Technical Advice Paper

Heatstar
Energy Technology Systems

Swimming Pool Environmental Control

What is ‘Heat Recovery’

A closer look at this 'hot topic', the Technical Team at Heatstar set out to explain the basic principles of Heat Recovery and to broaden knowledge and appreciation of the key considerations.

WHAT IS 'HEAT RECOVERY'?

With the latest building regulations now stipulating minimum permissible efficiency for heat recovery, this has now become the latest 'hot topic' and has been the focus of many recent trade enquires for further information.

In response, the Technical Team at Heatstar has prepared this Advice Paper which sets out to explain the basic principles of the topic and to broaden knowledge and appreciation of the key considerations.

So what is 'Heat Recovery'?

In respect of building regulations, the focus is solely upon how much heat will be lost through exhausting some of the warm room air to atmosphere, whilst replacing this warm air with colder outside fresh air.

The term 'Heat Recovery' relates exclusively to how much of the heat which would otherwise be lost through this process, can be saved and re-used.

Why exhaust any warm pool room air to outside?

Generally, the replacement of room air with outside fresh air is associated with maintaining air quality, diluting any gasses / odours associated with chemical processes, and avoiding a potentially 'stale' environment.

Exhausting room air is typically used as the means to create a 'negative' air pressure within the pool room to limit air migrating into other areas and to discourage vapour from being forced into the building structure.

Whilst the majority of modern climate control systems primarily 're-circulate' the pool room air to limit unnecessary loss of heat, some systems still rely upon the introduction of drier fresh air as the only method of humidity control.

The amount of fresh air ventilation which requires to be deliberately introduced varies depending upon the nature of the application : A small lightly used domestic pool using a pool surface cover will require only minimal fresh air ventilation, a large commercial pool with high levels of usage will require a much higher rate of fresh air ventilation.

How is 'Heat Recovery Efficiency' expressed?

The term 'heat recovery efficiency' is usually expressed as a percentage. For example, if all of the heat contained within the exhausted room air can be 'saved', then that would be 100% efficiency.

Where heat recovery is applied, latest building regulations stipulate a minimum heat recovery efficiency of 70% for domestic pool applications. This simply means that at least 70% of the heat which would otherwise be thrown away and lost needs to be saved. Table 1, attached, applies simple example temperatures to this.

The tables shown on page 6 apply simple example temperatures to this.

What is the Minimum 'Heat Recovery Efficiency' necessary to comply with current Building Regulations?

For domestic applications, it is not stipulated that any heat recovery at all from the room air exhausted to outside has to be provided. This is in consideration of the practicalities of applying such a regulation to simple toilet and bathroom extract fans etc.

However, if heat recovery is being offered / installed, it must then achieve a minimum 'dry' efficiency of at least 70%. For all new non-domestic applications, it is now compulsory to offer / install heat recovery without exception and that it must achieve a minimum dry efficiency of at least 50%.

How a device is rated must also comply with the standards set out in BS EN 308:1997

Cautionary Note: Ask for a Compliance Certificate, which any supplier should have immediately available. If it is not, then be duly suspicious.

What is meant by 'Dry' heat recovery efficiency?

Building regulations stipulate minimum 'dry' heat recovery efficiencies.

Most heat recovery devices will result in the formation of condensation as warm air is brought into contact with cold surfaces as part of the process. As airborne moisture condenses to cold water, some latent energy will be released from the moisture and absorbed into heat recovery device, thereby supplementing the overall efficiency of the heat extraction process. The proportion of latent energy compared to the total energy extracted increases within higher humidity environments like indoor pools.

The latent energy proportion is more challenging to accurately measure and, accordingly, building regulations appear to have intentionally avoided any uncertainty in this regard by insisting that heat recovery devices are assessed simply upon the 'dry' efficiency achieved.

This simplification ensures that compliance to building regulations can be easily confirmed and enforced just by measuring and comparing the respective temperatures of the air in the pool room, the air exhausted to outside and the temperature of the outside fresh air.

Cautionary Note : If any supplier makes reference to reliance upon 'latent' heat recovered in order to achieve compliance, this is excluded for building regulations and may relate to a compliance issue.

