Small Greenhouse Surface Area Distribution
SGAFT continuation

The GPN article "Geometry: Small Greenhouse Surface Area Distribution"
https://www.nxtbook.com/greatamericanmediaservices/GPN/august-2024/index.php#/p/36
continues with additional discussion of its Table 2. In review, the comparison between two 24 foot wide greenhouses, one 40 feet long and the other 100 showed that the shorter, smaller house presents greater surface area exposure resulting in lower efficiency in its energy consumption.

Table 2. Greenhouse dimensions, surface area to footprint ratio, and surface area distribution

dimensions	surface area/ footprint	ends %	sides %	roof %	sides vs perimeter %
24 x 40	2.2	23	23	54	63
24 x 100	1.9	11	26	63	81
Difference	+16%	2.1x	0.9x	0.9x	

First, the shorter house has 16% more exposed surface area for every square foot of floor area than the longer house. That means more surface area for heat to be lost during the heating season. Second, the end walls of the shorter house make up twice as much of the house's total surface area compared to the long house. The shorter the house, the more important the end walls are regarding energy consumption.

What about the side walls

The last column of Table 2 shows the percent of each house's total perimeter length made up by its side walls. The side walls comprise 63% of the short house's perimeter compared to 81% for the long house. If the side walls were glazed with twin wall polycarbonate or inflated double poly we wouldn't have to spend additional time analyzing them.

In my house, however, neither glazing upgrade worked because I wanted natural ventilation and the budget didn't allow for traditional rack and pinion design that would accept twin wall polycarbonate. We went with the economical roll-up side wall consisting of a heavy woven, translucent material pictured in Figure 1.

Figure 1

As an aside, years ago in my commercial operation a couple 30 x 150 ft houses were retrofitted with ridge vents and roll up side walls. The ridge vents were automated via thermostat but the side walls were operated manually using the familiar hand crank at one end of the wall shown in Figure 2. It worked fine, provided a good morning and evening upper body workout, and eliminated the front to back temperature gradient we had lived with for decades using exhaust fans mounted on end walls.

Figure 2

That said, adjusting the opening height that controlled the volume of air entering the house was an ongoing task throughout the day. High on the priority list for my research house was automating the roll up walls…and it was non-negotiable. Wiring the motors to a thermostat was an exciting day for me (Figure 3).

Figure 3

The reality of compromising
Back to side walls and greenhouse perimeter, we've established that the side walls of the shorter house occupy 63% of the greenhouse's total perimeter compared to 81% for the longer greenhouse. For simplicity let's continue with the short house being mine and long house yours. If side wall exposure is a concern it should concern you more than me given that your house has more relative side wall exposure than mine. That said, it took a single, inaugural heating season for my side wall exposure to sound an alarm. Ands if an alarm sounded for me it should sound even louder to you and your long house regarding side wall management.

Terrific, I got my natural ventilation and was able to afford automated roll up side walls. That's the thumb up side of the compromise. What I experienced during the first heating season showed me a thumb down side to the decision. Let's make sure this doesn't sound like a complaint, it's not. Instead, let's discuss limitations that compromise brings. In this case, I observed three limitations in my roll up side walls. First was a less than permanent, by design, seal along the bottom edge of the side wall where the roll up pipe seats against the bottom of a 12 inch apron shown in Figures 4-7.


Figure 4. Roll up side wall showing 12" apron at base of wall providing a seal at closure.


Figure 5. Side wall passing apron during closure to create seal.


Figure 6. Fully closed side wall with rail seated along base of wall forming its maximum seal.


Figure 7. Closeup of seated fabric rail showing adequate but less than complete seal.

The second limitation was the single layer of heavy woven fabric flapping in and out with outdoor breezes and wind. This coupled with the less than complete seal along the bottom of the wall caused a gut feeling through that first winter that cold air was infiltrating the side wall and heated air was leaking out. This two part article's message that my small house is less efficient from an energy use perspective leaves anyone who's a grower knowing how a grower thinks. I need to fix this. My dad used to sit in his kitchen chair looking out over our greenhouses and say he could see dollar signs in the thick white condensate rising from the unit heater exhaust stacks on cold mornings. His words still ring in my ears.

The third limitation took more time to develop…wear and tear. The roll up wall has regularly spaced vertical guide rails mounted on the outside of the roll up fabric to keep it in place and minimize the "breathing" of the wall. Simple friction created a couple small holes in the fabric that added to my concern about cold air infiltration and heat leakage. A friction hole caused by a different reason is shown in Figure 8 to illustrate the point.

Figure 8. Fabric hole caused by friction during opening/closing of side wall. Note vertical guide rail to left.

