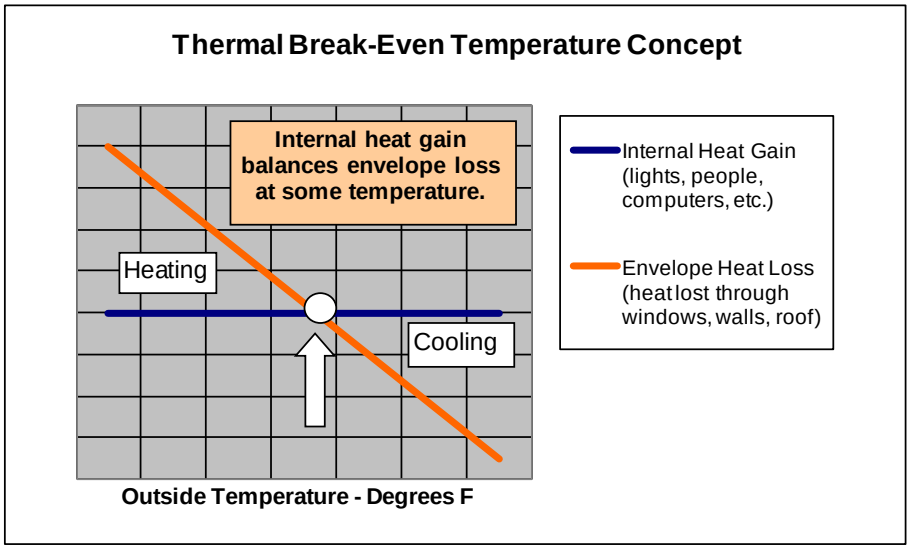
White Paper #11

Free Cooling – Outside Air Economizer

It's like opening a window when it's hot inside and cool outside.
How much does it save? The easy answer is "it depends."
To really find out, read further. You'll see there are a lot of factors.

Like all heat recovery concepts, a pre-requisite for success is to have the free heat (or free cooling) available at the same location and time as there is a need for it. The free heat in Atlanta has no practical use in Alaska because they are too far apart. Likewise, free cooling from outdoors doesn't provide any value unless it is warm indoors at that time.

Buildings are like boxes. They have thermal losses and gains through the shell (envelope), and they also have appliances and activities inside that generate heat. There will be a point where the envelope loss just matches the internal heat gains and neither heating nor cooling is required; above this break-even temperature cooling will be required.



The thermal break-even point is unique for each building. The magnitude of the envelope in relation to the internal gains creates a cooling load 'signature' for the building. This signature is an important factor in determining how much benefit can be expected from an air-side economizer. For example, the heating and cooling load for a house comes mostly from the envelope. So, when it's cold outside it's usually cold inside a house and this is why our homes are not good candidates for an air side economizer. In many commercial buildings, the heat produced by what goes on inside will offset heat losses in cool or cold weather, resulting in a need for some cooling even while cold outside. When this is the case and air-economizer is a benefit.

The greater the internal loads are, in proportion to the envelope losses, the greater the benefit of an air-economizer, because the thermal balance point is lower. With a low balance temperature, there are more hours when the building needs cooling *and it happens to also be cool outside*.

To sum it up: ***the lower the balance point, and the greater the number of hours this occurs, the greater the benefit.***

What is your building's balance temperature? It can be estimated with a method called regression, but there are also clues. If there is a lot of heat-producing equipment inside, the building becomes self-heating and will include hours in cooling mode when it is cold outside. Big Opportunity! If the heating and cooling load is mostly from envelope (not a lot of equipment), the balance point will be higher which means it probably won't be hot inside while it is cold outside. As you look at the charts of hours, you will note there is a big difference in savings depending on balance temperature and also the number of hours per year the building is operated.

STANDARD ECONOMIZER OPERATION

Standard economizer control is simple and reliable. Below some outside air temperature, often 55 degrees F, the economizer takes over the task of providing cooling. That is to say, when there is a call for cooling, it either comes from conventional equipment or from outside air, depending on how cold it is. Note that this control method is one or the other: either mechanical cooling or economizer cooling. The compressors turn off (energy savings) and the return/outside air dampers modulate to create cool outside air for free. The "55 degree" value is a convenient and forgiving choice because, regardless of relative humidity, 55F will not be a source of moisture problems in most buildings. Truth is, as long as it's fairly dry outside, free cooling with outside air is viable at temperatures above 55F. Of course, when bringing in outside air for cooling, an equal amount of building air needs to be removed from the building. Relief dampers, exhaust fans, and return fans are used to expel the warm air during economizer mode.

