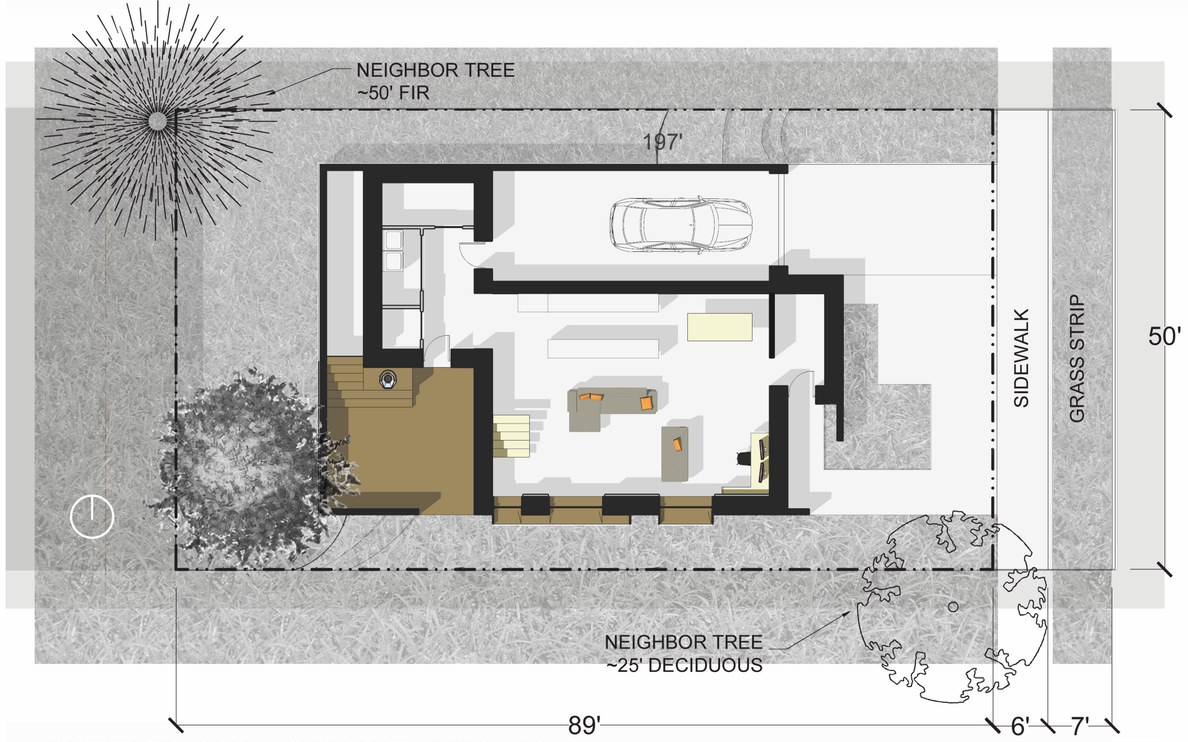
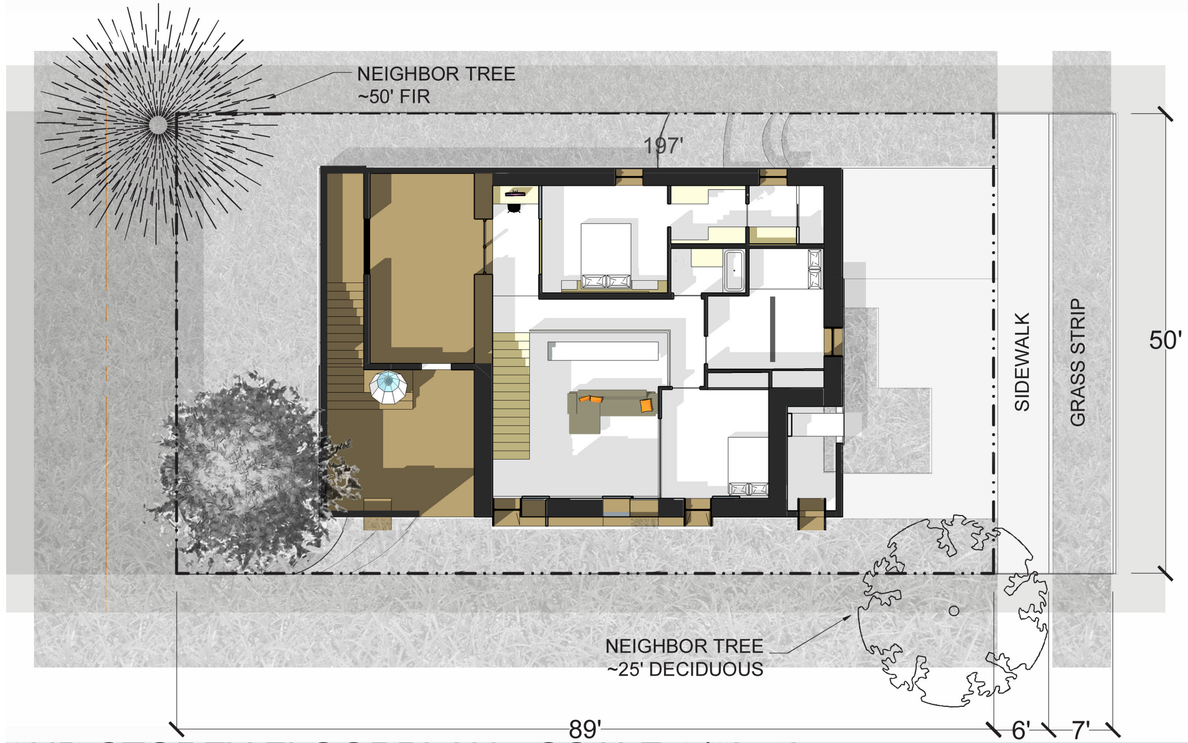
