7.0 – Electrical System – Breadth 1

One very interesting method to reduce the impact of a building on the environment is to include photovoltaic panels somewhere in the project. These panels make electricity from light, and are usually faced south on a wall or roof surface for most buildings in the US. The Life Science & Philosophy Building has a fairly steep roof rain screen covered with Vermont Slate. While this roof is very aesthetically pleasing, it is also very heavy and expensive. A simple way to reduce the overall effective cost of the building is to put PV panels on the roof instead of the slate, offsetting some costs up front, and providing a return on the initial investment, even if it is an extended period of time. The PVs are also a great deal lighter than the slate, and could provide some structural savings as well.

There are two main types of panels; standard "outside-the-building" panels, and Building Integrated PVs. These BIPV options are very enticing because they can directly replace a building material such as a brick facade or roof tile/shingles with an energy-producing element. However, these types of systems, as do most combined systems, tend to not work as well technically because some sacrifices must be made to fully integrate the panels into the building elements/envelope. This makes standard rack-mounted PV panels the simplest, most cost-effective efficient means of generating solar-power without damaging any of the infrastructure and initial investment. The rack system and panels will directly replace the slate tiles placed on the metal deck and plywood rain screen in selected areas of the building, offsetting a bit of the cost and weight of both systems. Since their lifetimes are similar (many PVs are still in use today from the 1970's), the short-term view of this material surface is called into question.

Since cost and reliability are very big concerns with this type of system, panels from BP Solar will be a likely selection. The BP SX3195 panels are 195 watt panels at peak power, and using these panels, the array can be sized up to a 34.71kW array. This layout is not concerned with shadow paths since the array will be mounted on directly south-facing roof (at 45° pitch), and will have no objects that could cast shadows on those surfaces. Some information for the SX3195 is below.

Electrical Characteristics2	SX 3195	SX3190
Maximum power (Pmax)3	195W	190W
Voltage at Pmax (Vmp)	24.4V	24.3V
Current at Pmax (Imp)	7.96A	7.82A
Warranted minimum Pmax	177.5W	172.9W
Short-circuit current (Isc)	8.6A	8.5A
Open-circuit voltage (Voc)	30.7V	30.6V

Temperature coefficient of Isc (0.065±0.015)%/ °C
Temperature coefficient of Voc -(111±10)mV/°C
Temperature coefficient of power -(0.5±0.05)%/°C
NOCT (Air 20°C; Sun 0.8kW/m2; wind 1m/s) 47±2°C
Maximum series fuse rating 15A
Maximum system voltage 600V (U.S. NEC rating)

To tie the DC-power into the building and the electric grid, grid-tie inverters must be used. Selected for this project is SMA-America's Sunny Boy line of inverters, specifically the SB6000US. This 95% or greater efficient inverter is designed with a single integrated AC/DC disconnect switch for servicing the system, and is compact in design to allow maximum mounting flexibility. The five (5) units that will be used can be mounted outdoors, provided precipitation doesn't fall directly on them. Mounting the inverters on the underside of the rain screen roof will provide them with sufficient weather protection and take up no space in the already tight electrical rooms on the 3rd floor. The inverters will be single-phase 208V, and will tie into both normal and emergency power systems in the building. This will help to offset some fuel consumption during generator use, and will provide utility offset year round.

SB6000US, with integrated AC/DC Disconnect

With the array placed on these south-facing sections of the roof, sized at the maximum 34.71 kW, energy production should be around 55,000 kWh per year, on average. This provides a sizeable reduction in annual electricity bills (~$5,100/yr), and reduces the Carbon Footprint of this particular building by roughly 40 tons of Carbon Dioxide per year. This array will not come anywhere near close to making the building net-zero energy, but it will help to reduce the impact of this building on the environment. This will also be F&M's first inclusion of solar energy on campus, and could be used as a great PR selling point to attract new students to campus and show their awareness of energy in our future.

Usually these PVs are mounted over an existing roof. They do not mount well over slate because attaching the racks can be very difficult through the slate. The slate tiles will not be installed in this area of the roof, but a fluid-applied roofing membrane will be applied instead. This will provide a waterproof surface behind the panels at a lower cost than the slate. Around this section of the roof the slate will remain to maintain the aesthetic appearance of the building.

The entire array will use 3,250 sq. ft. of roof space, and removing the slate at $52.13 per SF while adding the new roof membrane at $3.20 per SF and the installed cost of the PV array at $122.82 per SF comes out to an overall cost increase of $73.89 per SF, or $240,000 overall. The actual cost of the installed PV array will be much closer to $400,000 installed, but since the slate costs will be offset, this helps the finances quite a bit. Assuming average solar radiation and fairly constant electricity costs for the payback life of the system, an 82 year payback will make up the cost of the entire $400,000 PV system. However, when the cost of the slate is removed from the initial financing, the payback period is reduced to around a 48 year span. This combination shows the costs as they will be for the building, and give a payback time well within the foreseeable life of the building, without any electric energy cost increases through the years. The electric prices that will rise very quickly and very soon will continue to reduce the payback periods of such systems in conjunction with multiple governmental grants and tax incentives provided for installers and owners of these PV systems.

See Appendix A for cut sheets for the panels, as well as panelboard layouts for connection to the building's electrical grid.