
Aker Arctic Technology Oy

# Venäjän LNG-sektorista ja Aker Arcticin toimista Jamalin niemimaalla

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# Johdanto

- Tämä esitys keskittyy Venäjän maakaasun vientiin, erityisesti sen LNG-tuotantoon ja -kuljetuksiin nyt ja tulevaisuudessa
- Ajan mittaan Venäjä on nousemassa LNG:n viejänä suurimpien vientimaiden joukkoon samalla kun joidenkin perinteisten LNG-viejien osuus on laskemassa
- Myös uusia jakelukanavia tarvitaan yhä useampien tuotanto- ja energialaitosten sekä erilaisten laivojen alkaessa käyttää maakaasua pääasiallisena polttoaineenaan
- Itämeren piiriin syntyvillä uusilla laitoksilla ja jakelupisteillä on merkitystä kaasun saatavuuteen ja jakeluun myös Suomessa
- Suomalaisyrityksiä on mukana suunnittelemassa ja rakentamassa kuljetuksiin tarvittavia aluksia sekä niiden toimintaan tarvittavia apualuksia
- Lisäksi esitellään Aker Arcticin toimintaa, joka liittyy akrtisten laivojen kehittämisen ja suunnitteluun. Kaikissa Venäjän LNG-kuljetuksissa tarvitaan jäävahvistettuja laivoja, joiden tulee pystyä toimimaan kylmissä olosuhteissa.

# Sisällöstä

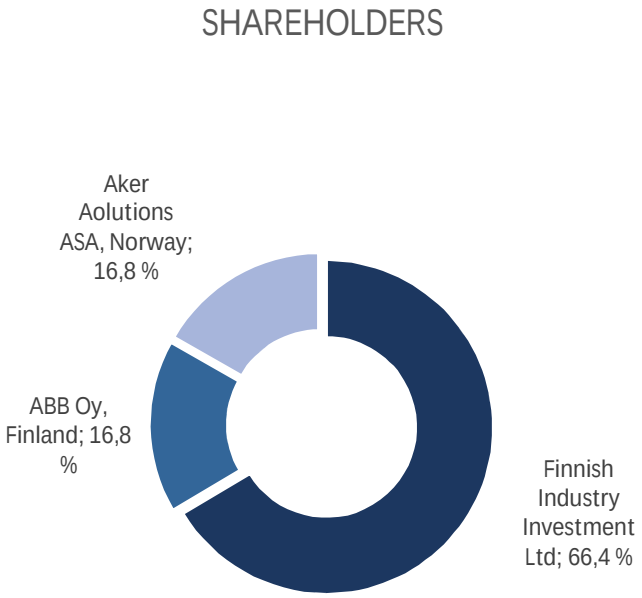
- Aker Arctic Technology Oy:stä lyhyesti
- Venäjän LNG-hankkeista
- Itämeren kaasukartta
- Arktisista LNG;n kuljetuslaivoista ja apulaivoista
- LNG:n jakelualuksista

Jamalin LNG-laitos rakenteilla

Enin osa lähdeaineistosta on vieraskielistä, siksi myös seuravien sivujen sisältö on englanniksi. Kuvien alkuperä: useista eri lähteistä.

# Aker Arctic Technology Inc. (“Aker Arctic”)

- Founded in 2005 as independent company as spin-off from Kvaerner Masa-Yards arctic R&D organization
- Originally ice model testing laboratory, started in 1969 as part of Wärtsilä Helsinki Shipyard
- Working globally with major maritime stakeholders
- Main services are design of ice-going vessels, ice model testing and arctic related consulting and engineering
- Turnover 10-14 MEUR
- Personnel about 50
- Location by Helsinki Vuosaari harbour




