

# Small-scale LNG plant capabilities:

## Simple design, low unit cost and a fast schedule



Air Products' liquefaction technology is used at this 140 TPD nitrogen recycle LNG plant in New York.



Air Products' LNG cold boxes installed at a plant site in Hokkaido, Japan (courtesy of JAPEX).

### Unmatched experience

For more than 50 years Air Products has engineered, and designed nitrogen recycle refrigeration technology and systems as the primary liquefaction process in air separation facilities. Air Products also owns and operates more than 100 nitrogen recycle (or air recycle) liquefiers and over 300 cryogenic plants. Year in and year out, our system-wide plant availability exceeds 99 percent, while achieving the industry's lowest levels of operating and maintenance costs. This world class capability and proven experience carries over to the design and engineering practices as well as the manufacturing of equipment utilized in plants Air Products builds for the natural gas liquefaction. As a result, Air Products' small LNG offerings provide cost effective and reliable solutions for owners and project developers.

### Small LNG plant applications

- Peakshaving and emergency reserve
- Mining and transportation fuel
- Remote gas monetization and virtual pipeline
- Shipboard and LNG terminal BOG reliquefaction

### Air Products small-scale LNG offerings include:

- LNG 200™ system - Standard/modular 200 TPD AP-N™ process
- LNG 400™ system - Standard/modular 400 TPD AP-N process
- AP-C1™ and AP-N customized and low-cost design for other small-scale capacity
- AP-SMR™ or multiple trains of AP-N process for higher capacity

The standard design also allows for flexibility in selection of cooling medium (air, water, or closed-loop glycol), type of drivers (motor or gas turbine), heavy hydrocarbon removal and nitrogen rejection technologies.

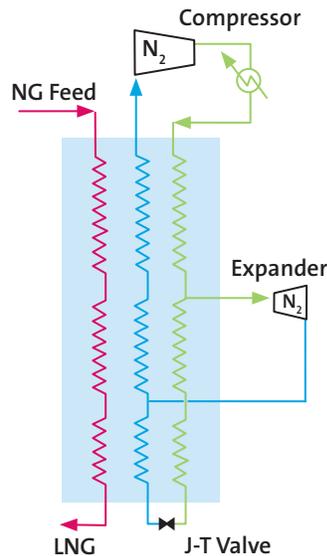
## Proven design

Air Products' efficient and reliable process designs have proven to be robust and reliable in natural gas liquefaction service. Small-scale liquefaction plants built by Air Products decades ago remain in service today, with many producing well over their original design capacity. Utilizing our experience from the sale of over 2,000 cryogenic facilities, Air Products can help with your small-scale LNG needs.

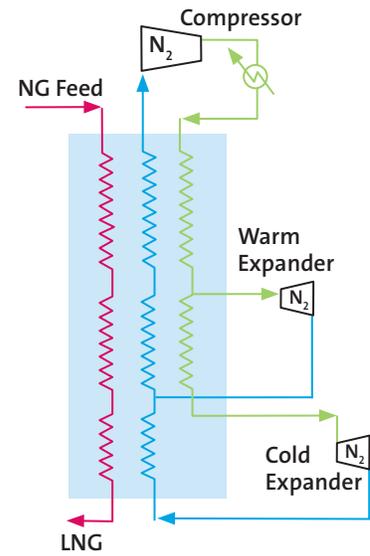
## Various process configurations available to suit your requirements

### AP-N™ Nitrogen recycle

This process is available in two options: single-expander or dual-expander.



Single-expander AP-N process offers standard designs, low capital cost and proven technology.

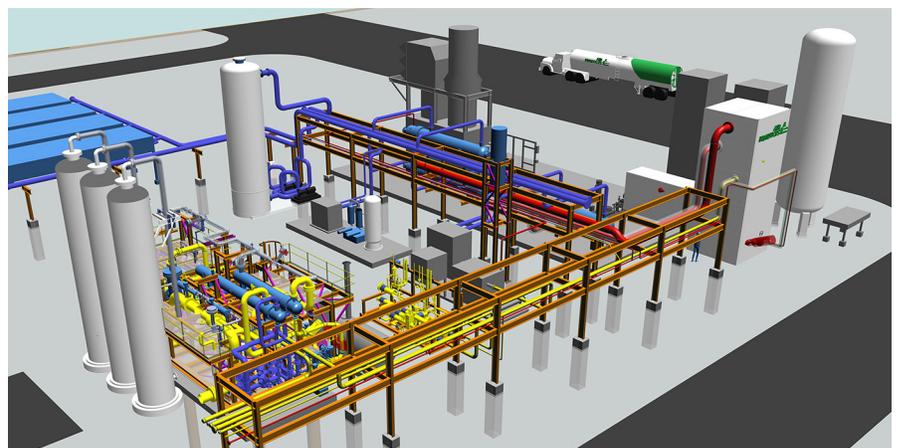


Dual-expander AP-N process offers standard designs, multiple expanders allow for higher efficiency at higher capacity.

