PAME

Protection of the Arctic Marine Environment

HEAVY FUEL OIL (HFO) USE BY SHIPS IN THE ARCTIC 2019

ARCTIC SHIPPING STATUS REPORT (ASSR) #2

20 OCTOBER 2020

PAME

Protection of the Arctic Marine Environment

ARCTIC COUNCIL

This report explores the use (combustion) of Heavy Fuel Oil (HFO) by ships in Arctic waters in 2019 whilst also discussing fuels in general.

Recent changes to international law will affect the type of fuels used globally including the Arctic. This report explores past fuel use in the Arctic and explains some of the legal changes that may impact the types of fuels used in the Arctic in the future.

The term HFO in this report refers to oils that have the characteristics specified in paragraph 1.2 of regulation 43 of the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex I.

HFO DEFINITION

MARPOL Annex 1 reg 43, paragraph 1.2:

"oils, other than crude oils, having a density at 15°C higher than 900 kg/m3 or a kinematic viscosity at 50°C higher than 180 mm2/s."

This report uses the geographic definition of the Arctic contained in the International Code for Ships Operating in Polar Waters (Polar Code) – The Polar Code area.

The Polar Code defines Arctic waters as the area in the figure.

Most larger ships that operate in this area must comply with the Polar Code.

Arctic Ship Traffic Data

All data in this report is from PAME's Arctic Ship Traffic Data (ASTD) System.

PAME's Arctic Ship Traffic Data (ASTD) project has been developed in response to a growing need to collect and distribute accurate, reliable, and up-to-date information on shipping activities in the Arctic. The ASTD System was launched in February 2019.

www.astd.is.

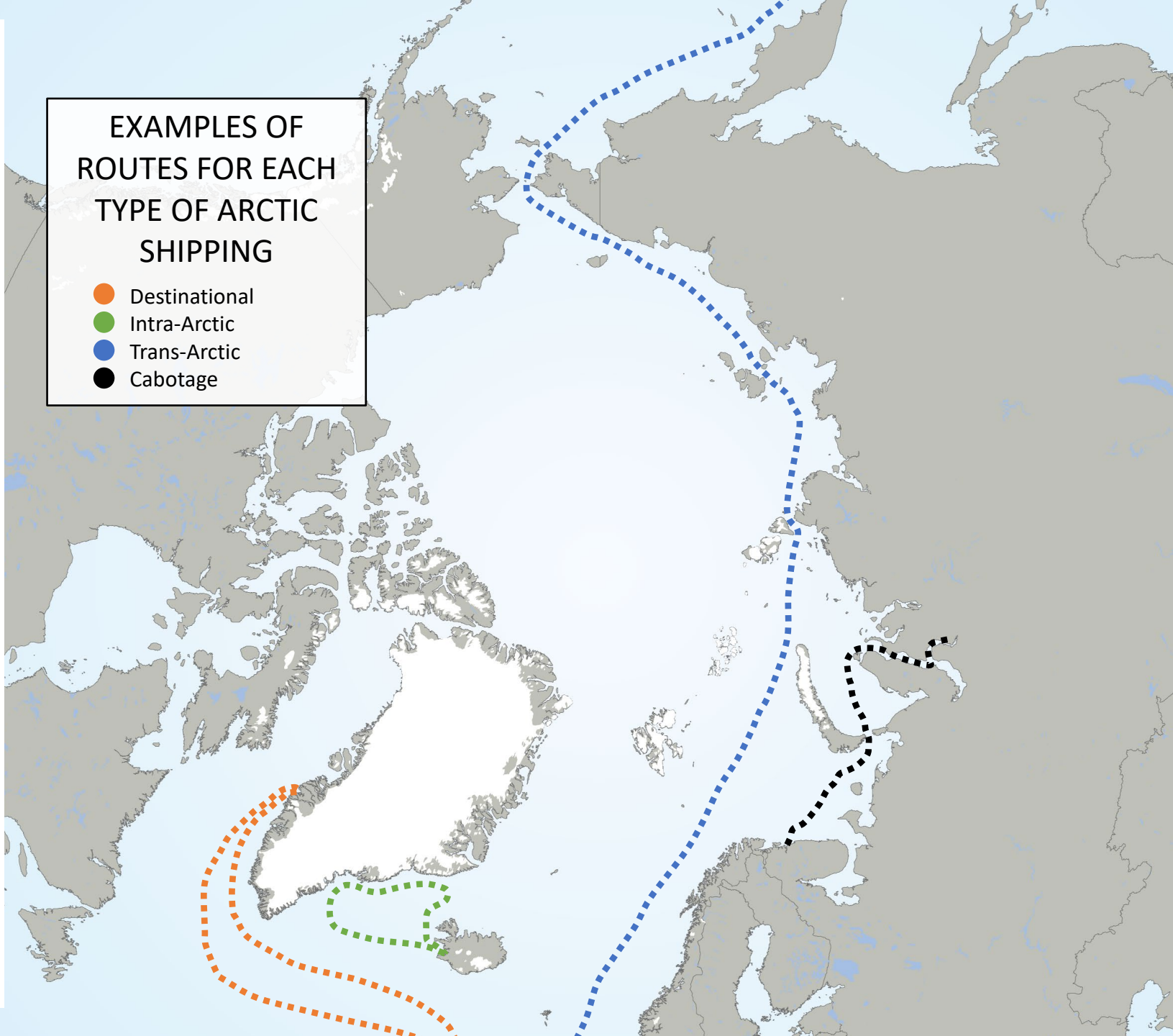
ARCTIC SHIPPING

PAME's 2009 Arctic Marine Shipping Assessment (AMSA) Report identified four types of Arctic Shipping:

- Destinational transport, where a ship sails to the Arctic, performs some activity in the Arctic, and sails south.
- Intra-Arctic transport, a voyage or marine activity that stays within the general Arctic region and links two or more Arctic States.
- Trans-Arctic transport or navigation, voyages which are taken across the Arctic Ocean from Pacific to Atlantic Oceans or vice versa.
- Cabotage, to conduct trade or engage in marine transport in coastal waters between ports within an Arctic State.

PAME: AMSA 2009 Report. Page 12.

Arctic shipping refers to all shipping activities within the area in question, unless otherwise stated.



SHIPS IN THE ARCTIC USE A VARIETY OF FUELS

Most ships operating in Arctic waters use several types of oil as fuel. By far, the most frequently used fuel in the Polar Code area in 2019 was **distillate marine fuel oil** (which is not HFO).

Ship operators may use different types or combinations of fuels based on their type, size, or operation. Other factors in the decision include logistics, chartering, and legal requirements and costs.

MARINE FUEL OILS

DISTILLATE FUEL

Petroleum products created by refining crude oil. Distillation is a key step in upgrading these products.

MOST COMMON IN THE ARCTIC

MARINE GAS OIL

100% distillate fuel

MARINE DIESEL OIL

Distillate fuel that may have traces of residual fuel

RESIDUAL FUEL

Residuals are all of the leftover components of crude oil that are separated from the upgraded, distilled products.

