Equipment and Solutions

LNG TRANSPORTATION, CARGO HANDLING AND FUELLING APPLICATIONS

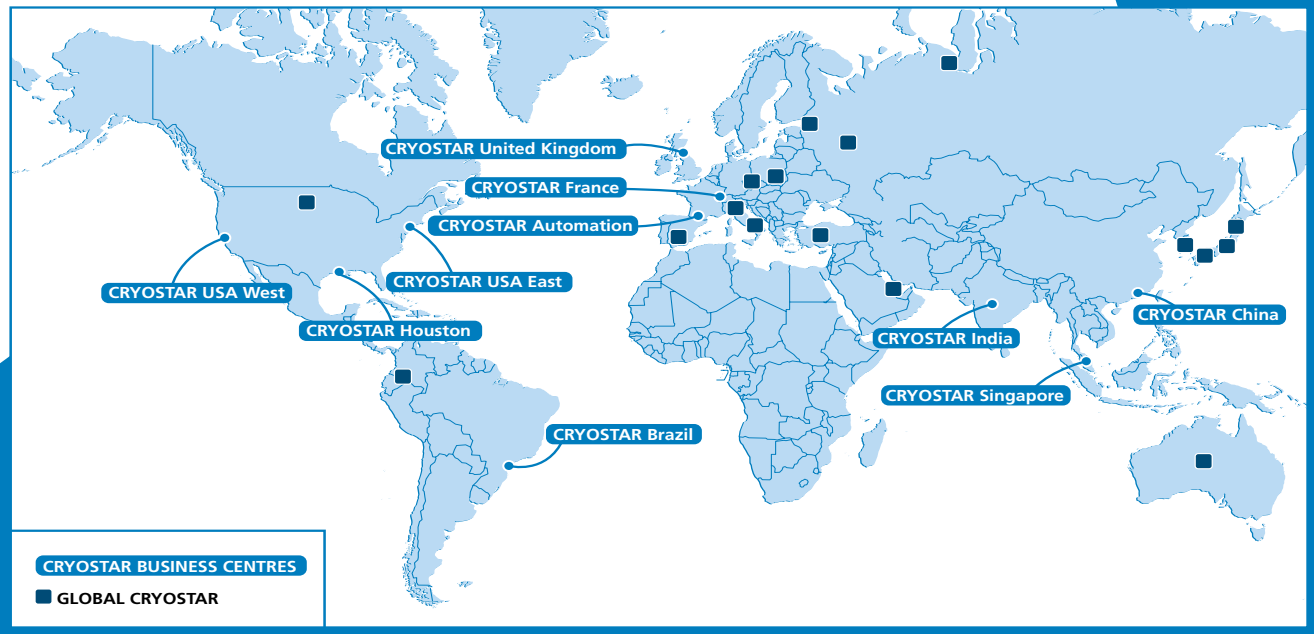
LNG TRANSPORT & TERMINALS
CRYOSTAR

THE Cryostar GROUP

Cryostar is a cryogenic equipment manufacturer with more than 600 employees including 150 engineers. With its headquarters located in France, the company operates five production sites and is present worldwide through eight business centers and 16 business partners.

Founded in 1966 the company has over 40 years experience with LNG and has become the world leader for boil off gas compressors and on-board liquefaction units for LNG carriers. The company has delivered thousands of cryogenic pumps for liquid hydrocarbon applications (including methane, ethylene, ethane, etc.)

Cryostar's engineers continuously innovate with patented solutions for various applications throughout the LNG supply chain such as small scale liquefaction, LNG transportation, LNG/LCNG vehicle refueling stations and LNG bunkering.



