AoFrio

WHITE PAPER

Improving energy savings in supermarket refrigeration

WT9504_i5 03/21

Overview

Shaded pole induction motors are the most popular type of motor used in supermarkets' refrigerated cases, especially in small chains and large older supermarkets. This study looks at upgrading the shaded pole motors to electronically commutated (EC) motors and the resulting economic benefits.

With the support of a major supermarket chain, AoFrio recently conducted a controlled trial to assess the energy savings achieved by replacing older induction motors with modern high-efficiency electronic motors (Wellington™ ECR).

To do this, we replaced all the induction motors in one line of cases with our modern ECR 2 motor. We then compared this to the energy consumption from another line that was identically configured with the same temperatures, doors, defrost configuration, and product types, only it still had the old induction motors.

The result was that ECR 2 motors reduced energy usage by over 84% and delivered a return-on-investment (ROI) of less than one year.

How did we test these motors?

The test was performed on two lines of display cases used for the presentation of dairy products. Each line contained four cases with three motors in each unit, for a total of 12 motors per line.

Illustration 1: Photo of where we performed the comparison test.

To ensure a fair comparison, we used the same case models with the same type of products, and in the same position within the store. We were also careful to measure the exact speeds of the induction motors since shaded pole motors usually don't turn at their design speed in practice. With this information, we reprogramed the ECR 2 motors to match the same speeds. This reduced the possibility of generating any difference in airflow. Also, we applied the same fan blades as the induction motors. This enabled us to identify any significant difference in performance and attribute it to the ECR 2 motor.

For this test, we also installed a AoFrio™ SCS controller on each of the display case lines. This measured individual motor power consumption and allowed monitoring of the test. With the SCS controller's remote monitoring feature, we could check for potential problems, such as issues with a motor or refrigeration circuit on either line that would adversely affect the test results.

Why ECR 2 is the best motor for this test

In this test, we compared 10W induction motors against AoFrio's Wellington ECR 2 motor. The ECR 2 has many valuable features that differentiate it from other motors on the market and make it the most suitable product for this supermarket application.

Some of the most important benefits include:

- Efficiency of up to 70%, compared with about 20% efficiency of normal induction motors;
- Universal voltage, ie, can work at any voltage between 70 and 264V and 50/60Hz frequency, without any speed variation or additional equipment needed;
- Automatic speed control, which allows the motor to operate at a stable speed using impellers ranging from 100mm to the more common 200mm;
- Motor speed and direction programming, either at the OEM, or in the supermarket;
- The electronics architecture enables ECR 2 fan motors to have a much higher power factor than most competing EC fan motors;
- IP67 protection that guarantees against the entry of water and dust, which is a widespread issue in this application;
- Programmability, which enables a motor stock-keeping-unit (SKU) to meet the needs of all cases in the supermarket. This makes managing spare parts much easier for the supermarket and maintenance contractors.

Results: what we learned

This performance test compared the technologies and confirmed energy usage across a range of normal operating conditions for one month.

Over the trial period, the display cases fitted with the ECR 2 motors used 84.2% less power. The ECR 2 line consumed 54.4 kWh compared to 347kWh for the induction motor line.

Technology	Number of motors	Average power consumption (W)	Average power per motor (W)	Monthly energy consumption (kWh/month)
Induction motor	12	482	40.17	347
ECR 2 motor	12	76	6.33	54.4
Saving		406	33.84	292
Improvement	84.2%			

Table 1: Initial results by motor type and savings.

This difference in power consumption varies with the speed chosen for the ECR 2 motor, but this is representative of the operating conditions in a typical supermarket.

The graph here shows the energy consumption of both motors, and enables us to easily identify another advantage of the modern ECR 2 motors. The red line shows how the induction motor's power consumption and performance changed with minor changes in the voltage level. Because ECR 2 is a universal voltage motor, voltage variations do not affect its power consumption as much. There is also notably less variation of the motor's speed. Therefore, the ECR 2 has significantly more stable performance across varied operating conditions than induction motors. Another exciting aspect of applying ECR 2 motors is that they also generate much less heat. This is because they have much higher efficiency than induction motors.

