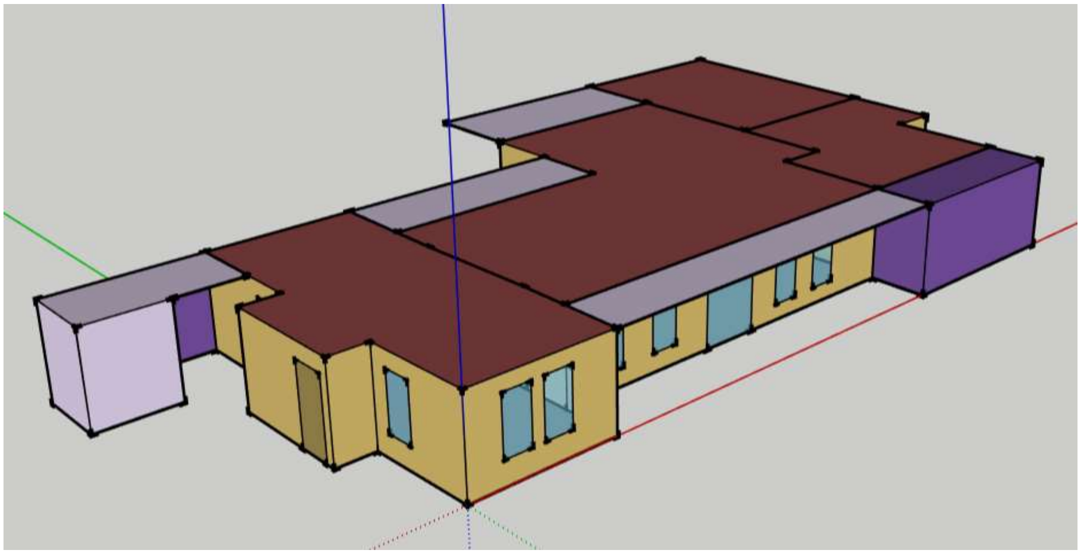
Case Study: Contrasting Zones

Condense

Building decisions in full context, less time.

This case study demonstrates the relative accuracy of the simplified Condense energy modeling platform compared to traditional whole building Energy Plus modeling, particularly when the project contains adjacent zones with very different loads. We examined a very small commercial building with a fitness room (high load) adjacent to a lounge (low load) and office. We also examined a larger office building with centralized chiller and three examples of a contrasting zone embedded in the middle of the building: a restaurant, a high-tech office, and a data center. The Condense energy results varied from traditional modeling results by only 0.6%-3% in every case except the data center, yet Condense was much quicker and easier to use, with far less opportunity for human error in entering inputs. In a building with a zone adjacent to a data center or some similar space with extremely high loads on the order of 100 watts/sf, Condense is not useful for examining any space adjacent to the high-load space. However, Condense is indeed still useful for modeling the data center itself (or any other high-load space) and for testing energy efficiency measures on that particular space.

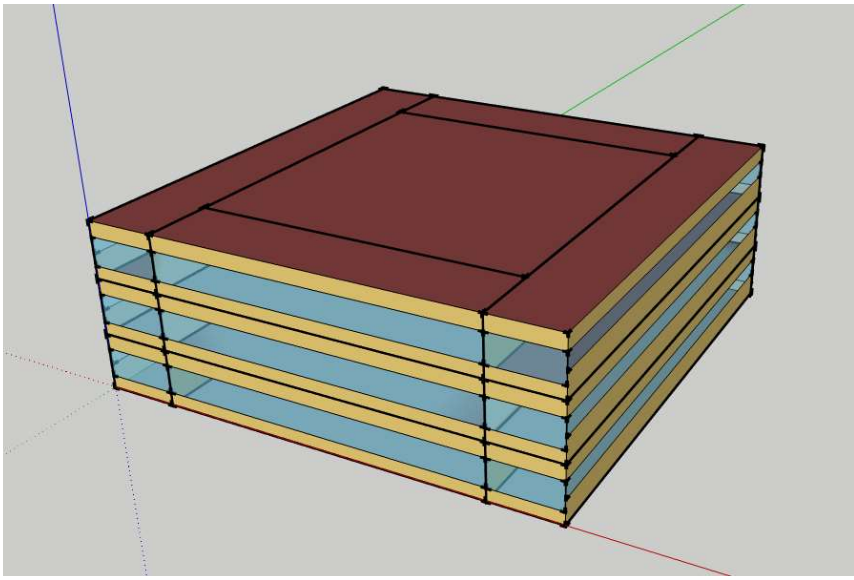
Traditional Models



Small Amenity center with fitness room on far right, lounge in center, and office on the near left

