Tips for the HVAC Sales Professional
Understanding the Advantages of X13 Motor Technology

By
Brian Michael
Brand Manager
Johnson Controls, Inc.
Building Efficiency
Unitary Products
Norman, OK 73069
Email: brian.k.michael@jci.com
Website: www.johnsoncontrols.com

Introduction

There are a variety of motor technologies currently used in the heating and air conditioning industry. The type used in any product design is dependent upon several criteria and considers the performance goals of the product, the positioning of the product, the costing of the product and the potential application of the product. Historically, the two predominant motor types in our industry have been PSC (Permanent Split Capacitor) single-speed motors and ECM 2.3 (Electronically Commutated Motor) variable-speed motors. Most HVAC sales professionals understand the key differences between these two motor types and are comfortable discussing the benefits of one technology over another in their sales dialogue.

In 2006, Regal-Beloit (General Electric) introduced a third motor technology to the HVAC industry. Referred to as the X13 motor, it has significantly gained in popularity among all heating and air conditioning equipment manufacturers. What is an X13 motor and how does it compare to PSC single-speed and ECM variable-speed motor technologies? Why have they become so popular? Why is it important for the HVAC sales professional to understand the importance of X13 in their sales proposition?

What Is An X13 Motor?

X13 motors are high-efficiency motors that were originally developed by Regal-Beloit (General Electric) to help manufacturers meet the 13 SEER mandate implemented by the federal government in 2006 (hence the branding name of X13). They are based on ECM (Electronically Commutated Motor) technology and can contribute to increasing the overall cooling efficiency of a complete HVAC system when used as the circulating air blower motor in a furnace, air handler or packaged unit. Regal-Beloit (General Electric) refers to the X13 motor as a standard ECM motor.

For clarification sakes, it is worth noting that the general naming of “X13” that the field has adopted for these motors is not the most accurate. “X13” is Regal-Beloit’s (General Electric) brand name. Several other motor manufacturers offer similar motors. Therefore, they should correctly be referred to as high-efficiency motors in general statements. However, for the purpose of this article, the term X13 will be used since it is the most recognized.

X13 Motor Technology vs. PSC and ECM Motor Technologies (Differences and Benefits)

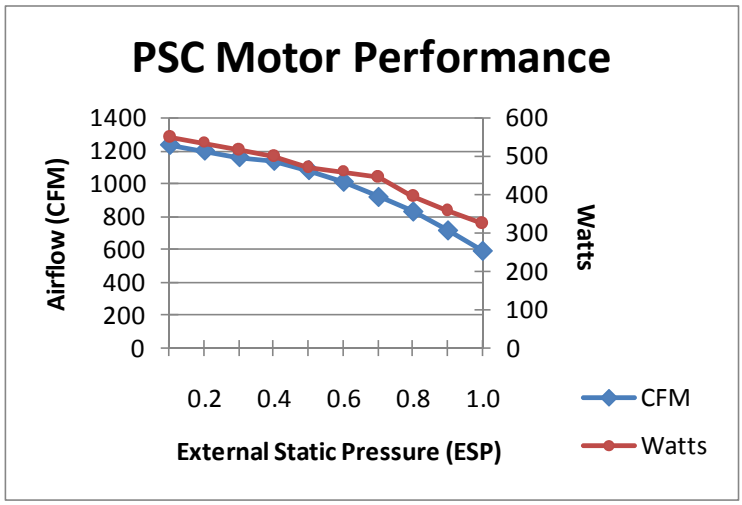
In order to understand the benefits of X13 motor technology, it is important to look at, understand and compare the two other motor technologies that are prevalent in the HVAC industry (PSC single-speed and ECM 2.3 variable-speed). X13 motor technology offers several benefits with respect to efficiency, operation, comfort and cost when compared to these two other motor technologies.

