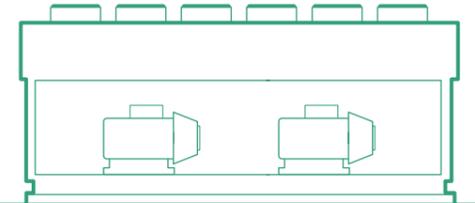




EcoDesign Directive

Minimum Energy Efficiency Standards for Refrigeration Systems



How does the new legislation affect chiller efficiency?

For the last six years, the European Commission (EC) has been consulting with the industrial refrigeration industry to establish EU-wide rules for minimum energy efficiency and labelling requirements for refrigeration and cooling products. The regulation sets requirements for minimum efficiency performance standards (MEPS).

Fundamentally, the new efficiency requirements will allow refrigeration end users to easily compare chiller efficiency performance by looking at two well-defined and straightforward set of figures based on the Minimum Energy Performance Standards (MEPS) requirement established by the directive: the Seasonal Energy Performance Ratio (SEPR) for industrial process chillers and Seasonal Space Cooling Energy Efficiency for comfort cooling chillers.

This set of data required by the EcoDesign Directive is expected to supersede other energy efficiency indices in Europe, such as Eurovent's European Seasonal Energy Efficiency Ratio (ESEER), and the Carbon Trust's Energy Technology List (ETL), which have been criticised for relying on ideal laboratory conditions to test energy performance, leading to a lack of real world data.

It is expected that through the use of standardised, reliable and application-based energy performance ratios, users will be able to make better and more informed decisions, which take into account 75% of the total life cycle costs as opposed to focusing on capital costs alone. Energy consumed during refrigeration plant operation normally amounts to 60% of the plant's total life cycle cost, with only a further 15% attributed to initial capital investment. The remaining 20 - 25% is accounted for by maintenance and aftercare.

The EcoDesign Directive will have a great impact on cutting carbon emissions and has the potential to save end-users millions of pounds on energy bills.

The Directive encompasses all electrical appliances which are going into the market place.

EcoDesign Directive and chiller application ranges

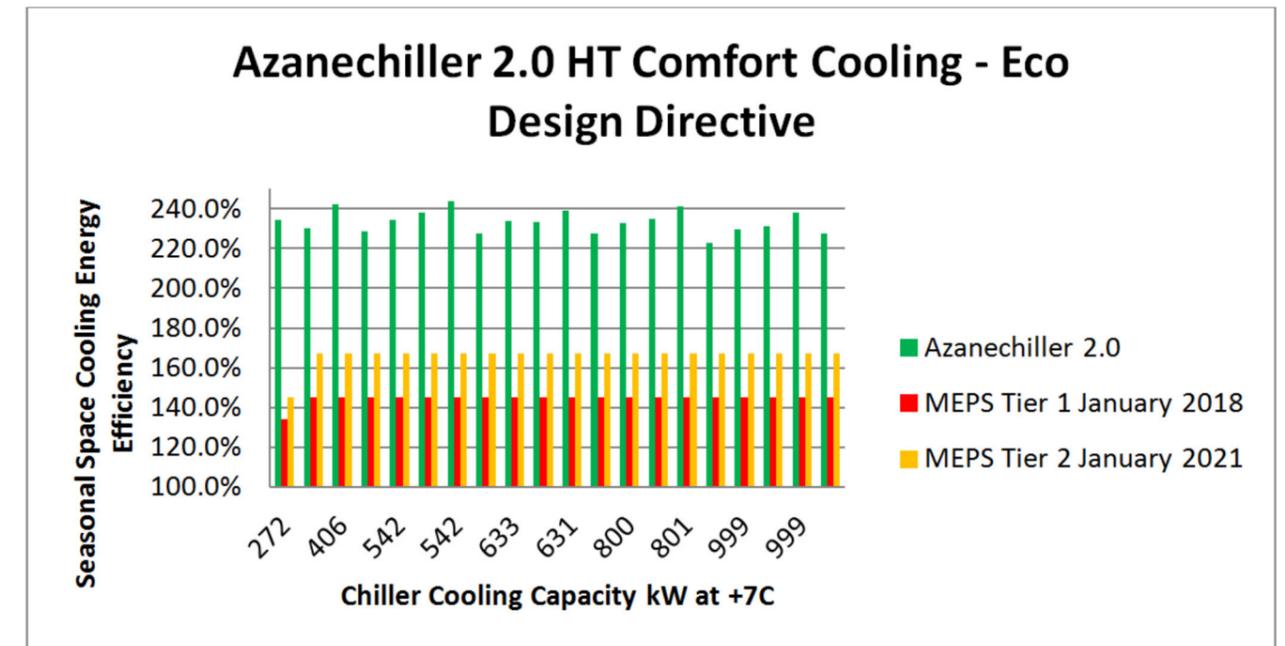
Under the EcoDesign Directive (2009/125/EC), the European Parliament set a framework for development of minimum requirements for the energy and environmental performance of energy-using products (EuP) and energy-related products (ErP) throughout their life-cycle.

