White paper

Guest Room Control Systems

How much energy can your hotel save
with Interact Hospitality?

In partnership with:

CUNDALL

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01.
Executive Summary

Tackling the global climate crisis is a responsibility for us all. The way we design and operate buildings can play an important part in the process. And right now, it needs a change of direction. In hospitality, we can reduce greenhouse gas (GHG) emissions within the built environment. After all, it's only through collective action that the commitments made under the Paris Agreement will be met.

It has been estimated that, on average, we'll need to see a GHG reduction per guest room of 66% from 2010 levels by 2030, and 90% by 2050[1], to limit average global temperature increase to 2°C. Some hotels have double the energy intensity of a similar-sized office building, putting a special responsibility on the hospitality sector.

This report has attempted to establish the savings in both energy and cost from a connected hotel guest room control system. We conducted studies that included on-site energy auditing, based on typical occupancy patterns and simulations of cooling energy demands at the individual guest room level. They focused on two scales of hotel in Singapore: a luxury/upscale property and a smaller, midscale hotel, both of which have an operational Interact Hospitality control system. A key difference between the hotels, apart from guest room size is the cooling system. The luxury building operated a water-cooled chiller system, with the midscale hotel used a unitary VRF cooling system.

The results? We have shown that the luxury hotel consumed 28% less energy per guest room at 80% occupancy in contrast to a guest room with no connected smart control system in operation. For a midscale hotel, the expected energy saving would be up to 25% using Interact Hospitality.

On average, for each hotel studied, approximately 65% of these energy savings were due to the Interact Hospitality's integration with the Property Management System (PMS). The remaining 35% energy savings were achieved by the real time occupancy control.

Significant energy savings were seen in all individual controlled systems. The data showed, however, that the bulk of savings overall were attributable to the control of the Air Conditioning and Mechanical Ventilation, which dominates energy consumption in the guest room. Based on typical temperature set-points seen in the different hotels studied, the ACMV energy savings accounted for between 55–65% of total energy savings for the luxury hotel and 65–70% of total energy savings for the midscale property. Overall, however, the data shows that more energy can be saved through the control of a central chilled water system than with a VRF cooling system.

The control of automated blinds, which close when the room is unoccupied, has been shown to yield an energy saving of 4% on the baseline. This figure accounts for the reduction of cooling required in the guest room, due to the reduction of solar radiation when blinds are closed.

Further savings on energy

There's another potential source of energy savings. It comes from the 'adaptive comfort hypothesis', which predicts that air conditioning set to a temperature in the low twenties will feel unseasonably cold in buildings located in hot tropical climates, such as Singapore. The Greenmode uses the bandwith of the adaptive comfort range further to save additional energy. If the guests selects Greenmode, a further energy saving of 10% could be achieved during the guests stay, due to the dominance of the ACMV from an energy stand point.

Although this study has presented cooling energy savings for hot climates such as Southeast Asia and MENA, we would expect to see similar heating energy savings for hotels in temperate climates, such as Europe and North America. For the other systems, i.e. lighting and small power, the potential energy savings presented in this study represent possible figures that hotels around the world might reach.

We have prepared a potential cost-impact analysis for the global market in Table 6. This shows that hotel operators could expect favorable returns on investment, compared to a guest room without a smart control system in operation.

02.
Introduction

2.1. Tackling the Climate Crisis — the role of hospitality

In 2019, the language of the scientific world shifted. For the first time, global warming or climate change gained a new, more alarming term: the 'climate crisis'.

Scientists across the globe agree that the acceptable limit of global temperature rise should be no more than 2°C above the average temperatures reached before the industrial revolution (IPCC). That means we need a 50–80% global emissions reduction from 2010 levels by 2050.[2]

The hospitality industry already accounts for over 1% (UNWTO) of global emissions. And this is set to increase as demand continues to grow. Meanwhile, the built environment as a whole contributes half of all emissions. That is why the International Tourism Partnership (ITP), a global organization with 30,000 member hotels, has embraced the science-based targets at the heart of the Paris Agreement. A report commissioned by the ITP confirms that the global hotel industry will need to reduce its GHG emissions per room per year by 66% from 2010 levels by 2030, and 90% by 2050 [Ref 4], in order to stay within the 2˚C threshold agreed at COP21.

How will this be done?
The ITP report confirms that the vast majority of this reduction target (75%), will need to be achieved on the ground at the building level, through a combination of energy efficiency measures and adoption of renewable energy. This paper discusses how integration of control systems into key building services (HVAC, lighting and power), can play a major role in reaching these targets in a cost-effective way, while still maintaining guest comfort.

66%
of GHG emissions will have to be reduced per room per year from 2010 levels by 2030

90%
of GHG emissions will have to be further reduced by 2050

2.2. The importance of guest rooms

The guest experience
It's clear that the guest room is the most important part of any hotel[3]. The design and layout of each room is vital to guest satisfaction, playing a critical role in ensuring guest loyalty.

The room impacts guests in several ways[4]. As people interact with the space around them, the interior decor and facilities — including lighting, ventilation and air conditioning — need to work together to optimize the overall experience.

Studies undertaken in various markets show that the room was the factor that contributed most to guest satisfaction[5].

Space allocation and revenue
Guest rooms are just as important to hotel operators as they are to visitors. A significant portion of a hotel's operating costs typically goes into servicing them. This includes staff labor costs[6] — which are typically the single largest overhead for a hotel — but also energy. One reason is that guest rooms usually account for the majority of space in a hotel.

Hotels feature three distinct zones[7]: guest rooms, public spaces and service areas. The space allocation between these three zones varies depending on the type of hotel. For example, guest rooms in a mid-range hotel could take up as much as 90% of the floor plan. A large luxury hotel with convention facilities, on the other hand, will typically allocate around 65% of space. Table 1 illustrates the standard space allocation within different types of hotels, based on a combination of good design practice and data collected globally[8].