# Aker Arctic's Services

Consulting and Technology Development

Ship Design & Engineering


Ice Model Tests

Products for Ice Operations

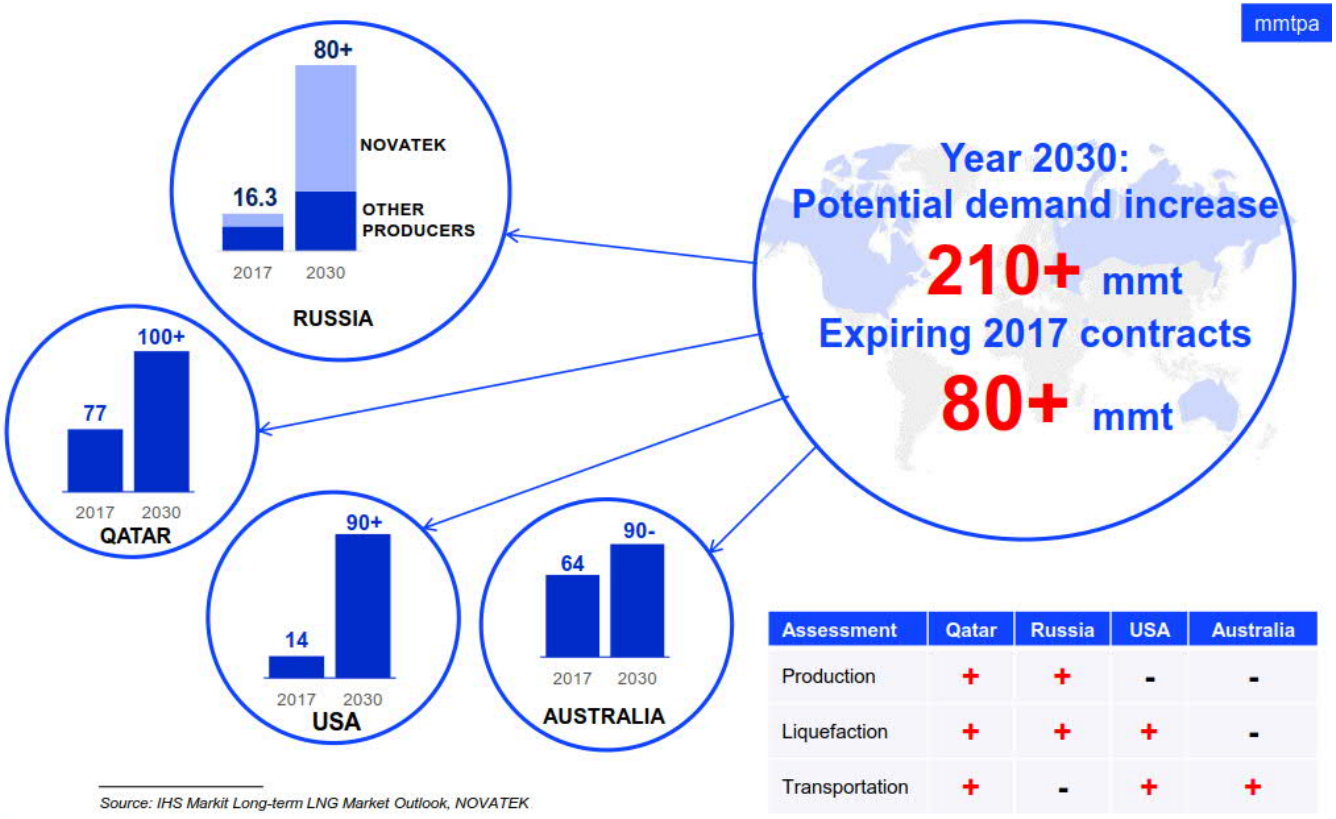
Full Scale Tests

Operational Services

# Growth of LNG exports

## RUSSIA TO BECOME ONE OF MAJOR LNG EXPORTERS (by 2030)

### Four main LNG production centers



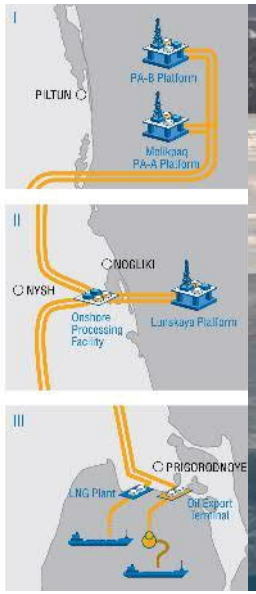

| Assessment | Qatar | Russia | USA | Australia |
|---|---|---|---|---|
| Production | + | + | - | - |
| Liquefaction | + | + | + | - |
| Transportation | + | - | + | + |

*Source: IHS Markit Long-term LNG Market Outlook, NOVATEK*

# Russian LNG Projects

**SAKHALIN-2**

- An LNG plant with capacity of 9.6 Mt/a based on the gas resources on Sakhalin Island
- The project's operator is Sakhalin Energy, co-owned by Gazprom (50%), Shell, Mitsui and Mitsubishi
- Started in 2009, the first Russian LNG project – expansion projects planned
- LNG shipments to Far East
- LNG carriers with low ice class are needed to transport LNG from Sakhalin


# Russian LNG Projects

**YAMAL LNG**

- An LNG plant with capacity of 16.5 Mt/a located on Yamal peninsula by Ob Bay
- LNG plant in *Sabetta* consists of three production trains, completed in early 2019
- A new type 0.9 Mt/a pilot plant is under construction, ready in early 2020
- Shareholders include Novatek (50.1%), Total (20%), CNPC (20%) and the Chinese Silk Road Fund (9.9%)
- LNG transported in winter season to West/Europe and in summer season mainly to East (via Northern Sea Route)
- LNG shipments by 15 large arctic LNG carriers of which 11 in service (May 2019)
- The arctic ships take the LNG direct to destinations or via transhipment with a fleet of ordinary LNG carriers
- Challenges: Remote location, long lasting hard winter, very cold climate, all infrastructure to be built
- NEWEST DEVELOPMENT: Novatek to expand LNG production in Sabetta by building a 3-train plant based on Russian technology, capacity 3×1.8 Mt/a; “OB LNG” to be in operation gradually by end 2023.