PSC Single-Speed Motor Technology: PSC (Permanent Split Capacitor) single-speed motor technology has been the standard in the HVAC industry for many years and represents the highest install base. PSC motors are typically positioned by most manufacturers as a standard product offering and are used in furnaces, air handlers, condensing

units and packaged products. The popularity of the PSC motor can be contributed to its simplicity, reliability, low cost and flexibility.

PSC motors, often referred to as induction motors, typically use alternating current (AC) and include two key components in their design – a stator (stationary section of the motor) and a rotor (the rotating section of the motor). A magnetic field is induced in the rotor opposite in polarity of the magnetic field in the stator. Therefore, as the magnetic field rotates in the stator, the rotor also rotates to maintain its alignment with the stator's magnetic field. In this operation, the rotor constantly lags behind the magnetic field in the stator, resulting in what is known as asynchronous (i.e. – not synchronized) operation. This operational characteristic, which also generates excessive heat, greatly contributes to the degraded operational efficiency of PSC motors (which are at best only sixty percent efficient). However, since there are few mechanical components, this design has proven to be very simple and reliable and can be manufactured at a relatively low cost.

PSC motors are considered single-speed (i.e. - speed refers to the rate of rotational motion) because they do not have any internal controls that can be programmed to automatically vary the rotation of the motor over an operating range.



For example, an equipment manufacturer may utilize a ½ HP motor in a 3-ton drive furnace in order to deliver an average airflow of 1,200 CFMs within a range of external static pressures (ESP) often found in assorted applications. But what if the duct system layout in a specific application has an increased static pressure because the mechanical contractor added a very restrictive media filter? How can the furnace's blower speed be adjusted, or varied, so that the proper airflow can be delivered in order to maintain the correct furnace air temperature rise (ATR)? In order to make PSC motors more flexible for a variety of applications, they include speed taps that allow the mechanical contractor (or manufacturer) to manipulate the speed of the motor to ensure that the correct amount of airflow is delivered for both optimal performance and safety within a range of external static pressures. It should be understood that there is a limit to the amount of static pressure the motor can handle. As static pressure increases, a PSC motor's performance drops off because it cannot adjust speed or torque. As a result, higher static pressures equate to lower airflows. Although the lack of programmability may appear to be a disadvantage, it actually makes PSC motors more flexible or universal because they can be used for most retrofit and OEM applications.

Because of the design, there are some disadvantages inherent to PSC motors. They are significantly less efficient than X13 or ECM 2.3 motors because they consume more watts, making them more difficult for a manufacturer to apply to a high SEER system design. On average, they will use approximately 552 watts in cooling mode and 515 watts in continuous fan mode. Therefore, they are not ideal for continuous fan operation because they run close to full speed when applied in this manner, using more energy than this function really requires (as a comparison, imagine the power consumed by five 100 watt light bulbs lit all day long). This also makes them less attractive for continuous filtration applications. Additionally, since they are not programmable and the motor speed cannot be easily varied, it is also more difficult to apply them to two-stage or advanced systems.

PSC motors are also the least quiet of the three motor technologies, possibly degrading the emotional aspect of the comfort equation. A quiet environment often equates to ideal emotional comfort and it should be considered, especially if the equipment will be located in a living space such as the laundry room, workshop or finished basement. In

addition, PSC motors do not offer customized airflow patterns, which are often critical in designs intended to manage humidity. Consistent air stratification and temperatures are also harder to obtain. Finally, products that utilize PSC motors typically do not qualify for the federal tax credit program based on the motor itself. However, if the rest of the system components meet performance requirements as outlined under the program (specific SEER, EER and HSPF combinations or a minimum of 95% AFUE), then the installation may be eligible for the program.

