KUALA LUMPUR 2012 WORLD GAS CONFERENCE

25th world gas conference

"Gas: Sustaining Future Global Growth"

Arctic LNG Industry Development:

Overcoming Regional Challenges

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Date:

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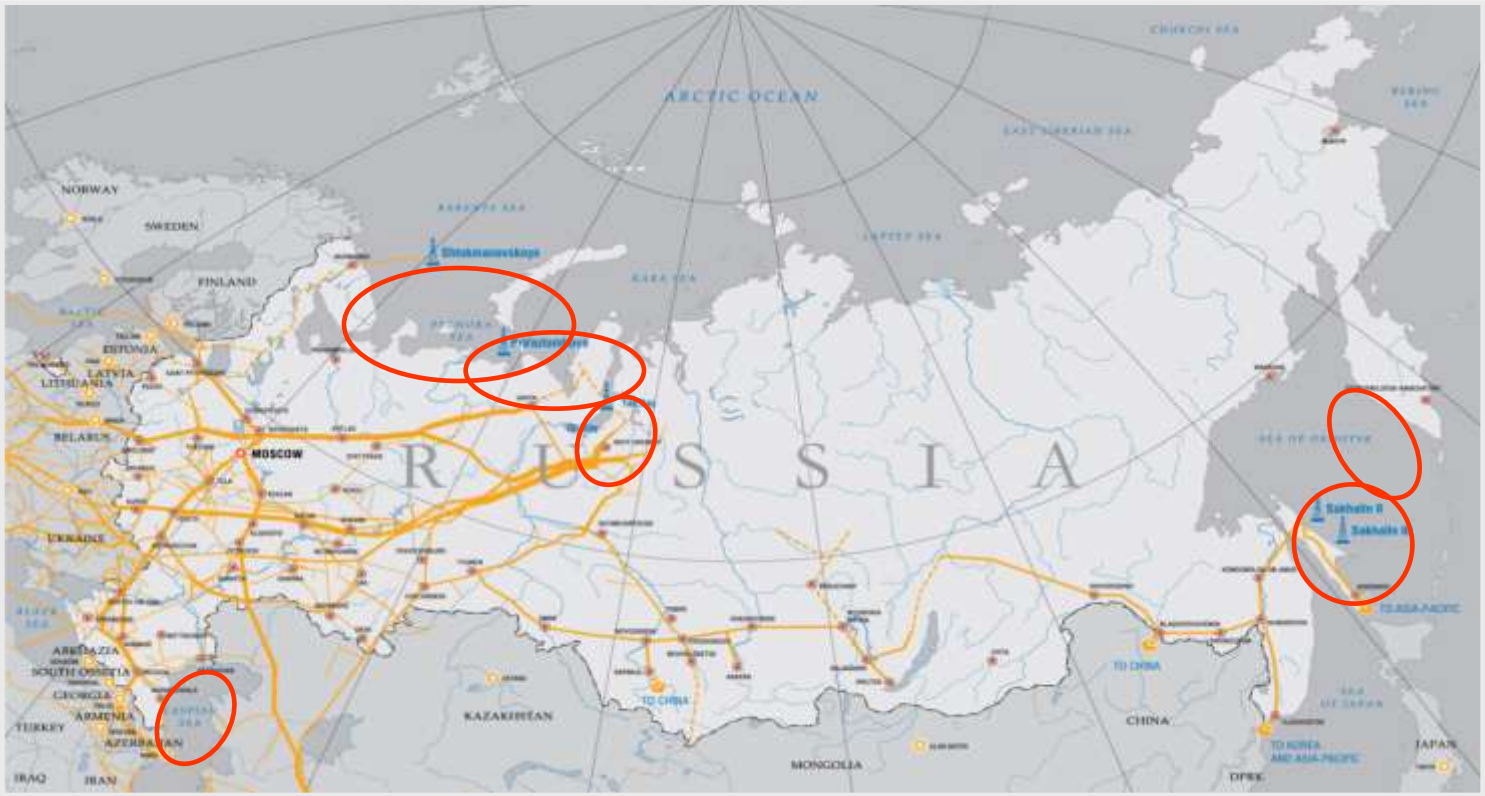
Arctic continental shelf – unique source of hydrocarbons

- Arctic region is known for very high prospects of new hydrocarbon resources
- High oil and gas prices, and the increase of fossil fuel consumption reawakened interest the North's vast oil and gas potential
- Some regions of the Arctic are particularly interesting in terms of perspective oil and gas production