In terms of cooling and heating products, the decision to act came after the EC identified the "high potential" for energy savings that refrigeration equipment had due to its high energy consumption and long operating times. To illustrate, recent research carried out by the Carbon Trust showed that over 90% of the energy costs in the Cold Storage sector can be attributed to refrigeration. In process cooling for example, over 50% of electrical spend for cooling would not be unusual.

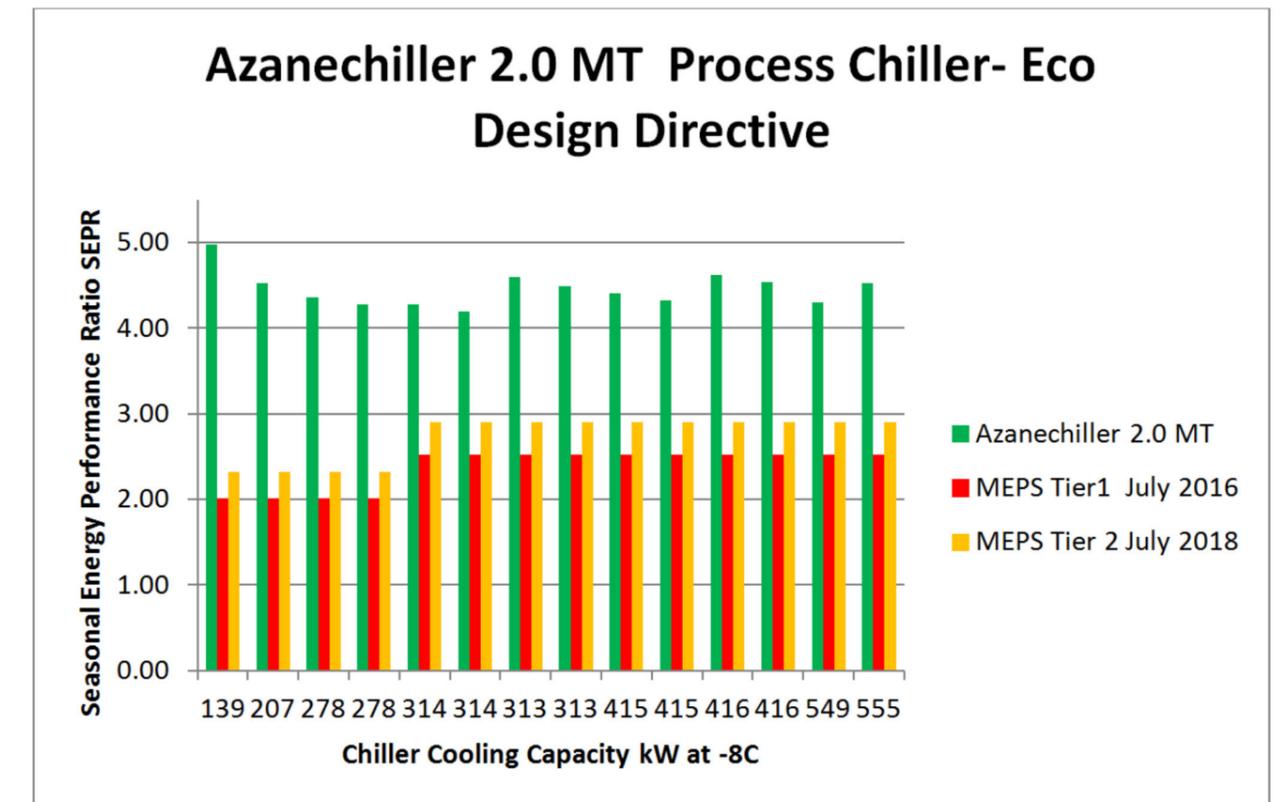
The EcoDesign and Energy Labelling Directives provide end users with clear information that allows them to choose more efficient products.

It also allows them to increase energy efficiency and, therefore, the level of protection of the environment; and finally, to ensure the free movement of energy-related products in the European Union.

The actual minimum energy and performance requirements of the Directive for EuP and ErP were developed for each specific product group – depending on application – instead of the previous one size-fits-all approach, which led to buyer's confusion when chiller performance data was used to compare and measure efficiency of refrigeration systems for applications they were not originally built for or for ambient conditions not relevant to their particular location. For example, the regulations now define separate chiller utilisation rates in recognition of the fact that a process chiller is much more likely to operate at higher load in lower ambient conditions than a comfort chiller.



For the high temperature (HT) process chillers operating with water temperatures of +7°C off, the metric used is the SEPR. The graph below shows the range of HT process chillers which have a minimum efficiency performance standard of between 4.5 and 5, introduced from January 2018. Star Refrigeration's ammonia chillers exceed this benchmark also by a wide margin, with the best unit being above 8.00, against a standard of 5.00.

