The low sulphur fuel starting from the bottom of the barrel: EST a novel and industrial proven technology

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AGENDA

- Existing Legislation
- Expected Impacts at 2020
  - ✓ Shipping
  - ✓ Refining
- EST (Eni Slurry Technology)
- Conclusions

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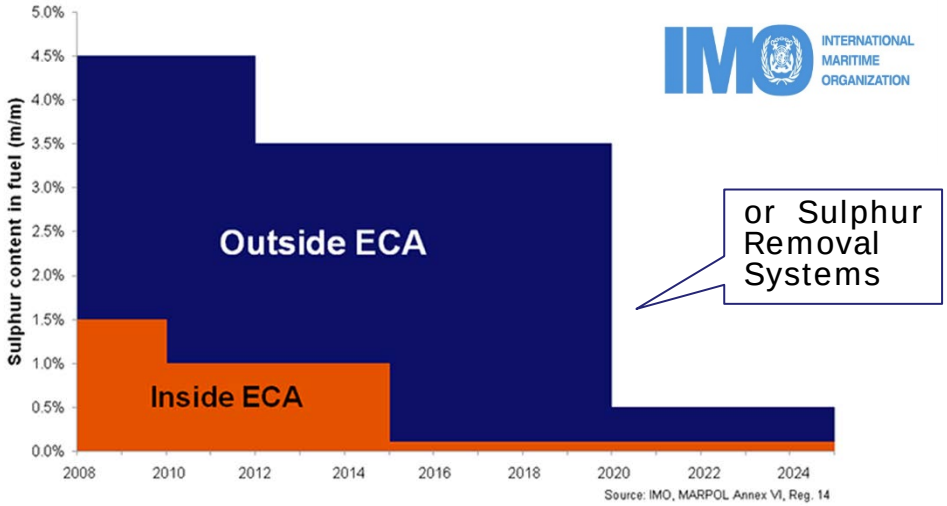
MARPOL Annex VI–sulfur content for marine fuels

- In 2008, IMO has adopted a resolution to amend Annex VI of the MARPOL Convention that came into force on July 1st 2010.
- Annex VI introduces, moreover, more stringent limits to sulfur content for marine fuel:
  - in the SECA area (1,00 % from July 1st 2010 and 0,10 % from January 1st 2015)
  - outside of the SECA (3,50 % from January 1st 2012 and 0,50 % from January 1st 2020 or from 2025
  - by decision of October 27th 2016 IMO has established the transition at January 1st 2020



Bunker Fuel Oil – impact of new legislation

According to the study of CE Delft (commissioned by IMO to decide SGC at 2020)

- At 2019 the global maritime transport consumption of HS HFO (High Sulphur Heavy Fuel Oil) is estimated at 253 million t/y.
- At 2020, the use of HS fuels for ships equipped with scrubbers will still be limited to around 48 million t/y.
- The shift to marine bunkers with 0.5% S cap in 2020, accounting for the use of alternative fuels (LNG) and the partial use of smoke removal systems (scrubbers), will result in the substitution of little less than 200 million t/y of HS HFO.

- **The decision is a milestone: after sulfur removal in gasoline and diesel, now is the time of fuel bunker for further and significant reduction of SO2 emission.**

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Expected impact on the shipping system

With the new specification on the maximum sulfur limit of 0.5%, ship owners will have three possible options to adapt ship emissions: switch to LNG, Scrubber installation, **new bunker fuel 0,5%S**