SAFETY AND STANDARDS

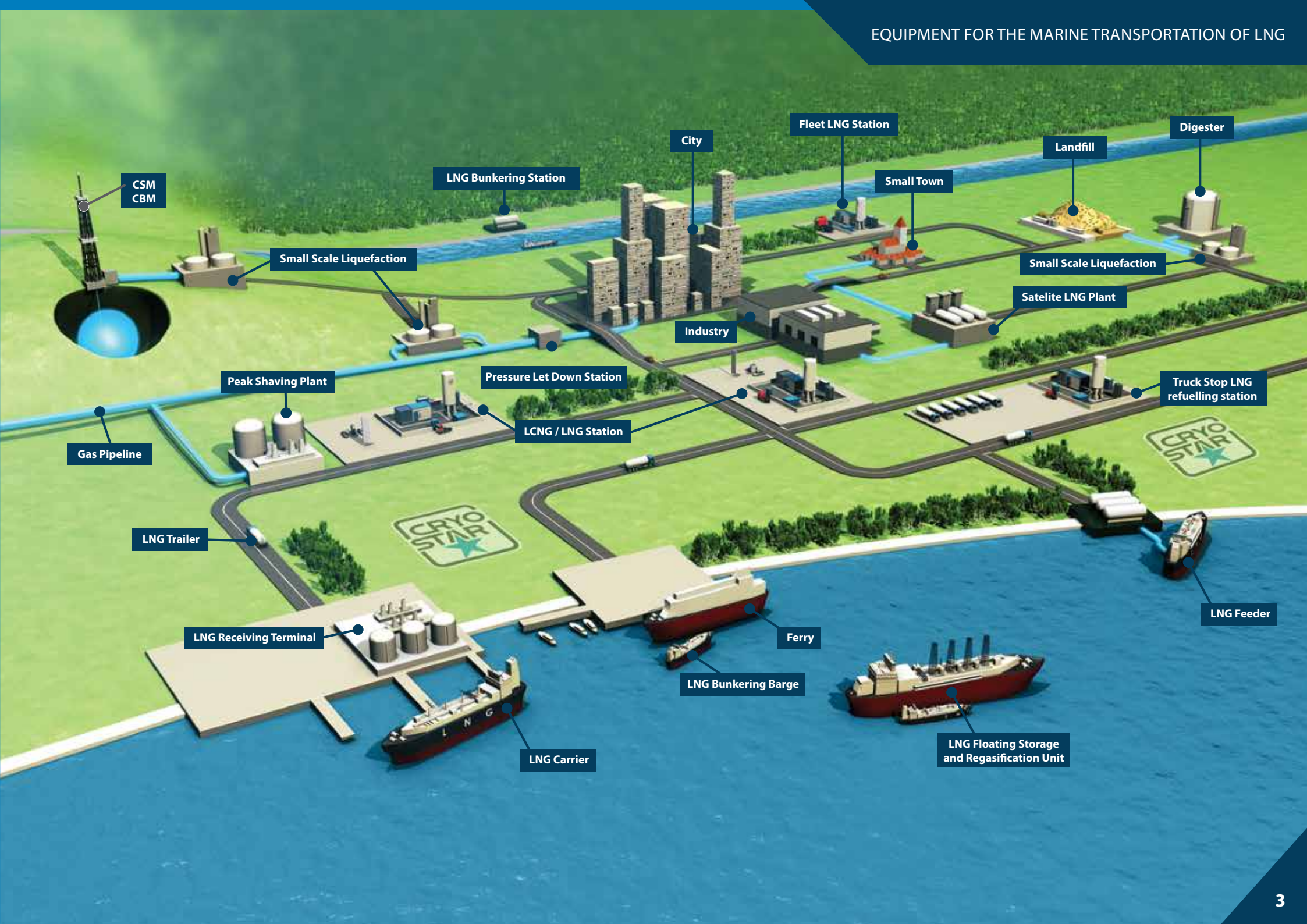
Safety is an integral part of Cryostar's management and manufacturing commitments. For each new development or project, the company performs a risk analysis using approved techniques such as HAZOP (Hazard and Operability) and FMEA (Failure Mode and Effects Analysis). Cryostar's solutions comply with most stringent machine and safety regulations such as the Pressure Equipment Directive 97/23/CE (Module H and H1) and ATEX.
"All marine equipment is Class approved before shipping and Cryostar has experience with numerous Classification Societies."

FACTORY AND ON-SITE ACCEPTANCE TESTS

Cryostar's headquarters host the world's largest and most sophisticated liquid nitrogen test facility for cryogenic pumps as well as three test facilities dedicated to turbines. Cryostar engineers subject each pump and turbine to a performance test prior to shipment, offering customers guaranteed performance. Cryostar provides commissioning, start-up and support for onsite performance for liquefaction plants and refueling stations.

QUALITY AND ENVIRONMENT

Cryostar is ISO 9001-2008 certified. To structure its environmental approach, Cryostar has used the ISO 14001 standard to set up all the organizational and operational processes necessary for an aspiring Environmentally Responsible company. In parallel, Cryostar has applied this approach to Health and Safety through the OHSAS 18001 standard. ISO 9001-2008/ ISO 14001-2004 / OHSAS 18001-2007 quality assurance system.

