



An International Look at Arctic Energy

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- Extreme climatic conditions –
  - facilities need to be designed for low temperatures & to manage offshore ice
- Locations remote from infrastructure and markets –
  - long distance pipelines usually required
- High development costs –
  - typically 2 x more temperate locations, e.g. US Gulf coast
- Environmentally sensitive region –
  - difficult to permit, e.g. ANWR, Canadian offshore moratorium
- Mega projects require huge economies of scale –
  - e.g. Prudhoe Bay / TAPS, Mackenzie Gas Pipeline Project, Alaska LNG
- Specialist Arctic knowledge required –
  - Aging workforce with experience in Arctic development

# Major Milestones in Arctic Energy Development

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## Canada

- 1<sup>st</sup> oil export using ice breaking tankers - 12 mmbbl of oil was discovered in 1974 at the Bent Horn field on Cameron Island in the high Arctic. 1<sup>st</sup> production achieved in 1985 with oil export to Montreal.

## USA

- 1<sup>st</sup> major onshore oil discovery - 10 Bn bbl of oil was discovered in 1968 at the Prudhoe Bay field on the North Slope of Alaska. 1<sup>st</sup> production in 1977, after the completion of the 800 mile Trans Alaska Pipeline System (TAPS).
- 1<sup>st</sup> offshore oil development – Northstar discovered in 1984, 1<sup>st</sup> oil production in 2001