For hotel operators looking to reduce energy consumption, guest rooms are the perfect starting point. They contribute more towards hotel revenue — including total profit[9] – than other areas, meaning assessment of their use can save significant costs.

		Percentage of total hotel area		
	Typical Number of Guest Rooms	Guest rooms	Public Area	Back-of-House
Mid-range hotel (2-3*)	< 100	90%	5%	5%
All suite hotel (4-5*)	100 – 200	80%	12%	8%
Urban business hotel (4-5*)	100 – 300+	75%	14%	11%
Resort hotel (4-5*)	100 – 500	70%	16%	14%
Convention hotel (4-5*)	300 – 1,000+	65%	20%	15%

Table 1: Typical space allocation to different hotel types

03.
Energy consumption in hotels

Hotels are big players when it comes to energy consumption. They consistently rank among the highest energy consumers of the tertiary building sector, alongside healthcare and some forms of retail[10]. Some hotels consume double the energy per unit floor area than a similar-sized office building, demonstrating that the hospitality industry should be first in line to tackle climate change within the built environment.

Unlike office buildings – where space usage is pretty consistent – different areas of a hotel can be used or occupied at different levels. While most commercial buildings have fixed operating hours, it's difficult to define the core operating hours of a hotel, with visitors coming and going all the time.

One possible explanation for hotels' high energy output is that they are centred around the guest experience, prioritizing the comfort of visitors over anything else, including energy-efficient practices[11].

Despite this, recent studies have shown that hotel guests are increasingly willing to participate in environmental programs. Especially when hotels offer incentives such as loyalty points[12]. These studies have also shown that levels of guest satisfaction are not reduced by sustainability programs.

Energy consumption variance between hotels

Although data shows that hotels are major energy consumers, consumption from one hotel to another can vary greatly[13]. Some hotels can consume vast amounts of energy – up to five times that of a typical office building. Key factors include the type of building (e.g. high rise/low rise), age of the building, type or age of building services systems installed and whether it is a luxury or mid-range hotel. The location of a hotel is a factor too, as climate also plays a big role in how energy is consumed. In short, does the building need to be heated or cooled?

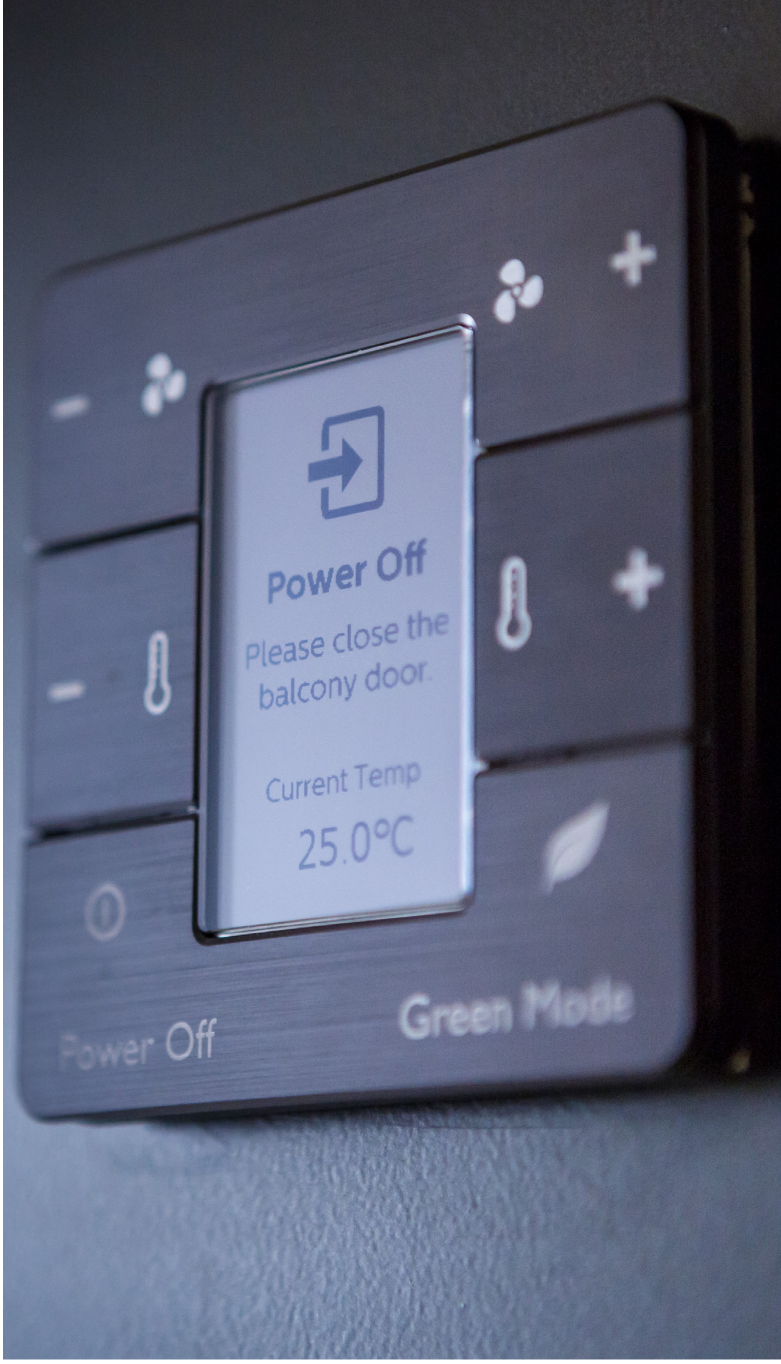
A global energy audit [Ref 5] of over 10,000 hotels, conducted by the Cornell University School of Hotel Administration in 2018, illustrated that this variance is consistent in all global regions, even for similar hotels in the same city. For instance, of the 61 four and five-star hotels audited in Singapore, the average Energy Use Intensity (EUI) was 422 kWh/m².yr. Of these hotels, the minimum EUI recorded was 146.7 kWh/m².yr, with the maximum EUI being recorded — at almost 10 times this figure — at 1,271.6 kWh/m².yr [Ref 04].

