

“Capacity Building and Strengthening Institutional Arrangement”

Workshop: Quantitative risk assessment of oil and gas plants

## Production Technologies Aspects

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## 1. Introduction

An oil refinery is an industrial process plant where crude oil is processed and refined into useful petroleum products.



## 1. Introduction

The process of converting crude oil into useable by-products involves three stages:

- Separation
- Conversion
- Treatment



## 2. Separation

Separation begins with vaporizing crude oil, by pumping it through pipes in hot furnaces.

The vapours separate inside the towers, based on density and boiling point. Light vapours rise to the top of the tower and the heavier vapours descend to the bottom. The vapours then condense back into liquids.

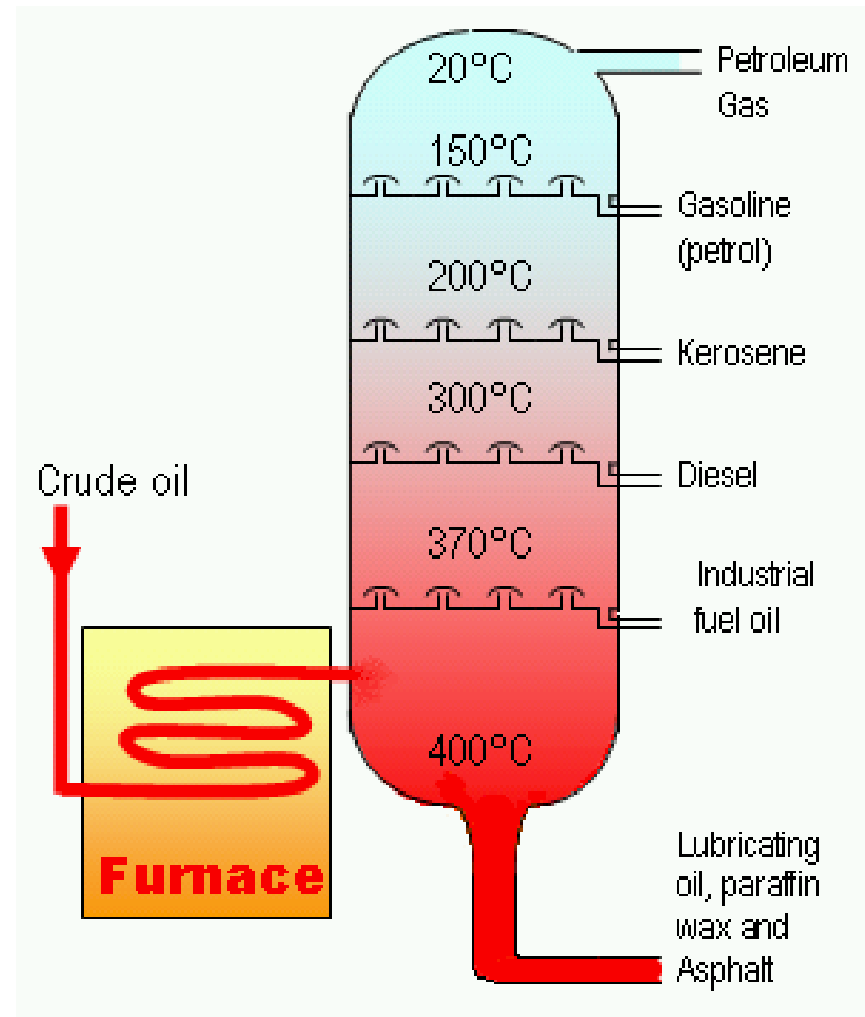


## 2. Separation

Crude oil is separated into fractions by fractional distillation.

The fractionating column is cooler at the top than at the bottom so the vapours can condense more easily while moving up the column.

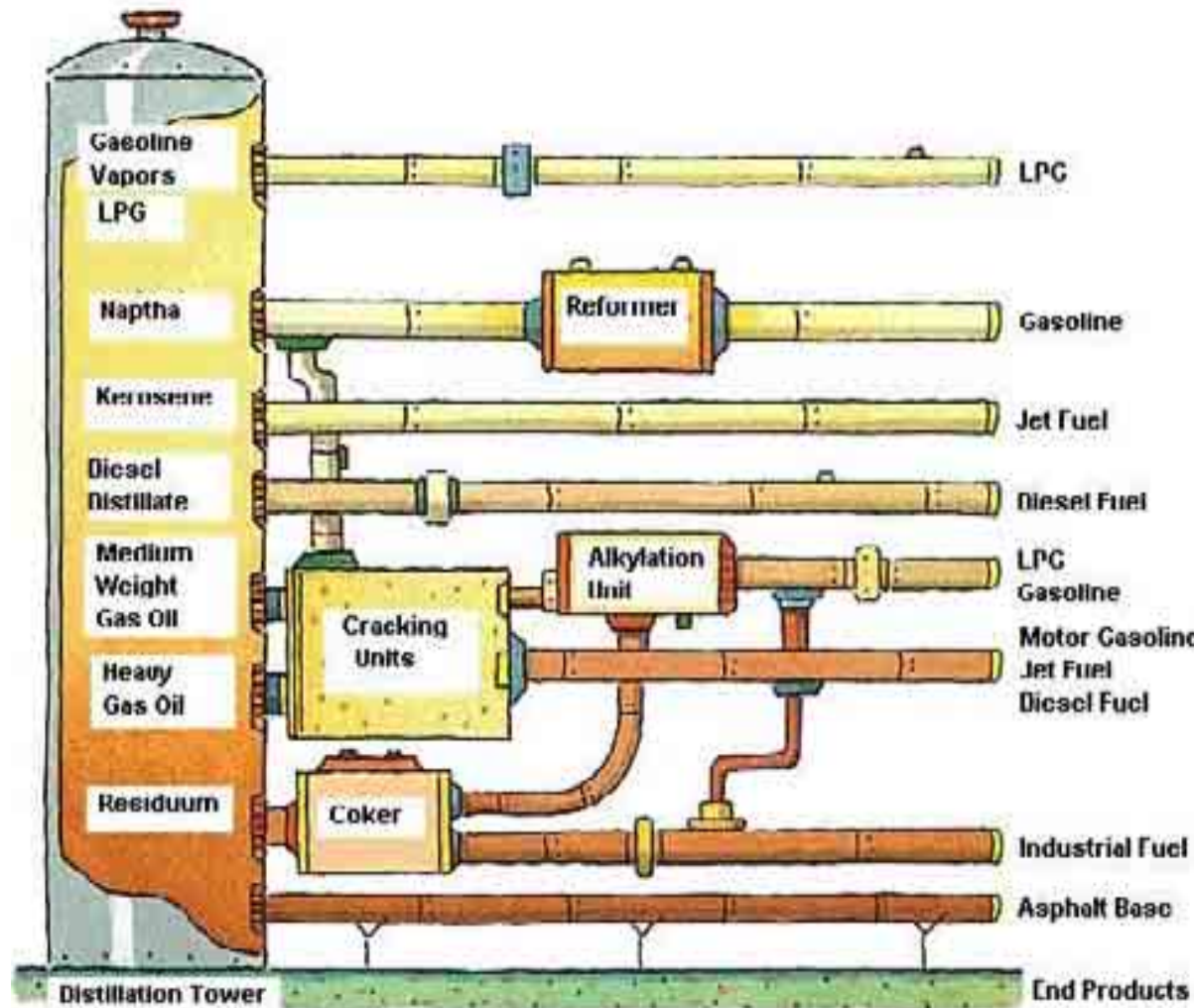
The heavier fractions that emerge from the bottom of the fractionating column are often broken up (cracked) to make more useful products.



