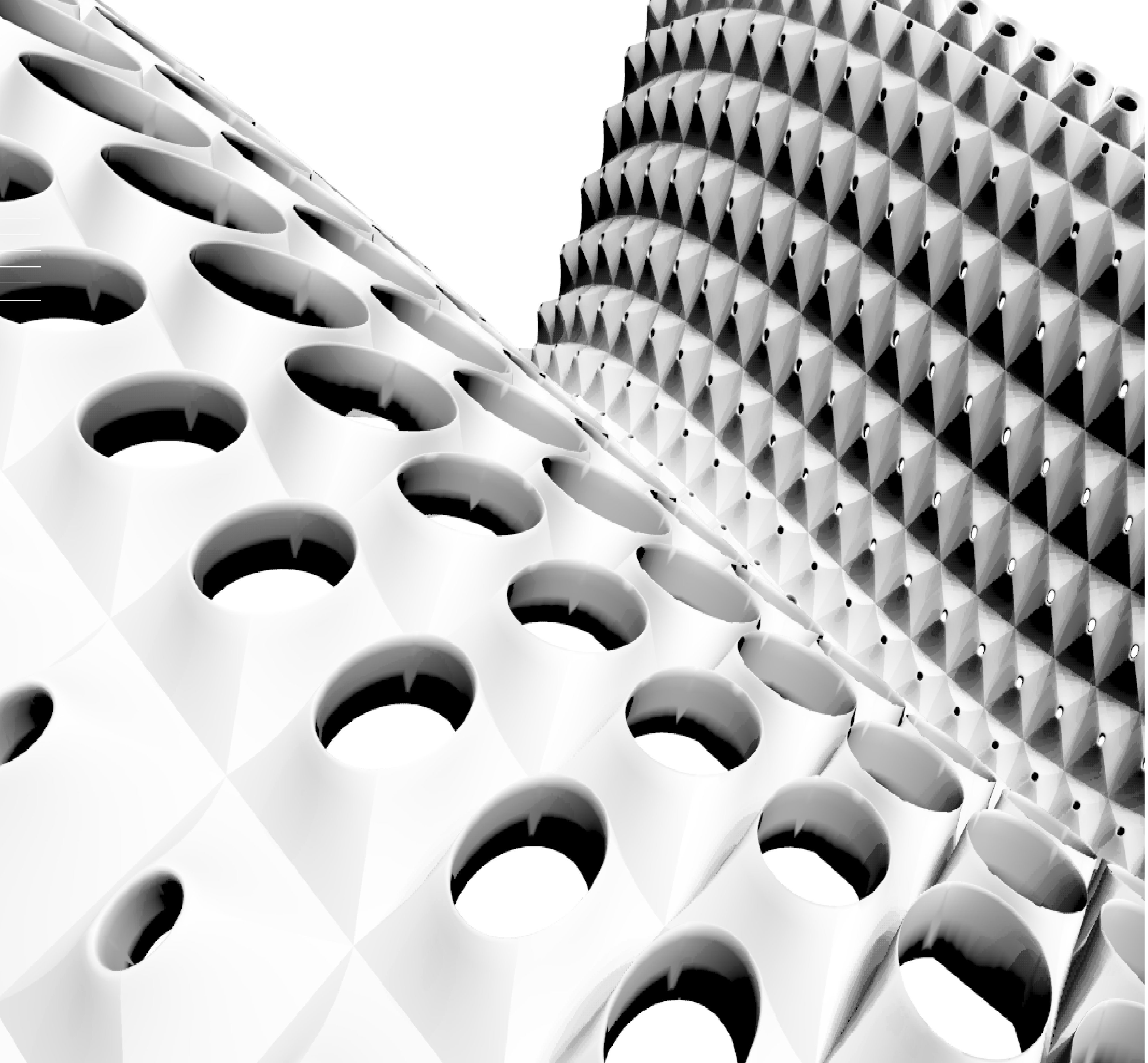

Environmentally Responsive Parametric Tools

The building envelope is the interface between the natural exterior environment and the controlled interior environment of occupied spaces. In high-performance building facades there may be multiple levels of response which vary around the exterior facade. These may included different U-values, coatings, frit patterns, shading devices, or glass make-ups on each side and at different heights. The increased level of variation across the facade does not have to be random, but can instead be accurately controlled by environmental data.