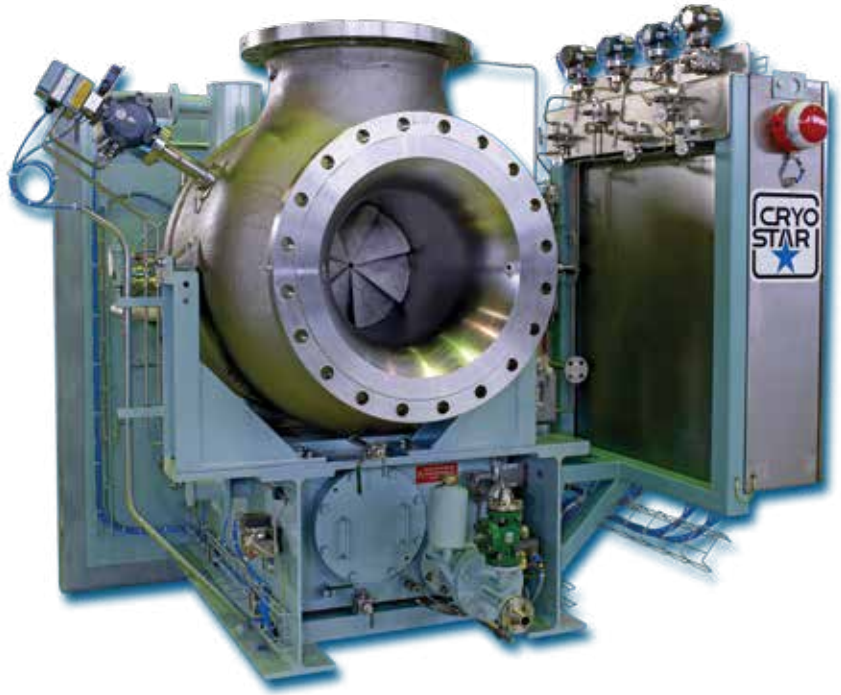

CSM
CBM
LNG Bunkering Station
City
Fleet LNG Station
Small Town
Landfill
Digester
Small Scale Liquefaction
Small Scale Liquefaction
Satelite LNG Plant
Industry
Peak Shaving Plant
Pressure Let Down Station
Truck Stop LNG refuelling station
Gas Pipeline
LCNG / LNG Station
LNG Trailer
LNG Receiving Terminal
Ferry
LNG Feeder
LNG Bunkering Barge
LNG Carrier
LNG Floating Storage and Regasification Unit

Boil-off gas as a fuel – LNG carriers are the cleanest ships around !

Cryostar has been supplying machinery allowing LNG carrier boil–off to be used as fuel gas since the 90's. The natural boil-off vapour from the cargo tanks is compressed and routed to the vessel's propulsion systems, providing both a clean fuel and handling the gas generated from the tank storage. Many of the improvements to enhance efficient operation of these vessels have been realised with Cryostar's support in developing versatile, efficient and reliable machinery.

From steam turbines to low pressure 2-stroke engines

Cryostar began producing compressors to supply boilers fitted to steam turbine propelled vessels. As new propulsion technologies were proposed, close co-operation with engine makers, shipyards and ship-owners led to the most versatile designs allowing flexibility for operational needs.



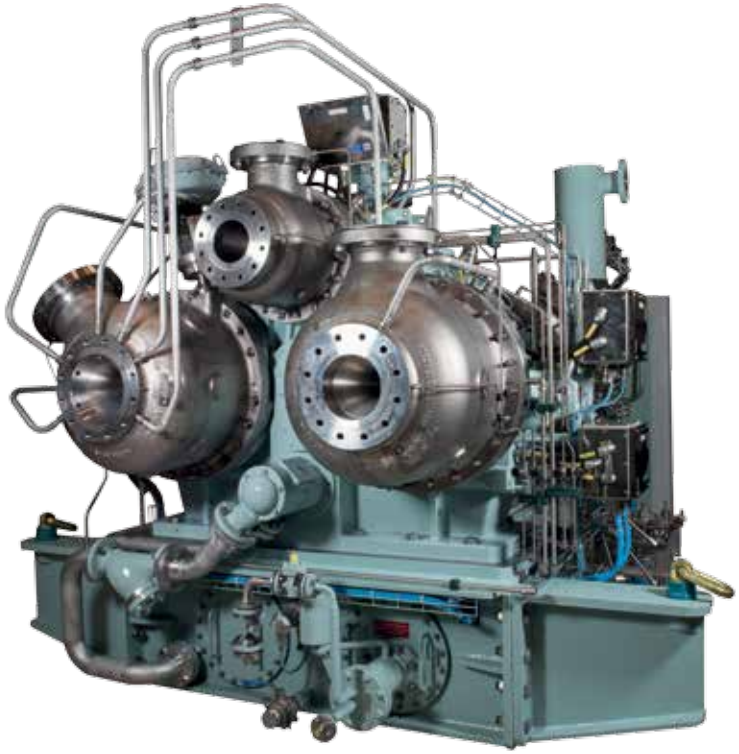
industry-leading developments are common…

