Primary oil and oil products

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Workshop on Energy Statistics for Western African Countries
15-19 October 2019, Dakar, Senegal
Content

- Importance of oil
- Primary Production
- Transformations and transfers
- Other flows
- Commodity balances
- Definition of oil products
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- Units in energy statistics
Importance of oil
Oil is the largest source of world’s energy supply.

World Total Final Consumption, 2016

Importance of oil for transportation

UNSD, *Energy Statistics Pocketbook, 2019*
Importance of oil for the region

Share of oil in final energy consumption, 2016

- Benin: 45%
- Equatorial Guinea: 30%
- Gabon: 34%
- Ghana: 52%
- Guinea: 24%
- Lesotho: 20%
- Liberia: 16%
- Senegal: 42%
- Togo: 28%

Africa: 29%
Primary production
Oil flows in an economy
Primary production

Wellhead Production

Onshore oil well

Offshore oil well

Gathering centre
(Gas & water separation facilities / Gas processing plants)

Marketable Production

Storage tank
(at shipment terminal)

Refinery

Direct use
Conventional crude oil

A mineral oil of fossil origin extracted by conventional means from underground reservoirs, and comprises liquid or near-liquid hydrocarbons and associated impurities such as sulphur and metals.

The various crude oils may be classified according to their sulphur content (sweet or sour) and API gravity (heavy or light).
Natural gas liquids (NGL)

- Natural gas liquids are a mixture of ethane, propane, butane (normal and iso), (iso) pentane and a few higher alkanes collectively referred to as pentanes plus.

- NGL are produced in association with oil or natural gas. They are removed in field facilities or gas separation plants before sale of the gas. All of the components of NGL except ethane are either liquid at the surface or are liquefied for disposal.
Other hydrocarbons

• Includes non-conventional oils and hydrogen. Non-conventional oils refer to oils obtained by non-conventional production techniques, that is, oils extracted from reservoirs containing extra heavy oils or oil sands which need heating or treatment (e.g., emulsification) in situ before they can be brought to the surface for refining/processing.

• They also include oils extracted from oil sands, extra heavy oils, coal and oil shale which are at, or can be brought to, the surface without treatment and require processing after mining (ex situ processing). Non-conventional oils may also be produced from natural gas.
Transformations and transfers
Transformation is the process where part or all of the energy content of a product entering a process moves from this product to one or more different products leaving the process.
Oil flows – transformations

Crude, NGL* and Oil products

Refining
- Refineries
- Oil products

Transformation to power
- Electricity/heat plants
- Electricity
- Heat

Other transformations
- Petrochemical plants
- Refinery feedstocks
- Gas plants
- LPG
- Ethane

*includes additives and oxygenates and other hydrocarbons
Refinery intake

- Conventional crude oil
- Natural gas liquids (NGL)
- Additives and oxygenates*
- Other hydrocarbons*
- Refinery feedstocks

For more information, refer to IRES, https://unstats.un.org/unsd/energystats/methodology/ires/

* can also be secondary products
Refrinery intake

• Additives and oxygenates
  - Compounds added to or blended with oil products to modify their properties (octane, cetane, cold properties, etc.).
  - Examples are: (a) oxygenates such as alcohols (b) esters and (c) chemical compounds

• Refinery feedstocks
  - Oils or gases from crude oil refining or the processing of hydrocarbons in the petrochemical industry that are destined for further processing in the refinery excluding blending.
  - Examples are: naphthas, middle distillates, pyrolysis gasoline and heavy oils from vacuum distillation and petrochemical plants.
Refinery output

- LPG: 2-5%
- Naphtha: 20-35%
- Gasoline: 30-40%
- Kerosene: 25-75%
- Gas/diesel Oil: 25-75%
- Fuel Oil: 25-75%
- Others: 2-5%
Refinery efficiency

