FLORIDA SOLAR ENERGY CENTER®

FINAL REPORT EXECUTIVE SUMMARY

Field Monitoring and Hourly Simulation of Energy and Demand Savings from Use of the Telkonet SS5000 System Hotel HAC Occupancy Control

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Executive Summary

A study of heating and cooling energy savings was performed by the Florida Solar Energy Center (FSEC) at the request of Florida Power and Light. Telkonet SS5000 HVAC occupancy sensors/controllers were installed in 56 guest rooms in a relatively new (built 2005) three-story national chain hotel in Sebastian, Florida. The controllers have the capability of adjusting heating and cooling (HAC) setpoints when the room is detected to be unoccupied. The controllers can also log the operation of the HAC system and room conditions. Experiments were carried out to compare the HAC energy use in 28 rooms in which the SS5000 controllers were actively adjusting setpoints (experimental rooms) versus 28 rooms in which the SS5000 controllers did not adjust setpoints (control rooms). In all 56 rooms, the units recorded the HAC system and room conditions as shown in Table E-1. The guest rooms open only to the conditioned corridors and there are no patio doors or operable windows providing access to outdoors.

Table E-1 Hourly recorded data provided by Telkonet to FSEC

Data collected by SS5000	Units
AC compressor run time	seconds/hour
Heating run time	seconds/hour
Fan run time	seconds/hour
Cooling status selected	seconds/hour
Heating status selected	seconds/hour
Auto status selected	seconds/hour
Off status selected	seconds/hour
Room occupancy status	seconds/hour
Thermostat setpoint temperature	^{O}F
Room temperature	^{O}F
Room relative humidity	%

Steps were taken to ensure that the control rooms and the experimental rooms were similar and that environmental and occupancy factors would not bias the results. To achieve this we selected every other guest room to be control and the others were experimental. By selecting control rooms and experimental rooms to be every other room, variations in heating and cooling load associated with surface area envelope exposure and solar radiation exposure on walls and windows would be largely eliminated. Additionally, we examined the occupancy of the control and experimental rooms (as detected and recorded by the SS5000 units) at the end of the data collection and found only a 1.1 percentage point difference in occupancy (41.6% occupancy for the control rooms and 42.7% occupancy for the experimental rooms) for the entire data collection period. We conclude, therefore, that occupancy and envelope exposure factors should not have introduced significant bias into the energy savings and demand reduction analysis.

The floor area of the guest rooms is shown in Table E-2. The cumulative floor area of the control rooms was 10,858 ft^2. The cumulative floor area of the experimental rooms was 10,858 ft^2.

A total of 56.7 tons of cooling serves the 56 guest rooms (total floor area of all rooms is 21,716 ft^2), which equates to 2.61 tons of cooling per 1000 ft^2 of guest room floor area. This compares to about 1.75 tons per 1000 ft^2 for a typical single family home in central Florida. A total of 145.9 kW of electric resistance heating serves those 56 guest rooms, which equates to 6.72 kW (22,930 Btu/hr) of heating per 1000 ft^2 of guest room floor area.

Table E-2 Cooling capacity and floor area of hotel guest rooms

	Total room cooling capacity (tons)	Floor area Studio rooms (ft^2)	Floor area mid-size suite (ft^2)	Floor area 3-room suite (ft^2)	Total room floor area (ft^2)	Tons/ 1000 ft^2
First floor	10.68	2,496	2,760	0	5,256	2.03
Second floor	18.13	3,744	3,714	772	8,230	2.20
Third floor	17.92	3,744	3,714	772	8,230	2.18
Total	46.73	9,984	10,188	1,544	21,716	2.13

The experimental rooms had slightly more total cooling capacity than the control rooms. The experimental rooms had total cooling capacity of 23.8 tons while the control rooms had total cooling capacity of 22.9 tons. The experimental rooms had significantly more total heating capacity. The cumulative PTAC heating capacity of the experimental rooms was 77.0 kW while the cumulative PTAC heating capacity of the control rooms was 68.9 kW.

There were two common room sizes; 321 ft^2 and 460 ft^2. All rooms were served by a single PTAC (package terminal air conditioning) unit, except for two large guest room suites (each with 772 ft^2) each of which was served by three AC systems; two PTAC units and one 1.5-ton split AC with strip heat.