Premium ECM 2.3 Variable-Speed Motor Technology: ECM 2.3 (Electronically Commutated Motor) variable-speed motor technology has been, and continues to be, the ultimate design for superior cooling and heating comfort. Its operation can be compared to using a dimmer switch in lighting applications, meaning it is highly-variable, making its precise performance ideal for a variety of advanced applications. ECM 2.3 motors are typically positioned by most manufacturers as a premium product offering and are used in furnaces, air handlers, condensing units and packaged products. The popularity of the ECM 2.3 motor can be contributed to its performance, flexibility and reliability.

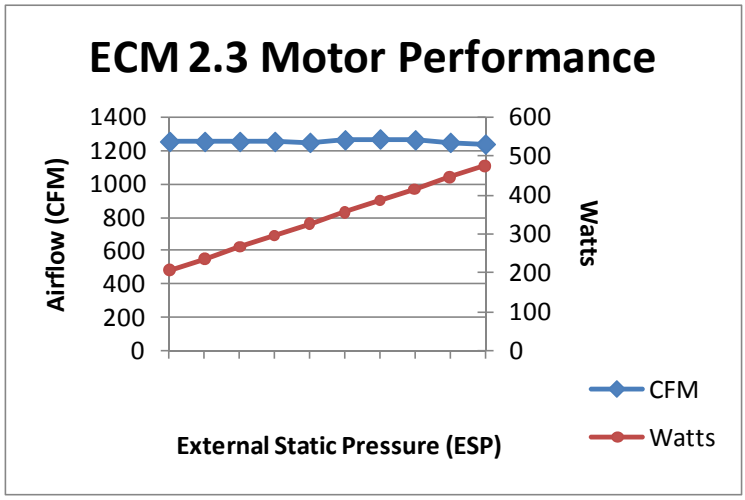
(**Note**: Regal-Beloit also offers several other ECM motor designs. These models are identified as ECM 2.5 or ECM 3.0 and include additional features that allow for more sophisticated programming options specifically intended for equipment utilizing communicating control systems (also known as four-wire systems). In any case, the discussion below generally applies to all three ECM motor types).

Electronically **C**ommutated **M**otor (ECM) technology (i.e. - commutate means to reverse the direction of an alternating electric current, which is the means by which all electric motors rotate) is based on a direct current (DC) design that is inherently more efficient and runs cooler than alternating current (AC) PSC motor designs (ECM 2.3 motors are approximately eighty percent efficient compared to the sixty percent efficiency found in PSC designs). But it doesn't end there – ECM 2.3 motors are even different in construction when compared to other traditional, efficient DC motors.

In a traditional DC motor, the stator (stationary section of the motor) is replaced with permanent magnets. The rotor (the rotating section of the motor) contains a series of windings wrapped around it. When electricity is applied to the motor, a magnetic field is created in the windings causing it to turn towards the magnetic field created by the stator. From there, brushes in contact with a commutator (i.e. - an electrical switch that periodically reverses electrical current) allow the current and magnetic field to shift from winding to winding, forcing the rotor to continuously rotate. Unfortunately, the brushes and the commutator eventually wear out resulting in motor failure. Traditional DC motors are then controlled by components that are independent of the motor.

So what makes ECM 2.3 motor designs better than their traditional DC counterparts? First, in the ECM 2.3 motor, the magnets and windings switch positions – the permanent magnet is on the rotor and the series of windings are placed around the rotor. This makes the ECM 2.3 a brushless motor, eliminating the failures caused by worn brushes and commutators. Second, the design combines a microprocessor and an electronic control directly with the motor. These electronics precisely manage the commutation of the stator so that it is always synchronous (i.e. – in tune) with the rotor and also make the motor programmable. Another nice fact about this design is that in the case of a failure, either the control or the motor can be replaced without necessarily replacing the whole unit

