Energy Efficiency and Renewable Energy Use in the Hotel Industry - Two Case Studies (Hawaii and Sweden)

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Abstract

Tourism is the world's largest industry, currently employing in excess of 210 million people (Hoffman, 2000). There are over 300,000 hotels worldwide, accounting for more than 11 million rooms (IHRA, 1996). It is an industry that is highly dependent upon a clean and scenic environment. Unfortunately, the hotel industry is also energy- and resource-intensive. There is a definite need for a more efficient use of energy and other resources in the hotel industry, as well as for an increased use of indigenous renewable energy resources to supply much of the remaining energy requirements.

This paper provides a comparative case-study analysis of the energy use of a typical hotel (50-100 rooms) in a tropical climate (Hawaii), and in a temperate climate (Sweden). An analysis is made of the current energy use and the potential energy (and cost) savings from a retrofit of these facilities with energy-efficient and renewable energy technologies. The paper also looks at the energy efficiency potential of these same facilities if they were constructed from-the-ground-up using the best available resource efficient and renewable energy technologies.

The results of both case studies clearly demonstrate that hotel facilities can be significantly more resource efficient. Increased use of resource efficient technologies and renewable resources can make such facilities more sustainable and provide numerous benefits to their owners, operators, and customers.

1. Introduction

Tourism is Hawaii's largest industry. Hawaii has more than 70,000 hotel rooms (DBEDT, 2000). Hawaii also has some of the highest electricity rates in the country. Commercial rates range from 11 to 22+ cents/kWh. And, Hawaii relies on expensive imported fossil fuels for more than 90% of its energy needs (DBEDT, 2001). In general, Hawaii does not have a heating demand. Air conditioning, lighting, and domestic hot water production dominate hotel energy use.

Energy efficient and renewable energy technologies evaluated for the Hawaii case study include: (1) solar water and pool heating; (2) desiccant and heat pipe dehumidification; (3) seawater air conditioning; (4) natural ventilation; (5) insulation, radiant barriers, and weatherization; (6) daylighting; (7) energy efficient lighting; (8) energy management systems; (9) combined heat and power systems using biofuels; (10) recycling and solid waste reduction; (11) reduced water use and wastewater recycling; and (12) photovoltaics, other renewable sources (based on availability and accessibility).

Tourism is also a large industry in Sweden, accounting for 3.3% of Sweden's GDP in 1996. Sweden has more than 100,000 rooms in its tourist accommodation facilities and the average hotel has 50 rooms. Space heating is the dominant load in Sweden (Bohdanowicz, 2001). For one hotel chain, heating represented around half of the total consumption. In some cases, cooling can also create a significant load in summer. Ventilation and lighting are major components of the base load energy use. In general, relatively little space cooling is required.

Energy efficient and renewable energy technologies evaluated for the Swedish case study include: (1) passive solar heating (2) district heating (and cooling); (3) combined heat and power systems (perhaps using biomass or biofuels); (4) geothermal heat pumps; (5) insulation and weatherization; (6) waste heat recovery; (7) daylighting; (8) energy efficient lighting; (9) energy management systems; (10) recycling and waste reduction; and (11) reduced water use and wastewater recycling.

For both locations, the benefits of reduced water use will be analyzed only with respect to the associated energy use (e.g., reduced hot water use). Any cost benefits associated with the actual reduced use of water will not be considered, but will contribute to the overall cost effectiveness of sustainable hotel developments.

2. HAWAII CASE STUDIES

Few data are available about the energy use of a typical hotel in Hawaii. The range of energy use data for hotels in other sub-tropical/tropical areas (e.g., Florida, Mexico, Caribbean) was quite large (as summarized by Bohdanowicz, 2001). The data presented in Table 1 are a reasonable estimate of energy end use data for Hawaii.

2.1 Description of the Base-Case Hotel for Hawaii

The Base-Case hotel for Hawaii is described in detail in Table 1. The Base-Case hotel is assumed to have 75 rooms, is fully electric, and has restaurant facilities. This hotel is located on the island of Kauai. Kauai has relatively high electricity rates, even for Hawaii, which has some of the highest electricity rates in the world. The Base-Case hotel is relatively energy intensive and no energy conservation measures have been applied.

For an average-size, hotel in Hawaii, the largest energy end use is for space cooling (air conditioning). This is followed by cooking/refrigeration, lighting, domestic hot water, other uses and pool heating. Hawaii does not have any space-heating requirement in the area where the Base-Case hotel is located. Annual energy use is typical for a hotel of this size (RETEC International, 2001). These data are also shown in Table 1.