# Russian LNG Projects

**YAMAL LNG (continued)**

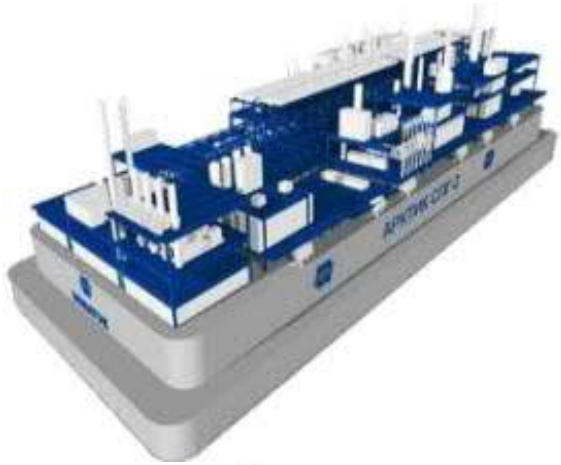
- During the first full year of operation in 2018, when the first two production trains were completed, the produced LNG was sold on spot market
- Spot cargoes were transported to Europe to various LNG terminals in Belgium, Holland, UK, France and Spain; Many cargoes were transhipped further, to India USA and China
- Long-term contracted shipments started in late 2018 with full production capacity
- The LNG production trains have been completed ahead of original schedule – an achievement - but arctic LNG fleet of 15 ships are being delivered acc. to original schedule
- The utilisation of the existing 11 arctic ships have been improved by regular transhipments in Norwegian waters (off Honningsvåg village); A temporary arrangement during winter season
- Ordinary LNG carriers arrive in Honningsvåg waters and are anchored for cargo transfer from arctic LNG carriers 'ship-to-ship'
- In this way the arctic special ships can manage with shorter voyages and will have enough capacity to transport full LNG production.

# Russian LNG Projects

## PLANNED OR UNDER CONSTRUCTION (likely to come true)

### ARCTIC LNG II

- A sister project to Yamal LNG, based on the Gydan Peninsula, above the Arctic Circle, almost opposite to Yamal LNG by the Bay of Ob
- LNG plant with capacity of 19.8 Mt/a, consisting of three production trains, each based on gravity based structure (GBS) that will be constructed in Murmansk area and will be floated to the site
- The LNG plant will be built in three phases, scheduled for start-up in 2023, 2024, and 2025 respectively
- In May 2019: Arctic LNG 2 and TechnipFMC signed a contract on engineering, procurement, supply, construction and commissioning of the integrated liquefied natural gas facilities
- LNG will be transported in the same pattern and to similar destination as in Yamal LNG project
- Another series of new high ice class arctic LNG carriers as well as a number of low ice class and ordinary LNG carriers will be needed! Fleet size and number of ships are under considerations.

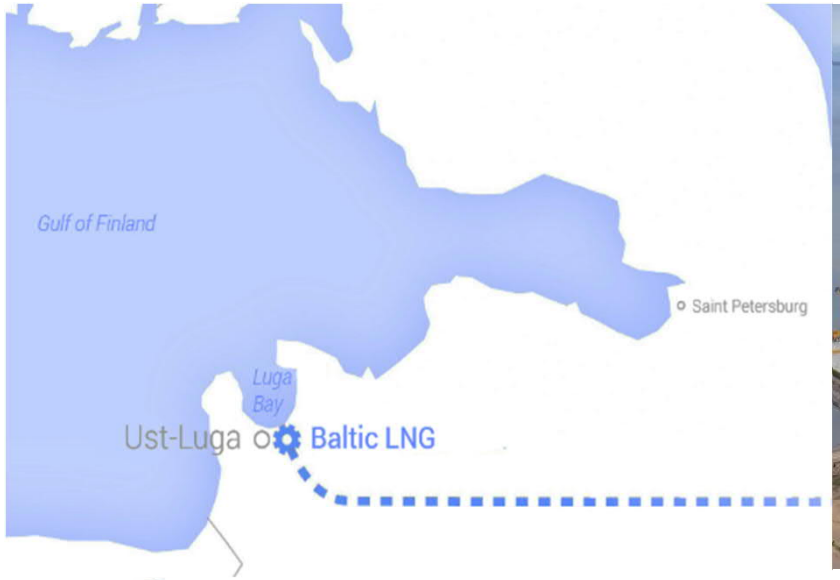



# Russian LNG Projects

## PLANNED OR UNDER CONSTRUCTION (likely to come true)

### BALTIC LNG

- A project to construct an LNG plant with a capacity of 10 or up to 13 Mt/a at the port of Ust-Luga in the Leningrad Region
- Gazprom and Shell established a joint venture in June 2017 to operate the project, decision to implement the project was made recently (early 2019)
- Comprising two LNG production trains, in operation by 2024 and 2025 respectively
- Gazprom will supply natural gas for the plant by pipeline.




# Russian LNG Projects

## PLANNED (but haven't come true)

### SHTOKMAN

- The Shtokman LNG project entails the construction of an LNG plant with a capacity of 7.5 Mt/a based on the Shtokman field on the Barents Sea shelf
- Was planned as the second major Russian LNG project but haven't come true
- Intention was to process gas in a floating production unit far away in open sea, with long underwater gas pipeline to continent close to Murmansk where LNG liquefaction plant and LNG terminal would be located
- Total reserves 3.8 trillion $m^3$ of gas
- The planned project operators were Shtokman Development AG, with 51% interest (owned by Gazprom), 25% by Total and 24% by StatoilHydro
- The challenges: Gas field and production unit location in open sea area with over 300 m water depth, 600 km off Murmansk.

