



Rice Global E&C Forum  
**Engineering &  
Construction**



# 2019 RICE GLOBAL E&C ANNUAL FORUM



## The LNG Industry Evolves

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[www.forum.rice.edu](http://www.forum.rice.edu)

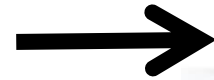
# What is LNG?



- Means of delivering energy
- Colorless, odorless liquid
- Stored at atmospheric pressure at  $-162^{\circ}\text{C}$  ( $-260^{\circ}\text{F}$ )
- Used for power generation, domestic heating, transportation fuel
- 1 ton LNG = 52 MMBTU = 1.3 tons of crude oil
- 1 MTPA of LNG = 800 MW power
  - Requires 16 LNG tanker deliveries per year
- $1/600^{\text{th}}$  the volume of natural gas



# Why liquefy natural gas?



# Air Products' Role in LNG Project Development



- **Engineering studies**
- **Liquefaction area process design**
- **Supply of key liquefaction equipment and related engineering**
- **Process license**
- **Technical service during project execution**
- **Continued service during commercial operation**

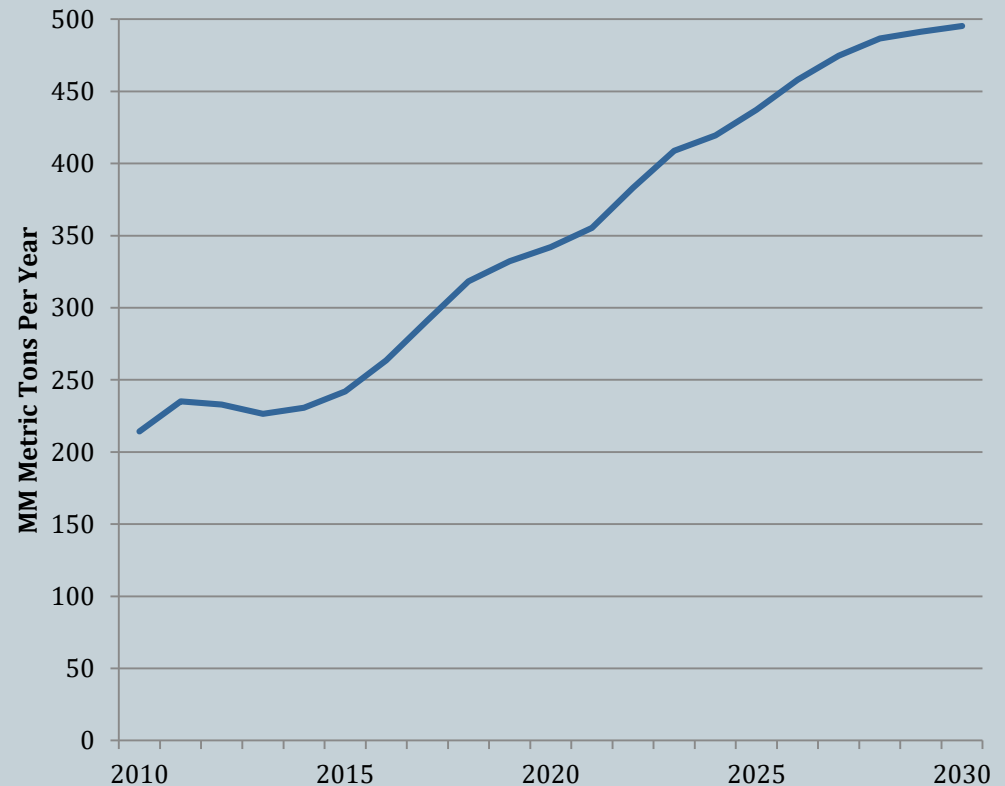


# LNG Demand Drivers

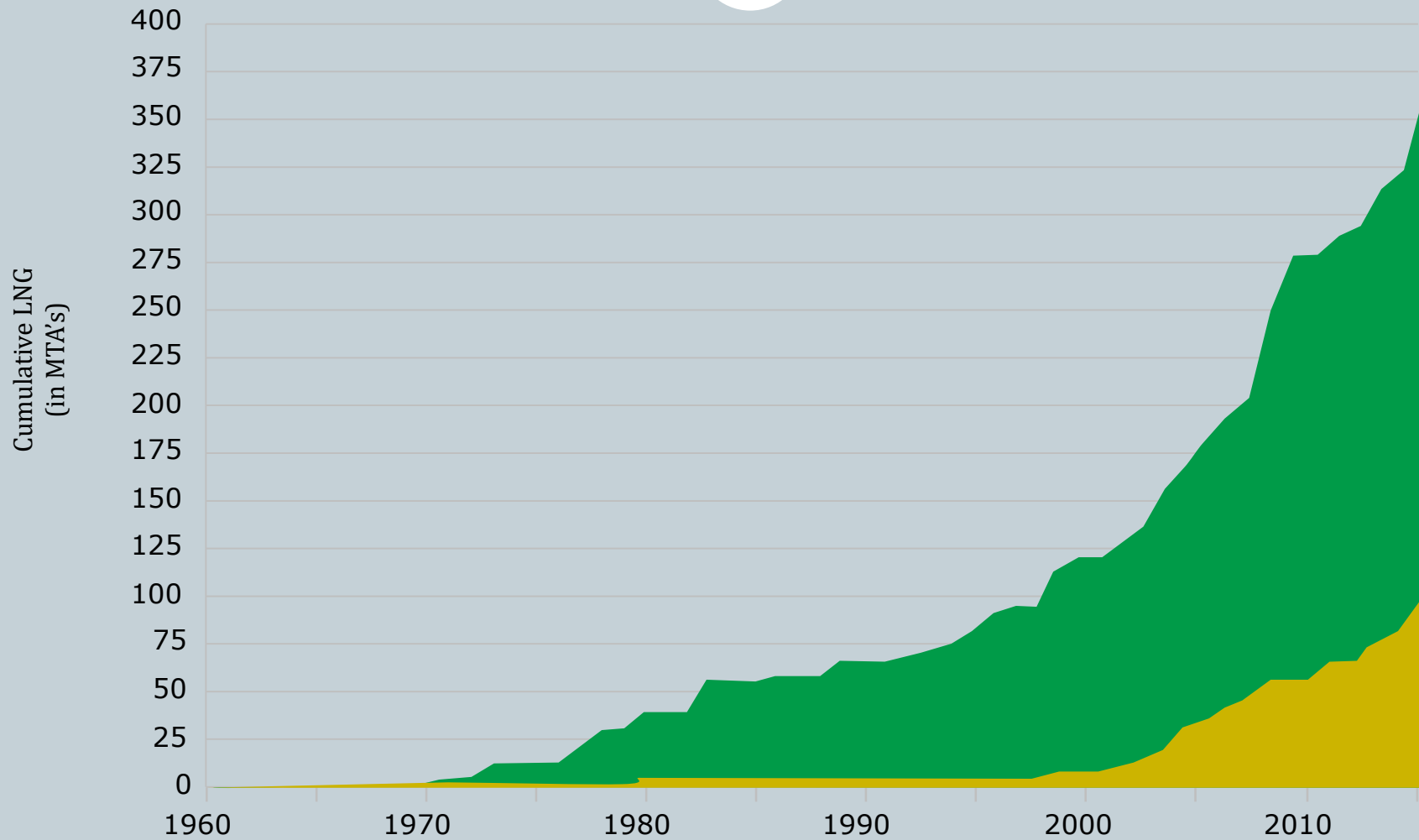


- **Energy demand growth**
- **Greenest of fossil fuels**
- **Fuel oil replacement**
- **> 4.5% CAGR through 2030**

