

IHS CHEMICAL

Small-Scale Floating LNG

PEP Review 2015-13

March 2016

ihs.com

PEP Review 2015-13

Small-Scale Floating LNG

Ron Smith
Sr. Principal Analyst



PEP Review 2015-13

Small-Scale Floating LNG

Ron Smith, Sr. Principal Analyst

Abstract

Offshore cryogenic liquefaction to produce liquefied natural gas (LNG) offers an attractive means to monetize the stranded gas fields in the deep seas and to stop flaring of associated gas produced along with oil, among other advantages. However, there are potentially many commercial and technical challenges ahead. Expander processes and several of its variations need to be considered for offshore LNG applications.

Expander cycles using nitrogen as the refrigerant have all-gas service and no refrigerant storage, which decrease the plot area requirement, and are more suitable for desirable heat exchanger core arrangements and modularization since most surface area is dedicated to a gas-to-gas service. However, while the process efficiency is the lowest for the expander process, it is possibly the safest process for the N₂ expander process.

For now, an operational project has yet to prove the technology. There are many aspects of the technology that have yet to be worked out and proven as well, such as the offloading equipment needed to transfer LNG from the floater to LNG carriers.

In this review, the first of its kind, we explore the technologies and economics for production of LNG offshore on a small scale. This review will be useful for those who are considering entry or are currently involved in building projects that will operate from a floating maritime platform for the monetization of stranded gas or shale gas resources offshore.

Contents

1	Introduction	6
	Commercial expansion devices	7
	Cooling media	8
	Refrigeration drivers and power generation	8
	Compressor drivers	8
2	Summary	10
	Markets	10
	FLNG technology	12
	Process requirements	12
	Hull design and function	14
	Conclusions	17
3	Industry status	19
	Introduction	19
	LNG	22
	Gas to liquids	22
	Compressed natural gas (CNG)	23
	Compressed liquefied petroleum gas (LPG)	23
	Global natural gas monetization	23
	Flaring	24
	Stranded gas	25
	LNG liquefaction processes	26
	Drivers of FLNG development	26
	Liquefaction process types	27
	Liquefaction products	27
	Pretreatment of wellhead gas	29
	Comparative compressed power consumption and cooling loads	30
	Comparison of refrigerant systems	30
	Comparison of liquefaction processes	31
	FLNG technology development	32
	Potential locations for FLNG projects	35
	Examples of foreign LNG and FLNG projects	36
	FLNG projects	37
	Conclusion	39
4	Technology review	40
	Introduction	40
	FLNG liquefaction technology	40
	Wellhead gas pretreatment	42
	FLNG ship operations	43
	Overall FLNG process description	45
	Nitrogen refrigerant	46
	Overall FLNG processing train	48
	Acid gas removal	49
	Mercury removal	50
	Water removal	51

CO ₂ removal	51
FLNG storage containment for LNG product	52
Cryogenic pumps	53
Boil-off gas reliquefaction	55
General observations	56
5 Small-scale FLNG topside process	57
Review of processes	59
Dehydration	59
Acid gas removal/sulfur recovery	59
Tail gas treating	60
Sulfur recovery	60
Liquefaction	60
Process description	61
Wellhead gas pretreatment (Section 100)	63
Acid gas removal (Section 200)	64
Gas drying (Section 300)	64
Liquefaction (Section 400)	64
Fractionation (Section 500)	65
Claus sulfur recovery (Section 600)	65
Super SCOT [®] tail gas treatment (Section 700)	66
Process discussion	78
Materials of construction	78
Cost estimates	78
Capital costs	78
Production costs	79
Appendix A—Design and cost bases	88
Design conditions	89
Cost bases	89
Capital investment	89
Plant operating and maintenance costs	90
Chemicals and waste costs	90
Co-products and by-products	91
Effect of operating level on production costs	91
Transport, storage, and monitoring design assumptions	91
Overall estimate confidence rating	91
Appendix B—Cited references	93
Appendix C—Patent summaries	100
Appendix D—Process flow diagrams	102

Tables

Table 2.1	Comparative product costs	17
Table 3.1	Alternative technologies for utilizing stranded gas	22
Table 3.2	Example feed gas composition	27
Table 3.3	Lean versus rich feed gas composition	28
Table 3.4	Comparative liquefaction refrigeration cycle power requirements and cooling loads	30
Table 3.5	Comparison of refrigerant systems	30
Table 3.6	Comprehensive comparison of liquefaction processes	31
Table 3.7	LNG liquefaction pretreatment requirements	33
Table 3.8	Qualitative comparisons—Large- versus small-scale FLNG plants	35
Table 3.9	Major FLNG projects under construction	37
Table 3.10	Global FLNG projects—Examples	38

Table 4.1	Sweet and sour gas	42
Table 4.2	FLNG basic systems	44
Table 4.3	Medium-scale FLNG—Typical main features	45
Table 5.1	Project constructions in progress	58
Table 5.2	Small-scale FLNG—Design bases and assumptions	62
Table 5.3	Small-scale floating LNG (FLNG)	67
Table 5.4	Small-scale floating LNG (FLNG)—Major equipment	74
Table 5.5	Small-scale floating LNG (FLNG)—Utilities summary	77
Table 5.6	Small-scale floating LNG (FLNG)—Total capital investment	79
Table 5.7	Small-scale floating LNG (FLNG)—Capital investment by section	80
Table 5.7a	Process unit capital absolutes	82
Table 5.8	Small-scale FLNG—Production costs	82
Table 5.8a	Comparative product costs	84
Table 5.9a	Process section operating costs	87

Figures

Figure 1.1	Simple refrigeration cycle	7
Figure 3.1	Price of natural gas as a function of oil price	19
Figure 3.2	Relative size of global gas resources	20
Figure 3.3	Distribution of gas fields by size	21
Figure 3.4	Size of gas fields as a function of distance to shore	25
Figure 3.5	FLNG ship components	34
Figure 3.6	Potential locations for worldwide FLNG projects	36
Figure 3.7	Potential LNG and FLNG projects worldwide	36
Figure 4.1	Typical FLNG process scheme	41
Figure 4.2	LNG FPSO systems	43
Figure 4.3	Simplified nitrogen expander process flow schematic	46
Figure 4.4	Detailed PFD for nitrogen dual-expander refrigeration system	47
Figure 4.5	Detailed PFD for nitrogen single-train expander cycle refrigeration system	48
Figure 4.6	Overall simplified dual liquefaction LNG train configuration with electrical power generation	49
Figure 4.7	Mercury removal using regenerable silver-promoted molecular sieves	51
Figure 4.8	FLNG storage containment for LNG	53
Figure 4.9	High-speed submersible LNG cryogenic pump	54
Figure 4.10	Refrigeration system for recovery of LNG boil-off gas	55
Figure 5.1	Process flow diagram—Small-scale floating LNG	103

IHS Customer Care:

Americas: +1 800 IHS CARE (+1 800 447 2273); CustomerCare@ihs.com
Europe, Middle East, and Africa: +44 (0) 1344 328 300; Customer.Support@ihs.com
Asia and the Pacific Rim: +604 291 3600; SupportAPAC@ihs.com