To put this into perspective, data collated by the Singapore Building Construction Authority[14] shows that an office in Singapore will typically have an average EUI of between 230–250 kWh/m² yr, with a variance typically of no more than +/- 50–70 kWh/m².yr.

Global trends

Despite these inconsistencies, we can still pick up on trends from region to region. When reviewing the data, some clear similarities emerge.

Figure 1 provides an overview of data [Ref 5] from thousands of three, four and five-star hotels in three different climate zones: temperate, arid and tropical. The average energy consumption of the same hotel types in different regions is markedly similar.



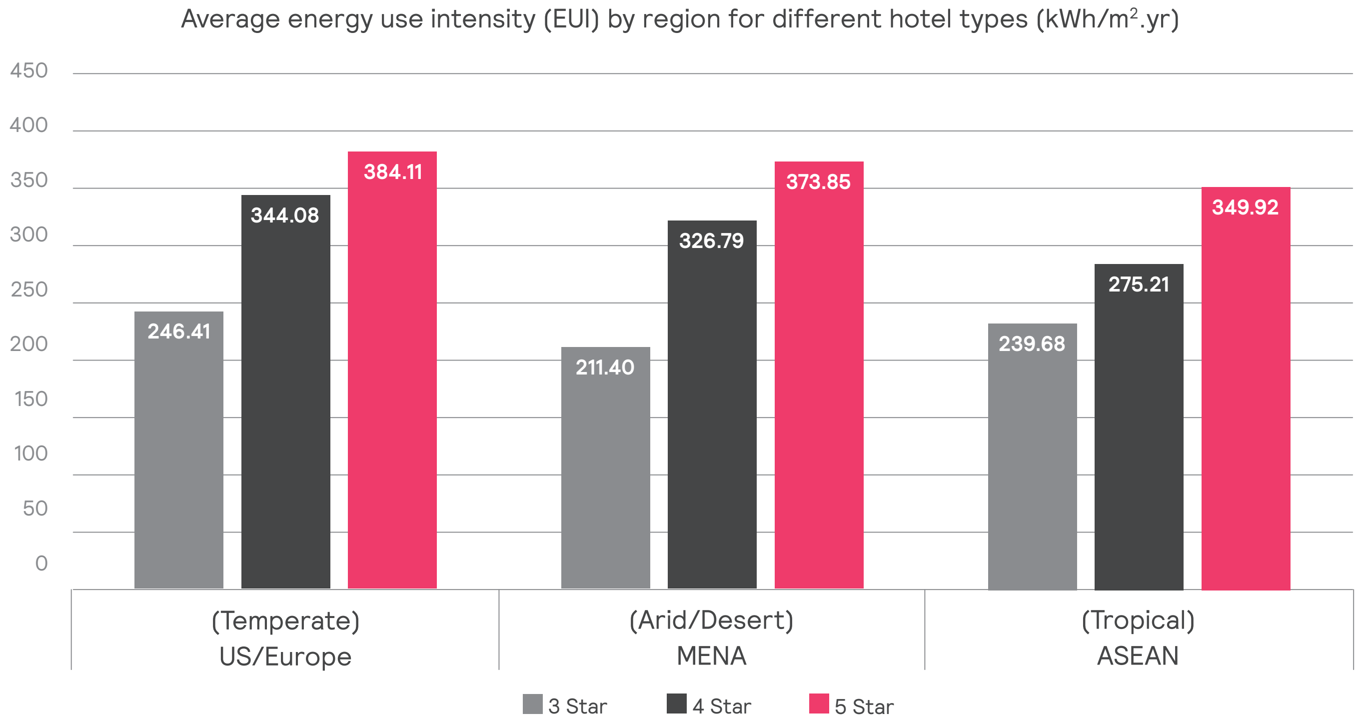


Figure 1: Global trends in hotel energy consumption

Hotel energy consumption breakdown globally
A hotel mostly consumes energy for domestic hot-water heating, space heating or cooling and lighting. Catering areas and other core building services — for example, elevators — are also key energy consumers, particularly for hotels on the luxury end of the scale.

Figure 2 outlines the split of energy consumption between different climates. One clear takeaway is that space cooling or heating typically accounts for between 55–65% of energy consumption in a hotel, whether it's fossil fuel consumption in the case of a gas boiler, or electricity in the case of a chiller plant in hot climates. Lighting consistently uses between 10–15% of a hotel's energy consumption.

As temperature control and lighting use the most energy, solutions to reduce consumption in both of these areas offer potential for significant energy and cost savings.