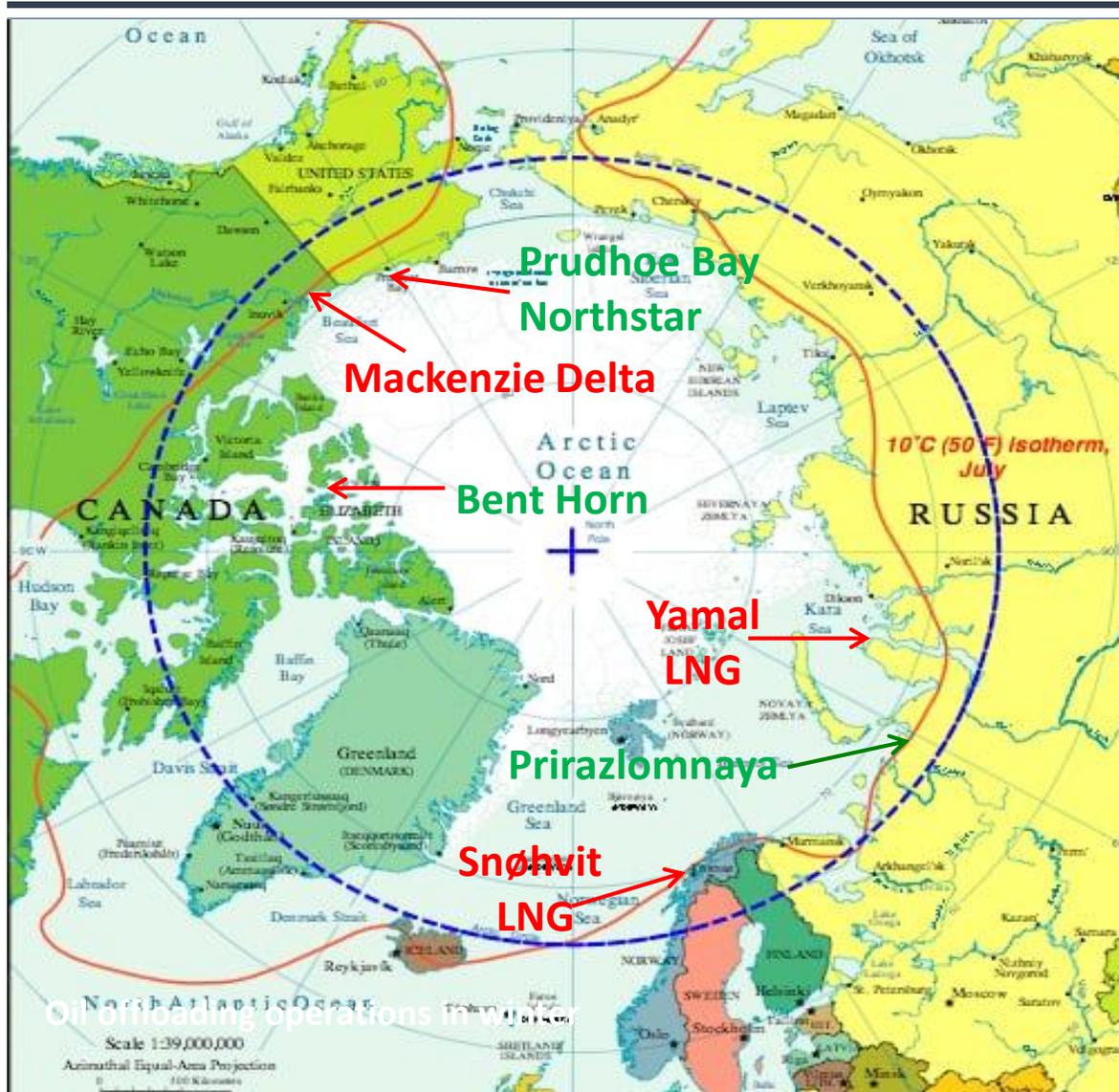
## Russian Federation

- 1<sup>st</sup> offshore oil production – Prirazlomnaya field developed using a Gravity Based Structure (GBS) in the Pechora Sea, startup 2013
- 1<sup>st</sup> LNG export using ice breaking carriers – the 16.5 Mtpa Yamal 1 LNG project in the Kara Sea started up in 2017 with export West to Europe and East through the Bering Sea to Asia.

## Norway

- 1<sup>st</sup> LNG plant built in a shipyard and floated into location, Snøhvit startup 2007
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# Polar Map – of Arctic Oil and Gas projects



## Canada:

- Bent Horn (startup 1985)
- Mackenzie Delta (startup ?)

## USA:

- Prudhoe Bay (startup 1977)
- Northstar (startup 2001)

## Norway:

- Snøhvit LNG (startup 2007)

## Russian Federation:

- Prirazlomnaya (startup 2013)
- Yamal LNG (startup 2017)