- Mass units (e.g. tonnes) – small losses and no gains.
- Volume units (e.g. barrels) – gains are possible and likely because lighter products are produced.
- Energy units (e.g. TJ, toe) – small losses with no gains.
Transformation to power

- Gas Diesel
- Electricity
- Own use

Electricity plants

Transformation input

Gross production

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Gas plants

Non hydrocarbon gases

- Separation facilities / Gas processing plants
- Condensate

Natural gas (dry)

- Ethane
- Propane
- Butane
- Pentane
- Pentane Plus

Liquefaction plants (LNG)

LPG

NGL

- Condensate

Oil products

- LPG (propane, butane)
- Naphtha
- Motor & aviation gasoline
- Kerosenes
- Gas / diesel
- Fuel oil
- etc...

Natural gas (wet)

- Crude oil

Crude oil
Transfers

- Transfers are essentially statistical devices to overcome practical classification and presentation issues resulting from changes in use or identity of a product.

- Transfers comprise products transferred and interproduct transfers.
  - **Products transferred** refers to the reclassification (renaming) of products, which, for example, is necessary when finished oil products are used as feedstock in refineries.
  - **Interproduct transfers** refer to the movements of fuels between product categories because of reclassification of a product that no longer meets its original specification. For example, aviation turbine fuel that has deteriorated or has been spoiled may be reclassified as heating kerosene.
Final consumption
Final consumption

Manufacturing, construction and non-fuel mining industry

Transport
- Road
- Rail
- Domestics navigation
- Pipeline transport
- Others

Other
- Households
- Agriculture, forestry, fishing
- Commerce and public services
- Not elsewhere specified (other)

Non-energy consumption

Final energy consumption
International Bunkers and Transport

- **International bunkers** are quantities of fuels delivered to merchant ships (including passenger ships) and civil aircraft of any nationality for consumption during international voyages/flight transporting goods or passengers.

- International voyages/flights take place when the ports of departure and arrival are in different national territories. Fuels delivered for consumption by ships during domestic transportation, fishing or military uses are not included here, but are considered part of final consumption of energy.
Non-energy use

- Lubricants and grease for their slippery properties
- Bitumen (asphalt) for its waterproofing properties
- Naphtha, gas oil, LPG, ethane - feedstocks to petrochemical plants (fertilizers, plastics, synthetic rubber, pesticides)
- Petroleum coke - the manufacture of soda ash, silicon carbide and carbon anodes.
Other flows
Trade

**Imports** of energy products comprise all fuel and other energy products entering the national territory.
- goods simply being transported through a country (goods in transit) and goods temporarily admitted are excluded,
- re-imports (i.e. domestic goods exported but subsequently readmitted) are included.
- The bunkering of fuel outside the reference territory by national merchant ships and civil aircraft engaged in international travel is also excluded from imports.

**Exports** of energy products comprise all fuel and other energy products leaving the national territory.
- Goods simply being transported through a country (goods in transit) and goods temporarily withdrawn are excluded, while
- re-exports (i.e. foreign goods exported in the same state as previously imported) are included.
- Also excluded are quantities of fuels delivered for use by merchant ships (including passenger ships) and civil aircraft of all nationalities during international transport of goods and passengers
Stock changes

- Stock changes.
  - For the purposes of energy statistics, stocks are quantities of energy products that are held on the national territory and can be used to:
    (a) maintain service under conditions where supply and demand are variable in their timing or amount due to normal market fluctuations, or
    (b) supplement supply in the case of a supply disruption.
  - Stocks used to manage a supply disruption may be called “strategic” or “emergency” stocks and are often held separately from stocks designed to meet normal market fluctuations, but both are considered here.
  - Stock changes are defined as the increase (stock build) or decrease (stock draw) in the quantity of stocks over the reporting period and thus are calculated as a difference between the closing and opening stocks.
Commodity balances
Why to create commodity balances