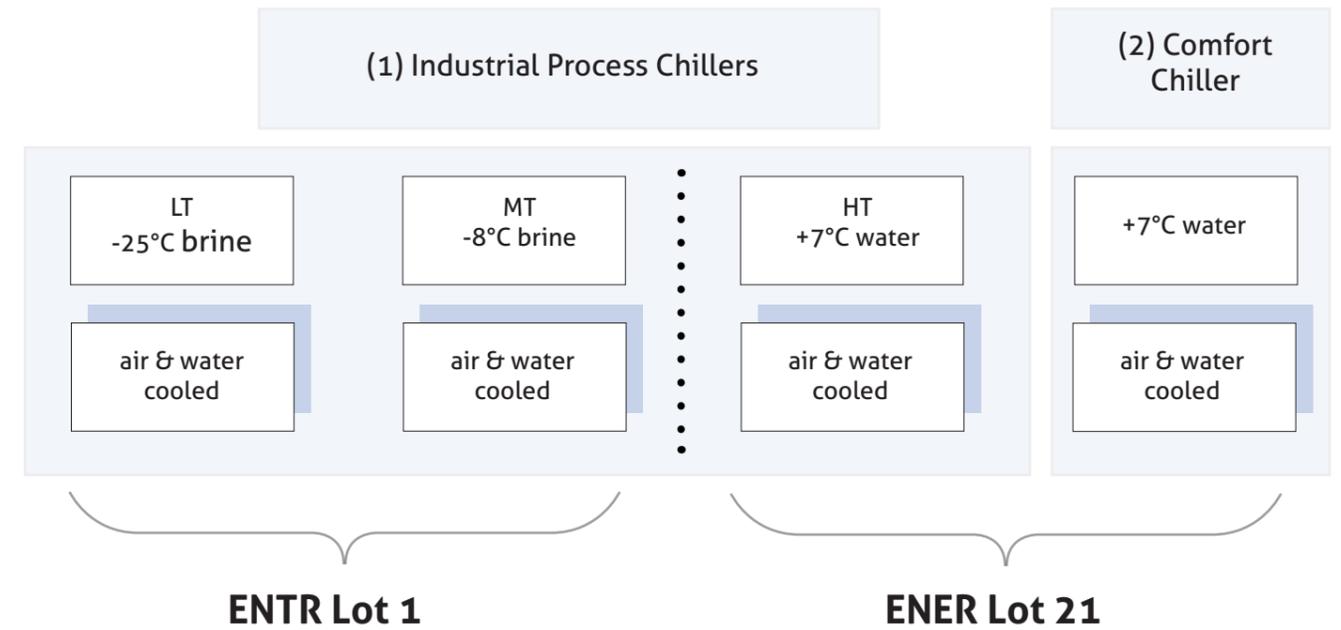


For low temperature (LT) and medium temperature (MT) process chillers with a nominal design glycol off-temperature of -25°C and -8°C respectively, the metric used to measure efficiency is the Seasonal Energy Performance Ratio (SEPR). The minimum efficiency performance standard being introduced from July 2016 is between 2.02 and 2.52 for MT process chillers accounting for the bonus applied where the refrigerant has GWP < 150. The first Star MT process chiller manufactured for 415kW has an SEPR 71% higher than the standard.



With the introduction of the EcoDesign Directive, the different product categories are separated into groups called LOTS. The key issues and legislation that affect industrial refrigeration end-users are collected in two product groups, referred to as ENTR Lot 1 (Refrigeration and Freezing equipment, in particular Medium Temperature (MT) and Low Temperature (LT) process chillers and condensing units) and ENER Lot 21 (High Temperature (HT) process chillers and comfort cooling (HVAC)).

ErP related Chiller



A process chiller is defined as a product consisting of at least one compressor and evaporator capable of cooling down and continuously maintaining the temperature of a liquid in order to provide cooling to a refrigerated appliance or system. It may or may not integrate the condenser, coolant circuit hardware and other ancillary equipment. The Directive does not, however, apply to custom made chillers assembled on site and made on a one off basis, or chillers exclusively using evaporative condensing.

A low temperature (LT) process chiller is capable of delivering its rated capacity with a process fluid outlet temperature of -25°C. This product falls under Commission Regulation (EU) 2015/1095 with minimum energy efficiency requirements being in place from July 2016.

A medium temperature (MT) process chiller is capable of delivering its rated capacity with a process fluid outlet temperature of -8°C. This product also falls under Commission Regulation (EU) 2015/1095 with minimum energy efficiency requirements being in place from July 2016.

A high temperature (HT) process chiller is capable of delivering its rated capacity with a process fluid outlet temperature of +7°C. The system being cooled by the HT process chiller shall not have the purpose of cooling of a space for the thermal comfort of people. A comfort chiller is defined as a cooling product which may use a vapour compression or sorption cycle to cool a water based cooling system to a temperature not lower than +2°C. The condenser may reject heat to the ambient air, a water/brine circuit or to the ground. A comfort chiller would typically have the purpose of cooling of a space for the thermal comfort of people.

