Presentation to RICE
Snamprogetti’s Highlights
EST Technology

by
Romolo Montanari

Snamprogetti S.p.A.

Viale De Gasperi, 16 - 20097 San Donato Milanese – Italy

romolo.montanari@snamprogetti.eni.it
Giving life to your projects
Snamprogetti Capabilities and Roles

Capabilities

Feasibility and Consulting Studies
Project Financing Assistance
Basic Design
Detailed Engineering
Procurement
Construction
Commissioning and Plant Start-up
Training

Roles

- Main Contractor
- Project Managing Contractor
- Technology Supplier

Overall Project Management
Experience

In 101 Countries since 1956

Over 70 grass-roots plants (refining, petrochemical, gas processing), over 1,400 process units

74,500 km onshore pipelines designed
21,500 km of submarine pipelines designed
Major Projects Under Way (1)

**ITALY**

• **Visbreaker Tar Gasification Plant**
  Location: Sannazzaro de’ Burgondi
  Client: Eni Refining & Marketing division
  Capacity: Tar 1,200 t/d

**LIBYA**

• **Green Stream Offshore Gas Pipeline**
  Location: Mellitah to Gela (Italy)
  Client: Agip North Africa
  Technical Characteristics: 32”, 520 km
  Maximum Depth: 1,109 m
  *Record of depth in relation to diameter*

• **Onshore gas treatment plant**
  Location: Mellitah
  Client: Agip Gas B.V. Libyan Branch
  Capacity: 6,6 bcm/y

---

*Record of depth in relation to diameter*
Major Projects Under Way (3)

**NIGERIA**

- **Fourth, Fifth and Sixth LNG Train**
  - Location: Bonny Island
  - Client: Nigeria LNG Limited
  - Capacity: 4 million t/y each
  - LSTK in JV

**QATAR**

- **Fourth and Fifth LNG Train**
  - Location: Ras Laffan
  - Client: Ras Laffan Liquified Natural Gas Company Ltd.
  - Capacity: 4,7 million t/y each
  - EPC in JV

- **Dukhan Field Gas Lift**
  - Location: Dukhan
  - Client: Qatar Petroleum (QP)
  - Capacity: to maintain a production of 440,000 b/d
  - LSTK

- **Al-Khaleej Gas Project**
  - Location: Ras Laffan
  - Client: ExxonMobil
  - Capacity: 750 MMSCFD
  - EPC in JV
## Major Projects Completed in 2001/2004 (1)

<table>
<thead>
<tr>
<th><strong>ABU DHABI</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Natural Gas Treatment Complex</strong></td>
<td>EPC</td>
</tr>
<tr>
<td>Location: Asab</td>
<td></td>
</tr>
<tr>
<td>Client: ADNOC</td>
<td></td>
</tr>
<tr>
<td>Capacity: 856 million SCFD</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>ITALY</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IGCC Plant</strong></td>
<td>LSTK</td>
</tr>
<tr>
<td>Location: Sarroch</td>
<td></td>
</tr>
<tr>
<td>Client: Sarlux</td>
<td></td>
</tr>
<tr>
<td>Capacity: 550 MWe</td>
<td></td>
</tr>
</tbody>
</table>

*The world’s largest IGCC plant*

<table>
<thead>
<tr>
<th><strong>RUSSIA - TURKEY</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Blue Stream Project</strong></td>
<td>Engineering Services</td>
</tr>
<tr>
<td>Client: Saipem/Bouygues Consortium</td>
<td></td>
</tr>
<tr>
<td>Total length: 385 km (2 x 24”)</td>
<td></td>
</tr>
<tr>
<td>Maximum depth: 2,150 m</td>
<td></td>
</tr>
</tbody>
</table>
WORLDWIDE REFERENCES
RESIDUE HYDROCONVERSION UNITS

PEMEX
Capacity: 50,000 BPSD
Licensor: IFPNA
Technology: E.B.
Inv. Cost: 600 MUS$
Scope of Work: T.K.L.S.
Start Up: 1997

PKN ORLEN S.A.
Capacity: 34,000 BPSD
Licensor: IFPNA
Technology: E.B.
Inv. Cost: 130 MUS$
Scope of Work: Eng. & Mat. Supply
Start Up: 1999

Raffineria Mediterranea
Capacity: 25,000 BPSD
Licensor: ABB LUMMUS GLOBAL
Technology: E.B.
Scope of Work: Eng. Services
Start Up: 1997