1. Switch to LNG as main fuel:

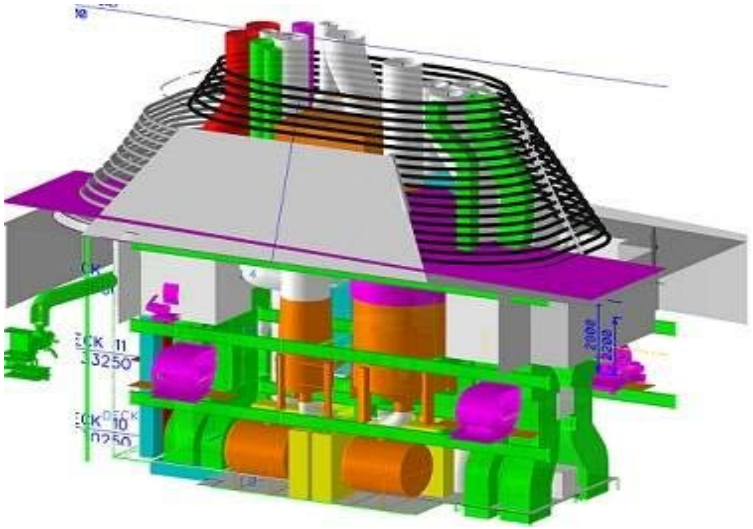
+ no emission of SOx
+ reduction of NOx and PM emissions
+ more compliant with EU de-carbonization policy of fuels
- doubled storage capacity for fuel
- expensive retrofitting of existing fleets
- need for new port infrastructure
- possible only short/medium range routes

Expected impact on the shipping system

2. **Exhaust gas cleaning systems (scrubbers)**

- On board complex and interconnected system in large vessels.
- Difficult and expensive to retrofit small cabotage vessels.
- Port facilities for treatment of sludge produced by closed-circuit or hybrid scrubbers.
- On board expertise to manage both the control system as well as the waste products.
- Continuous monitoring of the abatement systems to ensure and prove to Authorities the correct operation and use of compliant fuel.

\+ Possibility to stay in business utilizing HS HFO



3. Using new bunker fuel 0.5% S (LS HFO)

No investment for shipping industry:

+ no additional bunker tanks and piping systems
+ no scrubbers to reduce PM and SOx
+ no fuel treatment equipment
+ same engine maintenance

Bunker fuel onboard plant & maintenance:

+ provides safer working environment for ships' staff and shore side workers
+ avoids carriage of multi-fuels and fuel blending switching problems
+ reduces control and monitoring requirements
+ lowers burden for crew
+ lessens harmful impact of bunker spills

Poll Question

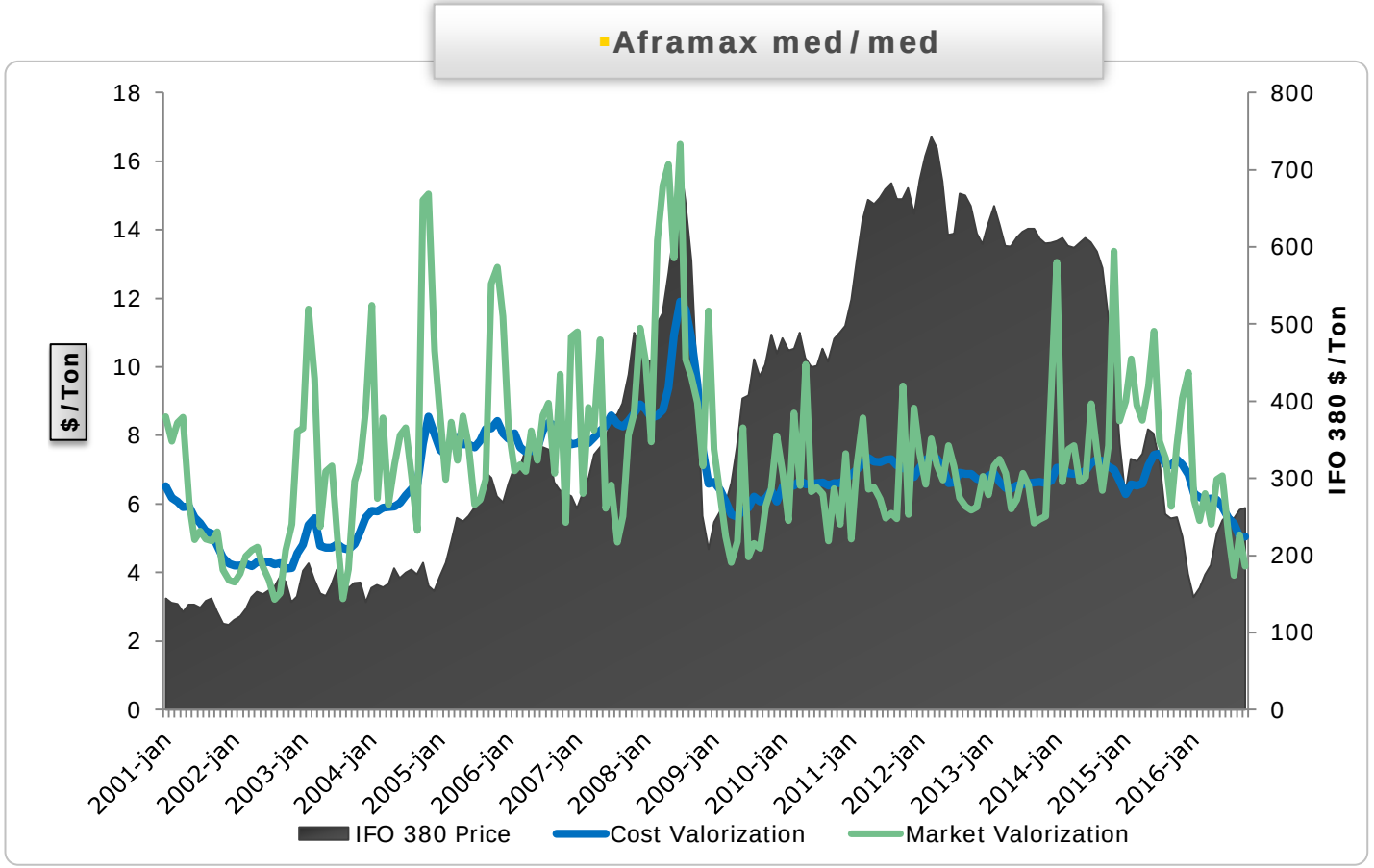
In your opinion, what solution would have the lowest impact on cost to shipowners ? (assuming given market freight quotation)

