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# Balancing Optimal Daylight and Optimal Solar Gain using Climate-Based Daylight Modeling

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Analysis validated how architectural elements such as shading devices, diffusing panels, and light shelves made it possible to balance optimal daylighting with optimal solar gain.

INTRODUCTION:

Designing an envelope that optimizes the solar radiation entering a building is critical to the quality of interior spaces. Some of this radiation is necessary for illumination. This decreases the need for electric lighting and significantly contributes to the quality of architectural space. In contrast, direct solar radiation can heat a space. In large buildings this heating often contributes to the cooling load and decreases overall energy performance. This study analyzes the daylighting potential of a five-story children's hospital in Kentucky. It was an ideal candidate for a building which required both high quality daylight and minimal sol ar gain.

METHODOLOGY:

The conventional workflow with BIM software often includes the use of simple rendering software to document the shadow patterns of a proposed site. This type of study is limited due to the assumptions that must be made about the local environment. Climate-based daylight analysis software such as DIVA create site specific virtual environment and project specific material specifications. The new methodology shown in figure 1 includes the use of DIVA to analyze designs that are in the schematic design phase.

The first step in the new workflow was to export the necessary BIM (Revit) geometry into Rhinoceros. Once the existing design geometry has been imported and organized within Rhinoceros, DIVA entails a project specific setup depending on the requirements of each project analysis. The first input which is always required by DIVA is the environmental data in the form of an .epw file. This data informs the simulation software of the global position and local weather information of the project site.

The methodology for this research focused on which shading devices would balance optimal daylighting with optimal solar gain. Large buildings such as the case study have a cooling load for the majority of the year. The light which contributes to solar gain was measured in irradiance.

Solar radiation can contribute to solar gain, but it is also responsible for the quality and quality of visible light which enters a space. The illumination ranges set forth by the Illuminating Engineering Society suggest an overall illumination range of 5-100 footcandles (50-1000 lux) for hospital spaces other than operating rooms. The design team designated this range as a general comfort range for this study. Illumination values above or below this range we labeled as extremes.

Once the preliminary shadow studies are complete, designers need to set up a control. The case study did not have any shading devices included in the design at the time of the research, so the existing design was used as the control for additional shading strategies to be compared against. Once the analysis for the control is complete, there are a number of options for generating potential shading strategies.

