- Chosen case study is emergency temporary housing for displaced people Better Shelter's Relief Housing Unit
- 190,000 deployed in 80 countries

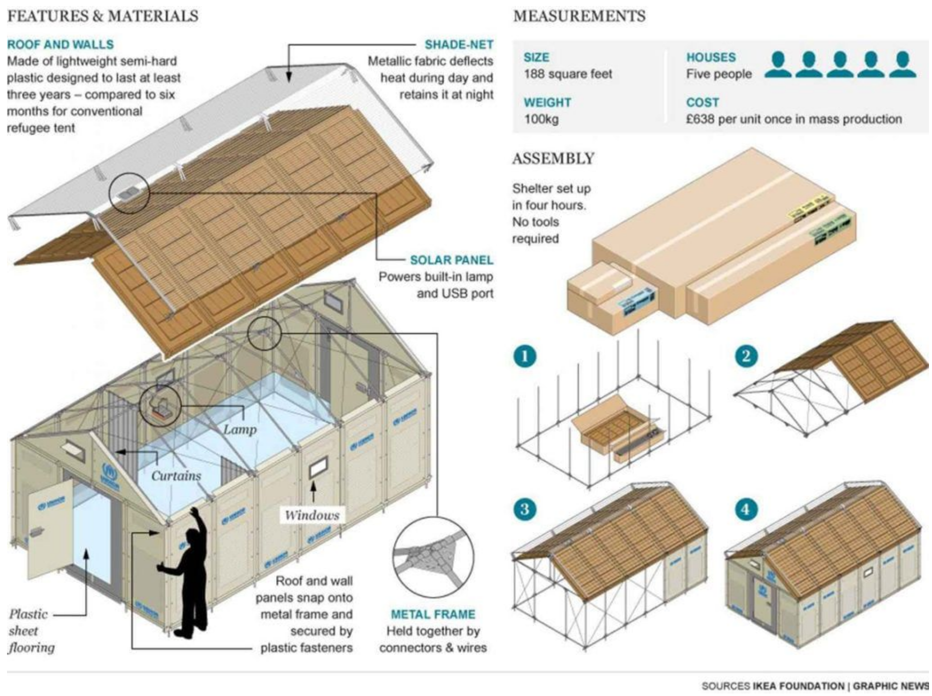
Strengths

Fast and easy assembly

Optimized production

Long-term alternative

Multipurpose expandability



- Fast and easy assembly (4 hours, 4 people, no tools)
- Optimized production (4 flat packed boxes, relatively low cost and weight)
- Long term alternative (lasts 3 years, more secure and durable than tents)
- Multipurpose expandability (steel structure can be combined to become bigger for schools and infirmaries)