### 3. Conversion

Conversion is the process of transforming the output of distillation towers into streams that eventually become finished products.

Some products emerge from the distillation process as ready-to-use products such as gasoline, and liquefied petroleum products.



## 4. Products

The use of the oil crude and oil products has strongly increased in the last decades, as the following dates show:

- the 40% of all the world primary energy comes from oil
- the 90% of all energy used for transports comes from oil
- the 65% of oil world production is used to produce fuels

It's also important to consider the power energetic produced by oil

### Example

Energy produced by 1 Litre of fuel = energy produced by 1000 litres natural gas  
= energy produced by 24 solar panels working all day



## 4. Products

Main Products from oil refineries:

- Asphalt
- Fuel oil
- Diesel fuel
- Gasoline
- Kerosene
- Liquid petroleum gas (LPG)
- Lubricating oils
- Paraffin wax
- Bitumen

## 4. Products

Asphalt is a sticky, black and highly viscous liquid or semi-solid that is present in most crude petroleums and in some natural deposits. Asphalt is composed almost entirely of bitumen.

Fuel oil is a fraction obtained from petroleum distillation, either as a distillate or a residue. Fuel oil is made of long hydrocarbon chains, particularly alkanes, cycloalkanes and aromatics.

Diesel fuel or Diesel is a specific fractional distillate of fuel oil (mostly petroleum) that is used as fuel in a diesel engine.

## 4. Products

Gasoline, also called petrol, is a petroleum-derived liquid mixture consisting primarily of hydrocarbons and enhanced with benzenes to increase octane ratings, used as fuel in internal combustion engines.

Kerosene is obtained from the fractional distillation of petroleum at 150°C and 275°C. Kerosene directly distilled from crude oil requires some treatment to reduce its sulphur content and its corrosiveness. Kerosene can also be produced by a hydrocracker, which is used to upgrade the parts of crude oil that would otherwise only be good for fuel oil.

## 4. Products

Liquid petroleum gas (LPG) is a mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles, and increasingly replacing chlorofluorocarbons as an aerosol propellant and a refrigerant to reduce damage to the ozone layer.

Lubricating oils or liquid petrolatum is a by-product in the distillation of petroleum to produce gasoline. It is a chemically inert, transparent, colorless oil composed mainly of alkanes and cyclic paraffins, related to white petrolatum.

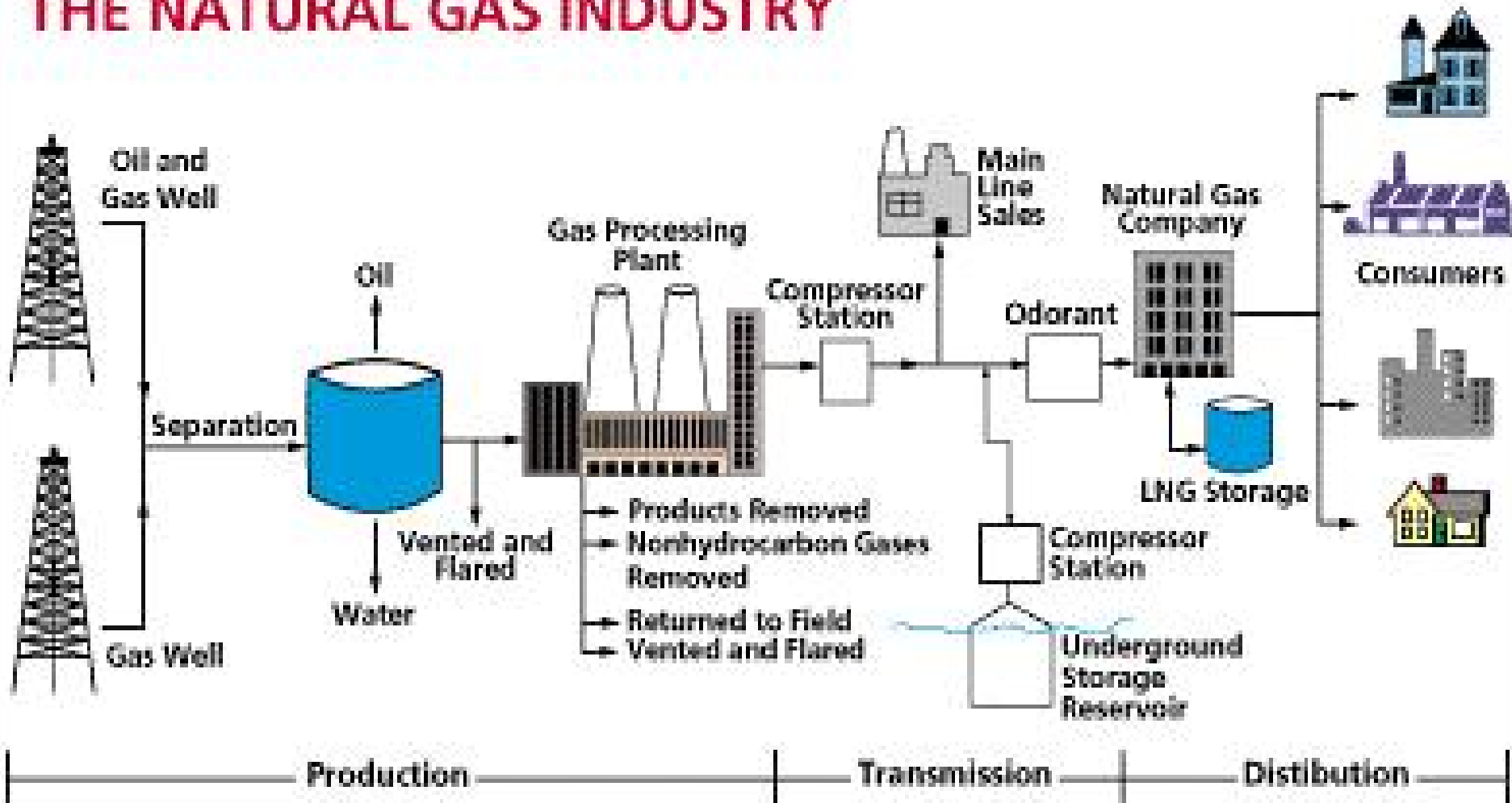
## 4. Products

Paraffin waxes are complex mixtures of many substances. They mainly consist of saturated hydrocarbons. These crude oil derivatives are purified and refined.

Bitumen is obtained by fractional distillation of crude oil. Bitumen being the heaviest and being the fraction with the highest boiling point, it appears as the bottommost fraction.

