



EST technology:
an advanced way to upgrade the bottom of the barrel
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**WORKSHOP: ADVANCED PROVEN TECHNOLOGIES INCREASE
PRODUCTIVITY QUALITY, SAFETY AND SECURITY**

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Bottom of the Barrel conversion

Current C-rejection technologies (i.e. Coking) do not provide complete *bottom of the barrel* conversion

H/C 1.3



+ 4% wt. Hydrogen

H-addition

C-rejection

- 24% wt. Carbon

H/C 1.9

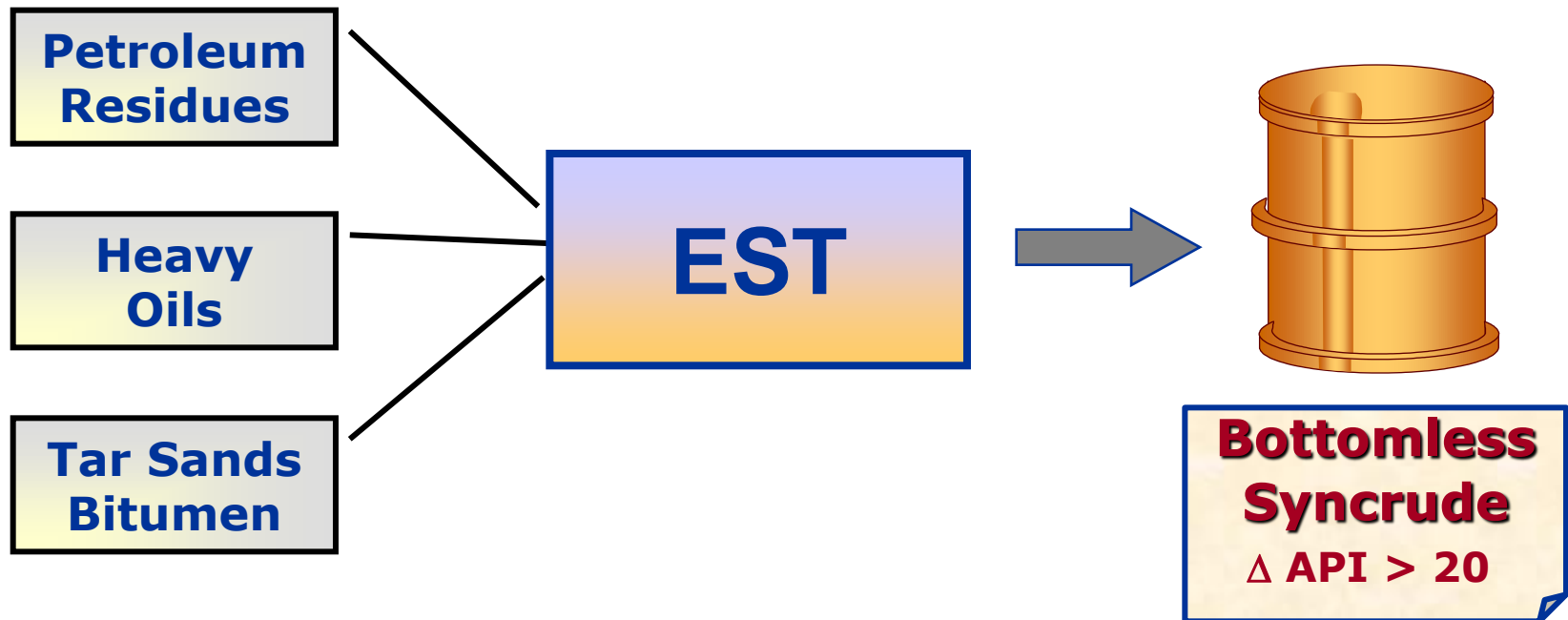


Over 100 million tons of petroleum coke produced annually world-wide



What is EST ?