Results

Data was collected by Telkonet by means of network download for a total of 292 days, from mid-December 2008 through September 2009. Due to data problems (especially missing data and values far out of range, created by datalogger or transmission malfunction), only 87 days of data were available for the analysis. Annual HAC energy savings were simulated based on best-fit least squares second-order polynomial equations (normalizing daily HAC energy use to outdoor temperature) combined with TMY3 data for four Florida Cities (weighted as follows: North (Daytona Beach) 12.82%, South (Miami) 50.77%, East (Palm Beach) 19.23%, and West (Ft. Meyers) 17.18%). Figure E-1 is a plot of daily HAC energy use versus daily outdoor temperature at the hotel. Figure titles using the term PTAC (package terminal air conditioner) refer all units providing heating, cooling and air circulation. Second-order polynomial equations were developed based on best-fit least-squared correlation to the data points. The annual energy savings simulation procedure consisted of applying TMY3 daily temperature data to the best-fit equations, in effect calculating the total heating and cooling energy use for each day for the 28 control rooms and the 28 experimental rooms. Annual energy savings were obtained by subtracting the simulated HAC energy use of the experimental rooms from the simulated HAC energy use of the control rooms.

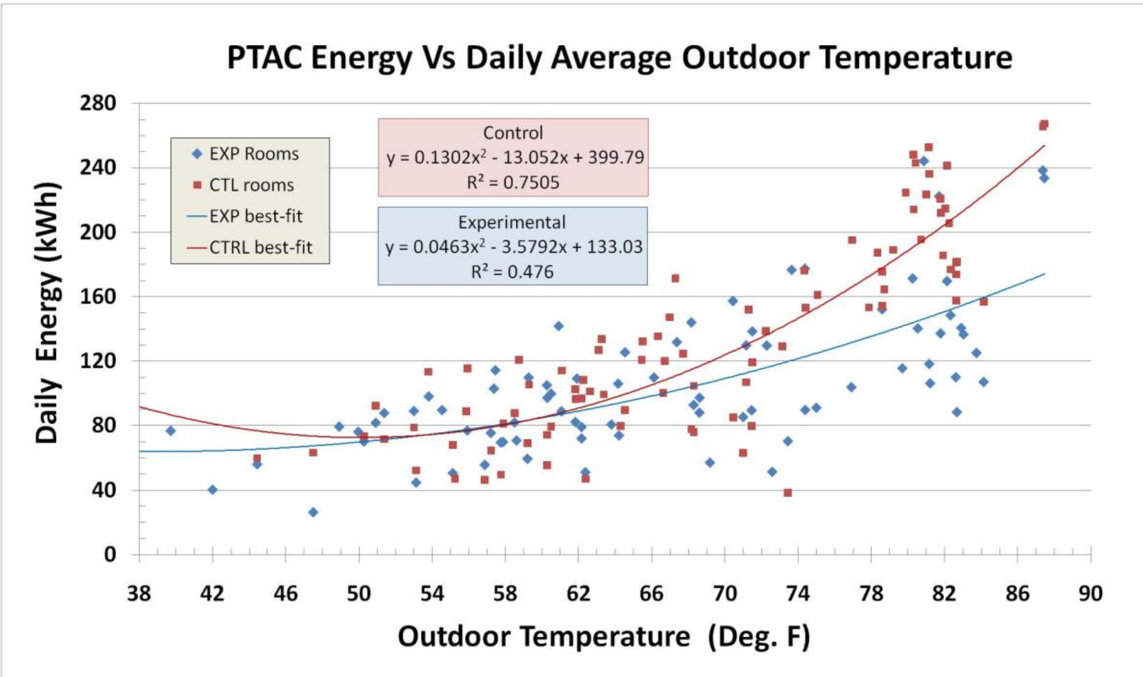

Figure E-1 Plot of daily HAC energy consumption versus daily average outdoor temperature

Table E-3 Annual HAC energy savings per 28 rooms resulting from occupancy control based on best-fit equations and TMY3 data

	28 Control rooms kWh/yr	28 Experiment rooms kWh/yr	Energy Saved kWh/yr	Energy Saved
Daytona Beach	49,910	41,797	8,113	16.3%
Miami	60,940	47,824	13,116	21.5%
W P Beach	57,445	45,914	11,531	20.1%
Ft. Meyers	58,174	46,334	11,840	20.4%
Weighted *	58,378	46,428	11,950	20.5%

* weighting as follows: Daytona Beach 12.82%, Miami 50.77%, Palm Beach 19.23%, and Ft. Meyers 17.18%

Based on this simulation, annual energy savings from use of the Telkonet SS5000 control system was 427 kWh per room (11,950kWh/28). This is a 20.5% reduction compared to the control rooms. If the occupancy control system had been active in all 56 hotel guest rooms, then the projected (simulated) annual heating and cooling energy savings for this hotel would have been 23,900 kWh.

