

The Relation Between Gasoline Quality, Octane Number and the Environment

Rafat Assi

National Project Manager

Jordan's Second National Communications on
Climate Change (www.snc.gov.jo)

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Content of Presentation

- Octane number (ON) concept
- The need for ON enhancement
- Impact of gasoline on the environment
- Elements to be considered in Vehicular pollution control

What is Gasoline?

- Motor gasoline is a complex mixture of light hydrocarbons containing 5-12 carbon atoms,
- Produced in oil refineries,
- Used in internal combustion engines,
- Straight run gasoline from crude distillation does not meet the required specs for modern engines but form part of the blend
- Refinery streams used in the blend: catalytic reformat, FCC gasoline, isomerase, alkylate, oxygenates, etc.

What is Gasoline?

- Gasoline is comprised of over 200 chemicals. Many of these are hazardous substances regulated in USA, such as:
 - benzene (up to 5%),
 - Toluene (up to 20%),
 - naphthalene (up to 2%),
 - trimethylbenzene (up to 5%) and others
- Names: Gasoline shortened “Gas” (North America), Petrol (Commonwealth Countries), Benzin or some variants of the word, Germany, Denmark, European countries, **in Jordan: Benzin**

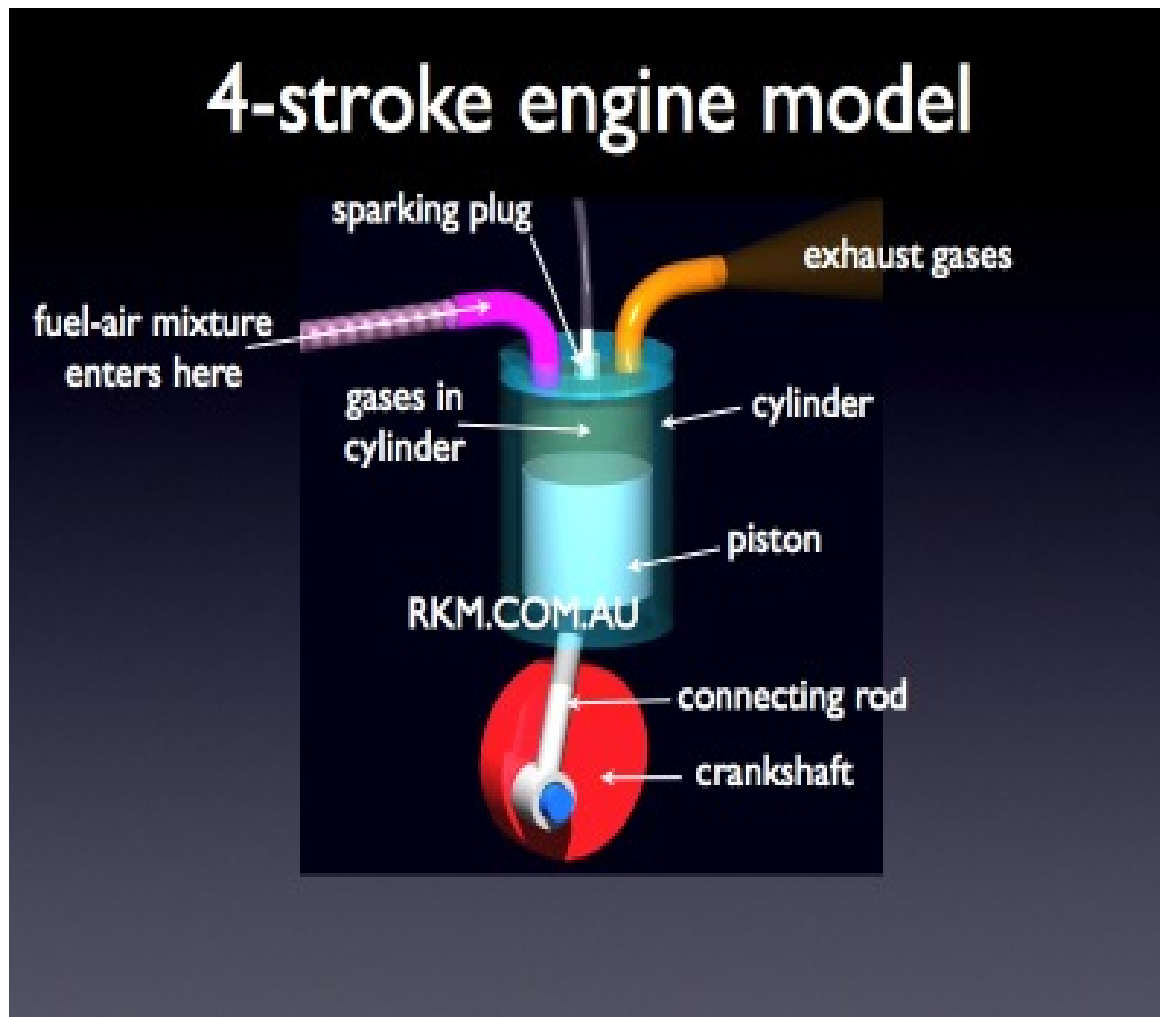
What is the Octane Number?

- A measure of how the gasoline engines run smoothly
- A measure of how resistant the gasoline is to abnormal combustion phenomenon called knocking or detonation
- How it is measured?
n-heptane has an octane number of 0, while **iso-octane** (2,2,4-trimethyl pentane) is 100. Linear combinations of these two components are used to measure the octane number of a particular fuel. A 90%/10% blend of iso-octane/n-heptane has an octane value of 90. Any fuel knocking at the same compression ratio as this mixture is said to have an octane number of 90.