Condense models are discretely broken out by zone, which engineers would expect present some limitations in their ability to predict the interaction between zones. However, as you will see through our tests, this is limitation is not significant when testing energy improvements. On a very small commercial building, we examined how accurately Condense modeled energy use when there's a fitness room (high load) next to a lounge (low load) and an office in the same building. This is about the smallest commercial building you might see (3200 sf) and is very sensitive to this test since the high-load fitness room is a whole third of the square footage with a very long shared interior wall.

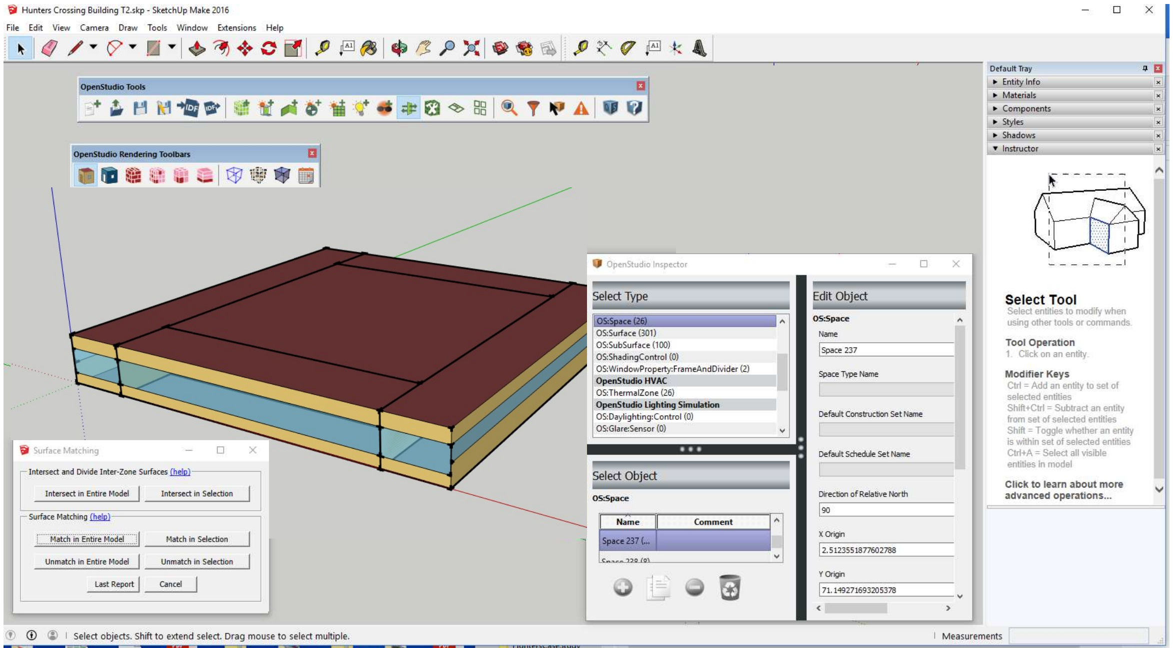
Traditional Models



Larger Office building with high-load space on middle floor

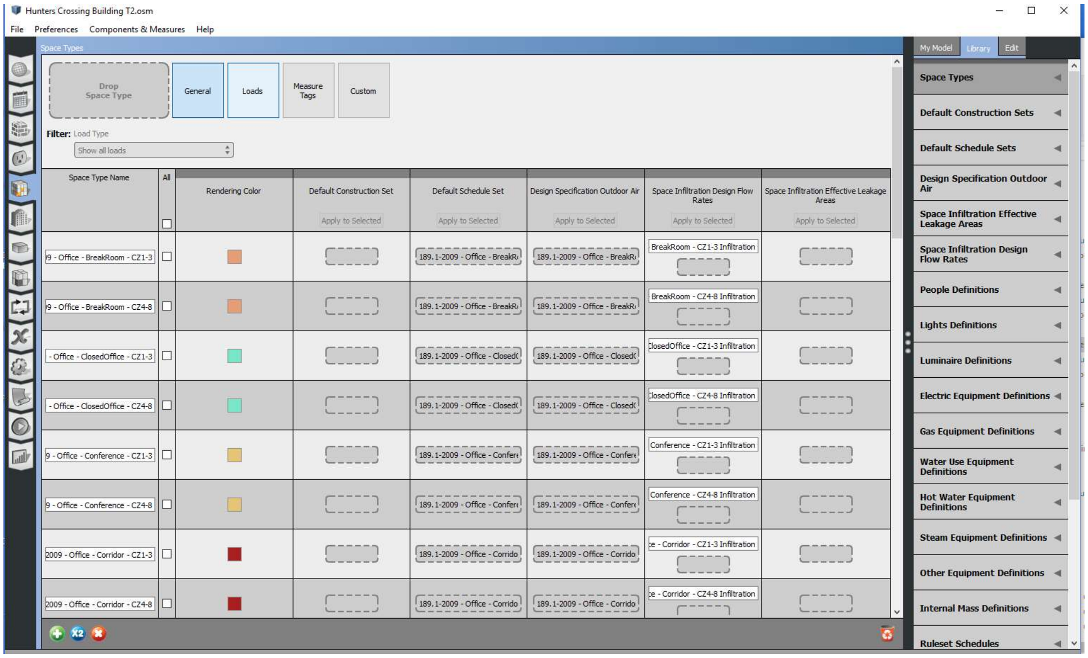
On a larger commercial building with centralized chiller, we tried three different tests. In test one we embedded a restaurant dining area across the entire middle floor core, with a commercial kitchen on the east perimeter zone. In test two of the larger building we embedded a high-tech office space in the middle floor core. The high-tech office space had much higher plug loads (5w/sf) than a typical office space (1.5 w/sf). In test three, we embedded a data center in the middle floor core. This data center had huge loads totaling 300,000 watts (61 w/sf) that ran for 24 hours in contrast to the office loads which mostly ran only during office hours. While the larger