PROPOSAL 12/8/2015

SUNNYLANDS

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MECHANICAL

PENNSTATE

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EXECUTIVE SUMMARY

The purpose of this proposal is to identify possible alternative designs to the additions to the Sunnylands campus. Following the investigations led in Technical Reports 1, 2, and 3, a proposal for a different design scheme can be proposed. This new design scheme will be evaluated in the upcoming semester and presented at the end of the academic year. The changes to the Sunnylands buildings are meant to improve the efficiency of the mechanical system by taking advantage of the climate.

For the depth of this proposal, the use of evaporative cooling will be investigated. Currently, the Sunnylands campus buildings all implement direct expansion loops to accomplish the cooling needs of the occupiable spaces. While this accomplishes the task of cooling the space, it isn't the most appropriate system for the dry environment. By implementing an evaporative cooling system, energy can be saved in the cooling proves. In order to quantify the value of this change in design, the amount of energy required to operate the Sunnylands campus buildings will be assessed with both options.

Additionally, there will be two breadth analyses performed to analyze the effects of this change. The first breadth under investigation is the impact of the evaporative cooling system on the campus' goals of meeting net-zero energy status. With a more efficient system, the energy demands will decrease and the photovoltaic array may be able to decrease in size. The number of required PV panels will be assessed as well as the best placement for the panels on site. Additionally, by switching to a water-based cooling system in southern California, there are social impacts that must be considered. By switching to water, the Sunnylands site will be drastically increasing their water consumption on site. In a drought ridden area it's critical to assess the impact of this decision on the surrounding areas. An investigation will be led to determine ways to offset the amount of water used in the operation of the mechanical system.

BUILDING OVERVIEW

Sunnylands North Campus is a new complex of administration buildings totaling to approximately 45,500 square feet. The complex is located in Rancho Mirage, California on the North side of an existing campus. The new construction package will include four buildings designed to house administrative services, archives, operations management offices as well as support buildings. Figures 1 and 2 depict the location of the site and the relative location of the buildings respectively.

FIGURE 2 SITE LOCATION

FIGURE 2 ADDITION TO EXISTING SITE

Set into the beautiful Sunnylands campus, the new buildings are intended to attract the best technical employees to further develop and oversee the nonprofit organization known as the Annenberg Foundation. This is accomplished through high performance, state-of-the-art facilities that can be marketed by the Annenberg Foundation as an innovative and inspirational work environment. Embodying these high performance qualities are two quantifiable goals for this project: LEED Platinum certification and net zero status.

In addition to the technological innovation incorporated throughout the campus, the architectural designs of the buildings are meant to inspire those who work on the campus. Exterior materials include plaster, CMU blocks, and aluminum. The interior spaces are designed to keep employees happy, comfortable and focused.

MECHANICAL OVERVIEW

Each of the four buildings being added to the Sunnylands campus will receive their own rooftop unit to provide ventilation, exhaust and a portion of the conditioning for the spaces within. The unit sizes and capabilities of the units are outlined below in table 1.

TABLE 1 ROOFTOP UNITS

Building	RTU	Supply	Cooling MBH	Heating MBH
Storage	RTU – 1A	3750 CFM	142.25	102
Operations	RTU – 1B	2000 CFM	57.1	68.2
Archive	RTU – 1C	1250 CFM	83.3	68.2
Administration	RTU – 1D	3750 CFM	142.25	102

The reason for the differences in units can be attributed to building size and intended use. Some of the buildings have much higher loads than others. Additionally, some buildings have unique conditioning requirements. The Archival Building has a wide array of storage conditions that must be met to preserve the works within. For more information about the requirements of the Archival Building, please reference Technical Report 2.

Once preliminary conditioning has been completed in the air handler, the air then enters the buildings and is distributed to the zones. Additional cooling and/or heating may be required to satisfy the needs of the zone to which it will be supplied. Additional cooling or heating can be accomplished through the use of fan coil units. These units pull a constant volume of air from the spaces back up unto the ceiling cavity in a duct where it is further conditioned in a heat exchanger that is fed from an outdoor variable refrigerant flow unit. Once cooled or heated to the space requirements, the air is moved back into the space at a constant volumetric rate.

The VRVs providing this second level of conditioning are located outside of the buildings. Each fully conditioned building has its own VRV on its roof. Table 2 below documents the capabilities of the VRV units associated with each building.

TABLE 2 VRV UNITS

Building	VRV	Cooling MBH	Heating MBH	IEER
Operations	HRU – 1C	98.3	144.4	9.5
Archive	HRU – 1B	166.2	272.0	11.8
Administration	HRU – 1A	290.0	427.0	11.7
Administration	HRU – 2A	127.8	204.0	12.5

The only new building without an outdoor VRV unit is the storage building. This building is treated as a semi-conditioned space. Since it will primarily be used for vehicle storage, the main concern of this building is ventilation for safe breathing. The air handler circulates adequate fresh air to maintain safe breathing conditions. However, the air supplied to the space is not conditioned for occupant comfort.

