



WWF is working in partnership with Cambodia Tourism Federation to upgrade cooling systems in Cambodia's hotel sector.

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CAMBODIA TOURISM FEDERATION



**KEEP GUESTS COOL, SAVE MONEY,
HELP THE PLANET**

Upgrading Cooling Systems in Cambodia's Hotel Sector

July 2025

Foreword

Cambodia's tourism sector stands at a defining moment in its journey toward sustainability. As the country rebuilds from the impacts of the COVID-19 pandemic, the hospitality industry has a unique opportunity to lead by example—reducing its environmental footprint while improving competitiveness and guest comfort. Energy efficiency in cooling is central to this transformation.

The study “Keep Guests Cool, Save Money, Help the Planet – Upgrading Cooling Systems in Cambodia's Hotel Sector” is a milestone under the project “Building Back a Climate-Friendly and Inclusive Tourism Sector in Cambodia,” implemented by WWF-Cambodia with funding support from the Swiss Agency for Development and Cooperation (SDC). The project seeks to demonstrate how clean energy and efficient cooling can drive both environmental and economic benefits for Cambodia's hotel industry, paving the way toward a climate-friendly tourism future.

WWF-Cambodia is deeply grateful to SDC for its long-standing partnership and trust in advancing sustainable energy transitions across the Mekong region. We also extend sincere appreciation to our partners—the Cambodia Tourism Federation (CTF) for mobilizing private-sector engagement and championing green competitiveness in tourism, and the Culture and Environment Preservation Association (CEPA) for their collaboration with community-based eco-tourism sites that bring clean energy benefits directly to local livelihoods.

We thank the hotel partners—Raffles Le Royal, Himawari Hotel Apartments, Sunway Hotel, Sofitel Puketra, and Empress Angkor—for their openness and commitment to exploring innovative cooling solutions that balance guest comfort with energy savings. Their leadership has provided invaluable data and insights that will inspire further action across Cambodia's tourism sector.

This report reflects WWF-Cambodia's vision of a tourism sector that thrives economically while protecting the planet. By investing in efficient cooling systems, Cambodia's hotels can lower operational costs, cut carbon emissions, and set new benchmarks for sustainability in Southeast Asia's hospitality industry.

Together—with our donors, partners, and the private sector—we can build a tourism future that keeps guests cool, saves money, and helps the planet.



Chap Vibol

Country Director
WWF-Cambodia

Executive Summary

Project Overview

In response to the challenges posed by COVID-19, WWF-Cambodia launched a project in Cambodia's tourism sector, focusing on energy efficiency and carbon emission reduction in hotels and restaurants. Acknowledging that outdated cooling systems contribute significantly to high energy consumption in some hotels, WWF-Cambodia commissioned this study to explore how the introduction of new equipment can lower electricity bills and CO2 emissions.

The study examined in detail the cooling systems in five hotels and identified significant savings from upgrading chillers and air conditioning systems. Indeed, hotels can save up to \$100,000 per year on their cooling system bills by upgrading their systems, with a payback time as short as three years. This represents a significant opportunity for the sector. A summary of the savings can be found below.

Table 1: Summary of economical cooling investment

Energy Efficiency Measures	Investment Required (\$k)	Savings (\$k/year)	Simple Payback (years)
Hotel #1	366	103	3.6
Hotel #2	448	63	7
Hotel #3	368	60	6
Hotel #4	168	33	5
Hotel #5	47	17	2.7

To finance these investments, hotels may choose from the following options:

- Self-finance: Low upfront cost with quick implementation but higher risk.
- Bank loans: Medium project cost with medium-sized risk.
- Energy Service Company (ESCO): Higher (long-term) project cost with lower risk.

However, challenges remain in realizing these energy efficiency investments. A primary issue is the "**split incentive**" or "**ownership-management disconnect**," where owners often prioritize short-term financial gains over long-term energy savings and are reluctant to enter long-term contracts due to the potential for hotel sales. Additionally, the inherent **uncertainty within the hotel business**, exacerbated by a slower-than-expected post-COVID recovery, makes owners hesitant to commit to long-term energy efficiency investments. Finally, hotels often exhibit a **reluctance to embrace collaborative, shared-benefit arrangements** with maintenance firms and equipment suppliers, desiring full control over their systems while being unwilling to share the financial rewards of new, efficient installations, even when providers assume upfront risk or offer performance-based contracts.

Addressing these challenges requires a multi-pronged approach.