4 stage BOG fuel gas compressor

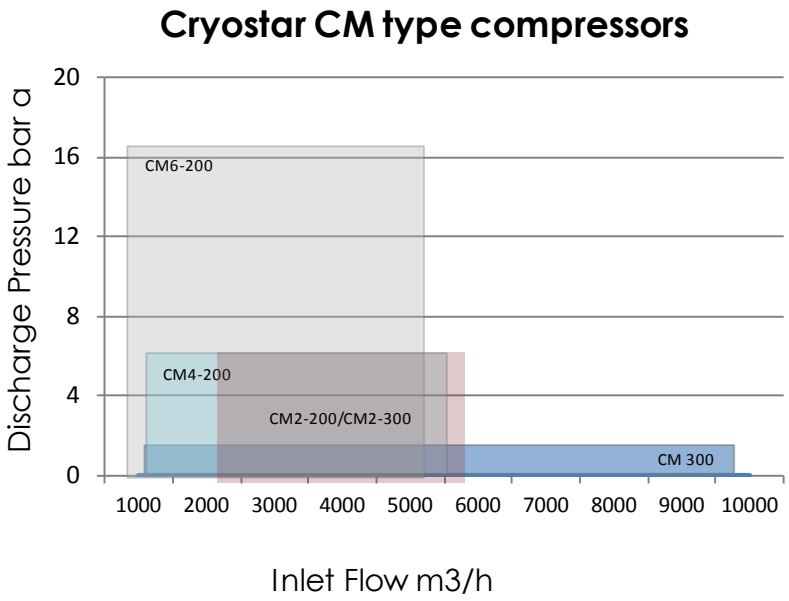
Dual fuel 4-stroke and 2-stroke

The diesel electric and low speed diesel propelled vessels require stringent control of flow and delivery pressure for the fuel gas. The CM4-200 and CM6-200 BOG compressors are perfectly suited to fulfil these exacting requirements.

Coupled with stepless flow control, extremely low vibration levels and no pulsations, this technology is perfectly suited to the long term requirements of an LNG carrier. Long service intervals are standard. Simple operation is possible, with all safety controls integrated into the vessel's main control system.



6 stage BOG fuel gas compressor

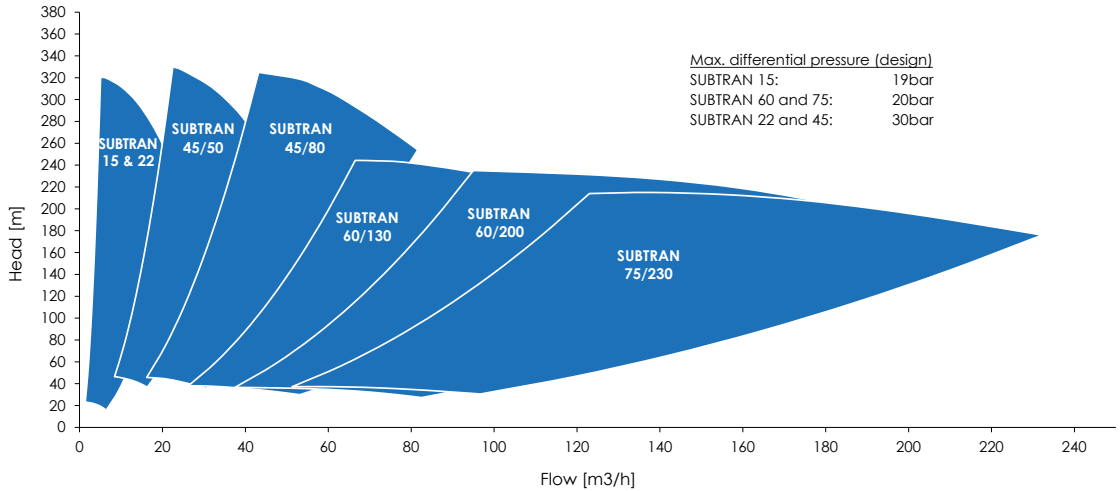


Fuelling for the future...

In recent years, vessel emission regulations have progressively tightened. This means that alternative methods are necessary to achieve compliance. Fuelling with LNG is one of the simplest and cleanest ways to achieve compliance.

From fuel tank to engine

Small in-tank pumps supply the liquid to the high pressure pumps located deck-side.
Perfectly suited for this application, they are fitted with ceramic bearings for extended lifetime. Mounting can be either in an external sump, or internally in the tank.