AGIP Petroli Taranto Ref.
Capacity: 14,000 BPSD
Licensor: SHELL
Technology: F.B.
Inv. Cost: 160 MUS$
Scope of Work: T.K.L.S.
Start Up: 1994

HEAVY RESIDUE HYDROCONVERSION UNIT
HYDROCONVERSION UNITS REACTORS VIEW
REFERENCE “A”
HYDROCONVERSION UNITS MODEL VIEW
REACTORS & CATALYST HANDLING
REFERENCE “B”
HYDROCONVERSION UNITS
REACTORS LIFTING
REFERENCE “C”
HYDROCONVERSION UNITS
REACTORS VIEW
REFERENCE “D”
H-OIL UNIT VIEW
REFERENCE “D”
“EST”
Eni Slurry Technology
### R & D ACTIVITIES

<table>
<thead>
<tr>
<th>Activity</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catalyst Screening and Evaluation of Best Process Option</td>
<td>from 1988 to 1995</td>
</tr>
<tr>
<td>Laboratory Microreactor Tests</td>
<td>1996</td>
</tr>
<tr>
<td>Bench Scale Tests</td>
<td>from 1997 to 1998</td>
</tr>
<tr>
<td>Pilot Plant Eng./Constr.</td>
<td>from 1998 to 1999</td>
</tr>
<tr>
<td>Pilot Plant Tests</td>
<td>from May 1999</td>
</tr>
</tbody>
</table>
EST Technology Main Features

Stability limit
Phase separation
Asphaltenes
Maltenes
Asphaltenes recycle + catalyst

The EST approach

Time Course of Reaction
EST Flow Diagram

- Vacuum
- Residue
- Catalyst Make-up
- Slurry Reactor
- Hydrogen
- Fractionator
- GAS + LPG + H₂S
- Naphtha
- Gasoil
- VGO
- Solvent (C3 or C4)
- Conv. Unit Feed
- DAO
- Purge
- Asphaltene / Catalyst Recycle
- S.D.A.
## R & D and ENGINEERING ACTIVITIES

**From May 1999 to present**

- Pilot Plant Tests on various feedstock
- Fluid Dynamic Study
- Erosion / Corrosion Tests
- Product Reactivity Tests
- Process and Detailed Engineering Design of Commercial Demonstration Plant (CDP)
The EST Pilot Plant

- Capacity 0.3 bbl/d
- In operation since 1999
- Several feedstocks processed
- Continuous recycle operation
- No evidence of coke formation
FEEDSTOCK & PRODUCTS

Naphtha → Gasoil → DAO

No Coke
Characteristics of Different Feedstocks Processed in the 0.3 bbl/d Pilot Plant

<table>
<thead>
<tr>
<th>Feedstock Properties</th>
<th>Ural</th>
<th>Arabian Heavy</th>
<th>Zuata</th>
<th>Maya</th>
<th>Athabasca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity (g/cm³)</td>
<td>1.0043</td>
<td>1.0312</td>
<td>1.029</td>
<td>1.0643</td>
<td>1.0147</td>
</tr>
<tr>
<td>°API gravity</td>
<td>9.4</td>
<td>5.7</td>
<td>6.0</td>
<td>1.5</td>
<td>8.0</td>
</tr>
<tr>
<td>500°C+ content (wt%)</td>
<td>91</td>
<td>96</td>
<td>95</td>
<td>99</td>
<td>60</td>
</tr>
<tr>
<td>H/C</td>
<td>1.494</td>
<td>1.366</td>
<td>1.349</td>
<td>1.333</td>
<td>1.42</td>
</tr>
<tr>
<td>Sulphur (wt%)</td>
<td>2.60</td>
<td>5.28</td>
<td>4.24</td>
<td>5.24</td>
<td>4.58</td>
</tr>
<tr>
<td>Nitrogen (wt%)</td>
<td>0.69</td>
<td>0.45</td>
<td>0.97</td>
<td>0.81</td>
<td>0.48</td>
</tr>
<tr>
<td>Ni and V (ppm)</td>
<td>74 / 242</td>
<td>52 / 170</td>
<td>154 / 697</td>
<td>132 / 866</td>
<td>70 / 186</td>
</tr>
<tr>
<td>n-C7 Asphaltenes (wt%)</td>
<td>10.5</td>
<td>19.5</td>
<td>19.7</td>
<td>30.3</td>
<td>12.4</td>
</tr>
<tr>
<td>CCR (wt%)</td>
<td>18.9</td>
<td>22.9</td>
<td>22.1</td>
<td>29.3</td>
<td>13.6</td>
</tr>
</tbody>
</table>
Comparative Performance of Different Feedstocks in the 0.3 bbl/d Pilot Plant