Table 1. Base-Case Hotel for Hawaii

Parameter	Value
Location	Kauai, Hawaii
Type of hotel	All electric, With restaurant
Number of rooms	75
Average occupancy	70%
Total hotel area/Room	55.7 m^2
Total hotel area	4,181 m^2
Electricity usage (annual)	1,080,000 kWh/yr
Specific electricity usage	258 kWh/m^2
Average electricity cost	US$0.2187/kWh
Electricity cost (annual)	US$236,200/yr
Energy end use	
Space cooling	45.0%
Space heating	0.0%
Lighting	14.0%
Domestic hot water	12.0%
Pool heating	3.0%
Cooking/refrigeration	16.0%
Other uses	10.0%
TOTAL	100.0%

2.2 Retrofit-Case - Hawaii

Energy and cost savings, simple paybacks, and installation costs were calculated and are presented for each energy end use category in Table 2.

Space Cooling (Air Conditioning)

As a tropical island state, Hawaii has a year-round, relatively uniform need for air conditioning. The Base-Case analysis assumes mostly window units with an EER of 8.0. A radiant barrier is installed to reduce solar heat gain. Estimated savings for this energy conservation measure (ECM) are 10% (i.e., the cooling load is reduced by 10%). Installation of more efficient air conditioners (EER = 10.0) reduces the energy requirement further. Heat generated by lighting contributes a significant portion of the heat load that must be removed by the air conditioning system. Reducing lighting heat load reduces the cooling even load further.

Space Heating

As stated previously, Hawaii does not require space heating in the area where the Base-Case hotel is located.

Lighting

For this analysis, it was assumed that one-third of installed lighting wattage are low-efficiency, magnetically-ballasted, fluorescents operating 75% of the time, and two-thirds of installed wattage are incandescents operating 50% of the time. Higher-efficiency fluorescents with electronic ballasts replace low-efficiency fluorescents. Compact fluorescents replace incandescents.

Domestic Hot Water

Hawaii has an excellent solar regime with relatively constant insolation throughout the year (the typical solar fraction is 85%). Hawaii also provides a 35% State income tax credit for solar systems. Combined with some of the highest electricity rates in the world, these factors make Hawaii an ideal location for solar water heating. This analysis also assumes that hot water usage can be reduced by 20% by various means (e.g., energy saving shower heads and flow control devices) and the water heater Energy Factor (EF - a measure of water heat storage tank heat loss) is increased from 87% to 93.5%.

Pool Heating

Again, solar pool heating is ideal for Hawaii. And, the collectors generally cost less than those used for domestic hot water. A 35% State income tax credit is also available. Smaller increases in EF were assumed for this analysis (i.e., from 96% to 98%).

Cooking/Refrigeration

There are a number of ECMs that can be applied to cooking and refrigeration. Cooking generates a lot of heat and humidity. A good exhaust hood can remove this heat and humidity from the kitchen space without requiring this heat and humidity to be removed by the air conditioning system. The "Flashbake" oven uses quartz lights to cook. Similar to the bulb in a halogen floor lamp, the oven uses seven lights to provide cooking energy. There are some similarities to microwave cooking (FEES and Miller, 2001).

Other cooking ECMs include: replacing inefficient cooking equipment; installing timers on hood fans, exhaust systems and hood lights; resetting timers seasonally; using convection ovens when possible instead of conventional ovens; and cleaning grills and grease filters daily for greater heat transfer (FEES, 2001).

Keeping refrigerator and freezers closer to full improves their efficiency. Condenser and evaporator coils should be cleaned to increase their heat exchange effectiveness. Additional insulation will reduce refrigerator and freezer energy requirements. Ensuring that refrigerator and freezer doors remain shut (e.g., with counterweighted automatic doors) will also reduce energy requirements.

Other refrigeration ECMs include: installing open-door buzzers on walk-in doors; installing vinyl air curtains or air blowers over the doors of walk-in refrigeration; consider using heat recovery equipment on large refrigeration units to preheat water for kitchen use; disconnecting lights or remove the bulbs in dessert and salad refrigerators located in kitchens; locating outside ice machines and drink boxes under cover in shaded areas; performing regular maintenance on refrigeration equipment; replacing inefficient refrigeration equipment with new efficient units; and checking door gaskets and closures for damage and replace as needed (FEES, 2001).