**Global Estimated LNG Demand**



# LNG Market Supply Growth



# LNG Market Evolution



1993

Small  
~0.5 mtpa



Large  
to 3 mtpa



2019

Small  
~ 0.05 mtpa



MidSize  
0.25 to 2.0 mtpa



Floating  
1-6 mtpa



Large  
to 5 mtpa



Mega  
to 8 mtpa



# Traditional Characteristics of LNG Plants

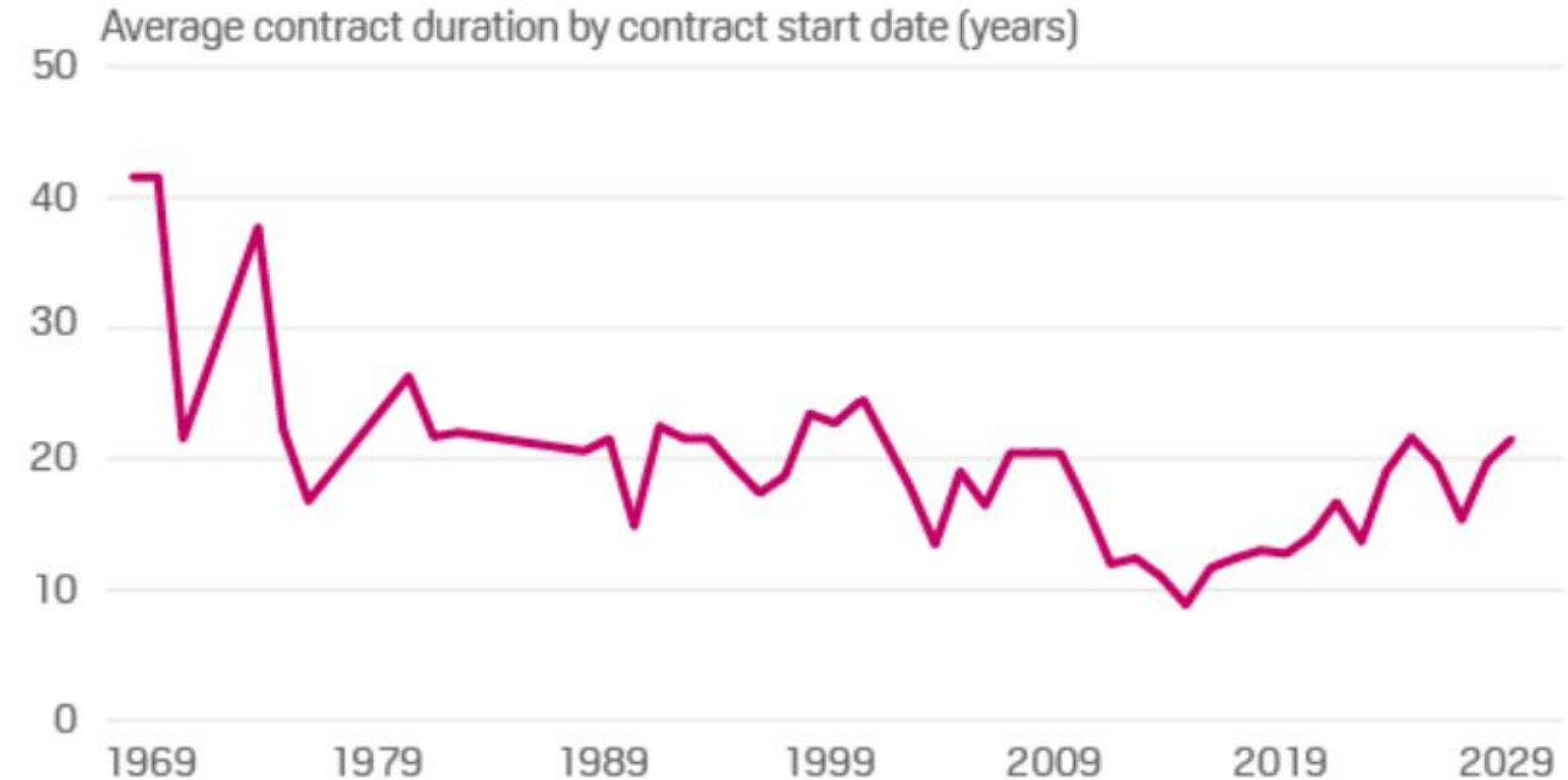


- **Co-located at large natural gas source**
- **Generally multiple process trains per site**
- **Multi-billion dollar investment**
- **Conservative industry, proven technology**
- **Long gestation period**
- **IOC or NOC project lead**





# Long term sales contracts traditionally underpinned LNG Plant Investment



Source: S&P Global Platts Analytics

# Large LNG Trains – 2 to 8+ MTPA

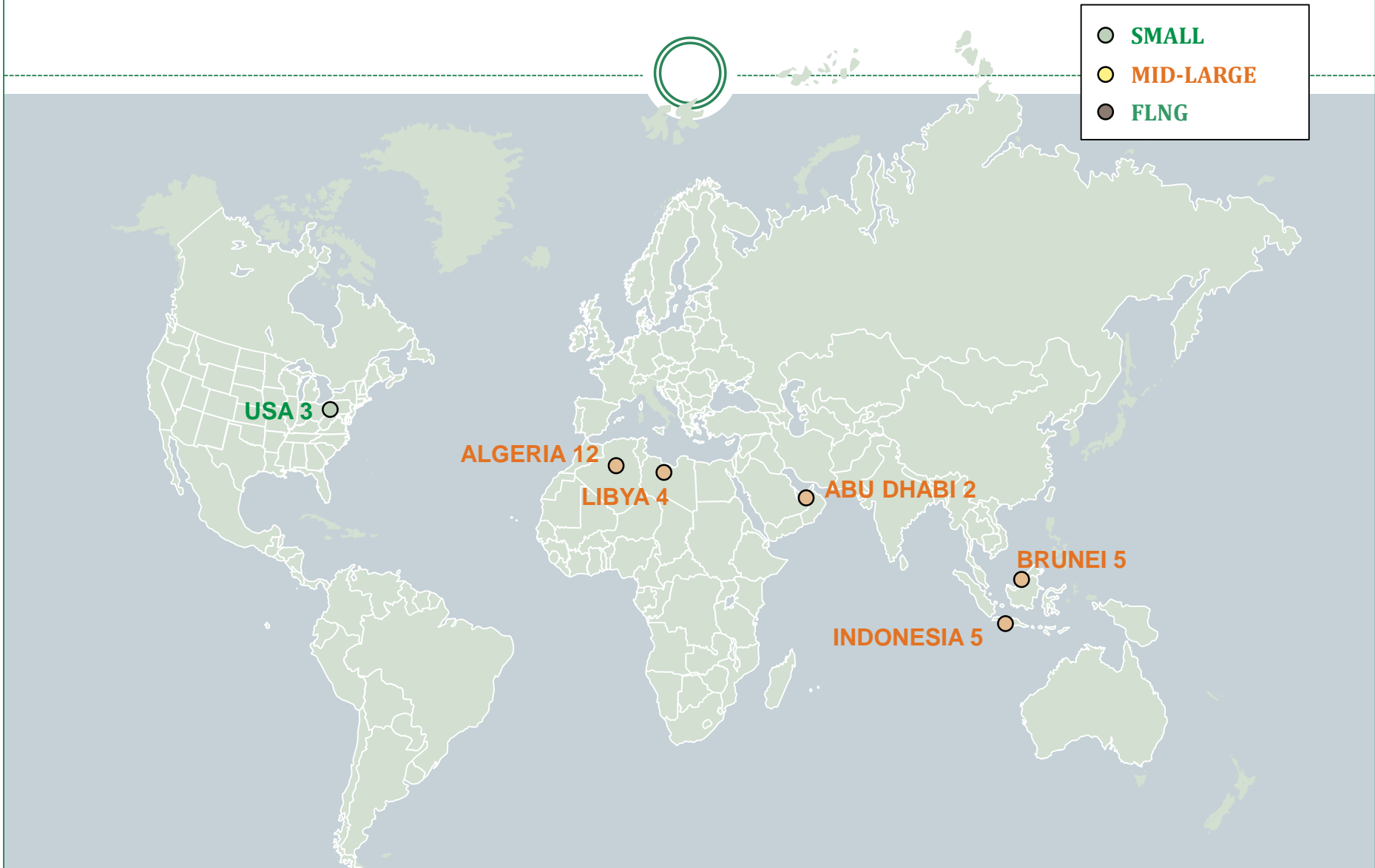
## Taking advantage of Economies of Scale



