# Advanced aerodynamics and retail refrigeration...

Walk into a supermarket or food outlet in any town, city, railway station or airport in the UK, and there is a strong chance you will see an Aerofoil on the front of each shelf in the refrigeration cabinets. We asked Paul McAndrew and the team at Aerofoil Energy to enlighten us.

### What is the Aerofoil and what is its application in the retail sector?

The Aerofoil is an aerodynamically-profiled aluminium blade that attaches to the shelves of open-fronted multi-deck fridges. The Aerofoil incorporates a profiled ticket strip and takes the place of the original price ticket rail. Multi-deck fridges employ a curtain of refrigerated air blown down across the open front of the shelves to help maintain the contents at a consistent target temperature. However, much of this cold 'air-curtain' spills out of the front of the cabinet and into the store aisles. Not only is this wasteful from an energy perspective, but it also causes 'cold-aisle syndrome' with a consequent negative impact on the customer. In simple terms, deploying Aerofoils on the edge of each shelf in the cabinet draws the cold air-curtain back into the fridge, thereby reducing spill, reducing energy consumption and improving aisle temperatures.

### How did you develop the concept of using Aerofoil technology?

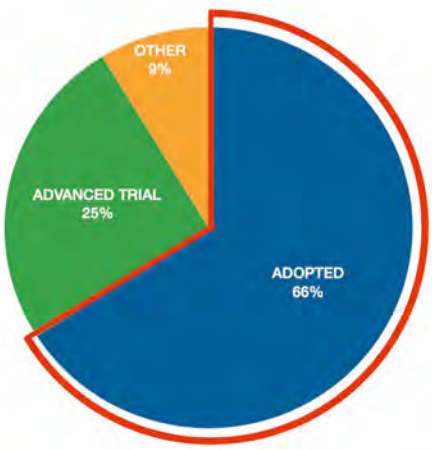
Before I developed the Aerofoil, I worked for a refrigeration manufacturer and then had my own fridge supply company. So I was acutely aware of the energy-intensive nature of open-fronted cabinets. It occurred to me that the problem was actually an aerodynamic one, whereby a wing shape could be used to steer an airflow in essentially the same way that it is used to create lift.

Admittedly, convincing anyone early on even to try this out was a challenge, though fortunately the first prototype delivered a surprisingly good result in laboratory trials. From then on, it was a question of refining the profile to maximise its aerodynamic properties in a multi-deck fridge application. We did this in partnership with Williams Advanced Engineering, part of the Williams Formula 1 group, who brought to bear their expertise in aero- and thermodynamic analysis and computational fluid dynamic (CFD) modelling.

We set up a new company in 2013, Aerofoil Energy, with the support of my co-founder, Dean Frost, and four 'angel' investors. Their initial capital, along with subsequent investments, has supported our product development, patent processing, and commercial growth since our formation. As of today, we have sold over one million Aerofoils, which have been installed in over 4,000 stores, in effect covering about 70% of the addressable market in the UK. Most of the top UK grocers have adopted our technology, including Tesco, Sainsbury's, ASDA, M&S and Co-op, as well as other major retail chains such as SSP, WH Smith and Boots.

### Why have so many UK grocers adopted the Aerofoil?

According to studies, the food retailing industry in the UK accounts for ca. 3% of the country's total electrical energy consumption. Of this, refrigeration can account for more than half of the energy costs of running supermarkets and convenience stores. Hence, there is significant scope for energy savings and associated $CO_2$ reductions by tackling inefficiencies in retailers' refrigerated estates. More specifically, the greatest energy consumption is seen in the compressors, and these are mainly working to support the chilled open multi-deck display cabinets. Other refrigeration cases, such as freezers, chilled counters and cold-rooms also use energy, but the open multi-deck is the chief consumer and tends to be the most common fridge you'll see in a supermarket or convenience store.