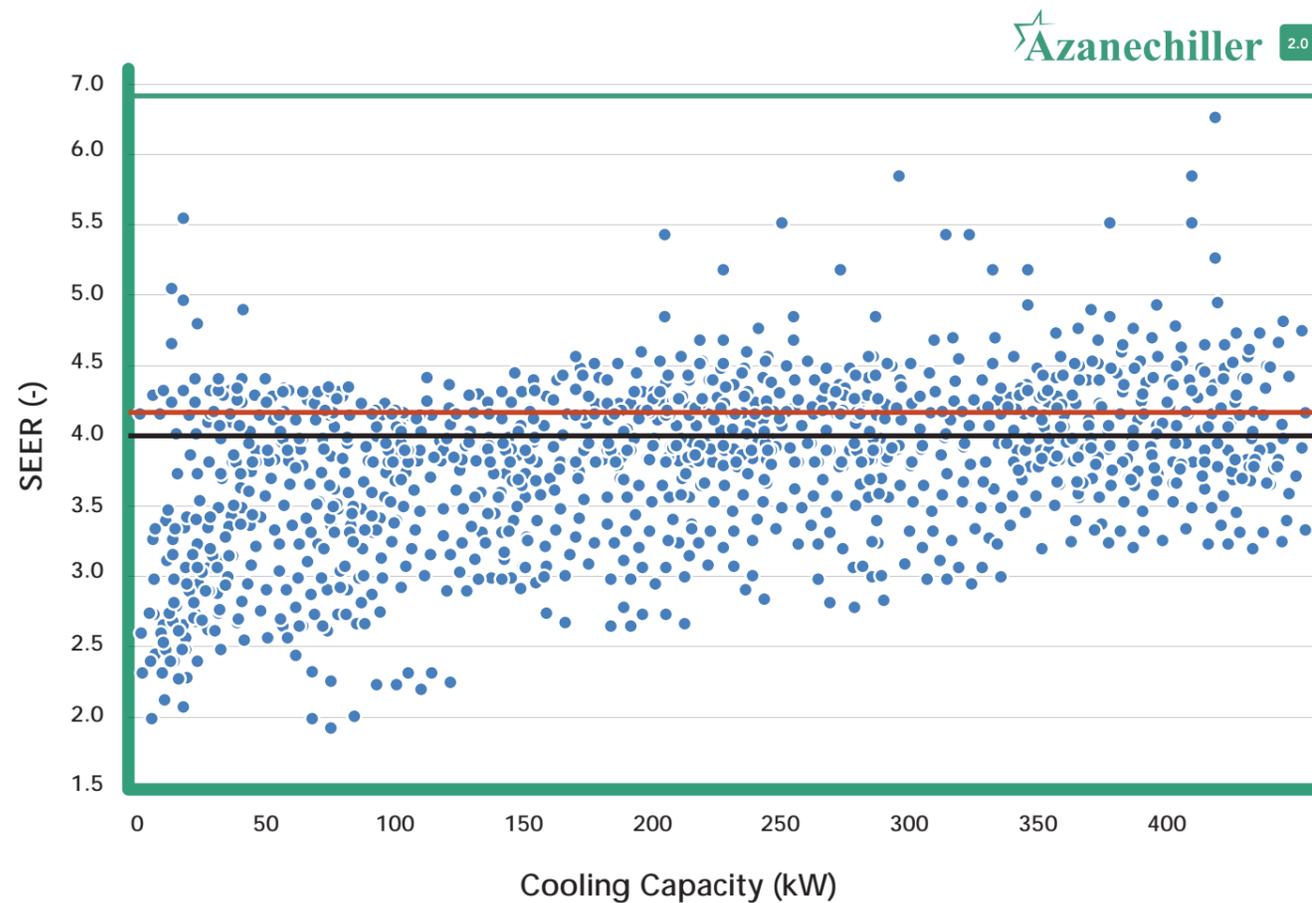
The directive not only establish the MEPS but to further limit the environmental impact of professional refrigeration products, it also states that manufacturers provide instruction manuals on installation to optimise energy efficiency and information on disassembly, recycling or disposal.

How does the new EcoDesign Directive affect the current chiller market?

The EcoDesign Directive will have a dramatic impact on cutting our carbon emissions and will provide massive savings for Europe's businesses as the less energy efficient products are driven out of the market and substituted for lower energy consuming chillers.

For manufacturers, the EU targets will no doubt present great challenges as all non-compliant chillers will not be allowed to be sold on the European market, but also opportunities, as this will mean going back to the drawing board and redesigning new, more technologically advanced energy efficient chillers.

According to a data set published by standards organisation EUROVENT in May 2015, 80% of comfort chillers below 400kW will not make the first cut of the EcoDesign Directive as the proposed minimum energy performance standards are not met, with a further 8% of chillers expected to be withdrawn from the market by 2021 when the proposed minimum energy performance standards for comfort chillers are further tightened. This effectively means that the majority of refrigeration chillers for comfort cooling applications currently being manufactured must be dropped from the market by 2018.