Image courtesy of Oman LNG

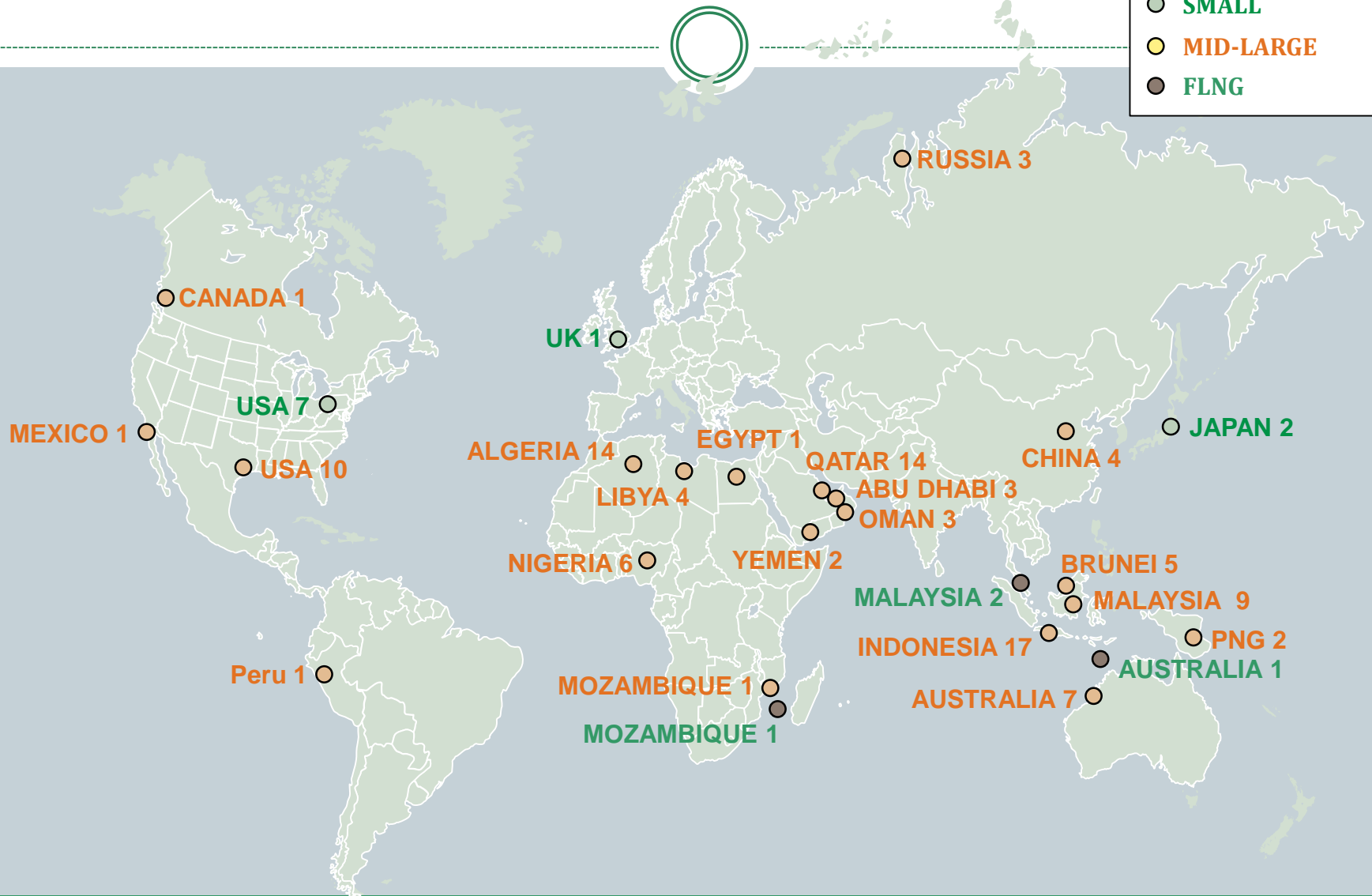
- Large train capacities to take advantage of economies of scale
- Proven technology
- High reliability, high efficiency
- Safety
- Designed for long operating life
- Operate at full capacity