Other End Uses and ECMs

Other typical energy end uses include laundry, fans, pumps, motors, elevators, icemakers and vending machines, spas, and landscaping and maintenance. ECMs that can be applied to these ends uses (and some of the previous ones) include energy management and control systems, occupancy sensors, power factor controllers, waste heat recovery, energy-efficient windows, energy-conscious housekeeping and maintenance practices, and employee and guest involvement.

Table 2. Retrofit-Case Costs and Savings Relative to Base-Case Hotel for Hawaii

End Use	Relative to Base-Case Hotel for Hawaii				
	Energy Savings (%)	Energy End Use (%)	Cost Range	Annual Savings	Simple Payback (yrs)
Space cooling	33.1%	30.1%	$126,300	$35,150	3.6
Space heating	-	-	-	-	-
Lighting	63.7%	5.1%	$7,150	$21,060	0.3
Domestic hot water	88.8%	1.3%	$52,400 - $80,610	$25,180	2.1 - 3.2
Pool heating	85.3%	0.4%	$10,410 - $16,010	$6,050	1.7 - 2.6
Cooking/refrigeration	10.0%	14.4%	$5,670 - $11,340	$3,780	1.5 - 3.0
Other uses	10.0%	9.0%	$3,540 - $7,080	$2,360	1.5 - 3.0
TOTALS	39.6%	60.4%	$205,530 - $248,550	$93,580	2.2 - 2.7

Energy and Cost Savings and Simple Payback Periods

Based on the results presented in Table 2, nearly 40% of Hawaii's Base-Case hotel energy use can be saved through a variety of simple and cost-effective ECMs. Annual cost savings are in excess of US$93,000. This provides for a simple payback period of less than three years. The lower figures in the cost range of ECMs and simple payback periods is due primarily to the 35% State income tax credit for solar systems.

2.3 New Construction-Case - Hawaii

Space Cooling (Air Conditioning)

The New Construction-Case also employs a radiant barrier and benefits from a heating load reduction from more efficient lighting. It also assumes that better design and a chiller control system will further reduce energy demand for air conditioning by 15% (but, at some additional cost). Finally, the use of an air conditioning system with an EER of 12.0 is used (air conditioning systems with EERs >12.0 are available). Significant cost savings are achieved owing to the reduced system size (reduced design capacity). This more than offsets any premium costs associated with more efficient systems.

Other simple measures, like planting trees or installing awnings on the South side of buildings, can further reduce air conditioning requirements (ASE, 2000). A room assignment plan can reduce space-conditioning costs significantly. During periods of low occupancy, it may be possible to close down entire wings or floors of the hotel. Cooling systems in unoccupied rooms or areas can be turned off completely (Johannesen, 2001).

Hawaii's weather allows for minimal use of air conditioning for a significant portion of the year as natural ventilation is often sufficient. The system can use ceiling fans in winter. Operable vent windows located on the front face and operable skylights at the back of the room can be added to allow natural ventilation. To increase ventilation, the number of vent windows can be increased, and the height of the skylight box can be raised to create a stronger draw. This natural ventilation system ensures that indoor air is healthy (EB, 2001).

Most conventional air-conditioning systems are designed primarily to control the temperature of the air (sensible cooling), not the humidity (latent cooling). The dehumidification capacity is usually 15-35% of the total system capacity (FEES and Miller, 2001). This need for moisture removal could provide an excellent opportunity for the use of desiccant- or heat pipe-assisted air conditioning. Roofing insulation can be used to further reduce heat gain (over and above that of a heat barrier).

Lighting

Energy savings are the same as for the Retrofit-Case, except that installation costs are typically significantly less in a new installation than they are in a retrofit.

Other lighting ECMs are possible. Exit signs should be converted to LED, and mercury lights (used outdoors) should be converted to metal halide or high-pressure sodium (ASE, 2000). The facility can be designed to make use of natural light. Whenever adequate light from windows is available, draperies can be opened and shades raised while setting up or tearing down function rooms. Draperies and shades should be closed when rooms are vacant. Whenever possible, natural lighting should be used in the lobby area (Johannesen, 2001). Daylighting is one promising lighting ECM, particularly for Hawaii.

Domestic Hot Water

The calculated energy savings are the same as for the Retrofit-Case; however, the installed costs can be decreased by at least 15% by incorporating the solar system into the original building design, and into the roof structure.