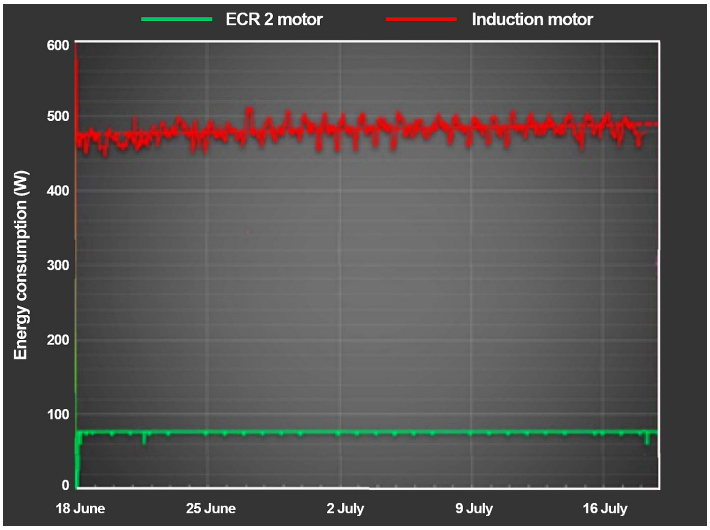

Illustration 2: Energy consumption of ECR 2 motor and induction motor.

ECR 2 motors are up to 70% efficient, depending on voltage and load. By comparison, the induction motors in this test are applying only 11% of their power for air displacement, and 89% is transformed into heat!

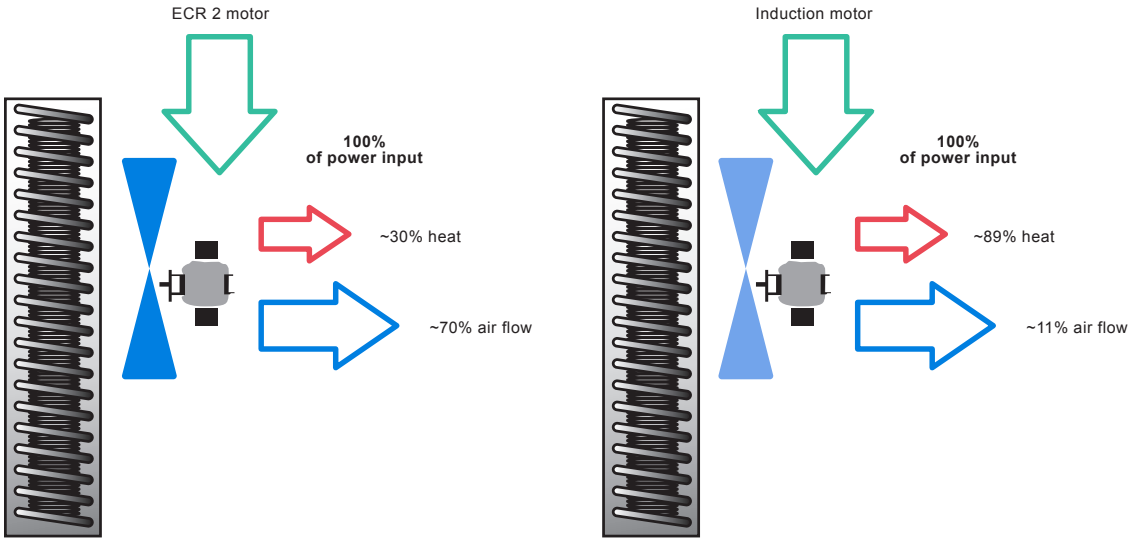

Illustration 3: Comparing the heat produced and air flow delivered by each motor type.

The supermarket where we performed the test had 213 induction motors. These generated an extensive amount of unnecessary heat, which the external cooling unit had to spend more energy removing.

The heat generated by these 213 motors inside the supermarket is shown below.