A. **LNG:** Higher Investment for LNG on board + Cost of Port for LNG facilities + LNG Price effect

B. **SCRUBBERS:** Investment and management of on board Scrubber + Cost of Scrubber sludge treatment at Port – HS HFO minor price effect

C. **LS Bunker:** Incremental Cost of New Marine Bunker vs. HS HFO

Freights trend market and cost valorization



The estimate price of the new bunker fuel, between diesel and LFO, will affect only marginally the freight cost.

Source: Clarkson

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What can the refining industry do to cope with this change?

To supply bunker fuels 0,5% S, the refining industry has two available paths:

1. Process ultra low sulfur crude (eg. African crudes such as Djeno Melange, Sarir, Westerm Desert, Asian crudes, North Sea crudes).

2. Make major investments in bottom of the barrel conversion plants

Technologies for Petroleum Residue Upgrading

- Several commercial technologies conversion of vacuum residue to lighter products
- Increase of low H/C of residue to higher H/C of products via thermal or catalytic:

carbon rejection (thermal)

Coking offers high feedstock flexibility
but
poorer quality of distillates
loss of liquid yield,
ca. 30% wt of low value coke

>300 M TPY petcoke produced worldwide

hydrogen addition (catalytic)

Fixed/Moving bed (low metals content feed)
Ebullating bed (relatively higher metals feed)
but
limits the maximum conversion achievable
fuel oil remains a fatal product

