TOTAL Operations in Hostile environment: Arctic Operations

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TOTAL Operations in Arctic
TOTAL Operations in Arctic: **Majors in the Arctic**

- **Gas**
  - Timan-Pechora (Russia)
  - West Siberia (Russia)
  - Arctic Canada
  - Sakhalin (Russia)
  - Sakhalin 1
  - Sakhalin 2 (LNG)

- **Oil**
  - Cook Inlet (US Alaska)
  - North Slope (US Alaska)
  - Prudhoe Bay, Kuparuk River, Colville River
  - East Coast (NE Canada)
  - Hibernia
  - Sable Island (HMDC)

**Source:** Wood MacKenzie – Pathfinder – Mars 2010

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**TOTAL’S ACTIVITIES IN CONDITIONS OF EXTREME COLD OVER THE PAST 40 YEARS**
TOTAL Operations in Arctic:

- **Shtokman**
  - Total 20%, Gasprom 75%
  - Participation since 2007
  - Ph-1 Plateau: 23.7 bcm/y

- **Shushki**
  - Total 16.8%
  - Gas production: mid 2007
  - Europe’s first LNG plant
  - World’s longest (145 km) multiphase pipeline
  - Plateau: 5.8 Gt/y/year

- **Termokarst**
  - Total 49%
  - JV with Novatek 51%
  - Field potential: > 47 bcm gas + 10 million tons of condensate.
  - 1 well drilled in 2010, 4 in 2013

- **Kharagash**
  - Total 16.4%
  - Phase 1 Development in progress
  - 300 kbar production
  - Production start-up: 2013
  - 01 Plateau: 1.5 MMboe
  - H2S 15%

- **Kharalmyk**
  - HOA signed with KazMunaiGas to develop the Kharalmyk gas and condensate field:
    - Lukoil 50%, operator
    - KazMunaiGas 25%
    - Total 27%
    - GdF-Suez 8%
TOTAL Operations in Arctic:

**Snøhvit**
- Three fields: Snøhvit, Albatross, and Askeladd
- Statoil (33.53%), Petoro (30%), Total (18.4%), GdF (12%), Amerada Hess (3.26%), RWE (2.8%)
- A 145-kilometer pipeline for gas to Melkoya Island: processing, liquefaction, storage and loading facilities
- CO₂ content: 5.3% Snøhvit, 7.9% Albatross
- CO₂ from the Snøhvit reservoir separated onshore, piped back offshore and injected into a water-bearing reservoir
- Europe’s first LNG plant: 4.2 Mt/y prod
- Temperature range: -18°C / +22°C

**Kharyaga, the Timan-Pechora basin**
- Located in Timan Pechora, in the Nenets autonomous district 60 km north of the Polar circle
- 1st onshore PSA signed in 1995
- Total operator (40%), Statoil (30%), Zarubezhneft (20%), Nenets OC (10%)
- Complex carbonate reservoirs
- Waxy oil, with high pour point (+29°C), with H₂S content
- Production: 30 000 bopd since end of 2009, never stopped for 12 years
- Phase 3 development in progress, production kept at 30 000 bopd, stop flaring gas sold to Lukoil

Experience on:
- Permafrost engineering and operation
- Working Conditions:
  - -53°C absolute minimum temperature
  - Temperatures range from +20°C to -50°C
  - Important wind (annual mean 4.2 to 6.1 m/s with a winter variation from 18 to 24 m/s)
TOTAL Operations in Arctic: Kharyaga experience

- Rig & Equipment winterization
- Limited number of drilling pads with highly deviated wells reaching up to 3 km of total departure ➔ Limited footprint and environmental impact
- All installations built on piles anchored in the permanently frozen layers

TOTAL Operations in Arctic: Kashagan – Kazakhstan

- Operated by North Caspian Operating Company (NCOC): KMG (16.8%), Total (16.8%), ExxonMobil (16.8%), ENI (16.8%), Shell (16.8%), ConocoPhillips (8.4%), Inpex (7.5%)
- Development in a water depth of 2 to 9 m, reservoir at 4,000 m, high pressure (800 bar), high level of H2S
- Phased development:
  - Phase 1 - planned in the eastern part of Kashagan (plateau 300 kb/d)
  - First oil: 2013
  - Full field development - cumulated production: above 10 Gbo over 40 years
TOTAL Operations in Arctic: Yamal LNG

- Project operator: Yamal LNG
  Novatek: 60% - TOTAL: 20% - CNPC: 20%
- Extremely harsh Arctic environment
- LNG plant built on permafrost
- LNG plant capacity: 3 x 5.5 Mt/y
- Fleet of 16 ice-class LNG carriers
- Drilling more than 200 wells
- Very important support from Russian Authorities:
  - Tax breaks and financing of marine infrastructures
  - Promote Russian and local content
  - LNG sales (70% already marketed)

Target first LNG end 2017
TOTAL Operations in Arctic: Extreme Cold Challenges

- Essential to preserve the environment in a sensitive ecosystem
- Extreme weather conditions:
  - Sea Ice and Icebergs
  - Icing
  - Polar night
  - Low temperatures
  - Permafrost area
  - Strong winds
- Winterization (snow, icing, wind...)
  - Construction, Installation & process integrity
  - Personnel protection
- Remoteness - Transportation of personnel and equipment
- Escape, Evacuation and Rescue
  - Different environments: wave and ice
  - Offshore: floating platform too far from shore for evacuation by helicopter,
  - Onshore: ice road vs helicopter but seasonal restrictions...