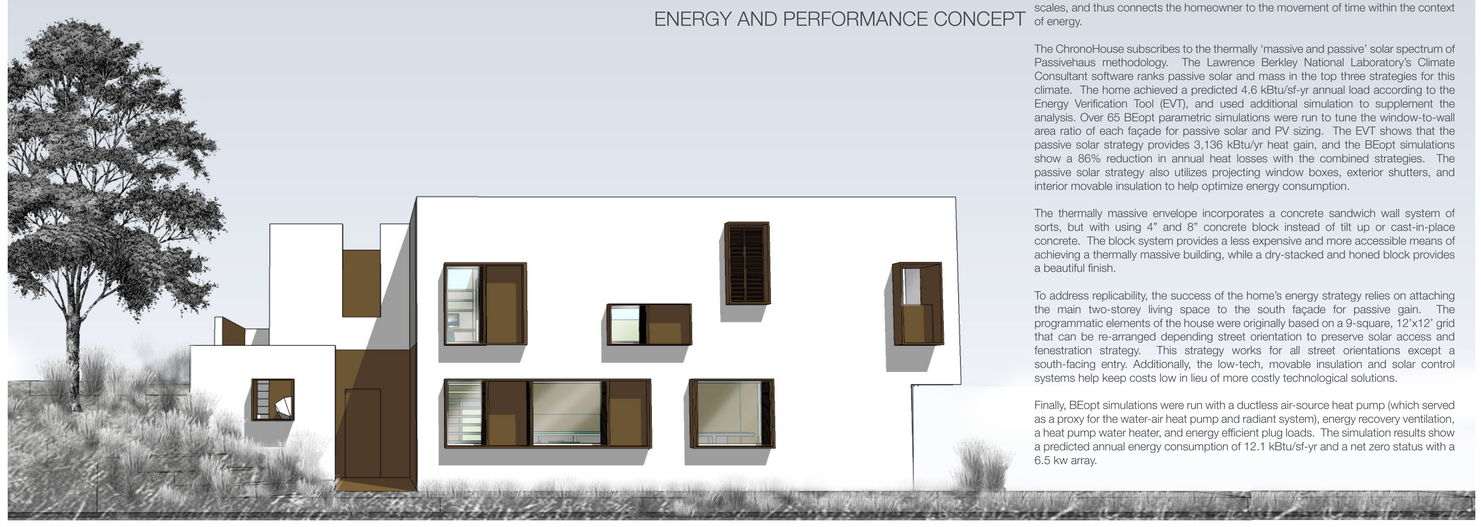