1. To overcome the split incentive, it's crucial to **articulate the comprehensive financial value of energy efficiency** to both owners and management, emphasizing enhanced asset value and operational savings while fostering a shared sustainability vision and clear communication. This study contributes to this challenge by providing a neutral perspective. Other studies in different hotels can help build a strong evidence base for management decisions.
2. To address the challenges posed by market uncertainty, a **phased implementation strategy** can mitigate risk. Hotels can start with smaller, less capital-intensive projects that offer quicker returns, building confidence for gradual investment as market conditions stabilize. The recommendations in this report are primarily phased.
3. To combat the "control versus shared benefit dilemma," **showcasing successful case studies of shared benefit models** that illustrate their financial advantages can help build trust and demonstrate how partnerships can de-risk projects for the hotel while ensuring performance and long-term savings. Beyond energy efficiency investments, hotels can also implement measures to boost the performance of their existing systems. This includes:
 - Conducting regular and thorough maintenance of cooling systems, including water analysis, leak inspections, and cleaning.
 - Maintaining indoor temperatures between 24-26°C with visible reminders.
 - Implementing strategic operational optimizations, such as running multiple smaller chillers at partial capacity and rotating their use.
 - Introducing monitoring systems, from basic sensors to comprehensive Building Management Systems (BMS), which are highly recommended.
 - Utilizing energy-efficient distribution equipment like IEC3/4 class pumps and Variable Speed Drives (VSDs).

Collectively, these actions can reduce energy bills and carbon emissions. More technical details can be found in this report.

1. CONTEXT OF THE STUDY

Recognizing the need for sustainable energy solutions, the Royal Government of Cambodia (RGC) introduced the National Energy Efficiency Policy (NEEP) for 2022-2030. This policy outlines ambitious goals to reduce total energy consumption by at least 19% by 2030. Particularly, the commercial sector is targeted for a 25% reduction, which represents one the largest reduction among all sectors (energy consumption expected to drop from 8,552 GWh to 6,431 GWh). Cooling technology is a key focus of this plan, as it accounts for a significant share of energy demand.

Cambodia's hotels face high energy consumption due to outdated cooling systems. While electricity tariffs are relatively affordable, they remain slightly higher compared to those in neighboring countries. The adoption of new technologies offers a chance to reduce electricity bills and CO2 emissions. Embracing these innovations not only benefits the hotels but also opens significant opportunities for green finance investment.

Funded by the Swiss Agency for Development and Cooperation (SDC), the project entitled "Building Back a Climate-Friendly and Inclusive Tourism Sector in Cambodia" was launched in September 2022. Its goal is to facilitate the sustainable energy transition of the Cambodian tourism sector through the adoption of efficient cooling solutions in hotels.

WWF-Cambodia is implementing the Cool and Solar project within the tourism sector, aimed at reducing carbon emissions from hotels and restaurants. Sevea and MEP-E, a specialized consultancy, are assisting five selected hotels in Phnom Penh and Siem Reap in adopting more efficient cooling systems.

2. ACTIVE COOLING SYSTEMS FOR HOTELS IN CAMBODIA

Split Inverter: A type of air conditioning system consisting of an indoor unit and an outdoor unit. The inverter technology allows the system to adjust the speed of the compressor motor to maintain a consistent temperature and reduce energy consumption.

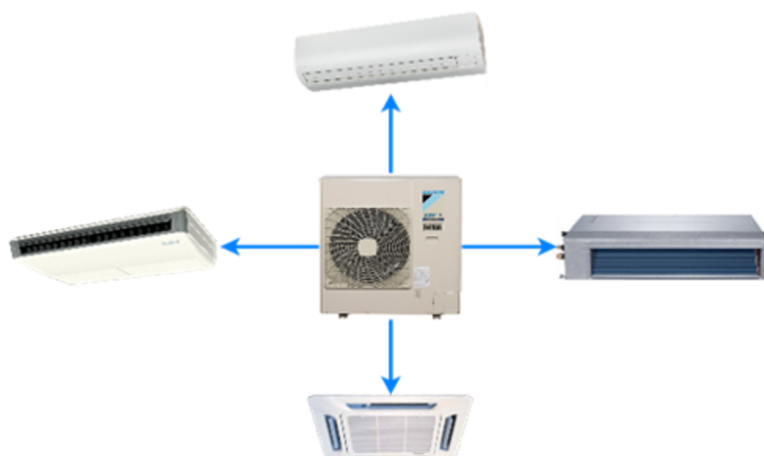


Figure 1: Split-type air conditioner system

Variable Refrigerant Flow (VRF):

A type of air conditioning system that uses multiple indoor units connected to a single outdoor unit. This system can adjust refrigerant flow to each indoor unit based on the room’s needs, providing more precise temperature control. Split systems are generally more suitable for small hotels.