9 M BPSD fuel oil produced in the world

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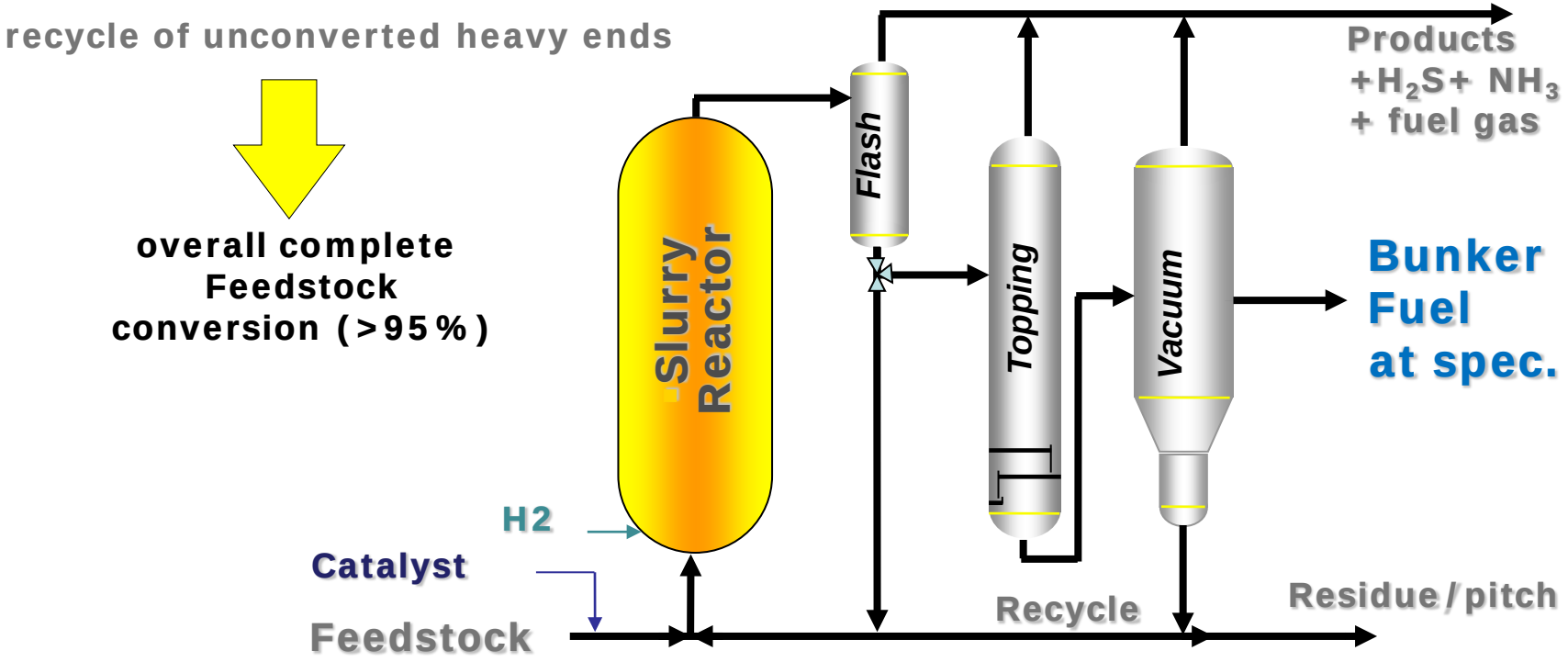
EST simplified process scheme

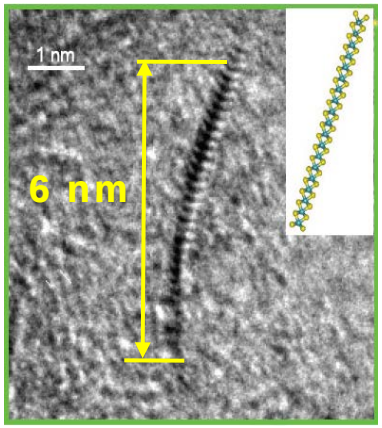
EST is a hydrocracking process based on two unique features:

1. **Nanodispersed (slurry) non ageing catalyst**
2. **Homogeneous & isothermal slurry bubble column reactor**



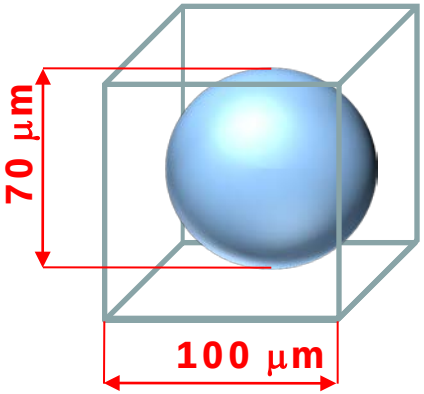
EST can easily handle very heavy feedstock

