Herzstein Hall Air Conditioning and Light Control Renovation

RESET Proposal

I. **Project Participant Information**

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II. **Project Background**

We have heard from many students that the temperature in Herzstein Hall is often too cold in the summer, especially during the night. As we investigated the situation, we discovered that students have reported their discomfort with the air conditioning to Rice officials and our administration is very concerned with this problem. In addition, our estimates reveal that the annual cost of air conditioning in Herzstein Hall tops $100,000, with much of it gone to keeping unoccupied rooms unnecessarily cold. This motivated our Herzstein energy efficiency project.

Herzstein is currently the home of the Rice Physics department. It houses the largest classroom on campus, the Amphitheater. There are mainly physics labs and two large classrooms (210 and 212) on the second floor, mostly small classrooms and physics department offices on the first floor, and several physics, chemistry and biology labs in the basement.

As indicated in Table 1, most rooms, including the Amphitheater, are cooled to the same temperature as in the hallway (Herzstein General) throughout the day. Two rooms, however, were found to deviate from this pattern significantly. One is Room 207, the Physics 101 lab, and the other is Room 210, a classroom with maximum capacity of 125 occupants.

Location / Time	Amphitheater	Room 210	Room 212	Room 207	Herzstein General
Morning	75-76 ℉	75-76 ℉	75-76 ℉	N/A	75-76 ℉
2:00 PM	75-76 ℉	75-76 ℉	74 ℉	N/A	75-76 ℉
4:00 PM	74-75 ℉	70 ℉	73-74 ℉	N/A	73-74 ℉
5:00PM-10:00PM	73-74 ℉	69-70 ℉	73-74 ℉	71-72 ℉	73-74 ℉
After 10:00PM	N/A	N/A	N/A	N/A	75-76 ℉

Note: By regulation all the classrooms are locked after 9:30PM. Outside night temperature generally ranges from 76 ℉ to 80 ℉ in October.

Table 1. Actual temperature measurement results inside Herzstein

According to the FE&P Air Conditioning department, the default summer indoor temperature target is 76℉. In fact, 75-76℉, which is the temperature in Fondren Library during the afternoon, feels quite comfortable to most people during summer. On the other hand, 68 ℉ is usually the winter indoor temperature setting at Rice, and 70 ℉ is unreasonably cold and wasteful for the summer. The temperature in Room 210 is kept at levels only slightly above the winter heating threshold temperature, indicating a great waste of energy.

Even for the general Herzstein temperature, there is still a lot potential for energy savings. The information from Rice faculty shows that for every degree in temperature increased in the summer, 4% of the energy can be saved. That is, if we adjust the temperature from 73.5 ℉ to 75 ℉ during the late afternoon to evening hours, we save 6% of the energy bill for air conditioning.

When we consulted Mr. Windham, who is in charge with Rice air conditioning control and energy, he explained to us that Herzstein Hall is equipped with computerized and digitalized sensors as well as control software. One example is that the air conditioning is automatically reset to 76 ℉ after 10:30PM to conserve energy. The problem is that this control system has been given insufficient attention for some time, we are confident that with more research and a detailed schedule, we can optimize the system to achieve both comfort and energy efficiency.

On top of this, turning down air conditioning even more when the room is unoccupied could yield significant additional benefits. The occupancy situation in Herzstein Hall is as follows: the class schedule in Herzstein indicates that most room will be empty after 5:00PM, and there are also significant empty intervals during the day. Between 6:00PM and 10:00PM, the occupancy varies from day to day, but generally, there are about 10 people in Amphitheater, and 5 people in Room 212. Depending on the Physics 101 lab schedule, there can be 15 people in Room 207 and 2 professors in their offices. We also noticed that there is almost never anyone in

Room 210, the room that is abnormally cold.