Different methods of Heat Recovery

We will look here at the most common methods applied for indoor swimming pools. As Heatstar offer all types of systems, we are well placed to assess the respective benefits of the various approaches

Example 1:

'Active' exhaust air heat extraction via a dehumidifier 'cold' coil

Here any warm room air that is to be exhausted to outside is first passed through the dehumidifier 'cold' coil, where both dry heat and latent energy from the contained moisture is extracted and absorbed into the dehumidifier. The dehumidifier can then use the heat pump principle to deliver the extracted heat back into the pool room air or also possibly the pool water.

Therefore, the dehumidification 'cold' coil effectively has a dual purpose, to dehumidify the re-circulated room air and to also extract heat from any room air which is subsequently to be exhausted to atmosphere.

Typical Heat Recovery performance:

Air in pool room -	30°C	(A)
Outside fresh air -	4°C	(B)
Initial temperature difference between Air in Room and outside fresh air -	26°C	
After application of 'active' heat recovery		
Room air leaving building -	22.7°C	(C)
Fresh air entering building -	11.3°C *	(D)
Heat recovery achieved -	28.1% 'dry' efficiency	

* assumes extracted heat is returned into air. Compressor motor power consumed excluded.

It will be immediately obvious that the achieved heat recovery rate described above is not particularly impressive and is nowhere near meeting the minimum requirements of building regulations.

This is because the actual quantity of heat which the dehumidification coil can 'extract' from the room air to be exhausted is broadly fixed and consistent all year and is generally not affected or influenced by the outside fresh air temperature.

Therefore, in terms of the actual 'percentage' of heat being extracted from the exhaust air compared to the amount of heat being lost through the simultaneous introduction of outside fresh air, this understandably diminishes as the fresh air becomes progressively colder during the winter months.

Accordingly, with the room air leaving the building still at a comparatively warm 22°C, and with no ability to increase the heat saving rate when the outside fresh air temperature becomes colder during the winter months, the heat recovery efficiency is understandably compromised.

To demonstrate how far away from the required standard we are with this approach, for this type of system to achieve the minimum 70% efficiency at an ambient fresh air temperature of 0°C, with a pool room temperature of 30°C, any exhausted air would have to leave the building at a temperature no more than 9°C, which is all but impossible.

The situation is not addressed even if the 'wet' latent energy content is also added in. That would increase the overall heat recovery efficiency to around 44%, but that is all.

Such a system would only be able to demonstrate a true 70% 'dry' heat recovery efficiency during warmer summer weather when it is not particularly relevant or useful.

It is also important to remember that, if the dehumidification system is not being called upon to operate because the pool room humidity is at a satisfactory level, then there will be no heat recovery at all on any exhausted air during such times.

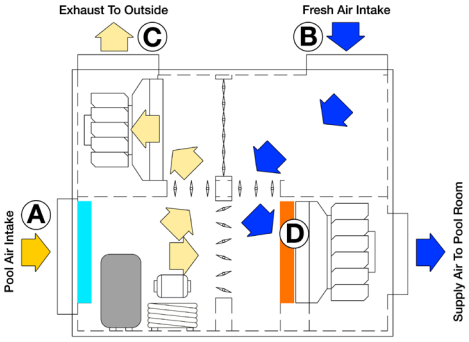
Why is it called 'active'?

This type of system is described as 'active', because the dehumidification coil system needs to be driven by a refrigeration compressor electric motor, which actively pumps a refrigerant around the coil circuits to achieve the cooling and heat re-introduction processes.

In order for this type of system to genuinely comply with minimum building control standards for a genuine heat recovery system, it would be necessary to install an additional heat recovery device, like a large plate recuperator, within the exhaust and fresh air duct work.

Dehumidification process efficiency - an unrelated subject

An efficiency rating quoted for the dehumidification process using a refrigeration system, which could be as high as 300 to 400%, relates to an entirely different and unrelated subject and should never be confused with efficiencies relating to 'heat saved from the exhausted air / fresh air replacement process'.



Example shown: Heatstar Hydrus

The dehumidification efficiency simply relates to how much heat is being put back into the re-circulated room air in comparison to how much energy is consumed by operating the compressor motor. Bear in mind that nearly three quarters of any re-introduced heat is either being sourced from the electricity input driving the compressor motor or has already been 'borrowed' from the warm pool room air.