EST catalyst vs. conventional HCK catalysts



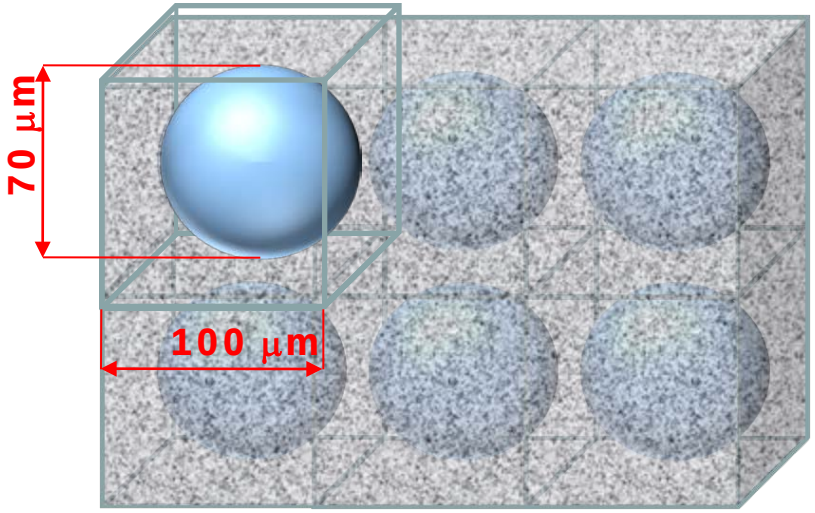
HRTEM of EST catalyst

- The active phase is unsupported molybdenite (MoS_2) in isolated layers with excellent dispersion
- Generated in situ from oil-soluble precursors
- High surface area
- No plugging from metals and coke deposits