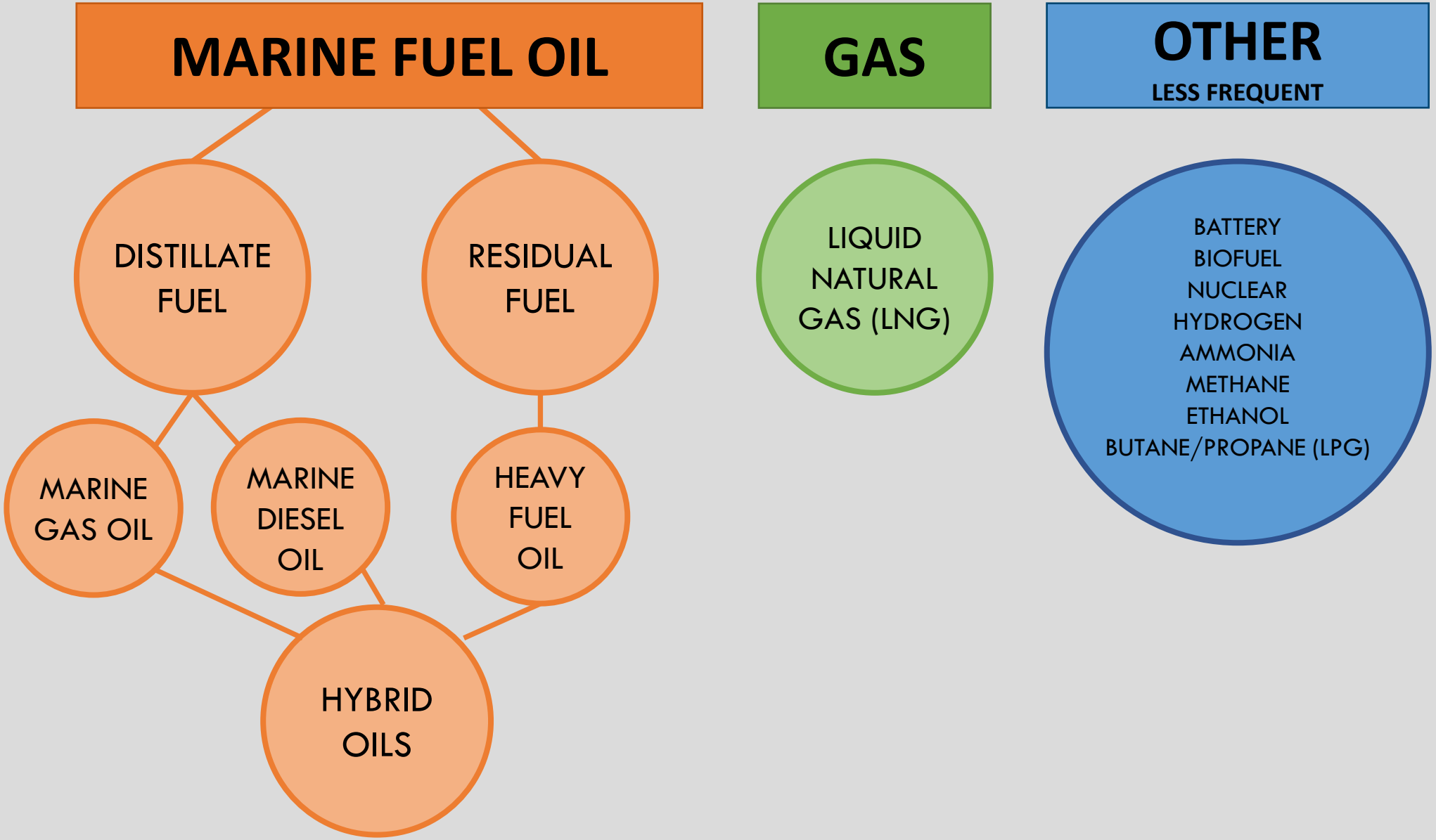
HEAVY FUEL OIL

Heavy Fuel Oil (HFO) is one of several terms used to cover a rather broad range of different marine residual fuels, or blends of residual and distillate fuels

HYBRID OILS

A new generation of fuel oils has been developed for global use and is produced in order to meet new requirements to and regulations of airborne emissions of potentially harmful substances such as sulphur.

FUELS USED BY SHIPS IN THE ARCTIC



As of 2020, a new era of marine fuels is emerging

The reasons for this include stricter new IMO regulations.
As of 1 January 2020, the allowable amount of sulphur content in fuel was reduced to 0.5% m/m.
This affects the shipping sector worldwide, including in the Arctic.

These regulations will also affect the type of fuels and fuel blends used by ships in the Arctic.

New fuel blends have been and continue to be developed to meet this regulation. Some of these fuels will fall into the MARPOL Annex I, regulation 43 definition of HFO; but some may not.

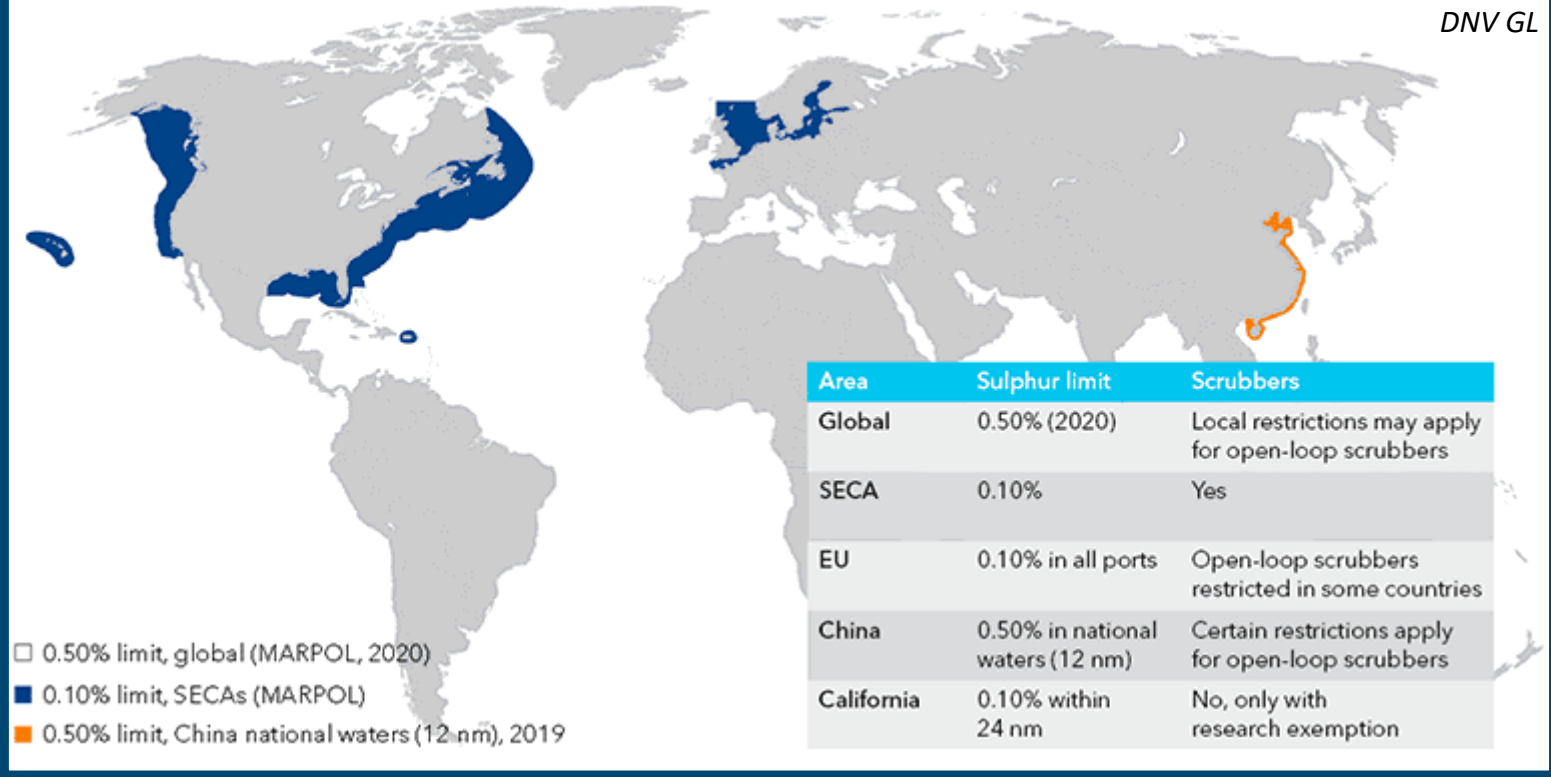
THE NEW ERA HAS BEEN EMERGING

SPECIFIC REGULATIONS ON FUEL SULPHUR CONTENT UNDER MARPOL ANNEX VI HAVE BEEN IN EFFECT FOR SOME TIME IN CERTAIN AREAS. THIS INCLUDES MARPOL ANNEX VI EMISSION CONTROL AREAS (ECAs).

Fuel sulphur limits of 0.10% have been in place in several ECAs since 2005.

