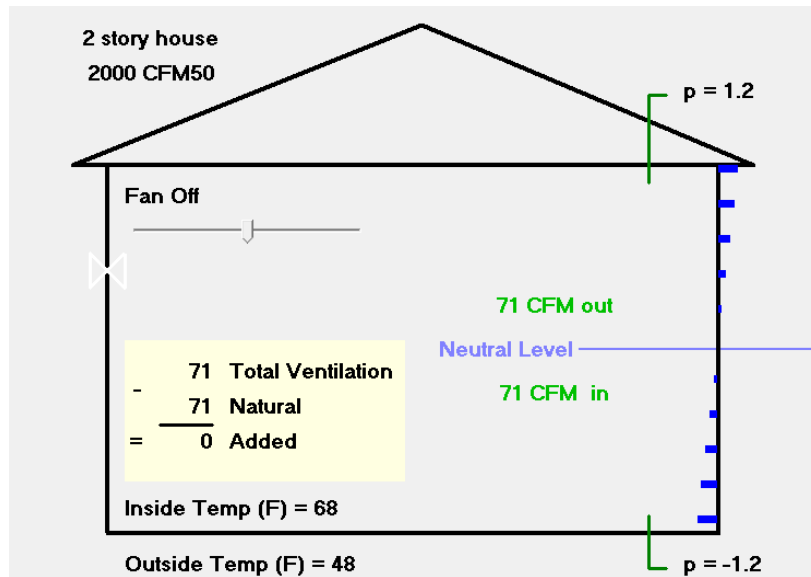


SeeStack Trainer

Software User's Guide



The **ENERGY**
CONSERVATORY

DIAGNOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

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Chapter 1 Introduction to SeeStack Trainer

The SeeStack Trainer is a training aid that will help students visualize how outdoor temperature, building height, and the location of the neutral pressure plane can affect their baseline readings. It will also demonstrate how outdoor temperature, building height, and location of the neutral pressure plane affect the natural ventilation rate of a building and how building pressures change as exhaust, supply or balanced ventilation fans are turned on. One of the surprising facts that the SeeStack Trainer will show is that adding exhaust or supply ventilation will only add about half of its flow to the total ventilation rate of the building under some typical weather conditions.

Installing the SeeStack Trainer

The SeeStack Trainer will be available on the Energy Conservatory Website. The program will self-extract and prompt you through the installation process.

Starting SeeStack Trainer

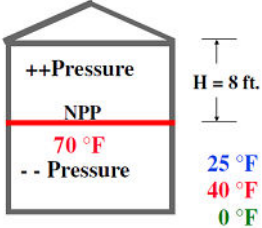
To start the program, click on **Start...Programs...Energy Conservatory...SeeStack Trainer**.

Chapter 2 Overview of Stack Effect

Neutral pressure plane

The neutral pressure plane is a horizontal plane where the size of the holes in the pressure boundary above and below this plane are approximately equal. If the wind is blowing there will not be a simple horizontal neutral pressure plane but the stack effect will still be operating, causing the house to generally be more negative in pressure (with reference to outdoors) at the bottom than at the top.

Temperature and height of the building

<p>Stack effect pressure is to close approximation a function of a constant (0.0067) times the height from the neutral pressure plane level times the temperature difference between inside and outside the building. The examples on the right are for a building with the neutral pressure plane level in the center of the total height; therefore, the + pressure at the top will be equal to the – pressure at the bottom.</p>	<p>Stack Pressure (sea level) (Pa) = (0.0067 × H × ΔT) H = Distance from NPP (ft.) ΔT = Inside/outside temp. diff.</p> <p>• example calculation Stack Pressure * = a) .0067 × 8 × 45 = 2.4 Pa b) .0067 × 8 × 30 = 1.6 Pa c) .0067 × 8 × 70 = 3.8 Pa</p> <p>* (at top & bottom)</p> 
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Sealing attic bypasses

Sealing attic bypasses will lower the neutral pressure plane. This will increase stack effect pressure at the top of the building and reduce it at the bottom.