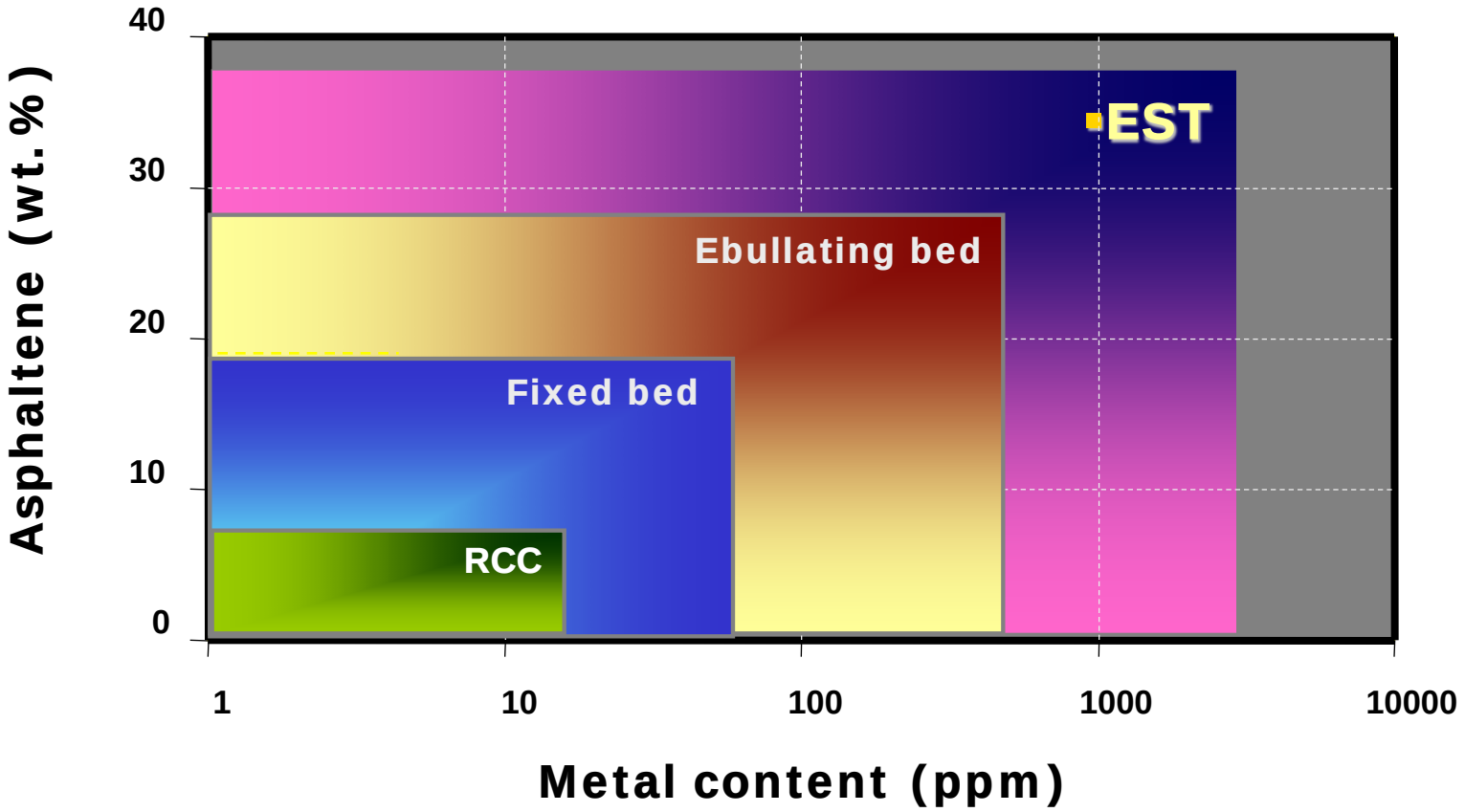


Conventional catalysts

8 x 10^{10} MoS_2 particles



EST: Maximum Feedstock Flexibility



EST: Development Road

First License Agreement

Start of R&D activities

Pilot Plant start-up

Commercial Demonstration Plant start-up

First Commercial Plant Start-up

1990 1995 2000 2005 2010 2015

Research and Development activities

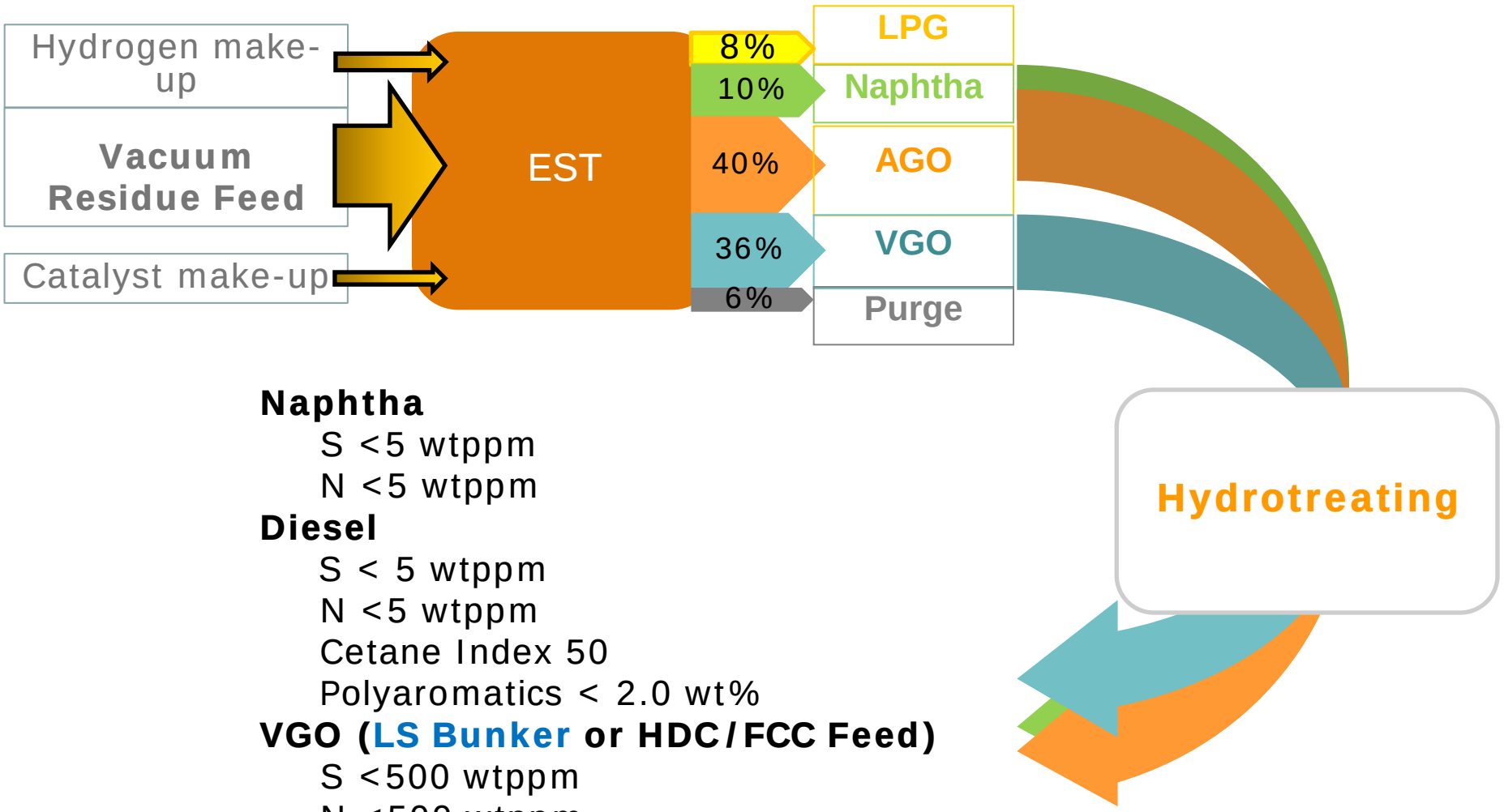
Pilot Plant activities

Demo Plant activities

Commercial Unit in Operation

EST Sannazzaro today

Product yields and quality



Naphtha
- S <5 wtppm
- N <5 wtppm

Diesel
- S < 5 wtppm
- N <5 wtppm
- Cetane Index 50
- Polyaromatics < 2.0 wt%

VGO (LS Bunker or HDC/FCC Feed)
- S <500 wtppm
- N <500 wtppm
- Metals <1 wtppm

Exploring how the technology can be utilized in the MENA region

In the future the e.e. will be more and more produced from renewables

Coke and HSFO will be hardly sold

EST, latest industrial proven technology in the world, in the refining industry But EST also means……

- Very High conversion (about 95%) to light and middle distillates (or upgraded syncrude in upstream contexts)
- Feed flexibility
- **Premium, clean fuels production like new low sulphur bunker fuel according to IMO GSC 2020**
- Environment-friendly technology (coke or fuel oil production reduced/eliminated)
- high energy efficiency
- excellent option for natural gas valorization
- PCH Plant Integration