DESIGN OBJECTIVES

There were two main bodies of influence for the mechanical design team on the Sunnylands buildings. The first factor in the decision making process was the overall "greenness" of the building. The owners put an emphasis on achieving LEED Platinum certification and net-zero energy consumption. At the beginning of the design process, the team investigated the feasibility of a "total plus" building, one where not only is the project not taking from its environment in any way, it's actually giving back. In order to achieve this, the buildings would have to reach net-zero energy, water, carbon, and waste. After extensive feasibility studies, the team established the goals outlined below.

Category	Goal	Strategies
Energy	Net-Zero Building	Low energy use intensity design and onsite renewable energy
Carbon	Carbon Neutral	No combustion on site to eliminate carbon use
Water	50% Reduction	Reduce use, water cycle, contract engineered wetlands on site for gray water
Waste	90% Reduction	Construction waste diversion

The second factor in the decision making process was aesthetics. The Sunnylands campus is designed to be a retreat for global leaders. It also houses the Annenberg Foundation Trust, a family foundation that provides funding and support to non-profit organizations around the world. As a foundation working on some of the largest global education projects, they Annenberg Foundation aims to attract some of the brightest minds to the project team. In order to do this, they require a state of the art facility that is both beautiful and functional.

The desire to keep the spaces aesthetically has made a considerable impact on the mechanical system. One of the major areas impacted by this decision is the open office space in the Administration Building. The space has an open slatted ceiling that eliminates the need for diffusers in the ceiling space. Additionally, the exterior of this space is almost completely clad in glass. The abundance of glass resulted in the mechanical and architectural teams collaborating to find glazing with lower U-values and developing overhangs and shading devices to mitigate the direct solar gains to the space.

PROPOSED ALTERNATIVES

Below is an outline of the potential alternatives for the depth of this proposal. For the purposes of this proposal, each of these options were investigated roughly and discussed with the HGA Architects and Engineers mechanical design team that worked on the Sunnylands project. Each design proposal is discussed briefly below. Only one of these possible alternatives will be explored in depth next semester.

ALTERNATIVES CONSIDERED

Several possibilities were taken into consideration for the redesign of the mechanical system(s) at Sunnylands' campus. Multiple factors such as energy consumption, operating cost, maintainability, and geographic relevance were considered in the decision making process. Options considered for the potential re-design are listed below.

- Central Plant
- Evaporative Cooling
- Geothermal Cooling and Heating

Most of these alternatives will not be carried out into a full re-design. A full description of the depth and breadths selected for full analysis can be found later in this report as well as the proposed methods for executing the research, design and comparison to the original design.

Central Plant

Currently, all four additions to the Sunnylands campus are conditioned at the building level. In the figure at right, you can see the building proximity of the buildings on campus. There are four occupiable buildings in the addition to the site as well as two existing buildings on site. The oldest building on site is a midcentury modern estate located in the middle of the golf course on the South end of the site. The other existing building, the Annenberg Retreat, was constructed in 2002 and is a certified LEED Gold project. While the Annenberg Retreat is a very energy efficient building, it is not a net-zero building. Bringing this building to net-zero status was a goal of the owner.

By proposing a Central plant, an investigation will be led to determine the efficiency improvement combining the loads of the existing buildings and the additions to the campus to be treated in a singular plant. The existing buildings on campus are not operated on an office-like schedule. They are open later in the and into the night to host events. Alternatively, the buildings on the North-West side of campus will most likely be operated from 9-5 Monday through Friday. By bringing these buildings' loads together into one central plant, the system can operate more efficiently with a better distributed loading profile.

Evaporative Cooling

The buildings on the Sunnylands currently use direct expansion cooling to condition the occupied spaces. While the current set up adequately conditions the air, it isn't the most efficient way to do so. In the warm, dry climate of Southern California, evaporative cooling is a much more efficient method of removing heat from the buildings.

The reason the design team didn't move forward with evaporative cooling was due to owner request. The Annenberg Foundation Trust did not want to use a water-cooled system due to the impact it would have on the drought in California. In response to this owner argument, this depth will explore the impact of designing the additions with evaporative cooling. This impact will examine the amount of domestic water consumed in the buildings as well as the amount of water consumed by the golf course on site. Additionally, there is an engineered wetlands on site that will treat the gray water on site.