office building model is only 30,000 sf, it offers the most conservative or sensitive test for any size medium to large commercial building. To learn more about these models, please see our other case studies which describe more basic tests and the rationale behind these particular test shapes and sizes. The traditional models started with full building 3D CAD models, with each zone drawn and placed, and realistic window placement.

Traditional Models



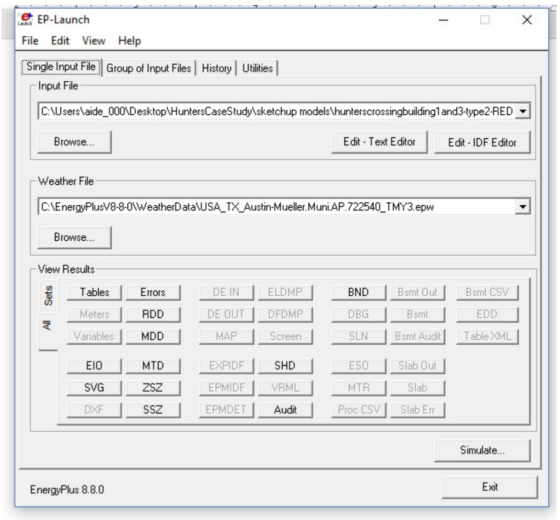
These models were created in Sketchup 2016, then, using an Open Studio plugin compatible with that Sketchup version, they were translated into Energy Plus Open Studio models with thermal zones and matching of adjacent surfaces to model heat transfer between zones. Many things can go wrong during this step, and must be troubleshooted: a stable version of Sketchup that is compatible with the Open Studio plugin must be maintained, 3d model surfaces must be complete and not overlapping, windows must drawn and placed flat on exterior walls then cut out of the walls, adjacent surfaces must be matched to translate into the idf file, zones must be identified by clicking in the 3d model. (Alternatives to Energy Plus exist, such as Equest, however Equest is even less facile at modeling complex building and space shapes, less accurate or robust than Energy Plus, and less able to model newer and green technologies. Other direct 3D-CAD platforms exist, but of course these require a 3D model, which, as discussed above, is problematic.)