SUBTRAN Head-Flow ranges

Subtran submerged pump

40 years of experience in every pump…

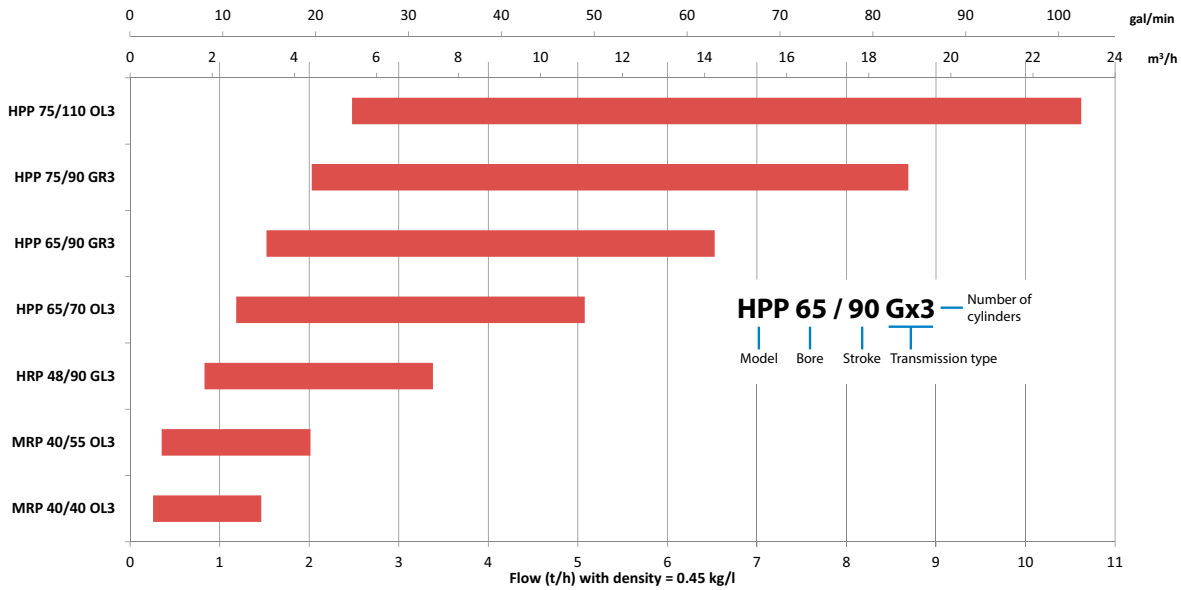
Triplex reciprocating pump

Dual fuel 2-stroke marine engines

The high pressures required to fuel a 2-stroke diesel cycle engine on gas are well within the range of these exceptional pumps. Developed over a period of 40 years, they represent the very highest quality available.

Extremely low NPSH levels coupled with high reliability and efficiency, make Cryostar the natural choice. Simple maintenance and option of belt, gear or hydraulic drives complete the package. The pumps are delivered on completed skids fully tested in our world-leading facility in France.

Pumps for ethane fuelling complete our portfolio.



Boil-off gas recovery for overall vessel efficiency

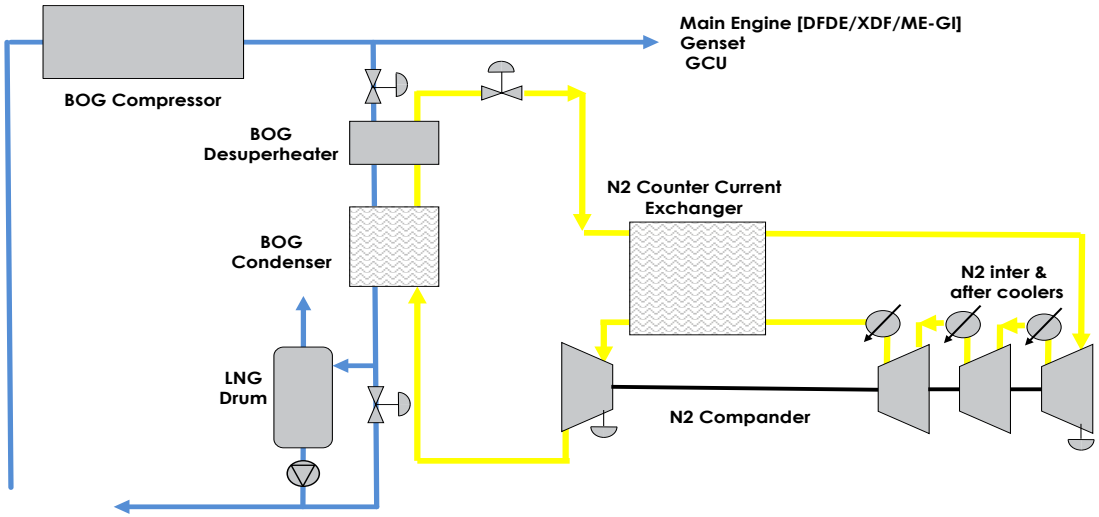
Since the boil-off generated in the cargo tanks has to be handled on board and often the engine fuel gas consumption is lower than the natural boil-off, it is necessary either to burn or reliquefy the surplus gas. This surplus can then be traded rather than being lost.

EcoRel-S

Cryostar built their first marine reliquefaction plants in 2007 for the entire fleet of Q-Max vessels. These giants have by now accumulated a large number of running hours and tremendous experience has been gained, complementing the extensive studies performed for the initial unit.

EcoRel-S is best suited for vessels with low speed 2-stroke engines, or DFDE vessels with 4-stroke propulsion.

Cryostar's patented desuperheater provides maximum system protection, allowing faster plant cooldown from ambient and faster load-up from idle than its competitors.