SITE PLAN - SCALE 1/8’=1’



2ND STOREY FLOORPLAN - SCALE 1/8’=1’

EAST ELEVATION - SCALE 1/4’=1’



SOUTH ELEVATION - SCALE 1/4’=1’

CHRONOHOUSE

ENERGY AND PERFORMANCE CONCEPT

The architectural concept of the ChronoHouse was inspired by the chronometer, an instrument designed to precisely measure the passage of time. The ChronoHouse plays on this idea by integrating its ideas about performance on four different time scales, and thus connects the homeowner to the movement of time within the context of energy.

The ChronoHouse subscribes to the thermally ‘massive and passive’ solar spectrum of Passivehaus methodology. The Lawrence Berkley National Laboratory’s Climate Consultant software ranks passive solar and mass in the top three strategies for this climate. The home achieved a predicted 4.6 kBtu/sf-yr annual load according to the Energy Verification Tool (EVT), and used additional simulation to supplement the analysis. Over 65 BEopt parametric simulations were run to tune the window-to-wall area ratio of each façade for passive solar and PV sizing. The EVT shows that the passive solar strategy provides 3,136 kBtu/yr heat gain, and the BEopt simulations show a 86% reduction in annual heat losses with the combined strategies. The passive solar strategy also utilizes projecting window boxes, exterior shutters, and interior movable insulation to help optimize energy consumption.

The thermally massive envelope incorporates a concrete sandwich wall system of sorts, but with using 4" and 8" concrete block instead of tilt up or cast-in-place concrete. The block system provides a less expensive and more accessible means of achieving a thermally massive building, while a dry-stacked and honed block provides a beautiful finish.

To address replicability, the success of the home’s energy strategy relies on attaching the main two-storey living space to the south façade for passive gain. The programmatic elements of the house were originally based on a 9-square, 12’x12’ grid that can be re-arranged depending street orientation to preserve solar access and fenestration strategy. This strategy works for all street orientations except a south-facing entry. Additionally, the low-tech, movable insulation and solar control systems help keep costs low in lieu of more costly technological solutions.

Finally, BEopt simulations were run with a ductless air-source heat pump (which served as a proxy for the water-air heat pump and radiant system), energy recovery ventilation, a heat pump water heater, and energy efficient plug loads. The simulation results show a predicted annual energy consumption of 12.1 kBtu/sf-yr and a net zero status with a 6.5 kw array.

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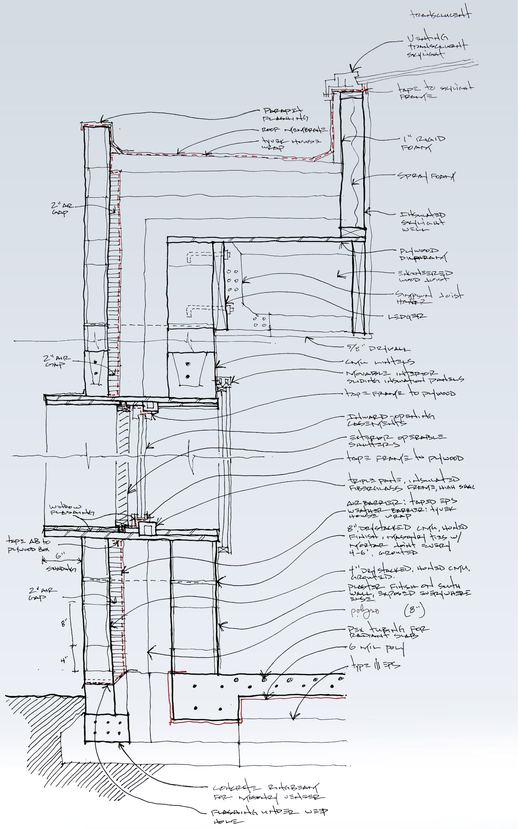
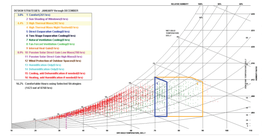
HAMMER & HAND



WALL SECTION - NTS

PERSPECTIVES

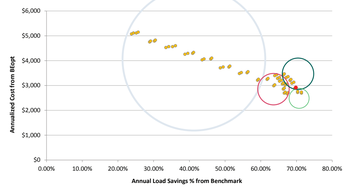
ENERGY ANALYSIS



PSYCH CHART

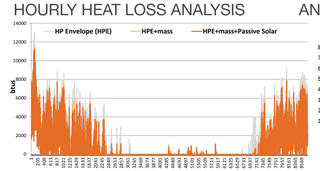
Olympia, Washington's Typical Meteorological Year (TMY) was used for climate analysis. Overlaying passive strategies on the chart shows that passive solar with direct gain can add 780 hours (8.9% of the year) to the comfort zone, while thermal mass alone can capture 382 hours (4.4%), which comprises most of hours hotter than the comfort zone. The Lawrence Berkley National Laboratory's Climate Consultant tool ranks passive solar and thermal mass amongst the top 3 passive strategies for this climate.