Figure 2: VRF air conditioning system

Chiller System: A chiller is a sophisticated cooling system designed to handle the cooling needs of expansive spaces such as commercial buildings, industrial facilities, and large-scale processes. Unlike conventional inverter air conditioning systems, which rely solely on refrigerant gas to directly cool air, chillers employ water as a primary cooling medium. This approach provides a more efficient and versatile solution for managing substantial cooling demands.



Figure 3: Air-cooled and water-cooled chiller systems
 Table 2: Key attributed on the chiller, VRF, Split AC systems

	 Typical Use Case	 Control	 Investment Cost	 Efficiency & Performance	 Installation Complexity
	Small spaces (e.g., residential, smaller hotels)	Individual systems	0.6 time the cost of VRF	COP:3.5-5	Installation and maintenance simpler with lower cost
	Medium and large spaces (e.g., offices, hotels, hospitals)	(Medium) Centralized systems	Reference	COP: ~4	Higher installation and maintenance skills and cost compared to split
	Large spaces (e.g., hotels, hospital, supper markets, commercial buildings)	Centralized systems	1.5 times the cost of VRF	COP: 4.6	Requires continuously water supply for water-cooled chiller

Key: Excellent Good Fair Challenge Neutral

In summary, chillers are highly efficient but require a higher investment and are more challenging to install. VRF systems provide a compromise between these two solutions.

Table 3: Available cooling requirement suppliers in Cambodia

No.	System	Supplier Available in Cambodia
1	Split system	         
2	VRF/VRV system	         
3	Chiller	     

3. COOLING SYSTEM RECOMMENDATIONS FOR HOTELS

The following recommendations are based on the situation of hotels in 2024. Most of them are operating at low to medium occupancy levels. If hotel occupancy increases significantly, it may affect the applicability of the recommendations. However, considering the instability of the tourism sector and recent unforeseen events (e.g., COVID-19), the recommendations remain relevant in any scenario where future occupancy levels are uncertain.

A. New Hotels

General Recommendation: Avoid installing air conditioning in common areas such as halls, corridors, and walkways. Instead, prioritize passive cooling strategies and the use of ceiling fans, even in large halls, to maintain acceptable thermal comfort while significantly reducing energy consumption. Focus on cooling only where it is truly essential, and avoid cooling circulation spaces where occupants do not stay for extended periods.

Hotel Type: Small/Medium Hotels or Large Hotels without Air-Conditioned Common Areas

Recommended System: Split / VRF system

For Guest Rooms: Prioritize split systems for energy efficiency, although they have a higher environmental impact compared to chiller systems. This approach will optimize energy consumption during high occupancy and especially reduce consumption during periods of low occupancy.

For Large Areas (e.g., halls, conference rooms, ballrooms): Prioritize VRF systems over the high cost of installing a chiller.

Hotel Type: Large Hotels with Air-conditioned Common Areas

Recommended System: Chiller system

For new hotels, the recommendation is to install centralized chillers only if they can be set up with different capacities and automated rotation to adapt to varying occupancy levels and ensure optimal performance, ideally operating between 60-80% of their full load capacity. If this recommendation is not fully considered, then recommendation A (split + VRF) needs to be implemented.

B. Existing Hotels

Chiller Replacement:

For new hotels, the recommendation is to install chillers only if they can be set up with different capacities and automated rotation to adapt to varying occupancy levels and ensure optimal performance—ideally operating between 60-80% of their full load capacity. If this recommendation is not fully considered, then recommendation (a) needs to be implemented.

If replacement is required, replace chillers with high-efficiency models. If not already done, ensure the system includes chillers with different capacities and automated rotation to adapt to varying occupancy levels and ensure optimal performance, ideally operating between 60-80% of their full load capacity.

Split / VRF System Replacement

If replacement is needed, replace split units with newer technology (inverter) split systems. Ensure proper F-gas recovery by certified suppliers (e.g., Lotus Green Team, Comin Khmer) to demonstrate your commitment to a sustainable approach.

General Note: Check the installation of new equipment upon delivery.



4. COOLING SYSTEM RETROFIT INVESTMENT IN CAMBODIA

Table 4: Potential upgrades for existing cooling systems (based on cooling assessment study of the 5 hotels in Cambodia)