## 4. Products

### THE NATURAL GAS INDUSTRY

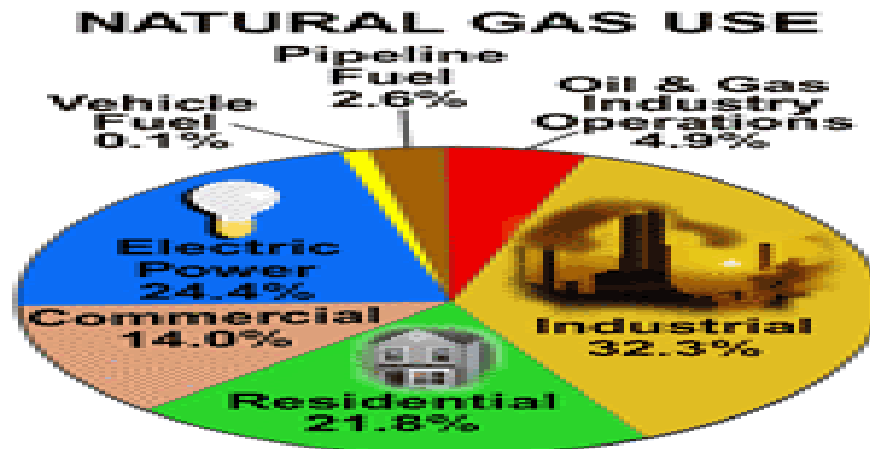


## 4. Products

Main products from natural gas production:

Methane, that is used as primary fuel and source of heat energy throughout the industrialized countries for a large range of residential, commercial and industrial applications. It's also used in the chemical industries

Propane and Butane are liquid gas used as fuel for domestic use, and to source energy in rural areas that do not have natural gas service. They are also used for heating homes, heating water, cooking and refrigerating food, drying clothes, and fuelling gas fireplaces.



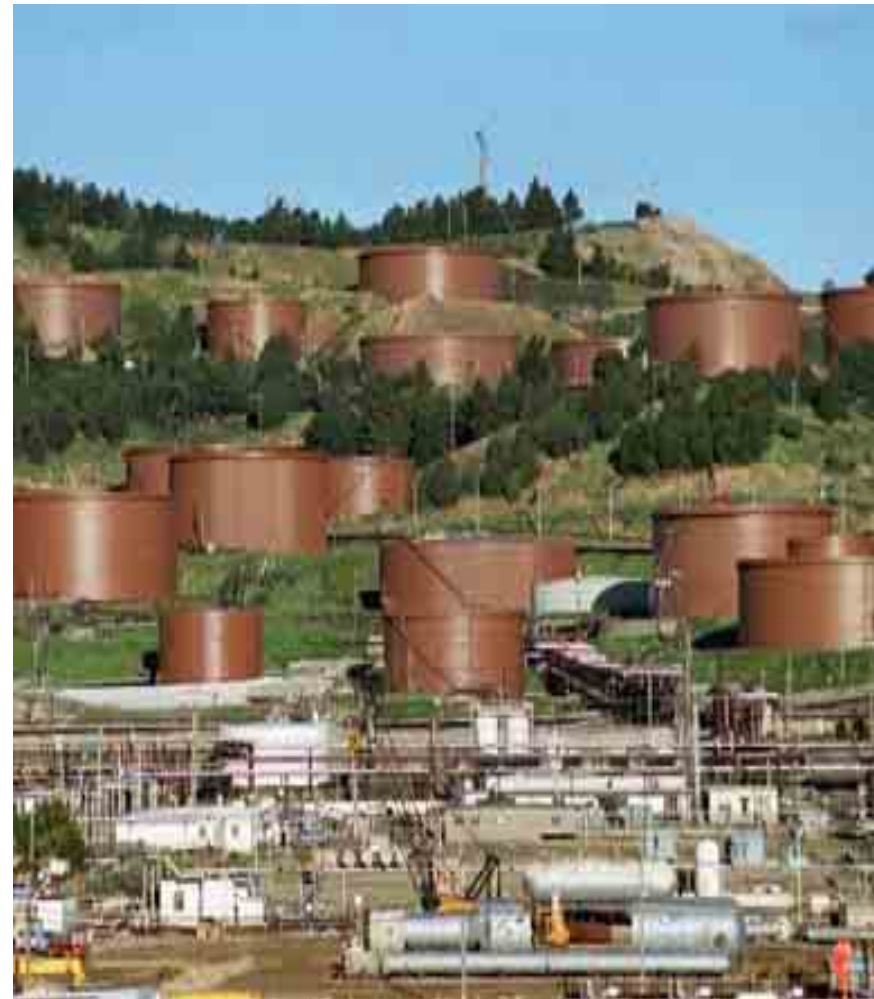
## 5. Treatments

The refining process releases numerous different chemicals into the atmosphere.

Many products must go through further processing to remove impurities, such as sulphur and nitrogen.

The emission of carbon monoxide is reduced through oxygenation.

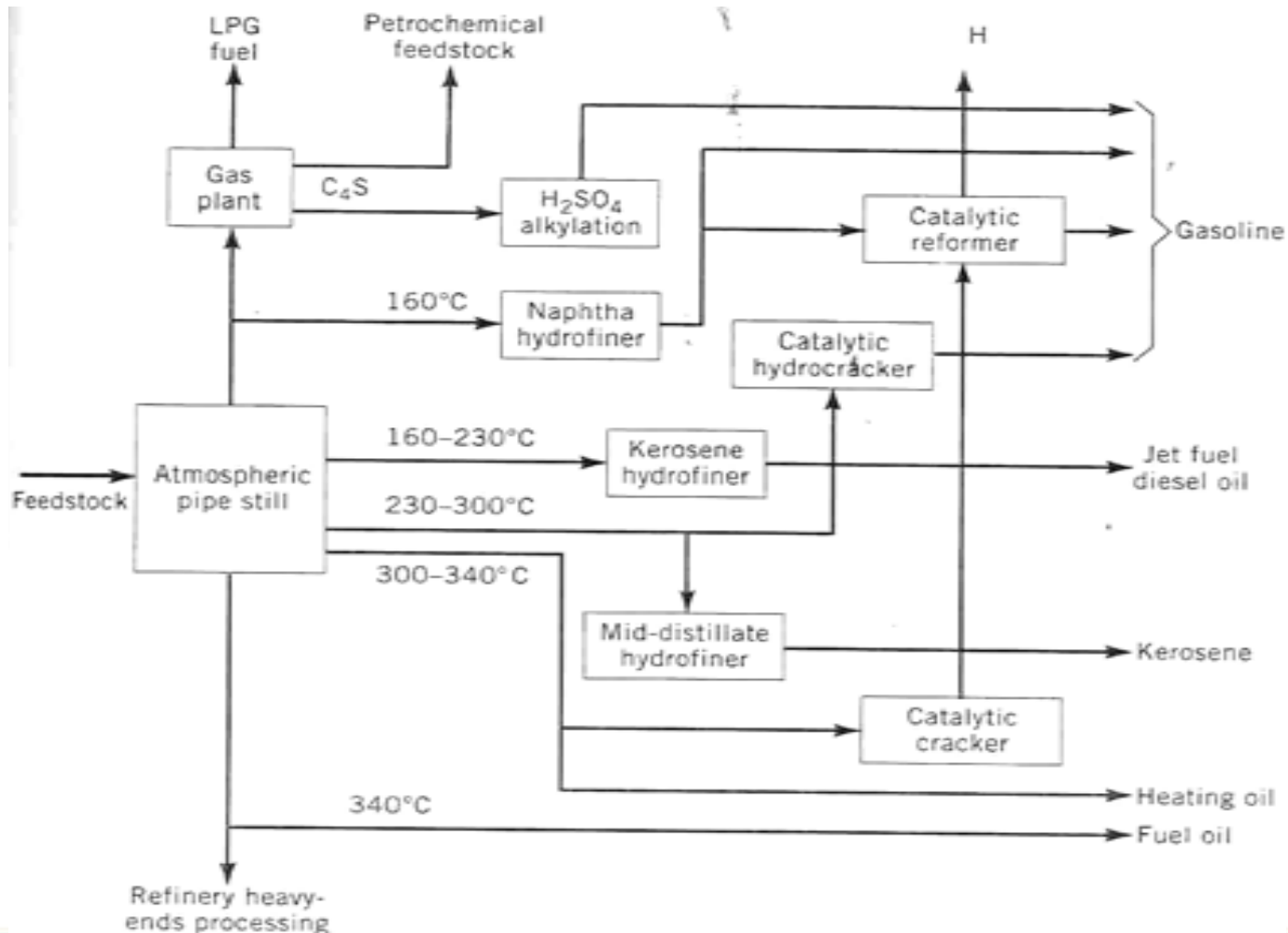
Oxygenation is achieved through the addition of ethanol, or other additives, to gasoline.