Improvements

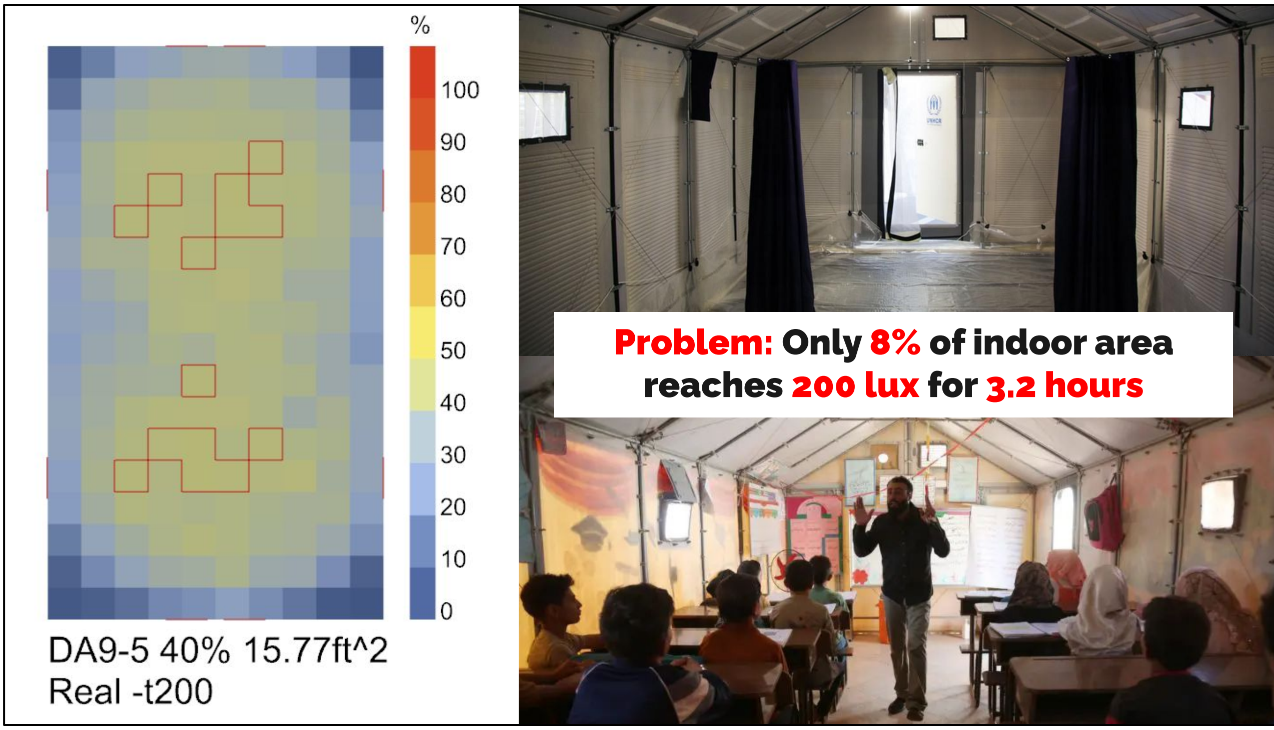
Wheelchair accessible

Stronger and non-flammable panel material

Separate release of the steel structure itself

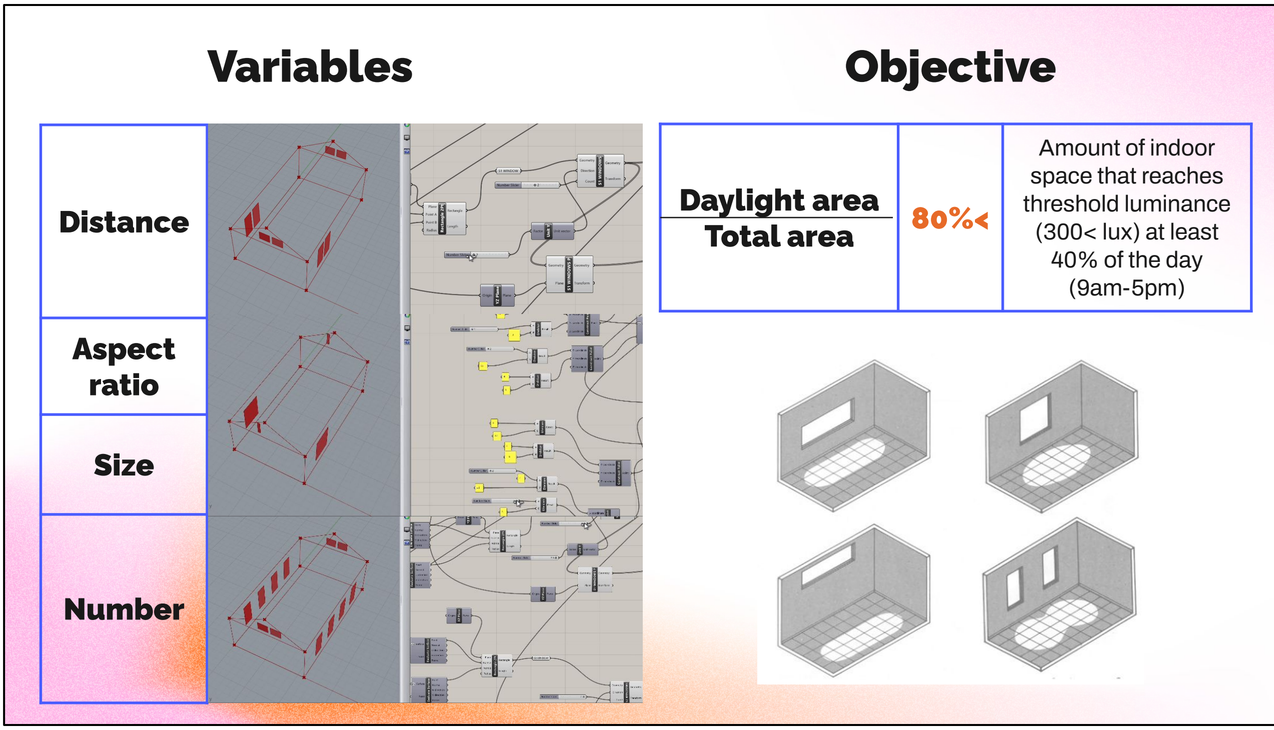
More windows

- Already has two design iterations with these improvements
- Increased accessibility, non-flammability, local employment and material use, ventilation