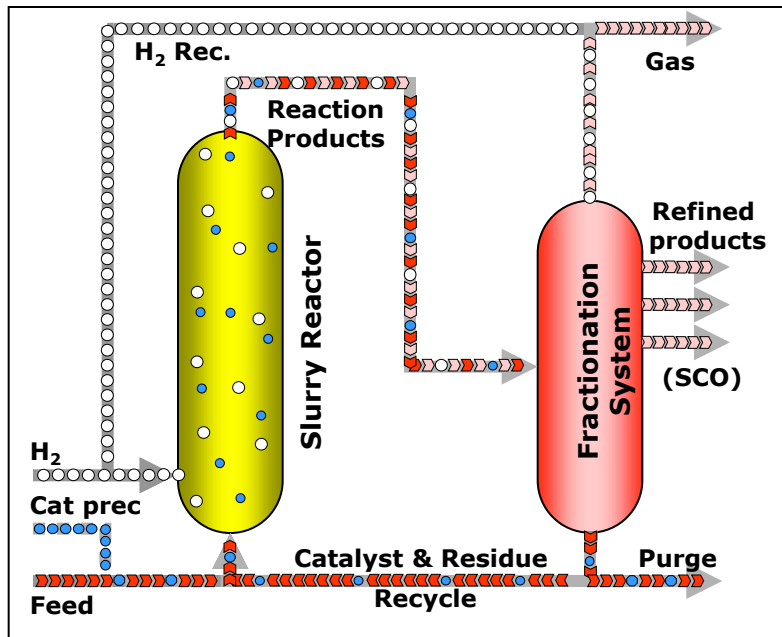
EST (Eni Slurry Technology) is a proprietary new process for heavy feedstock conversion & upgrading



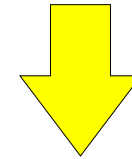
What is EST ?

EST is a hydrocracking process based on two unique features:

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



The recycle of unconverted heavy ends



allows the total conversion of the bottom of the barrel to good quality middle distillates (feedstock conversion >97%)

EST can easily handle very heavy feedstock



EST Meets Fundamental Needs of Refining Industry

- Eni Slurry Technology (EST) is a *new technology* for the full conversion of the bottom of the barrel to distillates
- The availability at industrial level of EST enables the oil industry to solve crucial needs:
 - Meet the declining demand of Fuel Oil converting surplus of Refinery Residues into Distillates (Zero Fuel Oil - zero coke Refinery)
 - Meet the increasing demand of cleaner distillates without increase of the CDU capacity
 - Increase the refinery flexibility to supply of heavier crudes

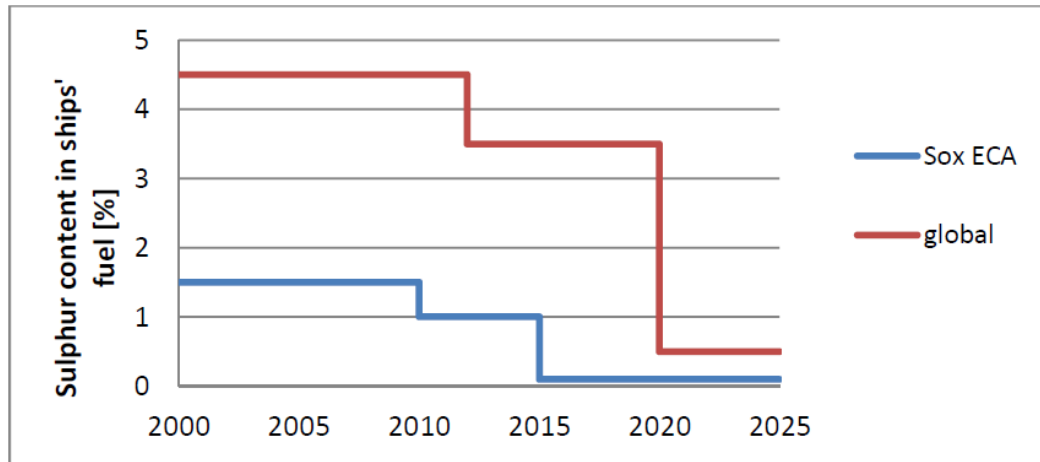
In this context, EST allows a better use of the conventional oil resources and promotes the use of non-conventional oil resources such as heavy and extra-heavy oils and oil-sands bitumen