Waste heat recovery from air conditioning or refrigeration systems can be used to heat, or preheat, water. Approximately 4,000 Btu/hr per ton of cooling can be recovered as useful energy by installing a refrigerant-to-water heat exchanger in the compressor-to-condenser line to produce up to 60 degree C, water for domestic use. Air conditioning and refrigeration electricity consumption is also reduced due to the cooling effect on the refrigerant discharge gas [PCJ, 1998]. Insulating hot water distribution pipes can also help to conserve energy.

Pool Heating

The calculated energy savings are the same as for the Retrofit-Case; however, the installed costs can be decreased by at least 10% by incorporating the solar system into the original building design, and into the roof structure.

Cooking/Refrigeration

Additional cooking and refrigeration ECMs are possible, with a corresponding increase in costs. Some cost reduction should be possible by incorporating these ECMs into the original design.

Table 3. New Construction-Case Costs and Savings Relative to Base-Case Hotel for Hawaii

End Use	Relative to Base-Case Hotel for Hawaii				
	Energy Savings (%)	Energy End Use (%)	Cost Range	Annual Savings	Simple Payback (yrs)
Space cooling	54.1%	20.7%	$24,700	$57,470	0.4
Space heating	-	-	-	-	-
Lighting	63.7%	5.1%	$2,490	$21,060	0.1
Domestic hot water	88.8%	1.3%	$44,540 - $66,520	$25,180	1.8 - 2.7
Pool heating	85.3%	0.4%	$9,370 - $14,410	$6,050	1.5 - 2.4
Cooking/refrigeration	15.0%	13.6%	$8,500 - $17,010	$5,670	1.5 - 3.0
Other uses	15.0%	8.5%	$5,310 - $10,620	$3,540	1.5 - 3.0
TOTALS	50.4%	49.6%	$94,910 - $137,750	$118,970	0.8 - 1.2

Other End Uses and ECMs

Additional ECMs are possible for other end uses, with a corresponding increase in costs. Some cost reduction should be possible by incorporating these ECMs into the original design.

Energy and Cost Savings and Simple Payback Periods

Energy and cost savings for the New Construction-Case are even better than for the Retrofit-Case. And, these savings are achieved at a lower premium cost. Based on the results presented in Table 3, more than 50% of Hawaii's Base-Case hotel energy use can be saved through a variety of simple and cost-effective ECMs. Annual cost savings are nearly US$120,000. This provides for a simple payback period of a little more than one year.

Photovoltaics

Much of the hotel's remaining electricity demand could be provided by photovoltaics. A 150-kWp system operating at a capacity factor of 23%, and a DC-to-AC conversion efficiency of 95%, could provide more than 287,000 kWh/yr. At an $8/Wp total installed cost, and with a 35% State tax credit, this system would provide electricity at a premium cost of ~US$0.09/kWh (the breakeven installed cost without the tax credit is $3.68/Wp). Solar energy (thermal + PV) would provide more than 61% of the hotel's total energy requirements.

Assuming an interest rate of 8%, an amortization period of 30 years, and no tax credit, the New Construction-Case hotel would cost the same to operate as the energy-inefficient Base-Case, but would do so in a much more energy-efficient and sustainable manner. It would also be a much more desirable facility for environmentally-conscious tourists.

3. SWEDEN CASE STUDIES

Some data are available about the energy use of a typical hotel in Sweden. However, as was true for Hawaii, the range of energy use data for hotels in Sweden was quite large (Bohdanowicz, 2001). The data presented in Table 4 represent a reasonable estimate of energy end use data for Sweden.

3.1 Description of the Base-Case Hotel for Sweden

The Base-Case hotel for Sweden is described in detail in Table 4. The Base-Case hotel is assumed to have 75 rooms, is fully-electric, and has restaurant facilities. This hotel is located in the vicinity of Stockholm, Sweden. Sweden has some of the lowest electricity rates in the world. The Base-Case hotel is relatively energy intensive and no energy conservation measures have been applied.

For an average-size, hotel in Sweden, the largest energy end use is for space heating. Cooking/refrigeration, domestic hot water, lighting, other uses and space cooling follow this. Annual energy use is typical for a hotel of this size (Bohdanowicz, 2001). The assumed room size for Sweden is smaller than that of Hawaii, and as a consequence, the specific energy use is higher. These data are also shown in Table 4.

3.2 Retrofit-Case - Sweden

Energy and cost savings, simple paybacks, and installation costs were calculated and are presented for each energy end use category in Table 4.