In addition to annual energy savings, the Telkonet SS5000 controllers also produced a reduction in electrical demand during the peak periods of 7-8 AM and 4-5 PM. Demand savings were determined based on the following analysis. Daily PTAC energy use (both cooling and heating) was summed for the control rooms and also summed for the experimental rooms for just the 7-8 AM hour and the 4-5 PM hour.

The data points shown in Figure E-2 represent the energy use of the entire group of control rooms (red dots) and experimental rooms (blue dots) for the 7-8 AM period plotted versus the 7-8 AM temperature. The data points shown in Figure E-3 represent the energy use of the entire group of control rooms (red dots) and experimental rooms (blue dots) for the 4-5 PM period plotted versus the 4-5 PM temperature. Best-fit lines (based on least-squares regression analysis) were developed for the peak hour energy versus temperature data points. The equations which define those best fit lines (curves) are used, along with TMY3 data, to calculate the PTAC electrical demand for the 28 control rooms and the 28 experimental rooms.

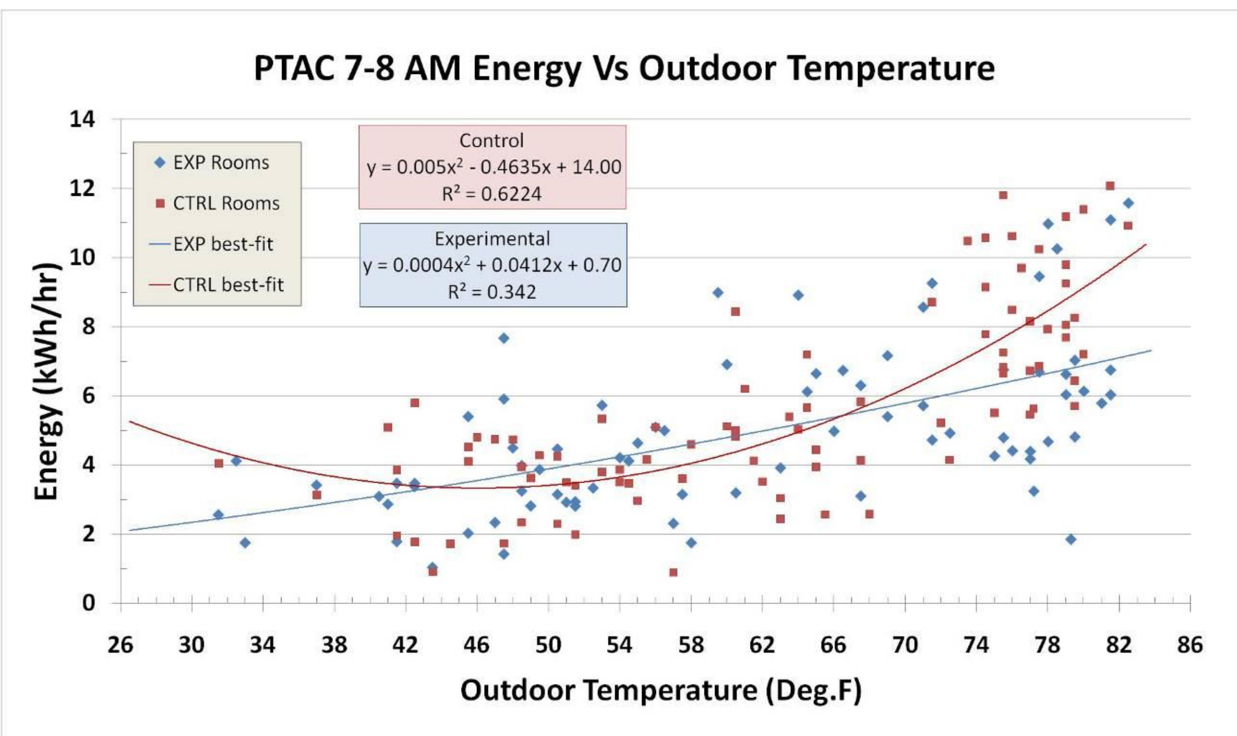

Figure E-2 Plot of 7-8 AM energy use versus outdoor temperature, plus best fit lines.