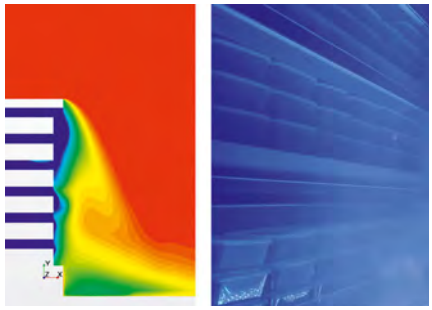

The designers of these cabinets are well aware of the need to improve their energy efficiency and devote a large amount of R&D resource into doing so. All the manufacturers have made large investments in test chambers that operate to the recognised design standard EN23953. Given this industry-wide effort, the Aerofoil has provided a timely, cost-effective and rapidly-deployable solution, and this is what has underpinned its success.

### What specific problems are you addressing with this technology?

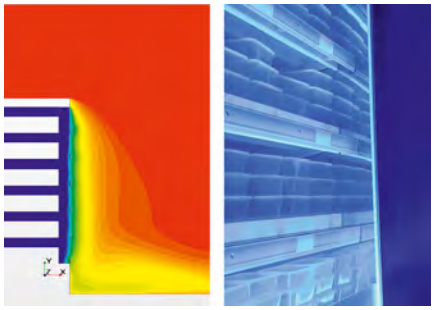
About 70% of the energy consumed by open-fronted fridges is for generating and maintaining the air-curtain – this is the cold air stream that is blown down across the front of the cabinet. Other components such as fans, lights, refrigerants, insulation or internal air-flow, account for the balance. Addressing inefficiencies in these components is more expensive and the electro-mechanical technology required typically cannot be retro-fitted to existing cabinets. Instead, therefore, it was more logical to focus on the area with the most potential for efficiency gains, i.e. improving the coherence of the air-curtain. In this regard, there are two phenomena that are responsible for high energy use. Firstly, cold-air spill, where the cold air-curtain escapes from the fridge and is lost into the shopping aisle. Secondly, infiltration, where warm air from outside the cabinet mixes with the cold air in the air-curtain.

With the help of CFD modelling, we can be even more specific with the diagnosis. For example, we can see that the spill effect mainly occurs from the front side of the air-curtain, and that this front side is further compromised by the infiltration effect because of its adjacency to warm air external to the cabinet. In contrast,

A typical Aerofoil installation, this one for M&S. Below left: How the technology has been adopted

CFD models show the break-down in a typical air-curtain before Aerofoils are fitted. Smoking the cabinet also shows cold air escaping



After Aerofoils are fitted to the shelves, the air-curtain is immediately straightened and more coherent in form, and very little if any cold air escapes from the cabinet.

the rear edge of the air-curtain is only exposed to the inside of the cabinet and, therefore, is relatively immune from spill and infiltration. So not only did we narrow down our focus to the air-curtain, but our analysis enabled us to focus specifically on its outer edge.

### How does the Aerofoil help to solve these problems?

In a perfect world, the air-curtain would maintain a strong linear pattern from its point of origin in the canopy of the cabinet to the base, where it returns via the fan system to the evaporator. However, in reality, while the air-curtain is strong at first, it quickly breaks up and loses its coherence by the time it reaches the base. CFD modelling and smoke tests highlight this issue.