<table>
<thead>
<tr>
<th>Product yields (wt%)</th>
<th>Ural</th>
<th>Arabian Heavy</th>
<th>Zuata</th>
<th>Maya</th>
<th>Athabasca</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas (HC+H₂S)</td>
<td>11.5</td>
<td>10.9</td>
<td>15.1</td>
<td>9.9</td>
<td>12.9</td>
</tr>
<tr>
<td>Naphtha (C5-170°C)</td>
<td>5.8</td>
<td>4.9</td>
<td>14.0</td>
<td>3.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Gasoil (170-350°C)</td>
<td>32.5</td>
<td>30.6</td>
<td>39.1</td>
<td>26.9</td>
<td>39.1</td>
</tr>
<tr>
<td>Vacuum Gasoil (350-500°C)</td>
<td>29.8</td>
<td>29.2</td>
<td>23.3</td>
<td>34.9</td>
<td>32.1</td>
</tr>
<tr>
<td>DAO (500°C+)</td>
<td>20.4</td>
<td>24.4</td>
<td>8.5</td>
<td>24.4</td>
<td>11.8</td>
</tr>
</tbody>
</table>

**Upgrading performance**

| % HDS       | 86  | 82  | 86  | 84  | 83  |
| % HDM       | > 99| > 99| > 99| > 99| > 99|
| % HDN       | 54  | 41  | 59  | 52  | 47  |
| % CCR reduction | 97  | 97  | 98  | 96  | 95  |
| % Conversion| > 99| > 99| > 99| > 99| > 99|
Comparison Crudes vs EST

-27
-48
-64
-70%
-60%
-50%
-40%
-30%
-20%
-10%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%

Ural
Ural EST
Maya
Maya EST
Athabasca
Athabasca EST
Zuata
Zuata EST

wt. %

°API
S
N
CCR
Ni/V

Vac Res DAO 350+500 170+350 C5+170 C1+C4 H2S

Snamprogetti
Yields Comparison

<table>
<thead>
<tr>
<th>Case</th>
<th>API</th>
<th>S</th>
<th>N</th>
<th>CCR</th>
<th>Ni/V</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athabasca EST</td>
<td>21.4</td>
<td>1.6</td>
<td>0.2</td>
<td>0.6</td>
<td>&lt;1 wppm</td>
<td>100 wt.%</td>
</tr>
<tr>
<td>Athabasca EB+ Naphtha &amp; Gasoil</td>
<td>21.4</td>
<td>1.6</td>
<td>0.2</td>
<td>0.8</td>
<td>44 wppm</td>
<td>100 wt.%</td>
</tr>
<tr>
<td>Athabasca DC + Naphtha &amp; Gasoil HDT</td>
<td>23.4</td>
<td>1.8</td>
<td>0.2</td>
<td>0.6</td>
<td>&lt;1 wppm</td>
<td>100 wt.%</td>
</tr>
</tbody>
</table>

Liquid Product Yield = 89.3 wt.%

**Note:** The values indicate the percentage yield and composition of the products from the different cases.
EST CDP View
Estimated Production from Top 9 Countries for 2003 and 2015

Source: BP World Oil Review, NEB and Lehman Brothers estimates
Estimated Production from Top 9 Countries for 2003 and 2015

Source: BP World Oil Review, NEB and Lehman Brothers estimates
To provide updated economics of application of EST technology for the upgrading of Athabasca Oil Sands Bitumen in comparison with other competing upgrading technologies

The merit of implementing an Upgrading Complex based on these technologies has been investigated by conducting a Cash Flow Analysis and by calculating the inherent profitability indexes

Cash Flow projections have been carried out in current US$ (2.5%/y) and unlevered terms (100% Equity Funding)
CRUDE OIL & NATURAL GAS PRICING


Athabasca crude oil (8.1 °API, 4.52 wt.%S) has been valued at 14.7 US$/bbl (year 2010) on the basis of °API value and Sulphur content

