CASE 6. ATTACHED GREENHOUSE DESIGN

A. The Client's Request

Jackie, an avid permaculture designer, came to us with a rough sketch of a greenhouse she wanted attached to the south end of her house. An existing deck off an upper story entrance would be modified, soil excavated from beneath the deck, and the greenhouse tucked under it, allowing the shallow rays of the winter sun to penetrate into its interior.

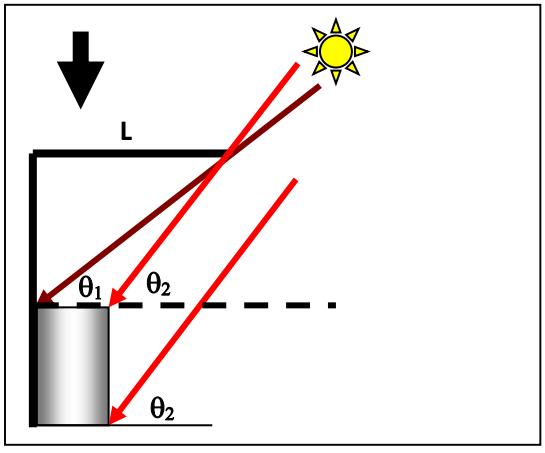
She wanted some help with solar analysis to refine her thinking, and suggestions on interior layout and heat storage.

B. Project Parameters and Analysis

1. Jackie's house, in Central PA, is 13 degrees east of the perpendicular to the south side of the house, so **true south** is approx. 2 degrees east of the perpendicular to the south face of the house: i.e., the south face is optimally sited for solar insolation.

2. The plan is to remove the deck and rebuild one 6" higher than previously, about 5 feet wide and with steps to the front yard. The estimated height of the greenhouse would be just over 7'. Jackie is 5' 7" tall.

3. We estimated that 347 cubic feet of soil would have to be moved/removed for greenhouse excavation. Since Jackie was going to do the digging herself, we calculated it would require 87 wheelbarrow loads of 4 cu ft each. At 5 wheelbarrow loads per day, that would take 17 days. From the dimensions above, we calculated two critical angles: (1) the angle at which the sun would just clear the edge of the deck to penetrate all the way to the back of the greenhouse and onto the top of a water barrel (θ_1); and (2) the angle at which the sun would just clear the edge of the deck to hit fully the front face of a water barrel (θ_2). These angles are, respectively, 39.2 degrees and 53.7 degrees. What this means is that when the sun's angle above the horizon is equal to or less than these values, the barrels will, respectively, receive full solar illumination or receive illumination fully on their front