Space Cooling (Air Conditioning)

A typical hotel in Sweden has a relatively small space cooling requirement and a relatively short cooling season. Therefore, it may be possible, through proper building design and other ECMs, to eliminate this cooling load entirely. Increased insulation (installed primarily to reduce heating demand) can reduce the cooling demand by 20%. Additional cooling load reductions result from a reduced lighting heat load owing to more efficient lighting. And, some of the cooling load can be provided by the proposed heat pump water heater. These ECMs can reduce the cooling load by nearly 55%.

Table 4. Base-Case Hotel for Sweden

Parameter	Value
Location	Stockholm, Sweden
Type of hotel	All electric, With restaurant
Number of rooms	75
Average occupancy	70%
Total hotel area/Room	40.0 m^2
Total hotel area	3,000 m^2
Electricity usage (annual)	1,080,000 kWh/yr
Specific electricity usage	360 kWh/m^2
Average electricity cost	US$0.0385/kWh
Electricity cost (annual)	US$41,580/yr
Energy end use	
Space cooling	4.0%
Space heating	48.0%
Lighting	10.0%
Domestic hot water	12.0%
Pool heating	0.0%
Cooking/refrigeration	16.0%
Other uses	10.0%
TOTAL	100.0%

Space Heating

Space heating is the largest single energy end use in a hotel in Sweden. Again, a 20% reduction in the space heating energy requirement can be achieved through better building insulation. However, the reduction in lighting heating load owing to more efficient lighting will increase the energy requirement of the space heating system by ~10%.

Sweden is one of the world's largest users of ground source (geothermal) heat pump systems. A ground source heat pump, with a COP of 3.0, has been proposed for the heating system retrofit for the Retrofit-Case hotel for Sweden.

Lighting

The same specific lighting level (W/m^2) has been assumed for both the Hawaii and Sweden hotels. However, the relatively smaller hotel area has resulted in a relatively smaller fraction of total energy being used for lighting. The same lighting distribution assumptions and ECMs that were used for the Hawaii hotel are used for the Sweden hotel.

Domestic Hot Water

The same per capita use of hot water is assumed for the Sweden hotel as for the Hawaii hotel. This analysis again assumes that hot water usage can be reduced by 20% by various means (e.g., energy saving shower heads and flow control devices.) and the water heater Energy Factor (EF - a measure of water heat storage tank heat loss) is increased from 87% to 93.5%. Solar water heating was not considered a viable option. A heat pump water heater with a COP of 2.0 was assumed.

Pool Heating

An indoor pool is assumed and pool heating is assumed to be part of the space heating requirement.

Cooking/Refrigeration

The same assumptions as were used for Hawaii were used for this energy end use category.

Other End Uses and ECMs

The same assumptions as were used for Hawaii were used for this energy end use category.

Table 5. Retrofit-Case Costs and Savings Relative to Base-Case Hotel for Sweden

End Use	Relative to Base-Case Hotel for Sweden				
	Energy Savings (%)	Energy End Use (%)	Cost Range	Annual Savings	Simple Payback (yrs)
Space cooling	54.8%	1.8%	-	$910	-
Space heating	70.7%	14.0	$171,990	14,120	12.2
Lighting	63.7%	3.6%	$5,110	$2,650	1.9
Domestic hot water	62.8%	4.5%	$25,050	$3,130	8.0
Pool heating	-	-	-	-	-
Cooking/refrigeration	10.0%	14.4%	$5,670 - $11,340	$670	8.5 - 16.9
Other uses	10.0%	9.0%	$3,540 - $7,080	$420	8.4 - 16.9
TOTALS	52.6%	47.4%	$211,360 - $220,570	$21,900	9.7 - 10.1

Energy and Cost Savings and Simple Payback Periods

Based on the results presented in Table 5, nearly 53% of Sweden's Base-Case hotel energy use can be saved through a variety of simple and cost-effective ECMs. Annual cost savings are nearly US$22,000. This provides for a simple payback period of around ten years.

Energy savings were even greater for the Retrofit-Case for Sweden than for the Retrofit-Case for Hawaii, and installation costs for Hawaii and Sweden were comparable. However, owing to the large relative electricity cost ratio (Sweden:Hawaii = 5.7:1), energy costs savings were much lower and simple payback periods much greater for the hotel in Sweden.

3.3 New Construction-Case - Sweden

Space Cooling (Air Conditioning)

It may be possible to eliminate any excess cooling demand altogether in the New Construction-Case through a variety of ECMs. These ECMs include better insulation, reduced lighting heat load, double or even triple pane windows, use of cooling provided by the heat pump water heater, use of cooler outside air, a Trombe wall, shading, and other building design features. Significant cost savings can be achieved by eliminating the need for costly air conditioning equipment (equipment that would otherwise have operated with a low capacity factor).