# Russian LNG Projects

## PLANNED (but haven't come true)

### PECHORA LNG (INDIGA LNG)

- Pechora LNG project is planned with an LNG plant, with capacity of over 4 Mt/a based on the gas fields in Nenets Autonomous area
- Various studies made since 2010 without realisation
- Investments estimated 10 billion USD, the project has suffered from lack of federal support


- Initial project owner Russian Alltech, later Rosneft's subsidiary RN-Gaz joined with 51% share but has withdrawn by 1% ownership. Another new 99% owner is waiting for a better future.

# Russian LNG Projects - Others

## TRANSSHIPMENT STORAGE TERMINALS

- In order to improve the shipments from arctic areas two large dedicated transhipment terminals, one in Murmansk area, the other in Kamchatka peninsula, are being planned
- LNG cargoes will first be transported with arctic ships, stored temporarily in a floating unit and loaded in ordinary LNG carriers for further transportation
- Gas supply also to local community by utilisation of boil-off gas and by regasification.

## FLOATING STORAGE & REGASIFICATION UNITS

- Recently, an FSRU (a new specially equipped LNG carrier) has been permanently moored in Kaliningrad to back-up gas supply in the area
- (A similar arrangement exists also in Lithuania, in the sea port of Klaipeda)

## SMALLER CAPACITY LNG PROJECTS

- Recently, Russian companies have started to explore the feasibility of smaller low-capacity LNG plants (annual capacity below 1 Mt/a)
- Consumers of such plants, including ship operators, small power generating companies and land transport companies, use LNG mostly in its liquid state
- A smaller land-based liquefaction plant using pipeline gas, with a floating ‘ship’ storage is under construction west of Viborg, for distribution of LNG for shipping industry
- Vysotsk LNG plant with 0.66 Mt/a capacity, start-up in 2019.

# Aker Arctic in the Yamal LNG Project

**TRANSPORTATION SYSTEM**

- Fleet studies made at early stage
  - Number and size of LNG and gas condensate tankers
  - Intended ports
  - Fleet performance, fuel costs, newbuilding price estimates
  - Cargo transshipment (ship-to-ship via shore and direct alongside)
- Port operation, protective structures
- Early stage ice and open water testing
- Ice management, ice freeing in port

# Aker Arctic in the Yamal LNG Project (continued)

**LNG CARRIER DESIGNS (alternatives and the final one)**

- Hull form (alt. bow and aft ship forms; initial, modified, final)
- Potential of Double Acting Ship concept (DAS)
- Performance (loaded/ballasted ship, in open sea and in various ice conditions)
- Alternative cargo containment systems (effect on ship design)

- Hull structural studies (rules and empirical)
- Winterization measures (de-icing, anti-icing, extra heating, impact of cold environment to systems)
- Alternative machinery and propulsion configurations
- Tender specification for Arctic LNGCs
- Other related fleet (icebreakers, tugboats, condensate oil tankers), designs & testing
- Final resistance, propulsion, seakeeping and ice model testing of LNG carriers
- Witnessing open sea performance
- Ice trial program, witnessing ice trials

# Yamal LNG Carriers – The ship design

## DEDICATED ARCTIC “YAMALMAX” LNG CARRIERS

Fifteen special RMRS Arc 7 ice class LNG carriers have been custom-designed and are delivered/being built in South Korea for the Yamal LNG Project to support year-round navigation without icebreaker assistance along westbound navigation routes, and during summer navigation season eastbound via the Northern Sea Route. Lead ship “*Christophe de Margerie*”


**Main characteristics of the first Arctic LNG carriers:**

- Effective cargo capacity 170,000 $m^3$ of LNG
- Installed propulsion power – 45 MW
- Service speed in open water – 19.5 knots (w. 21% sea margin)
- Speed in 1.5 m thick level ice – 5.5 knots
- Primary fuel natural gas (boil-off gas, forced vaporized LNG), secondary: fuel oil
- Dual fuel diesel-electric propulsion system equipped with three 15 MW Azipod propulsion units
- Vessel design is based on the Double Acting Ship (DAT™) concept: The bow has been optimized for navigation in open water and moderate ice, while the stern has been optimized to enable navigation in most severe ice conditions
- The design is the first of its kind and the ships are the largest arctic ships built so far.