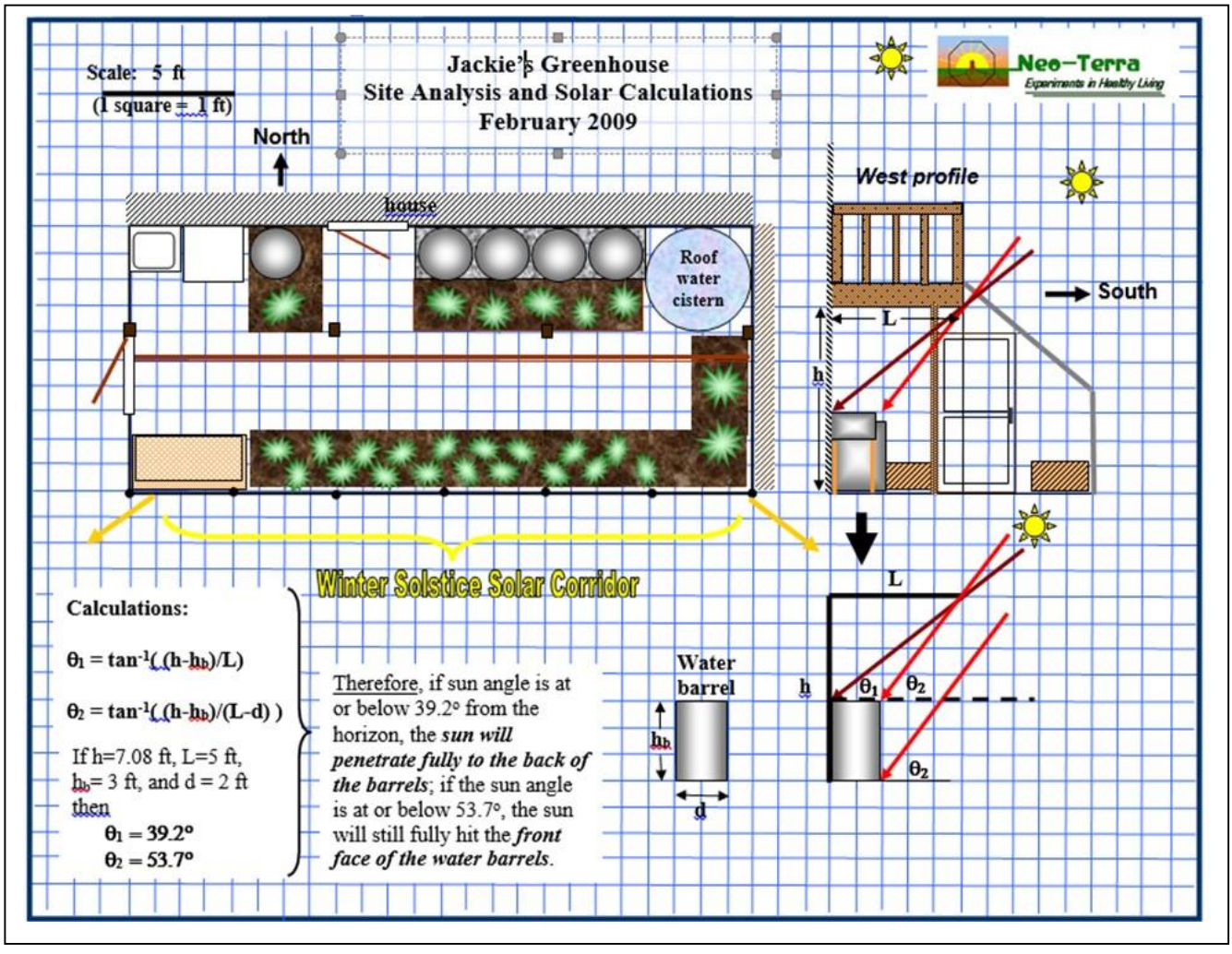


faces. More solar insolation will be captured the further the sun penetrates, but a substantial amount will be captured if the sun strikes the front faces of the barrels.

4. A typical 50 gallon water drum measures 23" diameter and 34.5" high, so for simplicity we round up to 24" diameter and 36" high. Based on the plan to raise the deck six inches, the ground-to-deck-joists height (= floor to ceiling of greenhouse) is expected to be 85" (7.08 ft) with a deck width of 5'.

5. The sun angle chart shows the various times of the year and hours of the day that satisfy these angular criteria. From approximately September 5th to April 1st, the sun should impinge fully on the front face of the water barrels all day. As September progresses, the sun will penetrate even deeper until, around October 15th, it fully reaches the back of the greenhouse *at the height of the barrels*, in which case the barrels enjoy the fullest amount of sun (or solar insolation) from that date on through about February 25th. Sun angle chart at: (http://solardat.uoregon.edu/SunChartProgram.php).

6. The diagram below summarizes the analysis and combines it with the greenhouse layout.



C. Summary and Recommendations

Site is optimally positioned (facing 2^{o} west of true south) for a passive solar structure. There are deciduous trees to the southeast and east that extend upwards to approximately 25^{o} above the horizon, but they pose little interference from winter solar gain and will offer slight benefit during summer months where restricted insolation is desirable.

If any of the assumed dimensions change here (i.e. barrel height, deck width, etc.), the formulas printed on the grid sheet can be used to calculate revised solar insolation angles for the barrels, from which you can then use the solar angle chart to deduce the dates when you can expect the sun to heat the barrels.

How much heat can be collected and what kinds of thermal fluctuations can be expected in the greenhouse? These are more complicated questions, and go beyond this first-cut approximation. It is easier to construct the greenhouse with best practices in mind and then monitor its performance through a winter to gauge how best to utilize the space and make improvements.

Based on the above, things to keep in mind:

- Large plants should not be placed in front of the (black-painted) water barrels or these will reduce the heat collection, although short plants will pose little problems.
- Plants placed on top of the thermal mass water barrels will not begin to receive direct peak sunlight until around October 15^{th} (see West profile sketch on grid diagram).
- Placing plants on top of the water barrels will diminish only slightly heat collection potential.
- Painting the concrete block wall a dark color would aid it in absorbing heat, but is not advised because inside a greenhouse, you want a light colored surface on the rear wall to provide as much reflected backlighting as possible for the plants.
- The northeast corner will receive the least amount of light.