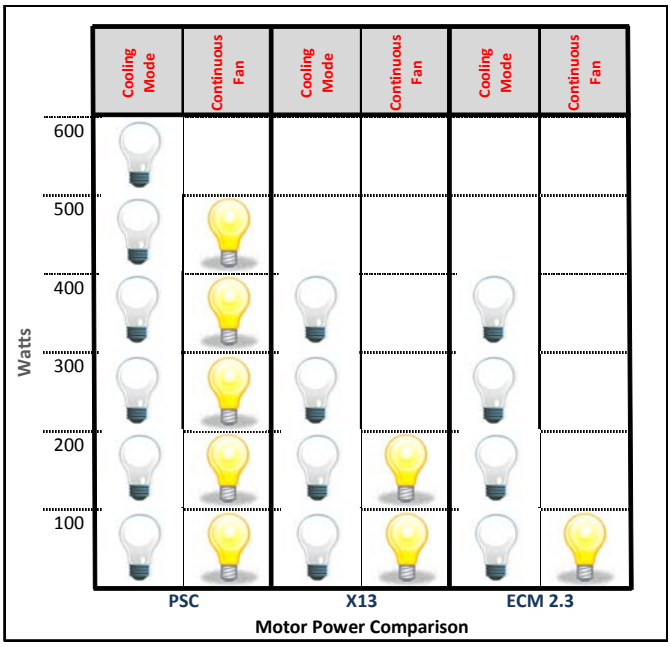
So what can be programmed into the ECM 2.3 motor? Options include a variety of characteristics, including the rotation direction of the motor, start and stop ramp rates, on and off blower delays, speed (i.e. - rate of rotational motion) of the motor and torque (i.e. - rotational force or power output down a shaft) of the motor. Unlike conventional PSC motors, which are designed to operate at one speed, ECM 2.3 variable-speed motors can run over a wide range of speeds. This



is critical because blowers need to be flexible in order to deliver the airflow needed by a multitude of system designs. ECM 2.3 motor technology provides the ability to program and deliver constant airflow over a wide range of external static pressures (ESP), typically up to 1.0 inches water column. This feature automatically compensates for any added pressure drop introduced to the system. For example, if a duct system layout has an increased static pressure due to a dirty filter, the presence of a media filter or simply because of poor design, the motor will automatically ramp up to ensure that the programmed amount of airflow is delivered. This is accomplished without the use of any additional components. Equipment manufacturers don't condone poor duct design, but ECM 2.3 motor technology can compensate for some applications if sized incorrectly. However, be cautious because increased noise levels, which is uncharacteristic of these motors, may result if the design in overly restrictive.

The ability to independently program any of these characteristics into the operating profile means that the motor can be customized to meet the specific performance requirements dictated by any cabinet or duct design. The programmability, which is managed by a programming tool created for both manufacturers and mechanical contractors by Regal-Beloit (General Electric), contributes to the motor's flexibility and can result in lower inventory requirements because one motor can potentially serve many applications while also allowing for features that are nearly impossible to create using conventional motor technologies.

Overall, ECM 2.3 motors draw the least amount of watts, which is what categorizes them as the most efficient. On average, they will use approximately 413 watts in cooling mode and only eighty-three watts (less than a 100 watt light bulb) in continuous fan mode. This combination of performance, reliability and programmable flexibility makes ECM 2.3 motors an ideal solution for high-SEER or multi-stage system designs and has the potential to increase overall cooling system performance by as much as one or more SEER points.