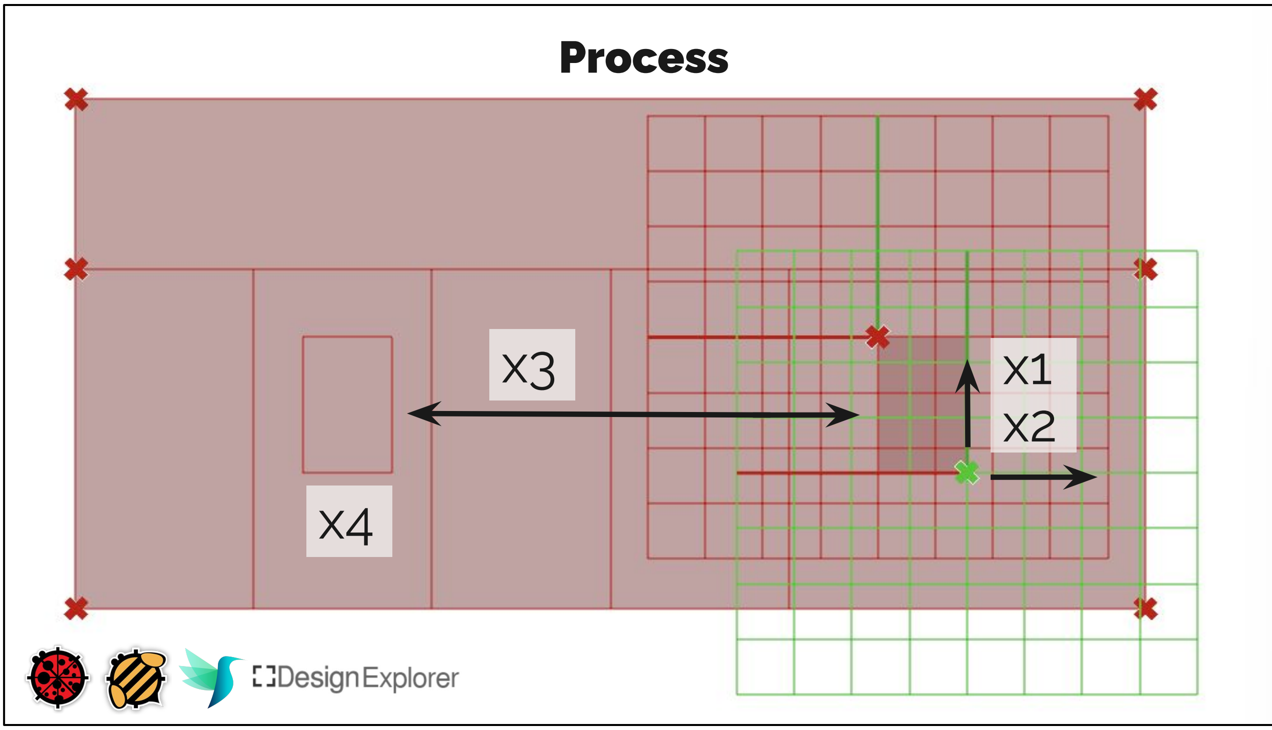


- But problem of sufficient daylight persists (tested with daylight analysis - location: Damascus, annual average)
- 8% of indoor area reached 200 lux (not even minimum for schools) for only 40% of the daytime
- Pictured above is the indoor area in artificial lighting and typical daytime