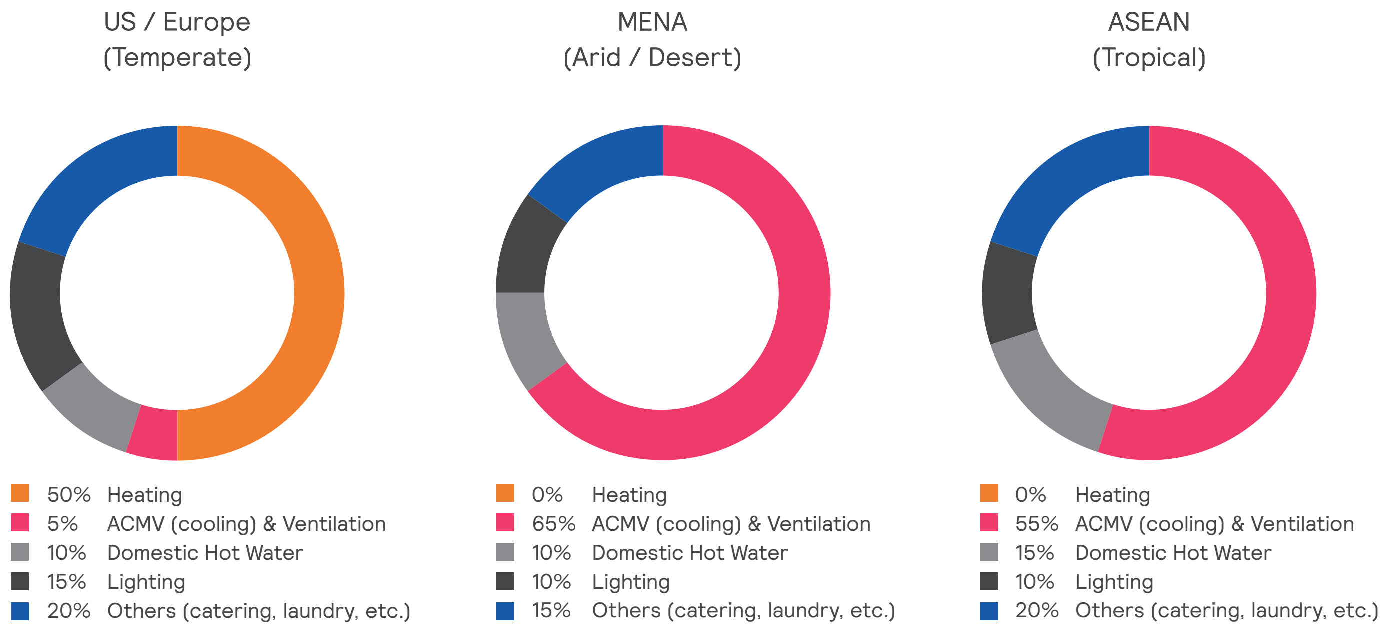


Figure 2: Typical energy consumption breakdown for hotels in different climates

3.1. How guest rooms use energy?

We know that guest rooms account for most of a hotel's space, as well as most of its energy consumption. In order to understand how energy is consumed and to establish how it is affected by guest behavior, it helps to focus on the individual systems involved.

Energy consumption in guest rooms is affected by many factors including:

- occupancy rate of the hotel
- occupancy in the room by the guest
- number of occupants
- size of the room
- building envelope (e.g. specification, area and orientation of glazing)
- HVAC specification and efficiency
- HVAC control systems
- temperature set-points
- lighting specification and control system
- other electrical equipment

Unfortunately, reliable data for how energy is consumed in individual guest rooms is practically non-existent. The cost of installing energy sub-metering individual distribution boards, or branches of chilled or hot water systems, can be unattractive to hotel operators and developers. Even sub-metering by floor is often too expensive for larger hotels.

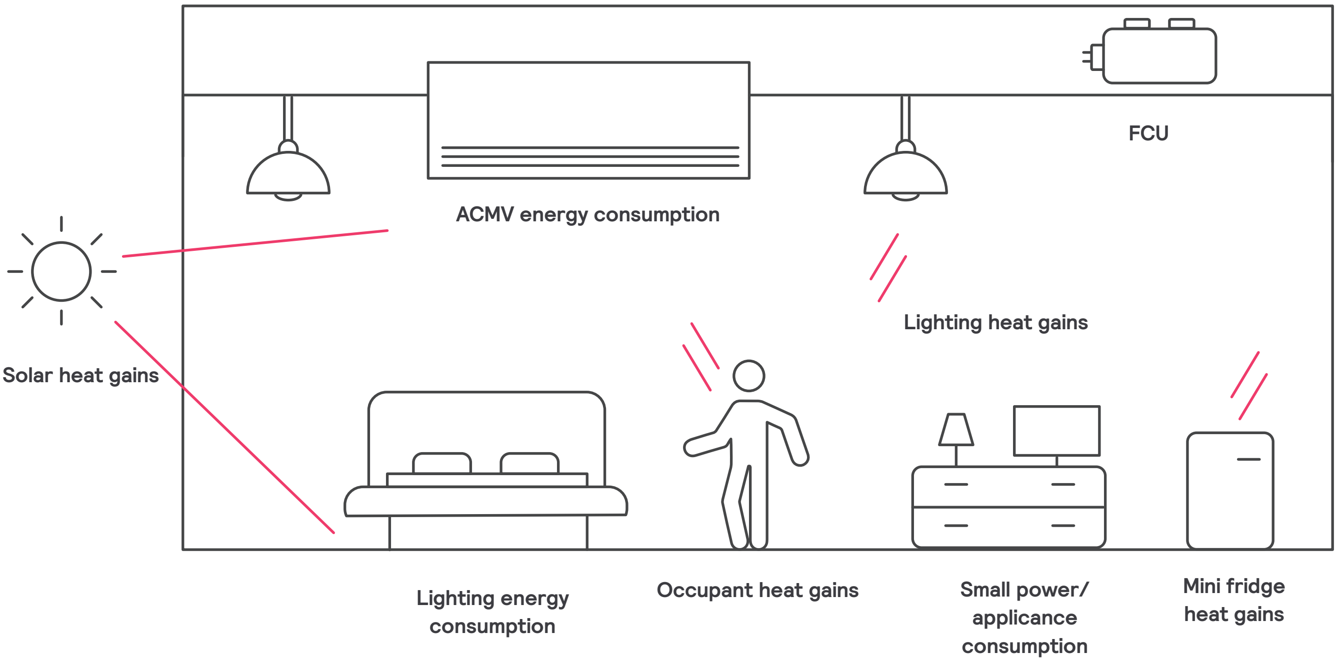


Diagram 1: Energy usage in a hotel guestroom

3.2. Guest rooms

In this study, we established end-use energy consumption benchmarks for both upscale and midscale hotels in Singapore, through a mixture of energy sub-metering and simulation. As described in further detail later in the report, we collated electrical energy data, by simulating typical guest behavior within a live hotel environment. Figure 3 illustrates the baseline with the Interact Hospitality system fully disabled in each hotel. The potential energy savings expected from the Interact Hospitality guest room control system are presented in Section 5.