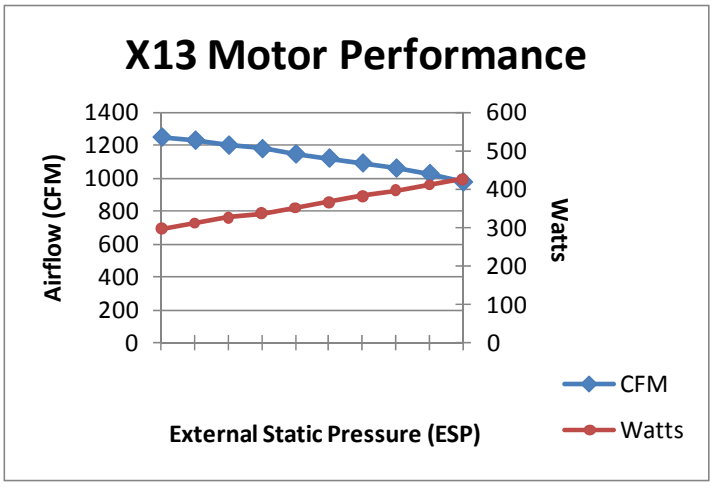
Beyond programmability and efficiency, ECM 2.3 motors offer many other advantages that enhance consumer comfort. These motors are the quietest of the three motor types because they have the ability to ramp up and down slowly, making them ideal for applications where noise is a concern. Variable-speed motors are also the best choice for constant fan or constant filtering applications because the motor will only run at about one-third of its designed speed, using less power than a 100 watt light bulb, resulting in both noise reduction and energy savings that the consumer will appreciate. The indoor environment will also benefit from better air stratification resulting in more consistent and precise temperatures. ECM 2.3 motors also have the ability to deliver customized airflow based on the consumer's geographic region, making them versatile in humid, arid or temperate climates. If dehumidification is required, variable-speed motors offer the best solution because of the wide

range of speeds and are particularly effective when combined with two-stage compressors and a dehumidification control. Lastly, most products that utilize ECM 2.3 motors may qualify for up to $1,500 under the federal tax credit program due to their efficiency.

ECM 2.3 variable-speed motors do have a few disadvantages. In order to enjoy the wealth of advantages, features and benefits, there is a cost premium associated with the use of these motors. On average, a mechanical contactor can anticipate a 40% - 60% cost premium for products that utilize ECM 2.3 motors. Although the programmability contributes to the flexibility and performance of the motor, it can also be considered a disadvantage. Most manufacturers program their own motor profiles and do not share the program codes. Therefore, the contractor typically must purchase a replacement service motor from the original equipment manufacturer (OEM) and is limited on using a universal motor. Out of warranty motor replacements can also be fairly costly for the consumer. Lastly, inexperienced service technicians may not understand how to properly diagnose problems with an ECM 2.3 motor. To assist the technician, Regal-Beloit (General Electric) does offer a troubleshooting tool.

Standard ECM X13 Single-Speed Motor Technology: X13 motor technology is quickly becoming one of the most popular motor technologies available. As a matter of fact, it is anticipated that it may totally replace PSC motors in the near future as government actions and regulations continue to mandate increased efficiencies. X13 motors are typically positioned by most manufacturers as a mid-tier product offering and are used in furnaces, air handlers and packaged products. The popularity of the X13 motor can be contributed to its performance and cost.

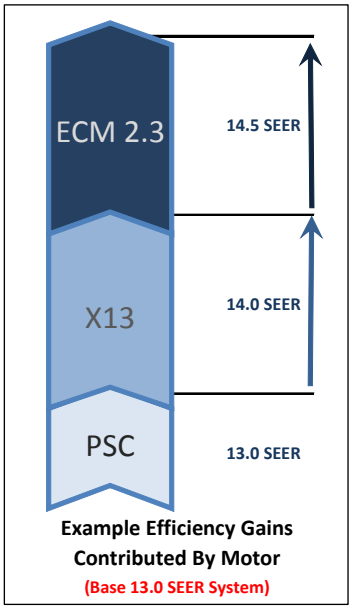
X13 motors are high-efficiency, brushless DC (Direct Current) motors that are based on the same ECM (Electronically Commutated Motor) technology described in ECM 2.3 variable-speed motors. They are controlled by twenty-four volt signals. They were designed so that original equipment manufacturers (OEMs) can program them using a programming tool at the factory for use in a variety of high-efficiency applications without modifying or increasing the size of existing product designs. The programming is not as flexible as a premium ECM 2.3 motor (it does not allow for wider speed ranges, climate-based airflow performance profiles or constant airflow algorithms). Although X13 motors utilize ECM technology, they are NOT variable-speed motors as many people have considered or defined them. This is probably one of the biggest misconceptions regarding X13 technology.