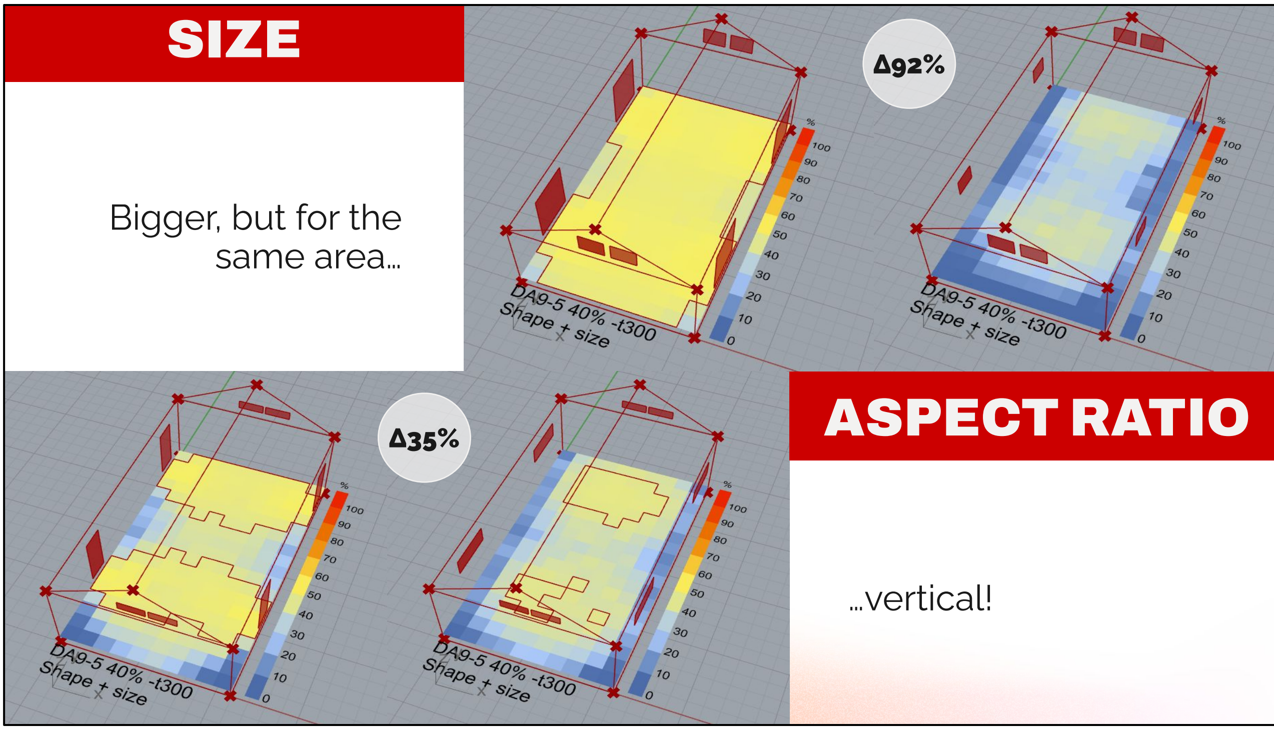
- Natural light is important for conducting tasks safely and for physical health
- Less dependence on solar panel can potentially reduce costs in its production and maintenance, can reserve it for cloudy days and night time
- Avoid disuse and waste since it’s been reported that a lot of units are not being used and they reverted back to standard UNHCR tent, which is half the price and assembly effort, not as durable and long-term but lets more light in