With many environmental analysis tools at the hands of architects and engineers today, it is paramount that Enclos takes leadership in developing strategies to interface with these many tools, as well as understand how logic can be introduced to the facade in complex forms and programs. These preliminary investigations look to generate routine definitions which may be applied across a wide-spectrum of input forms. The ultimate objective of this research is to effectively integrate environmental analysis as a driver in controlling the logic behind highly-variant facade designs.

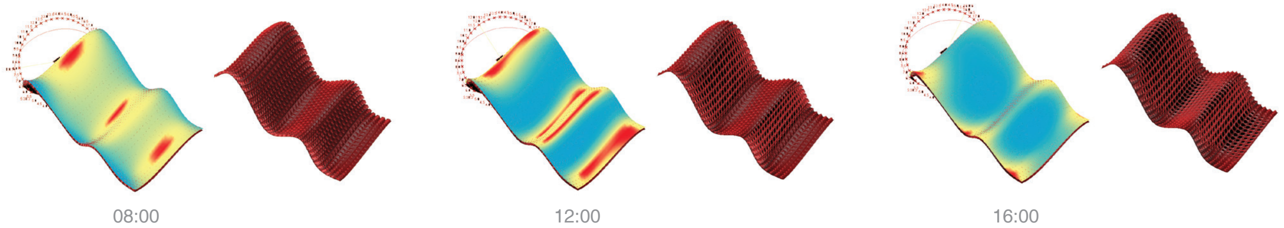

Figure 1. Panel Variations on April 18th
(populated surface offset for clarity)

INTRODUCTION

These preliminary investigations use complex double-curved forms as the base for a high-performance facade. In the first step a solar analysis is used to derive the size of opening for each panel across a smaller wavy surface – this could easily be transferred to equate to any number of frit patterns or coatings. The second step uses a similar solar analysis to generate the amount of exterior shading louvers across each panel. An experimental form for a high-rise tower is used to understand the tools abilities at larger scales.

SOLAR-RESPONSIVE SURFACE

This topic addresses environmentally-responsive architecture, where the building envelope adapts to natural forces, such as the sun. In one case, we have studied the panel composition of the outer skin. Mostly, these panels open and close in response to the sun's position showing their adaptivity to the surrounding environment. The images above represent a three-dimensional surface, modeled in Rhino, at different times of day. Using a parametric Grasshopper definition with the surface defined as an input, a panel subdivision is performed across the surface resulting in a mesh-like grid. At each grid-point a solar radiation value is calculated at anytime of the year using a sun position algorithm in VB.net based on NOAA's published algorithm. This analysis component can display the direct solar radiation throughout the year or daily. The paneling system partitions the RGB solar data on the mesh into 8 sub-ranges. Each sub-range is then assigned a variant of a paneling geometry with different aperture sizes. Imagine a complex form, but we want to control the number of unique panels.

There are two key elements which are exciting about this exercise. First is the use of an internal solar radiation analysis within the 3D modeling program. This eliminates the need to export to another analysis tool, such as Ecotect, and then re-import the corresponding data back into the Rhino model. Secondly, the parametric controls allow for the routine to be carried out in real-time when input parameters are "flexed", or changed. The original geometry can be any geometry including the surface used in this exercise, a sphere, a vertical surface, a skylight, or even a high-rise tower envelope. This is automatically generated for each panel across the entire surface. The number of unique components can be restricted or expanded as well. Instead of 8 unique panel types, this could be limited to four, or expanded to any number desirable.

PARAMETRIC HIGH-RISE TOWER

This is a parametric tower Grasshopper routine which twists and tapers an ellipse as it rises vertically. The ellipse geometry could easily be swapped out for any polygon with three sides or more within the slabs group of the Grasshopper routine. All parameters can be adjusted including height, area, geometry, floor-to-floor height, slab thickness, twist, and taper. The primary base constraint is the site plan – in this case a city block. Core, structure and glazing systems are applied.