With the investigation of energy savings and added water consumption associated with evaporative cooling systems as opposed to a direct expansion system, a plan will be generated to develop more water harvesting initiatives on site using the money saved from the energy savings of the more efficient system. With a desired payback period of 10 years, additional water harvesting strategies will be investigated to make up for the extra water consumption on site.

Geothermal Cooling and Heating

Another alternative to the direct expansion systems is geothermal cooling and heating. This method allows more efficient exchange of heat using the ground instead of the air. The advantage of using geothermal loops lies in the temperature difference between the air and the ground. The ground is at a stable 55 degrees year-round while the air temperature fluctuates between about 40 and 140 degrees during the year. It is particularly difficult to cool the interior spaces when the exterior temperature is nearly twice that of the interior. Simply put, it's hard to push any more heat outside when it's already so hot out.

While it would be a much more expensive option, a geothermal loop would be substantially more efficient than the current dx systems and would not require the use of water in the mechanical system. The major drawback of this option is the buy-in cost. The initial cost of installing the geothermal loop is substantially greater than the dx system and therefore is a less viable option.

MECHANICAL PROPOSAL

After investigating the possible alternatives listed above, a final proposal for a revised mechanical system design is proposed below. This proposal moves forward with the second option listed above, an evaporative cooling system. In addition to information regarding the depth of this re-design, there are two breadths discussed as well. The breadths listed below investigate the potential ripple effects of changing the mechanical systems to evaporative cooling systems.

DEPTH

The main analysis of the mechanical system at Sunnylands will be dedicated to switching the dx system with an evaporative cooling system. The four additions to the Sunnylands would each receiver their own evaporative cooling tower. The expected result of this change is a substantial reduction in annual energy costs. The evaluation of this energy savings will be carried out through the development of an energy model. The energy model will be created using Trane Trace 700 and will be compared to the energy model generated for the purposes of Technical Report 2.

Once an energy model has been created, an evaluation of annual water consumption and electricity consumption will be evaluated. The amount of water consumed per year by the mechanical system will be evaluated and a plan will be developed to offset this consumption by on-site water collection and modifications to the current landscape. A cost estimate will also be generated for this plan and the initial cost will be compared to the ongoing operating savings of the evaporative cooling system and a payback analysis will be generated to determine if the payback period is within the lifecycle of the system.

BREADTH 1

By switching to an evaporative cooling system, the mechanical systems will be able to operate more efficiently than the current design. As mentioned above in the depth description, an energy model will be generated to document the amount of energy saved by switching systems. Since the Sunnylands campus is designed to be net-zero, the campus will utilize a solar panel array to offset the energy consumption on site. By reducing the amount of energy consumed, the number of solar panels can be reduced. This proposal suggest re-evaluating the number of panels required to offset the energy consumption on site per year. In addition to re-evaluating the number of panels needed, the array location and arrangement will be studied as well.

BREADTH 2

The second breadth under investigation in response to the depth of this project is the impact of consuming more water on site. Since it is unlikely that there will be enough collectable rainfall on site to combat the use of water in the mechanical system, an investigation will be led into the impact in the community of the water consumption on site. This breadth will not be limited to the amount of water the mechanical system will consume, but will evaluate the overall levels of water consumption on site broken down into three categories: domestic, mechanical systems, and golf course. This total consumption will be eased slightly by the on-site water collection plan and the engineered wetlands, but not enough to counteract the vast majority.

In response to the great amount of water used on the Sunnylands campus, a responsible water consumption plan will be developed in depth 2. This consumption plan will recommend ways to save water on campus, evaluate the amount of water the Sunnylands campus takes from the surrounding community and the impact this has on the state of California in times of drought.

PROJECT METHODS

In the sections below, there is an outline of the tools that will be used in the execution of this project as well as a timeline for the progress of this project over the following semester. All tools proposed to be used in the execution of this re-design are all tools currently provided by Penn State's Architectural Engineering department.

TOOLS

Below is an outline of the computer software that will be used to determine the effectiveness of the above proposed solutions to improve the Sunnylands campus. Each program, its function, and intended use is outlined below.

Trane Trace 700

Trace will most likely be the most important tool in the analysis of this re-design. Through the implementation of Trace, a new energy model will be generated to evaluate the energy efficiency of the Sunnylands campus with the new evaporative cooling system. This model will be used to determine the energy consumed in the operation of the buildings and the initial and life cycle costs of the modifications.