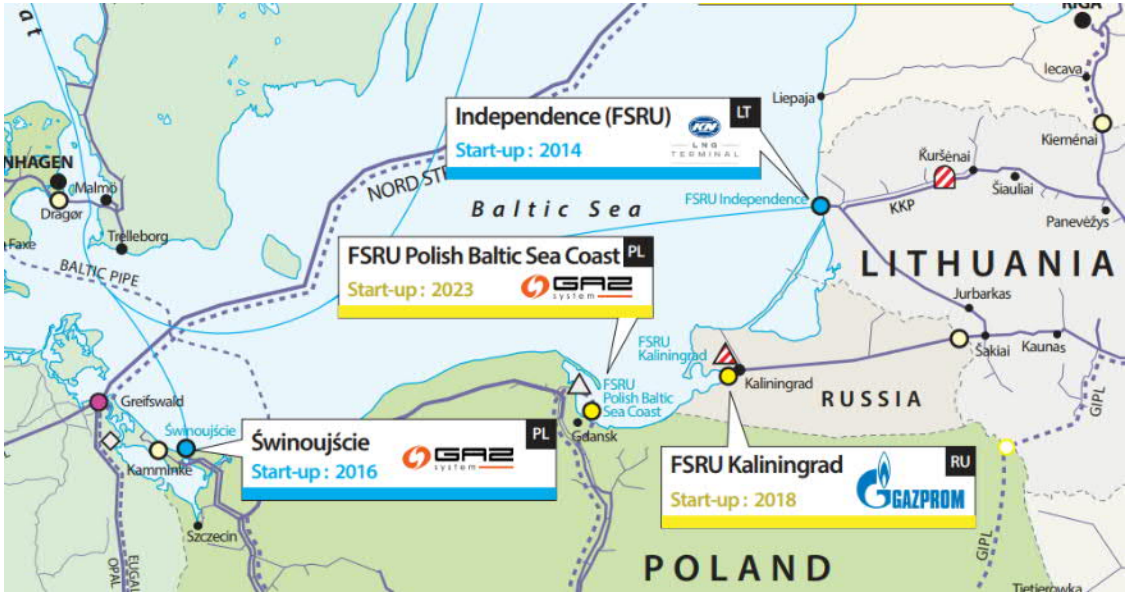
# LNG terminals in the Baltic Sea

An overview of the LNG infrastructure and future plans in the Baltic Sea

# LNG terminals in the Baltic, southern Baltic

- Świnoujście, Poland
  - Large receiving terminal, operating since 2016
  - Operated by Polskie LNG S.A.
  - 2 x 160,000 m³
  - Can accommodate at least Q-flex ships

- Klaipeda, Lithuania
  - ***FSRU Independence*** in Klaipeda harbour, 10 year contract
  - Capacity 170,000 m³
  - Since 2014
  - Also operating from Klaipeda: the LNG bunkering vessel ***Kairos***, 7500 m³

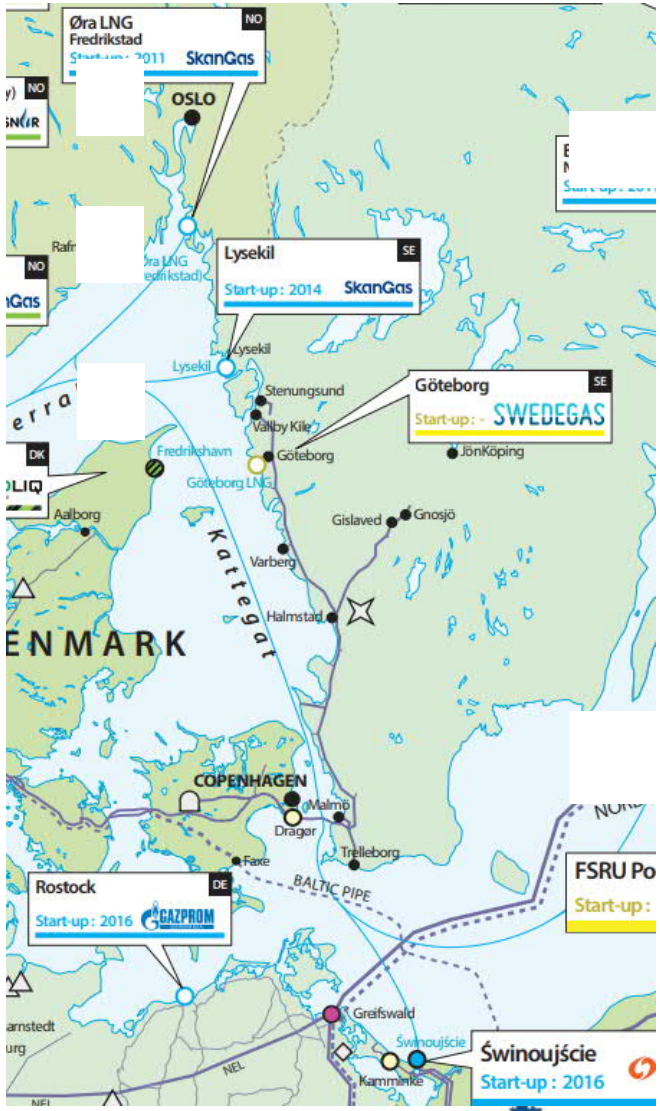



- Polish Baltic Sea Coast, Poland
  - FSRU, planned to operate in 2023
  - Operated by Polskie LNG S.A.
  - Nominal capacity: 4.10 – 8.20 billion Nm³/a, (6.8-13.7 million m³ LNG)

- Kaliningrad, Russia
  - Operated by Gazprom, from 2019
  - Land storage + FSRU with capacity 174 000 m³
  - Nominal capacity: 2.70 billion Nm³/a, (4.5 million m³ LNG)
  - Floating regasification plant "***Marshal Vasilevskiy***" moored to back-up reliability of the energy sector in the Kaliningrad Region.