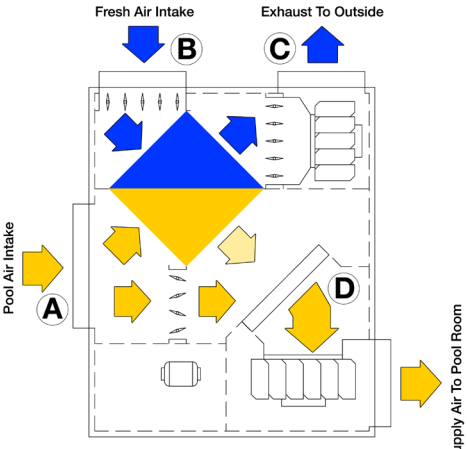
Accordingly, such a system could be described as being 100% efficient even if the dehumidifier is switched off, as no heat is being taken out or added as the room air is re-circulated through the unit.

Cautionary Note: If a supplier appears to be trying to 'fudge' the difference between these two obviously separate considerations - they may be trying to conceal a compliance issue!

DID YOU KNOW ?

Heatstar have been producing modern format packaged environmental control units longer than any other company and were amongst the first to become involved in this specialist field.
This experience is evident throughout the product range.

Example 2:
'Passive' heat recovery via a plate air-to-air recuperator



Example shown: Heatstar Phoenix XF EC

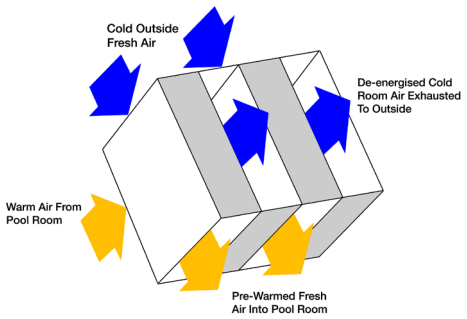
This is an older format of heat recovery which has been in use for decades. It is a comparatively simple and basic device, but remains relevant and effective today.

Here the warm room air that is to be exhausted to outside is first blown through a plate heat recuperator by the action of the 'exhaust air fan'.

The process involves the warm room air being diverted and passed through as many as 40 different channels within the recuperator as it is being routed to atmosphere.

At the same time, an equivalent quantity of fresh air is also sucked through the recuperator, usually by the main ventilation fan, but the fresh air is passed through a different set of channels which are immediately adjacent to those of the room air. The two opposing air streams do not mix but are separated by just a single metal plate which acts as a partition.

With one side of the plate cold and the other side warm, heat will naturally transfer from the warm side to the cold side, therefore a percentage of the heat contained within the warm room air, which would otherwise be lost and thrown away, is transferred to the incoming fresh air and is saved.



It is not dissimilar in principle to water to water plate heat exchangers, which are known for their comparatively high efficiency.

As the outside fresh air becomes colder, the 'quantity' of heat that can be transferred from the outgoing warm air actually increases, because the 'temperature difference' between the warm side of the plate and the cold side is naturally increased.

Therefore, the heat recovery efficiency percentage is always achievable and consistent, even when the outside air temperature is cold during the winter months.

Typical Heat Recovery performance:

Air in pool room -	30°C	(A)
Outside fresh air -	4°C	(B)
Initial temperature difference between Air in Room and outside fresh air -	26°C	
After application of 'passive' heat recovery		
Room air leaving building -	11.8°C	(C)
Fresh air entering building -	22.2°C	(D)
Heat recovery achieved -	70% 'dry' efficiency	

This type of system is able to comply with minimum building control standards for a heat recovery system and would do so all year.

However, a plate recuperator must be of sufficiently large physically size in relation to the air flow involved in order to achieve the required efficiency. If the recuperator is too small, the efficiency will be accordingly less.

Cautionary Note: Old style plastic type recuperator units may claim broad efficiencies 'up to 70%'. Even if this rating were at all realistic, this still is not sufficient to meet minimum domestic building regulation requirements. Because it is very easy for it to be checked on-site, a product which has an exaggerated heat recovery efficiency claim is likely to give rise to a potential issue.

Why is it called 'passive'?

A plate recuperator has no moving parts and consumes no power in order to function - it merely relies upon air being passed through it. Therefore, it is referred to as a 'passive' method of heat recovery.

Compliance and enforcement

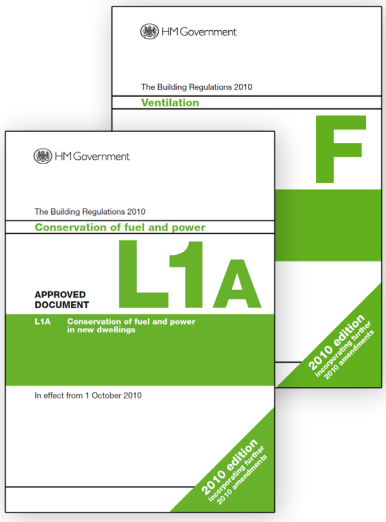
We have now encountered scenarios whereby non-complying equipment has been rejected from site. Needless to say, this has the potential to be awkward, embarrassing and very costly.