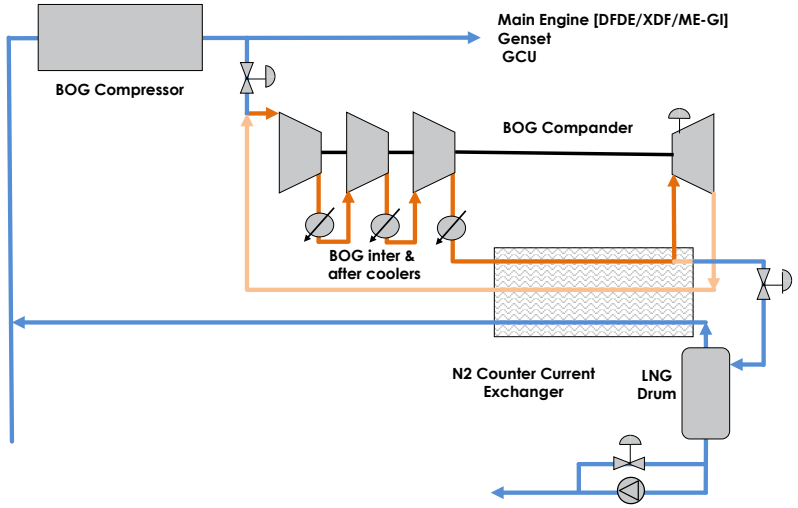
full reliquefaction is possible

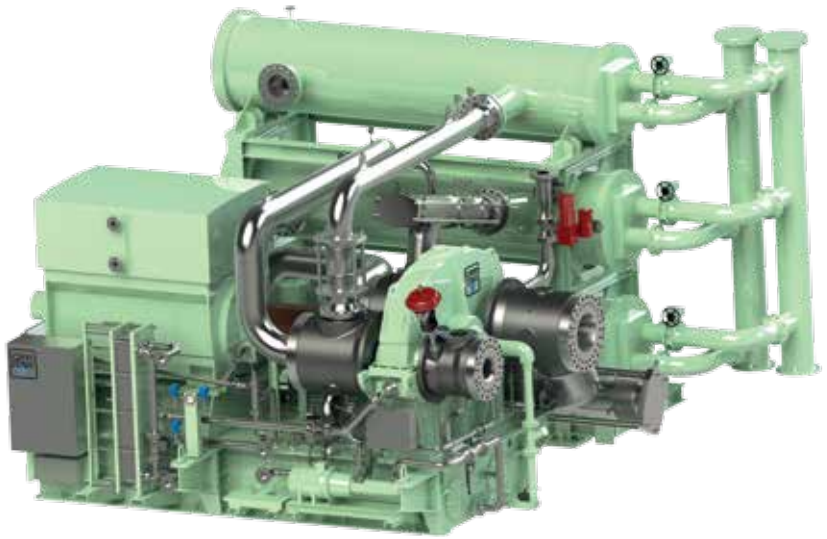
EcoRel-X

composition has smaller influence than for nitrogen-based systems

When 2-stroke medium speed XDF type engines were introduced, it was possible to benefit from the higher BOG pressure in the fuel gas line.

Cryostar has patented a system using BOG as the working fluid in a semi-open cycle. This allows superior exploitation of residual cold in the process to reduce the power consumption, while still returning excellent results for condensate recovery. Utilising a BOG compander, together with a JT valve, the system remains simple, and has no major effect on the primary design of the fuel gas system. The complexities of nitrogen inventory are avoided and the system can be easily integrated into vessel cargo systems.