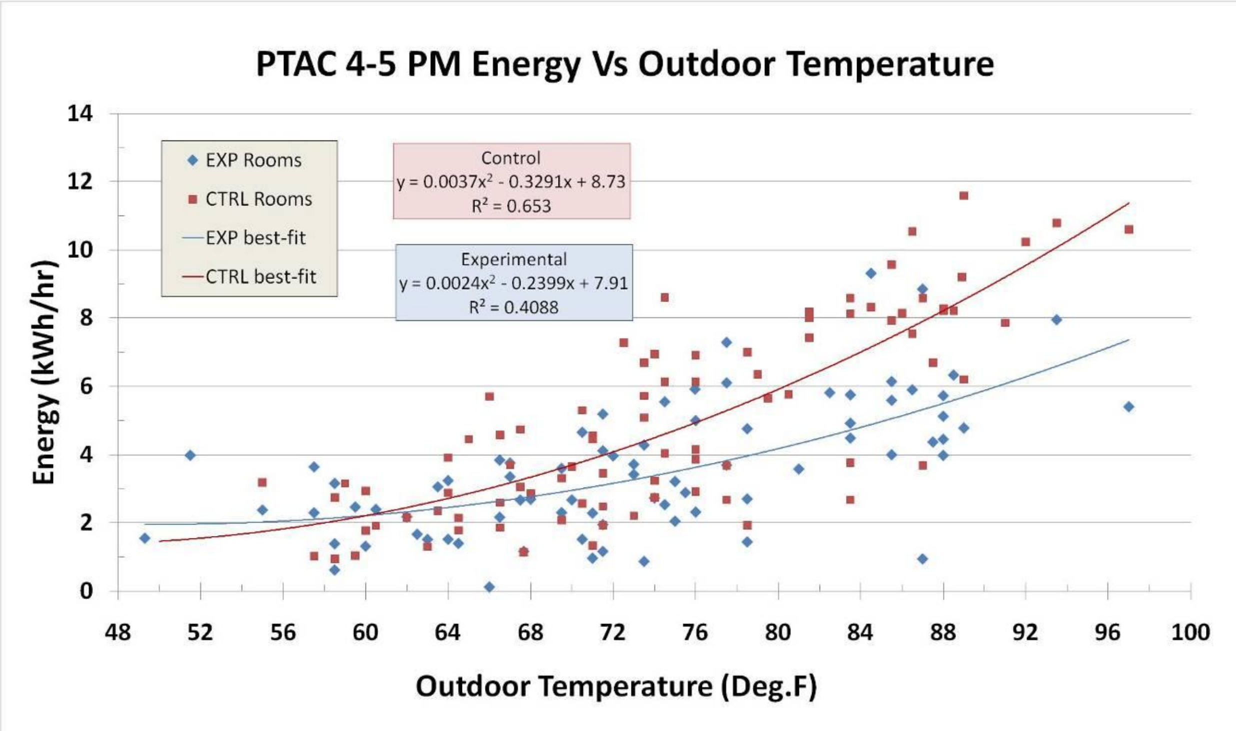

Figure E-3 Plot of 4-5 PM energy use versus outdoor temperature, plus best fit lines.

Table E-4 Weighted peak HAC demand (kW) reduction for 7-8 AM based on TMY3 data

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Control kW	3.79	3.41	3.56	3.90	5.52	7.25	7.54	6.54	6.53	5.26	3.39	3.39
Experiment kW	3.14	3.11	3.11	4.27	5.28	6.00	6.10	5.73	5.71	5.06	3.72	3.21
Reduction kW	0.65	0.30	0.45	-0.37	0.24	1.25	1.44	0.81	0.82	0.20	-0.33	0.18
Reduction %	17.1%	8.8%	12.6%	-9.5%	4.3%	17.2%	19.1%	12.4%	12.5%	0.4%	-9.7%	5.2%

Table E-5 Weighted peak HAC demand (kW) reduction for 4 PM - 5 PM based on TMY3 data

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Control kW	6.20	6.57	7.92	8.70	9.20	9.28	10.53	9.24	9.09	8.47	7.37	6.99
Experiment kW	4.14	4.35	5.10	5.54	5.83	5.88	6.59	5.85	5.76	5.41	4.79	4.58
Reduction kW	2.06	2.22	2.82	3.16	3.37	3.40	3.94	3.39	3.33	3.06	2.58	2.41
Reduction %	33.2%	33.8%	35.6%	36.3%	36.6%	36.6%	37.4%	36.7%	36.6%	36.1%	35.0%	34.5%

The 7-8 AM demand reduction for the four months of December through March averaged 10.9%.