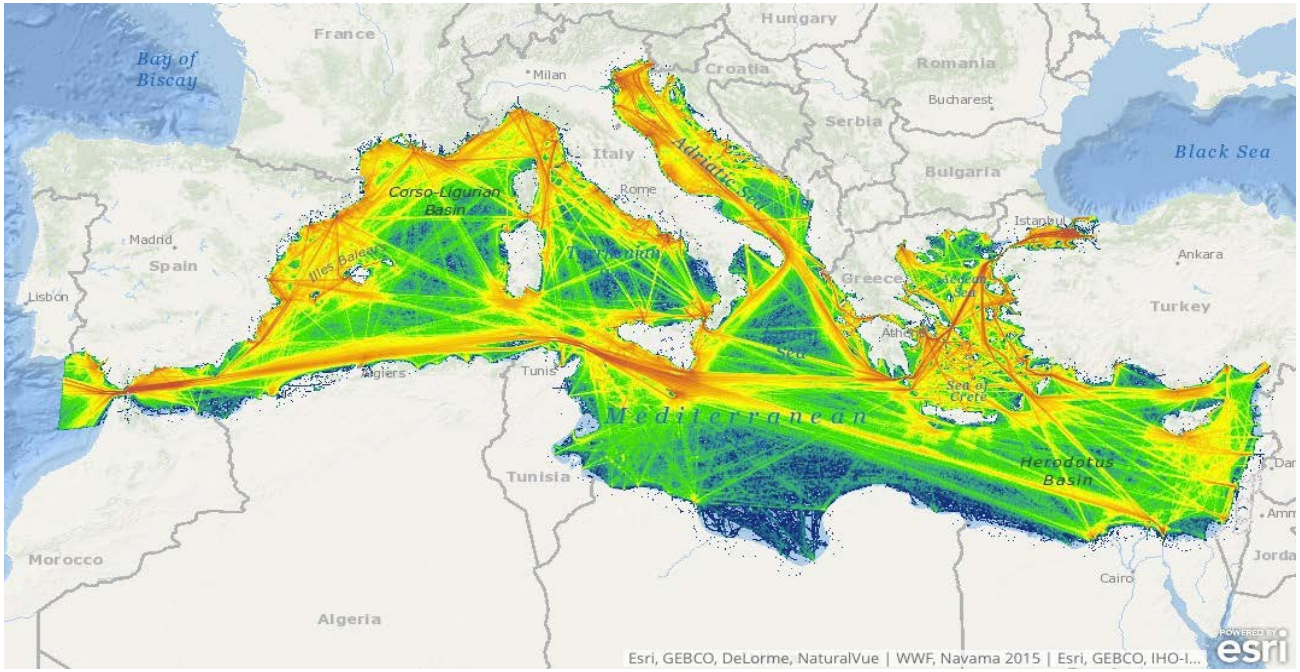
Eni's approch to fuel quality evolution

The Eni policy approach on product quality is to anticipate environmental legislation

Specification	Eni commitment (year)	Legislation Endorsement (year)
Zero lead gasoline	1987	2000
1% max vol Benzene	1997	2000
Max S 10 ppm diesel	2002	2009
Max S 10 ppm Gasoline	2004	2009
2 % wt PNA Diesel	2010 locally, 2016	nd
10 % renewable Diesel	2016	2020
0,5% S bunker fuel	**2016**	**2020**

Thanks to the implementation of the EST technology, Eni has achieved the goal of free sulfur in all fuels responsible for large amounts of SO2 emissions into the environment

Focus on Mediterranean traffic



About **1/3 of the world's** total merchant shipping traffic either trades to seaports or passes through the Mediterranean (surface: less than 1% world water surface).

- **More than 200.000 large** vessels (>100.000 dwt) per year.
- About **2000 ferries**, **1500 cargo ships** and **2000 local commercial craft** operate in the Mediterranean.

New Sulphur spec 2020 will have significant impact on pollution reduction in Mediterranean Sea and in the coastal areas

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- The new sulphur specification completes the sulphur removal in all fuels, light and heavy, with very beneficial effects on the environment
- Since mid 90s Eni has heavily invested in R&D of new deep conversion technologies. This has originated EST technology, suitable for the production of light distillates and low sulfur bunker fuel
- EST is now the best proven technology in the market for full conversion of bottom of the barrel, and Eni started its licensing out
- EST technology increases the H/C ratio of products and eliminates coke and fuel oil production. Thus the technology is environmental frieldly, sustainable and in the path of de-carbonisation.
- Thanks to this technology Eni is already capable of producing from its Sannazzaro Refinery over 400 kt/year of bunker fuels with sulfur less than 0.5% S (and 0.1% for SECA areas) with a price probably between LS fuel oil and diesel.
- The higher cost of the new fuel could impact freights moderately, as in the past where the shipping industry already faced fuel prices of 600 USD/t with minor effects on freights.
- LNG in the medium to long term should be attractive in the case of new ships. Most depends on development of Ports facilities.
- Installation of scrubbers appears, at the time, another possible solution butdifficult to implement and to monitor the performance of cleaning system on board.

Thank you for your kind attention

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Ice-Breaker Questions

- What is the biggest hurdle to your company while developing this new technology?

- An increasing in PetCoke production and market will be possible and/or sustainable in the future?