Space Heating

The New Construction-Case again assumes a 20% savings in the space heating requirement through the installation of better insulation. Other building improvements (e.g., a Trombe wall) could reduce the remaining space heating requirement, but at some additional cost. Again, the reduced heat gain owing to more efficient lighting will have to be made up. This case study assumes a ground source heat pump (GSHP) with a COP = 4.0. Much (if not all) of the cost premium of a GSHP with a COP = 4.0 (vs. 3.0) would be offset by the avoided capital cost for a conventional space heating system.

Lighting

The same assumptions as were used for Hawaii were used for this energy end use category.

Domestic Hot Water

This analysis also assumes that hot water usage can be reduced by 20% by various means (e.g., energy saving shower heads and flow control devices.) and the water heater Energy Factor (EF - a measure of water heat storage tank heat loss) is increased from 87% to 93.5%. A heat pump water heater with a slightly higher COP of 2.5 was assumed.

Cooking/Refrigeration

The same assumptions as were used for Hawaii were used for this energy end use category.

Other End Uses and ECMs

The same assumptions as were used for Hawaii were used for this energy end use category.

Table 6. New Construction-Case Costs and Savings Relative to Base-Case Hotel for Sweden

End Use	Relative to Base-Case Hotel for Sweden				
	Energy Savings (%)	Energy End Use (%)	Cost Range	Annual Savings	Simple Payback (yrs)
Space cooling	100.0%	0.0%	-$51,580 - $0	$35,150	3.6
Space heating	80.0%	9.6%	$142,120	15,980	8.9
Lighting	63.7%	3.6%	$1,780	$2,650	0.7
Domestic hot water	88.8%	1.3%	$25,050	$3,500	7.2
Pool heating	-	-	-	-	-
Cooking/refrigeration	15.0%	13.6%	$8,500 - $17,010	$1,000	8.5 - 17.0
Other uses	15.0%	8.5%	$5,310 - $10,620	$630	8.4 - 16.9
TOTALS	61.1%	38.9%	$131,180 - $196,580	$25,420	5.2 - 7.7

Energy and Cost Savings and Simple Payback Periods

As was the case for Hawaii, energy and cost savings for the New Construction-Case for Sweden are even better than for the Retrofit-Case. And, these savings are achieved at a lower premium cost. Based on the results presented in Table 6, more than 61% of Sweden's Base-Case hotel energy use can be saved through a variety of simple and cost-effective ECMs. Annual cost savings are more than US$25,000. This provides for a simple payback period of 5-8 years.

4. CONCLUSIONS

The application of a variety of energy conservation measures (ECMs) was shown to be cost-effective for a very wide range of energy (electricity) costs (US$0.0385 to 0.2187/kWh), for both Retrofit-Cases and New Construction-Cases, and for both Hawaii and Sweden.

Estimated energy savings were larger for the Retrofit-Case for Sweden (50%) than for the Retrofit-Case for Hawaii (40%). Installation costs for Hawaii and Sweden were comparable. However, owing to the large relative electricity cost ratio (Sweden:Hawaii = 5.7:1), energy costs savings were much lower, and simple payback periods much greater, for the hotel in Sweden.

Estimated energy savings were, again, larger for the New Construction-Case for Sweden (61%) than for the New Construction-Case for Hawaii (50%). However, installation costs for Hawaii were ~25-30% less than those for Sweden. As was the case for Hawaii, energy and cost savings for the New Construction-Case for Sweden are even larger than those for the Retrofit-Case. And, these savings are achieved at a lower premium cost (relative to the Retrofit-Case).

In the New Construction-Case for Hawaii, solar energy (thermal + PV) could provide more than 61% of the hotel's total energy requirements. Owing to high capital costs for renewable energy technologies, and low electricity costs, the potential for use of renewable energy resources to provide a significant portion of the New Construction-Case for Sweden appears to be more limited.

The results of both case studies clearly demonstrate that hotel facilities can be significantly more resource efficient. Increased use of resource efficient technologies and renewable resources can make such facilities more sustainable and provide numerous benefits to their owners, operators, and customers.

The bottom line is that there are great new business opportunities for sustainable tourism facility design.

5. RECOMMENDATIONS

The above analysis should be carried out in greater detail using an existing hotel in each of these locations, with the ultimate objective being from-the-ground-up design and construction of sustainable tourism facilities in both Hawaii and Sweden.

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