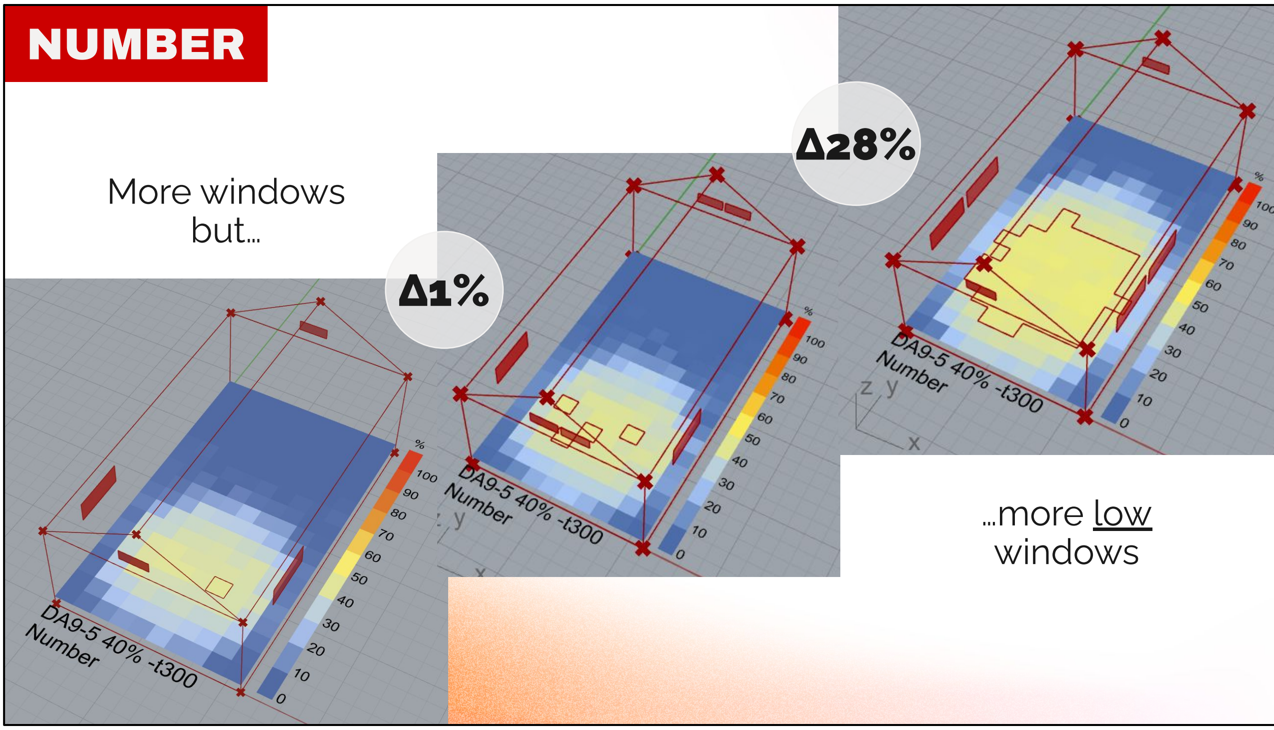
- Variables focused on windows (distance, aspect ratio, size, number), number slider demonstration
- Daylight analysis is measured by area reaching 300 lux threshold (max for housing and min for classrooms) at least 40% of the day (3.2 hours allows for some classes and necessary chores), daylight area divided by total area is the score used, and we are aiming for at least 80%