System	System Upgrade Options	Typical Cost in Average Size Hotel*	Investment Opportunities**
Split System	Replacing conventional air conditioners with inverter systems or old inefficient air compressors with new ones.	~\$500-\$1,500 depending on the room type and size.	Units older than 10 years: Up to 40% energy savings.
Chiller System	Replacing old inefficient chillers with new high-energy efficiency chillers.	High-end brand: ~\$300,000-\$400,000 Mid-range brand: ~\$150,000-\$200,000	Older than 25 years with no proper maintenance or rotation (COP~2.0): Replace with COP 6.0 chiller for up to 66.7% energy savings.
			Older than 25 years with proper maintenance and rotation (COP~3.5): Replacement with COP 6.0 chiller for up to 41.7% energy savings.
			Older than 15 years with proper maintenance and rotation (COP~4.0): Replacement with COP 6.0 chiller for up to 33.3% energy savings.
	Replacing old inefficient cooling towers to new high-energy efficiency cooling towers.	~\$15,000-\$25,000	Old inefficient to new efficient: 2% energy savings
	Replacing old inefficient distribution pumps to IEC3 or IEC4 motors for higher energy efficiency.	~\$2,500-\$4,500	Replacement from IEC1 to IEC3/IEC4 motor: Up to 4% energy savings.
Installation of VSD or VFD to reduce full load energy consumption.	~\$3,000-\$4,000	-	








*: The average cost presented here was collected from local suppliers and adjusted to fit the cooling system of each hotel.

** : The cooling investment opportunity savings are based on the studies of the 5 hotels.

5. FINANCIAL OPTIONS

This section provides a brief overview of financial options for hotels to consider, including self-financing, bank loans, and Energy Service Companies (ESCOs). Although the ESCO model is relatively new to the Cambodian market, this section also presents a brief overview of its affecting factors and disadvantages.

Table 5: Key attributes for financial options of self-finance, loan, and ESCO

	 Overall Project Cost	 Risk	 Time for Implementation	 Example
 Self-Finance	Low	Medium/High	Quick	
 Loan with Bank	Medium	Medium	Medium	World Bank/ADB loan
 Energy Service Company (ESCO)	Higher (long-term), with lower upfront costs	None - Low	Medium	BECIS/Green Yellow

Key: Good Fair Challenge

Energy Service Company (ESCO) financial model: Energy Performance Contract (EPC) based on Shared Savings Model.

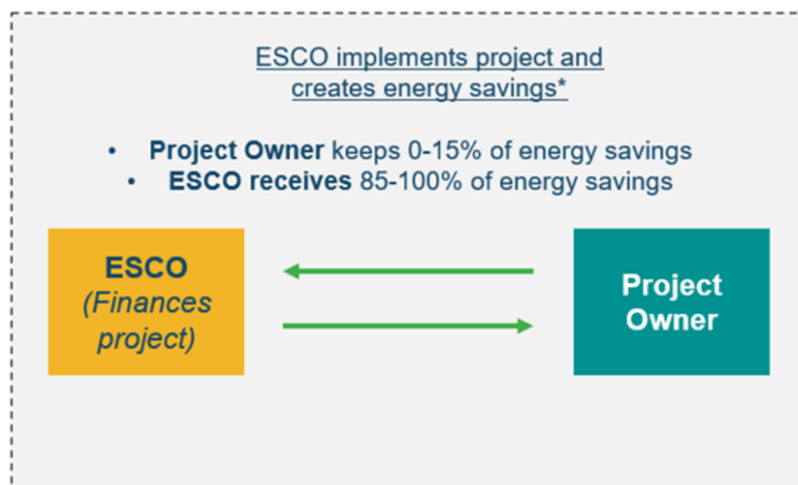


Figure 4: Structure of ESCO model

Factors that affect energy savings include the total cost of the project, total energy savings, contract length, and associated risks.

Advantages of ESCO:

- In-depth knowledge and expertise (including on novel or larger-scale technologies).
- Guaranteed energy-saving performance.
- Solutions tailored to business needs.
- No investment needed from the owner.
- Project owners share energy savings with the ESCO over the contract period.

Disadvantages of ESCO:

- Perceived loss of control over the system.
- Long engagement required for both parties.

6. CHALLENGES

Financing energy efficiency in the hotel sector faces significant challenges.

Firstly, the hotel sector has complex ownership structures, leading to often divergent interests between owners and management. Owners, who control capital allocation, are typically not involved in daily operations and may prioritize short-term financial objectives over long-term energy savings. They may also be considering potential sales or major refurbishments in the medium term, dissuading them from committing to long-term contracts.

This creates a "split incentive" or "ownership-management disconnect," where the responsibility for operational costs lies with management, yet investment authority rests with ownership. To address this, it is crucial to articulate the comprehensive financial value of energy efficiency to both parties, emphasizing enhanced asset value and operational savings. Fostering a shared sustainability vision and establishing clear communication channels are essential.

Another challenge is the inherent uncertainty within the hotel business, exemplified by fluctuations in occupancy rates and heightened market competition. In Cambodia, hotels continue to struggle to achieve pre-COVID occupancy levels. This uncertainty often makes owners hesitant to commit to long-term energy efficiency investments. A phased implementation strategy, beginning with smaller, less capital-intensive projects that offer quicker returns, can mitigate this risk, build confidence, and allow for gradual investment as market conditions stabilize.