The luxury/upscale hotel we studied includes a centralized chilled-water cooling system – typical to this type of property – and the midscale hotel is served by a unitary VRV cooling system. In each case, both guest rooms use ceiling-mounted fan coil units and efficient LED lighting. The conditions and assumptions for these baseline energy benchmarks are detailed within Section 5.

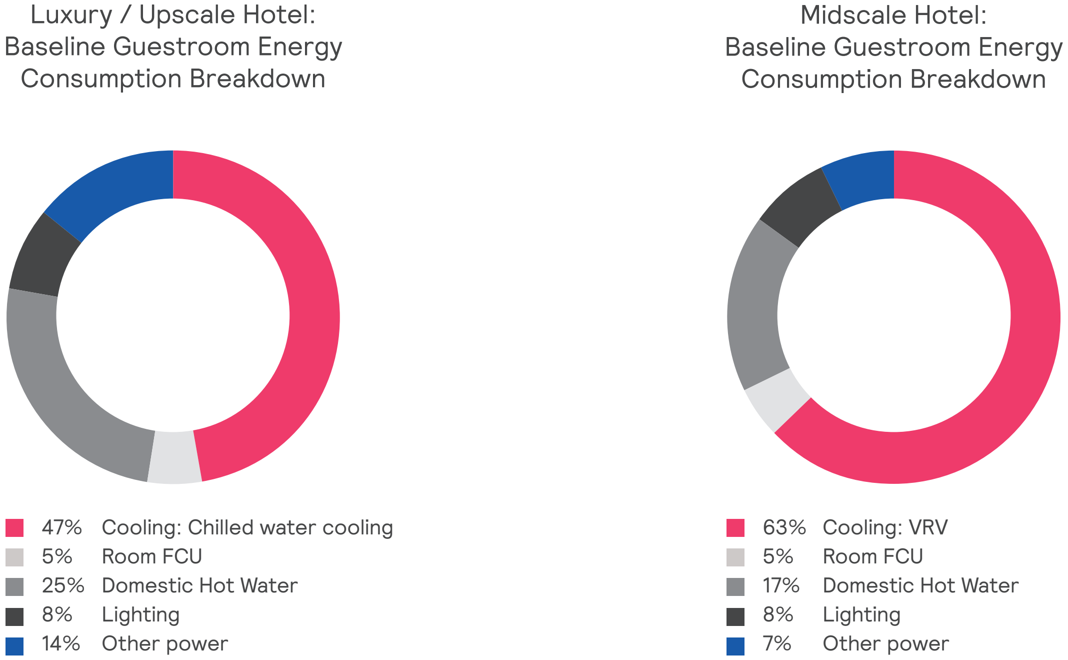


Figure 3: Baseline hotel guest room energy in Singapore

04.
Adaptive Comfort: Pathway to further Energy Savings

In choosing hotels, we needed to determine default seasonal set points for the guests' acceptable range of temperature. Thermal comfort research suggests that the range of temperatures we find comfortable inside buildings is related to the thermal environments to which we have been exposed in our recent past. Evidence shows that the comfortable temperature range drifts up in warmer climates, and sinks to cooler temperatures in the more temperate climate zones[15].

The relationship between the climate and a person's comfort is influenced by a range of biometeorological processes. These include:

- physiological (acclimatizing to your surroundings)
- behavioural (clothing choices)
- perceptual (how you perceive the climate of your living space)

All of these factors have an effect on how we experience the temperature of our surroundings.

This adaptive-comfort hypothesis predicts that air conditioning set to a temperature in the low twenties will feel unseasonably cold in buildings located in hot tropical climates. However in a more moderate climate this does feels comfortable.

A field study in an air-conditioned office building showed that using the adaptive-comfort model improved the thermal acceptance of occupants – while also lowering energy consumption – when compared to the standard ASHRAE thermal comfort model[16].

Other studies have shown that relaxing the thermal comfort criteria (i.e. raising indoor temperatures in warm climates), has a major impact on space-cooling energy consumption, saving more than 40% in tropical regions and regions with a hot summer climate[17]. The findings also suggest that the more control occupants have over their thermal environment in an air-conditioned building, the more they would be more willing to accept temperatures that might be considered uncomfortable (in the standard ASHRAE model).

Greenmode saves additional energy by making use of the complete adaptive comfort spectrum.

Table 2 provides example temperature set-points designers may want to consider for different climate and seasons, based on an adaptive-comfort approach.

Season	Outdoor temp (avg.)	Potential temperature set-point range	
		Low	High
North America / Europe			
Winter	5	18	23
Spring	12	19	23
Summer	23	22	26
Autumn	15	19	23
MENA			
Winter	20	23	25
Spring	25	23	26
Summer	35	24	27
Autumn	28	23	26
Tropical climates (ASEAN etc.)			
Warm season	29	24	27
Cool season	28	23	26

Table 2: Potential acceptable set-point temperature ranges using adaptive comfort approach

05. Interact Hospitality Energy Savings Study

5.1. Aims and objectives

With a limited availability of industry data and with guest rooms playing such an integral role in hotels, we needed a better understanding of how energy is consumed and what influences this. As illustrated in Figure 3, we have established some baseline energy benchmarks for typical hotel types found in Singapore.