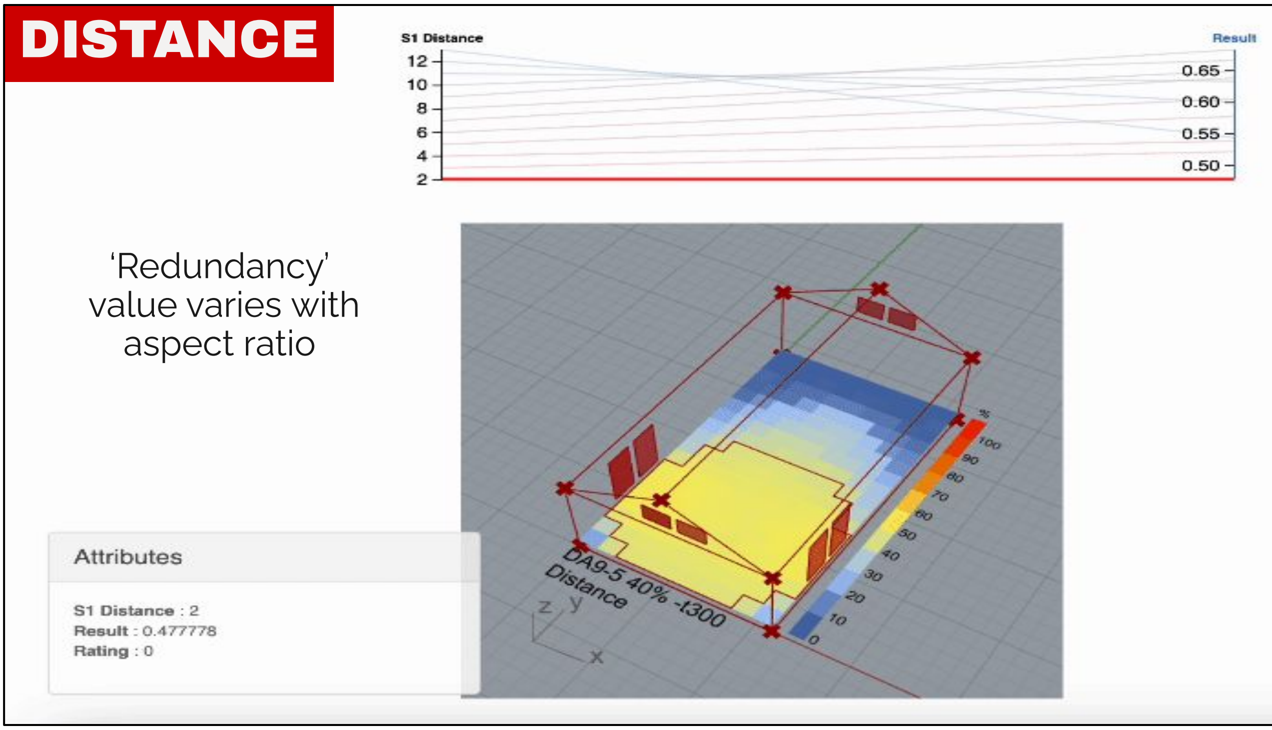
- Size (x1) and aspect ratio (x2) can be controlled by the x y coordinates of a single point of a 2 pt. Rectangle (other point is anchored), size is made bigger or smaller by moving diagonally, aspect ratio varies from horizontal to vertical
- Distance (x3) and number (x4) are controlled under the array function
- Had to simplify sliders involved because simulation takes 1 minute each combination
- Just need to control two surfaces (pictured above is only one surface, the second surface is the front of the house with the higher windows), these are then projected to the opposite wall automatically
- Ladybug + Honeybee = daylight analysis, Colibri optimization, Design Explorer to graph patterns