Furthermore, a barrier arises from hotel owners' reluctance to embrace collaborative, shared-benefit arrangements with maintenance firms and equipment suppliers. Hotels often seek to retain complete control over their systems while being unwilling to share the financial rewards of new, more efficient installations, even when providers assume upfront risk or offer performance-based contracts.

This "control versus shared benefit dilemma" reflects a desire to avoid risk without sharing potential gains, thereby hindering the adoption of innovative financing models such as energy performance contracts. Showcasing successful case studies of shared benefit models and illustrating their financial advantages can help build trust and demonstrate how such partnerships can de-risk projects for hotels while ensuring performance and long-term savings.

Table 6: Challenges on cooling investment and potential solutions

Challenges	Potential Solutions
Ownership vs. Management Disconnect	Showing the value of energy efficiency to hotel owners and managers
	Create a shared vision between owners and management
Future uncertainty of hotel business (current low occupancy rates, increased competition)	Implement a phased strategy for energy efficiency projects
Control vs. Shared Benefit Dilemma	Positive case studies of these shared benefits models' financial incentives for these arrangements

7. ENERGY EFFICIENCY RECOMMENDATION BEYOND INVESTMENT

This section explores energy efficiency recommendations that extend beyond significant financial investments, focusing instead on optimized operations, maintenance, and smart management of existing cooling technologies.

Table 7: Technical recommendations on cooling technologies

	Chiller	VRF	Single Split
Indoor Temperature Setting	Set the temperature to 24-26oC, Place visible reminders (stickers, posters) on remote controls and walls to raise awareness.		
Maintenance	<p>Annual water analysis and treatment. Regular maintenance of the water chiller, including monitoring compressor oil levels, inspecting oil and gas filters, cleaning the chiller, and replacing oil filters. Monthly leakage inspections; leaks should be fixed immediately. Acceptable leakage rate is below 0.01%. Regular inspections and cleaning of cooling towers. Ensure current reports from the manufacturer include the COP of their installation.</p> <p>Undergo a proper retro-commissioning process to ensure optimal performance before considering investments in new equipment.</p>	<p>Regular maintenance of outdoor and indoor units every 3 to 6 months, depending on operation.</p> <p>Ensure good thermal insulation in all refrigerant circuits.</p> <p>When replacements are made, F-gas must be properly recycled by experienced companies (e.g., Comin Khmer or GIST). The gas should be recycled or sent for destruction at Chipmong Cement Factory. Always request a certificate of destruction.</p>	

Monitoring	<p>Install sensors and monitoring equipment to measure performance, helping to determine when maintenance or replacement is needed. Implement building management systems for proper monitoring and control of the chiller system, as well as power and cooling usage.</p>	<p>An electric key card system is necessary. Granular monitoring is recommended but optional due to cost.</p> <p>Perform regular monitoring with a power recorder to trigger replacement if power usage is significantly higher than new equipment.</p>
Cooling Capacity	<p>Standard ratio for cooling capacity: 100-200 W/m².</p>	
Heat Recovery	<p>Heat recovery can be used to cover pre-heating hot water use.</p>	<p>For rooms where the outdoor units of split systems have exceeded their warranty period, upgrade the refrigerant circuit to incorporate a heat recovery system that bypasses the condenser and repurposes heat for hot water production.</p>
Operational Optimization	<ol style="list-style-type: none"> 1. Run/install multiple smaller chillers at 60% capacity instead of one large unit. 2. Use multiple chillers to match only the required cooling capacity. 3. Rotate chillers on a regular schedule (e.g., daily or weekly). 4. If no new investment is planned, replace one chiller, and run it continuously. 	<p>Assign guests to rooms with new AC units or prioritize room assignments based on newer requirement.</p>
	<p>Integrate energy efficiency (EE) practices into staff operating procedures.</p>	
Distribution Equipment	<ol style="list-style-type: none"> 1. IEC3 or IEC4 pumps are recommended. 2. Use Variable Speed Drives (VSD) for condenser and distribution pumps. 	<p>No distribution equipment specified.</p>

APPENDIX: HOTEL COOLING STUDIES

Hotel #1: Cooling System Assessment Summary

The hotel has three chillers, typically using one at a time, with a second activated during large events for extra cooling. The third chiller is inactive and serves only as a backup. The cooling system supports guest rooms, each equipped with individual fan coil units (FCUs), along with 79 FCU units in common areas, totaling over 288 FCU units and 27 air handling units (AHUs). Chiller #1 accounts for 31% of the total energy consumption, which is 2,616 MWh.