- Commodity balances allow all data for all products to be presented in the same way.
- Directly comparable concepts of key flows like production, own use, transformation inputs, transfers.
- Check on data completeness (product by product).
- A key step in generating energy balances.
### Energy data – commodity balances

| Production |
|------------|---------------------------------------------------------------|
| Off-shore production of crude oil |
| Refinery gross output |
| Production of LPG from natural gas separation plants |
| Gross generation |

<table>
<thead>
<tr>
<th>Own use</th>
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</thead>
<tbody>
<tr>
<td>Refinery fuel</td>
</tr>
<tr>
<td>Own use</td>
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<table>
<thead>
<tr>
<th>Domestic supply</th>
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<tbody>
<tr>
<td>Gross inland deliveries</td>
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<table>
<thead>
<tr>
<th>Final consumption</th>
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<tbody>
<tr>
<td>Inland consumption</td>
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</table>

<table>
<thead>
<tr>
<th>Energy industry own use</th>
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</thead>
</table>

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What flows are collected annually?

Production
• from plants/from refinery
• electricity and heat by source and type of plants
Receipt from other sources
Import and Export
Marine Bunkers
Stock Changes

= Total Energy Supply
Transfers and recycled products
Statistical Differences
Transformation Sector (21 sub-sectors)
Energy industries own use (17 sub-sectors)
Distribution Losses

Final Consumption =
Non Energy Uses
Final energy consumption
  Industry Sector (15 sub-sectors)
  Transport (6 sub-sectors)
  Other Sectors (4 sub-sectors)
Supply and use of energy products

Production
• from plants/from refinery
• electricity and heat by source and type of plants
Receipt from other sources
Import and Export
Marine Bunkers
Stock Changes

= Total Energy Supply

Transfers and recycled products

Statistical Differences

Transformation Sector (21 sub-sectors)
Energy industries own use (17 sub-sectors)
Distribution Losses

Final Consumption =
Non Energy Uses
Final energy consumption
  Industry Sector (15 sub-sectors)
  Transport (6 sub-sectors)
  Other Sectors (4 sub-sectors)
# Transformation and own use

## Gas Oil/ Diesel Oil (DL); Metric tons, thousand (WSR)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>DL08</td>
<td>Transformation</td>
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<tr>
<td>DL088</td>
<td>Transformation in electricity, CHP and heat plants</td>
</tr>
<tr>
<td>DL08811</td>
<td>Electricity plants - Main activity producers</td>
</tr>
<tr>
<td>DL08812</td>
<td>Electricity plants - Autoproducers</td>
</tr>
<tr>
<td>DL081</td>
<td>Coke ovens</td>
</tr>
<tr>
<td>DL082</td>
<td>Gas works</td>
</tr>
<tr>
<td>DL083</td>
<td>Briquetting plants</td>
</tr>
<tr>
<td>DL085PP</td>
<td>Petrochemical plants</td>
</tr>
<tr>
<td>DL087</td>
<td>Natural gas blending plants</td>
</tr>
<tr>
<td>DL089</td>
<td>Other transformation</td>
</tr>
<tr>
<td>DL09</td>
<td>Energy industries own use</td>
</tr>
<tr>
<td>DL0911</td>
<td>Coal mines</td>
</tr>
<tr>
<td>DL0912</td>
<td>Oil and gas extraction</td>
</tr>
<tr>
<td>DL0921</td>
<td>Coke ovens</td>
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<tr>
<td>DL0922</td>
<td>Gas works</td>
</tr>
<tr>
<td>DL0924</td>
<td>Blast furnaces</td>
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<tr>
<td>DL0925</td>
<td>Oil refineries</td>
</tr>
<tr>
<td>DL0927</td>
<td>Electricity, CHP and heat plants</td>
</tr>
<tr>
<td>DL0928</td>
<td>Other energy industry own use</td>
</tr>
</tbody>
</table>

Gas Diesel transformed into other form of energy (e.g. electricity)

Gas Diesel used to keep running the industry, e.g. some engines in the electricity plant.

