SMARTCOOL ECO3

ECO3 Technical Note #1 - Data Review

One of the great features of the ECO3 is the continuous cumulative collection of compressor operating data. These data allow one to:

- Verify the Installation
- Determine the effectiveness of a particular ECO3 Application
- Calculate specific HVAC parameters like:
    - Save Percentage
    - Load Factor
- Perform diagnostics of an HVAC system and operation
- Calculate Financials including dollar avings and actual payback

The ECO3 data consists of 4 registers of information, all are measured in hours. These are:

- Run hours (R) – Increments when in run mode and input (thermostat call) is active, represents cumulative number of hours the compressor has run.
- Save hours (S) – Increments when in save mode and input is active, represents cumulative number of hours the compressor was stopped from running by the ECO3.
- Manual bypass hours (BP-M) – Increments when in manual bypass mode and input is active, represents cumulative hours the compressor has run while the ECO3 was manually bypassed, this is essentially a timer on the compressor as there is no optimization.
- Automatic bypass (override) hours (BP-A) – Increments when in automatic bypass and input active, represents cumulative hours the compressor has run while the ECO3 bypassed itself. Automatic bypass occurs when the ECO3 detects the air conditioner cannot maintain the desired set point. This can be due to high outdoor temperatures, excessively low interior set points, sudden increases in heat load (open door), inadequate capacity, or malfunction of AC system.

Note that in all cases, for data to accumulate, the ECO3 must be in the particular mode **AND** the input (thermostat) must be calling for run. Both criteria must be satisfied.

Data is collected by simply pushing the one button on the ECO3. After each push the associated LED illuminates and the data is clearly and sequentially displayed. Note the period displayed, as in “0.011” which represents 11 hours. This is because the ECO3 uses European convention of a period for 1000’s separation. Also, the ECO3 uses integer rounding. This means all data displayed is rounded down to the nearest whole number. So even though the ECO may have internally accumulated 11.97 hours of save time, the display will only show 11 hours.

Note on resetting ECO3 hour logs: The hours can easily be reset to zero by cutting power to the ECO3 (via plug, circuit breaker, etc.), holding in the single button and re-applying power (cycle the power). Continue to hold the button for about 2 seconds. All values should now be zero.

This reset will also reload the ECO3 software into an “as delivered” configuration and, for Ver. 23 and later, will place the ECO3 into “FS” test mode (forced save). The FS mode may be cancelled by holding the button for 6-7 seconds or will expire normally in 6 minutes.
Remember all data is cumulative. If data for a specific period is desired, one must either reset the ECO3 to zero at the start, or take a set of readings and subtract from the later readings.

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ECO3 data collection should be sure to note the 4 registers of data and, equally important, write down the date and time of the reading plus the ECO3 location or installation number. If at all possible, the installation date/time (or latest reset if performed) should also be added to the data collection sheet. There are forms and spreadsheets available for all this, but exactly this precise data is essential for the calculations and reporting. Remember, a data reading consists of:

- ECO3 Data registers: R S BP-M BP-A (R, S, BP-M, BP-A)
- Reading date and time of day
- Reading physical location and/or location number
- Installation date/time (or latest reset if applicable)

Installation Verification

While the vast majority of installations go without issue, it is important for all Distributors and Installers to review the ECO3 data, ideally within 7-14 days of installation. In addition to providing some great positive feedback to the client (go get that referral!), this also allows early identification of any installation or operating issues, hopefully before the client even knows something is amiss. It is assumed that the installer verified operation of the HVAC system before leaving the site, so this discussion does not concern HVAC failure troubleshooting.

A couple of concepts to understand first— savings percentage (%S) and load factor (LF). The math is down a bit more, but first here are the concepts:

Savings Percentage (%S): Represents the savings as a factor of the total thermostat demand which the ECO3 interrupted. So this is save hours divided by the total thermostat demand hours.

%S is an important indication of savings and performance, but remember that all percentages are mathematically non-dimensional. This means that the percentage can be great (say 45%), but does not indicate whether the savings were worth $10, or $100 in a month or a year.

Load Factor (LF) : This is also a percentage which indicates the time the HVAC compressor is running. So 8 hour of running in a 24 hour period gives LF=30%. Since this measure uses elapsed time as the denominator, used in conjunction with %S one can gather an accurate idea of how the system is operating.

So, on to data review: consider data like this after a week:

0, 0, 0, 0 These are (R, S, BP-M, BP-A) in order of data display

This suggests the ECO3 is improperly connected (remember, the HVAC system is assumed to be operating). Possibly the common was not connected so the ECO3 never received a signal or the input and NC output were reversed. It may also just be a system that has simply not received a thermostat call in the test period, such as during cold weather.