Natural gas cost has been taken at 2.9 US$/MBtu (year 2010) at plant battery limits
STUDY CASES

- Athabasca Upgrading via EST (EST Case)
- Athabasca Upgrading via Ebullated Bed (EB Case)
- Athabasca Upgrading via Delayed Coking (DC Case)
**Crude Oil** (16,114 T/d) (100,000 BPSD)
- S.G. = 1.0136
- °API = 8.1
- S = 4.52 wt.%
- N = 0.36 wt.%
- CCR = 13.12 wt.%
- Ni = 72 wppm
- V = 194 wppm
- Na = 32 wppm

**NAPHTHA** (576 T/d)
- 57.2 °API
- S.G. = 0.750
- S = 0.6 wppm
- N = 0.7 wppm

**LIGHT GASOIL** (4,784 T/d)
- 34.6 °API
- S.G. = 0.852
- S = 10 wppm
- N = 50 wppm

**CONVERSION UNIT FEED** (9,799 T/d)
- 14.6 °API
- S.G. = 0.968
- S = 2.5 wt.%
- N = 2,777 wppm
- CCR = 1.19 wt.%

**FUEL OIL** (123 T/d)
- Visc. 50°C = 380 cSt
- S = 1.12 wt.%

**HYDROGEN** (Chemical) (233 T/d)

**LPG** (251 T/d)

**FUEL GAS** (269 T/d)

**PURE** (84 T/d)

**SOLIDS** (13 T/d)

**LIQUID SULPHUR** (483 T/d)
## EX-PLANT PRODUCT PRICES
(year 2010, current US$)

<table>
<thead>
<tr>
<th>Product</th>
<th>US$/t</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>247</td>
</tr>
<tr>
<td>Naphtha</td>
<td>246</td>
</tr>
<tr>
<td>Jet/Kerosene</td>
<td>294</td>
</tr>
<tr>
<td>Diesel Oil (&lt; 10 ppm wt S)</td>
<td>276</td>
</tr>
<tr>
<td>Conv. Unit Feed (&gt; 2.5 wt.% S)</td>
<td>166</td>
</tr>
<tr>
<td>Fuel Oil (&lt;1.0 wt.% S)</td>
<td>121</td>
</tr>
<tr>
<td>Sulphur</td>
<td>0</td>
</tr>
<tr>
<td>Coke</td>
<td>0</td>
</tr>
</tbody>
</table>
## FIXED INVESTMENT COSTS
(year 2004 MUS$)

<table>
<thead>
<tr>
<th></th>
<th>EST Case</th>
<th>EB Case</th>
<th>DC Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Units (*)</td>
<td>914</td>
<td>917</td>
<td>844</td>
</tr>
<tr>
<td>Utilities &amp; Offsites</td>
<td>176</td>
<td>180</td>
<td>205</td>
</tr>
<tr>
<td>Power Station</td>
<td>32</td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td>Storage</td>
<td>65</td>
<td>65</td>
<td>64</td>
</tr>
<tr>
<td>Export Facilities</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Land</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>FACILITIES COST</td>
<td>1,200</td>
<td>1,210</td>
<td>1,149</td>
</tr>
<tr>
<td>Pre-operating Costs</td>
<td>36</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>FIXED INVESTMENT COST</td>
<td>1,236</td>
<td>1,240</td>
<td>1,178</td>
</tr>
</tbody>
</table>

(*) Includes royalties and initial catalysts charges
## ECONOMIC RESULTS

<table>
<thead>
<tr>
<th></th>
<th>EST Case</th>
<th>EB Case</th>
<th>DC Case</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRR of Project Before Tax (%/y)</td>
<td>27.9</td>
<td>18.3</td>
<td>22.0</td>
</tr>
<tr>
<td>IRR of Project After Tax (%/y)</td>
<td>20.9</td>
<td>13.9</td>
<td>16.6</td>
</tr>
<tr>
<td>NPV of Project After Tax (MUS$) (@ 8.1%/y, year 2004 values)</td>
<td>1,430</td>
<td>613</td>
<td>861</td>
</tr>
<tr>
<td>NPV/PV Capex (@ 8.1%/y)</td>
<td>1.36</td>
<td>0.58</td>
<td>0.86</td>
</tr>
<tr>
<td>Refinery Margin After Tax (@ 8.1%/y, year 2004 US$/bbl)</td>
<td>5.3</td>
<td>1.1</td>
<td>2.0</td>
</tr>
</tbody>
</table>
## UPGRADING MARGIN