Total motors: 213
Amount of heat generated by 213 induction motors: (40.17 * 89% * 213) = 7.615 kW
Amount of heat generated by 213 ECR 2 motors: (6.33 * 30% * 213) = 0.414 kW

Therefore, the thermal load saved by replacing induction motors with ECR 2 is 7.21 kW (6,199 Kcal/hr or 24,601 BTU/hr).

Assuming a refrigeration system coefficient of performance (COP) of 4.0, this would require an additional 1.8kW of electrical power to remove from the system. This means ECR 2 motors saved over 9 kW of electricity.

How a motor update benefits an entire supermarket

Considering the similarities in a supermarket's refrigerated and frozen applications, and the differences in ECR 2 motor consumption versus induction motors, it is possible to extrapolate the reduction in energy consumption for a whole supermarket and a range of other store types.

Total potential energy savings for different store types

Technology	Savings per motor	Hypermarket	Supermarket	Neighborhood market	Convenience store
Approximate number of motors per store type	1	210	150	70	20
Direct energy saving (kWh/month)	24.3	5,115.6	3,654.0	1,705.2	487.2
Indirect energy saving (kWh/month)	6.1	1,278.9	913.5	426.3	121.8
Total energy saving (kWh/month)	**30.4**	**6,394.5**	**4,567.5**	**2,131.5**	**609**
Annual total energy saving (kWh/year)	**364.8**	**76,734**	**54,810**	**25,578**	**7,308**

Table 2: Potential energy savings by store type.

Note illustrative numbers only, results will vary per application.

Additionally, the low power consumption of ECR 2 fan motors and their very high power factor, can reduce the wiring costs and complexity in new build installations. Depending on the lighting power consumption of the cabinets, specifying ECR 2 motors allow up to 40% more cabinets to be connected to a single circuit. For more information on the high power factor of ECR 2 and how it benefits supermarket operators, see our white paper, **The importance of power factor in Wellington™ ECR 2 fan motors.**

What is the ROI by changing to ECR 2 motors?

If we consider the supermarket example from Table 2, the energy savings from switching from a shaded pole to an ECR 2 motor is 54,810 kWh per year.

Let us assume an ECR motor purchase price of USD$30.00, or, in our supermarket example with 150 motors a total purchase price of USD$4,500.

In the following table, we have applied the average cost of electricity in each of three regions, as of January 2021.

Country	USA	Europe	Mexico
Typical power cost	$0.105	€0.126	$1.75 pesos
Annual power saving per supermarket	54,810 kWh	54,810 kWh	54,810 kWh
Annual cost saving per supermarket	$5,755.05	€6,906.13	$95,918 pesos
Assumed motor cost	$4,500.00	€3,750.00	$90,966 pesos
Payback period to purchase motors based on energy savings	9.4 months	6.5 months	11.4 months
Potential cost savings over seven years, after motor purchase and assuming electricity cost is unchanged	$35,785.35	€44,592.91	$580,460 pesos

Table 3: Potential payback period and cost savings by region.

Note these calculations do not include the labor costs to install the ECR motors.

ROI summary

Table 3 shows significant energy cost reductions for supermarkets and other retailers that upgrade refrigeration and freezer motors from shaded pole to a AoFrio's Wellington ECR 2. These savings will be enhanced if the cost of energy increases.

Since each application is different, it is very difficult to predict the cost of the physical motor removal and installation. To obtain an accurate ROI based on your application, please contact your local AoFrio office so we can help you determine your return on investment.

With the new European energy regulations in place, and future US energy regulations on the horizon, Wellington ECR motors from AoFrio are a proven technology to help manufacturers and retailers meet even the most stringent performance standards.

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About AoFrio Limited:
AoFrio is a leading provider of IoT solutions, cloud-based fleet management platforms, energy-efficient electronic motors and connected refrigeration control solutions. It serves some of the world's leading food and beverage brands and refrigerator manufacturers and offers proximity-based marketing for Smart Cities to the Australian market. AoFrio's services and products improve sales, decrease costs and reduce energy consumption. Headquartered in Auckland with a global reach, AoFrio is listed on the New Zealand stock exchange under the ticker symbol NZ: AOF

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