For comparison's sake, X13 motors are basically upgraded next-generation PSC motors. What differentiates X13 motors from PSC motors is that they are able to deliver constant torque (i.e. - rotational force or power output down a shaft). In other words, if the external static pressure (ESP) changes, then the motor program will maintain the amount of torque that it was programmed for (this is not the same as constant airflow). Even though X13 motors can maintain torque, if the external static pressure increases, airflow will decrease similar to a PSC motor. However, the decrease is not as drastic since the torque is being maintained. On the other extreme, an ECM 2.3 motor has the ability via programming to increase torque in order to maintain constant airflow in response to changes in external static pressure.

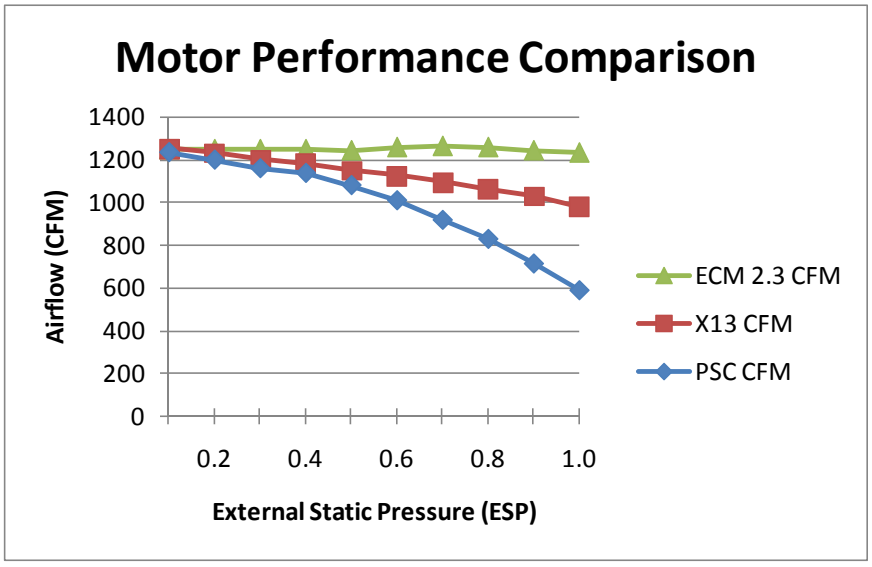
A second differentiator when compared to PSC motors is reduced power consumption in a similarly sized motor footprint (approximately 413 watts in cooling mode and only 200 watts in continuous fan mode compared to 552 watts and 515 watts respectively for PSC models, which makes their overall efficiency very similar to an ECM 2.3 variable-

speed motor, with is approximately 80% efficient). As a result, X13 technology contributes to increasing the overall cooling efficiency of a complete HVAC system when used as the circulating air blower motor in a furnace, air handler or packaged unit. This is their biggest benefit and, similar to an ECM 2.3 motor, provides the potential to increase overall cooling system performance by as much as one or more SEER points. Even more advantageous is that the price point for this benefit is significantly less when compared to full-blown variable-speed motors, typically averaging an increase in price point of approximately 3% - 5% instead of 40% - 60%. This combination of factory-programmability, exceptional performance and low cost makes X13 motors an ideal solution for high-SEER or even multi-stage system designs.