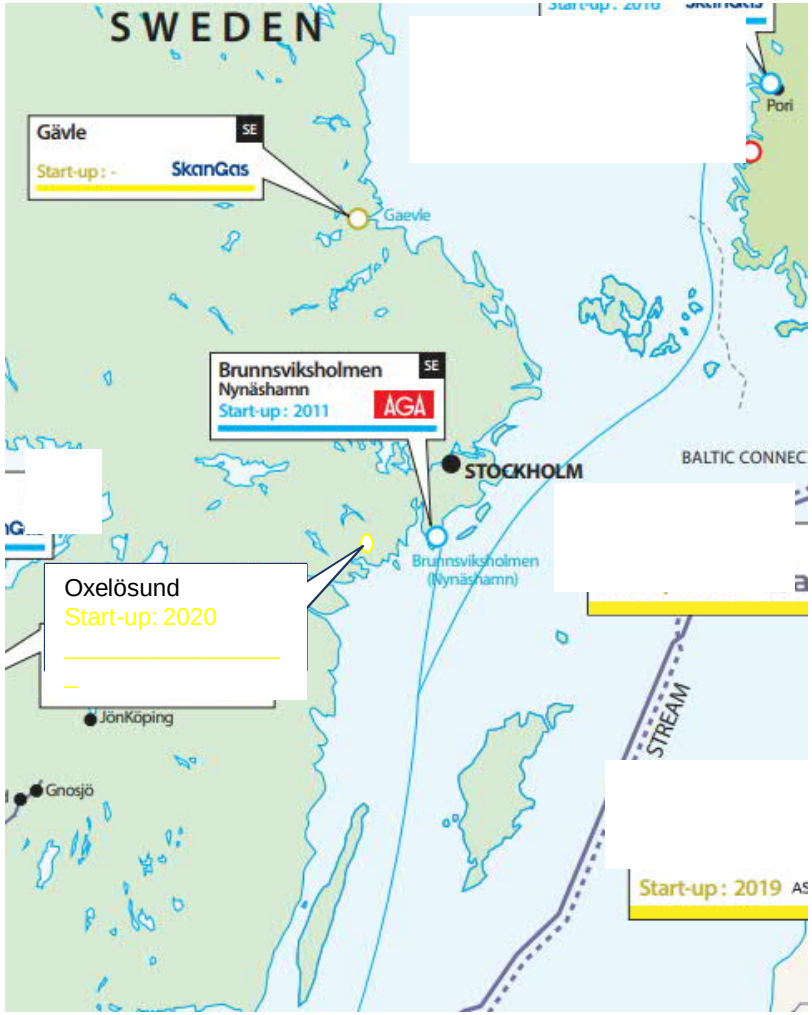
# LNG terminals in the Baltic, Kattegatt

- Øra, Norway
  - Start-up 2011, 6500 $m^3$ by Skangas
  - Capacity: 0.10 billion $Nm^3$/year, (167,000 $m^3$ LNG)
- Lysekil, Sweden
  - 30,000 $m^3$, 2014
  - Skangas, Preem
  - Capacity: 0.30 billion $Nm^3$/year, (500,000 $m^3$ LNG)
- Göteborg, Sweden
  - Swedegas, 30,000 $m^3$
  - Operational autumn 2018
  - Capacity: 0.50 billion $Nm^3$/year, (833,000 $m^3$ LNG)
  - Max. ship size: 75,000 $m^3$
- Rostock, Germany
  - Start-up 2016, Gazprom
  - Possibility for truck-to-ship LNG bunkering



# LNG terminals in the Baltic

- Gävle, Sweden
  - 30,000 $m^3$, planned, permit obtained
  - Skangas
  - Capacity: 0.30 billion $Nm^3$/year , (500,000 $m^3$ LNG)
- Nynäshamn, Sweden
  - Operational 2011, AGA
  - 20,000 $m^3$
  - Ccapacity: 0.30 billion $Nm^3$/year , (500,000 $m^3$ LNG)
  - Max. ship size: about 15,000 $m^3$
- Oxelösund, Sweden
  - Planned for 2020
  - 500 $m^3$ tank, next stage in 2023 having a 30,000 $m^3$ tank