The ECAs are one of the main reasons ships often carry multiple fuel types – often HFO for high seas transits and low sulphur distillates for navigation in ECAs.

DNV GL



Area	Sulphur limit	Scrubbers
Global	0.50% (2020)	Local restrictions may apply for open-loop scrubbers
SECA	0.10%	Yes
EU	0.10% in all ports	Open-loop scrubbers restricted in some countries
China	0.50% in national waters (12 nm)	Certain restrictions apply for open-loop scrubbers
California	0.10% within 24 nm	No, only with research exemption

HFO

is so named because of its high viscosity; it resembles tar when cold, and typically requires heating for storage and combustion.

HFO is a general term. The fuel type is also commonly known as bunker fuel, No. 6 oil, or residual fuel oil.

HFO is produced from a mixture of residual distillate fuel blended to achieve, for instance, the desired viscosity at a specific temperature (often 50 °C).

The quality and chemical makeup of HFO is highly variable, depending on its components and the way they are blended.

HFO

COMPARED TO MARINE OIL (MGO/MDO)

HFO behaves differently than distillate fuels when released into water. Due to its high viscosity and pour point, HFO may solidify and sink or remain neutrally buoyant in cold water. HFO is also extremely viscous and potentially could remain at sea for weeks, having a large potential to cause damage.

In ice-covered waters, an HFO spill could result in oil becoming trapped in and under ice, causing the oil to persist for a long time and enabling it to be transported over large distances.

When combusted, HFO has some of the highest levels of exhaust emissions among marine fuels; in particular emissions of Particulate Matter (PM) and Black Carbon (BC).

“THE THREAT OF AN OIL SPILL FROM SHIPS IN THE ARCTIC IS THE TOP RISK TO THE MARINE ENVIRONMENT”

PAME. Arctic Marine Shipping Assessment Report. 2009.

*“**The accidental spill of oil into Arctic waters remains the most significant threat from ships to the Arctic marine environment.** Future vessel traffic in Arctic waters is projected to rise, thus increasing the risk of a spill. Spill response in the Arctic, if carried out, could reduce environmental damage associated with an oil spill, but can be hindered by harsh weather conditions and seasonal periods of darkness.”*

Document MEPC 71/14/4 (Canada, Finland, Germany, Iceland, Netherlands, Norway and the United States) submitted to the IMO Marine Environment Protection Committee at its seventy-first session in 2017.

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*“**Oil spills could have particularly severe impacts on Arctic wildlife, the marine environment and could threaten Arctic communities’ food security and livelihoods.** This is due the slow rate of degradation, due to very limited evaporation (typically less than <10%) and limited dispersion into the water column.”*

PAME. Report on Alternatives to HFO. 2019.

FUEL VISCOSITY

FUELS ARE CLASSIFIED ACCORDING TO **VISCOSITY** (THICKNESS)

THEY ARE NUMBERED FROM 0-380 IN PAME's ASTD SYSTEM BUT CAN GO EVEN HIGHER

THE HIGHER THE NUMBER – THE THICKER THE OIL AT THE MEASURED TEMPERATURE (most often 50°c). IT THEN BEHAVES DIFFERENTLY WHEN IT SPILLS IN WATER.

FOR EXAMPLE: ISO-F-380 IS THEREFORE THICKER THAN ISO-F-80 AND IS CONSIDERED A *HEAVIER OIL*.

0-10

10-80

80-180

180-380 *and above*

VISCOSITY LEVEL

THERE ARE MANY EXEMPTIONS TO THIS; E.G. OIL CAN BE HFO EVEN IF THE VISCOSITY IS BELOW 180.

Fuel type	Price (USD/ton)
HFO Heavy Fuel Oil	$254
VLSFO Very Low Sulphur Fuel Oil	$288
ULSFO Ultra Low Sulphur Fuel Oil	$325
MGO Marine Gas Oil	$322

Prices in the port of Rotterdam. From the BunkerEx website. Retrieved on 14/9/2020

SHIP THAT BURNS 250 TONS OF FUEL PER DAY

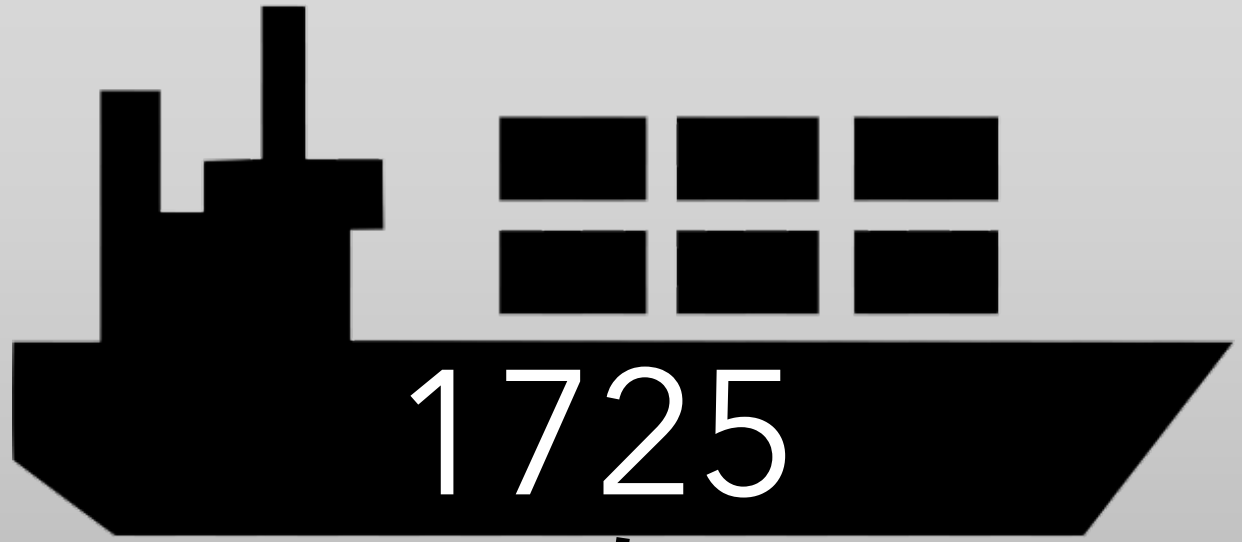
	1 day	7 days	30 days
HFO	$63,500	$444,500	$1,905,000
MGO	$80,500	$563,500	$2,415,000

MGO IS APPROX. *27% MORE EXPENSIVE THAN HFO*

WHY HAS HFO LONG BEEN SO POPULAR?

PRICE IS ONE REASON

BUT HFO HAS OTHER POSITIVE CHARACTERISTICS FOR SHIP OPERATORS. IT WORKS AS A LUBRICANT FOR SHIP ENGINES WHICH HELPS THEM RUN SMOOTHLY. IT ALSO PROVIDES MORE ENERGY PER VOLUME AND CAN BE EASIER TO WORK WITH THAN SOME OTHER FUEL TYPES.



UNIQUE SHIPS ENTERED THE POLAR CODE AREA IN 2019

This Report analyzes six types of fuel (the ASTD fuel types) used by ships in Arctic waters in 2019.

ASTD FUEL TYPES

1 Distillate marine fuel

Light petroleum products that are not residual fuels. These can be either Marine Gas Oils (MGO) or Marine Diesel Oils (MDO).

2 Residual marine fuel and heavy distillate (ISO-F10-80)

Residual marine fuel with a viscosity ISO-F10-80. This category refers to light residual marine fuel and heavy distillate (heavier then MGO and MDO).

3 Residual marine fuel (ISO-F-80 - 180)

Refers to heavier oils with viscosity between 80 and 180.

4 Residual marine fuel (ISO-F-180 - 380 or above) HFO

This is Heavy Fuel Oil. The viscosity is between 180 and 380, or above.