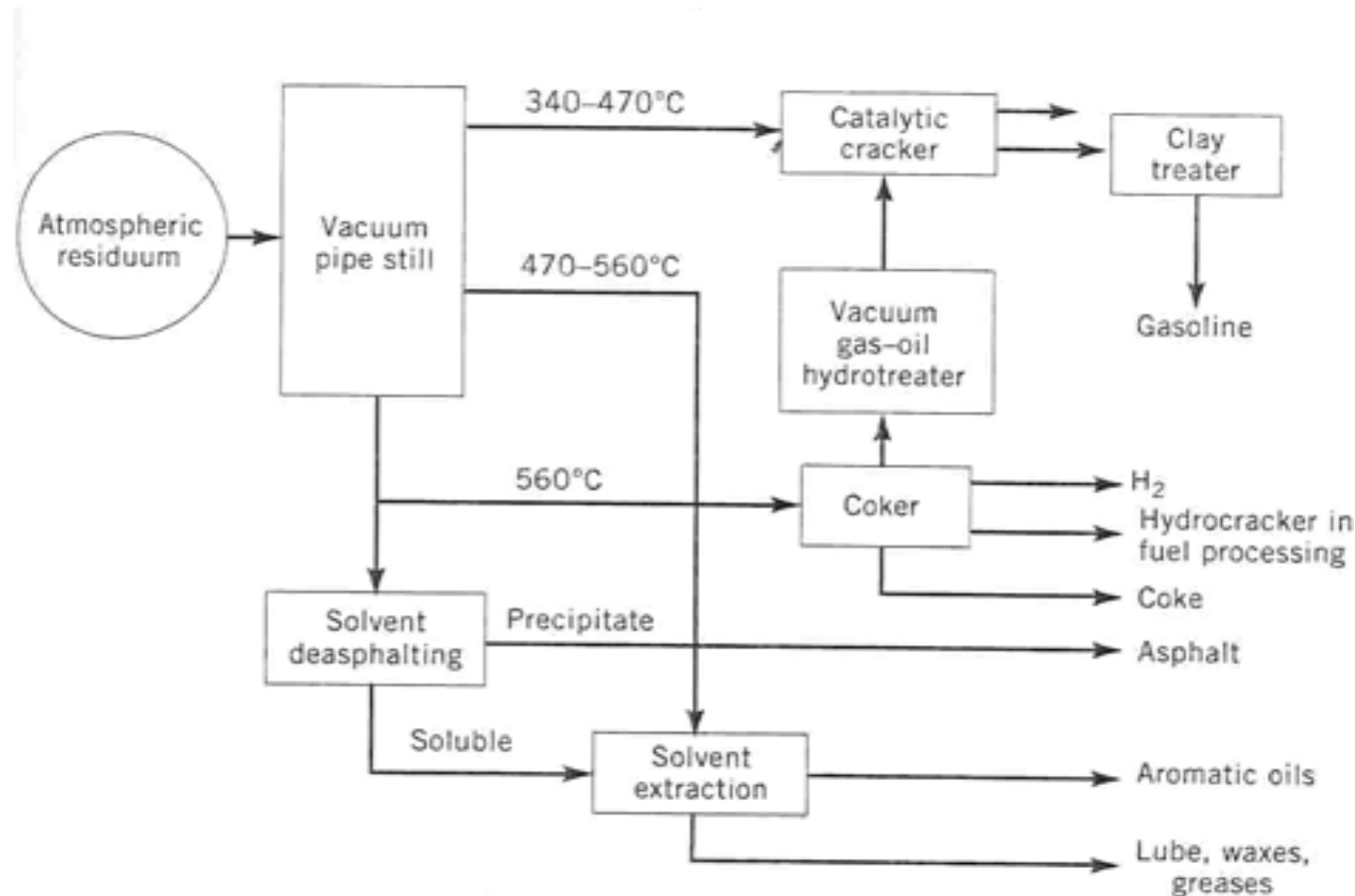
## 6. Scheme of general refinery operations

### light petroleum refining section



## 6. Scheme of general refinery operations

### heavy feedstock refining section



## 7. Quantitative Risk Assessment and Management

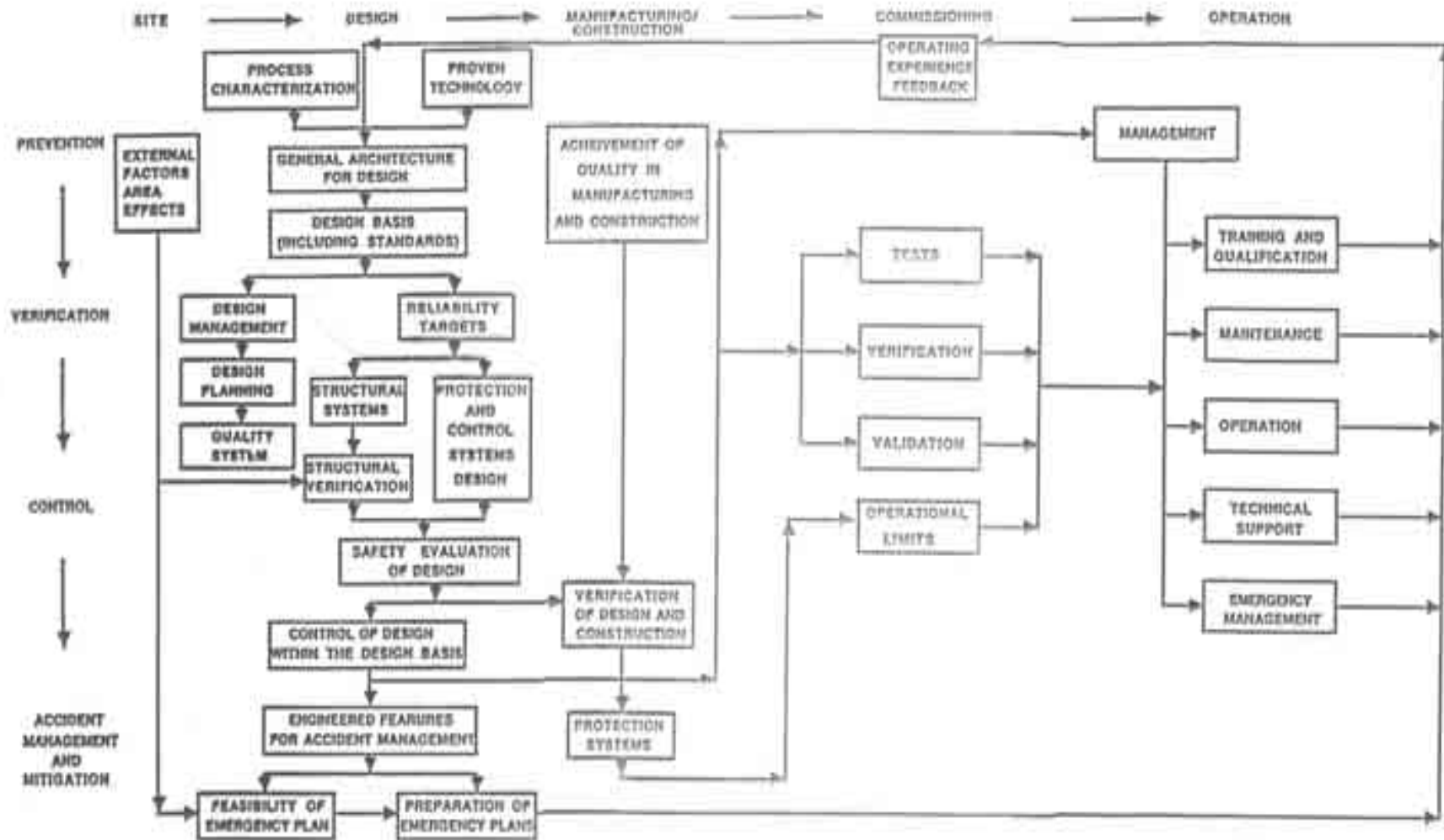
In any plants in which are treated, used, processed or storage hazardous substances can verify deviation from process's parameters or fault of components that can produce malfunction in the plants and possible hazard risk situations. The prevention of accidents is the first priority of designers and managers plant's that can be achieved by an integrated system of measures, concerning hardware and software components

