Oil Refining and National Refinery Data - An Introduction

IEA Online Statistics Summer School
Session 2

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Aim of Presentation

- Introduction of how to report refinery sector data on a national level
- Fundamentals for reporting refinery data
- Challenges in reporting refinery sector data
- Data Validation
Primary and Secondary Oil Products

What is produced?
Crude oil, NGL and other hydrocarbons

What is consumed?
Secondary petroleum products

- LPG: 2-5%
- Naphtha: 20-35%
- Gasoline: 30-40%
- Middle Distillates: 25-75%
- Fuel Oil:
- Others:
How many refineries exist worldwide?

- 50
- 300
- 700
- 1000
- 2000
How many of those refineries are exactly the same?

- All refineries are the same.
- About 75% of all refineries are the same.
- About half of all refineries are the same.
- About 25% of all refineries are the same.
- No two refineries are exactly the same.
Refinery Map

- Oil refining is a complex process
- Process varies between refineries, depending on configuration of the plant, inputs, etc.
What is the difference between light and heavy crude oils?

- Option A: Light crudes are located closer to the earth’s surface than heavy crudes
- Option B: Light crudes have a lower sulphur content than heavy crudes
- Option C: Light crudes have a lower density than heavy crudes
- Option D: Light crudes are cheaper than heavy crudes
Different Crudes = Different Yields

Refinery Output for Selected Crude Oil Grades

<table>
<thead>
<tr>
<th>Crude Oil Grade</th>
<th>API °</th>
<th>Sulphur %</th>
<th>Output</th>
<th>Heavy Products</th>
<th>Middle Distillates</th>
<th>Light Products</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saharan (Algeria)</td>
<td>44.0°</td>
<td>0.2%</td>
<td>5%</td>
<td>36%</td>
<td>26%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Brent (North Sea)</td>
<td>37.5°</td>
<td>0.3%</td>
<td>3%</td>
<td>39%</td>
<td>29%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Arab Light (Saudi Arabia)</td>
<td>34.0°</td>
<td>1.7%</td>
<td>3%</td>
<td>38%</td>
<td>22%</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Boscan Heavy Oil (Venezuela)</td>
<td>10.7°</td>
<td>5.3%</td>
<td>2%</td>
<td>74%</td>
<td>0%</td>
<td>2%</td>
<td></td>
</tr>
</tbody>
</table>
Simplification of a Complex Process

- IEA oil questionnaires focus on most important refinery flows
- A country’s refinery sector is imagined as a single refinery

![Diagram showing refinery process flow]

- Refinery intake
  - Crude oil
  - NGL
  - Feedstocks
  - Other

- Refinery losses

- Refinery fuel

- Refinery output
  - LPG
  - Naphtha
  - Motor and aviation gasoline
  - Kerosenes
  - Gas / diesel oil
  - Etc.

Refinery intake - Refinery losses = Gross refinery output

Gross refinery output - Refinery fuel = Net refinery output
Refinery Losses

- **Intake**
  - Intake of crude oil, NGL, other feedstocks, blending components
  - Crude oil: 100
  - Amount in kilotons: 99kt
  - Conversion factor barrels/ton: 7.40
  - Amount in kilobars: 740

- **Processing**
  - Conversion of primary into secondary oil products
  - Refinery Losses
  - 1% losses (1kt)
  - 5% gains (40kb)

- **Output**
  - Output of secondary oil products (e.g. gasoline, middle distillates, fuel oil)
  - LPG: 4
  - Naphtha: 5
  - Gasoline: 30
  - Middle Distillates: 35
  - Fuel Oil: 15
  - Other: 10
  - Weighted Average: 7.88
  - Total: 780kb
### Statisland

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Unit: Mt</th>
<th>Unit: Mtoe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude oil</td>
<td>26.06</td>
<td>26.48</td>
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</table>

<table>
<thead>
<tr>
<th>Outputs</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>Refinery gas</td>
<td>0.13</td>
<td>0.15</td>
</tr>
<tr>
<td>Liquefied petroleum gases</td>
<td>0.58</td>
<td>0.66</td>
</tr>
<tr>
<td>Naphtha</td>
<td>2.84</td>
<td>3.04</td>
</tr>
<tr>
<td>Motor gasoline</td>
<td>3.28</td>
<td>3.51</td>
</tr>
<tr>
<td>Kerosene type jet fuel</td>
<td>1.66</td>
<td>1.81</td>
</tr>
<tr>
<td>Kerosene</td>
<td>0.39</td>
<td>0.42</td>
</tr>
<tr>
<td>Gas/diesel oil</td>
<td>7.50</td>
<td>7.99</td>
</tr>
<tr>
<td>Fuel oil</td>
<td>7.99</td>
<td>7.77</td>
</tr>
<tr>
<td>Lubricants</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Bitumen</td>
<td>0.63</td>
<td>0.59</td>
</tr>
<tr>
<td>Petroleum coke</td>
<td>0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>Non-specified oil products</td>
<td>0.36</td>
<td>0.34</td>
</tr>
<tr>
<td>Total refinery output</td>
<td>25.89</td>
<td>26.75</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Refinery losses</td>
<td>0.7%</td>
<td>-1.0%</td>
</tr>
</tbody>
</table>

1) Energy quantity = calorific value (net) * physical quantity
2) Losses = (input - output) / input

**Cause:**
- Incorrect calorific values
- Crude oil, (non-specified)
Data validation – Refinery losses

World refinery losses 1971-2014

Source: IEA statistics

Same can be done for regions:
  • How does my country/refinery compare?
  • Explaining factors for differences?
Data validation - Output shares

World shares of refinery output 1971-2014

Source: IEA statistics

Same can be done for regions:
• How does my country/refinery compare?
• Explaining factors for differences?
Data validation - Refinery energy consumption

World refinery output vs. energy consumption 1971-2014

Same can be done for regions:

- How does my country/refinery compare?
- Explaining factors for differences?

Source: IEA statistics
Data validation - Anomalies in time series

Country examples:

Causes:
- Country A: Refinery accident in 2000
- Country B: Conflict in the country since 2011
- Country C: Problems with original official data

Source: IEA statistics
References

- **IEA**
  - IEA statistics website
  - Monthly oil data service website
  - IEA, Oil Market Report
    - [https://www.iea.org/oilmarketreport/omrpublic/](https://www.iea.org/oilmarketreport/omrpublic/)
  - IEA Energy statistics manual, IEA 2005
  - Joint IEA/Eurostat annual oil questionnaire

- **External**
  - International Recommendations for Energy Statistics, United Nations 2011
  - International Standard Industrial Classification (rev. 4), United Nations 2008

  - Deutsche Bank: Oil & Gas for Beginners – A Guide to the Oil and Gas Industry; 2010.