X13 motors are programmed by the original equipment manufacturer (OEM) at the factory. But what are they actually programming? Understanding that X13 motors are designed to deliver constant torque (and not speed), the same amount of torque may not be required for all functions or all applications. First, the equipment manufacturer determines the level of torque needed for each product application. Once determined, they program each of the motor's five speed taps to produce the desired airflow for heating, cooling or continuous fan operation depending upon which tap is used. The manufacturer has the flexibility to specify either a percentage of the maximum torque or the actual torque value in their motor programs. For example, tap 1 = 100% torque, tap 2 = 85% torque, tap 3 = 65% torque, tap 4 = 50% torque and tap 5 = 25% torque. Many manufacturers will only program the taps needed for the specific equipment design, meaning some taps may not be active. The manufacturer also programs any off delays needed at each tap. On delays cannot be programmed. However, the manufacturer can accomplish on delays with their external control boards (i.e. – integrated furnace control board or a fan control board). This method of motor programming can contribute to minimizing the number of motors manufacturers need to stock because the same motor may apply to a multitude of equipment models.

So how does the mechanical contractor use these taps? Let's assume that we have applied a 4-ton drive (1600 CFM nominal) gas furnace to a duct system. In order to make certain that the furnace is operating at the correct air temperature rise (ATR), which ensures proper and safe heating operation as well as heat exchanger longevity, the motor speed typically has to be adjusted. The technician will usually do this by re-assigning the heating speed tap from one designated speed to another (often labeled as low, medium low, medium, medium high and high). Now let's assume that the consumer has a fairly restrictive media filter installed at a later date. The technician most likely had to manipulate the motor speed once again in order to ensure correct operation. This manipulation interface is very familiar to all mechanical contractors. This is important because the reality is that changing tap connections on X13 motors does not actually change the speed of the motor, it changes the programmed torque levels of the motor (most technicians understand adjusting speed and not torque). The manufacturer will most often not provide the actual torque values, but instead

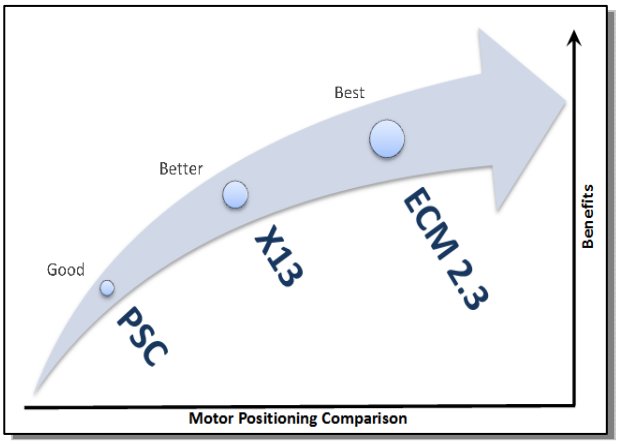


will typically show via a chart which of the five taps are to be selected for proper heating, cooling or continuous fan airflow.

X13 motors offer several consumer benefits. With increased SEER ratings in cooling mode, homeowners will appreciate lower utility bills. Since these motors utilize ECM technology, they are also slightly quieter than a traditional PSC motor and will contribute to the emotional comfort factor. Additionally, there can be a slight improvement in dehumidification with products that utilize X13 motor technology. Lastly, some products that utilize X13 motor technology may qualify for up to $1,500 under the federal tax credit program because of their efficiency (check with the equipment manufacturer for confirmation).

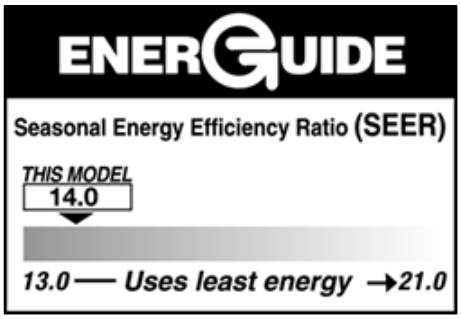
Key Highlights To Remember for An X13 Motor Sales Dialogue

Now that there is an understanding of the three main motor technologies used in the HVAC industry, the sales professional should realize the importance and benefit of having equipment in their product offering that includes X13 motor technology. Here are some key things to remember in your sales dialogue.