Appreciating that this may appear heavy on the 'scaremongering', in balance, we would also add that, perhaps surprisingly, Local Authority building control officers do not appear that pro-active in policing these regulations - as yet, at least.

However, specialist consultants are being increasingly employed on projects to scrutinise the heating & ventilation systems to ensure compliance, particularly on 'top end' or commercial applications. We have also witnessed indepth scrutiny from some end clients, who obviously expect a legally compliant design from their contractor.

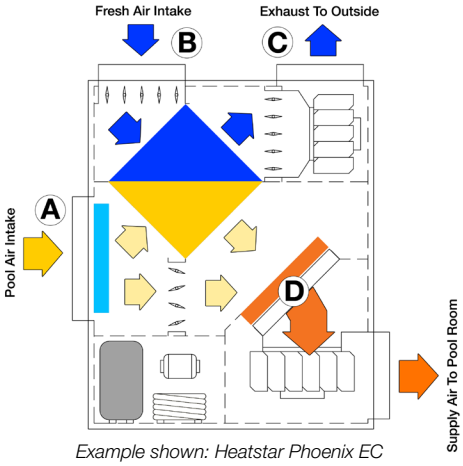
No one would ignore the obvious requirement to adhere to building regulations for thermal insulation of the building structure and, likewise, there can be no excuse for not being equally diligent with the building regulations applicable to indoor pool ventilation design.

Cautionary Note: Because of the clear and un-ambiguous wording of the regulation, and the intentional exclusion of anything other than 'dry' heat recovery, it is very easy for someone to 'test' an installed system for compliance,simply by measuring the various temperatures.



To download full copies of all current building control regulations visit **www.planningportal.gov.uk** *or*

Example 2:
Hybrid heat recovery utilising both 'active' and 'passive' methods



Example shown: Heatstar Phoenix EC

Here any warm room air that is to be exhausted to outside is first passed through the dehumidifier 'cold' coil, where both dry heat and latent energy from the contained moisture is extracted and absorbed into the dehumidifier.

The principle is the same as previously described with the active exhaust air dehumidification coil.

However, the difference here is that the air which has already had heat extracted by the dehumidification system is not simply exhausted to outside but is subjected to a second further process of heat recovery by being passed through a plate recuperator.

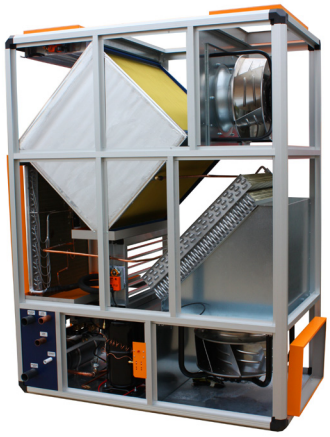
Typical Heat Recovery performance:

Air in pool room -	30°C	(A)
Outside fresh air -	4°C	(B)
Initial temperature difference between Air in Room and outside fresh air -	26°C	
After application of 'active' heat recovery Room air leaving building -	22.7°C	
After application of 'passive' heat recovery Room air leaving building -	9.7°C	(C)
Fresh air entering building -	24.3°C *	(D)
Heat recovery achieved -	78% 'dry' efficiency	

* assumes extracted heat is returned into air. Compressor motor power consumed excluded.

This type of system is able to comply with minimum building control standards for a heat recovery system and would do so all year. If the latent energy aspect is also included then an overall efficiency of 105% is possible.

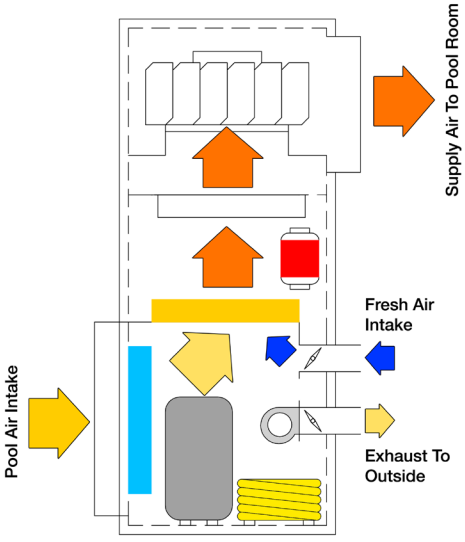
As previously described, the passive heat extraction possible through the recuperator is actually increased as the outside fresh air becomes colder, so the heat recovery efficiency percentage is always achievable and consistent, even when the outside air temperature is cold during the winter months.