Sulphur in Marine Fuels: towards new specifications

- New maritime regulations coming into effect starting in 2015
➔ significant reduction of residue demand

Marine fuels Sulphur standards : key steps



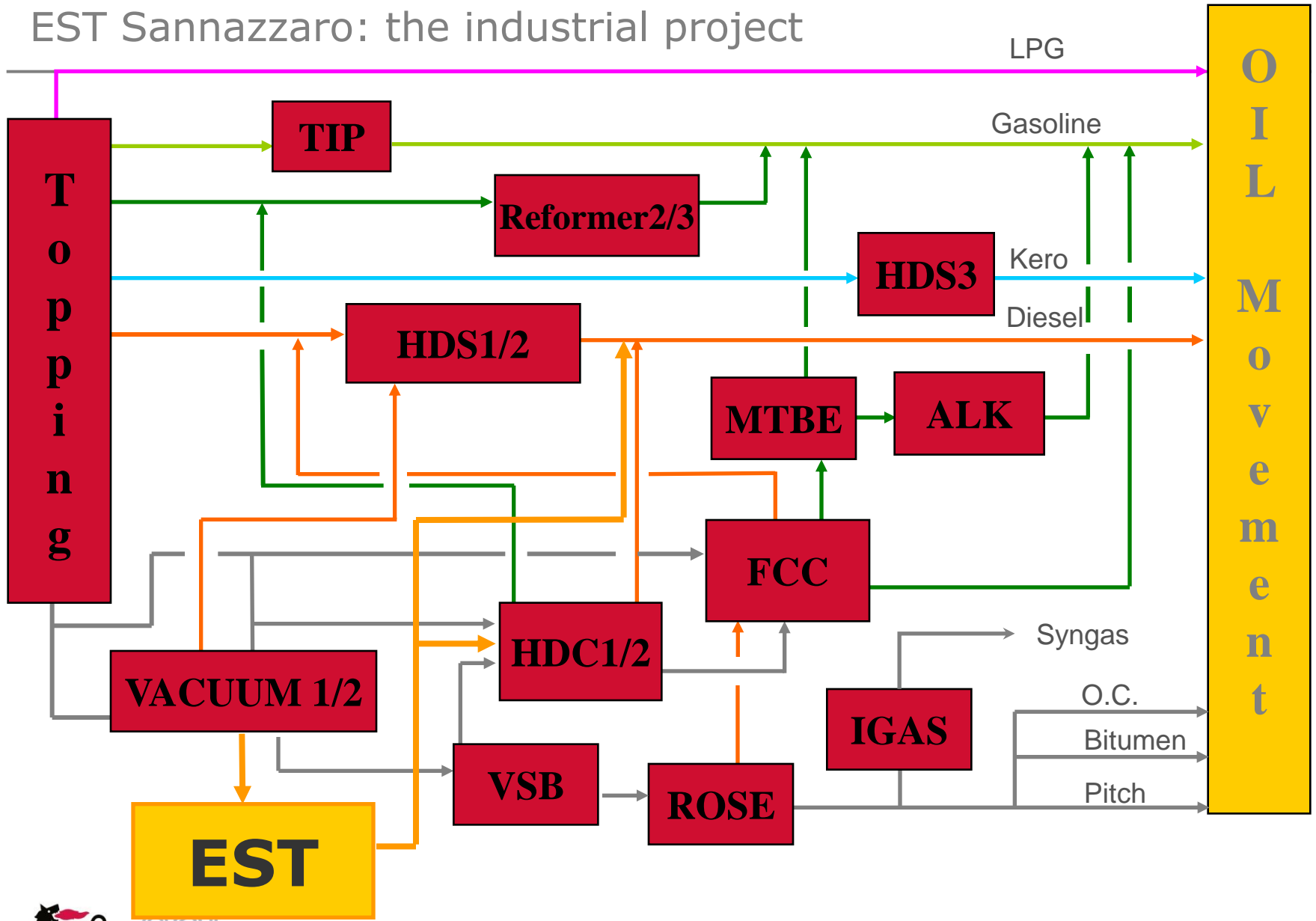
(Source: MARPOL 73/78, Annex VI Regulations for the Prevention of Air Pollution from Ships)