This section of the study builds on this baseline data, by establishing the expected energy savings through an integrated hotel guest room control system – in this case, Interact Hospitality. One key objective was to establish the impact of set-point temperature increase for different room states when the room is unsold or the guest away from the room.

As for the baseline figures, the study was carried out through the collation of electrical energy data within a live hotel environment, produced by simulating guest behavior across a 48-hour period, in contrast to the same guest room with no connected smart control system in operation. The data captured during this period was adjusted on a pro-rata basis for the year. We established ACMV energy loads and consumption through simulation, with development of a bespoke energy model that simulated the control by the Interact Hospitality system. The full methodology for the study is provided in Appendix A.

The Interact Hospitality guest room control system has the ability to control the following systems in real-time through the Property Management System (PMS), based on check-in/check-out status and determining realtime occupancy.

- Lighting
- Air Conditioning and Mechanical Ventilation (ACMV)
- Small power
- Automated blinds

5.2. Parameters used

We present savings relative to the baseline energy consumption benchmarks for a luxury/upscale and midscale hotel in Singapore.

These baseline figures represent the energy consumption of a typical guest room without any control system. Energy savings have been determined for each guest room system controlled, which has been established for both the PMS integration and the room occupancy sensor control, where relevant.

The figures presented section have been adjusted based on an assumed annual 80% occupancy rate.

There is a 2°C difference between an unsold room and occupied room for the luxury/upscale hotel and 3°C difference between an unsold room and occupied room for the midscale hotel.

Analysis was conducted for typical set-point temperatures for both standard operation and Greenmode. These are shown in Table 3 for each hotel type.

Guest room Temperature Set-point Scenario	Room state / Set-point temperatures Luxury / Upscale Hotels using CHW		
	Unsold, Unoccupied	Sold, Unoccupied	Sold, Occupied
Baseline: No Control System	23°C	23°C	23°C
Set-points with Interact Hospitality	25°C	24°C	23°C
Greenmode with Interact Hospitality	- -	25°C	25°C

Guest room Temperature Set-point Scenario	Room state / Set-point temperatures for Midscale Hotels using VRF		
	Unsold, Unoccupied	Sold, Unoccupied	Sold, Occupied
Baseline: No Control System	23°C	23°C	23°C
Set-points with Interact Hospitality	26°C	25°C	24°C
Greenmode with Interact Hospitality	- -	25°C	25°C

Table 3:Temperature Set-point Scenarios studied for each hotel type

5.3. Expected Annual Energy Savings

Total annual energy savings per guest room with Interact Hospitality

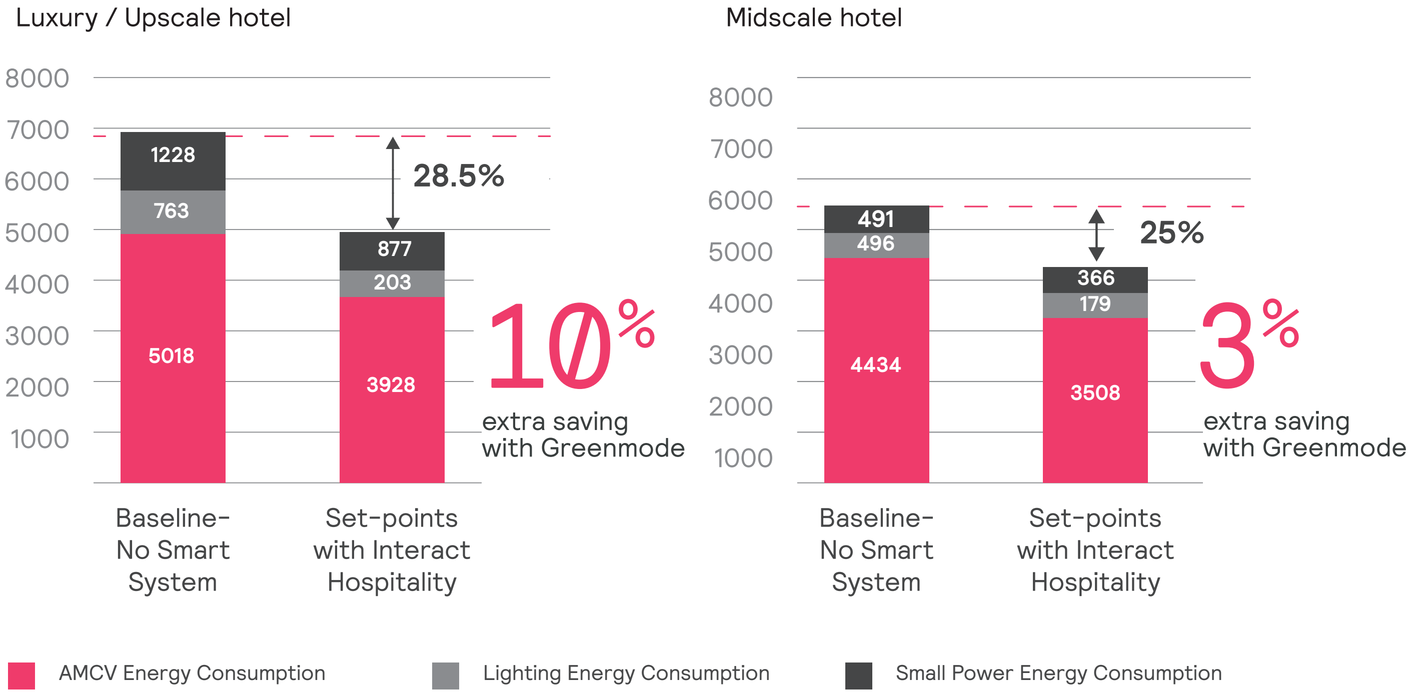


Figure 4: Total Annual Guest room Energy Savings from Interact Hospitality

Total energy savings
As illustrated in Figure 4, with standard set-point temperatures defined in Table 3, we can expect a total energy saving of approximately 25–28% for each hotel type studied through the Interact Hospitality system. This is equivalent to an annual electrical energy saving per guest room of 2000 kWh for a luxury hotel and approximately 1368 kWh for a midscale one, as compared to a guest room without a smart control system.