A Heatstar Phoenix EC unit, equipped with large air-to-air plate recuperator, refrigeration dehumidification system and intelligent EC fans.

The Phoenix EC is able to out perform all alternative equipment formats becuase it combines these two different technologies to achieve unrivalled heat recovery performance.

Example 4:
Exhaust / fresh air port arrangements



Example shown: Heatstar Andromeda EC

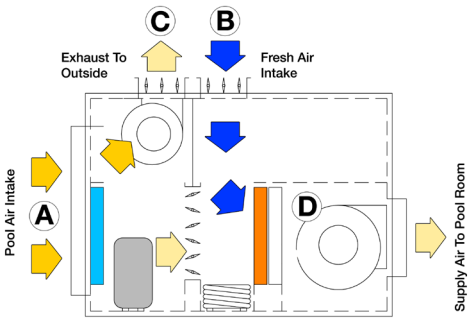
This is typical of a unit which primarily re-circulates the pool room air, utilising a refrigeration dehumidifier, and provides a comparatively limited amount of ventilation with fresh air for dilution purposes.

If the exhaust air is removed after the air has already passed through the dehumidifier cold coil, then heat extraction from the exhaust air will be similar to Example 1.

However, once again, if the dehumidification system is not being called upon to operate because the pool room humidity is at a satisfactory level, then there will be no heat recovery at all on any exhausted air during such times.

Be aware that some types of this format product extract the exhaust air prior to the dehumidification cold coil, preventing any possibility of heat recovert at any time.

Example 5:
By-pass exhaust air



Example shown: Generic

Here the warm room air that is to be exhausted to outside is simply passed above the dehumidifier coils and straight to outside. There is no heat recovery and no heat is saved. Although obviously wasteful, this approach remains not-uncommon.

Cautionary Note: To assess the general format of the heat recovery being provided, it is probably unwise to rely too heavily upon generalised drawn schematics within promotional literature. If in doubt - a simple look inside an actual unit would normally be sufficient to appreciate what is, or is not, genuinely going on in terms of the approach to heat recovery

DID YOU KNOW ?

Heatstar only manufacture dedicated equipment for swimming pools and all products are designed and manufactured solely in the UK.
With Heatstar you know what you are getting and where it is originating from.
If it's Heatstar, it's British.

Comparative temperature data for different heat recovery efficiencies

Table '1A': 0% Heat Recovery

Assuming the pool room air is at 30°C and the fresh air is at a typical winter condition of 4°C:

Air in pool room -	30°C
Outside fresh air -	4°C
Initial temperature difference between Air in Room and outside fresh air -	26°C
After application of heat recovery:	
Room air leaving building -	17°C
Fresh air entering building -	17°C
Heat recovery achieved -	0% efficiency

If the air leaves the building still at 30°C, and the fresh air entering the building is still at 4°C, then that would be considered, obviously, as 0% heat recovery, as no heat is saved.

Table '1B': 50% Heat Recovery

If half (50%) the heat which would otherwise be thrown away is saved, then that would be represented as follows:

Air in pool room -	30°C
Outside fresh air -	4°C
Initial temperature difference between Air in Room and outside fresh air -	26°C
After application of heat recovery:	
Room air leaving building -	17°C (30°C minus half or 50% of 26°C)
Fresh air entering building -	17°C (4°C minus half or 50% of 26°C)
Heat recovery achieved -	50% efficiency

Table '1C': 70% Heat Recovery

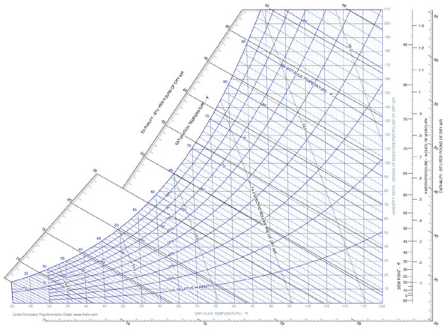
If, in line with building regulations for domestic pools, 70% of the heat which would otherwise be thrown away needs to be saved, then that would be represented as follows:

Air in pool room -	30°C
Outside fresh air -	4°C
Initial temperature difference between Air in Room and outside fresh air -	26°C
After application of heat recovery:	
Room air leaving building -	11.8°C (30°C minus '70%' of 26°C)
Fresh air entering building -	22.2°C (4°C plus '70%' of 26°C)
Heat recovery achieved -	70% efficiency

Psychrometric Charts

Psychrometric charts, although comparatively complex in appearance, are a useful reference tool for design engineers and offer information relating to the ability of air to support water vapour at differing conditions.