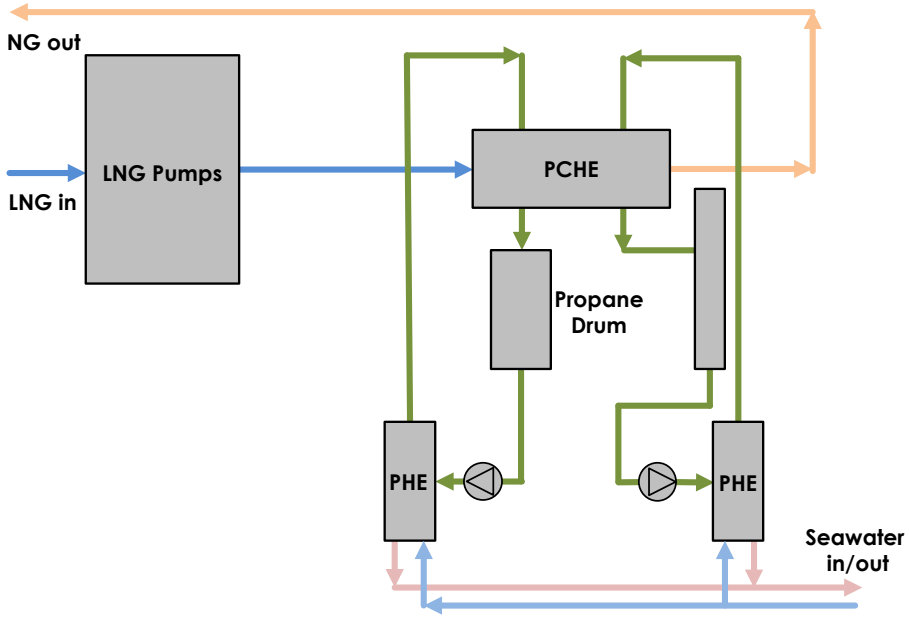
Cryostar compander

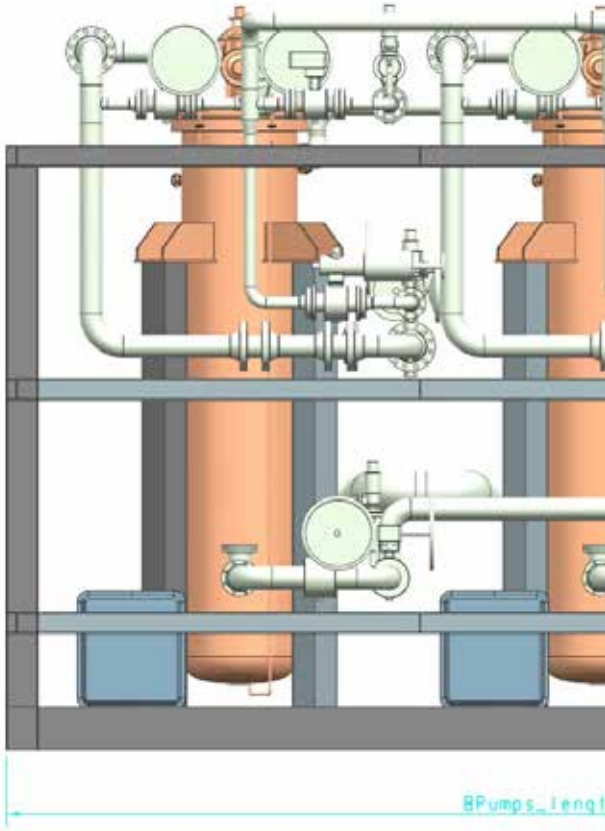
as a working fluid, BOG is readily available

EcoVap Propane Intermediate Loop

Cryostar has developed a unique solution for LNG regasification of LNG aboard FSRU vessels. The heat source is the energy available in the seawater. A propane intermediate loop provides a separation between the LNG and the seawater.

A modular approach to the design allows scaling flexibility for different design flows and compositions. The plant can be designed for maximum sendout flows, even in cold seawater conditions.

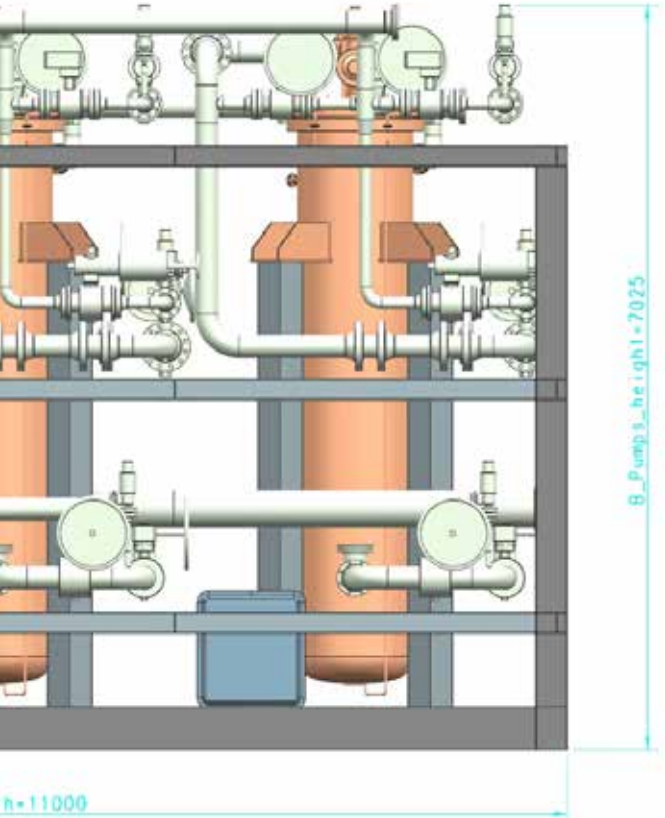




EcoVap Glycol Water Intermediate Loop

For owners who would prefer to avoid propane, a glycol water intermediate loop is available.

While designed for a specific seawater temperature, the unit can still be operated in colder climates by de-rating the output to minimise capital costs. The simplicity of the system configuration allows easy integration as original equipment or as a retrofit option. The easy handling of the intermediate fluid makes this an environmentally safe solution.