# Air Products' LNG Trains, 1981



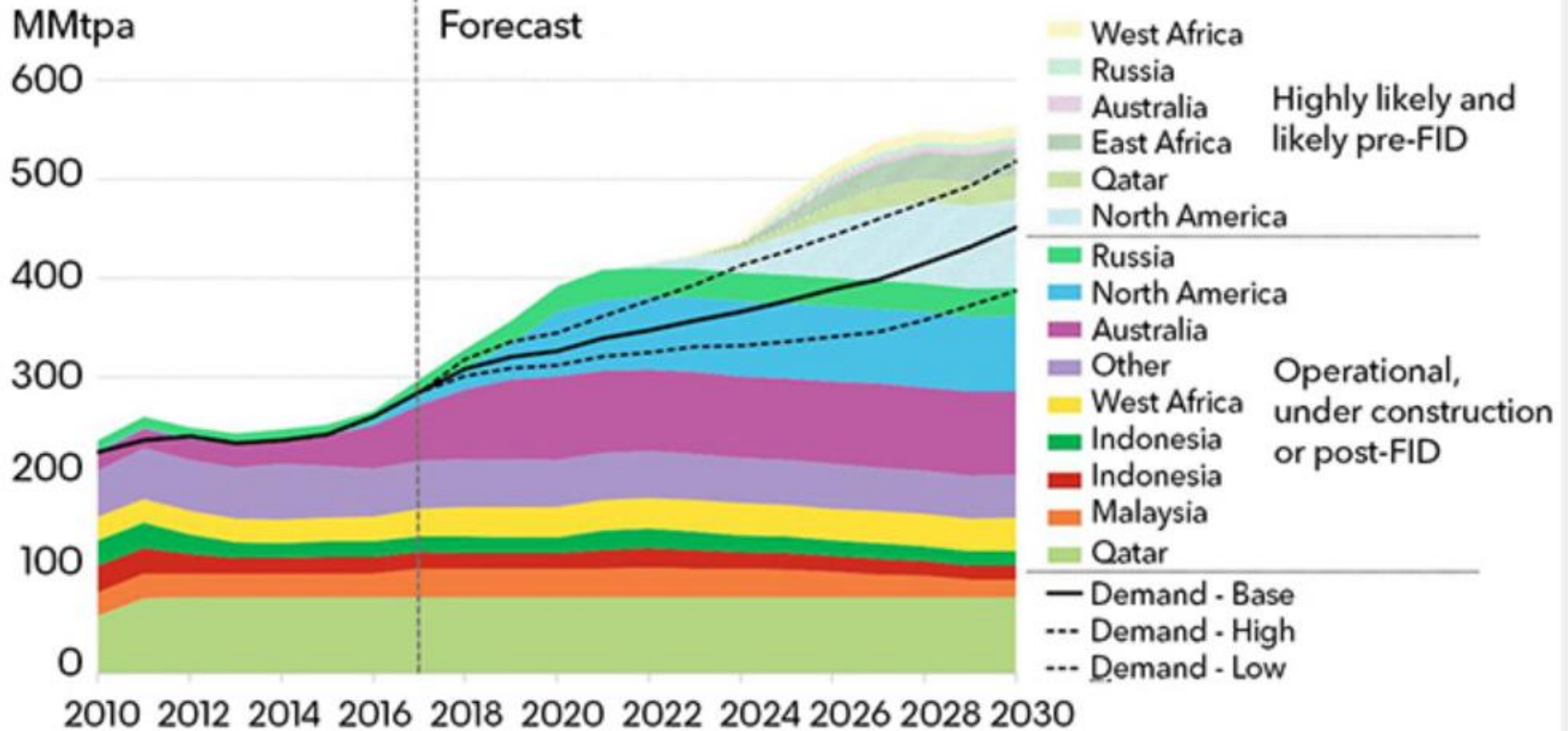
# Air Products' LNG Trains, 2019

(in operation and under construction)



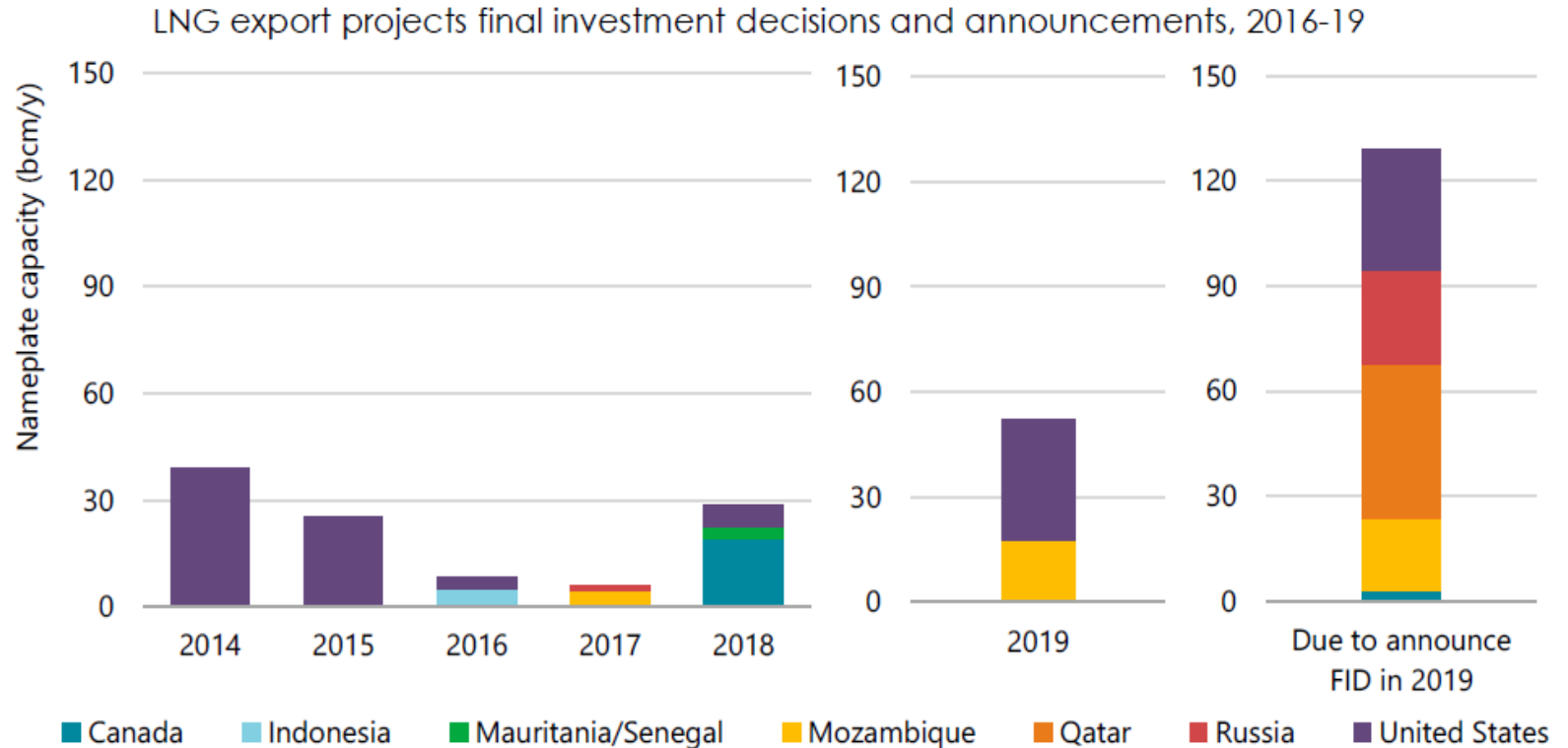
# LNG Supply/Demand Forecast, Sept. 2018