March 2014: the SECAs established to limit SOx and particulate matter emissions are:

1. Baltic Sea area – as defined in Annex I of MARPOL
2. North Sea area (including the English Channel) – as defined in Annex V of MARPOL
3. North American area (entered into force on 1st August 2012); and
4. United States Caribbean Sea (entered into force on 1st January 2014)



EST Sannazzaro: the industrial project

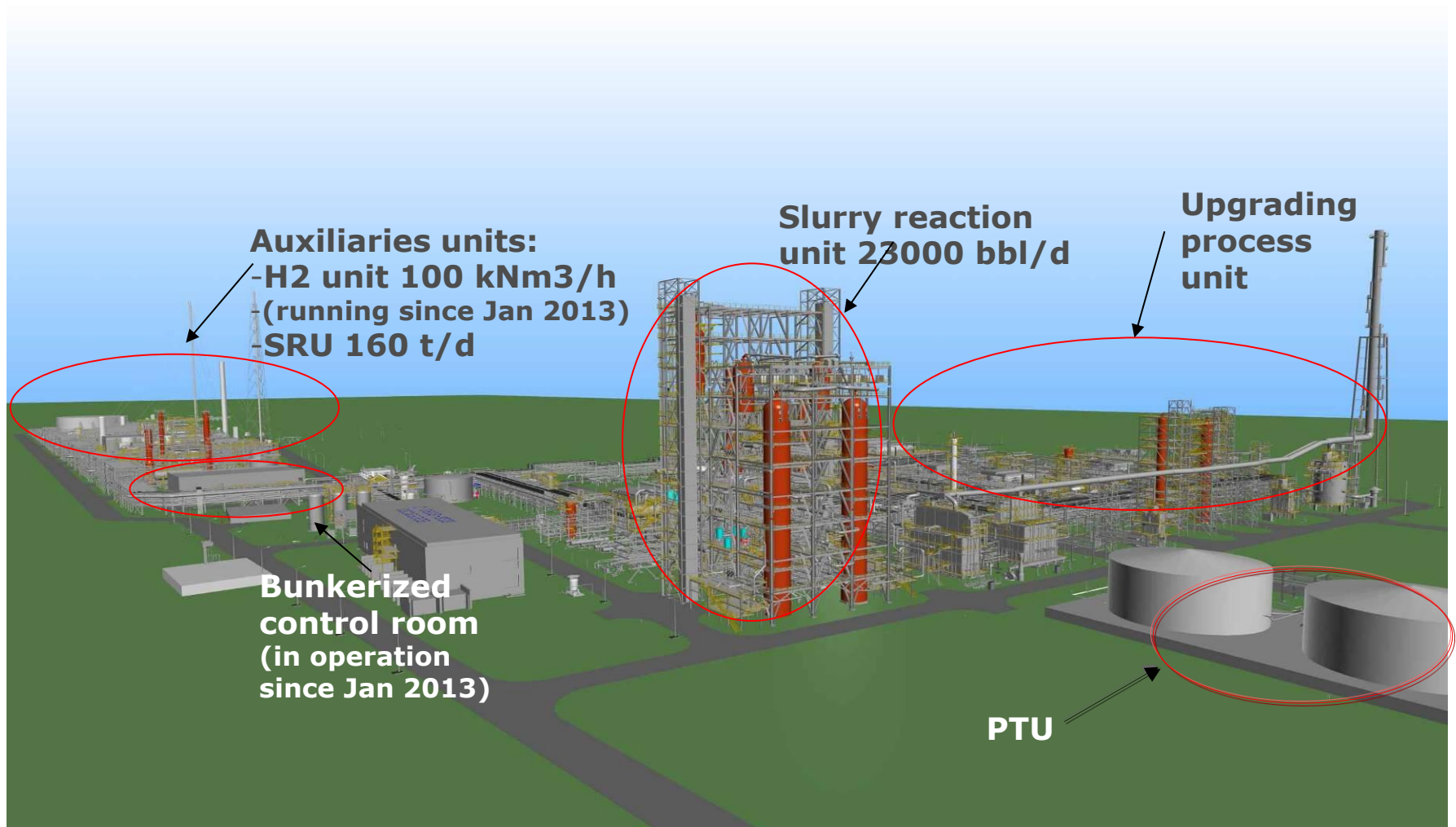


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Integration of EST Complex in the Sannazzaro Refinery: Total refining capacity 11Mt/y



EST Complex Lay-out



EST Sannazzaro today