Product Positioning: Since you know the benefits of X13 motor technology, be prepared to discuss the key reasons why the consumer should buy them. Recall the fundamentals of the retail selling process. Present the consumer with multiple options in your proposal and tier them into a "best, better, good" manner. Independent research confirms that consumers prefer choices and will often migrate to the middle option when presented to in this manner. The end result is often a better buy for the consumer and an increased profit margin for the retailer. Products with X13 motor technology are typically positioned as a mid-tier product offering - they are the "better" in your "best, better, good" retail sales story. It is doubtful that the price point to upgrade to a product with X13 motor technology will be hard to defend.

Reduced Utility Bills: Many consumers are interested in lowering their energy costs, especially in the current economic climate. When applied as a complete system, X13 motors can increase the overall cooling efficiency by as much as one or more SEER points. Depending on the consumer's lifestyle, the size of their home and the region where they live, this can equate to several hundred dollars in energy savings per year! In addition, some products that utilize X13 motors may be Energy Star-qualified, another indicator to the consumer that they may reduce their energy bills. Stand out from your competitors in your sales process and include operational cost evaluations with your proposal whenever possible.



Federal Tax Credits: Furnace products that utilize X13 motor technology may qualify for up to $1,500 in tax credits under the current federal tax credit program due to the motor's contribution to efficiency (check with the furnace equipment manufacturer to determine eligibility). If eligible, the X13 motor would be defined as an advanced air circulating fan, meaning that the motor itself has an annual electricity usage of no more than two percent of the total annual energy used by the furnace as determined by Department of Energy (DOE) test procedures. It should be noted that this criteria, including the tax credit itself, does not apply to air handlers with X13 motors because

the benefit of the advanced main air circulating fan has already been accounted for in the overall energy efficiency ratings of the outdoor products. X13 motors can help you sell the tax credit benefit to consumers at a more appealing and competitive initial cost. Unlike ECM 2.3 variable-speed motors, the price point to upgrade to X13 technology is more easily palatable. Provide as much information as you can to your customer in order to educate them about the federal tax credit program so that they decide to upgrade their home comfort system before their water heater, insulation or windows. You deserve the sale!

Improved Comfort: One of the biggest reasons consumers often decide to replace aging equipment is to improve their overall comfort. The obvious example of comfort is consistent space temperatures. However, don't forget the emotional comfort aspect. X13 motors are quieter than PSC motors and a quieter environment often equates to ideal emotional comfort. Discuss quiet operation as part of your improved comfort discussion, especially if the equipment will be located in a living space such as the laundry room, workshop or finished basement.

Sustainability: One of the hottest buzzwords out there today is "sustainability". All service technicians should be aware of what it is and how to use it as a potential selling feature. Per the Environmental Protection Agency (EPA) website, sustainability means "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Sustainability certainly applies to the HVACR industry, although it may be more evident from the condensing unit side of the business due to refrigerant debates. However, don't overlook its potential power when given the opportunity in your sales dialogue – it may be a very important issue to your customer. Some obvious points of discussion that equate to improved sustainability in products with X13 motor technology include lower electrical usage that eventually equates to less environmental pollution. But don't just stop there. Depending on the equipment manufacturer, some other items to consider talking about include "green" or recycled packaging and even sound. Research what the manufacturers of the brands you sell are doing to help the environment and leverage their commitments to sustainability in your comfort proposition.

Final Thoughts

By understanding the advantages of X13 motor technology, you can create a unique, professional selling proposition. Be distinctive and propose something different! Understanding all of the features and benefits of X13 motor technology will set you apart from your competition while contributing higher profit margins to your company's bottom line. It's a win-win for both you and the consumer.

* References:
Technical information about the three motor technologies was primarily obtained from Regal-Beloit (General Electric) documentation.
For additional details, please visit their websites (www.thedealertoolbox.com and www.regalbeloit.com).