The main phase of the life-cycle of a plant are:

- Design
- Sitting
- Building and manufacturing of components and systems
- Commissioning (start-up, testing, etc..)
- Operation- Activities (in normal and abnormal conditions of the plant)
- Decommissioning

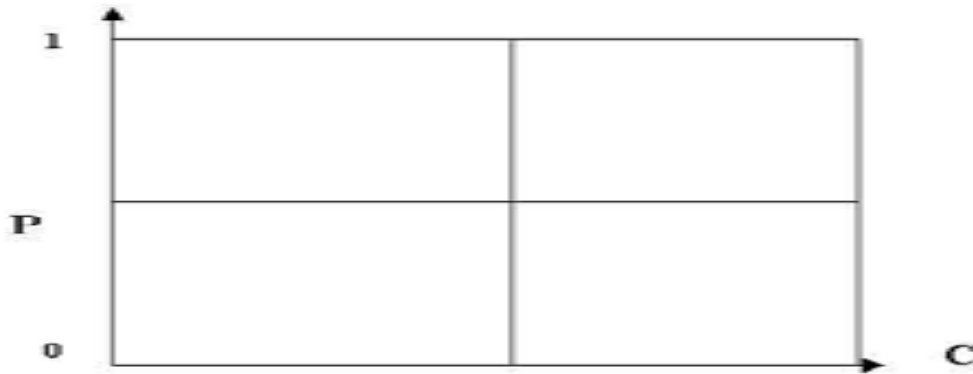
# 7. Quantitative Risk Assessment and Management

## General scheme



## 7. Quantitative Risk Assessment and Management

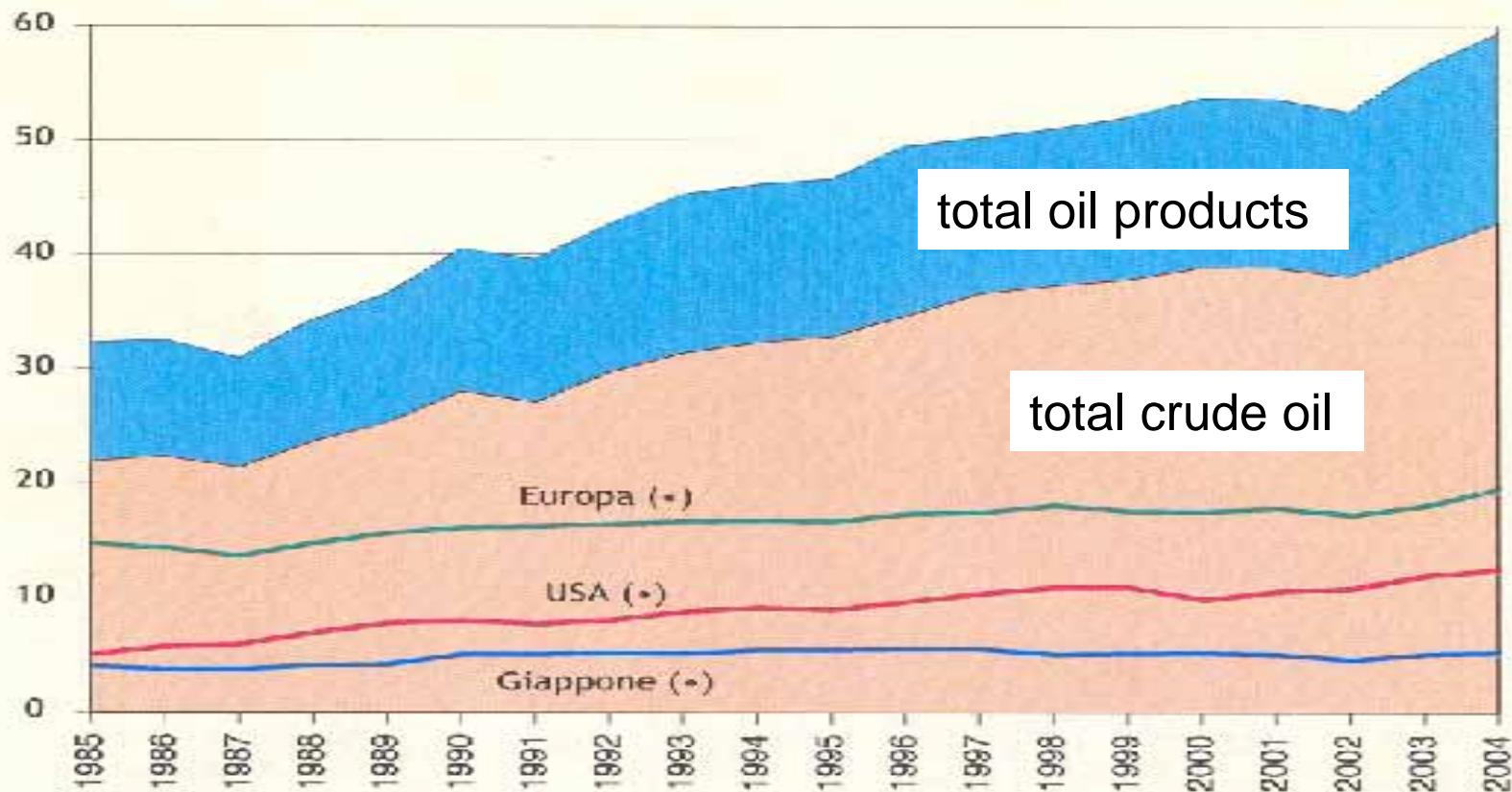
$$\text{Risk} = \text{Probability} * \text{Consequence} / \text{Management System}$$



1. Hazard Incidents identification by a proper methodology
2. Calculation of incidents frequency (number/year)
3. Calculation of incidents consequences (distance for death injury)
4. Risk calculation (individual or social)
5. Request for authorization (safety report, comparison with risk limits, approval/prescriptions)