On average for each hotel studied, approximately 65% of these energy savings were due to the Interact Hospitality's integration with the Property Management System (PMS), while the remaining 35% energy savings being achieved because of the real time occupancy of guests.

5.4. Energy saving related to ACMV

The data shows that potential savings are dominated by the ACMV system, as it's the largest energy demand in guest rooms.
Across the year, hotels might typically experience an 80% occupancy rate on average, as assumed in this study. A room that is in its unsold status is actually in its lowest energy mode. Even at 100% occupancy, rooms can be in this state for almost 20% of the time, because of the hours between guests checking out and new guests checking in.

Since the energy savings achievable are dominated by the ACMV system, we decided to take a closer look at the different set points and the impact on the energy usage. It's clear the shift from a steady-state room temperature (in this case 23°C constantly) to higher temperatures for the different room states, we can expect energy savings of up to 34% in the ACMV system.

Guest room Temperature Set-point Scenario	Room State			% Energy Savings	
	Unsold, Unoccupied	Sold, Unoccupied	Sold, Occupied	VRF system for Midscale hotel	Chilled Water system for Lux/Upscale hotel
Baseline: No Smart System	23°C	23°C	23°C	-	-
Set-point Scenario 1	25°C	24°C	23°C	15%	18%
Set-point Scenario 2	25°C	25°C	25°C	22%	33%
Set-point Scenario 3	26°C	25°C	24°C	21%	30%
Set-point Scenario 4	**26°C**	**25°C**	**25°C**	**24%**	**34%**

Table 5: Scenario analysis of ACMV energy saving with different temperature set-points

As shown in Table 5 more energy savings are expected through Interact Hospitality with a centralized chilled water system than with a unitary VRF system, due to the assumed degradation of the part-load efficiency of VRF systems at higher set-point temperatures. Based on these results for VRF systems, a law of diminishing returns is established by increasing the set-point temperature above 25-26°C.

The control of automated blinds found in some luxury hotels, which close when the room is unoccupied, has been shown to yield an energy saving of 4% on the baseline. This figure accounts for the reduction of cooling required in the guest room, due to the reduction of solar radiation when blinds are closed. For the purposes of this study, the guest room has been assumed to be facing due East and receive significant amounts of direct sunlight during the morning period in Singapore.

Other ACMV energy savings in the study are those that come from the activiation of the room FCU in the luxury/upscale hotel when opening the guest room balcony door. ACMV savings were seen to be in the order of 1%, due to a conservative assumption that the door would only be open for 15 minutes in the morning and evening. Further energy savings would be expected if the balcony door were open for prolonged periods, especially during the middle of the day, as the system would ramp up to maximum fan speed and chilled water flow rate to compensate for the sudden temperature change.

4%

energy saving with control of automated blinds

5.5. The impact of Greenmode

By enabling Greenmode in an luxury/upscale guest room, the energy saving per guest room would be expected to be a further 10%. Correspondingly, for a midscale hotel, we can expect energy saving of 3% per guest room. The savings are lower in the midscale hotel, as the setpoints are closer to the Greenmode temperature choosen.

5.6. Lighting energy savings

Annual energy savings in lighting, monitored onsite, reached between 64 and 73%. These achievements are related to:

- Impact of the automatic nightlight, as without them, 35% of the guests leave the light on in the bathroom during the night.
- Realtime occupancy information, which switches lighting off automatically after a period of 10 minutes when no one is detected. This is of high value when guests use the hotel facilities for prolonged periods or when they go out for the day.
- Savings from the scene-setting dimming control based on the time of day, i.e. 'bright' for morning time and 'relaxed' for evening times. Our baseline condition assumed a constant bright lighting level at all times of the day.

5.7. Power energy savings

Potential small power energy savings, as monitored onsite, were between 25 – 29%, for each hotel. These energy savings were achieved through the deactivation of non-essential power to the TV, coffee machine and power sockets, whilst the room is in the unsold state. Our baseline assumption across the year is that, on average, the TV will be left on by 40% of guests when they leave the room and that it will be on for up to three hours afterwards. Switching off the power could account for an annual saving of approximately 150kWh per guest room alone. Some research has shown that is common for housekeeping to turn on TVs before guest arrival with a welcome screen and that in a worst-case scenario, these TVs can be left on for days in an unoccupied room[18].

06.
Interact Hospitality has a big impact on reducing energy costs

We have shown that it's possible to estimate energy and therefore cost savings across different types of hotel for an entire year. This could prove to be a significant benefit for hoteliers aiming to reduce costs and lessen their environmental impact. As the figures demonstrate, it is possible to achieve favorable returns on investment.

The projected 1-year and 10-year energy cost savings expected through the Interact Hospitality control system for the different hotel types in this study are presented in Table 6. The electricity tariff rate has been taken as $0.14 USD ($0.19 SGD) per kWh. This electricity tariff has been established based on research undertaken in July 2019 for commercial tariffs available in the open electricity market in Singapore.