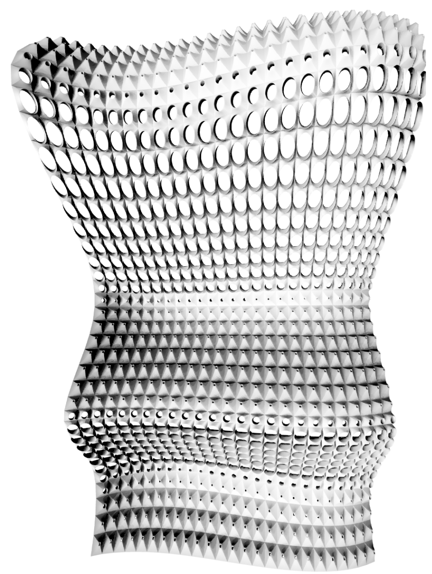

Figure 2. Plan view of varied surface.

A louvered shading system is layered on the facade exterior in response to an annual solar analysis on the controlling geometry mesh. This definition extends the Grasshopper power-copy-component to be parametrically associated with the solar geometry obtained through the insolar radiation algorithm. It is part of a larger series related to the idea of environmental response using parametrics.

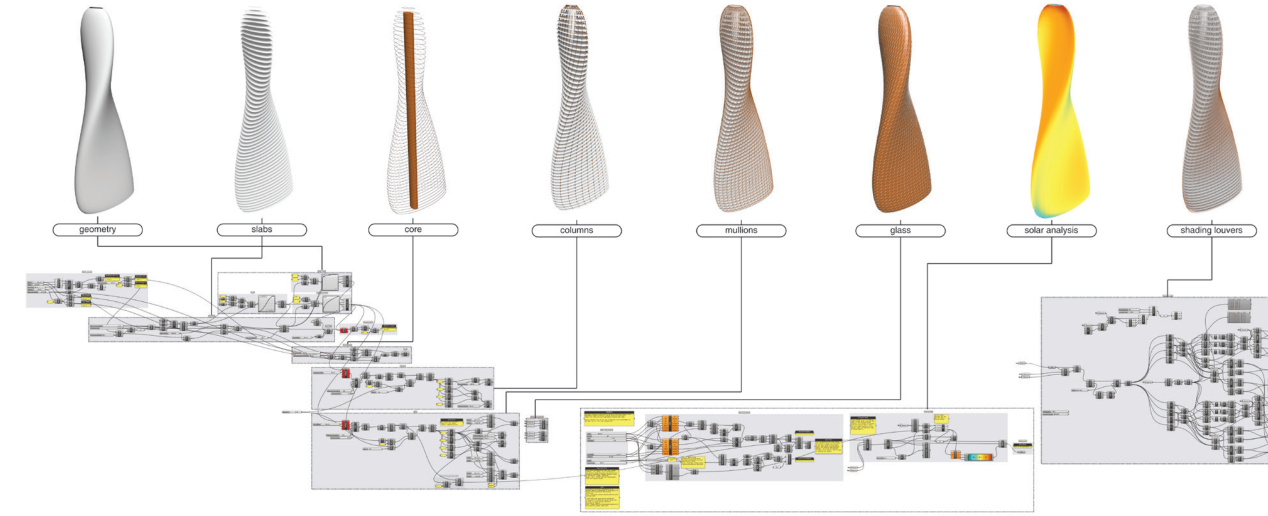

Figure 3 (above). Visual sequence of parametric high-rise tower Grasshopper definition.

Figure 4 (below). Solar-responsive high-rise tower placed in downtown Los Angeles.

CONCLUSION

These experiments show the power of parametrics to integrate environmental analytics into the iterative design process. The routine shown here use abstract form to test the versatility of the definitions, but may be applied to conventional geometries and project forms with minor re-configurations to the routines. Foreseeable applications of these routines could be used to evaluate where and how often shading devices may be used. But the opportunities are boundless. The important step here is the integration of the solar analysis into the study of form within the same modeling environment. Future studies will explore similar processes using external analysis tools, such as Ecotect, to develop a workflow cycle of data between the modeling and analysis environments.