Using exhaust only ventilation

The total ventilation rate shown in SeeStack is equal to the total rate (CFM) of air entering the building, which is also equal to the total rate of air leaving the building¹. This rate is calculated from the combined effect of stack driven (or natural) infiltration and the mechanical exhaust ventilation. Wind driven and other mechanical driven ventilation are not considered. You will notice that the total ventilation rate is not simply a matter of adding the natural and exhaust ventilation. As it gets colder outside, an exhaust only system will add a smaller and smaller percentage of its actual flow rate to the total ventilation. Across a wide range of outside temperatures and airtightness levels the added infiltration will be about half of the flow rate. This is often referred to as the ½ fan rule and was pointed out in the context of residential ventilation by Larry Palmiter.

Exhaust only ventilation is often used in northern climates where humidity levels are higher indoors than outdoors for the majority of the year. An exhaust ventilation system will be pulling dryer air from the outdoors into the building envelope cavities. Running an exhaust only ventilation system can reduce humidity levels indoors during the heating season and will raise the neutral pressure plane and decrease the stack effect pressure at the top of the building.

¹ Technically it is the mass flow rate (kg/second) of air entering and leaving which is equal, and not the volumetric flow (CFM). In SeeStack the changes in air density due to temperature (expansion and contraction) are ignored except for the stack effect they create.

Using supply only ventilation

As with exhaust only ventilation, you will notice that the total ventilation rate is not simply a matter of adding the natural and supply ventilation. Once again, Larry Palmiter's $\frac{1}{2}$ fan rule applies. As it gets warmer outside, the fan will add a smaller percentage of its flow rate to the total ventilation.

Supply only ventilation is often used in southern climates where humidity levels are lower indoors than outdoors for the majority of the year. In this case the supply ventilation system might be pushing dryer air from the house into the building envelope cavities. Running a supply only ventilation system will lower the neutral pressure plane and increase the stack effect pressure at the top of the building.

Using balanced ventilation

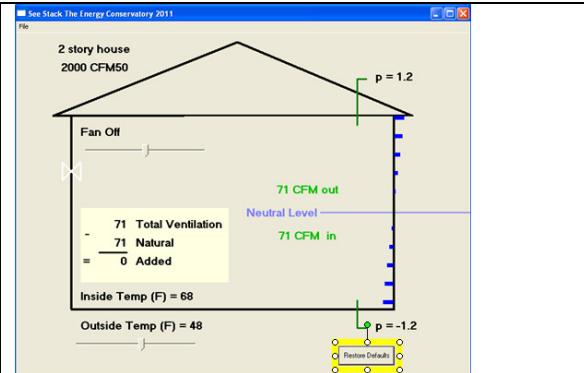
With a balanced ventilation system, the total ventilation will be equal to the natural ventilation plus the mechanical ventilation system flow. A truly balanced ventilation system will not affect the neutral pressure plane or stack effect pressures of the building. Note that a balanced ventilation system which is integrated (interconnected with) with a forced air heating or cooling system may not always operate in a balanced mode due to changes in duct system pressures. For example, heating and cooling systems may operate at multiple speeds and filters may change in resistance causing changes in duct pressures.

Chapter 3 SeeStack Trainer Features

This chapter reviews the options that you have to make changes to a variety of things that effect pressures in a building.

Restoring default settings

Clicking on the *Restore Defaults* button will restore the settings as they were when the program was first opened.

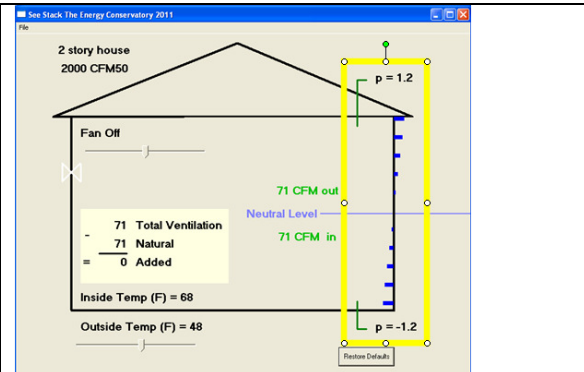


Height of the building

The height of the building can be adjusted using the number keys on your keyboard. The numbers 1, 2 and 3 correspond to 1, 2 and 3 story homes. Each story is 2.5 meters or 8.2 feet.