Eurovent data base 05.2015: ESEER translated into SEER net
 Tier - 1 (2018): MEPS are not achieved by ~80%
 Tier - 2 (2021): MEPS are not achieved by ~88%

The EcoDesign Directive has set as its ultimate aim to reduce the energy consumption (and therefore reduce CO2 emissions) and other negative environmental impact, particularly at the design stage.

Azanechiller 2.0 vs EcoDesign Directive MEPS

At Star we have always placed great emphasis on the chillers' development stages, specifically at the design and manufacturing phases to eliminate sources of energy waste.

Star's chillers have been proven to significantly reduce overall energy consumption and minimise adverse environmental impact throughout their entire life-cycle.

For reference, the charts below demonstrate how the Azanechiller 2.0 energy efficiency figures compare with the EcoDesign Directive Minimum Energy Performance Standards (MEPS) requirements.

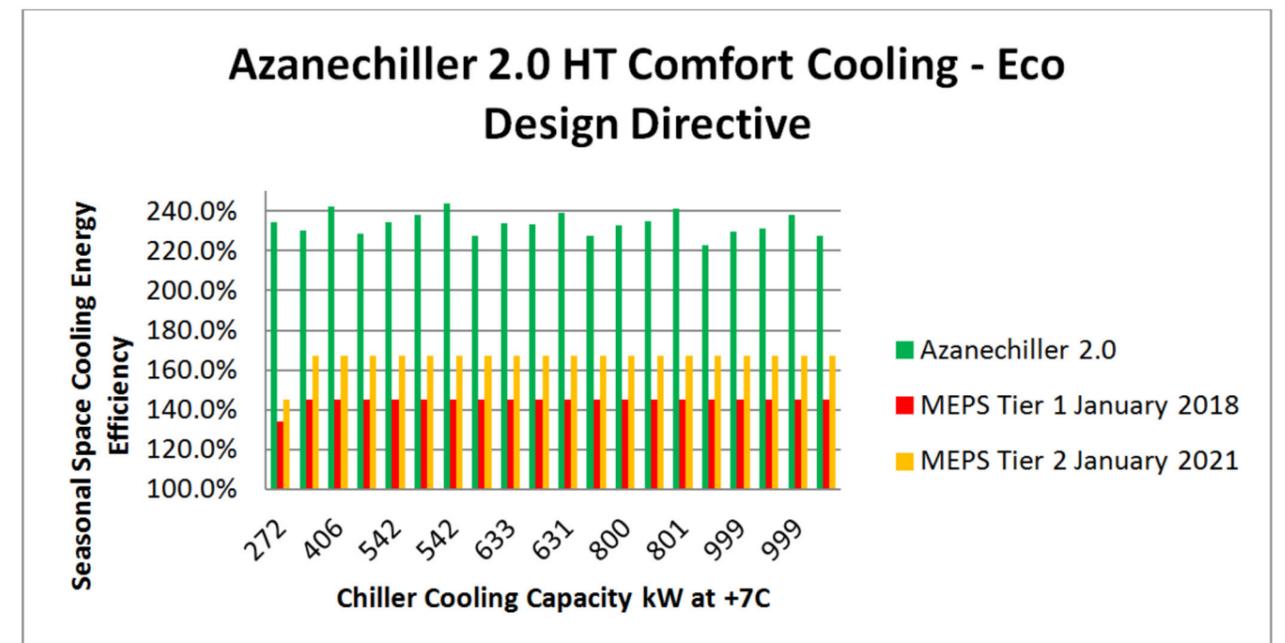
The company's latest development, the Azanechiller 2.0 sets a new benchmark in chiller performance with efficiency figures that are up to 146% higher than the European EcoDesign Directive requirement for Medium Temperature chillers, up to 100% higher for Comfort Cooling chillers and up to 74% higher for High Temperature chillers.

Star Refrigeration chillers meet even the most stringent 2nd tier targets of the EcoDesign Directive. The Seasonal Space Cooling Energy Efficiency for comfort cooling applications is 236% and the Seasonal Energy Performance Ratio (SEPR) is 8.01 for process cooling.

Comfort Chillers

For high temperature +7°C chillers used for comfort cooling, typically for building services, the metric used by the EcoDesign Directive is called Seasonal Space Cooling Energy Efficiency (SEER * 0.4) and it is expressed as a percentage. The graph shows cooling capacity across the bottom and Seasonal Space Cooling Energy Efficiency for comfort chillers on the vertical axis.

The minimum energy performance standard is between 134% and 145% for ammonia chillers (taking account of the bonus applied where the refrigerant has GWP < 150). All of the high temperature (HT) Azanechillers 2.0 exceed the benchmark by at least 77%.



have a vast experience working in collaboration with main contractors, with ice rinks being a key specialist sector, which proved to be fundamental for this project as the contractor required to be fully reliant on Star's expertise to execute the new ice rink facility and guarantee a successful delivery.