Figure 1: Methodology Diagram

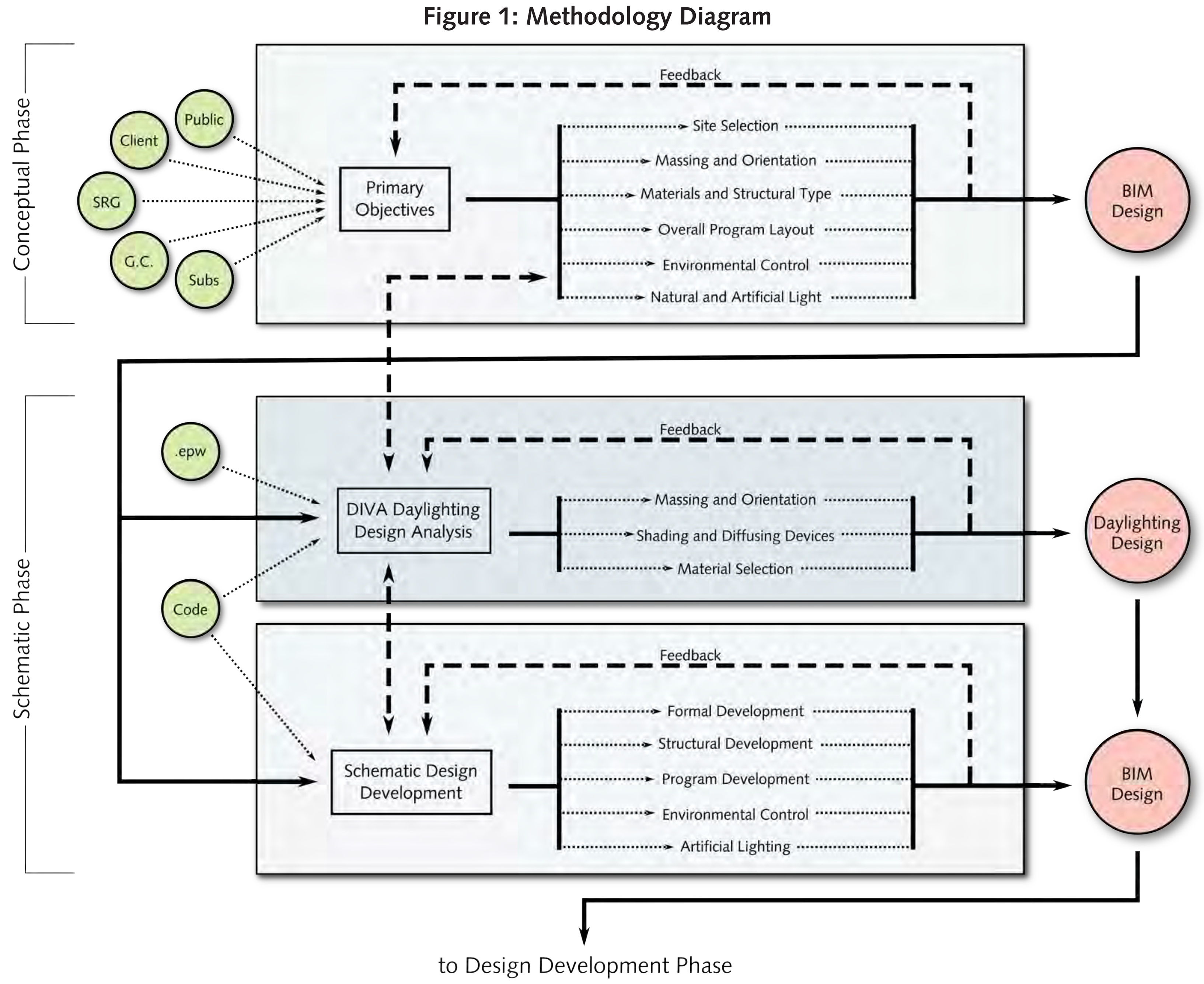



Figure 2: Workflow Diagram

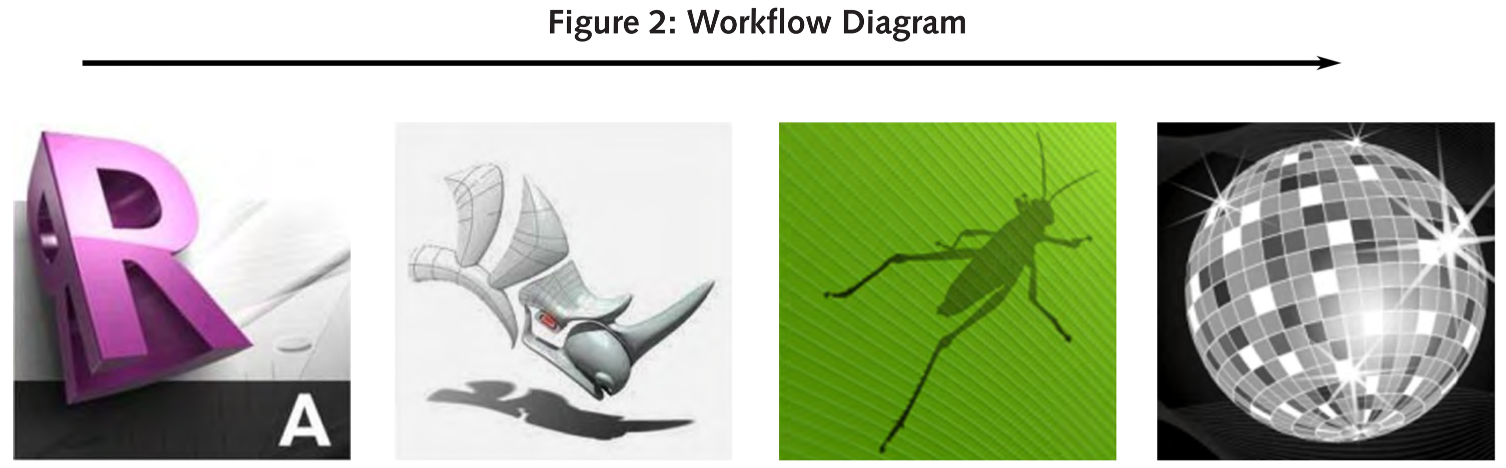
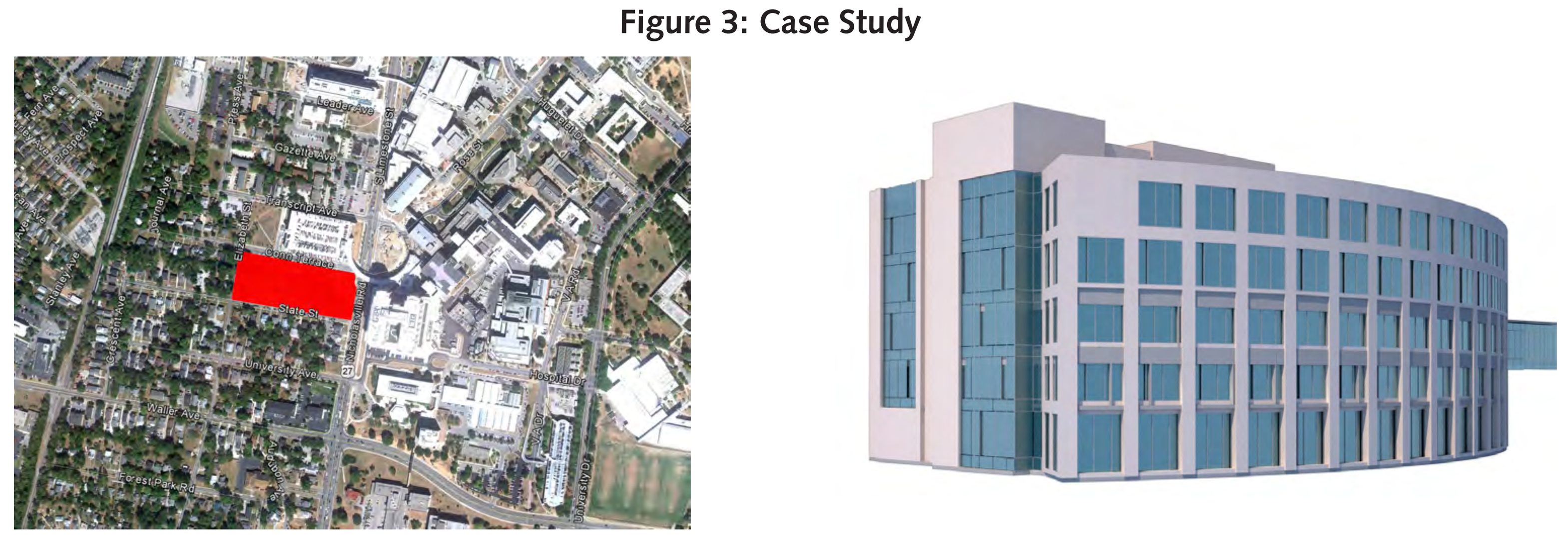


Figure 3: Case Study



DATA:

The initial simulations compared an analysis of the existing design with the different parameters such as materials and geometry. This offered insight into the abilities and limitations of the DIVA. The analysis is Figure 4 shows the effect of different sky conditions on the current design. Once the abilities and limitations of the climate-based daylight simulation software had been established, the study was focused on balancing optimal daylight and optimal solar gain with different design strategies. While the building will have five levels, the floor plane of level three was the analysis plane for the case study simulations.

The analysis in Figure 5 compares the solar radiation received by the third level floor plane with and without shading devices. The east side of the building receives the majority of the building's direct solar radiation with the current design. Only exterior shading devices can decrease the solar gain of a building. Once direct solar radiation has entered the building, very little of it will escape and it will ultimately convert to heat. The exterior shading devices shown above reduce the amount of direct solar radiation transmitted by the building envelope.

The analysis in Figure 6 compares the solar radiation received by the third level floor plane with and without shading devices. Interior light shelves are a significant element in controlling glare and deep penetration of daylight. The glare that would be experienced on the east side of the building with the current design was drastically reduced with the use or multiple shading strategies, the most significant of which were the interior light shelves. These elements work to both reduces the specular light at the exterior side of a room while allowing diffuse light to more deeply penetrate the building.