EXTENDED ECONOMIZER OPERATION

At 55 degrees outside air (OA), the moisture content of that air doesn't matter, but above 55 degrees OA, the air ***may or may not be suitable*** for use in free cooling – depending upon its moisture content. The air in Colorado is usually, although not always, suitable for use at temperatures up to 65 degrees.

For extended economizer operation, the ***compressors run in conjunction with the free cooling dampers.*** By expelling the building "return" air and replacing it with outside air, this acts to lower the heat content of the air stream entering the mechanical cooling unit coil. A maximum of 65 degrees is suggested for this extended operation. Dew point can be measured directly, or calculated.

Suggested Maximum Outside Air Dew Point for use in Extended Air Economizer Free Cooling.

Inside Final Conditions	Outside Air Max Dew Point Temp
72F, 40% rH	47F dp
72F, 50% rH	52F dp
74F, 40% rH	48F dp
74F, 50% rH	54F dp

Values based on maximum resulting indoor relative humidity of 40% at final indoor air temperature with 100% outside air. Increasing OA dew point limit will increase economizer hours but will also increase indoor relative humidity.
Dp=dew point in degrees F.

By raising the cut-off point, the hours of use and savings for the air-economizer are extended, and can be attractive. To capture these savings, some additional investment in controls and system attention are required. To decide if the **extended economizer** approach is worth it for you, weigh the benefits against the added cost and complication and then decide. Another approach for enabling extended economizers uses recommendations based on statistics that say, for example, in Colorado Springs it is "usually" OK to operate in extended economizer mode up to 65F outside air (dry bulb) since it is "usually" dry. This is true, just bear in mind on those few moist days it will get muggy inside.

A Few 'Watch-Outs' for Air-Economizers

- Economizer dampers moving around can affect building pressure. If not properly specified or controlled, you may experience problems like the building front doors standing open, or feeling a "vacuum" on the doors, making them hard to open. In extreme cases, you may experience ceiling tiles lifting. If any of this is happening, it can usually be improved with control adjustments, however if there is no return fan or a power exhaust the use of air economizer will be limited to the extent the building air can find its way out. If the building routinely becomes "negative" (the vacuum effect) this is a particular concern in winter, since it is then possible for pipes to freeze if located near a perimeter – depending on where the cold air finds a way inside.

- For buildings with low thermal break even points, using very cold air for cooling requires that it be "mixed" with the return air, and blended to make a reasonable air delivery temperature. The colder the air gets, the more it tends to settle to the bottom by its density. This is called "stratification" and can cause freezing damage or nuisance tripping of freeze controls. If your system uses an air economizer in very cold weather, some method of mechanically mixing the air streams will be required to avoid these troubles.

- Economizer controls that come with packaged rooftop air conditioners need proper care just like any other controls. When neglected, it is common to find the economizer feature not operating properly after 5 years or so….which means the savings have stopped. Incorporating an economizer checkup along with other annual service work will help assure the economizer is working as intended. Suggested check items:

    - Temperature where economizer mode becomes active upon a call for cooling
    - Temperature where compressor is locked out
    - Dampers modulate smoothly to maintain supply air set point
    - Air relief devices function properly to maintain building pressure during economizer mode
    - Outside air and relief dampers close fully, and return air damper opens fully, when the unit is shut off
    - When operating but not in economizer mode, proper minimum outside air setting is used for ventilation

Economizer Savings

Percent of Cooling Load Removed by Economizer for Colorado Springs, CO

Building Operating Hours	Standard economizer: Dry bulb control, either air or compressor. Compressor off 55F						Extended economizer: Compressor and outside air cooling between cut in and 55F. Compressor off 55F					
8760 hours	0	0	0	5	12	19	0	5	12	22	30	37
6A-6P hours	0	0	0	3	8	13	0	3	8	15	21	27

References:
Technical information for this paper from Commercial Energy Auditing Reference Handbook, Fairmont Press