<table>
<thead>
<tr>
<th>Values in US$/bbl</th>
<th>EST Case</th>
<th>EB Case</th>
<th>DC Case</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upgraded feed value</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>less:</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opex</td>
<td>3.4</td>
<td>3.9</td>
<td>2.9</td>
</tr>
<tr>
<td>of which gas</td>
<td>0.8</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>Capex (@ 8.1%/y)</strong></td>
<td>3.8</td>
<td>3.8</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>Net-back Crude Price</strong></td>
<td>20.0</td>
<td>15.8</td>
<td>16.7</td>
</tr>
<tr>
<td><em>less:</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base Crude Price</td>
<td>14.7</td>
<td>14.7</td>
<td>14.7</td>
</tr>
<tr>
<td><strong>UPGRADING MARGIN</strong></td>
<td>5.3</td>
<td>1.1</td>
<td>2.0</td>
</tr>
</tbody>
</table>
ECONOMIC OUTCOME

- The EST economic benefits can be duly evaluated by the return on invested capital: up to 20.9%/y after tax and by the significant NPV close to 1.5 Billion US$ after tax for the “Trend 2010 Oil Scenario” (having considered a 8.1%/y remuneration of capital);

- The outlined economic benefits are maintained for a wide range of investment and feedstock cost variation, and to a lesser extent also for the products value;

- The sensitivity analysis to natural gas cost (i.e. hydrogen production) shows that EST remains attractive even for a major variation of its cost.
SYSTEM BOUNDARIES

Refinery Step

Alternative Cases
- Refinery + Ebullated Bed on Vacuum Residue
- Refinery + Delayed Coking on Vacuum Residue
- Refinery + EST on Vacuum Residue
REFINERY + EBBULLATED BED
ENERGY and MASS MACRO-BALANCES

Production

Middle Distillates = 3,887 kt/y

Refinery Balance (Kt/y)

INPUT
- Crude Oil: 5,371 kt
- Gas: 5,580 kt

OUTPUT
- Middle Distillates: 3,887 kt
- Fuel Oil: 1,148 kt
- Sulphur: 158 kt
- Internal Fuels: 225 kt
- Losses & Adj: 162 kt

Utility Production

- Additional Electric Power: 279 GWh
- Combined Cycle Nat. gas eff. 53%
- Natural Gas: 231 Kt
- Athabasca Bitumen: 5,371 kt
- Catalysts: 22 Kt
- Vacuum Residue: 2,802 kt
- Distillates: 3,887 kt
- Sulphur: 158 kt
- Fuel Oil: 1,148 kt
- Internal Fuels: 225 kt
- Losses & Adj: 162 kt

Snamprogetti
REFINERY + DELAYED COKING
ENERGY and MASS MACRO-BALANCES

**Production**

- Middle Distillates = 4,077 kt/y

**Refrinery Balance**

<table>
<thead>
<tr>
<th>INPUT</th>
<th>Crude Oil</th>
<th>5,371</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,541 Gas</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>

**OUTPUT**

<table>
<thead>
<tr>
<th>Middle Distil.</th>
<th>4,077</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke</td>
<td>899</td>
</tr>
<tr>
<td>Sulphur</td>
<td>118</td>
</tr>
<tr>
<td>Intern. Fuels</td>
<td>263</td>
</tr>
<tr>
<td>Losses &amp; Adj</td>
<td>184</td>
</tr>
</tbody>
</table>

**Utility Production**

- Natural Gas: 150 Kt
- Combined Cycle Nat. gas eff. 53%: 26 Kt
- Additional Electric Power: 175 GWh
- Internal Fuels: 263 Kt
- Losses & Adj: 243 Kt

**Refinery**

- Vacuum Residue: 2802 kt
- Athabasca Bitumen: 5,371 kt
- Catalysts: 170 Kt
- Distillates: 4,077 kt

**Delayed Cokking**

- Coke: 899 kt
- Sulphur: 118 kt
- Losses & Adj: 184 kt
REFINERY + EST
ENERGY and MASS MACRO-BALANCES

Production
Middle Distillates = 5,063 kt/y

Refinery Balance Kt/y
INPUT
- Crude Oil 5,371
- Gas 219
OUTPUT
- Middle Distil. 5,063
- Sulphur 159
- Internal Fuels 129
- Losses & adj 239