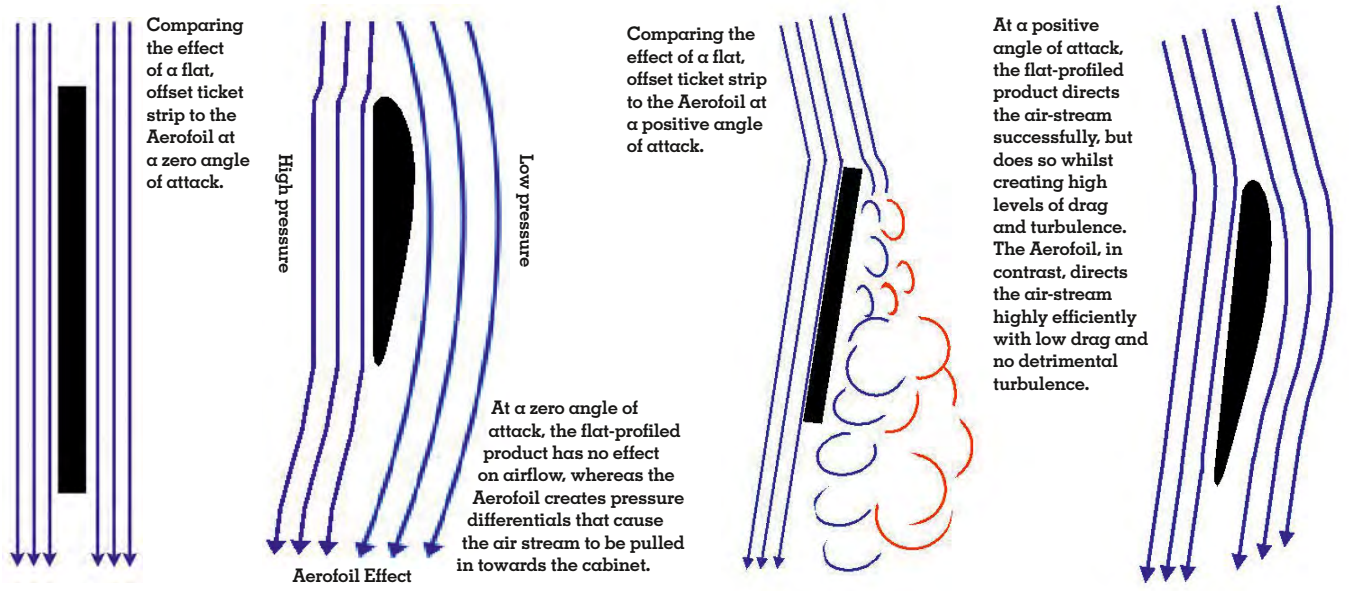
The most important feature of the Aerofoil is that it is, in a word, an aerofoil. From an aerodynamic perspective, it is most effective profile possible. As air flows across each side of an aerofoil, it has to travel a greater distance to traverse the curved, outer edge and therefore increases in speed. This results in air pressure differences either side of the aerofoil. When used in a horizontal plane, for example, in an aeronautical application these pressure differences create lift and, conversely, in motorsport they generate down-force. When we apply it in a vertical plane, i.e. on multi-deck shelves and blow air across its surfaces, the Aerofoil instead has the effect of steering the airflow and, by extension, maintaining the coherence of the air-curtain all the way down the front of the fridge. This effect can be seen clearly in CFD models and also with smoke tests. By controlling the air-curtain, preventing cold air spill and warm air ingress, Aerofoils address directly the key inefficiency in open-fronted multi-decks. In the real, working store environment, they are delivering energy savings of 15% to 25% depending on the store configuration and cabinet type.

### Does the Aerofoil have any other important features?

Absolutely, yes. As you move from the perfect world of CFD models, through laboratory trials and eventually into a real-world store environment, the Aerofoil has to do more than just control the air-curtain. For starters, it has to be robust – busy supermarkets are no friend of the flimsy, weak or wobbly! So we decided very early on to make the Aerofoil from a solid aluminium extrusion. Then there was the question of how to fit it to the shelf edge, and how to do this quickly. Having fitted over a million so far, an extra few seconds saved on each installation adds up to a lot of days, and therefore a lot of cost savings for the retailer. Our bracket designs are essential components to the Aerofoil system and have often been critical to the feasibility of a roll-out. For M&S, we created a snap-fit bracket that reduced installation time to, literally, seconds. Moving on to the actual function of the Aerofoil as a medium for pricing display, we designed the ticket strip and its interface with the Aerofoil in such a way as to make it completely waterproof. Supermarket staff spend a lot of time replacing price labels due to product spillage, condensation and other damage; our ticket strip provides much more protection in this regard.

### There is other shelf-edge technology available, so what is unique about the Aerofoil?

Only Aerofoil Energy can supply the Aerofoil product, i.e. a front-facing extrusion with a curved outer surface. The key difference between the Aerofoil profile and a




flat-profiled extrusion is the Aerofoil's ability to steer the air-curtain at a zero angle of attack. A flat-profiled extrusion, for example an offset ticket strip, simply cannot do this. If instead you fit the offset ticket strip at an angle to the air-curtain, the flat profile succeeds in bouncing the air stream, which might help with cold-air spill, but also creates turbulence, which drags in warm air from outside. In contrast, the Aerofoil can be fitted at a zero or positive angle of attack, and is able to control the air-curtain without creating turbulence. Hence, it works more effectively and delivers greater energy savings. This is what sets it apart from all other shelf-edge technology.