## Features and benefits of nitrogen expander cycles

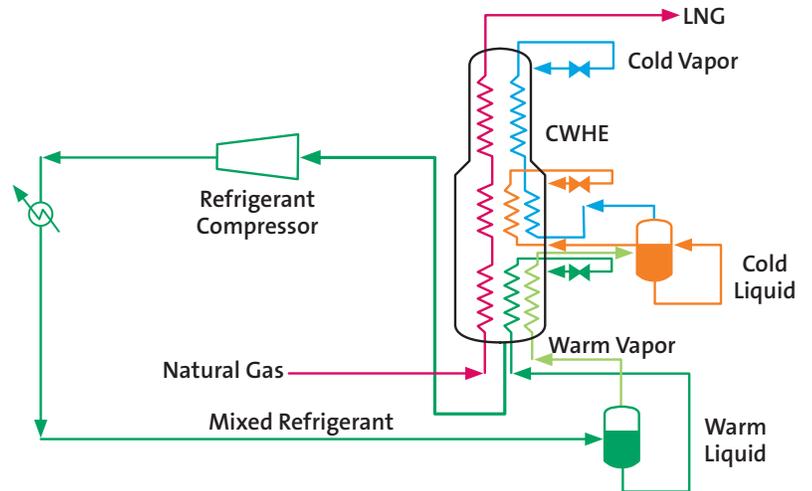
- Lower capital cost than competing mixed refrigerant technologies
- Simple operation and superior turndown efficiency
- Nonflammable and environmentally benign nitrogen refrigerant
- Low cost and ready availability of nitrogen
- Modularized design of the nitrogen recycle liquefier minimizes field construction cost

3D drawing of peakshaving LNG plant using the AP-N™ process.



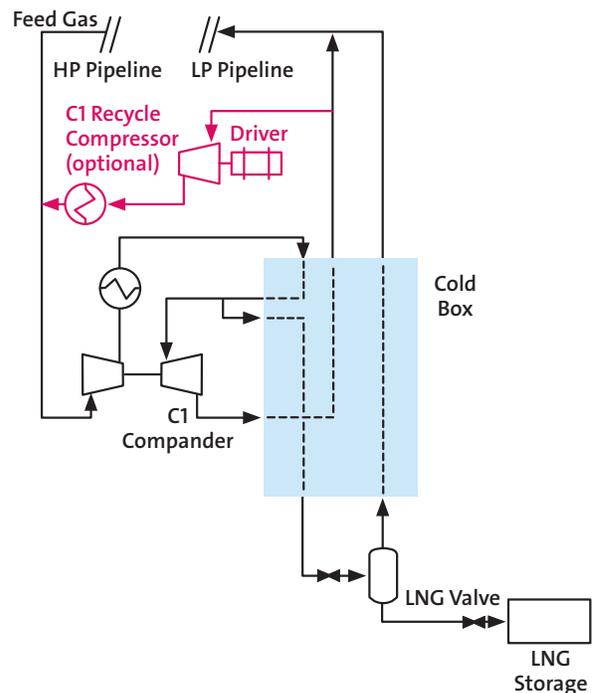
## AP-SMR™ single mixed-refrigerant process

The AP-SMR process incorporates Air Products' unique coil-wound heat exchanger (CWHE), offering an attractive and straightforward solution that minimizes process equipment and provides enhanced performance and reliability. To minimize fieldwork or depending upon plant site logistical challenges, the CWHE can be fully modularized. Air Products' mixed refrigerant process cycles with coil-wound heat exchangers benefit from years of experience and "know-how" gained in the LNG industry.



## AP-C1™ methane expansion process

The AP-C1 process uses the feed gas as the refrigerant therefore eliminating the need for external refrigerant components (e.g. N<sub>2</sub>) and reducing the costs associated with refrigerant import and storage. The technology is proven and can convert natural gas feed directly to LNG by taking advantage of the pressure differential between two pipelines, thereby eliminating incremental power input as well as a refrigeration compressor. An optional methane recycle compressor would provide increased process flexibility and availability. This process has been considered for peakshaving plants, BOG reliquefaction, and for LNG production at natural gas letdown stations.



### Comparison of small-scale LNG liquefaction process options

	Single-expander AP-N	Dual-expander AP-N	AP-C1	AP-SMR
Feed gas rate	5 to 20 MMSCFD	10 to 30 MMSCFD	3 to 30 MMSCFD	>30 MMSCFD
Efficiency	Good	Good	High	Higher
Capital cost	Lower	Low	Lower	Medium
Refrigerant components	N <sub>2</sub>	N <sub>2</sub>	C1	N <sub>2</sub> , C1, C2, C3, C4 or C5

## Air Products Rotoflow® Turbomachinery for N<sub>2</sub> and C1 expanders/ companders



Building turbomachinery with reliability, high efficiency, improved safety and lower operating costs is second nature at Air Products. Why? Because for more than seventy years we have been building turbomachinery equipment to exacting standards for our own use. As one of the only OEMs both manufacturing and operating turbomachinery, we intimately know the equipment and the processes.

## Small-scale LNG plant experience

Country	Customer	Start-Up	LNG Capacity MMSCFD (TPD)	Air Products Process
England	British Gas Council	1981	11 (227 TPD)	AP-SMR
Japan	Japex	2004	7 (144 TPD)	AP-N
		2007	10 (206 TPD)	AP-N
United States	Alabama Gas Co.	1965	5 (103 TPD)	Cascade
	Massachusetts	1973	8 (165 TPD)	AP-SMR
	Hopkinton LNG Corp	1977	19 (392 TPD)	Cascade
	Cove Point LNG	1994	15 (310 TPD)	AP-SMR
	Keyspan LNG	2001	6 (124 TPD)	AP-N
	Philadelphia Gas Works	2002	16 (330 TPD)	AP-C1
	National Grid	2019	20 (412 TPD)	AP-N

This experience enables us to deliver to you turbomachinery with exceptional performance, reliability, safety and value.

With nearly 1,000 units operating worldwide, we have unique access to operating data, giving us insight into every nuance of both equipment and processes. We continuously incorporate this operational feedback and knowledge into our machinery designs.



**Air Products' cryogenic expander used in the production of a small LNG plant.**

## About Air Products

Air Products is a world leading industrial gases company celebrating 75 years of operation. The company's core industrial gases business provides atmospheric and process gases and related equipment to manufacturing markets, including refining and petrochemical, metals, electronics, and food and beverage. Air Products is also the world's leading supplier of liquefied natural gas process technology and equipment.

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