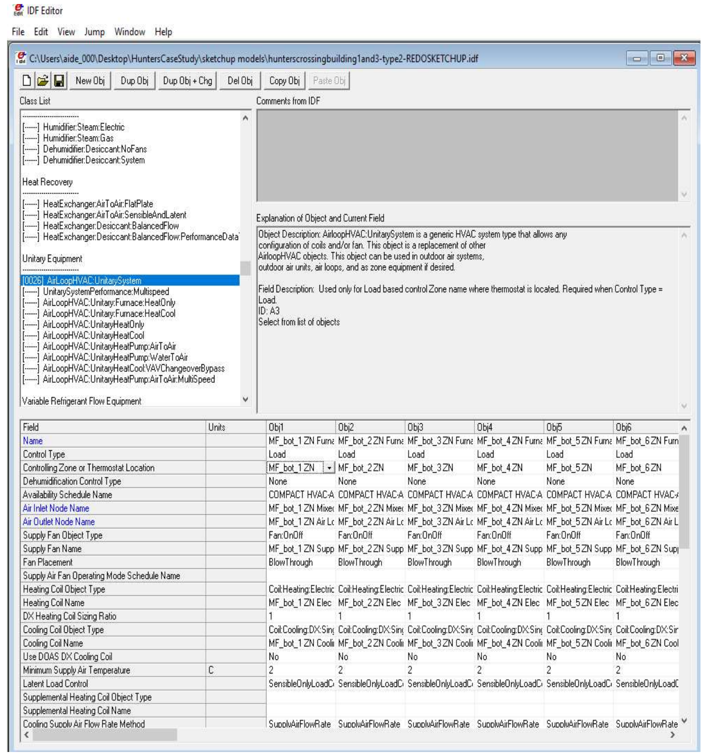
Traditional Models



The Open Studio files were then opened in Open Studio, and HVAC systems, lighting, insulation and other Energy Plus components were wired up. These components must all be selected from libraries and applied to each zone. HVAC systems must be designed with proper branching and integration of subcomponents.