## Total Electricity (EL); Kilowatt-hours, million (HWU)

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL015C</td>
<td>From combustible fuels – Main activity</td>
</tr>
<tr>
<td>EL015CE</td>
<td>From combustible fuels – Main activity – Electricity plants</td>
</tr>
<tr>
<td>EL0927</td>
<td>Own use by electricity, CHP and heat plants</td>
</tr>
</tbody>
</table>

Electricity from gas diesel used within the electricity plant!
Main activity producers & autoproducers

Gas Oil/ Diesel Oil (DL); Metric tons, thousand (WSR)
DL088 Transformation in electricity, CHP and heat plants
DL08811 Electricity plants - Main activity producers
DL08812 Electricity plants - Autoproducers
DL08821 CHP plants - Main activity producers
DL08822 CHP plants - Autoproducers
DL08831 Heat plants - Main activity producers
DL08832 Heat plants - Autoproducers

Main activity producers

- Privately or publicly owned companies
- Produce electricity or heat as their principal activity
- Formerly known as public utilities
- In practice, plants called: power plant, CHP plant, heat plant

Autoproducers

- Privately or publicly owned companies
- Produce electricity and/or heat wholly or partially for their own use as support to their primary activity
- E.g.: Waste recycling facilities, paper mill, etc
Electricity, CHP and Heat plants

Gas Oil/ Diesel Oil (DL); Metric tons, thousand (WSR)
DL088  Transformation in electricity, CHP and heat plants
DL08811  Electricity plants - Main activity producers
DL08812  Electricity plants - Autoproducers
DL08821  CHP plants - Main activity producers
DL08822  CHP plants - Autoproducers
DL08831  Heat plants - Main activity producers
DL08832  Heat plants - Autoproducers

Electricity plant
- Plants producing only electricity
- The electricity may be obtained directly from natural sources (e.g. hydro) or from the heat obtained from the combustion of fuels or nuclear reactions.

CHP plant
- Plants producing both heat and electricity from at least one generating unit in the plant.
- Sometimes called: “co-generation” plants

Heat plant
- Plants designed to produce heat only for deliveries to third parties.
- Including heat pumps and electric boilers.
- Deliveries of fuels for heat generated by an autoproducer for its own purposes are classified as final consumption.
Definition of oil products
Definitions of oil products

• Refinery gas
  - Includes a mixture of non-condensable gases, mainly consisting of hydrogen, methane, ethane and olefins obtained during distillation of crude oil or treatment of oil products (e.g., cracking) in refineries or from nearby petrochemical plants.

• Ethane
  - A naturally gaseous straight-chain hydrocarbon ($\text{C}_2\text{H}_6$).

• Liquefied petroleum gases (LPG)
  - LPG refers to liquefied propane ($\text{C}_3\text{H}_8$) and butane ($\text{C}_4\text{H}_{10}$) or mixtures of both. Commercial grades are usually mixtures of the gases with small amounts of propylene, butylene, isobutene and isobutylene stored under pressure in containers.

• Naphtha
  - Light or medium oils distilling between 30°C and 210°C that do not meet the specification for motor gasoline.
Definitions of gasolines

• Gasolines
  - Complex mixtures of volatile hydrocarbons distilling between approximately 25°C and 220°C and consisting of compounds in the C₄ to C₁₂ range

• Aviation gasoline
  - Gasoline prepared especially for aviation piston engines with additives that assure performance under flight conditions. Aviation gasolines are predominantly alkylates (obtained by combining C₄ and C₅ isoparaffins with C₃, C₄ and C₅ olefins) with the possible addition of more aromatic components including toluene. The distillation range is 25°C to 170°C.

• Motor gasoline
  - A mixture of some aromatics (e.g., benzene and toluene) and aliphatic hydrocarbons in the C₅ to C₁₂ range. The distillation range is 25°C to 220°C.