Key Findings:

- **Old Equipment:** The primary chiller, pumps, and cooling tower are from 1997, using outdated technology, including R-123 refrigerant, which has now been phased out.
- **Chiller Risk:** The old age of the equipment means that a failure of the main chiller could result in an outage of all cooling systems, which could temporarily shut down the hotel if proper backups are not in place.
- **Poor Performance:** The current chiller (Chiller #1) has a Coefficient of Performance (COP) of 2.13, whereas modern chillers can achieve a COP of 4 to 6. This discrepancy results in excessively high electricity bills and increased carbon emissions. In theory, replacing the existing chiller could lead to energy consumption that is up to three times lower than that of current chillers.

Proposed Solutions and Investments

Energy Efficiency Measure	Investment (USD)	Energy Savings (MWh/year)	Savings (USD/year)	Simple Payback Period (Years)	Carbon Emission Reduction (TeqCO2)	Remarks
Full replacement of 2 chiller systems	\$733,400	700	\$111,253	6.6	288	Can be considered if occupancy levels
Chiller system #1 replacement	\$366,700	650	\$103,302	3.6	267	Recommended

Current assessment indicates that both chillers (Chiller #1 and Chiller #2) are generally operating and covering the load at approximately 86%. Chiller #1, the primary unit, has a maximum load capacity of 90% and is used on a daily basis, while Chiller #2 provides additional support during larger events.

Replacing both chillers simultaneously would optimize the power load distribution between them, allowing for joint operation at 50-60% capacity. This improved balance would enhance performance by around 8% and lead to energy savings. While this approach may slightly extend the lifespan of the equipment, the investment cost is relatively high (\$733k), while energy efficiency gains are limited (700 MWh/year vs. 650 MWh/year) compared to the next option described below.

Replacing only Chiller #1 along with its associated pump sets and cooling tower could result in energy savings of up to three times compared to current consumption levels. This option also reduces the financial burden compared to replacing both chillers at the same time and results in a much shorter payback period.

Therefore, replacing only the primary chiller system is recommended due to the lower investment cost, shorter payback period, and significant savings from reduced energy consumption, while adequately meeting the hotel's current cooling needs and allowing for possible modest future expansion of the ballroom.

Hotel #2: Cooling System Assessment Summary

The hotel is equipped with three chillers. Chiller #3 (CH3) serves as the primary chiller and alternates operation with the two other chillers based on actual cooling demand throughout the day and night. The primary chiller system consumed 21% of the hotel's total energy consumption, amounting to 1,638 MWh, which translates to approximately \$260,000 spent annually on cooling demand alone.

Key Findings:

- **Inefficient Pumps:** The distribution pumps of the chillers date back to 2004. These pumps operate at a lower efficiency class (IEC 1) compared to modern pumps (IEC 4). The secondary pump's power load sometimes exceeds its rated power, which can cause overheating, loss of efficiency, and reduced motor lifespan.
- **Cooling Tower Inefficiency:** A high-temperature difference in the cooling tower's return water system indicates that the tower is not cooling water to the required temperature.
- **Aged Cooling System:** The current chillers are older than 2012 and use R-134A refrigerant, which has been phased out due to its high global warming potential. While these chillers have an acceptable Coefficient of Performance (COP) of 4.1, newer technologies can achieve COP ratings of up to 6. Upgrading to a new chiller would enhance performance and provide significant energy savings.

Proposed Solutions and Investments

Energy Efficiency Measure	Investment (USD)	Energy Savings (MWh/year)	Savings (USD/year)	Simple Payback Period (Years)	Carbon Emission Reduction (TeqCO2)
Replacement of 1 chiller (chiller #3) and its control equipment	\$410,000	321	\$50,784	8.1	103
Replacement of the cooling tower	\$26,000	20	\$3,207	8.1	8
Replacement of the distribution pumps and installation of VSDs	\$12,000	28	\$4,424	2.7	11.5
Review the existing settings VSDs the for the secondary pumps	\$500	29	\$4,582	0.1	12
Total	\$448,500	398	\$62,997	7.1	134

To enhance energy efficiency and yield substantial savings, It is strongly recommended to review the settings of the pump Variable Speed Drives (VSDs). This review incurs an estimated cost of \$500 and has the potential to generate savings of up to \$4,582 per year.

Moreover, It is advised to replace the existing pumps with a carefully selected number of new energy-efficient models, alongside the installation of Variable Speed Drives (VSDs). By prioritizing the operation of the new pumps, the Simple Payback Period (SPP) for these upgrades can be optimized to ensure a maximum financial benefit of \$4,424 per year.

It has been identified that the cooling towers are currently underperforming. To address this issue, it is recommended to activate the additional cooling towers currently in place to meet cooling demands. If this does not yield the desired results, the replacement of these towers with new, more efficient models is advised to enhance overall performance.