Global LNG demand/supply-capacity balance



Sources: Bloomberg NEF; Poten & Partners; Customs

# LNG Plant Final Investment Decisions



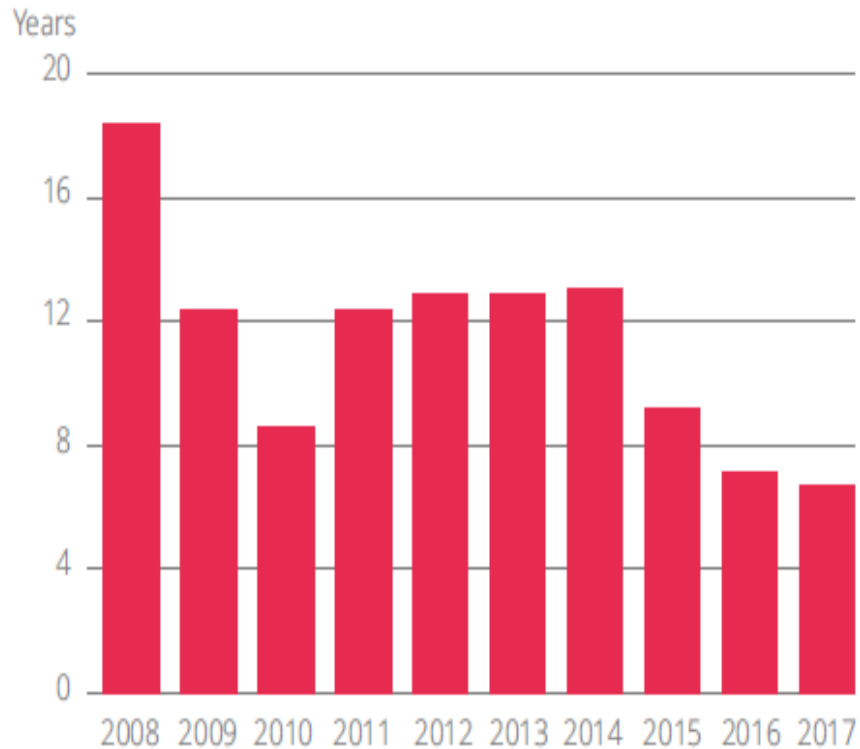
2018 and early 2019 mark a return to LNG investment growth, with a strong list of additional projects announced to take FID in the course of the year.