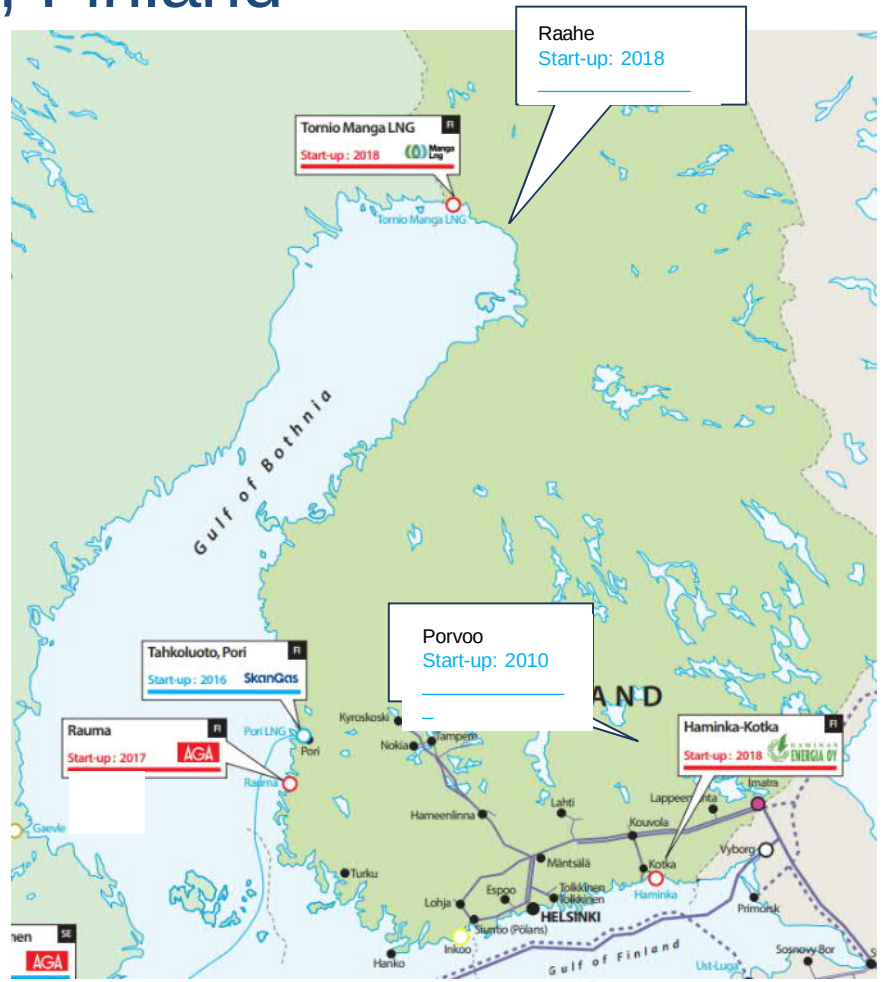
# LNG terminals in the Baltic

- Paldiski, Estonia
  - Estonian energy company Alexela, start-up: 2020
  - Storage: 160,000 $m^3$ of LNG with planned expanding to 320,000 $m^3$
  - Capacity: 2.50 billion $Nm^3/a$, (4.17 million $m^3$ LNG)
- Muuga, Estonia
  - Planned for 2018, Operator: Vopak
  - Capacity: 2.0 billion $Nm^3/a$, (3.3 million $m^3$ LNG)
- Skulte, Latvia
  - Planned for 2019
  - Capacity: 5.0 billion $Nm^3/a$, (8.3 million $m^3$ LNG)
- Baltic LNG, Ust-Luga, Russia
  - Large export terminal
  - Gazprom, planned for 2023
  - Capacity: 10 million tonnes/a
- Gazprom project in Satamaniemi under construction
  - Liquefaction plant + ship type floating storage
  - Close to the Finnish border


- Vysotsk LNG, Russia
  - Capacity: 0.66 million tonnes/a
  - Project under construction, operated by CryoGAS-Vysotsk, a JV between NOVATEK and Gazprombank
  - LNG storage tank with a capacity of 42,000 $m^3$ at the first phase. Visiting vessels of up to 170,000 $m^3$ size

# LNG terminals in the Baltic, Finland

- Tornio, Finland
  - Operated by Manga LNG, operational in 2019
  - 50,000 m³, ship's draft restriction 9 m
- Pori, Finland
  - Skangas, operational since 2016
  - 30,000 m³, ship's draft restriction10 m
- Raahe, Finland
  - Raahen Voima, no link to sea
  - Bunkered with trucks, 2-3 per day
  - 1400 m³
- Porvoo, Finland
  - Gasum, extension operational since 2010
  - Production capacity on 20,000 tonnes/a, 3×700 m3 LNG storage tanks
- Hamina
  - Hamina LNG Oy, a joint venture, operational in 2020
  - In the first stage, a 30,000 m³ LNG storage tank. 20 000 m³ extension planned
- Rauma
  - Planned, 12 m draft restriction.

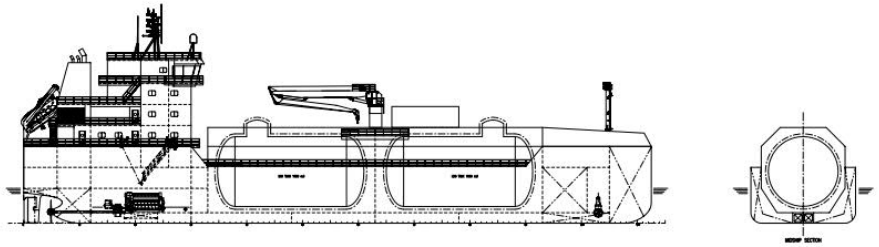


# LNG Bunkering vessels in the Baltic (no Aker Arctic involvement)

*The port of Klaipeda in Lithuania is using bunkering vessel Kairos as an addition to their FSRU, Independence.*


N.B. The LNG bunkering vessel intended for Tallinn missing here.