Russian continental shelf



- Natural gas accounts for 80% of Russia's total offshore resources
- 70% of Russia's offshore resources are concentrated in the Barents, Pechora and Kara Seas
- Natural gas and condensate prevail in the Barents and Kara Seas, while oil – in the Pechora Sea

Key Challenges of the Arctic Continental Shelf

Natural and climatic conditions:

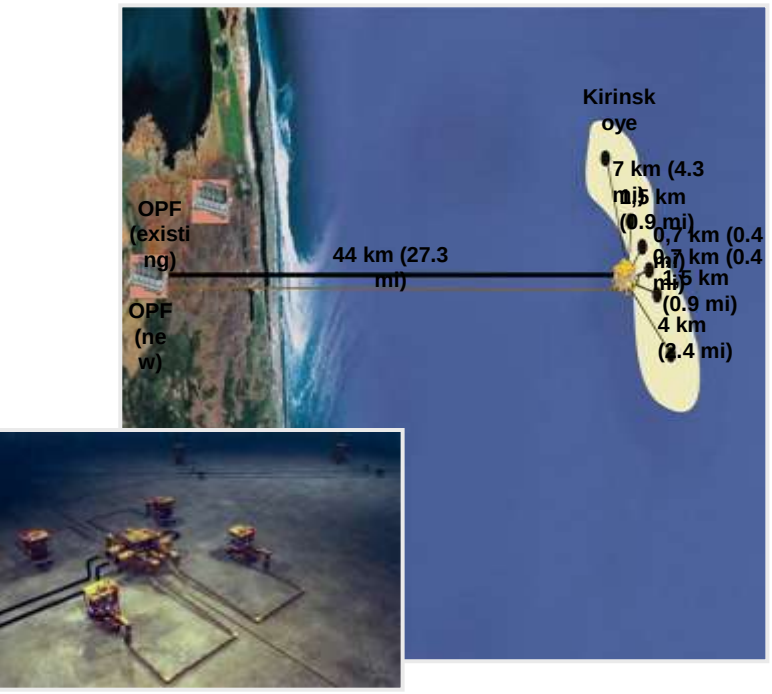
- Low temperatures and their seasonal variations
- Limited visibility because of fogs and precipitation
- Many days with stormy weather
- Favorable conditions for ice formation on engineering installations, especially in October-December
- Low water temperatures, especially near the sea bottom
- Considerable high and low tides, variations of sea currents speed, accompanied by substantial run-ups and roughness
- Drifting ice cover and its considerable variations
- Icebergs, ice hummocks, ice fields
- Seabed exaration

Environmental aspects

The concept of offshore oil and gas developments must be accompanied by an adequate environmental policy aimed at preserving the natural environment

- eradication, change and fragmentation of natural ecosystems
- cryogenic erosion as a result of eradication of natural plant formations
- invasion of alien plants and animals and displacement of endemic species
- damage of boicentric structure and disturbance of nutritive bas of plants and animals due to various types of pollution
- disturbance of migrations and wintering of animals

The usage of subsea production systems



The benefits of subsea production units in the Arctic conditions include:

- high reliability, the possibility of remote control and management,
- efficient repair ability due to their module based construction,
- ability to provide unique capabilities for defense from ice formations and icebergs.
- remove the necessity for the long presence of operational personnel on the remote sea oil and gas production units - the lesser personnel are involved in working in the Arctic harsh conditions the lesser is the risk of accidents, traumatism and injuries.

The choice of liquefaction technology

The design and construction of LNG plants which will operate in Arctic conditions should be in line with the following peculiarities:

- Low temperatures which may be used for the cooling of refrigerant after compression;
- The big difference in temperatures, the gap between summer and winter maximums and minimums may reach 40-60 ° C;
- Very limited experience of large scale LNG production in Arctic conditions. Among all world LNG plants there are only 3 which are working in the Arctic: one in the USA in the state of Alaska, one in Norway on Melkoya island and the one in Russia on Sakhalin island;
- The remoteness of transport networks and production infrastructure.

LNG technology evaluation for Arctic

CRITERIA	PROPANE PRE-COOLED MIXED REFRIGERANT		DUAL FLOW MIXED REFRIGERANT		MIXED FLUID CASCADE
PROCESS	C3MR	AP-X	DMR	PMR	MFC
LICENSOR	APCI		SHELL (NOT COMMERCIALLY AVAILABLE)		LINDE
REFERENCE IN ARCTIC CLIMATE	NONE		1 (SAKHALIN)		1 (SNOHVIT)
MAXIMUM TRAIN SIZE, MTPA	5	9 (10)	8	Более 10	Более 12
DESIGN FLEXIBILITY	LOW	MODERATE	MODERATE		HIGH
OPERATIONAL FLEXIBILITY	LOW		MODERATE TO HIGH		HIGH
PROCESS EFFICIENCY, KWH/T LNG	260		Примерно 250		245
SIMPLICITY OF OPERATION & ROBUSTNESS LOW CAPACITY END/HIGH CAPACITY END NUMBER OF MACHINERY CASING (LOW/HIGH END)	BEST/WORSE 3 / 9		GOOD/GOOD 3 / 5-6		GOOD/BEST 4 / 4-5