Oil offloading operations in winter

# Alaska North Slope - Northstar Offshore Island



# Russian Federation – Prirazlomnaya Gravity Based Structure



# Russian Federation, Yamal LNG 1 Project

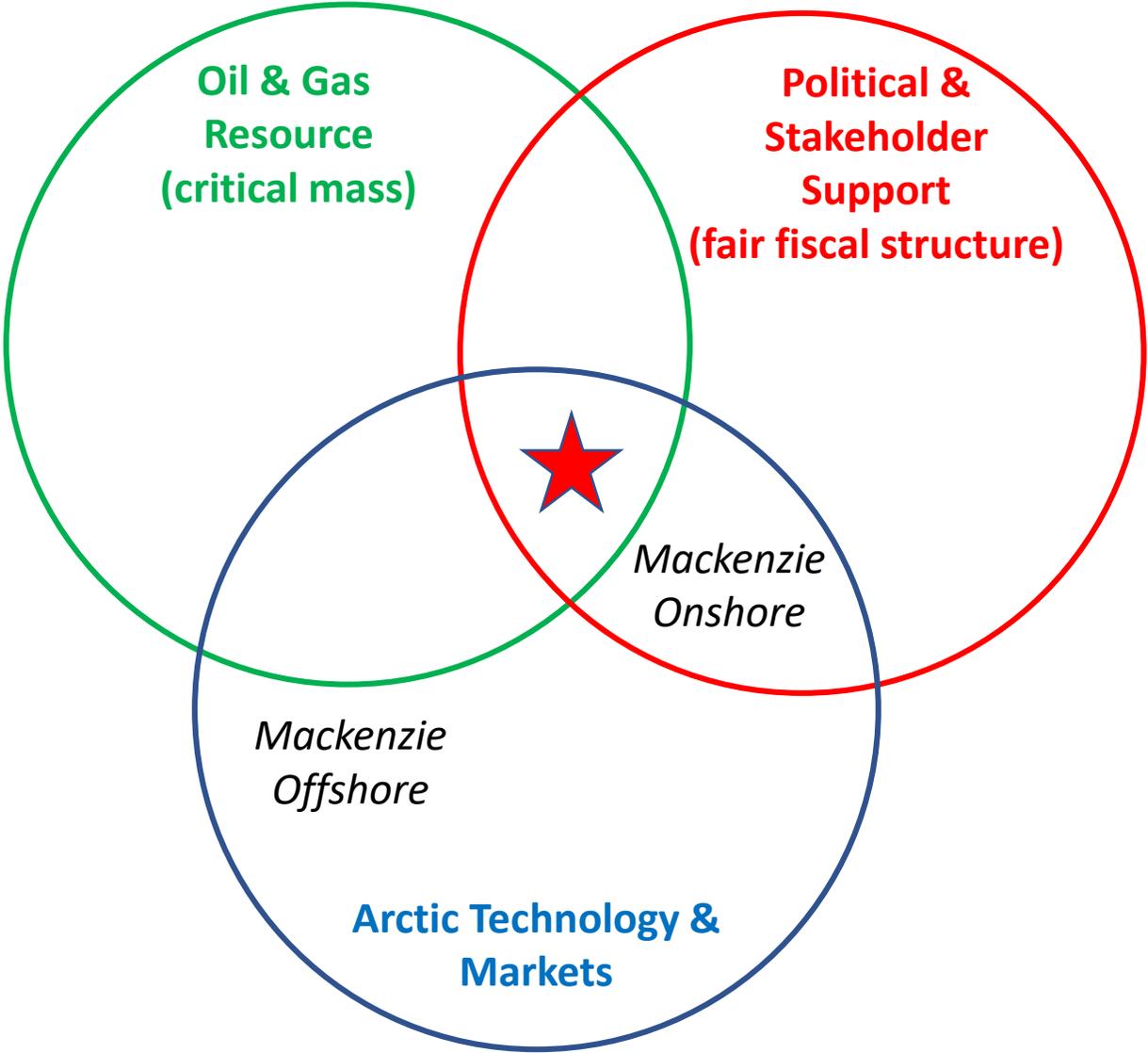


# Norway - Snøhvit LNG Project



**4.3 mmtpa  
Barge mounted  
LNG Plant**

# Keys to Successful Arctic Developments



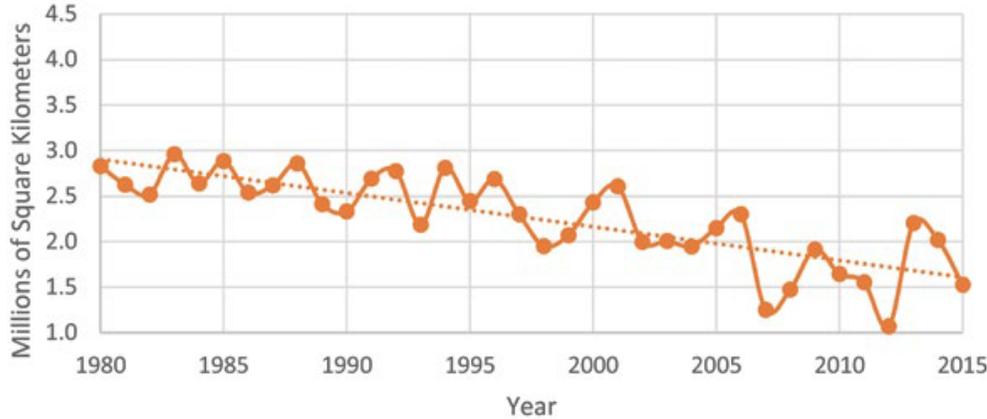
## ***3 major enabling changes:***

1. Climate change has resulted in warmer Arctic temperatures, later freeze up/earlier break-up and reduced multiyear ice in the Beaufort and Chukchi Seas, particularly, since 2006.
2. Floating LNG technology has significantly reduced the cost of liquefaction, particularly in remote areas.
3. The Yamal LNG project in Russia has successfully deployed dual acting ice breaking LNG carriers for use on the Northern Sea Route along the North coast of Russia.

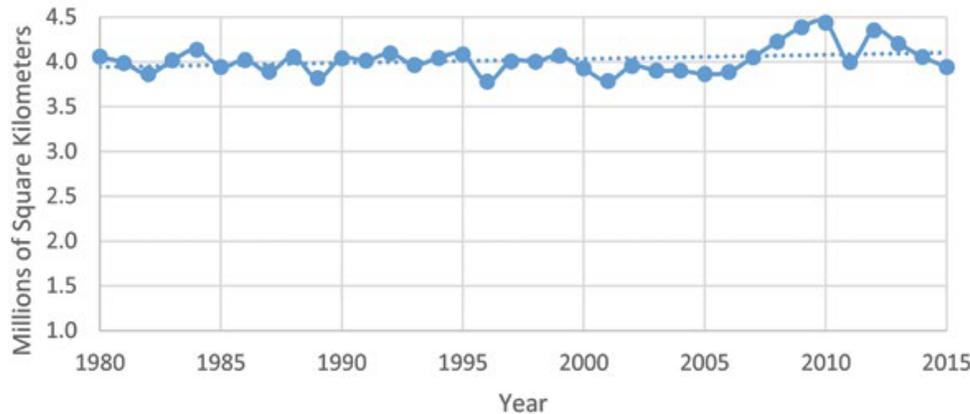
***“A good idea is never lost. Even though its originator or possessor may die without publicizing it, it will someday be reborn in the mind of another”...Thomas Edison***