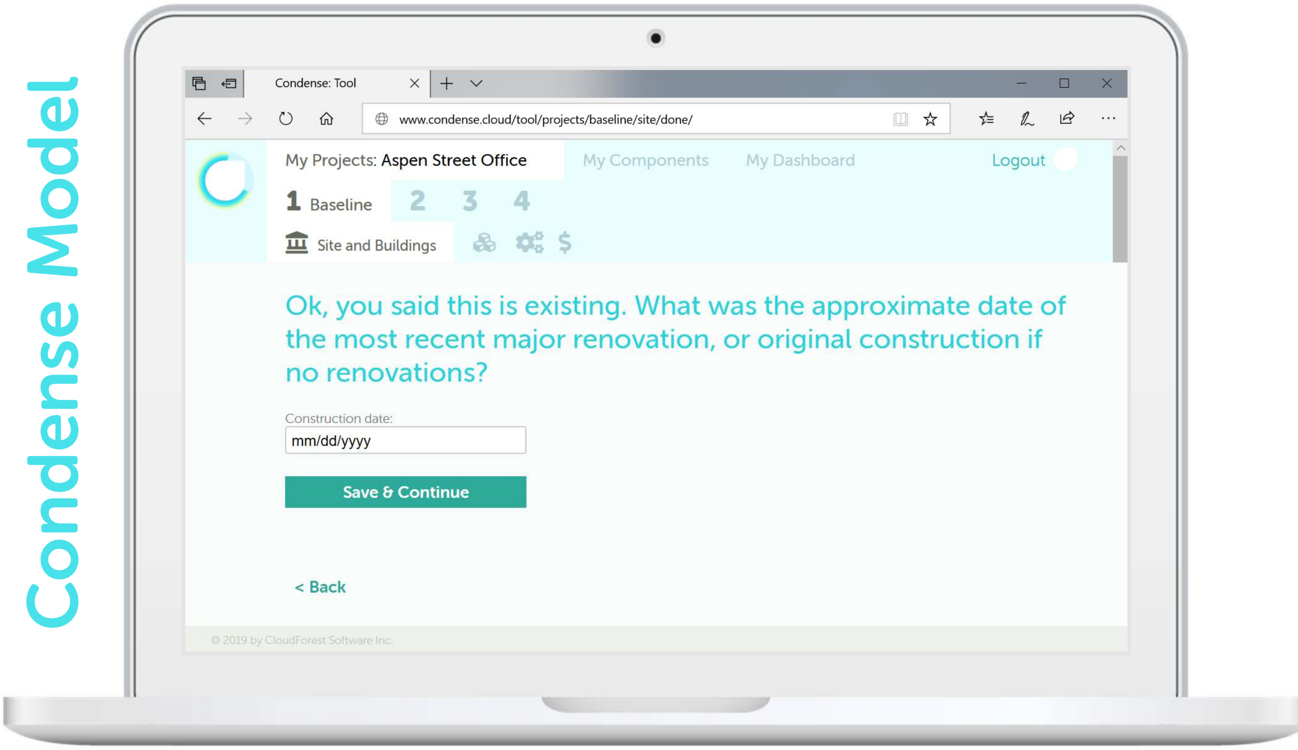
Traditional Models





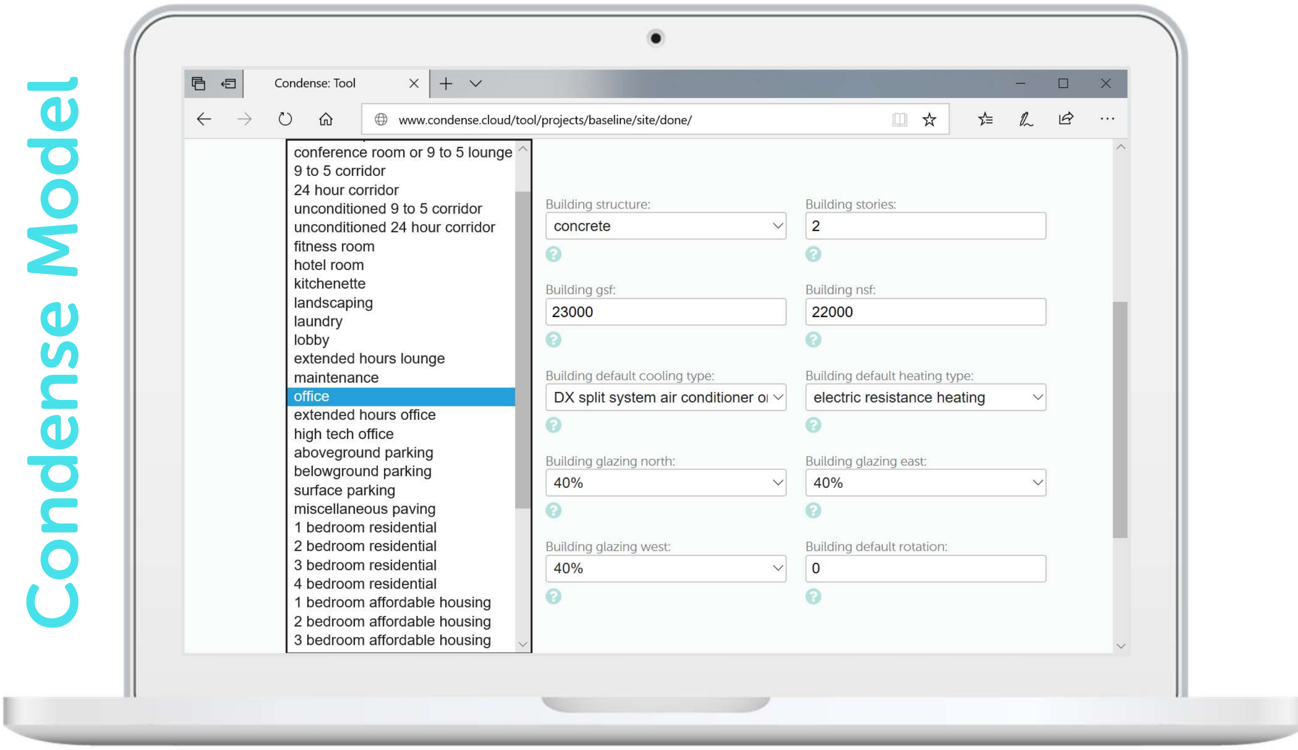
We exported the idf files from Open Studio and used the Energy Plus idf editor to more easily review inputs and make sure they were aligned with our Condense model inputs. Then we ran the model in Energy Plus with its correct weather file.