Snohvit LNG plant, Norway

- Start up in 2007
- MFC process
- One line capacity of 4.3 mtpa
- Up to 109 % load achieved
- No operational flaring after initial start-up phase (re-condensation system)
- All electric drive
- Record specific energy consumption of 243 kWh/t

Sakhalin LNG plant, Russia

- Start up in 2009
- DMR process
- Capacity 2x4.8 mtpa
- Up to 104 % load achieved
- Good operational flexibility and reliability

The usage of Arctic class LNG tankers

- **The usage of LNG tankers** which are designed for operations in the Arctic region is another important factor for the development of Arctic LNG projects
- So far there are only light ice class LNG tankers which are not designed to overcome heavy ice. Usually those LNG tankers require help of icebreakers.
- The development of new LNG projects in the Arctic Ocean requires the creation of new LNG tankers which will be capable to deliver LNG throughout the whole year from such remote locations like Yamal peninsular.
- The facilities for the crew should be exceptionally well designed to meet those challenges.

Arctic class LNG tankers development

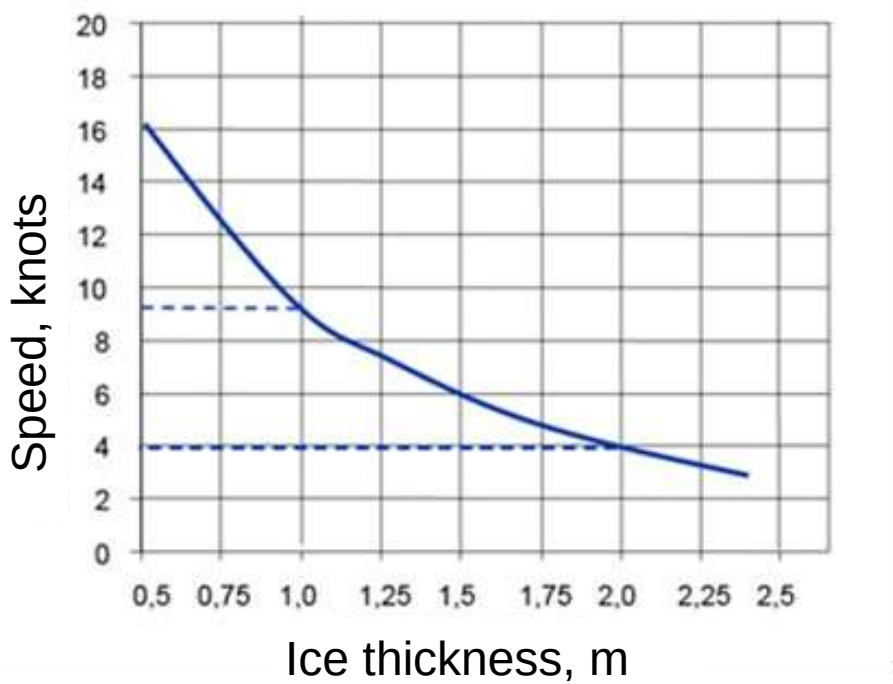
Country	Years of engineering and construction			
	1969-1984	1985-1999	2000-2009	After 2010
Sweden	SCF Arctic, SCF Polar, Kockums, 1969			
Norway				Arctic Shuttle, Aker Arctic
Japan			Arctic Princess, Arctic Lady, Grand Elena, Grand Aniva, Mitsubishi, 2006	
		Polar Eagle, Arctic Sun, IHI, 1993	Arctic Discovery, Grand Mereya, Mitsui, 2006	
			Arctic Voyager, Kawasaki, 2006	
Korea			M-Flex, Samsung, после 2009	Arctic-S, Samsung
				Arctic-D, Daewoo

Arctic shuttle LNG tanker concept of Moss Arctic Shuttle

Arctic LNG tanker concept of Kvaerner Masa

Some peculiarities of LNG transportation in Arctic

Speed in ice for Arctic LNG tanker Polar20 class (Capacity 50 MW, L ~ 274 m, B ~ 45 m, T ~ 10.5 m). DNV calculations



Electric pod drive

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