# Significant Changes in Areal Extent of Sea Ice

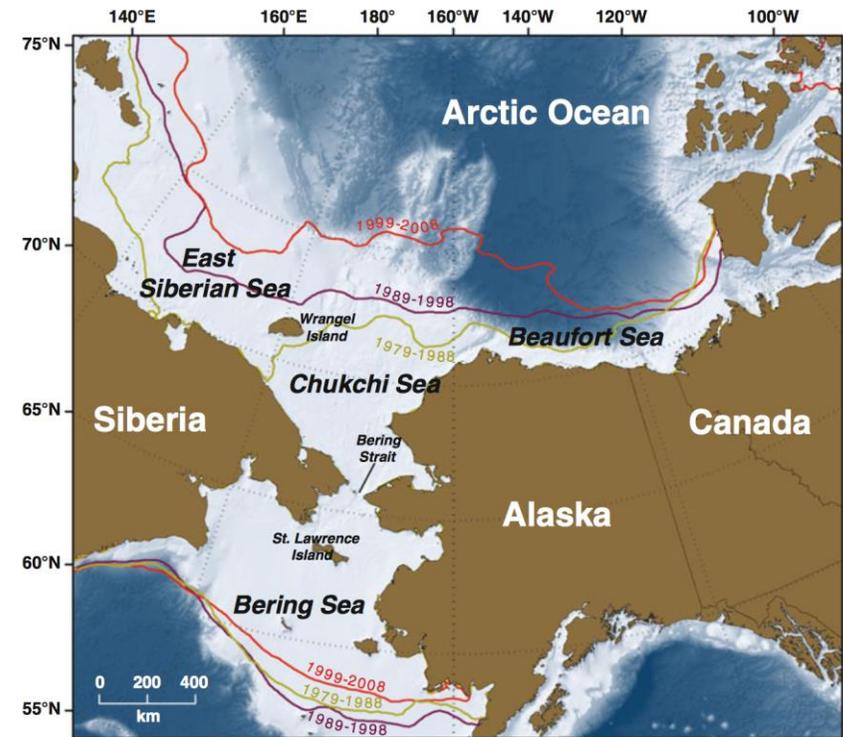
**September 1980-2015**  
Sea Ice Extent in Project Area