Cautionary note: Appreciating that the various detailed and complicated functions of a psychrometric chart are unlikely to be broadly understood, the chart is renowned as an effective 'sales tool', applied where there is deemed an advantage to be gained by intentionally 'baffling' people!



Example of a Psychrometric Chart

In truth, rarely would those applying climate control products need to utilise such information. If anyone would like to learn more about the genuine function of psychrometric charts, the Technical Team at Heatstar would be happy to provide some basic tutorials.

Summary

Despite current building regulations being applicable to all new projects first applying for planning after October 2010, some suppliers of climate control systems have been slow to respond in bringing complying products, together with the necessary support data, to the market.

It is initially important to clarify if a particular product for an application is intended to provide 'heat recovery' from the air exhausted to outside. If not, then there is flexibility for domestic applications to offer such a system as not intending to provide heat recovery. There is no such leeway for non-domestic applications.

From the basic information provided here, if there is an intention to provide genuine 'heat recovery' it can be appreciated that the exhaust air temperature leaving the building is a simple and unambiguous point of reference.

It can be easily be calculated that, in order to have recovered at least 70% of heat from the exhausted air, if the room air is 30°C, the outside fresh air is 0°C, the exhaust air temperature can be no greater than 9°C - it is that simple!

Equally relevant is the period of time when the 'heat recovery' device is switched on - if it is a refrigeration dehumidification coil, that will only be functioning when there is a demand for humidity reduction which, on a domestic pool, may be infrequent.

We hope that the information provided here will enable a broader appreciation of some of the considerations involved in this important topic.

For further information or details, please contact Heatstar Technical Team:

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CASE STUDY

Portrait Pools win energy award with special custom Heatstar System

Whilst Portrait Pools are certainly no strangers to winning awards for their 'top end' luxury indoor pool creations, 2013 marked their first SPATA Gold award for Sustainability, reflecting their commitment to offering their clients market-leading energy efficiency as well as breathtaking beauty.

This award winning luxury 16 metre x 4.2 metre pool is part of a converted farm in Cheshire. It has a constant water depth of 1.35 metres with one set of walk in steps and includes a powerful counter current unit. Finished with Ocean & Cuarzo pearlescent glass mosaics this beautiful pool also has a bespoke spa pool which seats 4/5 people and incorporates a fully tiled finish to match the main pool. The pool hall complements the pool with a stretch ceiling system to pool hall, gym and oak inserts. This includes a constant light box to the feature wall plus a ceiling wrap to form a light pelmet along the tiled feature wall in the pool hall.

This is wrapped in stretch ceiling material to match the main ceiling, highlighted by the colour changing LED lighting system - all installed by the Portrait team

Due to the unusual demands of the project, a custom manufactured Heatstar Phoenix climate control system was required, featuring a special 'quadruple' stage air heating battery and up-rated air fan system.

These special adaptions were necessary due to the available primary heating water circuit offering a design temperature of only 47°C, compared to a typical 80°C.

As the heat source was to be 2 off 22kW fresh air source 'domestic' heat pump boilers, as opposed to conventional fuel boilers, the low heating circuit temperature was necessary to ensure the heat pumps were able to operate with their high efficiency potential uncompromised.

With the pool room still requiring to be maintained at 30°C, the design of the Heatstar ensured that effective heating was still achieved, despite just 17°C of temperature difference.

The special air heating battery and the up-rated room air re-circulation flow rate enabled the necessary quantity of heat in kW to be 'delivered' into the project, despite the reduced circuit temperatures.

Commenting on both design and function the client summed up the finished nstallation by saying "The team from Portrait constructed our indoor swimming pool with tremendous attention to detail and we have ended up with a dream facility which we use every day."

To view this and other case studies visit our new website at www.heatstar.com

Contact Heatstar for detailed specifications and a full analysis of your heating and environmental control requirements.