# LNG Contract Trends

Source: DLA Piper/Petroleum Economist



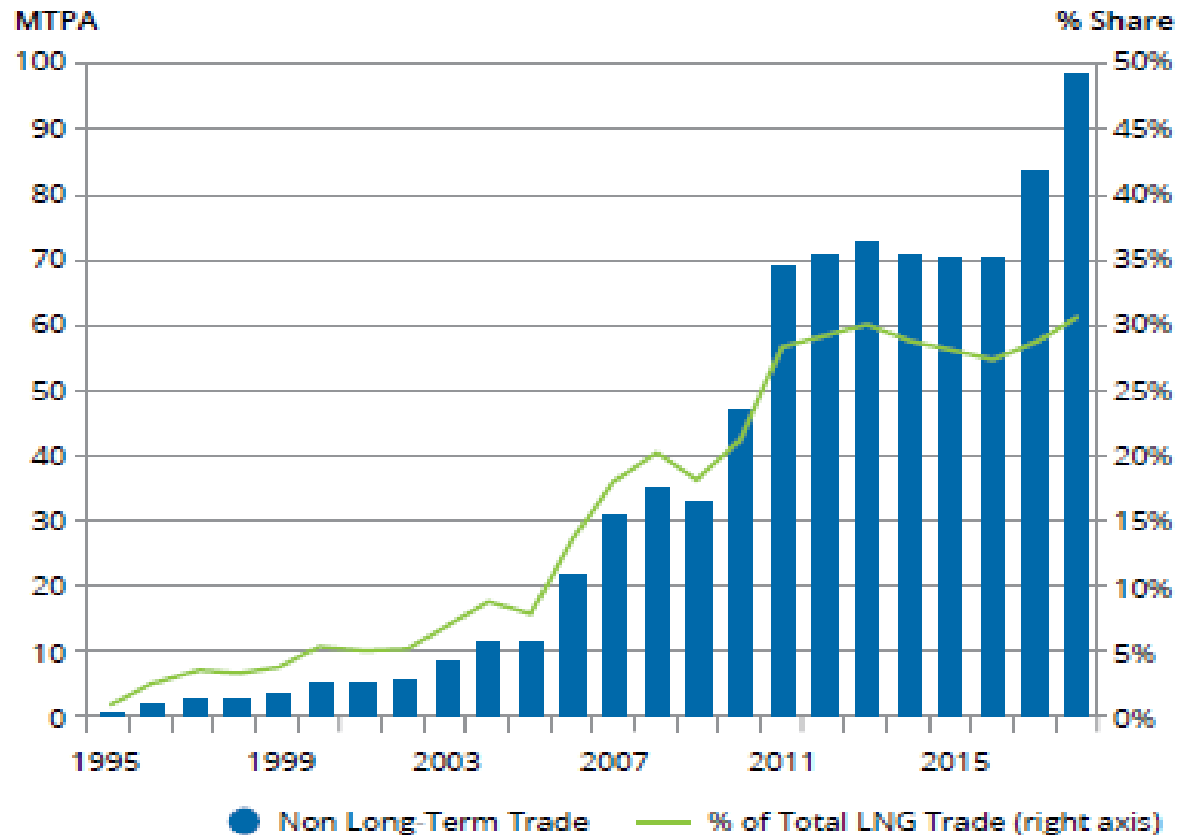
### Average contract length



### Average contract volume



# Increasing LNG trade without long term contracts



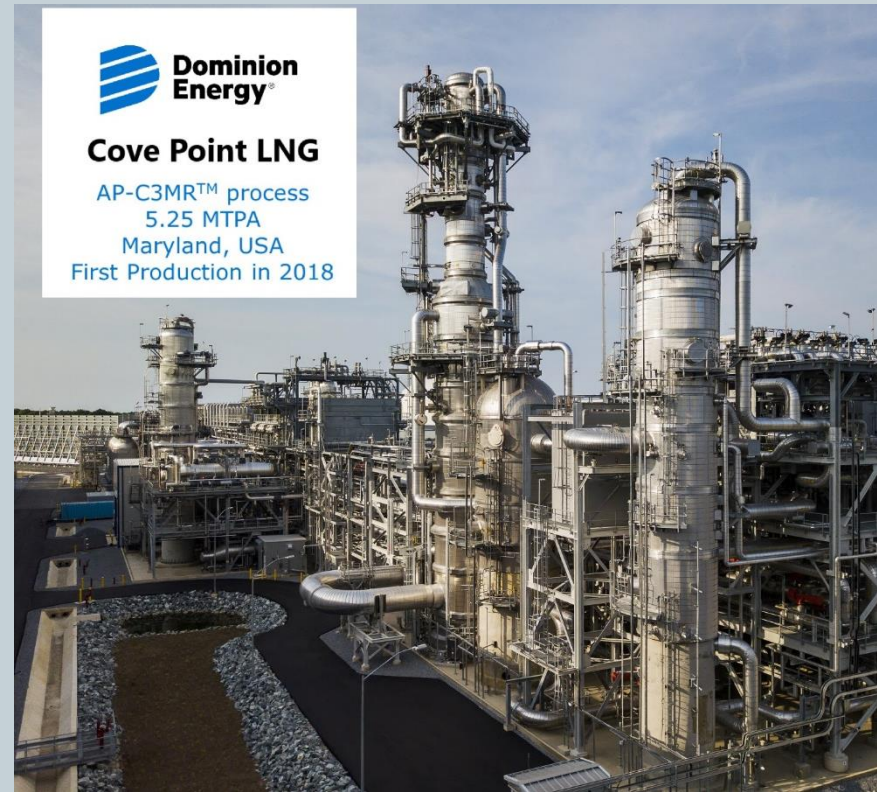
Sources: IHS Markit, IGU



# Emerging factors in response to market changes



- Market risk vs technical risk
- Focus on capital vs efficiency
  - Low initial capital vs lowest evaluated cost
- Multiple smaller trains to match market
- Deep turndown



# Multiple mid-size train option



- Less efficient simpler designs with reduced equipment count per train :
  - Smaller plot per train
  - Lower capital cost
  - Suitable for modularization
- Expedited product demand met with fast onstream times
- Ramped product demand curve closely matched with staged investments
- Less initial financing need

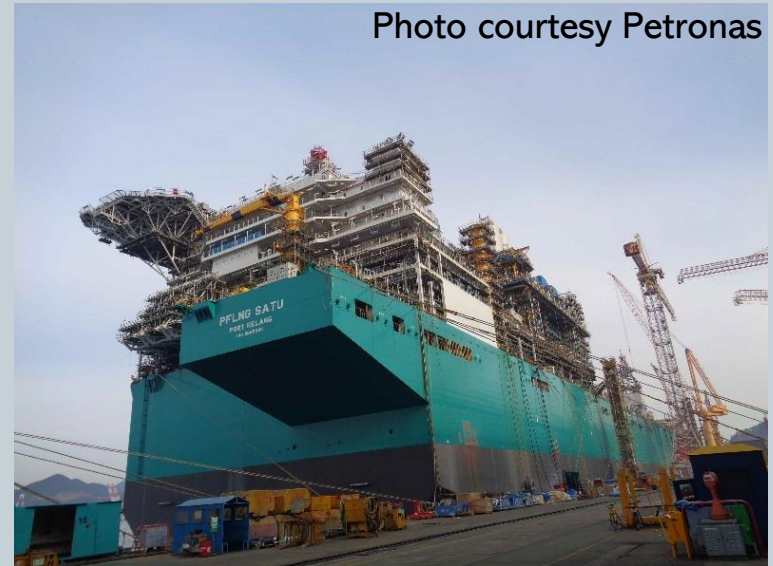


Photo courtesy of Ningxia Hanas Natural Gas Co. Ltd

# Floating LNG Option



- For offshore fields
  - Economic trade-off of pipeline plus land based vs. floating LNG
- Unique design considerations
  - Modular design
  - Ship motion
  - Blast considerations
  - Compact footprint



# Other execution considerations



- Liquefaction Process Flexibility
- Optimal Train Capacity (# trains)
- Parallel trains can improve availability but increase the number of trips/ start-ups
- Parallel equipment (e.g. compression) within the train
- Turndown Considerations
- Modular or stick-built



Photo courtesy Yangling LNG

# Why modularize?



## **1 : Factors Supporting Modularization**

- Safety
- Reduction of field construction time
- Reduced labor costs
- Labor availability
- Weather
- Quality

# Why Modularize?



## **2 : Factors Against (Limiting) Modularization**

- Transportation costs and material – labor and steel
- Transport size/accessibility limitations
- Increased engineering effort
- Schedule