5 Liquified Natural Gas (LNG)

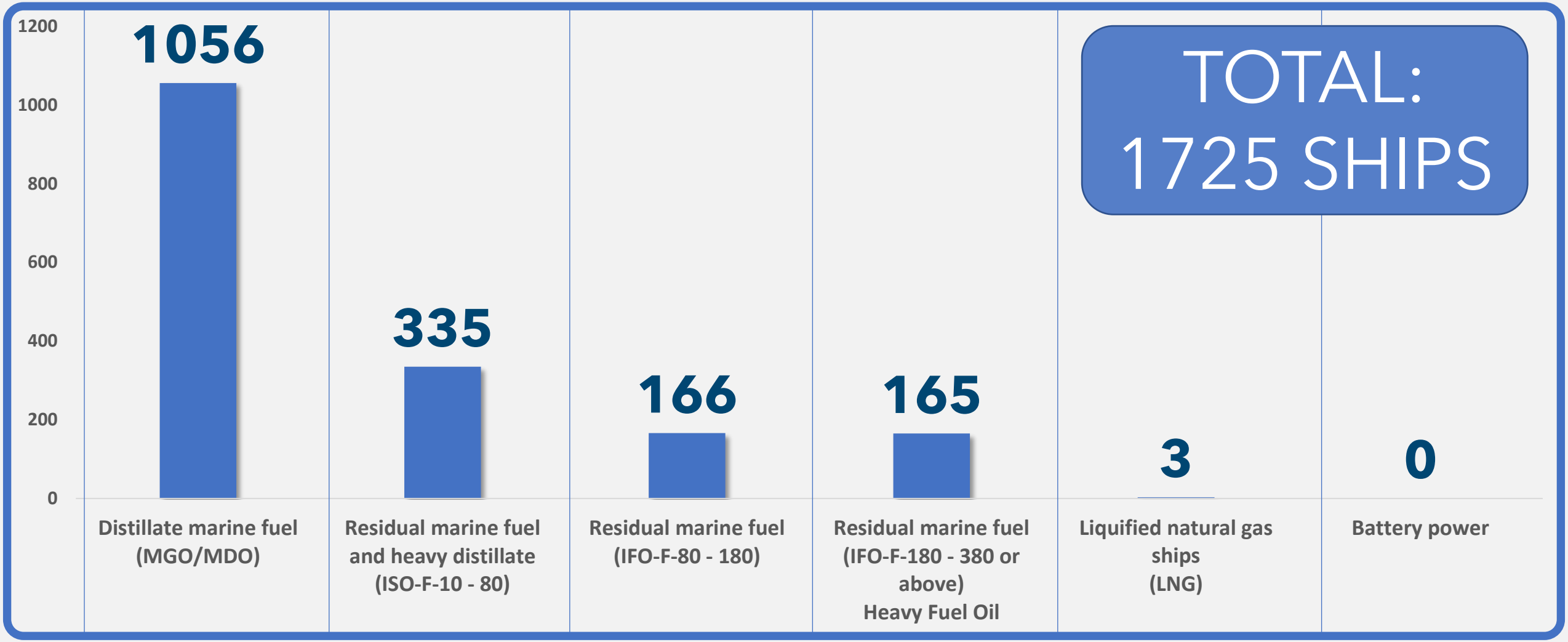
LNG is a natural gas (predominantly methane), cooled down to liquid form for ease and safety of storage or transport.

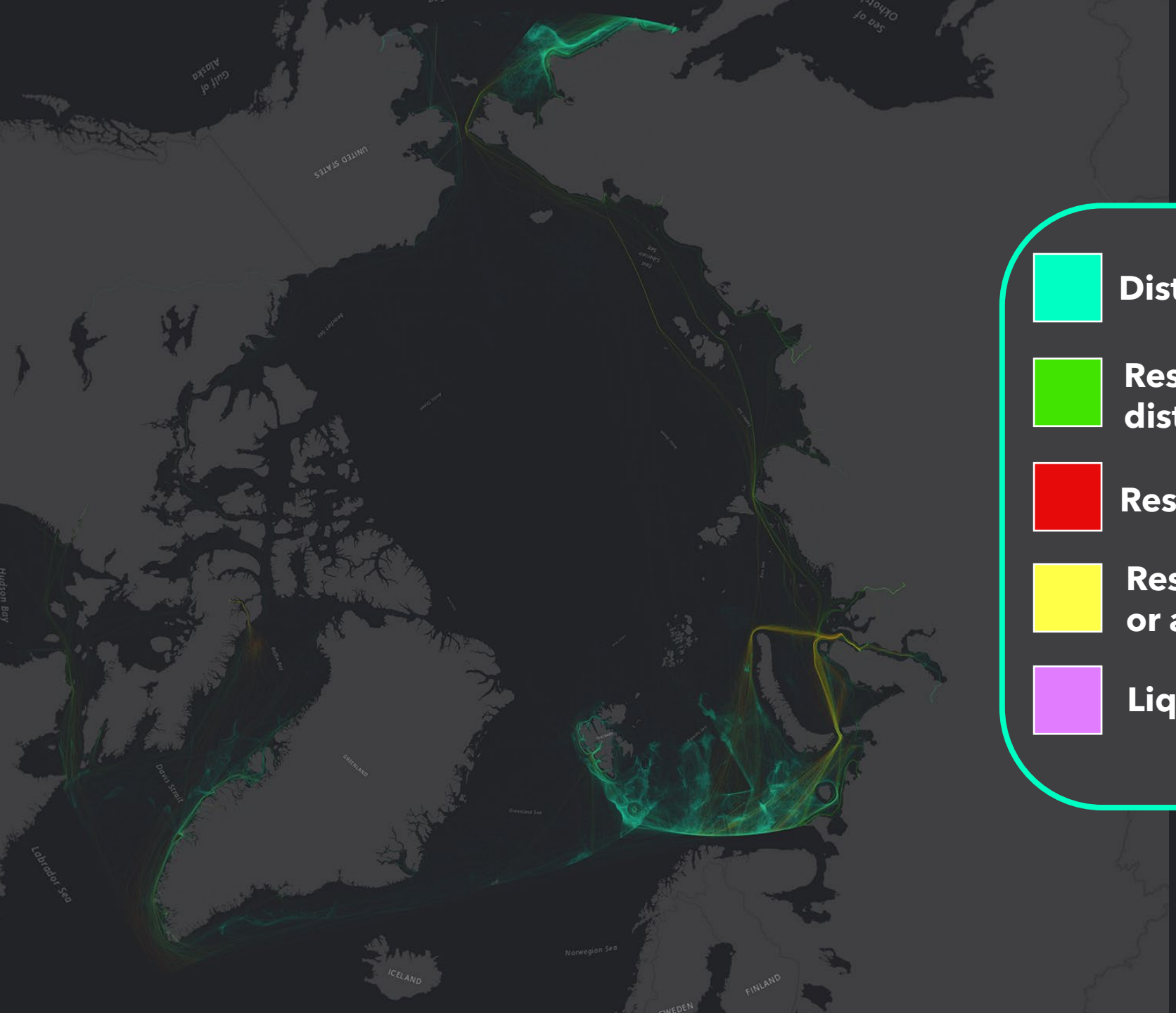
6 Battery Power

Ships run on 100% electricity.