Condense Model



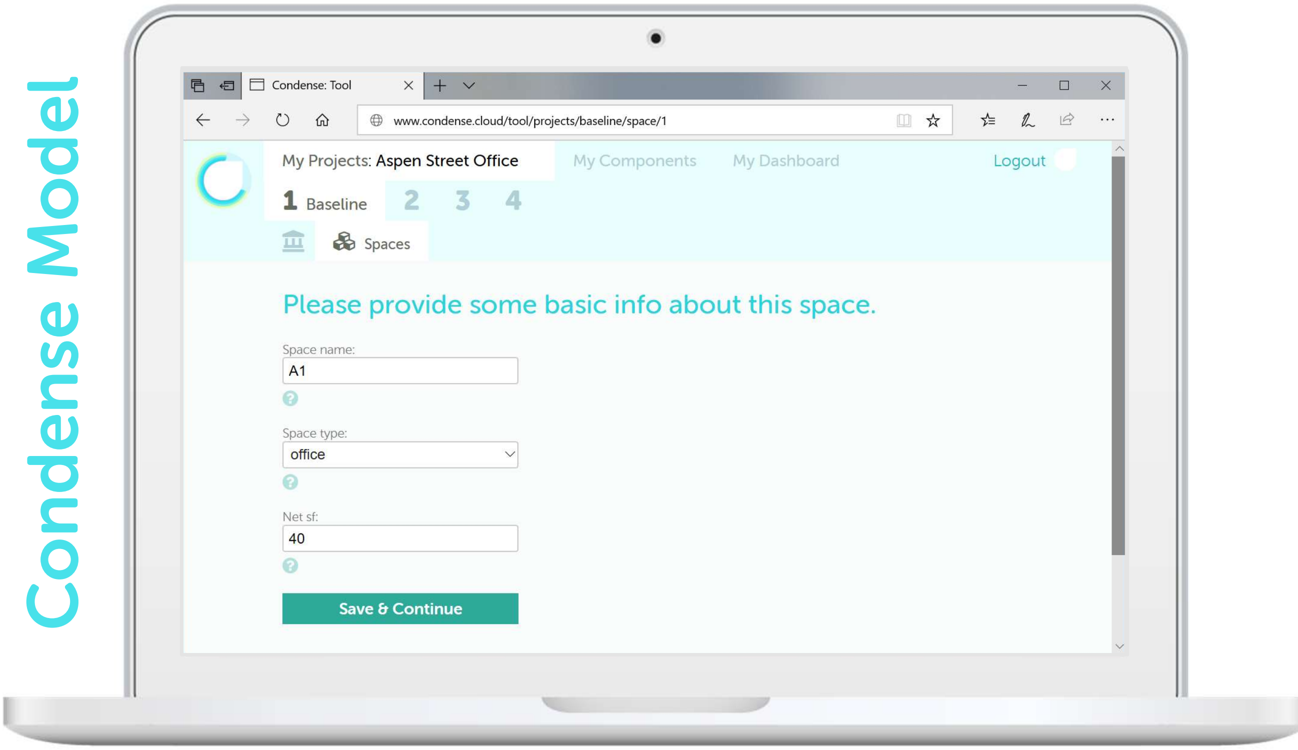
The Condense work flow was much simpler. The newest version of Condense is a modern website-based platform that guides you through with zero training required.

Condense Model



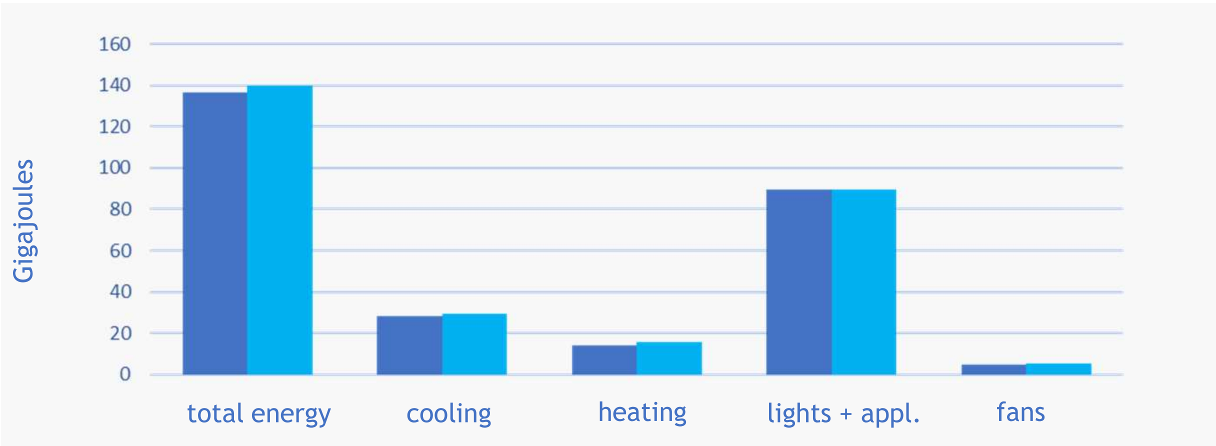
You can model new or existing buildings. You can model at the building level…