CONCLUSION:

The accuracy, efficiency, and versatility of combining climate-based daylight modeling make it a critical tool for designing quality energy-efficient architecture.Analysis validated how architectural elements such as shading devices, diffusing panels, and light shelves made it possible to balance optimal daylighting with optimal solar gain. Developing a workflow which synthesizes the traditional design process with computer simulation will be critical in allowing the integration of this software in modern architectural practice.

**Figure 4: Sky Condition Comparison- Illuminance**
3rd floor, Autumnal equinox, Current Design

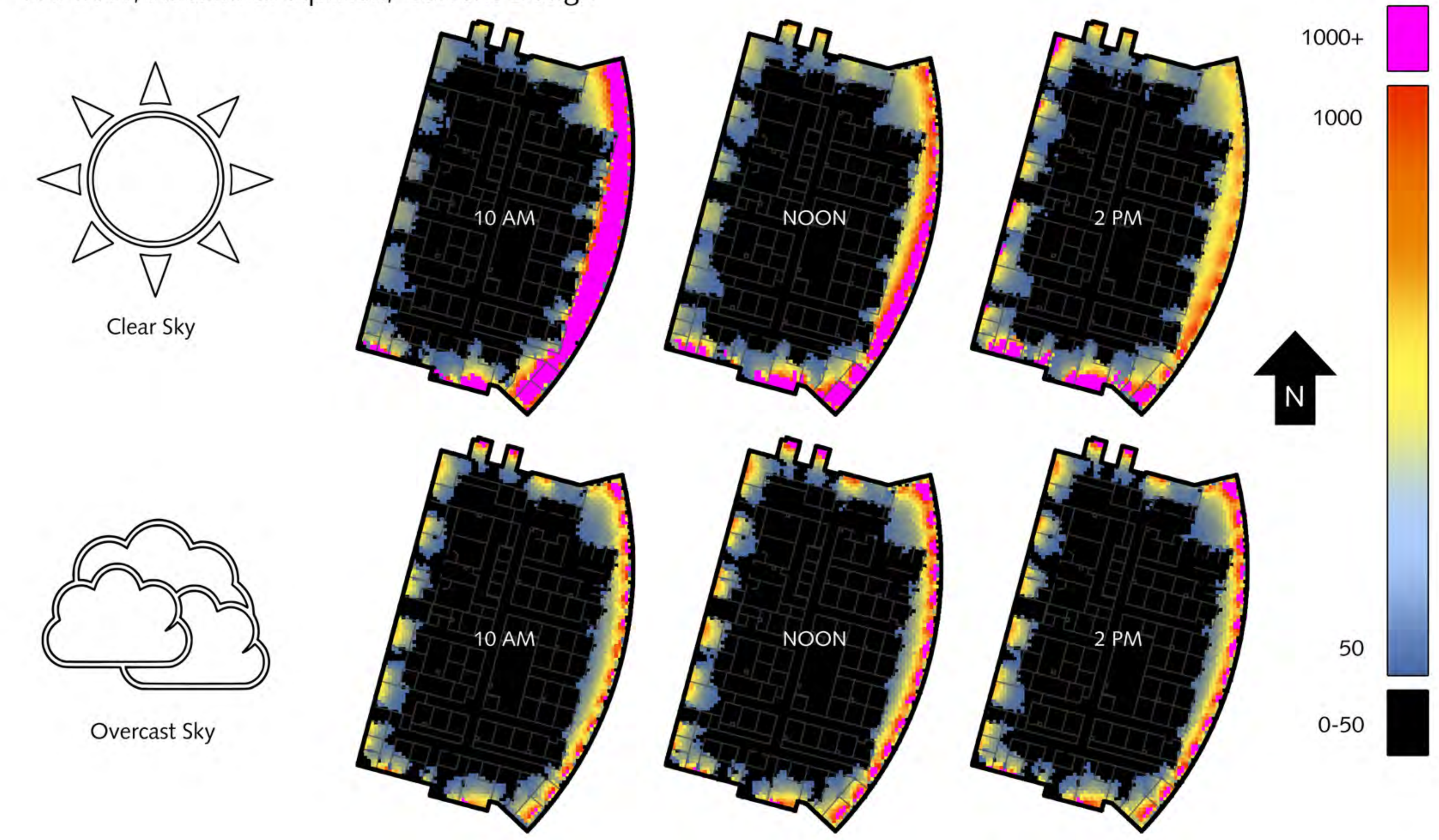



**Figure 5: Shading Design Comparison- Irradiance**
3rd floor, Autumnal equinox, Clear Sky with Sun

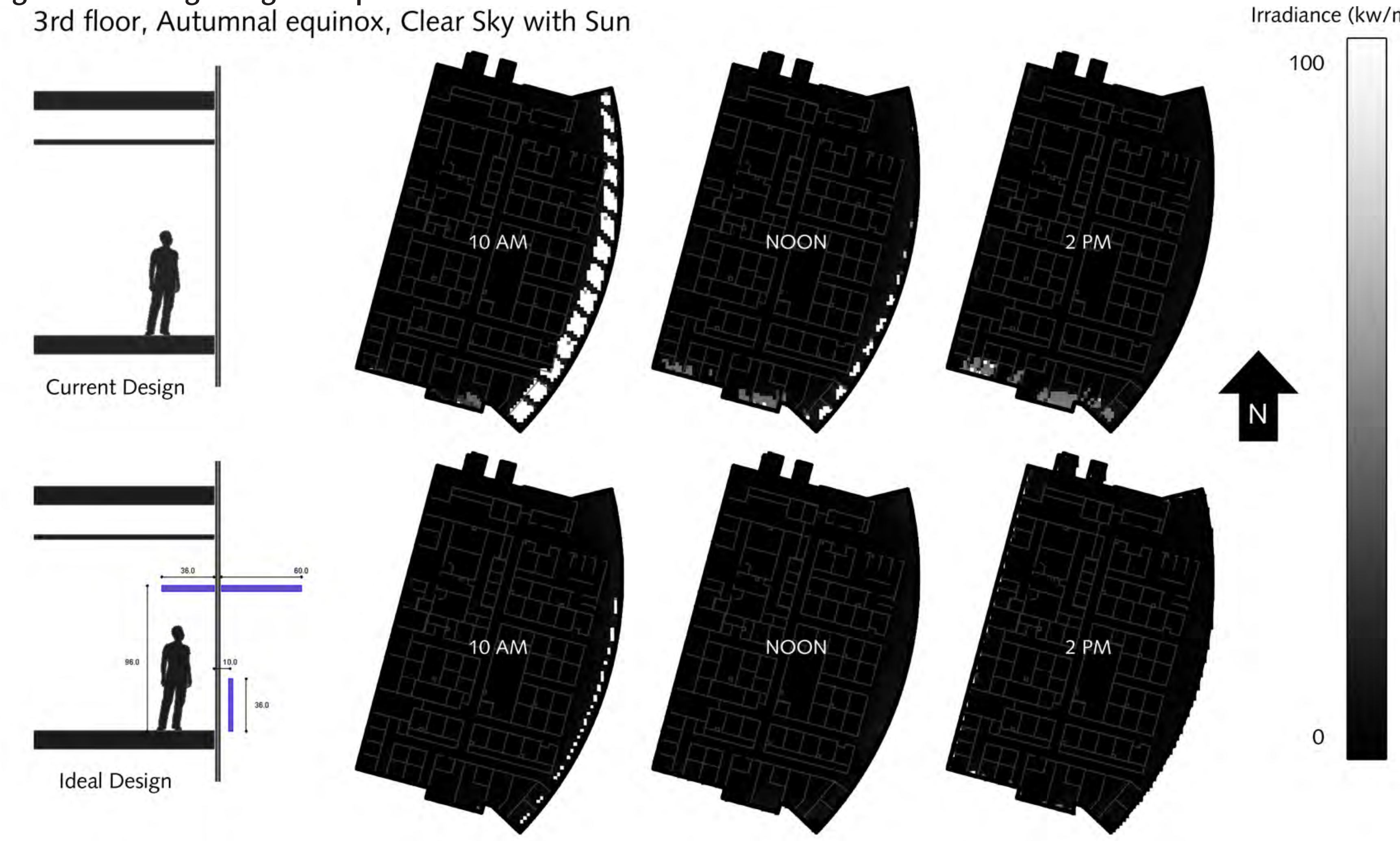



**Figure 6: Shading Design Comparison- Illuminance**
3rd floor, Autumnal equinox, Clear Sky with Sun