Finally, in the medium term, it is recommended to replace the main chiller, even though it has a good Coefficient of Performance (COP) of 4.1. This could lead to maximum savings of \$50,784 per year, with an estimated Simple Payback Period (SPP) of 8 years; however, this period could be reduced to 4 years with constant operation of the new chiller. If the chiller cannot be replaced due

to financial constraints, it is suggested to set up a monitoring system. This system will help improve the performance of the pumps, chillers, and cooling towers, leading to more efficient operation and cost savings while eliminating excessively cold conditions in the ballroom when it is only partially used.

Hotel #3: Cooling System Assessment Summary

The hotel has two chillers, typically operating one at a time. They alternate daily to ensure efficient cooling and prevent wear on a particular unit. The cooling system represents 47% of the hotel's total energy consumption, amounting to \$196,000 per year.

Key Findings:

- **Outdated Cooling System:** The hotel's cooling system, established in 1997, uses R-22 refrigerant chillers, which have been phased out due to their high global warming potential. These chillers have a Coefficient of Performance (COP) of 3.6, much lower than modern systems that can reach up to 6.
- **Inefficient Pumps:** The distribution and condenser pumps date back to 1996 and lack Variable Speed Drives (VSDs), leading to constant power consumption regardless of cooling demand. These pumps operate at a lower efficiency class (IEC 1) compared to modern pumps (IEC 4 recommended).
- **Cooling Tower Inefficiency:** A high-temperature difference in the cooling tower's return water system indicates that the tower is not cooling water to the required temperature.

Proposed Solutions and Investments

Energy Efficiency Measure	Investment (USD)	Energy Savings (MWh/year)	Savings (USD/year)	Simple Payback Period (Years)	Carbon Emission Reduction (TeqCO2)
Replacement of pumps and installation of VSDs	\$14,200	74	\$12,136	1.2	30
Replacement of 1 chiller and its control equipment (High-end brand)	\$338,000	279	\$45,756	7.4	115
Replacement of 1 chiller and its control equipment (Mid-range brand)	\$175,000	237	\$38,868	4.5	98
Replacement of the cooling tower	\$16,200	15	\$2,460	6.6	6

Considering the equipment's age, it is recommended to fully replace all production and distribution components of one chiller system, including the distribution pumps and cooling tower, while maintaining the old chiller and associated equipment as a backup. In addition to replacing the old equipment with new units, it is recommended to install Variable Speed Drives (VSDs) for both the distribution and condenser pumps. This installation can either be done with the new pumps or retrofitted to the existing ones, as the investment payback period is advantageous in both scenarios.

Replacing the existing equipment with a high-end brand chiller and installing Variable Speed Drives (VSDs) will save \$60,352 per year for an investment of \$368,400, with a Simple Payback Period (SPP) of 6.1 years. This savings represents 14.5% of total energy consumption with the old chillers. Opting for a mid-range brand chiller, such as Midea or Haier, would cut the investment to \$205,400 and reduce the SPP to 3.9 years, but would lower savings to \$53,464 per year. This option should be carefully weighed against long-term efficiency and performance. The above replacements could be carried out gradually, as this strategy maximizes the substantial energy and cost savings from each individual replacement.

Replacing both chillers at the same time is a possible option; however, it requires a substantial investment and would lead to a longer payback period. Additionally, this strategy is not advisable in the short to medium term, as it conflicts with the hotel's objectives, such as quickly clearing the rooftop spaces. It is recommended to keep the older chiller and its associated equipment (pumps and cooling tower) as a backup. However, regular testing should be conducted to anticipate their replacement in the future.

Hotel #4: Cooling System Assessment Summary

The hotel comprises spacious suites and apartments equipped with separate/split air conditioning units. Currently, 45% of the air conditioning units are from 2023, while 55% are older models from 2006. These split cooling systems consume electricity totaling 580 MWh (32% of total energy consumption), which equates to an annual electricity bill of \$91,640.

Key Findings:

- **Old Split-Type Air Conditioners:** 55% of the air conditioning units are from 2006. An actual measurement conducted at the hotel indicates that the old air conditioners consume 39% more electricity than modern inverter-type air conditioners.
- **Phased-out Refrigerant:** 55% of the old split-type air conditioning systems in the hotel use R-22 refrigerant. Installing new R-22 systems is prohibited because they significantly contribute to ozone depletion.
- **Monitoring System:** The hotel has no energy monitoring system for cooling production.

