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

Massimo Trani
VP Technology Licensing
Refining & Marketing and Chemicals - Eni S.p.A

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AGENDA

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

- **Expected Impacts at 2020**
  - ✔ Shipping
  - ✔ Refining

- **EST (Eni Slurry Technology)**

- **Conclusions**
In 2008, IMO has adopted a resolution to amend Annex VI of the MARPOL Convention that came into force on July 1\textsuperscript{st} 2010.

Annex VI introduces, moreover, more stringent limits to sulfur content for marine fuel:

- in the SECA area (1,00 % from July 1\textsuperscript{st} 2010 and 0,10 % from January 1\textsuperscript{st} 2015)
- outside of the SECA (3,50 % from January 1\textsuperscript{st} 2012 and 0,50 % from January 1\textsuperscript{st} 2020 or from 2025)
- by decision of October 27\textsuperscript{th} 2016 IMO has established the transition at January 1\textsuperscript{st} 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 about 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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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:**
   - doubled storage capacity for fuel
   - expensive retrofitting of existing fleets
   - need for new port infrastructure
   - possible only short/medium range routes
   + no emission of SOx
   + reduction of NOx and PM emissions
   + more compliant with EU de-carbonization policy of fuels
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 correct operation and use of compliant fuel.
+ Possibility to stay in business utilizing HSFO
Expected impact on the shipping system

3. Using new bunker bunker fuel 0.5% S

+ No investment for shipping industry:
  - additional bunker tanks and piping systems
  - scrubbers to reduce PM and SOx
  - fuel treatment equipment
  - engine maintenance
  - improved safety
  - marginal effect on the cost of freight

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
  + lessens harmful impact of bunker spills
  + lowers burden for crew
Question

What will be, in your opinion, the greatest incremental impact on the cost for shipowners @ fixed price of freight?

A. Scrubber on board investment + Cost of Port for Scrubber sludge treatment + HSFO less price effect

B. LNG on board investment + Cost of Port LNG facilities + LNG Price effect

C. Incremental Cost of LSFO vs. HSFO
The estimate price of the new bunker fuel, between diesel and LFO, will affect only marginally the freight cost.
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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 (e.g., African crudes such as Djeno Melange, Sarir, Western 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
  - **hydrogen addition (catalytic)**
    - Fixed/Moving bed (low metals content feed)
    - but Ebullating bed (relatively higher metals feed)
    - limits the maximum conversion achievable
    - fuel oil remains a fatal product

- >300 M TPY petcoke produced worldwide
- 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**

Recycle of unconverted heavy ends

Overall complete Feedstock conversion (>95%)

EST can easily handle very heavy feedstock

Bunker Fuel at spec.

Products +H₂S + NH₃ + fuel gas

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EST: Maximum Feedstock Flexibility
EST: Development Road

- Start of R&D activities
- Pilot Plant start-up
- Commercial Demonstration Plant start-up
- First Commercial Plant Start-up
- First License Agreement

Timeline:
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

Activities:
- 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
- Sulfur < 5 wtppm
  - Nitrogen < 5 wtppm
  - Cetane Index 50
  - Polyaromatics < 2.0 wt%

VGO (bunker fuel or HDC/FCC Feed)
- Sulfur < 500 wtppm
- Nitrogen < 500 wtppm
- Metals < 1 wtppm
Remarks on EST

EST, latest industrial proven technology in the world, ready to make the new bunker fuel 0,1-0,5 %S.

EST plant, already in operation from 3 years at Sannazzaro refinery

But EST also means......

- High conversion 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
The Eni policy approach on product quality is to anticipate environmental legislation.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Eni commitment (year)</th>
<th>Legislation Endorsement (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero lead gasoline</td>
<td>1987</td>
<td>2000</td>
</tr>
<tr>
<td>1% max vol Benezene</td>
<td>1997</td>
<td>2000</td>
</tr>
<tr>
<td>Max S 10 ppm diesel</td>
<td>2002</td>
<td>2009</td>
</tr>
<tr>
<td>Max S 10 ppm Gasoline</td>
<td>2004</td>
<td>2009</td>
</tr>
<tr>
<td>2 % wt PNA Diesel</td>
<td>2010 locally, 2016</td>
<td>nd</td>
</tr>
<tr>
<td>10 % renewable Diesel</td>
<td>2016</td>
<td>2020</td>
</tr>
<tr>
<td><strong>0,5% S bunker fuel</strong></td>
<td><strong>2016</strong></td>
<td><strong>2020</strong></td>
</tr>
</tbody>
</table>

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 2000s 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 <0.5% and <0.1% for SECAs.

- The refining industry and in particular Eni, is ready to make available on the market the new bunker fuel 0,5% S.

- Eni is already capable of producing today from its Sannazzaro Refinery over 400 kt/year of bunker fuels with sulfur less than 0.5% S (and 0.1% for SECA areas).

- Product price will be between LS fuel oil and diesel.

- The higher cost of the new fuel will impact freights, even though in the past the shipping industry already faced fuel prices of 600 USD/t, when, two years ago, the crude price was 120 USD/Bbl.
Conclusions

- EST is now the best proven technology in the market for full conversion of bottom of the barrel

- Eni started licensing out of EST

- EST technology, increases the H/C ratio of products and eliminates coke and fuel oil production. Thus the technology is environmentally friendly, sustainable and in the path of decarbonisation.

- LNG in the medium to long term should be the prevailing technology as more economical in the case of new ships and more compliant with the guidelines dictated by EU on fuel decarbonisation.

- Installation of scrubbers appears, at the time, a possible solution even though difficult to implement and to monitor the performance of cleaning system on board.
Thank you for your kind attention

massimo.trani@eni.com
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?