The hourly demand for each hour of the year was calculated, for the 28 control rooms and the 28 experimental rooms, using the equations which define the best-fit lines, and using the TMY3 data for the four Florida cities. Once this was completed, we identified the electrical demand for the coldest 7-8 AM hour for each month of the year and the warmest 4-5 PM hour for each month of the year, and put these values into Tables E-4 and E-5, respectively.

The 4-5 PM demand reduction was an almost identical 37% for the hot months of May through September. In fact, the 4-5 PM demand reduction for each month of the year fell in the range of 33 to 37%.

The summer demand analysis can be considered robust for two reasons. First, there are many hot days and hot hours of data collected at the Sebastian hotel, which means that we have good confidence in the shape of the best-fit curves for the control and experimental rooms. Second, the TMY3 data has many hot days and hours, so the modeled demand reduction can be considered representative of typical hot summer weather.

By contrast, the winter demand reduction analysis, as shown in Table E-4, cannot be considered robust, for two reasons. The first problem has to do with the winter weather (more specifically available winter data) which was experienced by the hotel. Data collection started about mid-December 2008 and ended in September 2009. During the winter period there were only a limited number of days of cold weather. Furthermore, much of the cold weather data was lost due to serious data problems. In all, only four days of data was available when the 7-8 AM temperature was below 40°F, and the coldest of these was only 32°F. Therefore, there are very few data points from which to develop the shape of the best-fit curve for the cold winter morning demand.

The second problem has to do with the type of winter weather contained in the TMY3 data. Specifically, it has to do with the fact that the TMY3 data is designed to be typical weather, and generally does not include extreme days. The coldest days included in the TMY3 data are considerably warmer than the once-a-decade cold snaps which occur sporadically throughout the Florida peninsula. The coldest winter days in the TMY3 data are shown in Table E-6, for November through April. Most of these cold morning temperatures are on the order of 10 to 15°F warmer than the every-decade lows. As a result, the simulated morning peak demand reduction based on the TMY3 data and weighted for the four cities is not representative of the demand reduction which will occur during the sporadic outbreaks of cold weather. This is especially true because of the shape of the best-fit curves, which show much more peak demand reduction at 30°F outdoors compared to 40°F outdoors. The reader will see in Table E-6 that most of the TMY3 month-low temperatures are in the 38 to 48°F range.

Table E-6 Coldest 7-8 AM temperature (°F) data in the TMY3 files for four Florida cities

	November	December	January	February	March	April
Daytona	42	39	22	37	41	48
Miami	50	46	49	41	44	61
West Palm	47	41	41	42	30	56
Ft. Myers	56	41	36	46	47	47
Average	48.8	41.8	37.0	41.5	40.5	53.0

In order to calculate more realistic demand savings for the winter months (focusing on November through April), we first looked up the record low temperatures for November through April for the four cities (Table E-7). We then created Table E-8, which is the record low temperature for each winter month plus an adjustment. The adjustment adds 5°F to the all-time record low for each month for each city, to be more representative of the once-a-decade-cold spell rather than the 100-year cold spell. We then recalculated the winter months (November through April) demand reduction using the best-fit equations shown in Figure E-2 and using the temperatures in Table E-8 rather than those in the TMY3 (also shown in Table E-6).

Table E-7 Record low temperatures (°F) for four Florida cities

	November °F	December °F	January °F	February °F	March °F	April °F
Daytona	27	19	15	24	26	35
Miami	39	30	30	32	32	46
West Palm	36	28	27	32	30	43
Ft. Myers	34	26	28	30	33	39

Source: http://www.sercc.com/climateinfo/historical/recordlow.html

Table E-8 Record low temperatures plus 5°F for four Florida cities

	November °F	December °F	January °F	February °F	March °F	April °F
Daytona Beach	32	24	20	29	31	40
Miami	44	35	35	37	37	51
West Palm	41	33	32	37	35	48
Ft. Myers	39	31	33	35	38	44

Using the monthly record low temperatures adjusted upward by 5°F (Table E-8), Table E-4 is now replaced by Table E-9 which has new 7-8 AM demand savings for November through April.