Utility Production

Additional Electric Power
247 GWh

Combined Cycle
Nat. gas eff. 53%

36 Kt

Natural Gas
413 Kt

194 Kt

Catalysts

219 Kt

Vacuum Residue
2802 kt

Athabasca Bitumen
5,371 kt

Internal Fuels 129 kt

Distillates 5,063 kt

Sulphur 159 kt

Losses & Adj 239 kt
## DISTILLATES PRODUCTION & CRUDE OIL SUMMARY
### Non Conventional Crude - Canada

<table>
<thead>
<tr>
<th></th>
<th>Eb. Bed Kt/y</th>
<th>Coking Kt/y</th>
<th>EST Kt/y</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPL</td>
<td>35</td>
<td>52</td>
<td>83</td>
</tr>
<tr>
<td>Naphtha</td>
<td>178</td>
<td>362</td>
<td>189</td>
</tr>
<tr>
<td>Gasoline 98 RON</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gasoline 95 RON</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Naphtha + Gasoline</td>
<td>178</td>
<td>362</td>
<td>189</td>
</tr>
<tr>
<td>Jet + Kero</td>
<td>0</td>
<td>110</td>
<td>0</td>
</tr>
<tr>
<td>Gasoil</td>
<td>1157</td>
<td>1515</td>
<td>1572</td>
</tr>
<tr>
<td>Conversion Unit Feed</td>
<td>2518</td>
<td>2038</td>
<td>3220</td>
</tr>
<tr>
<td>Total Gasoil</td>
<td>3675</td>
<td>3553</td>
<td>4792</td>
</tr>
<tr>
<td>TOTAL DISTILLATES</td>
<td>3888</td>
<td>4077</td>
<td>5064</td>
</tr>
<tr>
<td>Pet-Coke</td>
<td>0</td>
<td>900</td>
<td>0</td>
</tr>
<tr>
<td>Fuel Oil</td>
<td>1123</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>CRUDE OIL</td>
<td>5371</td>
<td>5371</td>
<td>5371</td>
</tr>
</tbody>
</table>
## DISTILLATES YIELDS

<table>
<thead>
<tr>
<th>Option</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upgrading Option</td>
<td>72.4 %</td>
</tr>
<tr>
<td>Ebullated Bed</td>
<td>75.9 %</td>
</tr>
<tr>
<td>Delayed Coking</td>
<td>75.9 %</td>
</tr>
<tr>
<td>EST</td>
<td>94.3 %</td>
</tr>
</tbody>
</table>

Refinery distillates yields (kg Dist/kg Crude) • 100
LCA EST Technology – Non-Conventional Crude
Upstream Case - Canada

CO2 Emissions - Gate to Gate
kg CO2/ton Dist

Refinery  Byproducts  Distillates  Total

RR + Ebullated Bed (EB)  RR + Delayed Coking (DC)  RR + EST

Snamprogetti

47
SO2 Emissions - Gate to Gate
Kg SO2/ton Dist

Kg SO2/ton Dist
0 10 20 30 40 50 60 70
RR + Ebullated Bed (EB) RR + Delayed Coking (DC) RR + EST

Refinery Byproducts Distillates Total

Snamprogetti

LCA EST Technology – Non-Conventional Crude Upstream Case - Canada
LCA EST Technology – Crude Comparison

Crude Oil Upgrading - CO2 Emissions
Kg CO2/ton Dist

Conservative Estimate to include Up-grading

EB DC      EST EB DC       EST
Kg CO2/ton Dist

Upgrading Distillates Byproducts Refinery

Heavy Crude (8.1 °API) Light Crude (34 °API)
API 21.5 API 24.7 API 22.9 API 50.4 API 49.9 API 49.1

Snamprogetti
The EST Benefits

- Total Feedstock Conversion
- Outstanding Product Qualities
- Total Metals Removal
- No Fuel Oil or PetCoke Production
- Low Catalyst Consumption
- Excellent Feedstock Flexibility
- Diesel Oil & Gasoline Meeting Future EU Specs
EST: The Ultimate Solution for Resid Upgrading

- Most Profitable Option
- Higher Internal Rate of Return
- Technologically Proven

- Bottom of the Barrel Upgrading
- Exploitation of Extra-Heavy Crude Oils
- Exploitation of Oil Sands Bitumen

Commercial Demonstration Plant on-stream within 2Q 2005