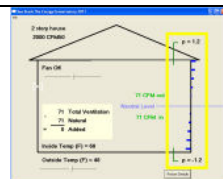
Indoor and outdoor temperature

The indoor temperature is fixed at 68 degrees and the outdoor temperature is adjustable using the slide bar at the lower left of the house. Clicking to the left or right of the arrow will move the temperature by 10 degrees. Using the left and right arrow buttons on your keyboard will move the temperature by one degree.



Vertical leak distribution

The neutral pressure level can be adjusted up or down by typing the letter V on your keyboard. Half of the house leakage is always in the walls. The other half will cycle between the floor, the ceiling and 50/50 floor and ceiling as you press the V key.



Center neutral level



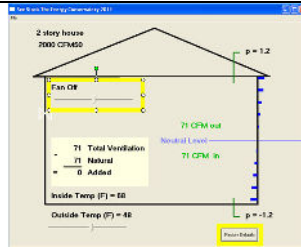
High neutral level



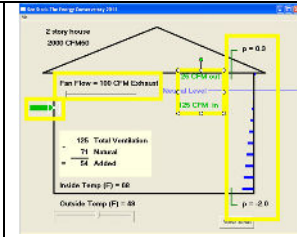
Low neutral level

Ventilation options

The default ventilation setting is with the fan off and the control slide in the center of the slide bar. Typing the letter F on your keyboard will activate the fan. Moving the slide bar to the left will exhaust

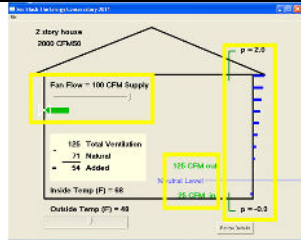


Fan Off

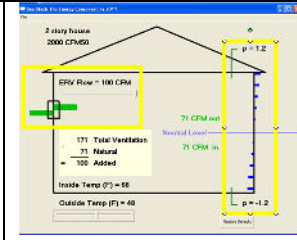


Exhaust Fan On

air from the house and to the right will supply air to the house. Typing E will activate the ERV / HRV balanced ventilation option. The green bar will indicate the direction and rate of the fan flow. The change in house pressure will be indicated on the right side of the house.

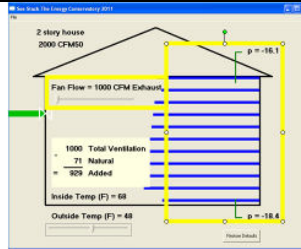


Supply Fan On

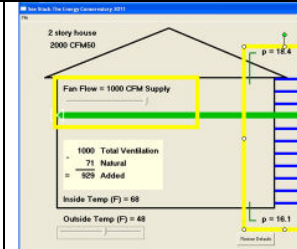


Balanced Fans On

If you would like to simulate a fan with a flow of between -1000 and +1000 cfm, type the letter B for Big on your keyboard. To change it back to the small fan setting between -100 and +100 cfm, type the letter S on your keyboard or click on the *Restore Defaults* button.



Big Exhaust on



Big Supply on

Chapter 4 Using SeeStack Trainer to demonstrate stack and mechanical effect

This section will guide you through a demonstration that will show the combined effects that temperature, building height, ventilation fans and house tightness can have on building pressures. It is best to add only one variable at a time so students will have a better understanding of each concept.

Outdoor temperature

Clicking on the *Outdoor Temp* bar will change the outdoor temperature in increments of 10 degrees and using the left and right arrow buttons on your keyboard will move the temperature by one degree. Click on the *Outdoor Temp* bar multiple times to demonstrate the entire range of outdoor temperatures, both warmer and colder. Notice the change in the length of the blue bars on the right side of the house and the pressure numbers at the top and bottom of the building as temperatures change. Also notice how the natural ventilation rate of the building changes with the outdoor temperature.

Building height

Click the default button and adjust the options for the height of the building by typing 1, 2, and 3 on your keyboard. Notice how this will change the building pressures and the natural ventilation rate of the building.