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EST start-up and first year of operation

- The EST hydrocracker unit has successfully and safely begun operations and is producing high quality distillates **(oil-in: 2013, October 14th)**
- Synchronized start up / operation of all the auxiliary facilities associated with the Unit
- First results confirm the proper design of the plant:
 - major equipments provided the expected performance (as per design)
 - some minor adjustments in order to improve the global EST plant performance



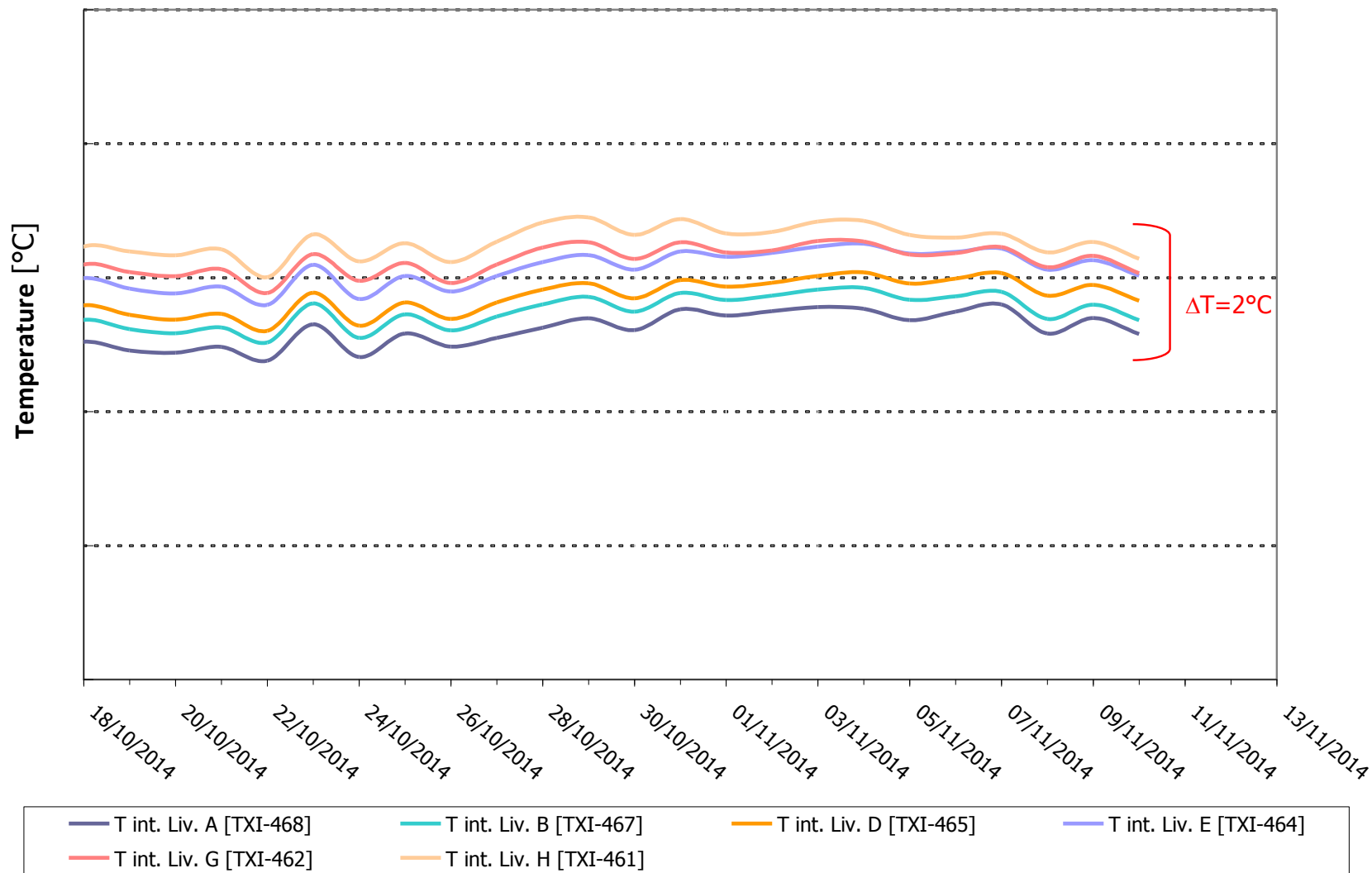
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EST first results