**March 1980-2015**  
Sea Ice Extent in Project Area

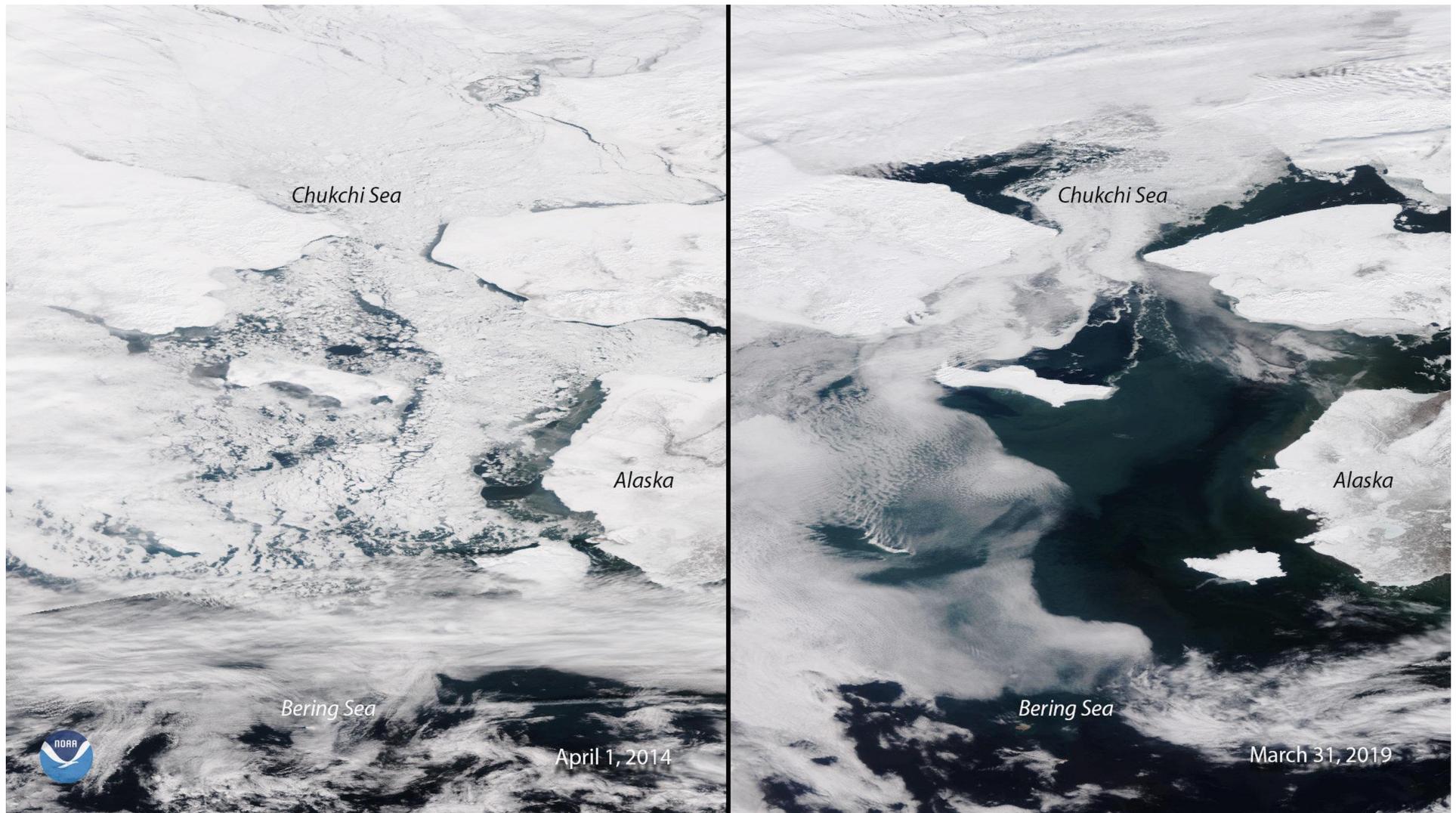


Bering Sea ice is 1<sup>st</sup> year ice that is pushed south from higher latitudes by winds. Translating into less change to the sea ice max extent that occurs in March while Sept. sea ice extent has decreased.



**Fig. 3.1** Location of the Pacific Arctic Region (PAR). Isolines (based on SMMR and SSM/I sea ice concentrations) indicate the position of the median sea ice edge (defined by a 15 % sea ice concentration threshold) for 1979–1988, 1989–1998, and 1999–2008 during both March (southern isolines) and September (northern isolines)

# Change in Bering Sea Ice – March 31<sup>st</sup> 2014 and 2019



# Floating LNG Vessel Advantages

- Constructed under controlled conditions in a shipyard
- Gas resource can be developed in phases
- 23 FLNG units are expected to receive funding over the 2018-2024 period



Shell Prelude FLNG - Australia



Hilli Episeyo - Cameroon



Yamal 2 LNG with Gravity Based Structures

# LNG Shipping Solution for Arctic Waters



Christophe de Margerie LNG Carrier



- Russian Register Arc7 ice-class standard Dual Acting LNG Vessel for Yamal LNG Project - *Equivalent to a level between Polar Classes 3 and 4*

- Large proven volumes of stranded gas – lack of a competing domestic market means that the gas is available at a relatively low price
- Geographical location close to Asian markets – shorter shipping distances, avoid Panama Canal fees
- Low cost gas and low shipping costs offset higher project development costs