Table E-9 Weighted peak HAC demand reduction for 7-8 AM using record low temperatures +5°F for November through April and TMY3 data for May through October

	Jan	**Feb**	**Mar**	**Apr**	May	June	July	Aug	Sept	Oct	**Nov**	**Dec**
Control kW	**4.39**	**3.88**	**3.82**	**3.36**	5.52	7.25	7.54	6.54	6.53	5.26	**3.49**	**4.29**
Experiment kW	**2.45**	**2.68**	**2.71**	**3.59**	5.28	6.00	6.10	5.73	5.71	5.06	**3.07**	**2.47**
Reduction kW	**1.94**	**1.20**	**1.11**	**-0.23**	0.24	1.25	1.44	0.81	0.82	0.20	**0.42**	**1.82**
Reduction %	**44.2%**	**30.9%**	**29.1%**	**-6.8%**	4.3%	17.2%	19.1%	12.4%	12.5%	0.4%	**11.9%**	**42.4%**

Demand reduction for the period 7-8 AM as shown in Table E-9 averages 36.7% for the four coldest months of December through March.

Conclusions

In summary, the Telkonet SS5000 HAC control system detects when hotel guest rooms are unoccupied and adjusts thermostat setpoints to reduce HAC system operation time. Simulated annual energy savings, weighted for the FPL territory, is 20.5% as a result of the HAC control system. Even greater demand reduction was found. The winter 7-8 AM demand reduction for the months of December through March averaged 36.7% with a winter utility peak reduction of 0.07 kW per room or 44.2% (based on record cold temperatures for those cities plus 5°F). The summer 4-5 PM demand reduction for the months of May through September averaged 36.8% with a summer utility peak reduction of 0.12 kW per room (36.6%). Energy and peak values are summarized for the Florida Power and Light service region below for the twenty-eight room groups and also on a per room basis in Tables E-10 and E11 respectively.

Table E-10 Summary of annual energy, summer peak, and winter peak savings per 28 rooms

	Total Annual PTAC Energy					August Peak Reduction 4-5PM		January* Peak Reduction 7-8AM	
	28 CNTRL kWh	28 EXP kWh	Saved kWh	Saved %		kWh/hr	%	kWh/hr	%
North	49,910	41,797	8,113	16.3%		3.48	36.8%	5.05	75.0%
South	60,940	47,824	13,116	21.5%		3.19	36.4%	1.28	32.7%
East	57,445	45,914	11,531	20.1%		3.19	36.4%	1.87	43.4%
West	58,174	46,334	11,840	20.4%		3.77	37.2%	1.66	39.9%
Weighted	58,378	46,428	11,950	20.5%		3.33	36.6%	1.94	44.2%

*Based on record cold data + 5°F.

Summary of annual energy, summer peak, and winter peak savings per room

	Total Annual PTAC Energy					August Peak Reduction 4-5PM		January* Peak Reduction 7-8AM	
	1 CNTRL kWh	1 EXP kWh	Saved kWh	Saved %		kWh/hr	%	kWh/hr	%
North	1,783	1,493	290	16.3%		0.12	36.8%	0.18	75.0%
South	2,176	1,708	468	21.5%		0.11	36.4%	0.05	32.7%
East	2,052	1,640	412	20.1%		0.11	36.4%	0.07	43.4%
West	2,078	1,655	423	20.4%		0.13	37.2%	0.06	39.9%
Weighted	2,085	1,658	427	20.5%		0.12	36.6%	0.07	44.2%

There may be more potential for savings to be realized from occupancy control. About four months into this study, the Telkonet vendor discovered that control rooms that were detected to be unoccupied for at least 24 hours were unintentionally allowed to go to a deep "vacation" set-back thermostat temperature. We have no means by which to eliminate this unintended impact. We suspect that the affect on the operation of the control room PTAC units was minimal. We can conclude, however, that the effect of this unintentional HAC control in the control rooms would cause an underestimation in the energy and demand savings that would result from the Telkonet controllers, particularly for winter months.

Based on a reported cost of $250 per room, 427 kWh per room savings, peak demand reduction of 0.12 kW for summer months and 0.07 kW for winter months, demand charges of $8.43/kW, and $0.0589/kWh cost (GSD-1 rates), the simple payback would be 7.6 years without program incentives. The peak demand reduction for the entire hotel (56 rooms) would be 6.72 kW in the summer and 3.88 kW in the winter. In addition to the energy savings benefit to the hotel owner, this energy conservation feature could be a source of improved corporate image and marketability of the hotel as a "green" lodging establishment.