## 8. Statistical data

### Imports of crude oil and oil products (barrels of billion / day)



\*Crude oil and products

Source :AIE, OPEC

## 8. Statistical data

Oil world consumption divided for areas and main products (barrels of billion / day)

	1995	2000	2003	2004	quote % su totale 2004
<b>Nord America</b>					
Benzine	9.235	10.106	10.675	10.897	44,3
Distillati medi	5.934	6.811	6.861	7.105	28,8
Olio combustibile	1.336	1.518	1.271	1.274	5,2
Altri	4.645	5.086	5.242	5.343	21,7
<b>Totale Nord America</b>	<b>21.150</b>	<b>23.521</b>	<b>24.049</b>	<b>24.619</b>	<b>100,0</b>
<b>Sud e Centro America</b>					
Benzine	1.149	1.274	1.216	1.246	26,3
Distillati medi	1.476	1.680	1.714	1.815	38,3
Olio combustibile	734	788	698	697	14,7
Altri	777	917	953	980	20,7
<b>Totale Sud e Centro America</b>	<b>4.136</b>	<b>4.659</b>	<b>4.581</b>	<b>4.738</b>	<b>100,0</b>
<b>Europa</b>					
Benzine	4.186	4.194	3.920	3.851	23,6
Distillati medi	6.050	6.748	7.129	7.297	44,8
Olio combustibile	2.283	1.971	1.958	1.900	11,7
Altri	2.773	3.077	3.162	3.240	19,9
<b>Totale Europa</b>	<b>15.292</b>	<b>15.990</b>	<b>16.169</b>	<b>16.288</b>	<b>100,0</b>
<b>Medio Oriente</b>					
Benzine	762	890	1.031	1.120	21,2
Distillati medi	1.435	1.541	1.668	1.708	32,3
Olio combustibile	1.199	1.266	1.276	1.354	25,6
Altri	764	903	1.060	1.106	20,9
<b>Totale Medio Oriente</b>	<b>4.160</b>	<b>4.600</b>	<b>5.035</b>	<b>5.288</b>	<b>100,0</b>

## 8. Statistical data

### Refining capacity (barrels of billion / day)

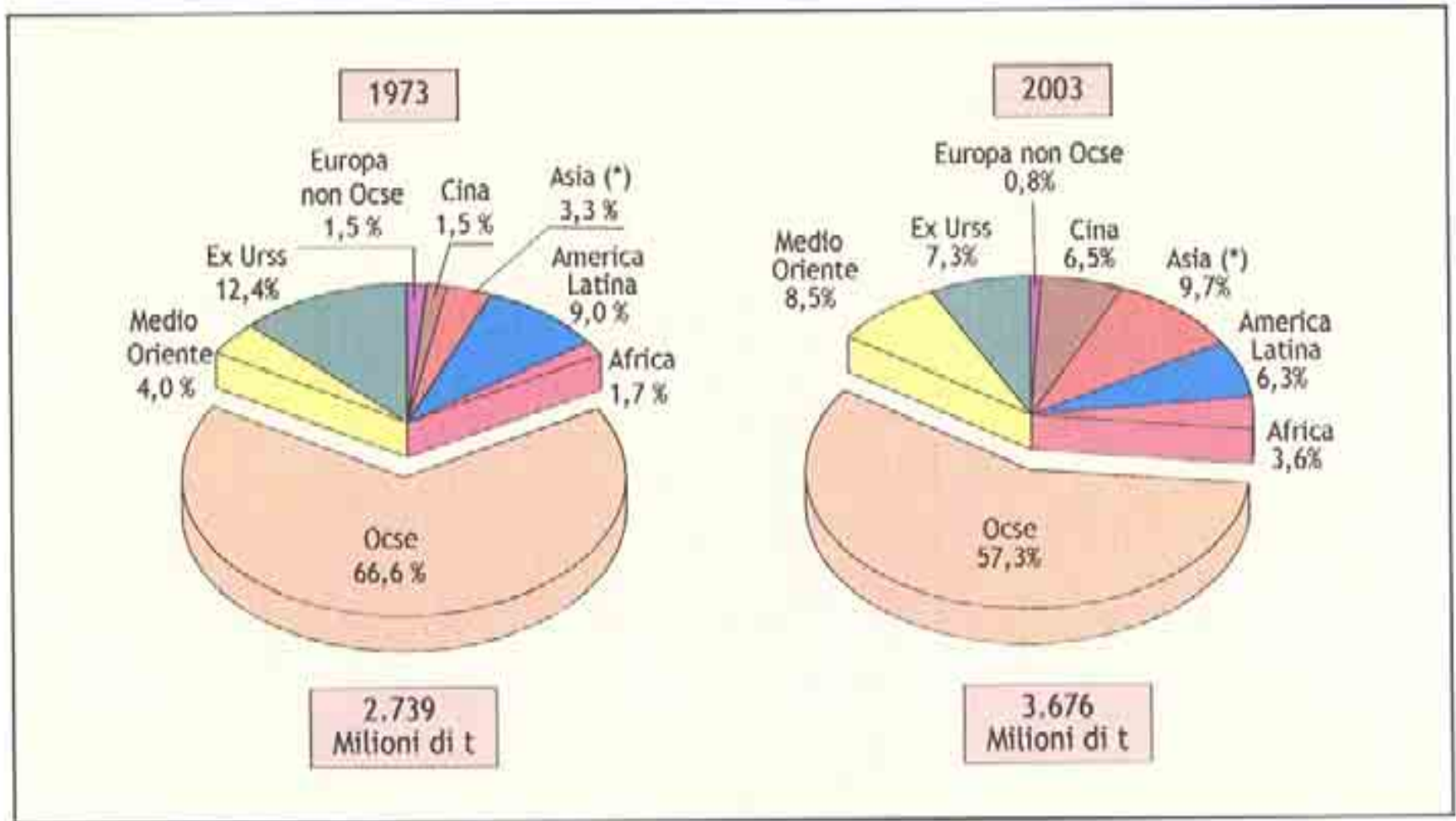
	1980	1990	2001	2004	% di variaz. nell'2004
USA :	18.520	15.880	16.894	17.247	20,2
Canada :	2.155	1.928	1.923	1.954	2,3
Totale Nord America :	20.675	17.808	18.817	18.996	22,5
Argentina :	506	590	611	611	0,7
Brazil :	1.392	1.440	1.540	1.940	2,3
Mexico :	1.207	1.595	1.463	1.463	1,7
Amiche Grandi :	760	310	625	565	0,7
Venezuela :	1.445	1.324	1.199	1.199	1,4
Altri :	2.058	2.370	2.240	2.254	2,7
Totale Centro e Sud America :	8.531	7.629	8.078	8.052	9,5
Belgio :	1.066	796	805	803	0,9
Francia :	2.326	1.699	1.667	1.977	2,3
Germania :	3.422	2.024	2.304	2.314	2,7
Italia :	4.142	2.416	2.296	2.294	2,7
Olanda :	1.822	1.201	1.237	1.243	1,5
Regno Unito :	2.614	1.850	1.813	1.812	2,1
Svezia :	1.392	1.245	1.333	1.356	1,6
Altri :	4.865	5.424	5.033	5.002	5,9
Totale Europa :	22.101	16.591	16.766	16.804	19,9
Ex Unis :	11.370	12.310	8.190	8.390	9,9
Arabia Saudita :	645	1.750	1.911	2.061	2,4
Rai :	1.300	777	1.584	1.634	1,9
Irak :	298	594	644	644	9,8
Kuwait :	581	540	905	905	1,1
Altri :	873	1.292	1.500	1.875	2,2
Totale Medio Oriente :	3.717	4.953	6.942	7.109	6,4
Africa :	2.118	2.722	3.113	3.211	3,9
Cina :	1.805	2.892	3.487	3.818	6,9
Corea del Sud :	508	748	2.598	2.598	2,1
Giappone :	5.643	4.324	4.645	4.531	5,4
India :	557	1.122	2.355	2.513	3,0
Indonesia :	302	867	1.026	1.056	1,2
Singapore :	1.069	1.060	1.255	1.255	1,5
Altri :	1.473	1.586	3.137	3.139	3,0
Oceania :	734	750	875	680	1,0
Totale Asia e Oceania :	12.443	11.631	21.576	21.935	25,9
TOTALE MONDO :	81.667	75.206	82.940	84.592	100,0