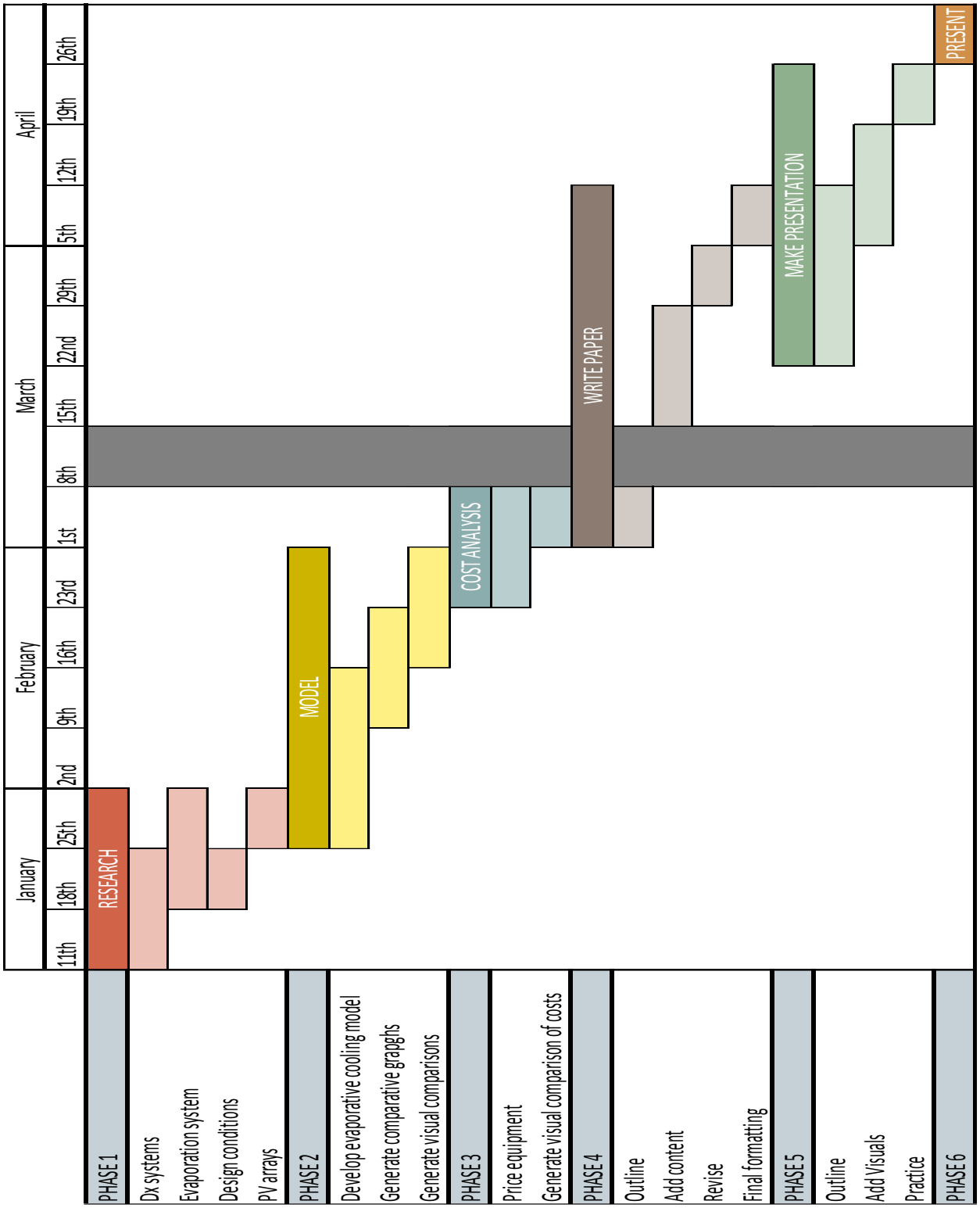
Microsoft Excel

Excel will be used to perform cost analyses that Trace is not capable of doing. The spreadsheets generated in Excel will provide a more accurate life cycle cost analysis, track energy consumption during peak times, mid-peaks and off times in accordance with the energy provider, the amount of money spent and earned per day on average each month in terms of energy consumption and energy harvesting.

Revit

Modifications to the Revit mechanical model will be made for the purposes of coordinating systems. With the limited ceiling space provided in the Administration Building, the three dimensional modeling capabilities of Revit will help to ensure the constructability of the proposed re-design.

SCHEDULE


January
February
March
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11th
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PHASE 1
RESEARCH
Dx systems
Evaporation system
Design conditions
PV arrays
PHASE 2
MODEL
Develop evaporative cooling model
Generate comparative grapghs
Generate visual comparisons
PHASE 3
COST ANALYSIS
Price equipment
Generate visual comparison of costs
PHASE 4
WRITE PAPER
Outline
Add content
Revise
Final formatting
PHASE 5
MAKE PRESENTATION
Outline
Add Visuals
Practice
PHASE 6
PRESENT

RESEARCH

Below is a preliminary library for the basis of research for the work that will be executed in accordance with this proposal. The references below are the beginning stages of research for this project. The research library for the next semester will be more substantial than the works listed below.

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