# Aker Arctic involved in designing of smaller LNG Carriers

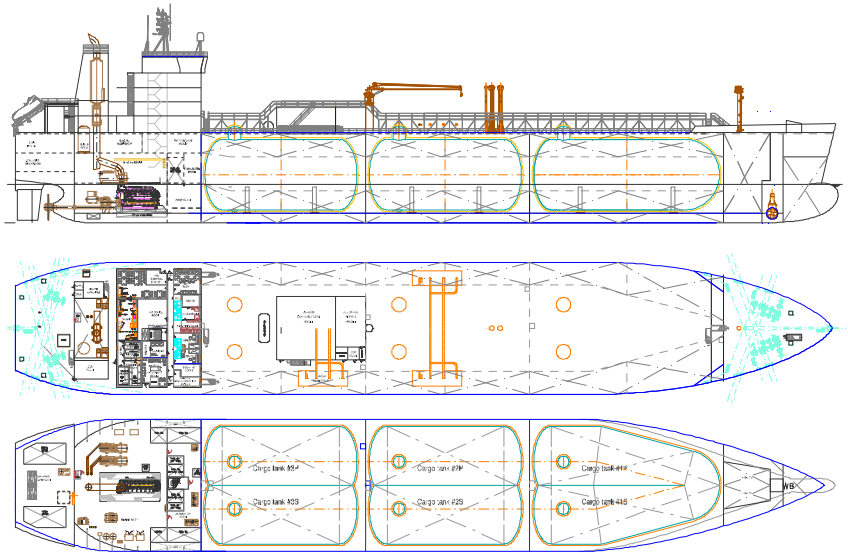


## Development of a Baltic LNG bunkering vessel concept

- Ice class 1A Super
- 1 m icebreaking capability
- Going through ridges (Gulf of Bothnia conditions)
- Cargo capacity 5,240 $m^3$
- Service speed about 12.5 knots
- Propulsion power 8 MW
- Gas or dual fuel machinery
- Azimuthing propulsion for manoeuvring and station keeping
- Cargo containment system: C-type

## 20,000 $m^3$ sized LNG feeder for Baltic and North Sea trade

Initial transportation study and two alternative ship concepts with 1A Super ice class were designed by Aker Arctic for the Tornio Manga LNG project.



# Other ship types: Arctic Gas Condensate Tanker

- Designed for year-round transport of gas condensate side product from the Yamal LNG gas fields
- Winterized to -50°C
- Double acting vessel – high icebreaking capability in both ahead and astern directions
- Concept and basic design by Aker Arctic
- One vessel to be built by Guangzhou Shipyard International Company Limited (China)
- Delivery at end of 2018

| | |
|---|---|
| Length | 214 m |
| Beam | 34 m |
| Draft | 12 m |
| Deadweight | 43,400 tons (condensate) |
| Propulsion | 2 x 11 MW azimuth thrusters |
| Icebreaking capability | Up to 1.8 m level ice |
| Ice class | RMRS Arc7 |

# Other ship types: Aker ARC 124 Port Icebreaker

- Heavy port icebreaker designed to support LNG carriers' operability at the port of Sabetta in the Gulf of Ob
- Concept and basic design by Aker Arctic
- First icebreaker with four azimuth thrusters (two in bow, two in stern)
- High operational capability in thick consolidated brash ice
- To be built by Vyborg Shipyard (Russia); start of production in summer 2016
- Delivery in 2019

| | |
|---|---|
| Length | 89.2 m |
| Beam | 21.9 m |
| Design draft | 6.5 m |
| Power plant | 3 x Wärtsilä 8V31 (3 x 4880 kW) |
| Propulsion | 4 x 3.0 MW ABB Azipod |
| Icebreaking capability | 2 knots in 1.5 m level ice |
| Ice class | RMRS Icebreaker7 |

# Other ship types: Arctic heavy cargo carriers

- Two arctic Module Carriers for ZPMC-Red Box Energy Services
- Designed and built to deliver LNG plant modules to Sabetta as part of the Yamal LNG project (direct from Far East or mostly as transshipments in Europe)
- Concept and basic design by Aker Arctic
- Two vessels built by Guangzhou Shipyard International Company Limited (China), deliveries in 2016
- “Audax” and “Pugnax” are the first of their kind of arctic ships.

| | |
|---|---|
| Length | 206.3 m |
| Beam | 43.0 m |
| Draft | 7.5 m |
| Propulsion | Diesel-electric<br>2 x 12 MW shaftlines |
| Icebreaking capability | 3 knots in 1.5 m level ice |
| Ice class | Polar Class 3 |

# Other ship types: An Icebreaking Support Vessel

- Icebreaking Support Vessel for Gazprom Neft's Novy Port oil export terminal in the Gulf of Ob
- Expanded concept design by Aker Arctic,
- Further development of the Finnish icebreaker "Polaris" with higher icebreaking capability and higher ice class
- Two ships were built at Vyborg Shipyard: *Aleksandr Sannikov* and *Andrey Vilkitskiy*
- Deliveries in 2018

| | |
|---|---|
| Length | 121.7 m |
| Beam | 25.0 m |
| Design draft | 8.0 m |
| Propulsion | 2 x 7.5 MW ABB Azipod<br>+ 1 x 6.5 MW ABB Azipod |
| Icebreaking capability | 2 knots in 2.0 m level ice<br>+ 30 cm snow cover |
| Ice class | RMRS Icebreaker8 |


Thank you!
Any questions?