OPTIMIZATION



BEopt was utilized to run parametric optimization studies to help tune the passive solar and thermal mass strategy of the ChronoHouse. The vertical axis shows BEopt's annualized cost metric, which is a combination of energy costs, constructions costs, mortgage payments, amongst other items. The horizontal axis shows the annual load savings, with dots on the right showing higher savings in comparison to the Building America 2012 benchmark house. The runs within the light blue circle show the cases with glazing evenly distributed on all facades is 25 square foot increments up to 250 square feet. The **pink circle** shows a series of runs that apply glazing mostly to the south façade, in increments of 50 square feet up to 250 square feet. The runs in the **dark blue circle** show the same set of simulations as the pink circle, but include the thermal mass of the walls and floor. The **green circle** contains the most energy efficient and cheapest configurations, however these represent the 25 square feet evenly distributed across all facades. The energy and cost performance of these runs are compromised by too few of windows and a low quality interior environment. Thus, the **red dot** was chosen as the best balance between cost, energy savings, and aesthetics. It represents 100 square feet of south glazing, minimal glazing on other facades, and high thermal mass in both the floor and wall system.

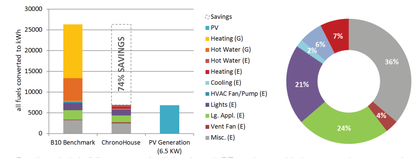
HOURLY HEAT LOSS ANALYSIS



ANNUAL ANALYSIS

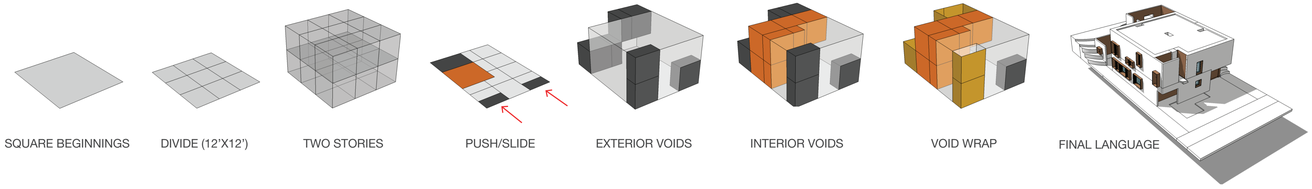
BEopt was also used to analyze the effect on heat losses throughout the entire year for three cases. The first includes only the high performance envelope of the ChronoHouse. Next, thermal mass was added to understand its affect beyond a super insulated and air tight shell. Finally, passive solar was added to the simulation to understand the full heat loss savings potential of all strategies combined. The graph shows that the thermal mass effects reduce heat losses by an additional 26%, while passive solar saves a 8% on top of that. Compared to the Building America benchmark, the ChronoHouse reduces heat losses by 86%.

ENERGY ANALYSIS

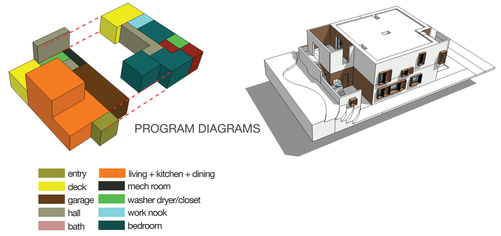


Running whole building energy simulation through BEopt also provided energy end use comparisons and PV generation studies. The graphs show that with an air-source heat pump, a heat pump water heater, high performance plug loads, etc., 74% savings over the benchmark is possible. This translates to an all-electric EUI of 12.1 kBtu/sf-yr, which can achieve net zero status with a 6.5 KW PV array. This amount of production would require covering roughly half of the roof area with photovoltaic panels.

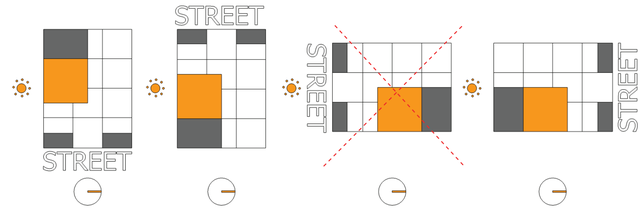
GENESIS DIAGRAM



PROGRAM DIAGRAM



REPLICABILITY DIAGRAM



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