The Smeal College of Business Building, referred to hereafter as the Business Building, is a 210,000 SF, four-story, academic and research facility on the Pennsylvania State University's main campus in University Park, Pennsylvania. The redesign of this building will involve a full study of its lighting and electrical systems in four predetermined spaces. The following report outlines each proposed area of study in more detail.

LIGHTING

The lighting depth study will be performed on four specific areas of the Business Building: a 12,000 SF, four-story open atrium, the building's primary circulation space featuring a suspended bridge and a curved, true-north-facing glass and aluminum curtain-wall; a 1,300 SF classroom that is typical of other classrooms in the building with a semi-circular, tiered seating arrangement; the 2,600 SF, Blue Chip Bistro Café by Sbarro, which includes a food servery, a Starbucks coffee bar, and a general dining area; and a 14,000 SF terrace, a bi-level outdoor gathering space that faces the campus center and leads visitors to one of the building's primary entrances.

The primary goal of the lighting design in all spaces will be to support the architecture of the respective space, support the spaces' functions (i.e., optimizing the lighting design to aid occupant tasks), or both. The Illuminating Engineering Society of North America (IESNA) handbook's recommended design criteria for each space will be used to help determine what takes priority in the design such as aesthetics versus performance. Ease in construction will be considered by making efforts to specify fixtures, lamps, and other supporting accessories from as few manufacturers as possible, which may also result in some cost savings. Energy savings will be attempted by specifying energy-efficient, long-lasting sources such as fluorescent and metal halide lamps, as well as by integrating lighting controls to reduce lighting levels when desired, and shut lights off automatically when spaces are not in use. The ASHRAE Standard 90.1-2004 will be utilized as the reference point to determine the amount of energy saved or overspent.

ATRIUM

The atrium is the center of the Business Building and serves as both a circulation space, and a meeting and gathering space. This lobby-like atmosphere will be complemented by a more aesthetically pleasing lighting design. The redesign will also attempt to emphasize the concept of the atrium as being the focal point of the building by highlighting it as a separate element in and of itself, an element that is independent from the two main wings of the building. Lighting controls will also be an important factor to consider in the design for energy conservation as the space operates 24/7 throughout the year and electric lighting may not always be necessary as there is an abundance of glazing that allows natural light to fill the space during the day.

CLASSROOM

Mechanical air terminals, speakers, a wireless internet router, three video projectors, and various luminaires all currently share the classroom's ceiling space giving it a cluttered and unattractive appearance. The new lighting design will aim for a cleaner ceiling appearance while still keeping the needs of the other systems in mind. However, performance takes precedence over aesthetics in this space so adequate lighting levels will also be one of the main factors that ultimately determines the final design. Unfortunately, there are no windows in this space so all lighting must be provided electrically. This can drive up the classroom's power density very easily so an efficient layout and proper lighting controls will be very important in keeping the lighting design's energy consumption minimal.

Flexible lighting controls are important in this space because of the variety of lighting needs that will occur based on the use of the classroom (e.g., general instruction versus digital slide show presentation). Occupancy sensors will also be implemented to turn lights off automatically when the room is empty in case the last user does not turn them off himself.

CAFÉ

The café's aesthetics versus performance needs are more equivalent than that of the other three spaces. Ample light will be needed for tasks in the food service areas as well as the cash registers, but the space should also be one that creates a positive and relaxed atmosphere in the dining area. This pleasing aura will be achieved by creating points of interest in the space with accent and decorative lighting. Some of the elements that will be highlighted are signage (e.g., menus) and the café's decorative colored-glass wall in the dining area. Also, the large amount of south and east-facing glazing creates an opportunity for the application of daylight harvesting since the café primarily operates during daylight hours anyway.

Another lighting strategy for the café is to provide higher levels of light at specific areas to attract the attention of the patron and help guide him around the space. Examples of areas that would benefit from being brighter than the rest of the café are the food service line, the exits, the coffee order pick-up station, the condiments table, and the cash registers. However, sufficient contrasts in illumination may be difficult to achieve due to the proximity of all these areas so decorative luminaires may need to be utilized as a supplement to general ambient lighting as the attention-grabber instead.

Three distinct but acceptable lighting schemes will also be designed specifically for the café's entrance signage with the ultimate goal of attracting attention to the entrance. The three alternate designs are (1) subtly backlight by creating a light cove with colored LEDs behind the sign, (2) use a combination LED/MR16 accent light to highlight the sign with a splash of color, and lastly (3) a simple linear wall-washer that illuminates the entire length and width of the wall that the sign is attached to, making the wall appear to glow. The cost, performance, energy, and constructability differences among the three different systems will be compared.