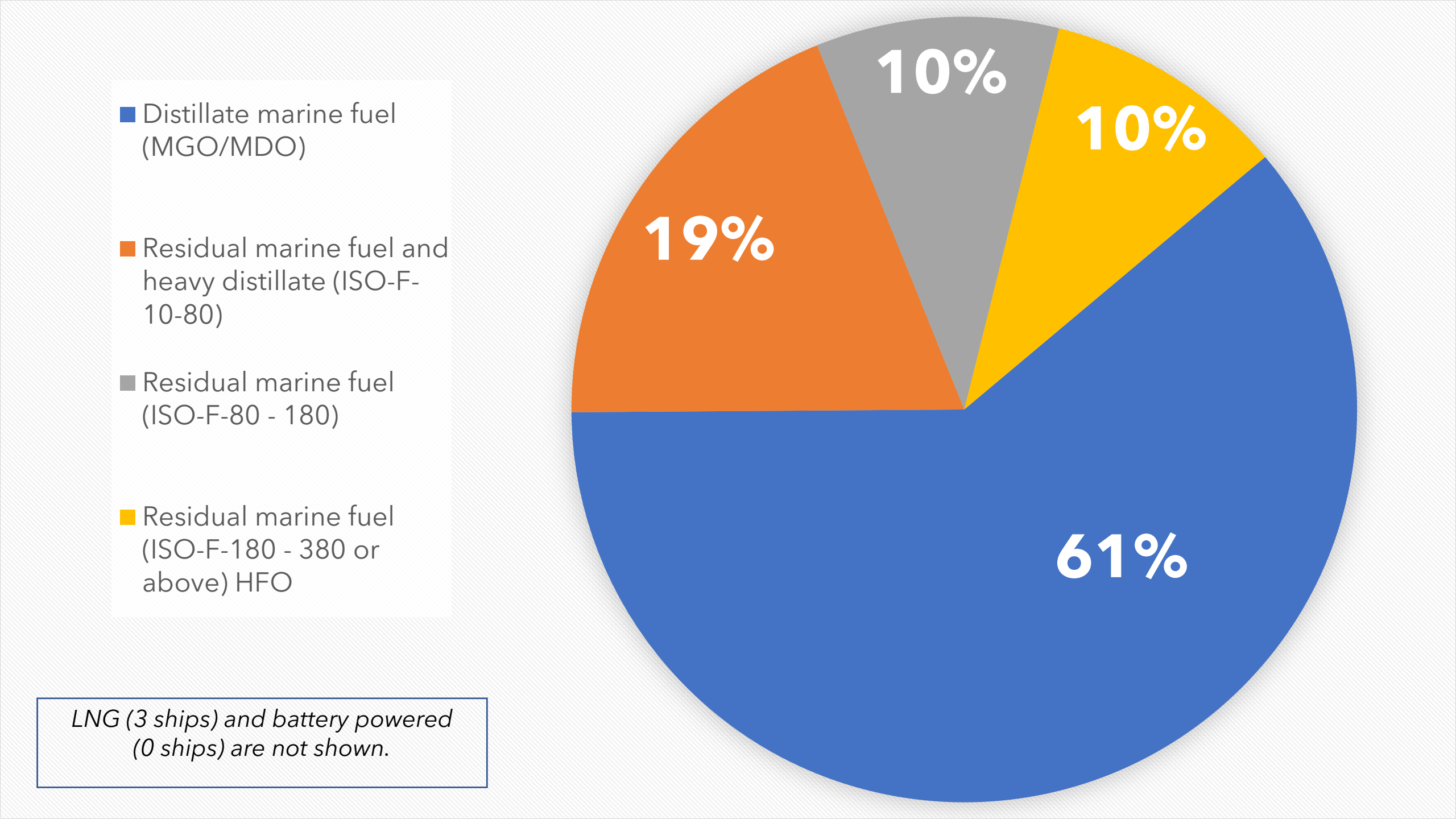
NUMBER OF SHIPS USING THE SIX FUEL TYPES

ARCTIC POLAR CODE AREA 2019





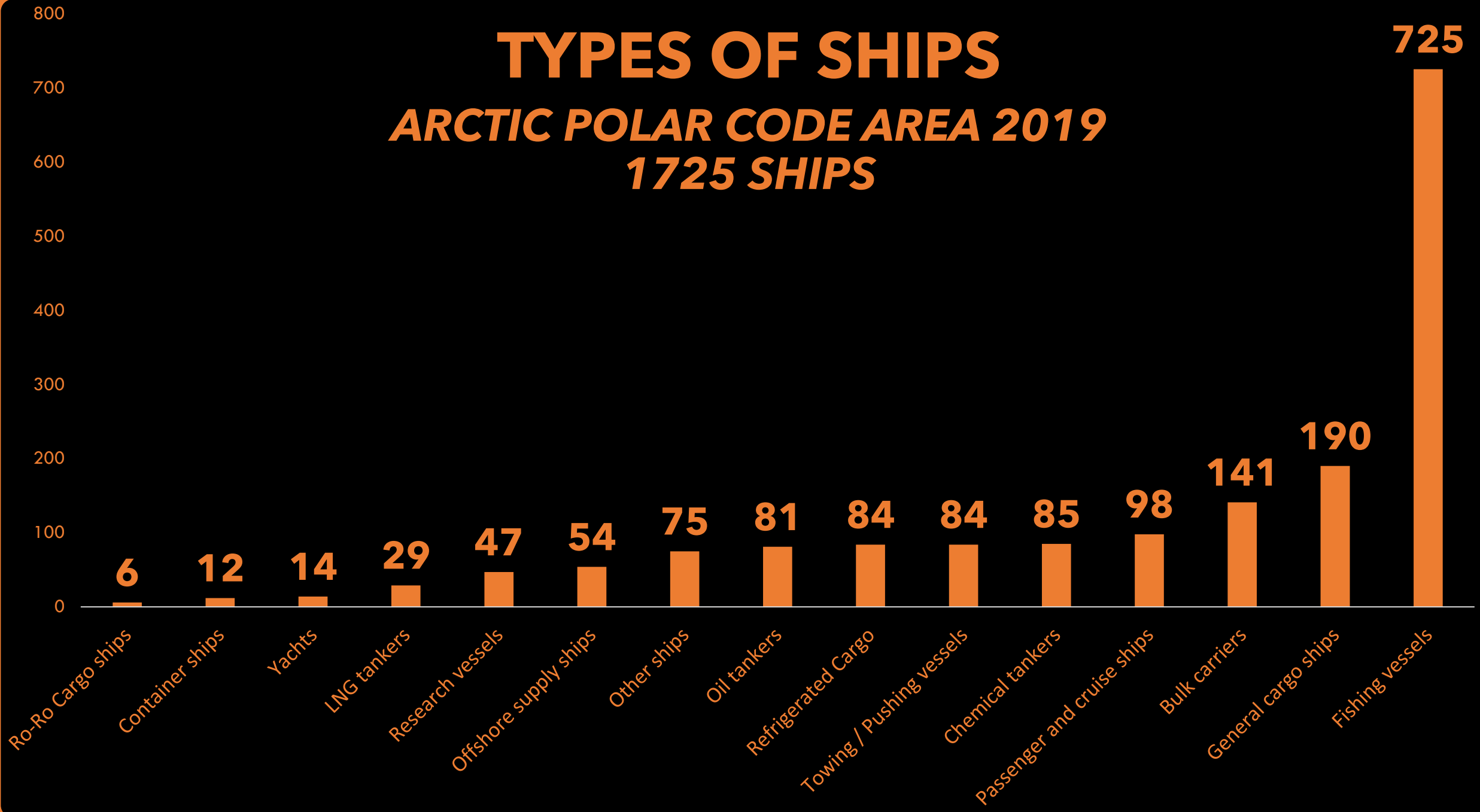
- Distillate marine fuel (MGO/MDO)
- Residual marine fuel and heavy distillate (ISO-F10-80)
- Residual marine fuel (ISO-F-80 - 180)
- Residual marine fuel (ISO-F-180 - 380 or above) HFO
- Liquified Natural Gas (LNG)



LNG (3 ships) and battery powered (0 ships) are not shown.