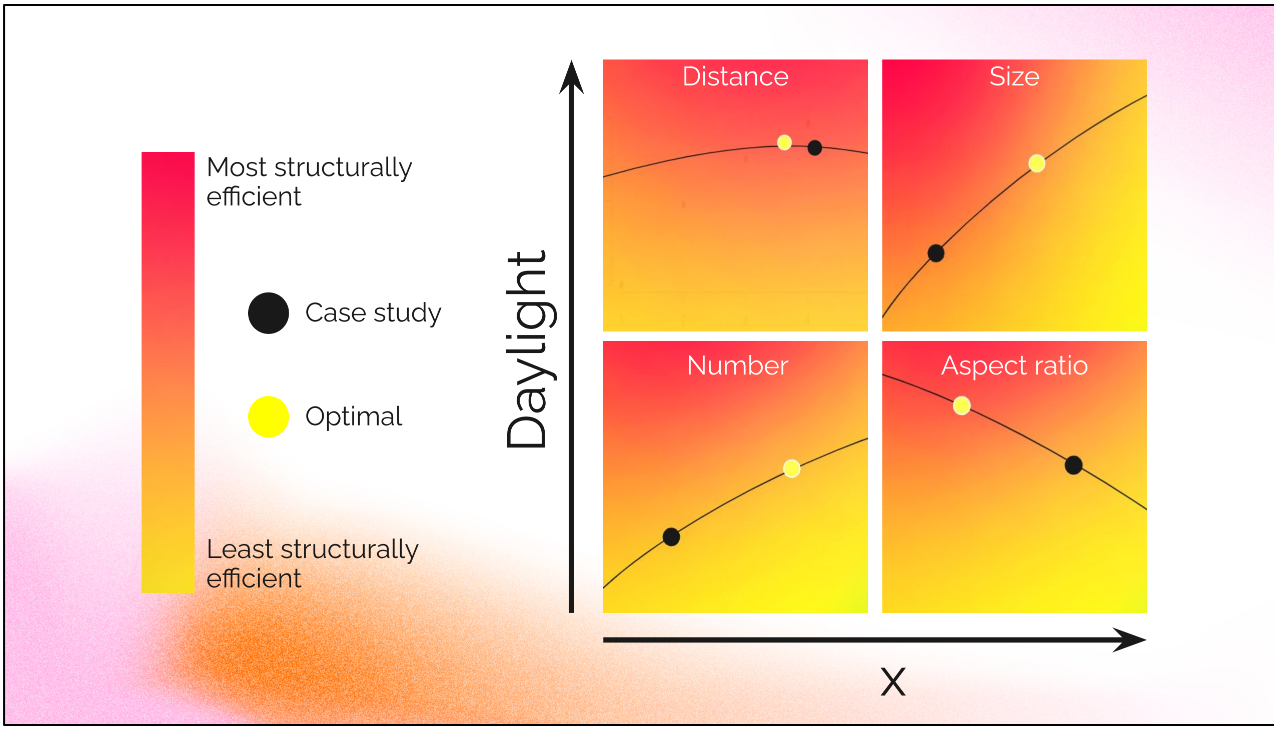
- Bigger size means more daylight, but for same area, vertical had more daylight, letting in 35% more than horizontal