Hotel Type / Operational Conditions	Cost Savings Period	Guest room No. & Energy Savings ($ USD)			
		100	300	500	1000
Luxury & Upscale Hotels: Interact Hospitality with Standard Set-points	1 year	$52,184	$156,551	$260,918	$521,837
	10 years	$521,837	$1,565,510	$2,609,184	$5,218,368
Midscale hotels: Interact Hospitality with Standard Set-points	1 year	$37,429	$112,286	$187,143	$374,285
	10 years	$374,285	$1,122,856	$1,871,427	$3,742,853

Additional up to 10% of energy savings can be achieved with the greenmode selected by the guest in the guestroom

Table 6: 1-year and 10-year estimated annual energy cost savings for different scales of hotel

07.
What is Interact Hospitality?

Interact Hospitality, a system designed with the Internet of Things (IoT) in mind, delivers real-time operational transparency across your entire property and brings energy-efficient, mood-enhancing lighting everywhere – from the lobby to the restaurants, ballrooms and guest rooms. With Interact Hospitality, you can reduce energy consumption in guest rooms by turning down systems when rooms are unoccupied, setting automating heating or air conditioning to turn off when a balcony door or window is open, and letting guests personalize the room's environment.

Enhance guest experience
Interact Hospitality helps you to deliver a seamless guest experience through the integration of lighting scenes and wellness features in the guest room. Bio-adaptive lighting provides different levels of light intensity and color temperatures at different times of the day to support well-being, helping to energize guests in the morning and supporting a good night's sleep by supporting the body's circadian rhythm. The API enables you to integrate room control into your hotel app enabling guests to change conditions in their room with their phone or tablet. For example, they can personalize the lighting to suit their mood or activities.

Improve staff efficiency
Interact Hospitality's open API enables integration with a variety of hotel systems, so that real-time data can be fed into everything from housekeeping to engineering systems, helping to make hotel operations more efficient. You can enjoy real-time visibility of your property's infrastructure in one intuitive Interact Hospitality dashboard, making it easy to streamline operations and improve guest services. What's more, the dashboard gives your management team visibility of guest room status (such as laundry requests, temperature settings and humidity levels).

Optimize energy consumption
Interact Hospitality also optimizes energy usage in unused guest rooms. You can manage in-room conditions like temperature levels and open curtains only when guests check in.

Appendix A
Energy study methodology

To determine the breakdown of total energy consumption, we completed both on-site electrical energy sub-metering and a cooling energy simulation. Comparing a pair of near-identical rooms, the study took place over a 48-hour period (4pm to 4pm).

One room had the Interact Hospitality control system fully enabled, while the other had the system disabled, allowing us to make a direct comparison of the energy consumption levels.

Both rooms needed to be located side by side on the same floor with a near-identical layout and orientation. This ensured both the electrical and cooling energy loads for the rooms would be equivalent across the study period.

Another challenge was to ensure the study was as realistic as possible. Conducted in a live hotel environment, participants followed a strict occupancy schedule developed to mimic the behaviour of a typical business traveller.

Room status and occupancy schedule
Across the 48-hour study period, three room states were analyzed. Table 4 outlines the most common occupancy levels a hotel typically experiences, along with their frequency. The full 48-hour occupancy schedule applied to each room in the study is provided in Appendix A.

Room state	Hours of occurrence / % of study period
Unsold, Unoccupied	7,6hrs (16%)
Sold, Unoccupied	18,9hrs (39%)
Sold, Occupied	21,5hrs (45%)

Table A1: Room states defined for 48-hour study period.

Energy data logging

Electrical feeds to each room's Fan Coil Unit (FCU), lighting circuits and the main feed to each board were all sub-metered. This enabled us to log small power usage in the room from the mini-fridge, TV and sockets. This energy data was aggregated for five-minute demand intervals across the 48-hour study period.

Equipment and materials

FLUKE 1738 series energy loggers were used to collate the data. This equipment is capable of aggregating electrical power data over short intervals, for each circuit monitored at the guest room distribution board. Each device can log three electrical supplies simultaneously, as required for this study.

Cooling energy simulation

Since energy sub-metering of either the chilled water system or VRV cooling system was not feasible, we conducted simulations for cooling loads and energy demand instead. We established cooling loads across the study period using Carrier's Hourly Analysis Program (HAP), taking into account the construction, orientation, size and occupancy schedule of each hotel room.

Based on the relevant system performance and commissioning data for each hotel, the respective cooling system's energy consumption was as follows:

- Luxury/upscale hotel: FCU chilled water flow rates and water-cooled chiller design system efficiency (COP)
- Midscale hotel: Full and part-load efficiencies of (COP) of the VRV system.

Energy consumption from the cooling systems was calculated for five-minute intervals across the 48-hour study period, matching the energy demand intervals of the electrical energy data logging.

Appendix B:
Baseline guest room definition

The baseline guest room represents a hotel room without any control systems installed. In each of the hotels studied, the baseline scenario assumes a set-point temperature of 23°C throughout the day. All other systems, including lighting, ventilation (room FCUs) and general power, have been assumed to be on manual control and therefore generally turned on for the majority of the day for the purpose of this study. The baseline energy consumption figures are again shown in Figure B1.

Upscale & Luxury Hotels		
	kWh/m².yr	
Cooling: CHW	130	47%
ROOM FCU	14	5%
DHW	65	25%
Lighting	22	8%
Other power	35	13%
	266	

Midscale Hotels		
	kWh/m².yr	
Cooling: VRV	152	61%
ROOM FCU	13	5%
DHW	46	18%
Lighting	20	8%
Other power	20	8%
	251	

Figure B1: Baseline guest room energy consumption benchmarks

References

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