Fonte: BP Statistical Review



## 8. Statistical data

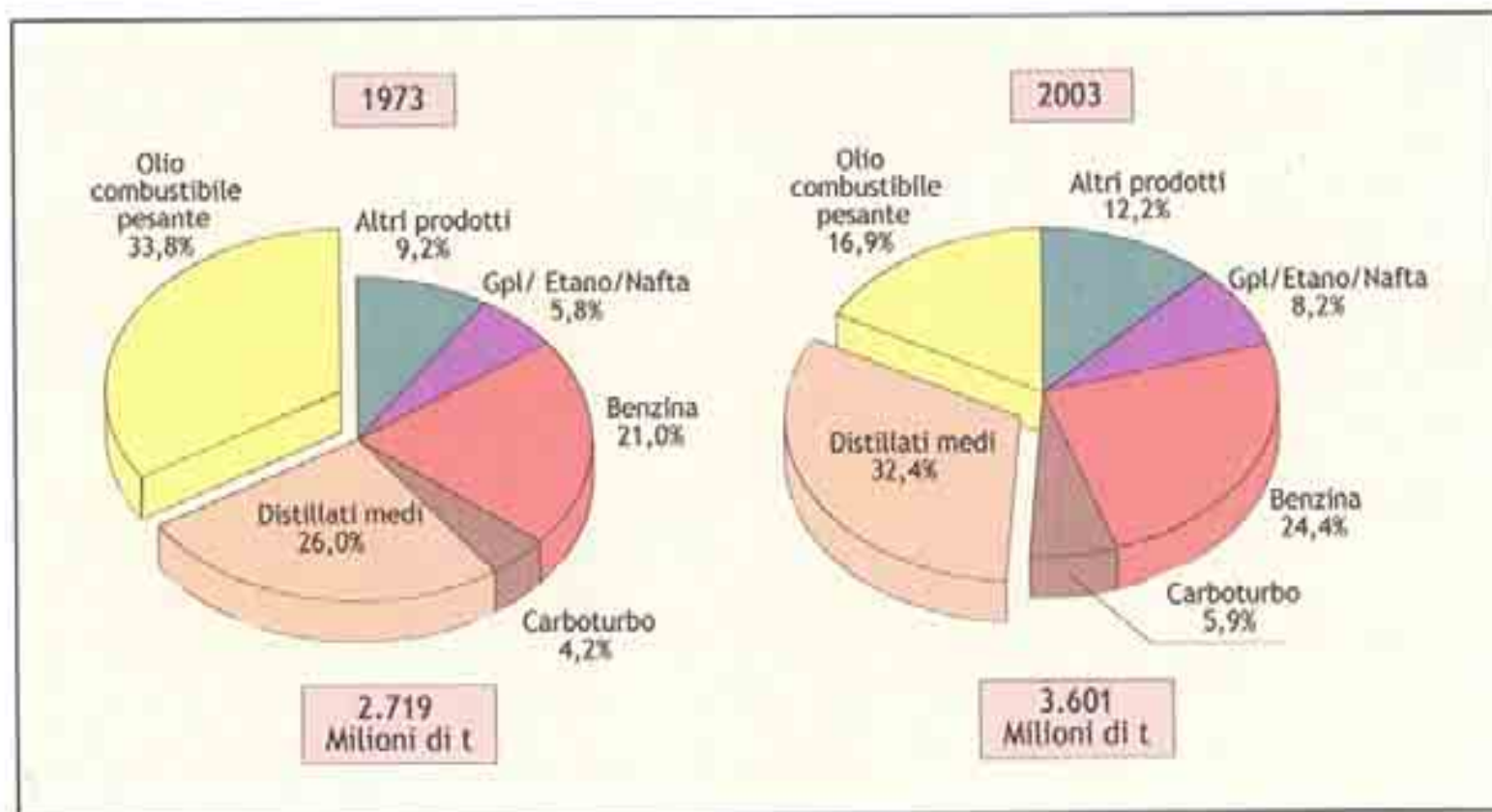
### Oil refineries processing (% for areas)