The standalone air cooled modular Azanechiller 2.0 AA415MT-2 model is part of a specifically designed MT range for medium temperature applications with two compressors to provide extra resilience, and will be installed with run/standby pumpset. The total installation offers numerous benefits, including reduced energy consumption, low maintenance requirements and the advantages of using a zero GWP refrigerant, which future proofs the ice rink against new environmental legislation. The Azanechiller also offers proven exemplary safety credentials and reliability, reduced life cycle costs when compared to the next best alternative, and a long life expectancy of over 20+ years.



East Kilbride Ice Rink's air-cooled ammonia Azanechiller is 71% more energy efficient than the EcoDesign Directive requirement, which will be applicable from 1st July 2016.

Lewis Brown, sales engineer for Star Refrigeration who is overseeing the project through from its inception, said, "East Kilbride ice rink's state of the art Azanechiller 2.0 has a Seasonal Energy Performance Ratio (SEPR) of 4.32, which is 71% higher than the EU EcoDesign Directive requirement."

"Our research showed life cycle cost savings of £278,000 and carbon savings of 1,204 tons of CO₂ over 20 years for this specific application when compared with 'best in class' ammonia screw chillers."

Star Refrigeration has long ties with East Kilbride ice rink, having installed their previous system – which lasted 26 years and operated round the clock – when it was first opened in 1989. The rink is also located just 10 minutes away from Star's head office and manufacturing facility with in-house design team in Glasgow. This is a welcome extra layer of assurance for the ice rink which will have a dedicated, fully qualified engineering team readily available 24/7.

The installation is expected to be completed by the end of the year. Star Refrigeration's local Bellshill branch will continue to offer support through a three year maintenance programme to ensure the ice rink performs at optimal design conditions.

Customer:	East Kilbride Ice Rink
Location:	East Kilbride
Equipment:	Azanechiller 2.0
Refrigerant:	NH3
Capacity	200kW – 1200kW
Temperature	-10°C – +10°C

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EcoDesign Directive Minimum Energy Performance Standards

The Minimum Energy Performance Standards (MEPS) are the minimum energy requirements a chiller must have in order to comply with legislation. Use the figures provided on the tables below to compare different chiller solutions and boost your business' bottom line - the higher the performance figures, the more energy efficient the chiller and the higher the energy and carbon savings.

From now on the efficiency of refrigeration products will be measured by: the Seasonal Energy Performance Ratio (SEPR) for LT, MT and HT process chillers and the Seasonal Space Cooling Energy Efficiency for comfort chillers, resulting from multiplying the Seasonal Energy Efficiency Ratio (SEER) by 0.4 with further corrections to account for energy consumption related to temperature control and electricity consumption of ground water pumps where applicable. The final value is expressed as a percentage.

Calculation of the efficiency measures are completed by the manufacturer and are in accordance with the methodologies set out in the regulations which also references other recognised methods of calculation e.g. EN14825.

The following tables show the minimum energy efficiency threshold requirements. You can refer to these two MEPS figures, by which refrigeration products sold in the EU are to be declared, to compare the energy efficiency of different solutions.

ENTR Lot 1: LT & MT Process chiller SEPR MEPS energy efficiency TIER 1

From July 2016

Chiller Type	Operating temperature	Rated cooling capacity <i>P_A</i>	Minimum SEPR value ≥ 150 GWP	* Minimum SEPR value < 150 GWP
Air	Medium (MT) - 8 °C	≤ 300 kW	2.24	2.02
		> 300 kW	2.80	2.52
	Low (LT) - 25 °C	≤ 200 kW	1.48	1.34
		> 200 kW	1.60	1.44
Water	Medium (MT) - 8 °C	≤ 300 kW	2.86	2.58
		> 300 kW	3.80	3.42
	Low (LT) - 25 °C	≤ 200 kW	1.82	1.64
		> 200 kW	2.10	1.64

* 10% bonus for refrigerants with GWP < 150.

ENTR Lot 1: LT & MT Process chiller
SEPR MEPS energy efficiency TIER 2 From July 2018

Chiller Type	Operating temperature	Rated cooling capacity <i>P_A</i>	Minimum SEPR value ≥ 150 GWP	* Minimum SEPR value < 150 GWP
Air	Medium (MT) - 8 °C	≤ 300 kW	2.58	2.32
		> 300 kW	3.22	2.90
	Low - 25 °C	≤ 200 kW	1.70	1.53
		> 200 kW	1.84	1.66
Water	Medium (MT) - 8 °C	≤ 300 kW	3.29	2.97
		> 300 kW	4.37	3.94
	Low - 25 °C	≤ 200 kW	2.09	1.89
		> 200 kW	2.42	2.18

* 10% bonus for refrigerants with GWP < 150.