Condense Model



... or walk through space by space. There is zero drawing required, no jockeying between CAD programs, and just a few critical geometric inputs (square footage, estimated length of exposed walls only (non-exposed walls are ignored), and estimated window area). So, on geometry, Condense is MUCH faster and more foolproof than the traditional approach. When it comes to specifications (lighting, insulation, HVAC systems), Condense translates your project basics (location, year of construction, etc.) to predict what specifications are most likely in your building. So you start with a completely specified predictive model. You can then check the specs, such as your HVAC system type and equipment efficiency rating, but Condense guides you through in a way that is simple and understandable even to non-experts.. Your simple inputs are translated by powerful algorithms into the 3D and expert engineering inputs required by Energy Plus. You will get automatically produced Energy Plus models, with results automatically summarized, long-term financial outlook, and more.

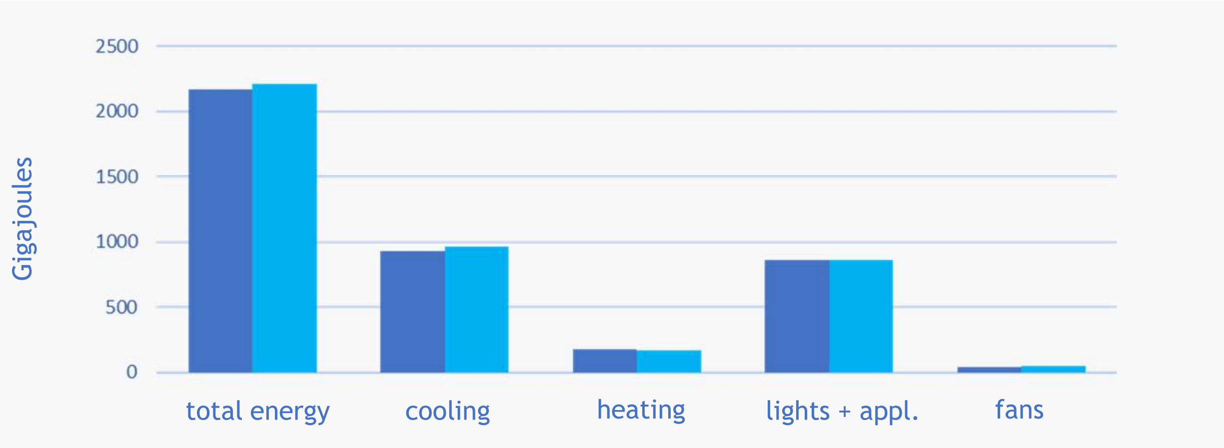
Results: Small Amenity w/ Fitness



- full traditional Energy Plus model from 3d CAD
- Condense

We compiled all results from the traditional vs. Condense energy models. The total margin of error was only 2.1% for the fitness room test. This test was run with a Richmond, Virginia weather file.

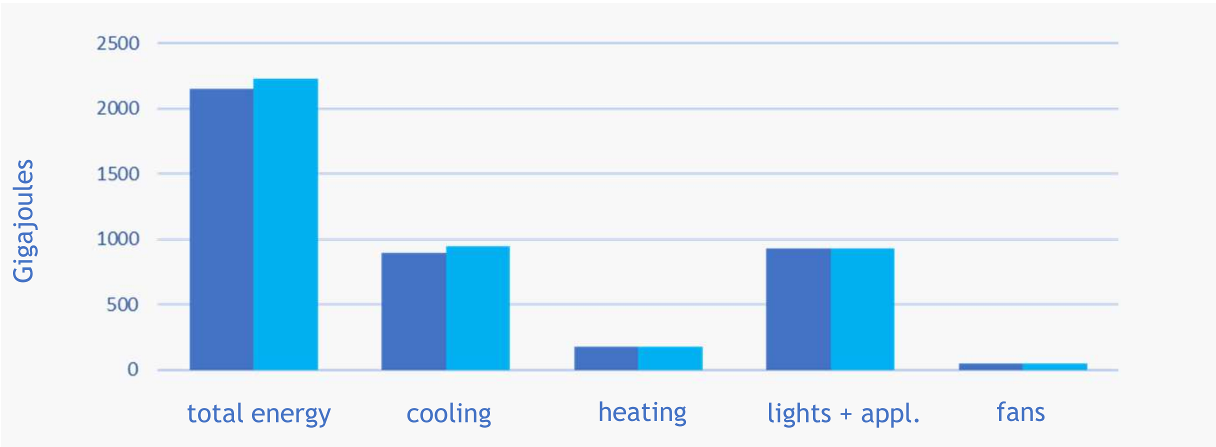
Results: Larger Office w/ Restaurant



- full traditional Energy Plus model from 3d CAD
- Condense

The total margin of error was only 1.8% for the restaurant test. This test was run with a Denver, Colorado weather file.