## **Prerequisites:**

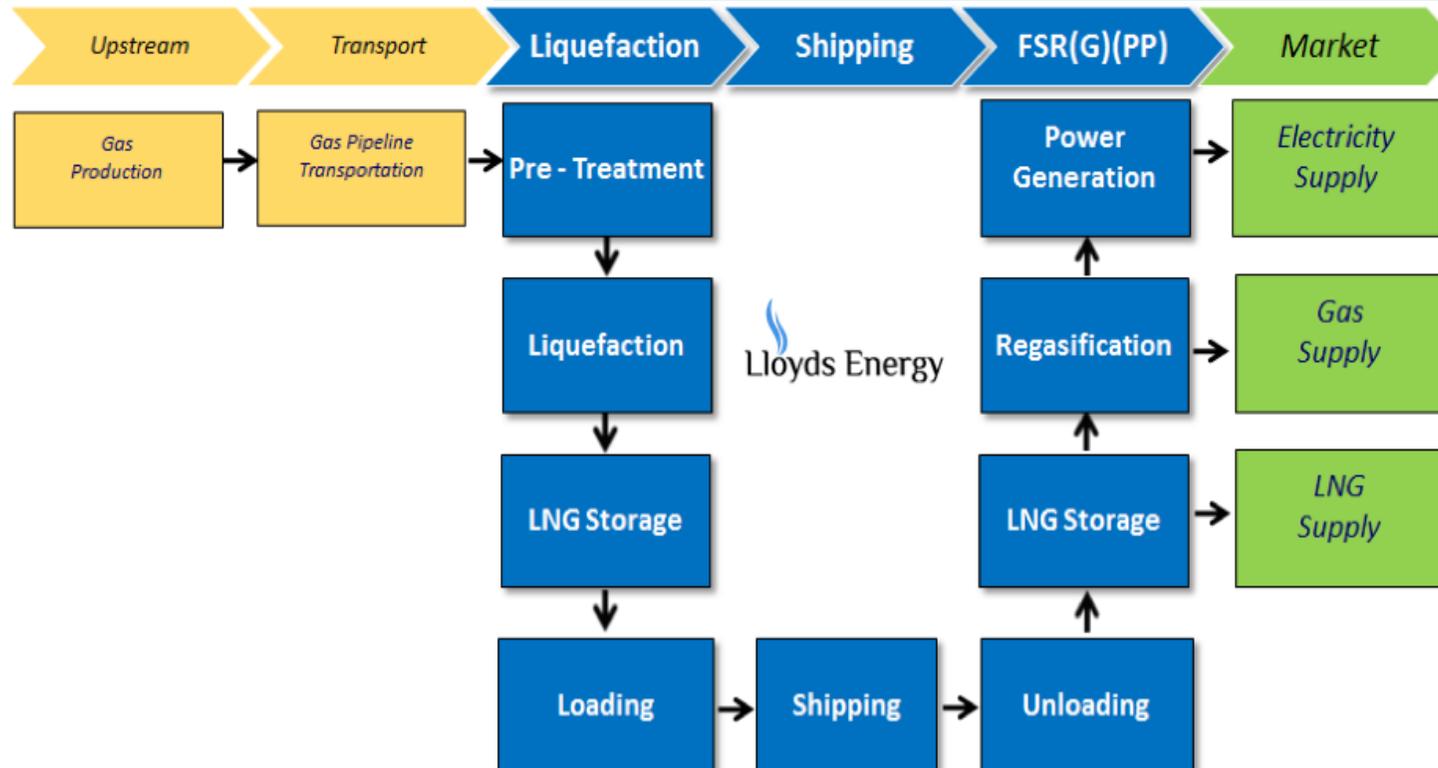
- Prove that development can be done safely and in an environmental sensitive manner
- Preservation of traditional subsistence lifestyle – food security
- Fair division of revenue between the Local, State and Federal governments, gas resource owners, and project developers

*Develop a globally competitive, innovative and environmentally sensitive LNG production and export project, the 1<sup>st</sup> in the North American Arctic, to monetize the vast natural gas resources in the Mackenzie Delta region, for the benefit of the Beaufort Delta region, Northwest Territories, Canada and the gas resource owners.*

# Integrated LNG Supply Chain Business Model



## LLOYDS ENERGY BUSINESS PORTFOLIO



# Arctic LNG – A Proven Concept

- Significantly reduced shipping cost to Asian markets vs Gulf Coast (even with ice breaking)
- Yamal LNG is already operating in these conditions, with more extreme routes
- Yamal is selling into Asian markets at a significant discount to US Gulf LNG
- Yamal LNG is a 2,600 mile trip from Yamal to the Bering Strait (where sea ice dissipates), whereas Qilaq LNG would be only 600 miles