Proposed Solutions and Investments

Energy Efficiency Measure	Investment (USD)	Energy Savings (MWh/year)	Savings (USD/year)	Simple Payback Period (Years)	Carbon Emission Reduction (TeqCO2)
Replacement of old split-type AC with inverter-type units	\$122,200	122	\$19,208	6.4	50
Assign guests to rooms with new inverter-type AC units	\$0	92	\$14,464	Immediate	38
Heat recovery from the split units for hot water	\$46,000	87.5	\$13,825	3.3	36
Total	\$168,200	301.5	\$47,497	3.5	124

Given that the hotel has established an appropriate temperature setpoint of 26°C and conducts regular maintenance, It is recommended to implement three specific energy efficiency measures (EEMs) to enhance operational efficiency and reduce costs.

First, replace outdated air conditioning units with new, high-efficiency inverter-type models. This investment has an estimated payback period of about seven years. Postponing replacements until operational conditions improve significantly is an option.

Second, optimize energy use by strategically assigning guests to rooms with newer units, avoiding the 55% of rooms that have older units. This approach could save approximately 92 MWh annually, translating to about \$14,464 in savings on electricity bills with no capital investment required. If occupancy rates rise, considering the first recommendation (EEM 1) would be beneficial.

Third, consider upgrading outdoor units for heat recovery from the condenser to produce hot water for each room. This upgrade requires modifications to the refrigerant circuit and has a payback period of just 3.3 years, offering annual savings of about 87.5 MWh or \$13,825 per year for an installation cost of \$46,000. It is recommended to implement this upgrade only after the AC manufacturer's warranty has expired.

It is important to note that implementing EEM 1 would affect the results of EEM 2; hence, they cannot be combined. Management can choose between EEM 2 with EEM 3 or EEM 1 with EEM 3, based on business case analyses.

In conclusion, It is strongly recommended to prioritize EEM 2 as an immediate and strategic step forward due to its cost-saving potential without investment, while conducting EEM 1 over time as the hotel refurbishes and upgrades the remaining rooms.

Hotel #5: Cooling System Assessment Summary

Guest rooms are all equipped with ceiling-concealed split-type air conditioning systems. Some units are inverter-type, while others are not. The cooling systems consume 259 MWh of electricity per year (26% of total energy consumption), equivalent to annual electricity bills of \$40,922.

Key Findings:

- **Condition of the AC Compressor:** The newly replaced compressors of the split-type systems, reportedly from 2023, were actually manufactured in 2019.
- **Harmful Phased-Out Refrigerant:** R-22 refrigerant has been found in the hotel's air conditioning system. This refrigerant has been phased out since 2020 due to its high global warming potential.
- **Monitoring System:** The hotel has no energy monitoring system for cooling production.

Proposed Solutions and Investments

Energy Efficiency Measure (EEM)		Investment (USD)	Energy Savings (MWh/year)	Savings (USD/year)	Simple Payback Period (Years)	Carbon Emission Reduction (TeqCO2)
1	Assigned guests to rooms with new AC units	\$0	10	\$1,563	Immediate	4.1
2	Replacement of the old split AC units	\$19,050	46	\$7,192	2.6	19
3	Heat recovery from outdoor units for hot water production	\$28,000	64.6	\$10,206	2.74	27
Total (EEM 1 & 3)		\$28,000	74.6	\$11,769	2.4	31
Total (EEM 2 & 3)		\$47,050	111	\$17,398	2.7	46

Considering room assignment options, three Energy Efficiency Measures (EEMs) are recommended.

EEM 1: If room assignments can be adjusted, prioritize rooms with newer AC units. This option requires no initial investment, as you likely have enough recent units to cover most bookings, leading to estimated savings of \$1,563 per year on electricity bills.

EEM 2: If keeping the current room assignments is preferred, replace old AC units (over 10 years old) with new inverter-type units. This option requires a \$19,050 investment but is estimated to save \$7,192 annually due to high occupancy.

Additionally, EEM 3 focuses on upgrading outdoor units to enable heat recovery from the condenser, potentially saving 64.6 MWh or \$10,206 yearly. This measure costs \$28,000 and has a payback period of 2.74 years. It is recommended to wait until the AC manufacturer's warranty expires before proceeding with this upgrade.

It is important to note that EEM 1 and EEM 2 are incompatible, as they utilize different energy efficiency strategies. Therefore, the hotel can choose to implement either EEM 1 and EEM 3 or EEM 2 and EEM 3. Additionally, discrepancies have been identified between the reported manufacturing years and the actual production dates of the equipment. It is crucial to ensure that delivered units match the specifications on the delivery order, as older units tend to be less energy efficient and more environmentally harmful.



KEEP GUESTS COOL, SAVE MONEY, HELP THE PLANET- UPGRADING COOLING SYSTEMS IN CAMBODIA'S HOTEL SECTOR



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