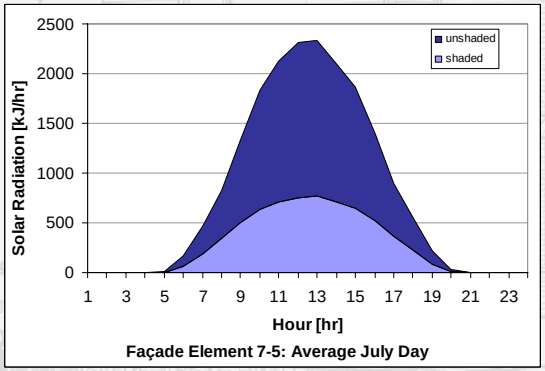
O'Neil Residence Conceptual Energy Design and Analysis

The O'Neil Residence Project was the perfect "let's get this right" project. The owners were interested in having the residence modeled early in the project so that the results could inform design. The O'Neil residence is a classic clerestory single family house design. As such is includes the high thermal mass and high south façade window area with overhangs that can significantly offset heating and cooling requirements but, which if poorly designed can also create an uncomfortable space. TESS's part in the project was to carry out modeling of the envelope, the shading features and a series of promising system alternatives. TESS worked in cooperation with Atelier 10, a leading environmental design firm, on the energy design of the project.

Shading Analysis

The first task in this project was to assess the performance of the south façade's shading features. The building was simulated with and without its shading features and for each of the 22 south façade elements, plots were generated showing the incident shaded and un-shaded radiation for various representative days throughout the year.



Façade Element 7-5: Average July Day

In addition to determining incident radiation on the façade elements, whole building energy use was also predicted with and without certain shading elements. It was discovered that while certain elements provided significant shading, the associated energy savings were minimal and that resources would be better used in other energy efficiency measures such as tightening the envelope to reduce infiltration.

System Alternatives

The O'Neil residence envelope offered us a number of possibilities for exploring innovative system designs that would have been out of the question in a more conventional, less optimized envelope. The significant southern exposure combined with well sized overhangs offset winter time heating requirements while the thermal mass of the space allowed us to consider both air and water based radiant heating options. The following system options were modeled and analyzed:

Base Case System: High-Efficiency Furnace and Split-System Air Conditioner

System Alternative 1: Geothermal Heat Pump

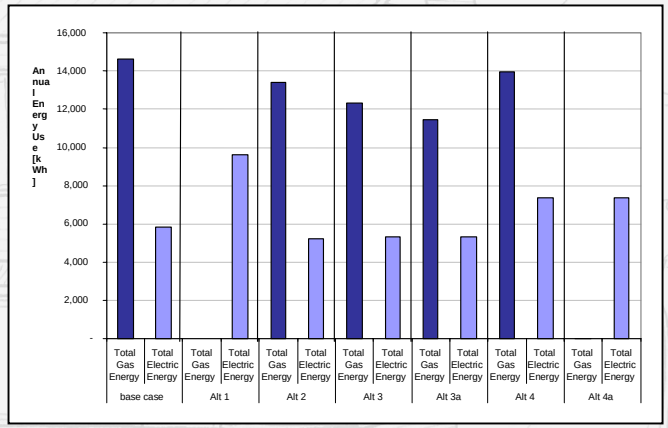
System Alternative 2: High-Efficiency Furnace with Decoupled Trombe Wall Assist and Split-System Air Conditioner with Earth Duct Assist

System Alternative 3: High-Efficiency Furnace with Air-Based Solar Collector Assist and Split-System Air Conditioner with Earth Duct Assist

System Alternative 3a: High-Efficiency Furnace with Air-Based Solar Collector Charging a Hypocaust and Split-System Air Conditioner with Earth Duct Assist

System Alternative 4: Boiler-Heated Radiant Floor with Split-System Air Conditioner

System Alternative 4a: Water-Based Solar-Assisted Boiler-Heated Radiant Floor with Split-System Air Conditioner



New Models

As many of our projects do, the O'Neil Residence analysis offered us the opportunity to write a new model for TRNSYS. In this case, we needed to model the earth duct cooling system. Complex and rigorous models of such systems exist but their level of required input detail made them inappropriate for this level of analysis. Instead, we wrote a simple ground heat transfer effectiveness model. While the effectiveness of the earth duct heat exchanger is essentially an unknowable quantity, we were able to run a parametric study and so determine the of earth duct cooling system fan power requirements for the entire range of possible ground heat exchanger effectiveness values.

Contact

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