Neutral pressure plane level

Click the default button and adjust the location of the neutral level of the building by typing the letter V on your keyboard. Typing V will toggle you through the options of having the neutral level high, low or in the center of the building. Notice how this will change the pressure at the top and bottom of the building and the natural ventilation rate of the building. Remember that this model is not considering how wind may affect the natural ventilation rate of the building.

Building tightness

Click the default button and adjust the building tightness. The building tightness can be adjusted in different ways: by using the + / - keys on your keyboard or by typing T for tight, M for medium or L for leaky on your keyboard. Notice how the pressure at the top and bottom of the building remain the same but the natural ventilation rate of the building changes.

Exhaust and supply ventilation

Click the default button and adjust the fan flow and direction.

Clicking to the left of the slide bar will exhaust air from the building in 10 cfm increments. Notice that turning on an exhaust fan has the following effects:

- Operating the exhaust fan will raise the neutral level of the building
- The total ventilation rate will increase, but not by the amount of the added exhaust flow
- The total cfm **in** is equal to the total cfm **out**

Clicking to the right of the slide bar will supply air to the building in 10 cfm increments. Notice that turning on a supply fan has the following effects:

- Operating the supply fan will lower the neutral level of the building
- The total ventilation rate will increase, but not by the amount of the added supply flow
- The total cfm **in** is equal to the total cfm **out**

Show or hide results

Typing the letter R on your keyboard will show or hide the natural, added and total ventilation system flow. Toggling between fan off and fan on with the results hidden will give the students a chance to think about how much actual ventilation is being added by the operation of the fan.

Balanced ventilation

Click the default button and type E on your keyboard. This will put the ventilation system in the ERV / HRV balanced ventilation mode. You can click on either side of the slide bar to adjust the flow. There will now be a fan exhausting air from the building and a fan supplying an equal amount of air to the building. The balanced ventilation system will not affect pressures in the building and will increase the total ventilation by the flow of the balanced ventilation system. To move from the ERV / HRV mode to the single fan mode, type F on your keyboard.

Chapter 4 Putting it all together

After the introduction to all of the functions of the SeeStack Trainer, you can start to understand the complex interactions of pressures in a building. When you add the affects of wind and the variability of sizes and locations of leaks in a building you can understand the complexity of trying to model annual ventilation rates. Listed below are some specific examples that allow you to put your knowledge of stack and ventilation effects to work to help you develop solutions to some common problems.

Reduce attic condensation in cold climates

To set up this example:

- click on the *default button*
- type the letter T on your keyboard to change building tightness to tight
- type the number 1 to change building to one story
- click once on left side of the *fan flow* bar to set exhaust flow to 50 cfm.

You will notice that the neutral level is now at the top of the building. All of the air leaving the building is going through the exhaust fan, which means that very little if any is going into the attic. The combined effects of spot ventilation to reduce moisture levels, drawing additional dry outdoor air into the building, and raising the neutral level to the top of the building is a very effective way of reducing attic condensation. Notice also that the negative pressure at the bottom of the building has been increased. This can increase infiltration of soil gas including water vapor and also interfere with venting of natural draft combustion appliances.

Help control indoor humidity levels in hot humid climates

To set up this example:

- use the same set up as above, except use 50 cfm of supply flow instead of exhaust flow and set the outside temperature to 100 F.

Now the stack effect is reversed. The house pressure (with reference to outside) becomes more positive as you move from top to bottom of the walls. It is as if the dense, cold, house air is trying to pour out of the leaks. You will notice that again the neutral level is at the top of the building. The entire building is under a positive pressure, which helps keep the higher humidity levels outside. Running the supply air through the duct system will help dehumidify nearly all the incoming air.

Reducing winter time storm window condensation on the upper floor of a 2 story building

Warm moist air exiting a building will leave behind condensation when it hits a cold storm window.

To set up this example:

- click on the *default button*
- type the letter T on your keyboard to change building tightness to tight
- click once on left side of the *fan flow* bar to set exhaust flow to 50 cfm.

You will notice that the neutral level is now in the area of the second floor windows, so the window will see very little air flow either in or out. The combined effects of spot ventilation to reduce moisture levels, drawing additional dry outdoor air into the building, and raising the neutral level to the area of the second story windows is an effective way of reducing second floor window condensation.