



GASCONSULT ZR-LNG LIQUEFACTION TECHNOLOGY

EXECUTIVE SUMMARY

The indicative performance of Gasconsult's ZR-LNG and ZR-LNG+ processes against competing technologies is provided in the table below.

At the highest efficiency end of the market, ZR-LNG+ achieves an efficiency comparable to the dominant DMR (Dual Mixed Refrigerant) and C3MR (Propane pre-cooled Mixed Refrigerant) base load technologies, but with 30-40% less equipment.

For conventional mid-scale plants ZR-LNG has a 5-10% higher efficiency and production capacity than the mainstream SMR (Single Mixed Refrigerant) technology but with a 25% lower equipment count.

For small-scale plants ZR-LNG has an equivalent equipment count to nitrogen expander technologies but with a significantly higher efficiency and production capacity.

These advantages lead to cost, weight and space savings, increased LNG production/revenues and low carbon emissions across the full range of plant capacities.

The lower equipment count, ~15% lower footprint and lower weight of the facility is particularly beneficial for FLNG application as it results in a reduced deck area and weight of the host hull or platform, further reducing capex. Alternatively, the reduced footprint allows installation of additional productive liquefaction capacity on an existing hull/platform, enhancing project economics.

TECHNOLOGY	SINGLE TRAIN EQUIPMENT COUNT IBL + OBL	RELATIVE POWER DEMAND	RELATIVE REVENUE PER MW OF POWER INPUT
HIGH EFFICIENCY			
ZR-LNG+	27	100	150
DMR/C3MR	37/45	100	150
MID-SCALE			
ZR-LNG	19	117	128
SMR	26	122-129	116-123
SMALL-SCALE			
ZR-LNG	19	117	128
3 X N2 EXPANDER	20	134	112
2 X N2 EXPANDER	19	150	100

The technologies enjoy significant patent protection. Please see Appendix 1.

The design and configuration of the ZR-LNG and ZR-LNG+ technologies has been independently validated by McDermott a leading engineering company expert in cryogenics. An index indicating the extent of detail in McDermott's work is included as Appendix 2.



There are two further variants of ZR-LNG. The IHR (Integrated Heavies Removal) process removes C5+ and aromatics from raw natural gas, avoiding the need to install an upstream NGL recovery unit to prevent freezing and plugging of the main cryogenic exchanger and ancillary equipment. IHR performs the same steps as an NGL unit but using expander and re-compression facilities already existing in the basic ZR-LNG configuration. This saves ~\$50 million relative to an upstream expander based NGL recovery unit for a 2 million tpa LNG train. A further recent development is production of high methane content LNG to meet the 99% methane LNG required for potential aerospace application. To achieve 99% methane LNG conventional technology would involve a complex and capital-intensive cryogenic distillation process in the LNG processing configuration. Gasconsult's solution, IHR+, is a minor variant of the IHR process. The only additional equipment items are a relatively low-cost compressor aftercooler and a single separator. Cryogenic distillation is avoided, making the new scheme highly competitive for this application.

APPENDIX 1 - PATENTS

Technology	Awarded Patents	Patents Pending
ZR-LNG	2012 – UK: GB 2486036 2016 – China: ZL 201280027025.X 2016 – Japan: 5984192 2017 – Mexico: 346703 2017 – Australia: 2012270148 2017 – South Korea: 10-1820560 2019 – Canada: 2,836,628 2019 – Malaysia: MY-172653-A	High efficiency ZR-LNG+ GB2404789.6
IHR (Integrated Heavies Removal)	2019 - EP 3338043 (DE, FR, ES, IT, GB) 2020 – JP 6640886 2020 – US 10641548 B2 2023 – KR 10-2498124	2023 High methane LNG – IHR+ GB2318454.2 superseded by 2024 PCT/GB2024/000053

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