Consider data like this after a week:

2, 1, 0, 165

This might also suggest an improper connection, possibly the supply voltage was also wired to the ECO3 input. It is also possible that the thermostat was pushed down to 60 degF—if the HVAC could not cool that far, the system would never shut off and the ECO3 spent the week in automatic bypass.

Another example, after a week:

26, 54, 0, 9

These data are somewhat contradictory, high save percentage (indicating a low load factor), but relatively high automatic bypass (indicating a high load factor). It may just be the unique load

profile of that facility, but it would be a good idea to re-check the installation wiring and while there, perform a back voltage test and/or remedy.

Smartcool calculations are intended to be straight forward (plug 'n chug), just plug the number into the formula, chug the calculator and voila! There is the answer.
So, suppose the set of numbers at the end of the first week in July looks like this:

55, 35, 0, 10 Keep in mind that a week is 168 hours long.

Calculate the savings with the formula: $\%S = \frac{(S)}{(R + S + BP-A)} = \frac{(35)}{(55+35+10)}$ = 35% savings

Then calculate load factor (LF) as: $LF = \frac{\text{(Total Demand)}}{\text{(Elapsed Time)}} = \frac{(55+35+10)}{(168)}$ = 60%

- So is 35% savings good or bad? How will it change over time?

1.

ECO3 savings percentages vary greatly between different residences or facilities depending on the AC capacity, insulation, heat loads and many other factors. Values tend to be consistent for a specific facility and vary a few percentage points seasonally as an inverse to changes in load factor. So as summer heat builds and load factor increases, the savings percentage will likely also decrease—even though the total save hours may actually increase due to more run time overall. ECO3 savings percentages typically run between 15-45%.
Automatic bypass hours, if present, will typically increase in summertime. Collecting 1-3 hours a day in August is within expectations and normal.

- So the answer is that 35% is a common, expected (and darn good) value. And since it is July, it will likely improve 5-10% or better in the cooler months.

Guidelines: Savings less than 15% suggest it would be wise to examine the facility and/or seek professional evaluation. Check the load factor and see if it is very high in the 80%+ range.
Savings more than 50-55% are exceptional, but can occur with specific load profiles and low load factors (theoretical maximum peaks at 90%). For values above 50-60%, verify back voltage potential was checked/mitigated (see technical notes on that topic).

- So is 60% Load Factor good or bad? Will it change?

Load factor is an indication of how "hard" the air conditioner is working. If the compressor is running 12 hours out of 24, this is a 50% load factor and is defined as average. Clearly as outside temperatures rise, so will the load factor. Should a manager or homeowner raise the thermostat temperature, load factor will then decrease as this is also a measure of how much heat needs to be moved. A well insulated and sealed home with a sizeable capacity could be at 30% in the summertime, the opposite extreme could be at 75-85%.

Note: Whenever there are two or more adjacent HVAC systems, the ECO3 LF calculation may show wildly different values. This is a serious and common problem. It is serious because if one HVAC system is running at 10% LF and the other (in the same conditioned space) is at 85%, clearly the harder working HVAC system will wear out faster while the ECO3 will operate sub-par in both due to the extreme LF's.
Usually the cause is improperly set or improperly calibrated thermostats though solar

and other thermal gain can also be the culprit. Raising the harder working AC thermostat by 1 degree may remedy the problem (the thermostats must be labeled and tamperproofed). If adjusting the thermostat more than 2 degrees does not remedy the condition, more serious HVAC work (such as re-ducting or relocation/replacing of the thermostats) may be required.

- So the answer is that 60% LF in July is normal and expected. Clearly it will drop significantly in the cooler months (unless it is a heat pump!).

Guidelines: Load factors of 15 – 65% are common depending on season.

Diagnostics of an HVAC system

The discussion above detailed using ECO3 LF data in a diagnostic mode to thermally balance a facility. By monitoring the data, it is also possible to catch failures and issues quite early.

Suppose the readings are like this:
May 455, 285, 0, 13
June 628, 391, 0, 28
July 692, 421, 0, 467
Clearly there is something awry. It could be low Freon, a bad fan, a ceiling ventilator left on full speed or an unnoticed open window.
The same logic applies to a dual stage system. If there is a sudden surge in the stage 1 run hours (regardless of stage 2), then there could be a problem with the stage 2 compressor or electrical system.
The bottom line is any dramatic change in the ECO3 data values indicates a need to investigate and even relatively small percentage changes have been tracked and correctly interpreted as dirty air filters, freezing coils and similar causes.