Other than air conditioning, lighting makes up another major part of energy consumption. We discovered that among the larger classrooms, the Amphitheater is often empty with all lights on, which is also the case for Room 210. In addition, all the lights in the basement hallway, as well as some in the labs, are on, although rarely anyone is there during the night. We discovered that these three places are equipped with motion sensors, with two sensors in each Room 210 and Amphitheater and three sensors in the basement hallway. However unlike Room 212 and second floor hallway, where the lights are automatically turned off soon after people leave, we found several problems that prevent these motion sensors from normal functioning, as shown in Table 2. A significant amount of energy could be saved by renovating and replacing these motion sensors.

Place	**Number of Sensors**	**Type of Sensors**	**No Human Motion**	**Human Motion**	**Problem**
Room 210	2	Dual	Inactivated	Activated	Disconnected from light switch
Amphitheater	2	Dual	Inactivated	Inactivated	Disconnected from power or broken
Basement Hallway	3	Ultra-sonic	Activated	Activated	Noise signals (Mounted on air diffusers, etc.)
Room 207	1	Ultra-sonic	Inactivated	Activated	None
Room 212	2	Dual	Inactivated	Activated	None

Note: Ultrasonic sensor detects motion by sound waves and is subject to the influence of high levels of vibration. Dual-technology sensor detects motion by both ultrasonic and infer-red.

Table 2. Current motion sensor situation and problems

III. **Project Description**

<u>Project Concept:</u>

Our project aims at providing a more efficient air conditioning and light control system in Herzstein Hall. We plan to start with Herzstein, and utilize our experience to move on to improve the energy efficiency of other buildings on campus during the following semesters in similar ways.

Implementation Details and Timeline:
The Herzstein project consists essentially of two parts:

Part I: Central Control System Adjustment.

1. Summer Period
   November 5th, 2010
   Estimated work time: 4-5 weeks
   2 members work on the central air conditioning control programming with Mr. Windham.

   - Monitor temperature in Herzstein hallways, Room 207, 210, 212 and Amphitheater daily
   - Adjust the central control software parameters accordingly
   - Integrate Herzstein Hall class schedule and Physics 101 lab schedule into the system
   - Puts signs in Herzstein Hall to encourage students and faculties to report any excessive air conditioning
   - Finally stabilize the temperature around 75 ℉ in all rooms in Herzstein Hall

2. Winter Period
   Starting at January 10th, 2011
   Estimated work time: 4-6 weeks
   Methodology remains similar to the Summer Period

Part II: Renovation and Replacement of Motion Sensors

Starting at the date our project is approved: November or December, 2010.
Estimated work time 4-6 weeks.
2 members work together with Rice technicians and Mr. Valentine, who will arrange the motion sensors renovation and replacement

- Research existing motion sensors in Herzstein Hall Room 207 and 212 to connect them to air conditioning control
- Renovate motion sensors in Herzstein Hall Room 210 and Amphitheater. Connect sensors to both light and air conditioning control. (Note: Amphitheater and Room 207, 210, 212 all have their own air conditioning systems. It is ideal to use occupancy sensor.)
- Choose locations and adjust the surrounding environment to replace ultrasonic motion sensors in Herzstein Hall basement with dual-technology sensors and connect them to light control.
- Test the effectiveness and possible flaws after the installation daily
- Feedback and Adjustment: Put signs in Herzstein Hall and encourage students and faculties to report any temperature discomfort.

IV. **Educational Function**

As a part of our implementation plan, we will distribute surveys and put signs throughout Herzstein Hall to get feedbacks of our project. While on one hand we expect to receive discomfort and inconvenience reports to help us improve our project, on the other hand we will write our project descriptions and goals on the signs. In this way the project is publicized, and over a year, thousands of students will be aware of our project and witness the change in Herzstein Hall.

V. **Maintenance and Potential Concerns**

1. Maintenance

Although the weather and night occupancy situations are not anticipated to change much each year, the ideal is to adjust air conditioning control yearly. Nevertheless, it is necessary to adjust air conditioning in the Room 207 according to physics lab schedule, which should not be difficult in the well-developed control software. The electricity consumption of occupancy sensors is negligible, usually less one dollar per year.

2. Potential Concerns

The notion of using a motion sensor to control air conditioning is not untested. In fact, it has been implemented on a mass-scale at Rice University in the two new residential colleges, Duncan College and McMurtry College.