ENER Lot 21: HT Process chiller
SEPR MEPS energy efficiency TIER 1 From 1 January 2018

Chiller Type	Operating temperature	Rated cooling capacity <i>P_A</i>	Minimum SEPR value
Air	High (HT) +7 °C	< 400 kW	4.5
	High (HT) +7 °C	≥ 400 kW	5.0
Water	High (HT) +7 °C	< 400 kW	6.5
	High (HT) +7 °C	≥ 400 kW & 1500 < kW	7.5
	High (HT) +7 °C	≥ 1500 kW	8.0



Case Study

CASE STUDY: East Kilbride Ice Rink

PROJECT: Azanechiller 2.0

East Kilbride ice rink receives Star Refrigeration's treatment, naturally!

Star Refrigeration is helping one of Scotland's most-loved ice rinks to improve both its service to skaters and curlers and its environmental credentials by replacing their existing R22 refrigeration system with an eco-friendly and highly efficient Azanechiller 2.0.

The natural cooling contractor's latest Azanechiller 2.0 will provide East Kilbride Ice Rink with a solution that will significantly reduce the rink's energy costs and environmental impact which avoids the uncertainty of synthetic refrigerants caused by the F-Gas Regulations.

East Kilbride's famous ice rink is currently undergoing complete replacement in order to bring the facility into the 21st century. Originally inspired by Houston's The Galleria shopping mall, the ice rink attracts between 115,000 and 120,000 visitors through its doors every year. Playing host to a wide range of events, from curling to ice skating parties and even family days out, the rink is very much a fixture in locals' lives and requires a strong, reliable backbone to support it into the future.



Providing top quality 'ICE' for 40 years – From curling rinks that helped prepare Team GB for a Bronze victory at Sochi 2014, to ice skating facilities where ice quality is critical, to the cutting-edge 'Ice Factor' climbing wall in Scotland, the largest indoor facility of its type in the world.

Star Refrigeration's expertise in the specialist field of ice rink design and installation helped the company succeed in securing the project following a competitive tender. Having designed and installed a significant majority of the permanent ice rink

facilities in the UK leisure industry for the last 45 years, including the original ice rink in the shopping centre, helped demonstrate that Star were the right choice for the job.

Gerry Campbell, the General Manager of South Lanarkshire Leisure and Culture said, "After a long and productive partnership with Star, SLLC are delighted that they have been selected to provide so much of the fundamental equipment at the newly refurbished East Kilbride Ice Rink."

"The new ammonia based chiller system with its significantly improved energy consumption will be an essential part of our successful operation."

"The excellence of the service received over the past 25 years from Star ensures we can look forward to the next years comfortable in the knowledge that the single most important piece of equipment will be well installed and well maintained."

The refurbishment project includes the removal of existing floor, plant and barriers, and the supply and installation of a new ammonia air cooled chiller, pump set, ice rink floor, barrier system, curling stone storage area, interconnecting pipework and wiring.

The Azanechiller 2.0 is an air-cooled, packaged ammonia chiller which incorporates energy saving technology and delivers cooling efficiencies that are 71% higher than the EU's EcoDesign Directive's requirements and 20% higher than competing high efficiency chillers. In addition, the use of ammonia, a natural occurring refrigerant with zero ozone depleting and global warming potential, will keep the rink in line with current regulations which have banned the use of R22 due to its ozone depleting potential.

The installation works are being carried out in conjunction with the main contractor's larger redevelopment of the area around the ice rink, within the Olympia Mall. In order to facilitate a successful and timely delivery, Star's engineering team scheduled the removal of the existing floor during the night, which allowed for the other works to continue without disruption. Star Refrigeration

The regulations also makes provision for each Member State to perform market surveillance checks i.e. any chiller placed on the market post-introduction of the regulations may be selected for testing by a body appointed by the Member State to verify that the chiller achieves the stated performance within an agreed tolerance. In the UK, this function is administered by the National Measurement and Regulation Office (NMRO). End users can therefore have confidence that the energy efficiency claimed by a manufacturer is indeed achieved.

How does the EcoDesign regulation affect end-users of cooling equipment?

The Directive has set very high energy efficiency requirements for the future. So much so that during consultations industry stakeholders voiced concerns about the Minimum Energy Performance Standards targets being "overstated." Targets were seen to be "very challenging" and a call to the EU Commission for lowering them was made without success - MEPS will be mandatory across Europe and it will be unlawful to place products within the EU market that fail to achieve the prescribed minimum energy performance standard.

Products covered by the new regulations which were installed before the date the regulations became effective are not affected by these requirements and need not be replaced or upgraded. MEPS will also trigger investment in cost effective solutions, thereby reducing energy use and associated cost and carbon emissions.

With such a stringent legislative environment, it will be essential that industrial refrigeration manufacturers commit to R&D in order to develop solutions that meet the normative and offer customers a better alternative than existing cooling products. This will stimulate market changes to speed up the rate at which energy efficiency upgrades to inefficient industrial cooling and heating systems take place.