Financial Calculations

This data also permits an approximation of the dollar value of the savings as well as months of payback and return on investment.
Suppose that after a week of operation, the ECO3 numbers are 33, 25, 0, 5

- The important values here are 1 week (168 hours) and 25 save hours.

The AC outdoor section should be labeled with important information. This includes:
RLA= Running load amperage (the current draw of the compressor) (ex. 26.6 amps)
FLA= Full Load Amperage (the current draw of the condenser fan) (ex. 3.4 amps)
Voltage= typically 208 or 230 (ex. 208 volts)
Phase = typically 1 (single) or 3 (ex. 3) NOTE: 3 phase power calc requires a 1.73 multiplier
Using the simple equation:
Power=Volts * Amps= (208 or 230) * (RLA+ FLA)= watts (multiply by 1.73 if 3 phase)
So from the numbers above, Power = (208)*(26.6+3.4)*1.73=10795 Watts, or 10.8KW

Since $Saved= (save hours)*(KW)*(KW Rate)
In the above example $S= (15)*(10.8)*(.14) (using 14 cents per KW-H)
= $22.68 cumulative savings to date (1 week)

For monthly savings, divide the cumulative savings hours by the elapsed time in hours and multiply by 832 (number of hours in a month= 30.5*24).
Monthly savings = $\frac{(\$22.68) \times 832}{(168)}$ = $112.32 per month

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Payback calculation: Payback (months) = Equipment Cost / Monthly Savings = ($1495.00) / (112.32) = 13.3 Months*

*For simplicity this calculation did not include installation costs or tax/rebate benefits.

Return on Investment (ROI): ROI= Annual Return (savings) / (Investment cost) = (12*$112.32) / ($1495.00) = 90%

Comment: Clearly the payback and ROI calculations depend on the size of the HVAC system, save hours as well as the pricing and installation. ECO3 paybacks and ROI's are typically so very good that it is easy to become overly focused on exceptionally quick paybacks.
But if the deal works out to 36 or 40 month payback, that still represents a very good performance for capital improvements. Solar hot water can often have a 6-8 year payback and that is after rebates and tax incentives. Solar Electricity is often 10 years plus. A 60 month payback capital improvement is normal, 48 month exceptional.

Many clients are unclear that a 12 month payback means a 100% ROI, a 24 month payback means 50% and even that a 60 month payback is 20% ROI.
Should a client fixate on particular payback (Got to have 24 months!), which is not supported by the proposal, it may be helpful to politely inform them that a 50% ROI is ridiculously good by any measure, and that few investments work out that well—and cite any CD, treasury bond or stock market statistic.

Data Review and Interpretation Examples

1. After 2 weeks, the data is (8,2,0,326). It is unlikely that an air conditioning system sees this much heat load 24/7. Observe the compressor for 15-30 minutes and verify it is cycling on/off. More likely this suggests a wiring error, possibly interrupting the common instead of the Y1 (see technical notes on common wiring errors). The installer should check installation and remedy.

2. After a week, 4 ECO3's on a single floor show load factors of 15%, 19%, 40%, and 85%.
   This information indicates that one system is picking up most of the heat load which also means the ECO3 savings are adversely impacted as savings improve with lower, even load factors of all the AC systems.
   a. This could be due to thermostats that are set differently or improperly calibrated (a common problem). One simple remedy is to raise the thermostat with the highest load factor by 1 degree. Check the data a few days later and adjust as necessary. More than a 2 degree adjustment without improvement means it is time to call the HVAC company as it could be ducting or other problems. Since there is operational data from the ECO3, the HVAC company will have a great leap on resolving the problem.
3. After a month the data is (126, 135, 0, 5). This data is within expectation though a little high on savings. Verify with the installer that a back voltage resistor was installed. If so, all is well.
4. After 3 weeks the data is (96, 169, 8, 0) on a walk in cooler. This data is a bit peculiar. Firstly, the savings significantly exceeds the run time so the installer needs to check for and remedy back voltage. Since it is a refrigeration system, the control voltages are all line voltages and so the back voltage remedy (at this time) is an isolation contactor. Finally, the manual bypass time should be explained. Few clients ever use this feature which indicates the possibility of tampering.
   a. Incidentally, walk in coolers are notorious for being left open to cool the kitchen. The data will show if this is happening and could save quite a bit for the client.

It is always possible to come across data that is unexpected, real data tends to be that way. Smartcool is always adding to the knowledgebase so feel free to email or call in a request for evaluation.

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