TYPES OF SHIPS

ARCTIC POLAR CODE AREA 2019
1725 SHIPS



THE 165 SHIPS USING HFO IN THE ARCTIC IN 2019

Density map of ships using HFO as fuel

Arctic Polar Code Area 2019

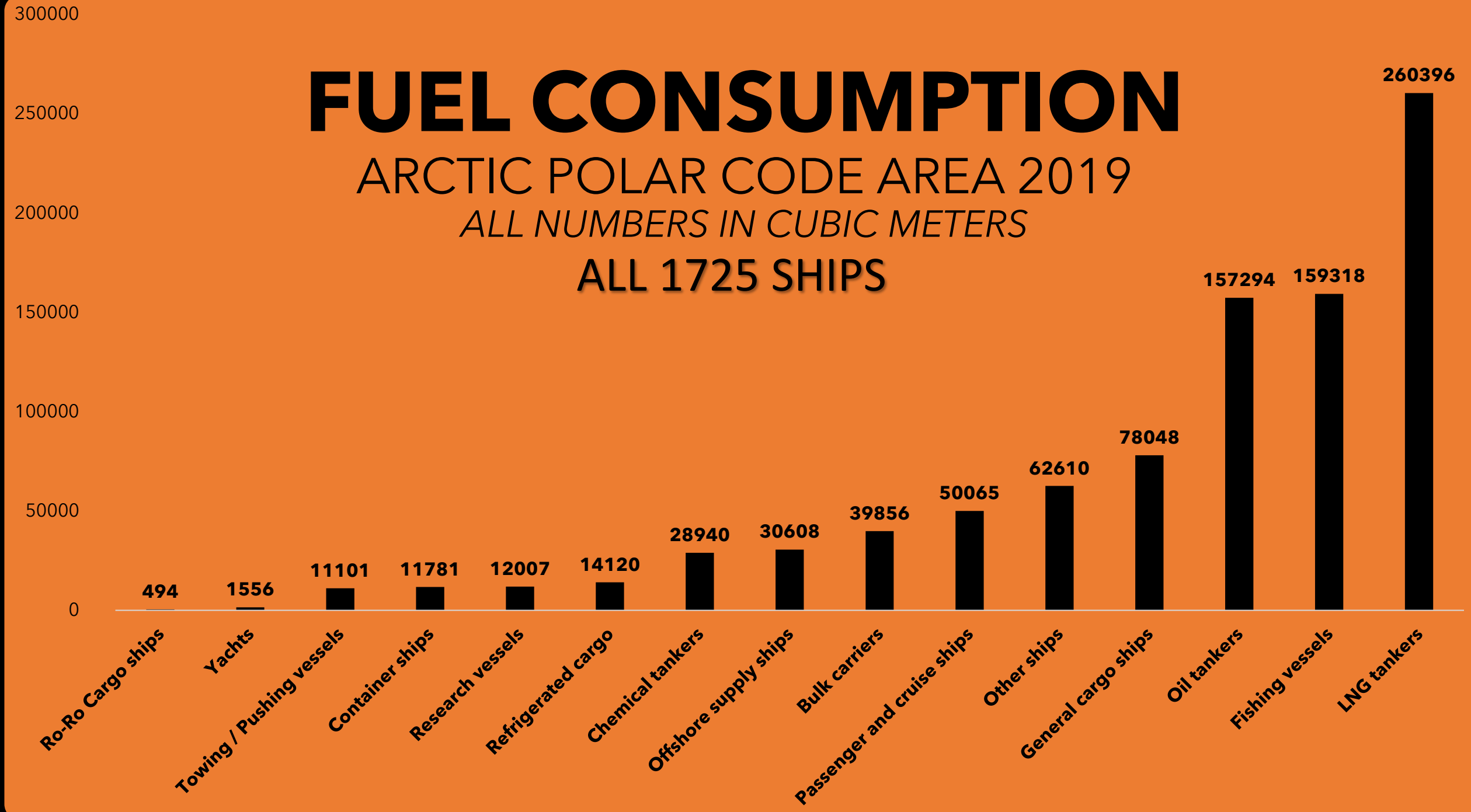
Residual marine fuel (ISO-F-180 - 380 or above) HFO