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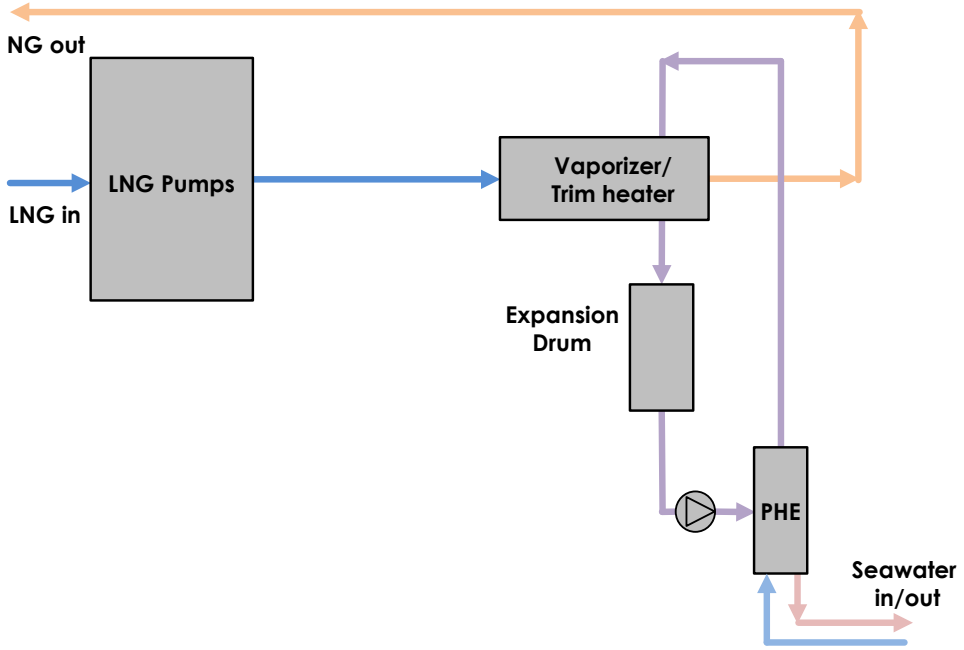


StarLite™

Cryostar's Starlite™ nitrogen loop liquefiers for landbased applications typically comprise a compander with air cooling and coldbox. Plants are available adapted for regular, as well as cold climates.

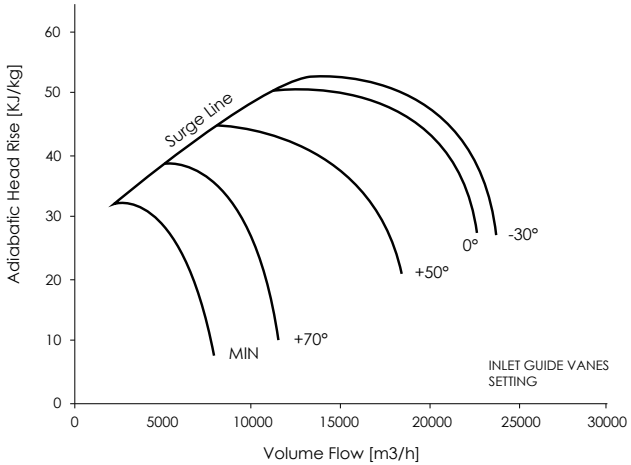
Gas feed from pipeline or biogas can be handled. Plants are available in the range of 20~100 tons per day. The system draws on the experience of the 18 EcoRel-S plants currently in service.

Typical Liquefier

Landbased BOG compressors and blowers

LNG Receiving Terminals are equipped with blowers to balance the gas volumes when LNG carriers unload. These machines are derivatives of the similar machines installed on the carriers themselves.

Built to different regulations, they benefit from the rugged reliability provided by the on-board machines.

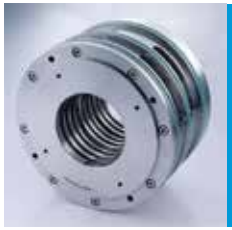


Multi-stage BOG compressor

Single stage return gas blower

Premium technology is our standard

When designing our machines, the best possible materials and components are sourced. Sophisticated tools are used to analyse and prepare the best possible solution for each design aspect. Finally the machines are proven by testing in rigorous conditions in one of our 5 test facilities.



Gas seals

Especially developed, together with a major sealing supplier, Cryostar uses the latest technology to minimise sealgas consumption while maintaining the safety of a gas tight seal.

Flow control

To provide the smoothest stepless flow control, Variable Diffuser Vanes are used. These systems are applied to thousands of our machines.

High-speed bearings

To allow long service intervals with the best possible performance, tilting pad bearings are utilised in all our high speed turbomachinery gearboxes.

Reciprocating pump Factory Acceptance Test

Caring for your equipment for 40 years

Since the production of equipment began in 1967, Cryostar has always emphasised the need to support the end-user for the life of the equipment.

In the world of marine applications, the reliability and efficient operation of the equipment is mission critical. This is why Cryostar allocates each vessel to a single point of contact for most efficient servicing, parts supply and technical back-up.

Many end-users benefit from our maintenance agreements when it comes to dry-dock servicing. Dedicated spare parts kits ensure that no critical parts are missing during this time-pressured period off-hire. Routine and major servicing can be handled by our large team of technical experts anywhere in the world.

Unplanned maintenance interventions are always a challenge, with the vessel presenting a moving target. It requires skill, patience and immense co-operation to achieve seamless service under these circumstances. Cryostar's service team is geographically distributed, affording quick reaction times wherever you may be, and the 24h service line means that you are guaranteed a response.

Most equipment only needs servicing at 5 and 10 year intervals, so it is key that the organisation is well planned and our team is always ready to work with you to define a course of action.

BRAZIL

CHINA

FRANCE

INDIA

SINGAPORE

UK

USA

For contact and address of Cryostar locations worldwide, please go to **www.Cryostar.com/locations**

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