• Gasoline-type jet fuel
  - Light hydrocarbons for use in aviation turbine power units, distilling between 100°C and 250°C. They are obtained by blending kerosene and gasoline or naphtha in such a way that the aromatic content does not exceed 25 per cent in volume, and the vapour pressure is between 13.7 kPa and 20.6 kPa.
Definitions of kerosenes

• Kerosenes
  - Mixtures of hydrocarbons in the range C₉ to C₁₆ and distilling over the temperature interval 145°C to 300°C, but not usually above 250°C and with a flash point above 38°C.

• Kerosene-type jet fuel
  - A blend of kerosenes suited to flight conditions with particular specifications, such as freezing point.

• Other kerosene
  - Kerosene that is used for heating, cooking, lighting, solvents and internal combustion engines.
Definitions of gas oil

• Gas oil/diesel oil and heavy gas oil:
  - This group includes gas oils and heavy gas oils

• Gas oil/diesel oil
  - Gas oils are middle distillates, predominantly of carbon number range $C_{11}$ to $C_{25}$ and with a distillation range of 160°C to 420°C.

• Heavy gas oil
  - A mixture of predominantly gas oil and fuel oil that distills in the range of approximately 380°C to 540°C.
Definitions of fuel oil

• Fuel oil
  - Comprises residual fuel oil and heavy fuel oil. Residual fuel oils have a distillation range of 350°C to 650°C and a kinematic viscosity in the range 6 to 55 cSt at 100°C. Their flash point is always above 60°C and their specific gravity is above 0.95. Heavy fuel oil is a general term describing a blended product based on the residues from various refinery processes.
Definitions of other oil products

• White spirit and special boiling point industrial spirits
  - White spirit and special boiling point (SBP) industrial spirits are refined distillate intermediates with a distillation in the naphtha/kerosene range. They are mainly used for non-fuel purposes and sub-divided as: (a) white spirit—an industrial spirit with a flash point above 30°C and a distillation range of 135°C to 200°C; and (b) industrial spirit (SBP)—light oils distilling between 30°C and 200°C.

• Lubricants
  - Oils, produced from crude oil, for which the principal use is to reduce friction between sliding surfaces and during metal cutting operations.

• Paraffin waxes
  - Residues extracted when dewaxing lubricant oils. The waxes have a crystalline structure that varies in fineness according to the grade, and are colourless, odourless and translucent, with a melting point above 45°C.
Definitions of other oil products

- Petroleum coke
  - Petroleum coke is a black solid obtained mainly by cracking and carbonizing heavy hydrocarbon oils, tars and pitches. It consists mainly of carbon (90 to 95 per cent) and has a low ash content.
  - The two most important categories are green coke and calcined coke.
    - **Green coke** (raw coke) is the primary solid carbonization product from high boiling hydrocarbon fractions obtained at temperatures below 630°C. It contains 4–15 per cent by weight of matter that can be released as volatiles during subsequent heat treatment at temperatures up to approximately 1330°C.
    - **Calcined coke** is a petroleum coke or coal-derived pitch coke obtained by heat treatment of green coke to about 1330°C. It will normally have a hydrogen content of less than 0.1 per cent by weight.
Definitions of other oil products

• Bitumen
  - A solid, semi-solid or viscous hydrocarbon with a colloidal structure, being brown to black in color.

• Other oil products n.e.c.
  - Products (including partly refined products) from the refining of crude oil and feedstocks that are not specified above.

For more information, refer to IRES, https://unstats.un.org/unsd/energystats/methodology/ires/
Data sources
Data sources

**Refineries** – a very reliable source of information
- Often only a few in a country, so easy to census
- They hold very detailed information to monitor their activity

**Oil product distributors**
- Data collection harder as more companies, so may need sample.
- Not many data on final users

**Administrative sources**
- Customs for data on trade
- Ministry of finance for fiscal data on oil companies
- Tax services generally have data on transport fuels

**Surveys**
- Often the only source on final use by households or business
Units in energy statistics
Energy products are initially measured in Original or Natural units. These units vary in different countries as a result of historical and other factors.