FUEL CONSUMPTION

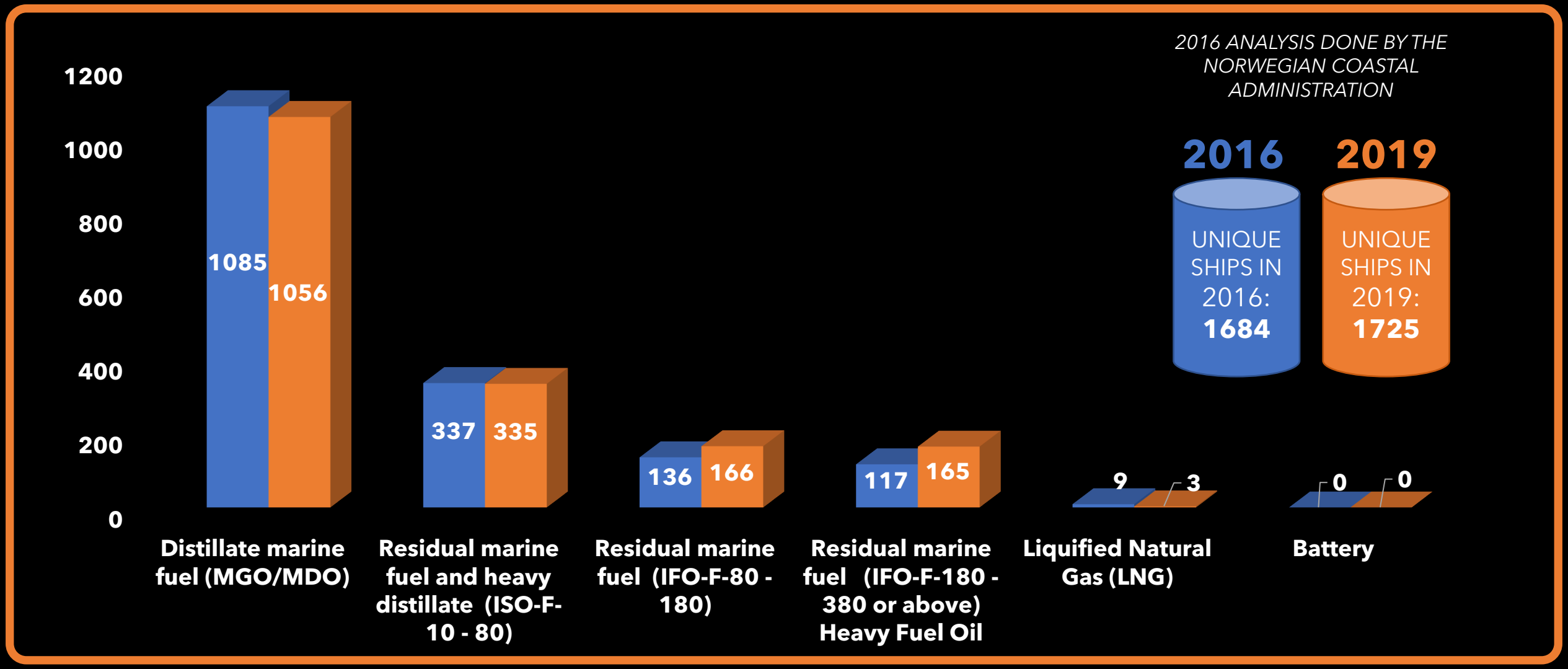
ARCTIC POLAR CODE AREA 2019

ALL NUMBERS IN CUBIC METERS

ALL 1725 SHIPS



THE NUMBER OF UNIQUE SHIPS IN 2019 AND 2016 ARE *ALMOST* IDENTICAL



HOWEVER, FROM 2016 TO 2019 FUEL CONSUMPTION GREW BY

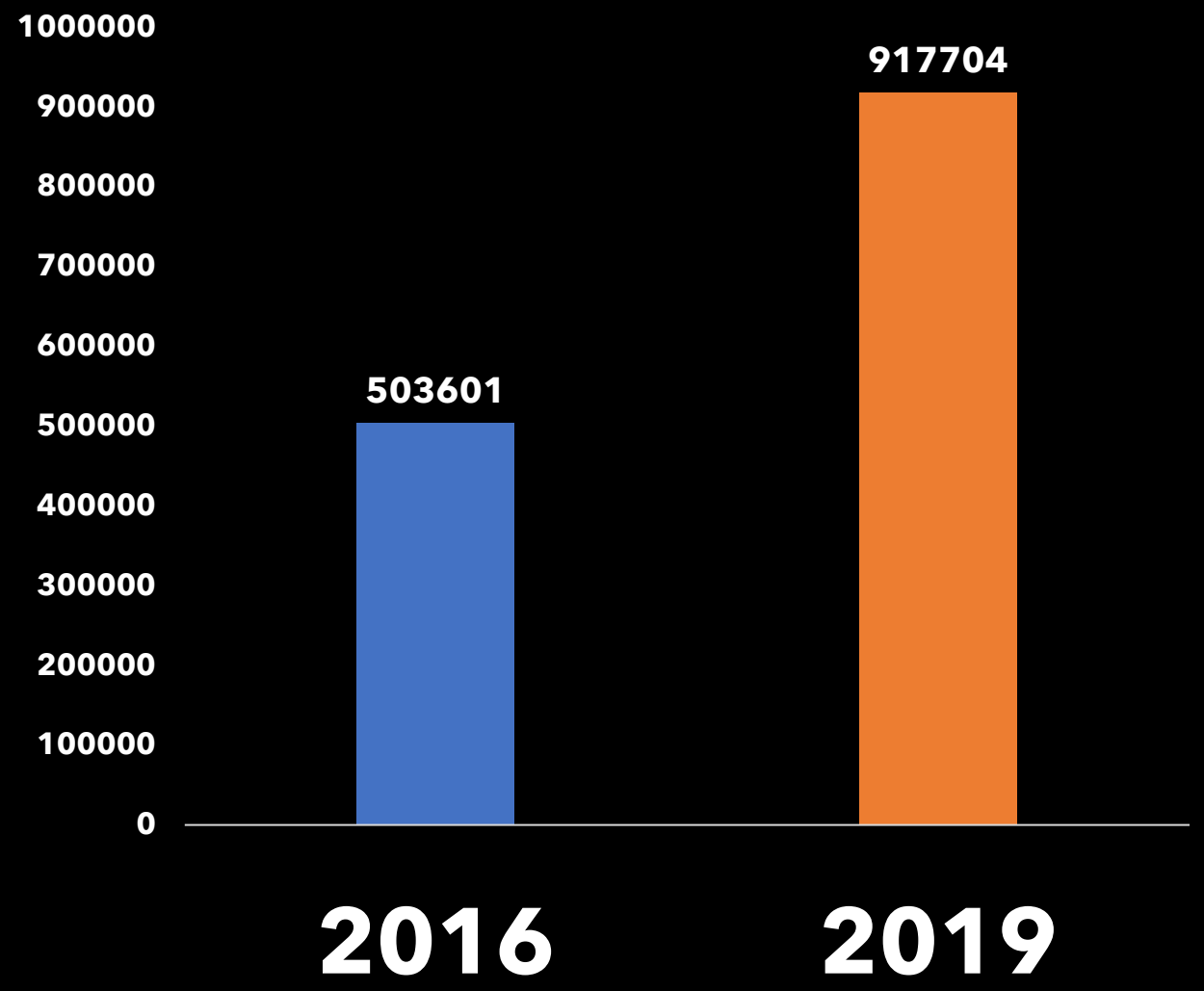
82%

FUEL CONSUMPTION

ARCTIC POLAR CODE AREA 2016 & 2019

NUMBERS IN CUBIC METERS

ALL 1725 SHIPS



WHEN ANALYSING THE DATA, THERE IS ONE STRIKING DIFFERENCE:

THE LACK OF LNG TANKERS IN 2016

THERE WERE NO LNG TANKERS IN THE POLAR CODE AREA IN 2016 AND THEREFORE NO FUEL CONSUMPTION BY LNG TANKERS

THAT CHANGED **SUBSTANTIALLY** IN 2019 WHEN THERE WERE 29 LNG TANKERS IN THE POLAR CODE AREA AND THEY WERE THE **BIGGEST CONTRIBUTOR** TO FUEL CONSUMPTION

IN 2019, LNG TANKERS CONSUMED 28% OF THE FUEL COMBUSTED BY SHIPS IN THE ARCTIC POLAR CODE AREA

LNG TANKER TRAFFIC IN THE ARCTIC

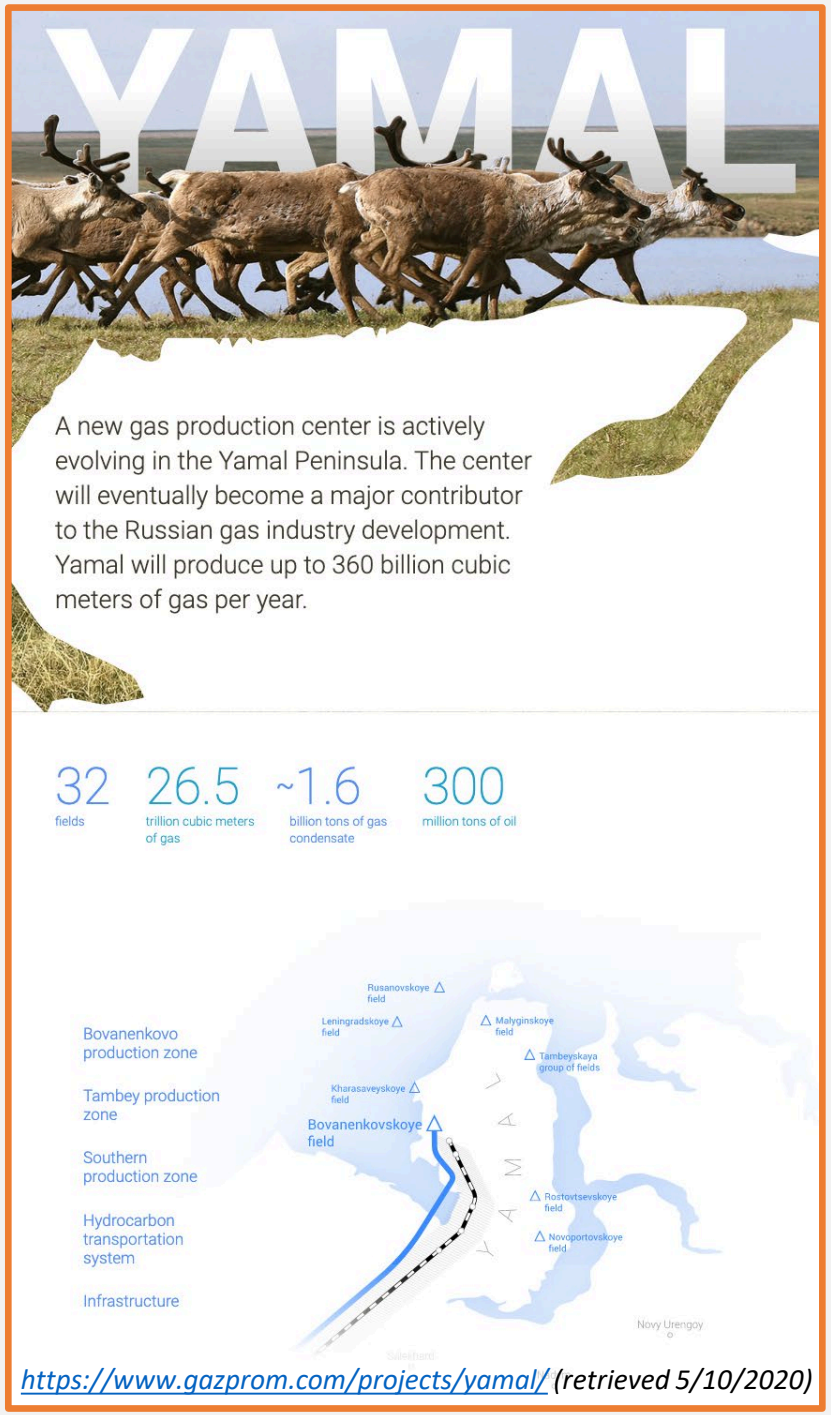
POLAR CODE AREA

THE REASON IS THE YAMAL MEGAPROJECT

Yamal will produce up to 360 billion cubic meters of gas per year.

www.astdi.is

LNG TANKERS IN 2019 SAILING TO THE YAMAL PENINSULA



https://www.gazprom.com/projects/yamal/ (retrieved 5/10/2020)

DUE TO REGULATION CHANGES – THERE IS A PARADIGM SHIFT IN THE LANDSCAPE OF MARINE FUELS IN 2020 AND IN THE NEAR FUTURE

2020

2029

2050

NEW ERA OF *SHIP FUELS*

STEP 1

2020

SULPHUR CAP

From 1 January 2020, the limit for sulphur in fuel oil used on board ships operating outside designated emission control areas is reduced to 0.50% m/m (mass by mass). This will significantly reduce the amount of sulphur oxides emanating from ships and should have major health and environmental benefits for the world, particularly for populations living close to ports and coasts.