Following my first heating season with the new house and observing the limitations described in these images I decided to insulate the side walls before the second heating season. The first iteration was hanging a single layer of poly inside the wall which could be bunched up and tied at the top to allow for three season ventilation. This worked okay and evolved into something more permanent before my third heating season. I installed twin wall polycarbonate on the inside that is easily mounted and removed seasonally. The project will be presented in pictures in another chapter of this sgaft.com series. For now I'll simply state…issue addressed.

Quonset to gutter connected surface area comparison

The final topic for this chapter compares surface area distribution of 9,000 sq ft of production space between a range of three 30 x 100 ft Quonset houses and a single 100 x 90 ft gutter connected structure in Table 3. The first line shows the surface area distribution of the three 30 x 100 ft houses in the last three columns. In total, this setup has 12% of its surface area in end walls, 22% in side walls, and 66% in roof totaling 100%.

Table 3. Surface area distribution of 9,000 sq ft of production space as either three 30 x 100 ft ground to ground structures or one 100 x 90 ft gutter connected structure.

Greenhouse	side wall	Floor	End wall	Side wall	Roof	Total	End wall	Side wall	Roof
	Ht (ft)	sq. ft.	sq. ft.	sq. ft.	sq. ft.	sq. ft.	%	%	%
3 30 x 100	6	9,000	1980	3600	10,800	16,380	12	22	66
gutter connect									
100 x 90	6	9,000	2000	1080	11,700	14,780	14	7	79
100 x 90	12	9,000	3200	2160	11,700	17,060	19	13	68

One of several attractive features of a gutter connected range is the reduction of side wall exposure. Imagine squeezing these three 30 x 100 ft houses together, doing so eliminates four of the six side walls. That's a significant amount of surface area reduction which, logically, pays off in better energy conservation.

That's not the whole story, however. Move down to the second line of the table describing a 100 x 90 ft gutter connected structure. This house and its line in the table match the 30 x 100 ft houses with the same six foot side wall height. This is unrealistic, the only humans who would function in such a house would be our pre-teenage children and grandchildren.

This line is included in the table to illustrate the concept of eliminating side wall exposure. In this gutter connected range only 7% of its surface area is in side walls while the three free standing houses have 22%. We squeezed the three Quonsets together reducing the number of side walls from six to two which reduced surface area exposure similarly by two-thirds. Reducing the side wall component from 22% to 7% is exactly that.

On a historic note, some reading this article can close their eyes and return to the 1970s when earlier gutter connected ranges had gutter/side wall heights not that much higher than line 2's six feet. A response to the 70's oil embargo was lowering gutter height to reduce greenhouse volume and conserve energy via the logic that less air to heat meant less fuel needed to heat it.

I remember touring ranges in the Midwest with gutter heights that weren't much higher than eight feet, unacceptable given what we've learned since. In the decades since we've learned that managing greenhouse energy involves more than just heating. Today's 12, 14, and higher gutter heights are designed to maximize natural ventilation by generating larger draft forces. We also learned along the way that conserving energy has less to do with greenhouse volume and more to do with high tech glazing materials, high efficiency furnaces, and state of art energy curtain systems.

All of these points bring us to the third and final row in Table 3, the same 100 x 90 ft gutter connected house but with a 12 ft side wall. Compare this more realistic structure to the three single Quonsets in line 1. The end walls comprise more of the total surface area, 19 vs 12%, compared to the Quonsets. This makes sense as raising the side wall height increases their surface area but also adds more height and area to each end wall.

Next, its side wall area is less than the Quonsets, 13% compared to 22%, which has been the message in this section. The reduction, however, is no longer a factor of 2/3 because we doubled the side wall height. Now the gutter connected side walls comprise 13% of the total surface area compared to the Quonset range's 22%. In other words, raising the side wall height in the gutter connected house gives back a portion of what was saved when we squeezed the three Quonsets together. From a small grower perspective I'd like to think this reality sort of tells us that Quonsets might not be all that bad after all. And when today's technology is used correctly the gap can be closed even further.

The third surface area component, the roof, is similar for both structures. The Quonsets have 66% of their surface area in their roofs and the gutter connected structure has 68%. Some of the difference between the two is likely due to the gutter connected range having four peaks as a result of my design and calculation assumptions. Bottom line, both greenhouses are similar in terms of roof area, the Quonset range has a smaller end wall component and a larger side wall component and, reciprocally, the gutter connected range has a larger end wall component and smaller side wall component.

Conclusion

Take home messages for this chapter:

1. Side wall management is not a passive task once a greenhouse is operational.
2. Compromises, by definition, include both positives and negatives.
3. Learning how free standing greenhouses and gutter connected ranges are similar and different, in this author's opinion, is knowledge worth acquiring.