- Slurry reactors: perfectly isothermal and homogeneous (axial $\Delta T < 2^\circ\text{C}$ and radial $\Delta T < 0.1^\circ\text{C}$)
- Gas/liquid separation: High efficiency of gas-liquid separation (no foaming occurrence)
- Conversion: EST plant has run at nearly 70-80% of design capacity (there are market constraints related to the reduction of purge volume accepted by cement factories compared to their planned absorption capacity). Feed conversion up to 95-96% without coke formation
- Product slate and quality: Results are in good agreement with the expected product distribution as calculated by process simulation (based on EST Demonstration plant data). Euro V diesel yields is higher than 40 wt.%



EST results: Slurry reactors temperature profile



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EST results: product yields

Typical EST Feed

$d_{15^{\circ}\text{C}}$: 1026 g/cm³

S: 2.9 wt.%

N: 0.6 wt.%

CCR: 20.1 wt.%

C5-Asph: 15.4 wt.%

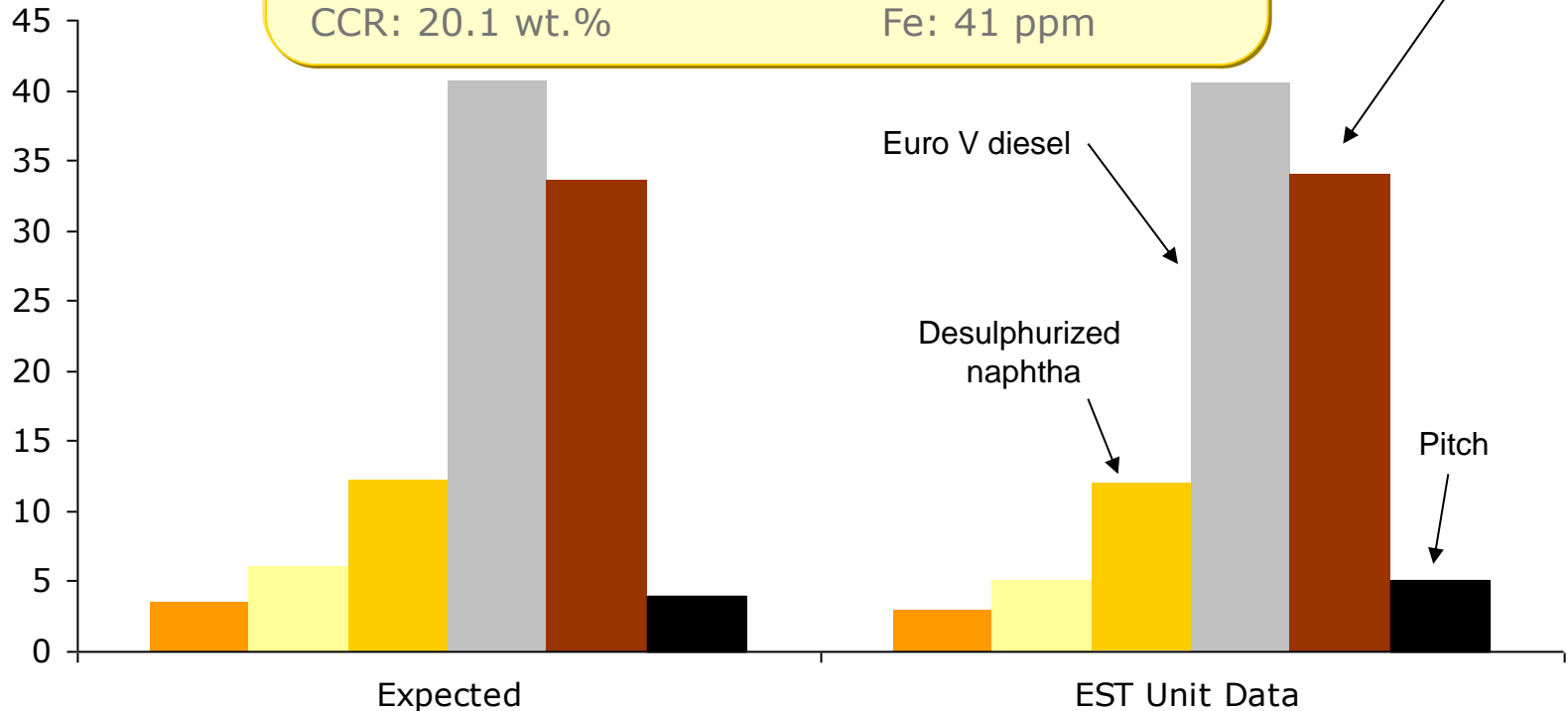
Ni: 88 ppm

V: 199 ppm

Fe: 41 ppm

Cat feed 0.1% S
(or marine fuel 0.1% S)

wt. %



■ C1-C2
 ■ LPG
 ■ Naphtha
 ■ Diesel
 ■ VGO
 ■ Purge



EST second run

- A power failure occurred in Sannazzaro refinery (about 3 months after start-up), causing the upset of Steam Reformer plant
 - Following this event, the decision of EST shutdown was taken, also supported by the following reasons:
 - the adverse scenario for cement industry that limited EST maximum production (due to reduction of purge volume accepted by cement industry whose capacity in Italy dropped by 40% in the last few years)
 - the opportunity to take advantage of maintenance activities to improve plant reliability, efficiency and operating procedures
- ➔
- ✓ New start up of EST unit: June 2014
 - ✓ Unit operating in a very stable mode
 - ✓ Still present constrains in cement market
 - ✓ Part of the pitch is sent to Sannazzaro existing gasification unit



Conclusion

- The first EST hydrocracker Commercial unit is in operation at eni's Sannazzaro refinery
- Key success factors:
 - Demonstrated reliability
 - High conversion to valuable products
 - No coke formation/production
 - Option to convert the Bottom of the Barrel overcoming conversion limitations
 - Environment-friendly technology
 - High energy efficiency
 - Excellent option for natural gas valorisation
- Further improvements of the technology are in the pipeline as a result of first year of operation
- Now, since the successful start up of the Unit, eni has started to license EST technology



Thank you for your attention