\* Excluded China

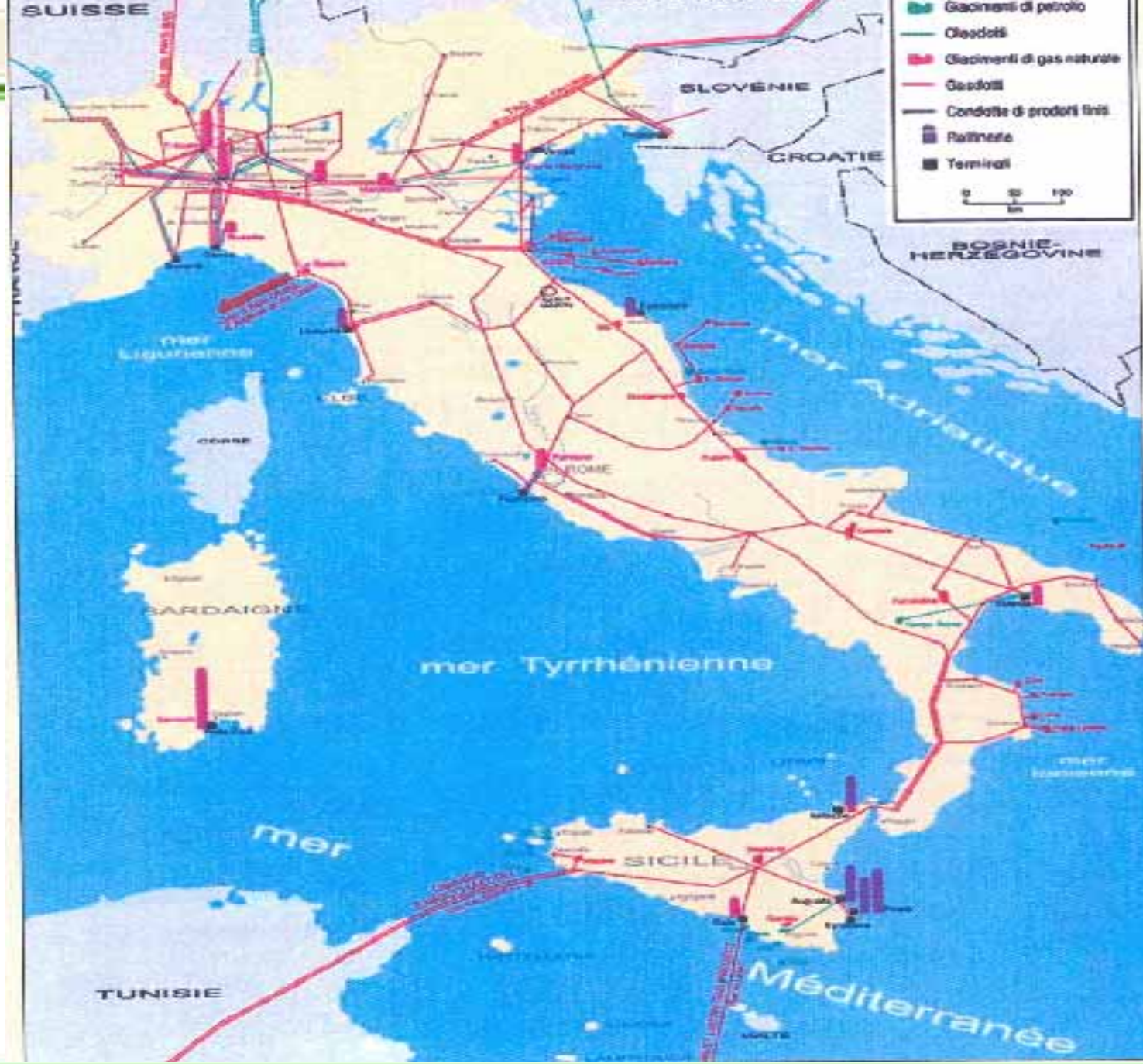
## 8. Statistical data






### Oil refineries production (% for kind of product)



Fonte: AIE

Rafineries,  
terminal and  
pipelines in Italy



-  Gasdotti e pipeline
-  Giardini
-  Condotta di prodotti fini
-  Raffineria
-  Terminal



Rafinerias,  
terminal  
and  
pipelines in  
Europe

## 8. Statistical data

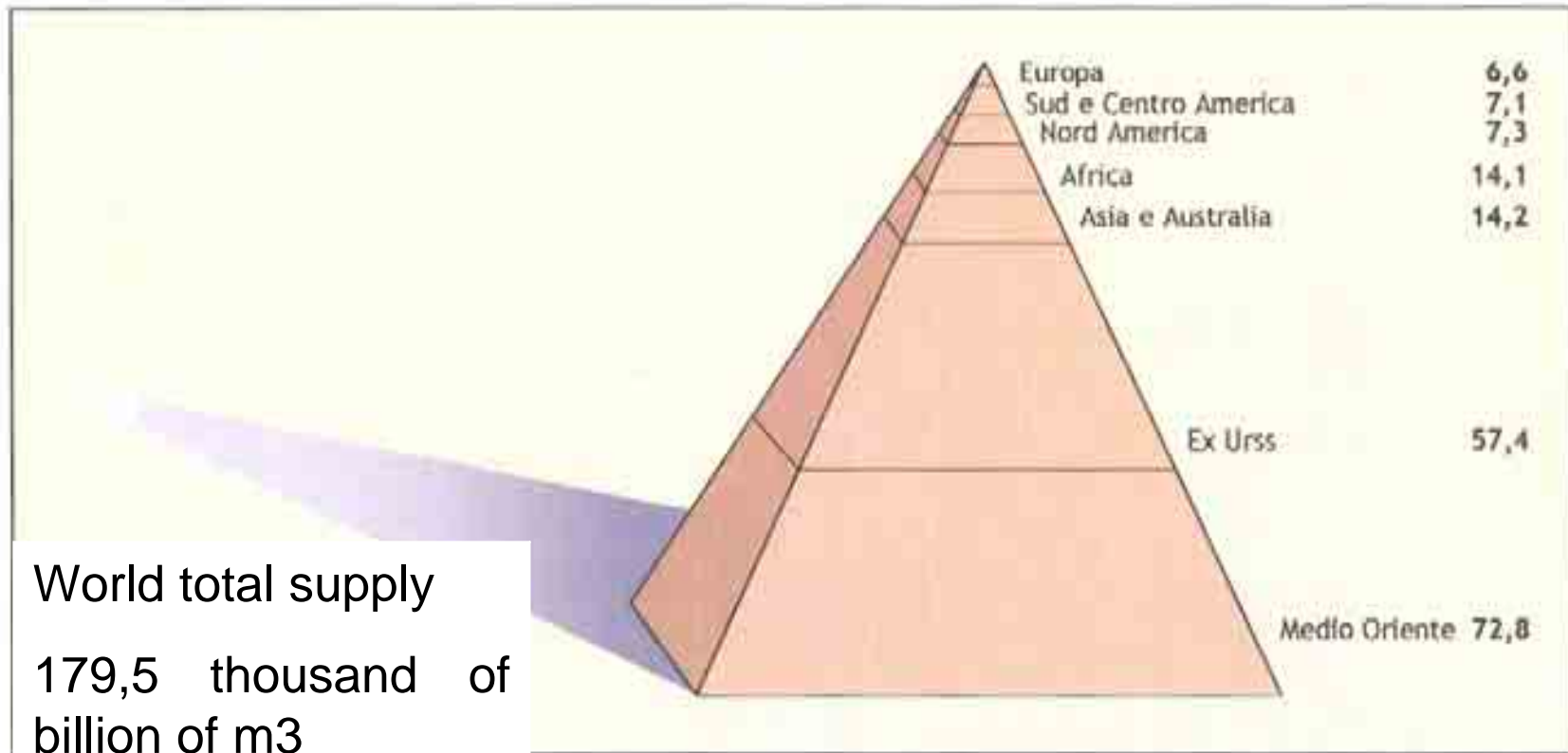
### NATURAL GAS: International trade of natural gas divided for exported geographical areas (2003)

	Production on market	IMP	EXP	Consumption
Nord America	721,5	121,8	117,1	726,2
America Latina	156,0	20,7	23,3	153,4
Europa	319,0	348,0	142,0	525,0
Ex Urss	773,4	135,2	272,2	636,4
Africa	144,6	2,3	73,8	73,1
Medio Oriente	260,1	14,1	48,0	226,2
Asia/Oceania	311,2	119,4	85,1	345,5
<b>TOTALE MONDO</b>	<b>2.685,8</b>	<b>761,5</b>	<b>761,5</b>	<b>2.685,8</b>

Unit of measurement: billion of m3

## 8. Statistical data

### NATURAL GAS SUPPLY (2004)



Fonte: BP Statistical Review

## 8. Statistical data

### NATURAL GAS:

#### Production and consumption divided for geographical areas (2003)

	Production				Consumptions			
	1995	2000	2003	2004	1995	2000	2003	2004
Nord America	624	660	659	653	647	677	664	662
Sud e Centro America	90	120	136	149	91	119	137	149
Europa	219	257	271	279	344	415	450	467
Ex Urss	594	607	651	667	492	497	517	531
Medio Oriente	134	186	234	252	128	167	203	218
Africa	75	114	127	131	40	50	60	62
Asia e Australia	191	246	277	291	196	270	312	331
<b>TOTALE</b>	<b>1.927</b>	<b>2.190</b>	<b>2.355</b>	<b>2.422</b>	<b>1.938</b>	<b>2.195</b>	<b>2.343</b>	<b>2.420</b>

Fonte: BP Statistical Review

Unit of measurement: tep