TOTAL Operations in Arctic: Outside working conditions

<table>
<thead>
<tr>
<th>Location</th>
<th>Lowest T (°C)</th>
<th>Wind (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snøhvit</td>
<td>-18</td>
<td>Mean: 7</td>
</tr>
<tr>
<td>Kashagan</td>
<td>-40</td>
<td>24</td>
</tr>
<tr>
<td>Khariaga</td>
<td>-53</td>
<td>Mean: 5 Max: 38</td>
</tr>
<tr>
<td>Shtokman</td>
<td>-40</td>
<td>28</td>
</tr>
<tr>
<td>Yamal</td>
<td>-57</td>
<td>Max: 32</td>
</tr>
<tr>
<td>Termokarst</td>
<td>-55</td>
<td>-</td>
</tr>
</tbody>
</table>

Changing conditions during the year: how to operate efficiently and safely while mitigating costs?
TOTAL Operations in Arctic: Care for sensitive environment

- Major natural reserve / wildlife refuge
- Migration zone, reproduction area
- Indigenous population: Living areas, Traditional lifestyle
- Sensitive ecosystems & marine mammals \(\Rightarrow\) Zero harmful discharge

TOTAL Operations in Arctic: Extreme Cold R&D focused on 4 areas

Specific program launched in 2008

- Health & Safety
  - Development of new solutions to protect / facilitate work
  - Define logistics rules adapted to each area of concern
- Engineering & technology
  - Ice action on performance & safety
  - Adequate monitoring technologies for environment & safety
  - Gap analysis of existing technology vs needs
  - Innovation for building design & ventilation
- Environment
  - Adaptation of techniques for a Zero harmful discharge policy
  - Prevention, early detection & remediation of HC’s spill (under ice, thaw/frost...)
- Standards harmonization
  - Development of general guidelines for safe production in Arctic waters \(\Rightarrow\) ISO/TC67/ SC 8 Arctic Operations & ISO/TC 67 offshore structure
TOTAL Operations in Arctic: Extreme Cold Activities

TARGET: Anticipate needs and work on innovative solutions

R&D

Projects

- Health, Safety & Environment
- Ice management
- Materials
- Drilling
- Pipelines
- Feedbacks & Scouting
- Operations
- Shipping

Kharyaga
Joslyn
Termokarstovoye
Onshore 2030
Bazhenov
Yamal
Kalamkas
Shтокman
Offshore 2030
Kara

TOTAL Operations in Arctic: Permafrost

- Definition
- Permanently frozen soil
- Classification solely based on temperature (<0°C for at least two years)

- Distribution
  - 63% of Russian territory
- Thickness range
  - Up to 300 m in Khariaga
  - Up to 500 m in Yamal
- Properties (depend on a given territory)
  - Distribution category
  - Depth of layers
  - Structure
  - Ice content
  - Water content and salinity
  - Temperature distribution
  - Subsidence
TOTAL Operations in Arctic: Permafrost and soil instabilities

- Impact on onshore & nearshore installation construction
- Need of data acquisition and soil characterization

Marine Transgression

Onshore Time Offshore

TOTAL Operations in Arctic: Environmental and societal challenges & studies

- Flora and fauna:
  - Important international natural reserve and wildlife refuge with protected flora and fauna species
  - Migration zones & reproduction areas
  - Low recovery factor

- Prevention, detection & Remediation of any pollution

- Online recording of molluscan bivalve behavior in Dalnie Zelentsy able to detect abnormal event such as pollution

- Risk evaluation of anthropogenic/ Norm pollutants
TOTAL Operations in Arctic: Arctic LNG carrier

It’s an High Ice-Class Double-Acting LNG Carrier

Ahead first in open water and light ice condition

Astern first in hard ice condition

TOTAL Operations in Arctic: Arctic LNG carrier design

LNG Carriers, Icebreakers, port support vessels:
Technical requirements

- Preliminary Discussions with ShipOwners / ShipYards / Class Societies
- Russian Marine Register of Shipping requirements.
- CNIIMF study. Calculation transportation chain and vessel requirements proposal.
- Ice model tests at Aker Arctic
- Aker Arctic
- Calculation transportation chain and vessel requirements proposal.
- Higher Capacity Azipods Development with various Suppliers
- Propulsion system requirements and green ship
- Experimental voyages and operational experience
- Navigation and Operations Comparison of cargo containments system
TOTAL Operations in Arctic: Ice load R&D strategy

TOTAL’s current involvement in Ice load & technical challenge
⇒ Help for a better design of floaters, vessels...

Achievement in 2011
Data acquisition with physical model experiments


TOTAL Operations in Arctic: Navigation in ice conditions

Subarctic & Arctic areas:
• 90% Russian gas reserves
• 60% Russian oil reserves

Stokloman LNG
Yamal LNG
Varandey Project (Oil)
TOTAL Operations in Arctic: Icebreakers working in tandem to open a wide channel for large vessel

TOTAL Operations in Arctic: NSR operability studies

- **Study**
  - Investigate ice conditions along the Northern Sea Route and sailability for different ice class type
  - Done for Shtokman development a.g.

- **Done with**
  - Canatec Ice 06 software
  - Database of ice conditions over Arctic areas covering from 1972 to 2010 (type, concentration, FY, MY, fast ice, thickness ...)
  - In-house capability to perform operability window assessment
  - Mapping of ice conditions vs ice class vessels
TOTAL Operations in Arctic: Conclusions

- Extreme cold areas have huge hydrocarbon potential
- Protected areas with sensitive ecosystems
- No universal techniques & solutions but adaptation to local context
- Need to reinforce internal expertise and to build strong partnerships

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