TERRACE

Low-profile pathlights will provide visibility at night and also act as markers to highlight the pathways to the building's door and vice versa into the rest of the university campus. Full cut-off bollards will provide the most light at the main path without spilling light up into the sky. Using the imagery of trees to conceptually connect the Business Building to the rest of the campus, uplights will highlight the columns at the building entrance and get caught at the metal grills at the upper half of the façade, similar in fashion to the way one may light a tree's trunk and branches. The overhang created by the terrace's upper level will catch the rest of the uplight helping to brighten that upper area even further to establish a "canopy" of light that is held up by "trunks" of light. This concept will be applied to the upper level as well but with colors to provide a decorative option, e.g., blue can be displayed during the week of a home football game, pink can be displayed in support of Breast Cancer Awareness month, etc. There are no grills at the façade of the upper level though and in fact, the entire vertical surface of that part of the façade is flat with no texture at all for uplights to grab to create the "canopy" lighting effect. Therefore, a horizontal element similar to that of the existing grills will be added to the façade to catch some of the uplight and complete the design. Light pollution will be avoided as much as possible for general good design practice but full compliance with the guidelines set by the International Dark-Sky Association will not be attempted.

ELECTRICAL

BRANCH CIRCUIT DISTRIBUTION REDESIGN

The lighting redesign of the four aforementioned spaces will change the electrical loads of the building. A branch circuit distribution redesign will be performed by deleting the existing lighting system of the four spaces and circuiting all of the new lighting loads instead. This should translate to the redesign of four electrical panelboards. The panelboard, load, wire, and overload protection device sizes and quantities will all be determined using standard design procedures.

PROTECTIVE DEVICE COORDINATION STUDY

Consequentially, the trip curves of a branch device, its distribution panel, and its switchboard, i.e., three devices in the same stream, will all be compared by utilizing information and graphs provided by a standard manufacturer and a computer graphics program to verify that they are coordinated. Short circuit calculations will also be performed to support this study using standard design procedures. The devices that will likely be used for this study, in order of going upstream, are a 150 kVA transformer (branch device), distribution panel 'DP4L1' (480/277 V, 600 A), and the 3000 A main switchboard 'MS4L'.

BUILDING INTEGRATED PHOTOVOLTAIC (BIPV) SYSTEM FEASIBILITY STUDY

University Park, PA does not receive the amount of daylight that would be required to take the Business Building off-grid economically. However, three of Penn State's photovoltaic powered structures on campus are nearby, the Office of Physical Plant, which is north of the stadium and has PV panels on its roof, the MorningStar PA home located by the PSU Visitor's Center, which uses both the traditional PV panels as well as solar slates (a PV panel designed to look like a building material), and a mechanically powered, pole-mounted, solar tracking PV array, which is by the bio-wastewater treatment plant at the Center for Sustainability. The Business Building's proximity to these structures may help contribute to Penn State's overall PV system resources and research opportunities by going beyond the traditional arrays and implementing building integrated photovoltaics (BiPV) to all the applicable glazed surfaces instead as these glass-integrated PVs are not yet in use anywhere on campus.

The power generated by these BiPVs could then be used to power a selected aspect of the building rather than the whole thing, such as all exterior and site lighting. However, ignoring the academic benefits and viewing this from a more commercial and fiscal standpoint, it is understood that due to the nature of the Business Building's location, attempting to supplant even just a small portion of the building's loads through photovoltaics may not be worthwhile. Therefore, the nature of this part of the electrical redesign will be that of a feasibility study. System performance, an economic analysis, and final recommendations will be included in the study.

If this is believed to be unacceptable for the electrical redesign requirements, please see the end of this report for the proposed alternative.

DISTRIBUTION PANELBOARD AND FEEDER REDESIGN

The distribution panel and its associated feeder that is most affected by the lighting change will be redesigned as appropriate to reflect the load changes using standard calculation and design procedures. Excel will be the primary tool utilized to organize and present this study including the applicable calculations for how loads, sizes, and quantities were determined for conductors and overcurrent protection devices. This distribution panel will likely be 'DP211', which is a 208/120 V distribution panel in one of the first floor electrical closets, or 'DP4L1', which is a 480/277 V distribution panel in the main switchboard room.

REDESIGN ALTERNATIVE: FULL SYSTEM ANALYSIS

If it is decided that the photovoltaic system feasibility study would not be acceptable for the electrical redesign requirements, a short circuit analysis, protective device coordination, arc fault study for the Business Building's entire electrical distribution system will be performed as an alternative using the SKM software. The study will start at the service entrance and cover all panelboards.