable. With the right risk-management strategies and support mechanisms in place, European hotels can transition effectively to a low-carbon future while preserving guest satisfaction and business performance.

7. CONCLUSIONS AND FUTURE OUTLOOK

A survey conducted across 19 tourism entities in various European countries provides valuable insights into the current penetration of sustainable energy systems in the tourism sector and the drivers and barriers influencing investment decisions. The participating entities—primarily hotels, resorts, and eco-lodges—have already implemented a range of sustainable energy technologies, such as solar thermal systems, solar photovoltaic installations, biomass boilers, heat pumps, advanced building energy management systems, and energy-efficient Heat Ventilation and Air Condition (HVAC) solutions. Their experiences present a representative snapshot of the sector's decarbonisation trajectory.

The survey indicates that all 19 tourism entities have adopted at least one sustainable energy system, confirming a clear sectoral shift away from fossil fuels. Solar technologies emerged as the most common solutions—particularly solar thermal for water heating and solar-PV systems for electricity production. Heat pumps and biomass boilers followed, mainly in regions with supportive regulatory environments and favourable climatic conditions. However, deployment levels are uneven. Larger hotels and resorts tend to adopt more complex systems (e.g., integrated heat pump loops, large solar-PV arrays with battery storage), while smaller, independent entities usually implement lower-cost

measures due to budget constraints. This suggests that decarbonisation is advancing, but not uniformly across the sector.

The adoption of sustainable energy technologies resulted in significant carbon-emissions reductions. Entities with multiple complementary systems—such as solar-PV systems combined with heat pumps or biomass—reported the highest reductions. Additionally, the shift away from fuel oil and LPG (Liquefied Petroleum Gas) toward electricity-based heating solutions (powered partly by renewable energies) further supported emissions savings. The majority oftourism-related enterprises achieved improvements in operational efficiency, including lower electricity and thermal energy consumption per guestnight. These findings indicate that sustainable energy investments deliver both environmental and economic benefits. The payback period of the implemented sustainable energy investments in most surveyed tourism entities was satisfactory.

The study confirms that financing was secured through a mix of:

- Own capital – the most common source, allowing quicker decision-making but limiting scale.
- Bank loans – used primarily for medium-scale investments; however, financing terms varied widely across countries.
- Public subsidies – highly influential in making larger renewable energy projects financially viable.

Public programmes—whether EU-level, national, or regional—played a decisive role. Entities receiving subsidies were more likely to implement higher-impact technologies such as heat pumps or biomass boilers. It is noticed that without subsidies, payback periods would have been significantly longer, making some investments unattractive.

Several tourism entities had limited know-how related to system design, contractor selection, and operational know-how. Smaller tourism businesses had limited in-house expertise, which sometimes led to suboptimal system sizing, integration issues, or poor monitoring and maintenance. Additionally, the lack of reliable data on energy use before and after upgrades made it difficult for many tourism entities to quantify benefits precisely.

The regulatory landscape is fragmented and overly complex. Differences in permitting procedures, eligibility rules for subsidies, and technical requirements across European countries have created uncertainty and delays. This is especially problematic for borderline cases such as heritage buildings, island locations, and protected natural areas.

Future Outlook

Drivers for further sustainable energy investments include rising energy costs, growing guest expectations for sustainability, and strengthening EU climate policies. As electricity grids across Europe decarbonise further, the emissions benefits of systems like heat pumps will continue to increase. Emerging areas of interest include:

- Battery energy storage systems
- Smart building energy management and digital monitoring
- High-efficiency heat pumps for space heating and cooling
- Electric vehicle (EV) charging infrastructure

These technologies are expected to become more cost-competitive, accelerating sector-wide adoption. The future growth of sustainable energy investments will depend significantly on the availability of predictable, streamlined support mechanisms. There is an important need for simplified subsidy applications, transparent selection criteria, and long-term funding stability. Harmonisation across the EU—particularly for permitting renewable energy installations—would further reduce administrative hurdles.

Capacity-building will be essential for unlocking further decarbonisation. Recommended actions include:

- Training programmes for hotel managers and technical staff
- Online tools to support energy audits and technology selection
- Sector-wide guidelines and best-practice case studies
- Collaboration with energy service companies (ESCOs) and certified installers

Such initiatives would reduce risk and increase confidence in new technological investments.

Green loans, energy-performance contracts, and sustainability-linked financing are expected to become more accessible, particularly for SMEs. Blended financing models—combining private capital with public support—will likely remain central to achieving large-scale transformation.