STEP 2

2029

HFO BAN

The IMO's PPR 7 proposed a draft regulation which would phase out the use as fuel oil and carriage for use as fuel oil of HFO by ships in Arctic waters starting in 2024. According to the draft regulation, which has not yet been adopted, States would have the ability to temporarily waive the requirement for individual ships until 1 January 2029, provided they report the particulars to IMO.

STEP 3

2050

50% REDUCTION OF GHG

IMO has adopted an initial strategy on the reduction of greenhouse gas (GHG) emissions from ships, setting out a vision to reduce GHG emissions from international shipping and phase them out as soon as possible, and no later than 2050.

Sulphur Content is a Key Differentiator of HFO

Based on sulphur content, there are three main classes of fuel for ships

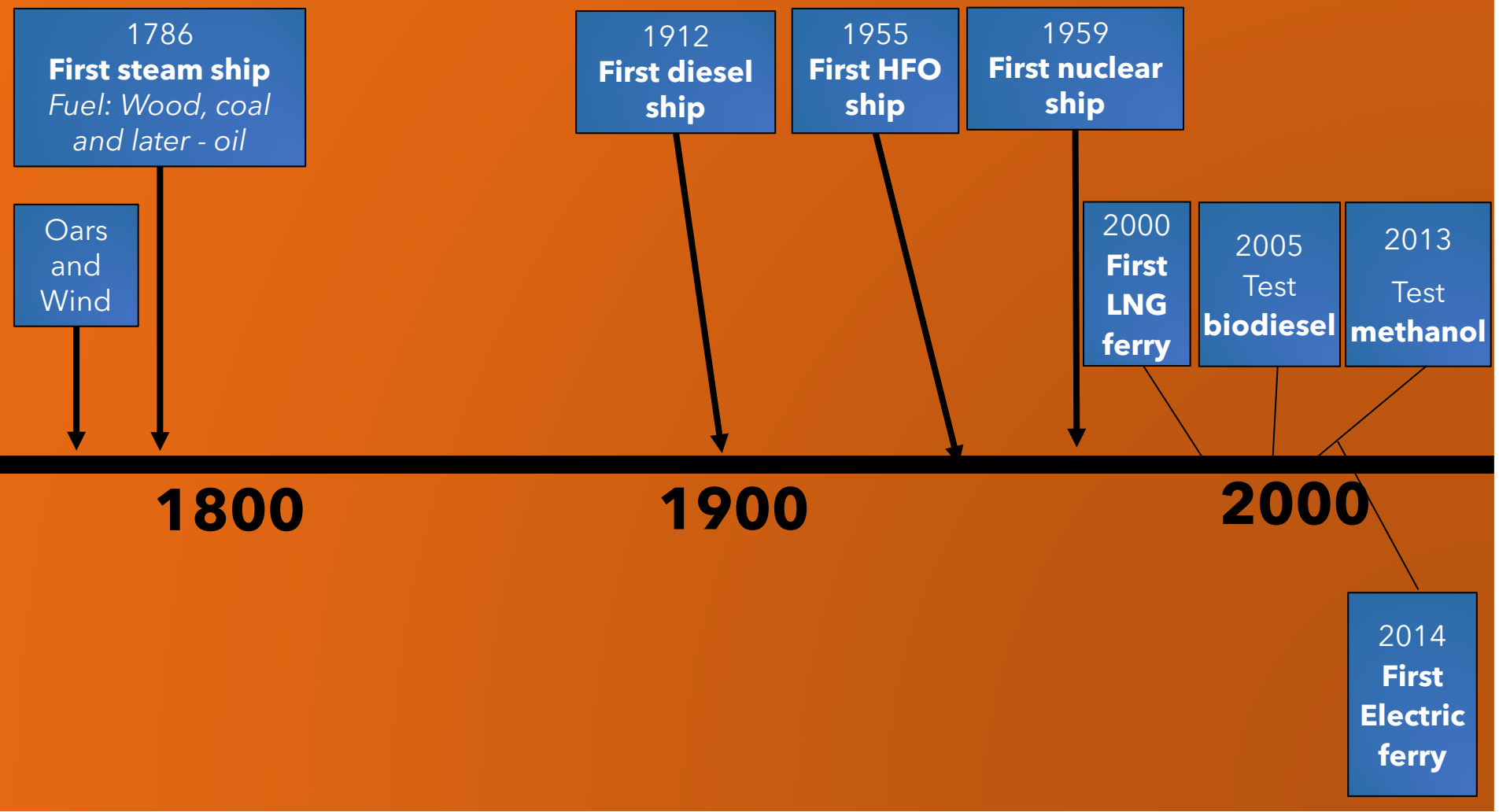
Marine Fuel	Max. Sulphur Content
High sulphur fuel oil (HSFO) *Only applicable to ships that have exhaust gas cleaning systems installed on and after 1 January 2020.*	**3.50% m/m**
Low sulphur fuel oil (LSFO) *Only applicable to ships that have exhaust gas cleaning systems installed on and after 1 January 2020.*	**1.00% m/m**
Very low sulphur fuel oil (VLFSO)	**0.50% m/m**
Ultra low sulphur fuel oil (ULSFO)	**0.10% m/m**

Global sulphur limit from 2020 is 0.50 % m/m

Crude oil contains sulphur which, following combustion in the engine, ends up in ship emissions. Sulphur oxides (SOx) are known to be harmful to human health, causing respiratory symptoms and lung disease. In the atmosphere, SOx can lead to acid rain, which can harm crops, forests and aquatic species, and contributes to the acidification of the oceans. Limiting SOx emissions from ships will improve air quality and protect the environment.

IMO. Sulphur 2020 – cutting sulphur oxide emissions.

EVOLUTION OF SHIP PROPULSION



2020
NEW ERA OF SHIP FUELS

IMO

Goal:
By 2050 to Reduce CO2 emissions by 50% relative to 2008

2029 Potential prohibition of HFO use and carriage for use as fuel by ships

2020
0.50 % m/m sulphur limit globally

2100

TO CONCLUDE

There is presently a knowledge gap as to the types of fuels combusted in the Arctic.

Another knowledge gap is the behavior of low sulphur fuels, which are designed to comply with the IMO's 2020 fuel sulphur limit, and how such fuels behave in cold Arctic waters.

Both of these knowledge gaps are being addressed by PAME and the Arctic Council's Emergency Prevention, Preparedness and Response (EPPR) Working Group in a new project led by Norway.

ABOUT THIS REPORT

This is the second report generated by PAME's Arctic Ship Status Report (ASSR) Project. The goal of the ASSR Project is to use PAME's Arctic Ship Traffic Data (ASTD) System to highlight topical issues related to shipping in the Arctic. Launched in 2019, the ASTD System is PAME's database for Arctic shipping activities.

Due to data updates and slight differences in analytical methodologies, the overall number of ships may differ slightly from ASSR to ASSR.

Special thanks to Karen Gouws, Earth Resources Technology; Integrated Ocean and Coastal Mapping; NOAA Office of Coast Survey.

The project gratefully acknowledges funding from the Nordic Council of Ministers.

Nordic Co-operation

PAME
Protection of the Arctic Marine Environment

Sources:

- ASTD – Arctic Ship Traffic Data
- IMO: Full Polar Code text
- DNV GL
- PAME: AMSA 2009 Report
- Document MEPC 71/14/4 (Canada, Finland, Germany, Iceland, Netherlands, Norway and the United States) submitted to the IMO Marine Environment Protection Committee at its seventy-first session.
- PAME Report on Alternative Fuels
- U.S. Energy Information Administration
- BunkerX – Fuel Prices
- Norwegian Coastal Administration: 2016 Fuel analysis
- IMO: Greenhouse Gases
- Nordic Council of Ministers: HFO Report
- IMO: Sulphur 2020 – cutting sulphur oxide emissions.