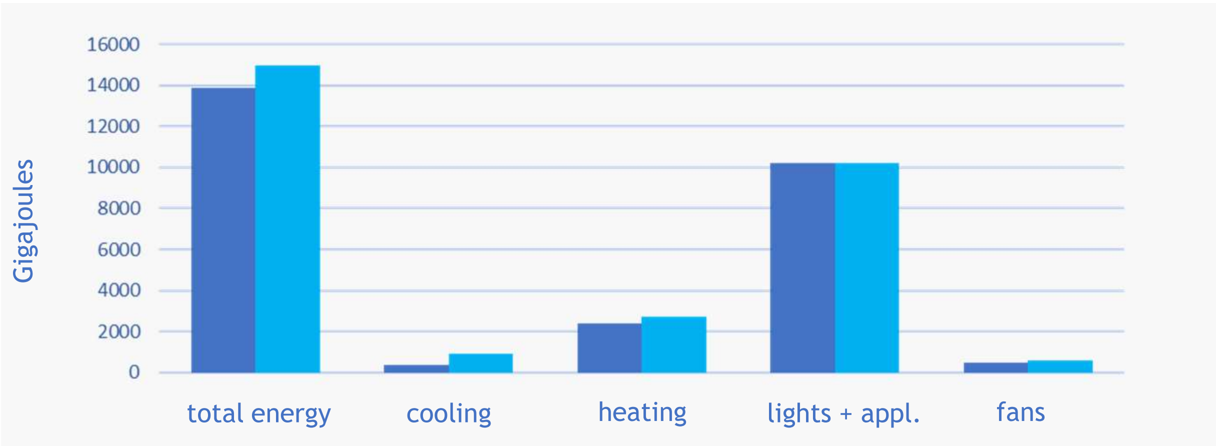
Results: Larger Office w/ High-Tech



- full traditional Energy Plus model from 3d CAD
- Condense

The total margin of error was only 3.3% for the high-tech office test. This test was run with a Denver, Colorado weather file.

Results: Larger Office w/ Data Center



- full traditional Energy Plus model from 3d CAD
- Condense

The total margin of error was 7.1% for the building with the data center. This margin of error is probably too large to effectively test energy improvements across the entire building. However, Condense could still effectively be used to examine the data center in isolation, since the interactive effects with the rest of the building would be eclipsed by the data center model.
This test was run with a Denver, Colorado weather file.

Can I still use Condense for Data Centers? Yes.

"Up to 3% of all U.S. electricity powers data centers. And as more information comes online, data centers will consume even more energy.."

From: "Energy 101: Energy Efficient Data Centers", U.S. Office of Energy Efficiency & Renewable Energy, Energy.gov, https://www.energy.gov/eere/videos/energy-101-energy-efficient-data-centers

Condense is not useful in the unusual case where interzone heat transfer is very large (such as modeling improvements on the office space adjacent to a data center). However, if what you're looking at is just the data center, Condense is very useful for testing energy improvements on the data center space itself. In that case, any interactive effects between the data center and the adjacent office space are eclipsed by the data center loads and energy use, and will not significantly impact the estimate of energy savings in the data center itself.

What about Heat Recovery and Redistribution?

"Often the interzone heat transfer is so small that excess heat gains in one zone bring little or no benefit for heating loads in another zone... The problem of divergent zone loads is one of the prime targets for energy conservation in large buildings... The first step is to reduce the loads through the envelope, by improved insulation and control of solar radiation... Finally, there is the possibility of heat recovery and redistribution between zones by heat pumps."

From: Heating and Cooling of Buildings: Design for Efficiency, Revised Second Edition, By Jan F. Kreider, Peter S. Curtiss, Ari Rabl

Heat recovery and redistribution between zones is sometimes a goal of centralized HVAC system (2 or 4 pipe systems, etc.) design for large commercial buildings. Condense is not the best tool for the actual engineering and sizing of a centralized HVAC system. However, as demonstrated in this case study, Condense is very useful for testing energy efficiency improvements on a building with a centralized system, including anything from LED lighting to night ventilation to improved COP of the chiller.