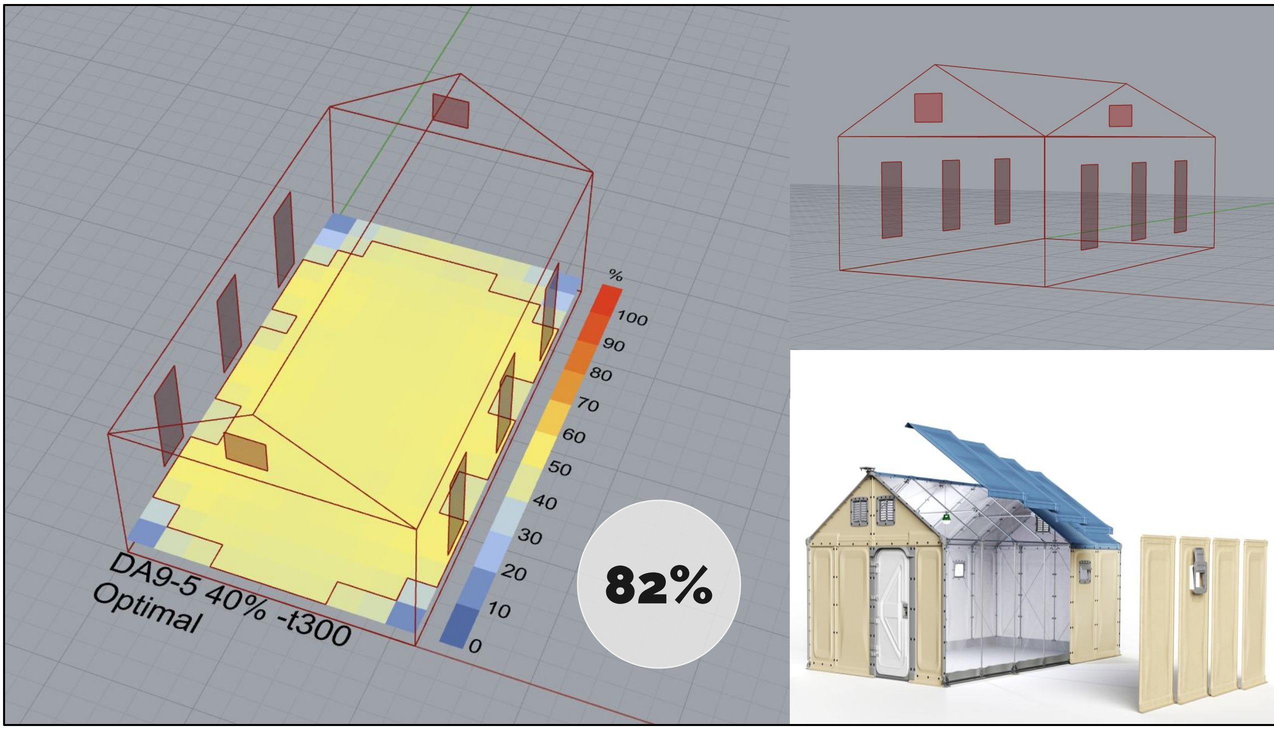
- More number of windows lets in more daylight, but there was much more let in with lower windows (28% difference) as opposed to higher
- Higher windows have more even distribution, but are not strong sources in themselves, hence only improving daylight area by 1% with one added window



- If you look closely to the gif, daylight area already starts to decline BEFORE reaching the end wall
- There seems to be a sweet spot when it comes to distance between windows, has to be far enough to avoid 'redundant' lighting but close enough to maximize shared middle area
- This differs with aspect ratio of windows, size of windows, and the size of room itself



- Fill = structural efficiency informed by preliminary tests
- Curve was plotted with each value, but only case study and optimal was shown on curve
- DISTANCE: maximum displacement shot up when windows were too close to each other and to the edges, which is why the red lands more in the middle of the x axis than all other plots, case study had windows too far apart for the sweet spot, curve demonstrates small changes in daylight until it starts to decline and plateau
- ASPECT RATIO: vertical was shown to handle more load than horizontal, so red was further left on the x axis (vertical is left, horizontal is right)
- NUMBER and SIZE had similar relationships to structural efficiency, more windows meant less load could be handled, bigger windows meant the same, hence the red is toward the left on the x axis as well, similar curves may imply that these can be interchangeable to make up for the lack of the other (i.e. more windows but smaller can yield similar results to less windows but bigger)
- Essentially, distance sweet spot + vertical + a balance between size and number would be best for maximizing structural efficiency and daylight area



- One of the optimal designs included less upper windows (square), but more lower windows (vertical)
- Area of windows was increased just by extending the length of the original square windows
- Distance between windows could not be further maximized because it'd be too close to the edges to bear load
- Threshold daylight area reached 82% of total indoor area, reaching objective

Insights

- Vertical and lower windows have more direct sunlight
- Distance depends on all variables and room size
- Number and size could be interchangeable
- Factors affect one another

Next Steps

- Structural analysis
- Heat/temperature
- Shade mechanisms
- Panel constraints

- Vertical and lower windows have more direct sunlight while higher windows are better for even distribution
- Finding distance ‘sweet spot’ depends on all variables and room size
- Number and size could be interchangeable to make up for the lack of the other
- Factors affect one another and should be isolated even further for next study
- Next steps include more in-depth structural analysis (max displacement, min thickness) for more informed optimization of all variables together
- Also can separate panels and project windows onto them individually rather than array function for more control
- Can even explore heat/temperature and shade mechanisms

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