## Why don't retailers fit glass doors to improve energy performance?

Of course, the obvious solution to cold-air spill and warm-air ingress is to fit a glass door to the fridge to act as a physical barrier, and many grocers in mainland Europe have done so. Indeed, there is a growing lobby to mandate this for supermarkets in the UK. The media have, for example, cited comments from the public such as "I have a door on my fridge at home, so why not in a supermarket?" The reality is, as ever, more complex. Although glass doors do improve the energy consumption in comparison with a standard, open-fronted cabinet, their application in a busy, heavily-shopped supermarket or convenience store presents very real challenges. Firstly, unlike the fridge door in your kitchen, those in a retail environment are opened much more frequently, often once or more every minute. Every time it is opened, cold air escapes and warm air intrudes, rendering the cabinet less and less energy efficient. The actual, true extent of energy savings from glass doors is therefore much debated; the reality is that they are not as effective as people might believe.

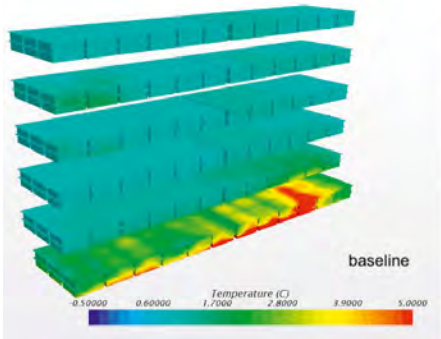
Aside from the question of their energy efficiency, glass doors are an expensive solution, especially so if they are retro-fitted to existing cabinets. Moreover, they need regular maintenance and cleaning to ensure that they remain hygienic and don't get jammed open (you'd be surprised how many suffer this fate). Glass doors also present a barrier to shoppers who are frail, partially-sighted or with disabilities; in the UK, retailers are particularly concerned about the customer journey and want to avoid undue inconvenience in this regard. In contrast, the Aerofoil presents no such barriers, which is another reason for its widespread adoption.

## Are there other benefits for retailers from installing Aerofoil technology?

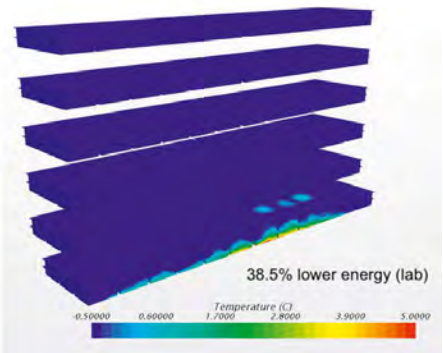
Yes, in addition to the energy savings, retro-fitting Aerofoils delivers other tangible benefits in terms of product temperature improvements and warmer shopping aisles.

Retailers require the food on chilled cabinet shelves to be maintained at temperature 3M0 or 3M1, as defined in standard EN23953:2, which in simple terms means that the coldest measuring pack must have a core temperature no lower than -1˚C and the core temperature of the warmest pack should be no higher than +4 ˚C(3M0) or +5˚C (3M1), when the ambient temperature in the test-room is 25˚C and the relative humidity 60%.