For refrigeration end-users, these measures mean good news all-round. EU targets will positively impact business owners' use of energy who should be able to see a reduction of the energy bill as soon as chillers that meet the directive are installed at their facilities:

End-user businesses will benefit from:

- More energy efficient equipment from manufacturers of industrial cooling equipment.
- More efficient chillers will help organisations manage their Carbon Reduction Commitment compliance and avoid penalties.
- The Directive will allow end users to use the information provided by manufacturers effectively in order to be able to make informed decisions that directly contribute to business success. The SEPR and Seasonal Space Cooling Energy Efficiency must be declared and technical documentation provided by the manufacturers – however, there is not a set energy rating label.
- The SEPR and Seasonal Space Cooling Energy Efficiency figures are based on more realistic conditions compared to other currently used ratios and provide the refrigeration end-user with more data to identify the most efficient solution. More efficient solutions will result in higher operating efficiency and reduced customer's energy bills.
- Energy efficient business can gain a competitive advantage over less efficient companies, leading to a profit increase.
- Investment in highly efficient, low Global Warming Potential (GWP) refrigeration technology will reduce the overall CO2 emissions of end user businesses and potentially serve as a significant marketing tool, as public perception of "green" companies takes an increasing role in purchasing decisions.

ENER Lot 21: HT Process chiller SEPR MEPS energy efficiency TIER 2

From 1 January 2021

Chiller Type	Operating temperature	Rated cooling capacity <i>P_A</i>	Minimum SEPR value
Air	High (HT) +7 °C	< 400 kW	5.0
	High (HT) +7 °C	≥ 400 kW	5.5
Water	High (HT) +7 °C	< 400 kW	7.0
	High (HT) +7 °C	≥ 400 kW & 1500 < kW	8.0
	High (HT) +7 °C	≥ 1500 kW	8.5

ENER Lot 21: Comfort chiller MEPS energy efficiency TIER 1

From 1 January 2018

* Chiller Type	Operating temperature	Rated cooling capacity <i>P_A</i>	GWP > 150	GWP < 150
Air	+7 °C	< 400kW	149%	134%
	+7 °C	≥ 400kW	161%	145%
Water	+7 °C	< 400kW	196%	179%
	+7 °C	≥ 400kW	227%	204%
	+7 °C	> 1500kW	245%	220%

* Driven by electric motor

ENER Lot 21: Comfort chiller MEPS energy efficiency TIER 2

From 1 January 2021

* Chiller Type	Operating temperature	Rated cooling capacity P_A	GWP > 150	GWP < 150
Air	+7 °C	< 400kW	161%	145%
	+7 °C	≥ 400kW	185%	167%
Water	+7 °C	< 400kW	200%	180%
	+7 °C	≥ 400kW	252%	227%
	+7 °C	≥ 1500kW	272%	245%

* Driven by electric motor

Implementation of the EcoDesign Directive

The regulation for each LOT will be implemented in two phases - a more lenient Tier 1 will be upgraded with stricter and final Tier 2 following a scheduled programme of action which will start in July 2016 and will conclude in January 2021.

The regulations make provision for the inclusion of a review at a later date (not exceeding 5 years after first implementation) which may further tighten requirements or extend the scope of the existing regulations to incorporate additional products (e.g. process chillers using evaporative condensers may be incorporated at a later date).

The EC regulation for MT and LT process chillers and condensing units will become applicable from 1st July 2016.

From this date it will become mandatory for refrigeration manufacturers of these products to declare performance and other technical details in accordance with the regulations. Some products covered by this regulation also require specific labelling under the Energy Labelling Directive (2010/30/EU), though this does not apply to process chillers or condensing units. Products not meeting the requirements of the regulations in any respect, may no longer be placed on the marked in Europe. The directive also introduces an energy efficiency bonus for condensing units and process chillers that use refrigerants with GWP < 150.

More information can be found at:
http://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=uris*97erv:OJ.L.2015.177.01.0019.01.ENG

The normative for High Temperature (HT) process chillers and comfort cooling (HVAC) is still in drafting process and was notified to the WTO in September 2015. The draft regulation proposes a bonus under the EcoDesign requirements for space cooling products to steer the market towards the use of refrigerants that are less harmful to the environment. As a result, the bonus will lead to lower minimum energy efficiency requirements for cooling products using refrigerants with GWP < 150. The proposed bonus for using low GWP refrigerants does not apply to HT process chillers. As noted above, the energy labelling requirements which apply to many EuP's and ErP's do not apply to HT process chillers or comfort chillers. More information about the draft directive can be found at http://www.eceee.org/EcoDesign/products/Lot21_Central_Heating_Products/EU301_EN_1_1.pdf

Time tables ENTR Lot 1 & ENER Lot 21 Entry into force

Chiller Type	Tier	Year of Application
LT & MT Process Chiller	Tier 1	July 2016
	Tier 2	July 2018
HT Chiller	Tier 1	January 18
	Tier 2	January 21
COMFORT Chiller	Tier 1	January 18
	Tier 2	January 21