# Why Modularize?



## **3 : Factors Influencing Modularization -**

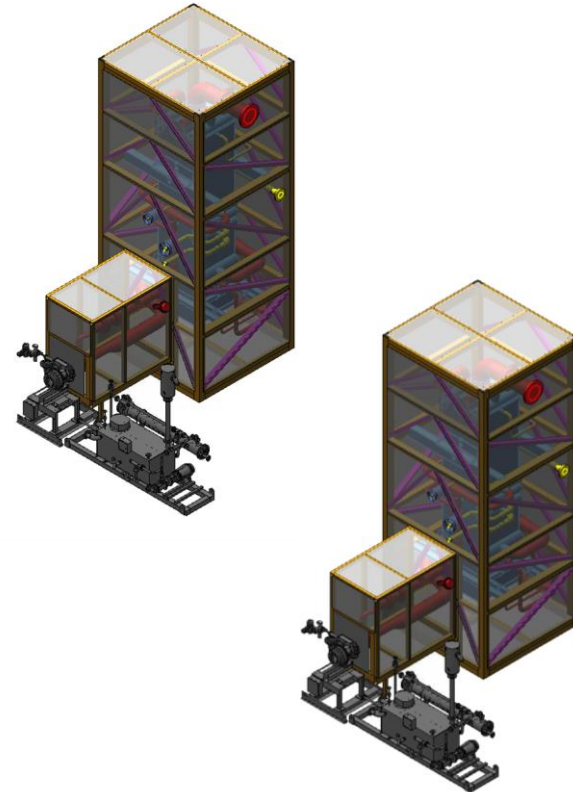
- Plant Location
- Labor Considerations
- Plant Characteristics - size, reuse, complexity
- Environmental and Organizational Factors
- Project Risks

# Additional module benefits through standardization



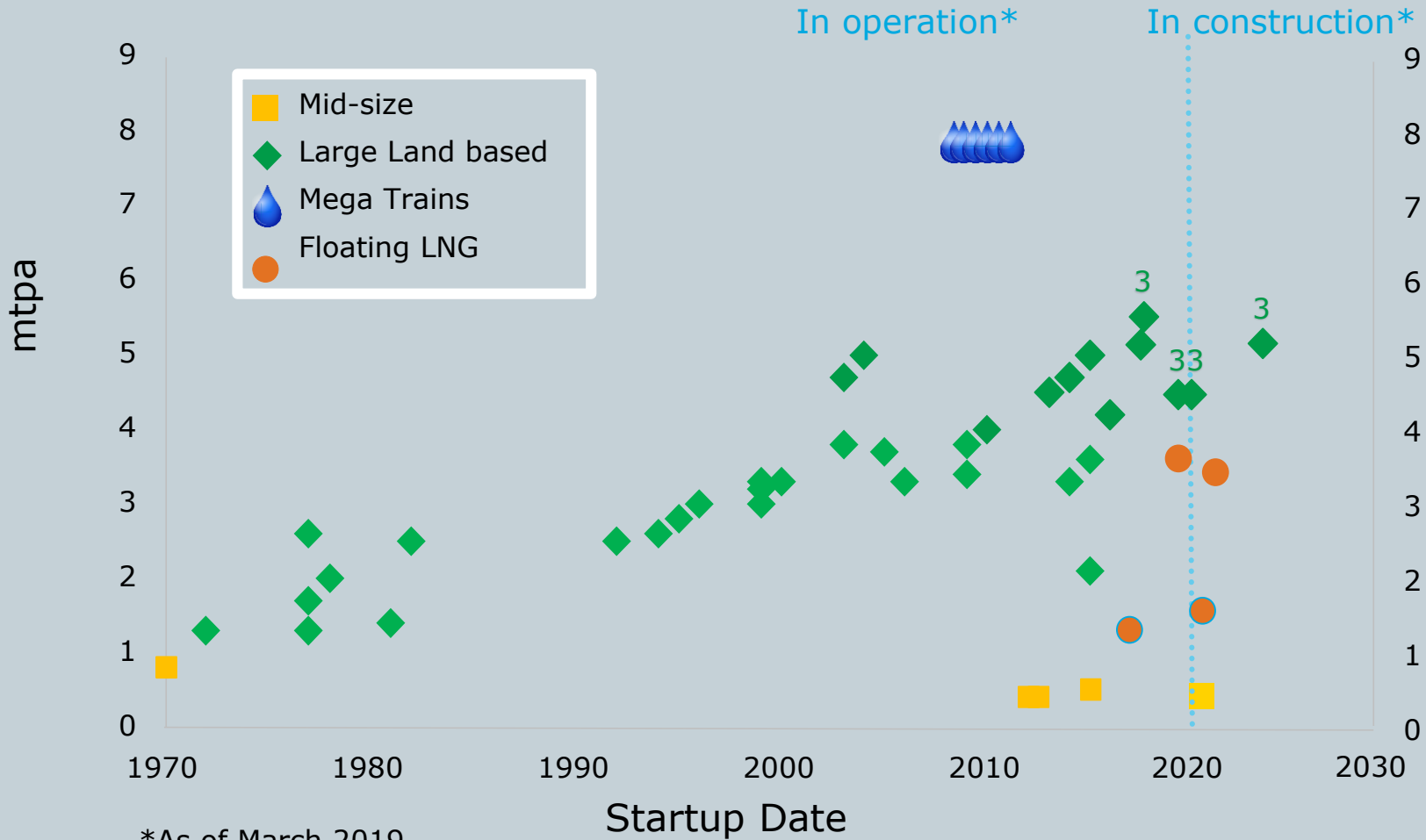
## **Benefits**

- **Shorter Schedule**
  - Design once built many times
  - Design and Procure in advance
  - Parallel engineering
- **Cost Effective**
  - Volume discounts
  - Materials management savings
- **Learning curves in**
  - Fabrication
  - Module Installation
  - Site Construction
  - Commissioning,  
Operations & Maintenance





# LNG Project Evolution



\*As of March 2019

# Factors influencing LNG project development



- NOC's have lost market share as new projects have come on-stream
- Projects going to FID without firm sales commitments
- Tolling arrangements vs long term sale and purchase agreements
- Weak price outlook driving cost cutting
- Political factors