- **Solid fuels** (e.g. coal) are measured in terms of their
  - mass (weight) (e.g. kilograms, metric tons);

- **Liquid fuels** (e.g. oil) can be measured in terms of their
  - volume (e.g. barrels, litres, gallon) or
  - mass (metric tons);

- **Gaseous fuels** (e.g. methane) are measured in terms of their
  - Volume (e.g. cubic metres).
Basic conversions

We can recalculate the quantities within the same unit category using constant values:
- $1 \text{ bbl} \approx 159 \text{ L}$
- $1 \text{ m}^3 = 1000 \text{ L}$
- $1 \text{ ton} = 1000 \text{ kg}$

Prefix are used to present values in simplify format:
- Kilo (k) - $10^3$
- Mega (M) - $10^6$
- Giga (G) - $10^9$
- Tera (T) - $10^{12}$

E.g. $1 \text{ kt} = 1000 \text{ ton} = 1000000 \text{ kg}$
Liquid fuels can be measure by their mass or volume.

- To move from mass to volume we need to know density (or specific gravity of the liquid)
- E.g. crude oil can be light or heavy and we should use specific densities for calculation
- If the densities are not know, we can use average densities for different product category.
Example: from volume to mass

Knowing that density of crude oil is 0.13569 (barrel/tonne), calculate how much weight is 1 mln barrels.

1 mln barrels = 1 000 000 barrels =
= 1 000 000 * 0.13569 tonnes
= 135 690 tonnes
= 135.690 kilotonnes
**Energy units**

*Electricity* is measured in units such as kilowatts or joules, and *heat* in calories or, in some countries, British Thermal Units (BTUs).

- **Typical energy units:**
  - GWh, joules, toe, tce

- **We can recalculate the quantities between different energy units using constant values**
  - $1 \text{ GWh} = 3.6 \text{ TJ}$
  - $1 \text{ ktoe} \approx 41.868 \text{ TJ}$
  - $1 \text{ ktce} = 0.7 \text{ ktoe}$
Examples: energy units

Knowing that 1 GWh = 3.6 TJ and 1 ktoe = 41.868 TJ, convert 7 ktoe to GWh.

- 7 ktoe = 7 * 41.868 [ktoe * TJ/ktoe]
- = 293.076 [TJ]
- = 293.076 / 3.6 [TJ / (TJ / GWh)]
- = 81.41 [GWh]
# Recommended units for dissemination

<table>
<thead>
<tr>
<th>Energy products</th>
<th>Dimension</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid fossil fuels</td>
<td>Mass</td>
<td>Thousand metric tons</td>
</tr>
<tr>
<td>Liquid fossil fuels</td>
<td>Mass</td>
<td>Thousand metric tons</td>
</tr>
<tr>
<td>(Liquid) Biofuels</td>
<td>Mass/Volume</td>
<td>Thousand Metric tons/ Thousand cubic metres</td>
</tr>
<tr>
<td>Gases</td>
<td>Energy</td>
<td>Terajoules</td>
</tr>
<tr>
<td>Wastes</td>
<td>Energy</td>
<td>Terajoules</td>
</tr>
<tr>
<td>Fuelwood</td>
<td>Volume/Energy</td>
<td>Thou. Cubic Metres/Terajoules</td>
</tr>
<tr>
<td>Charcoal</td>
<td>Mass</td>
<td>Thousand metric tons</td>
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<tr>
<td>Electricity</td>
<td>Energy</td>
<td>GWh</td>
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<tr>
<td>Heat</td>
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<td>Common unit (eg balances)</td>
<td>Energy</td>
<td>Terajoules</td>
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<tr>
<td>Elec. installed capacity</td>
<td>Power</td>
<td>MW</td>
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<tr>
<td>Refinery capacity</td>
<td>Mass/time</td>
<td>Thousand metric tons/year</td>
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