From the experience of the existing motion sensors, the main concern seems to be in the proper recognition of room use, as many students have reported that the lights would sometimes go out despite their presence in the room. On the other hand, motion sensors encountering problems in shutting down the air conditioning properly could also become a problem. Therefore, the reliability and accuracy of detecting the presence of room occupants is essential, and we will do further adjustment after the installations.

VI. **Cost and Savings**

Cost:

Our cost consists of the device purchase price and the labor fee in the renovation and replacement. Based on the guideline provided by Rice FE&P faculties and the anticipation of risks, we estimate the cost of replace the basement sensors to be $700 each and the renovation of the old ones is $250 each. We need to renovate 2 sensors in each Room 210 and Amphitheater, and replace the 3 sensors basement.

Item	**Cost**	**Explanation**
Sensors Replacement	$2,100	$700 per replacement, 3 replacements in total
Sensor Renovation	$1,750	$250 per renovation, 7 sensors in total
Total	**$3,850**	

Table 3. Estimated budget and justifications

Savings:

Note: For each degree Fahrenheit decreased in summer increased in winter, there is 4% more energy consumption.

Total air conditioning energy cost in Herzstein Hall last year: (Half of the electricity + Chill water cost + Hot water cost) =$65,284*0.5+$34,502+$38,438 = $105,582

Therefore, as we increase general temperature 73.5 ℉ to 75 ℉ from 4PM to 10:30PM each day, we are able to save about 6% more 6h/day.

Moreover, there are 22% energy savings in Room 210 with surface area 1079.29 square feet (From 69.5 ℉ to 75 ℉) and more than 14% energy savings in Room 207 with surface area 2370.40 square feet (From 71.5 ℉ to 75 ℉ and with schedule and occupancy sensor, it will save more). The total Herzstein building surface area is 43352 square feet, and therefore Room 207 and 210 occupy 5.46% and 2.48% of the total building surface area of Herztein Hall respectively.

We realize that humidity is also an influence factor in air conditioning control, and could therefore possibly limit savings. At this point, no evidence exists that the extraordinarily low temperature in certain classrooms is necessary to contain the humidity level, and we therefore assume that this would not become a significant factor in our savings calculations.

Due to the limitation of our investigation time, there's no data of winter air conditioning available so far. By considering Houston weather and comparing the cost of heating and cooling, we assume similar winter air conditioning situation and saving as in summer. Part I winter investigation will begin on December 1st.

Total annual savings of air conditioning:
(($105,582*5.46%BuildingSF*14%Savings+$105,582*2.48%BuildingSF *22%Savings +$105,582*92% BuildingSF *6%Savings)/(6h/24h))
= $2,840/year

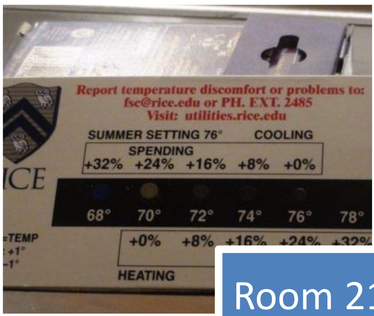
The total electricity cost (other than air conditioning) of Herzstein Hall is $32,642. Most of it will be the cost for light (Our estimation is $20,000 per year, considering other electronic devices such as computers and lab equipment). From the information of Supporting Material Part II, we estimate the savings in lighting to be 30%. The Amphitheater, Room 210 and basement hallway area together is one tenth of the whole building surface area. Thus the energy cost saved by smart light control is about $20,000*10%BuildingSF*30%Savings= $600/year

Total Savings: $2,840+$600≈$3,440 per year.
Expected payback time: 3,850/3,440 = 14 months