**Energy and temperature improvements resulting from the application of Aerofoil technology**

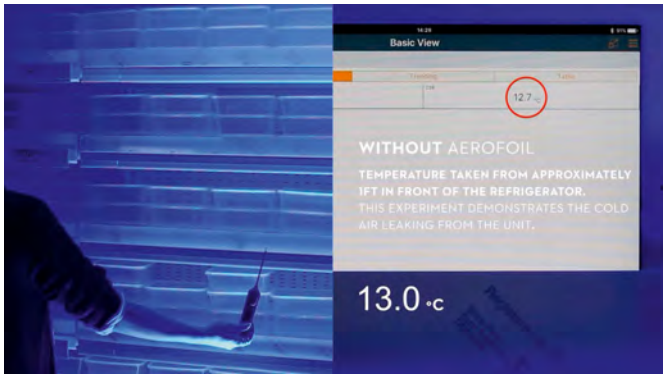


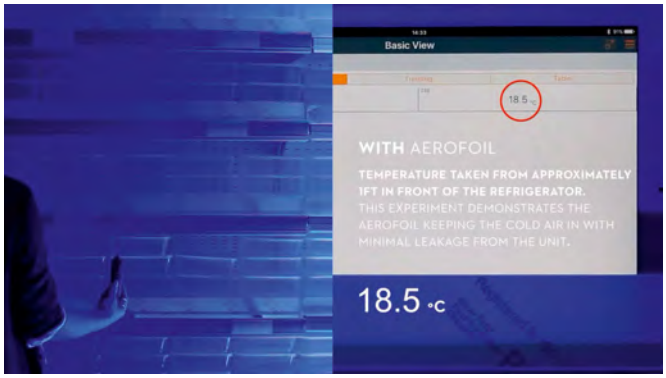

**Temperature range and gradients in a standard open-fronted multi-deck cabinet before Aerofoils are installed.**




**In addition to reducing energy consumption by nearly 40% (in lab conditions), fitting Aerofoils results in a narrower and lower range of product temperatures.**

**Temperature measurements taken in front of a cabinet before and after fitting Aerofoils**




In practice, a cabinet normally exhibits a range of product temperatures within these limits. When Aerofoils are fitted, the improved coherence of the air-curtain helps to narrow and lower this temperature range, so that the warmest pack temperature falls, typically by about 2˚C. This gives the retailer two options: either it can benefit from increased product quality and shelf-life by virtue of the lower product temperatures; or it can return product temperatures to their original levels, if acceptable, by adjusting the control set-point and thereby reducing the energy consumption of the cabinet still further.

Preventing cold-air spill has the direct, knock-on effect of increasing the aisle temperature outside the cabinet. In fact, most of the feedback we have received from store staff and shoppers highlights the more comfortable environment rather than commenting on the Aerofoils per se. Browsing time is an important determinant of sales for supermarkets, so this improvement in aisle temperature is likely to be having a beneficial impact on both.

As well as retro-fitting Aerofoils to their existing estates, many clients have specified Aerofoils to be installed on new cabinets. This presents a further opportunity for savings, because the cabinets can utilise lower-duty, less expensive compressors. In turn, this requires lower-cost, smaller plant, and the electrical supply into the plant-room and into the store can also be down-rated. These savings on reduced plant duty costs can easily outweigh the cost of the Aerofoils themselves, rendering them a cost-negative option on new-build refrigeration; a bit of a no-brainer really.

Finally, we as a company are also attuned to our own environmental impact and the sustainability of our own operations. All of our Aerofoils are made from 100% recycled aluminium, a product which itself requires only 5% of the energy that would otherwise be consumed in producing new metal. This has been an important criterion for the retailers in choosing Aerofoils, as well as the fact that virtually all of our components are fully recyclable in their own right.

### You've clearly had a huge impact in the UK; what next?

It's true that most of the major UK grocers and convenience chains have already adopted Aerofoil technology. So we are now in advanced trials with the largest retailers worldwide, in particular in North America. What is interesting is the different emphases that these retailers place on the relative benefits of energy vs. product life vs. customer journey, driven by internal considerations such as their own retail model, as well as external factors the most obvious being local energy prices.

But we haven't stopped at just Aerofoils. In 2017, we assembled a team of highly-skilled practitioners with over 150 years of combined expertise in the refrigeration industry and engineering sector. This team has been working on our Vortex technology programme in conjunction with our technical partner, Williams Advanced Engineering. Our Vortex programme has developed several new technical innovations that complement the Aerofoil product and enhance the energy and thermodynamic performance of multi-deck cabinets. These include, for example, enhancements throughout a cabinet's circuit, evaporator and fan system. Our goal is to offer technology, both for retro-fitting and new-build, that renders an open-fronted fridge as energy efficient as one with a glass door. We are already testing this with some of our clients and the results are exciting. Watch this space!

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