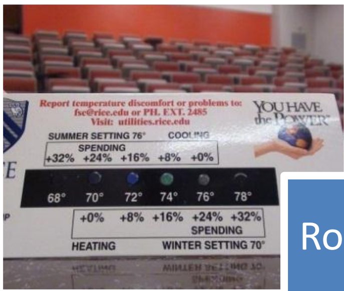
VII. **Additional Supporting Material**

Part I

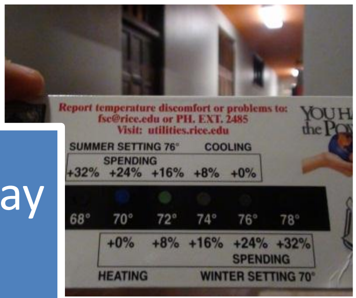
*For thermometer reading, Blue means a the actual temperature is a degree higher, Tan means a degree lower and Green means right the indicated temperature



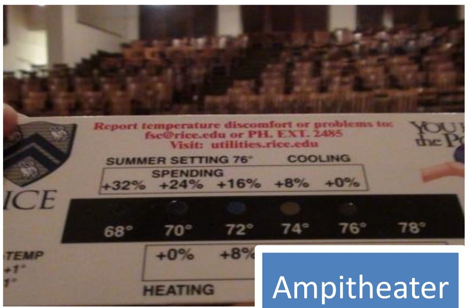
Room 210
69F



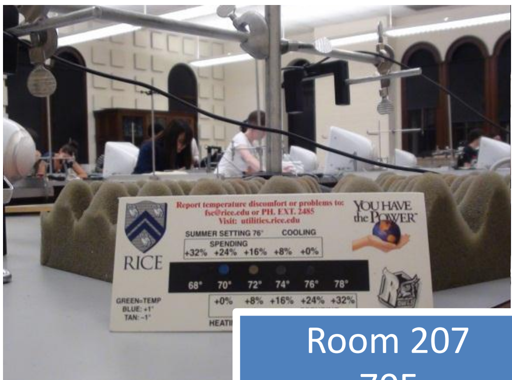
Room 212
74F



Hallway
72F



Ampitheater
73F



Room 207
70F

Part II

*A Research Result from one Motion Sensor Company about the energy savings. In our savings calculation we use 33%.

An EPA & Lighting Research Ctr. Study

Study Highlights

Sixty organizations, which were active participants in the EPA's Green Lights Program, provided a total of 158 rooms falling into 5 occupancy types: 42 restrooms, 37 private offices, 35 classrooms, 33 conference rooms and 11 break rooms. Each room was monitored for occupancy and lighting status over a 14-day period using Watt Stopper's Intellitimer® Pro light logger. The light logger data were converted to one-minute intervals, which made it possible to evaluate occupancy patterns, calculate energy savings, and estimate the demand reduction potential using simulated occupancy sensor time delays. Occupancy sensor time delays of 5, 10, 15, and 20 minutes were simulated in the study, although data for the minimum (5-minute) and maximum (20-minute) time delay simulations are presented here.

Energy Savings

The calculated energy savings for the 5- and 20-minute time delay simulations, and the percentage of energy waste that actually occurred for the 14-day period are summarized

Table 1. Energy savings for time delay simulations vs. actual energy waste*

Application	Energy savings with 5-minute time delay*	Energy savings with 20-minute time delay*	Actual energy waste**
Break room	29%	17%	39%
Classroom	58%	52%	63%
Conference room	50%	39%	57%
Private office	38%	28%	45%
Restroom	60%	47%	68%

*These are energy savings for the minimum and maximum time delay simulations (Von Neida et al., 2000).

**Maniccia and Tweed, 2000.

WattStopper

legrand

Part III
*Email from faculty mentor, Mr. Windham.

“I appreciate the work on such a proposal as this.

Let me note that I have been in my current position for a short time. The essential nature of it is to focus on energy savings rather than on maintenance. Therefore I will be able to devote my time to improving the system functionality.

This building had a humidity problem early on. Cooling (with the necessary re-heating) was necessary to get this in control. There are ways to dehumidify elsewise and I now have the time and directive to pursue these, and better scheduling techniques as well, in harmony with initiatives such as this.

As other controls and electrical personnel have the time as deemed by their supervisor we may implement the hardware additions. I will work with these supervisors to determine the feasibility of these additions by our staff.”

John Windham**”**