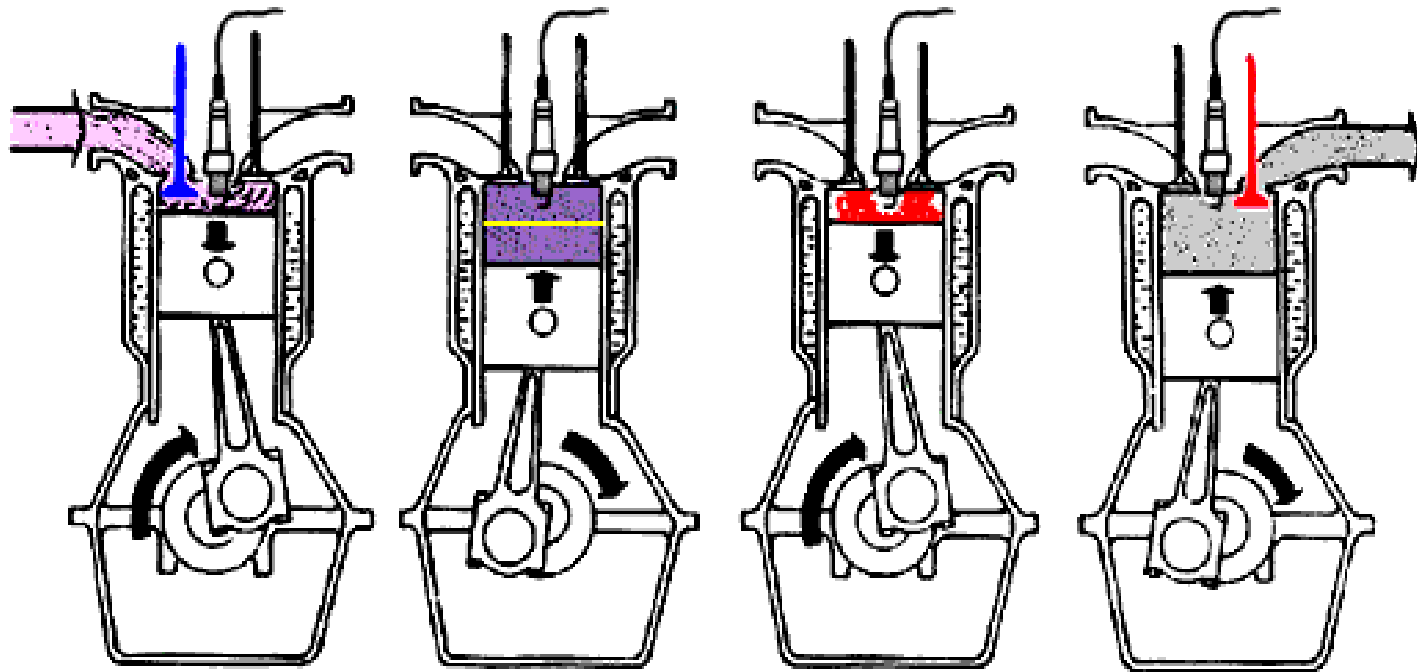
MON Versus RON

- Research Octane Number (RON): mild conditions (inlet temp and RPM), indicative of normal road performance.
- Motor Octane Number (MON): severe conditions (inlet temp and RPM), indicative of high speed performance.
- The spread between the two numbers (MON&RON) is known as the fuel sensitivity.
- Pump Octane Number (PON) or Anti Knock Index (AKI): An arithmetic average of RON and MON.
- RON is lower than MON
- Gasoline ON in Jordan refers to RON

4-Stroke Internal Combustion Engine



The 4-Stroke



a) induction

□ fuel & air mix

b) compression

■ TDC - set tappets here

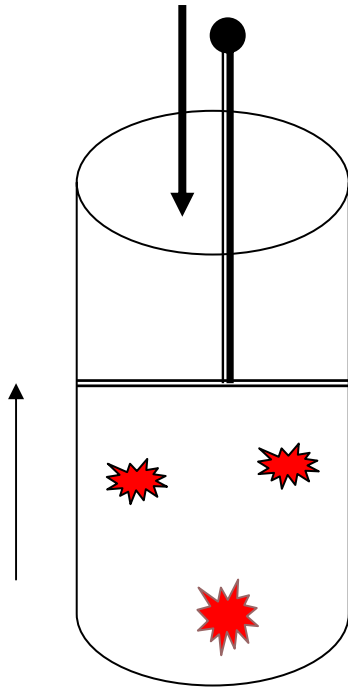
c) power

■ fuel burns and forces piston down

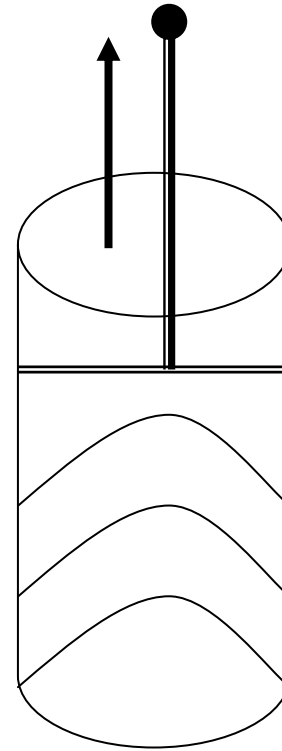
d) exhaust

□ exhaust exits as piston travels back up

Knocking Versus Smooth Falme



Knocking



Smooth Flame

Knocking

- During the **compression stroke**, the engine compresses the air/gas mixture into a much smaller volume before igniting it with a spark plug. The amount of compression is called the compression ratio of the engine
- If the mixture is spontaneously ignites, knocking happens, it pushes against the crank shaft instead of being with it.
- Knocking results in:
 - Erosion of the combustion chamber
 - Inefficient operation, waste power
 - Higher amount of unburnt hydrocarbon in the exhaust leading to **air pollution**

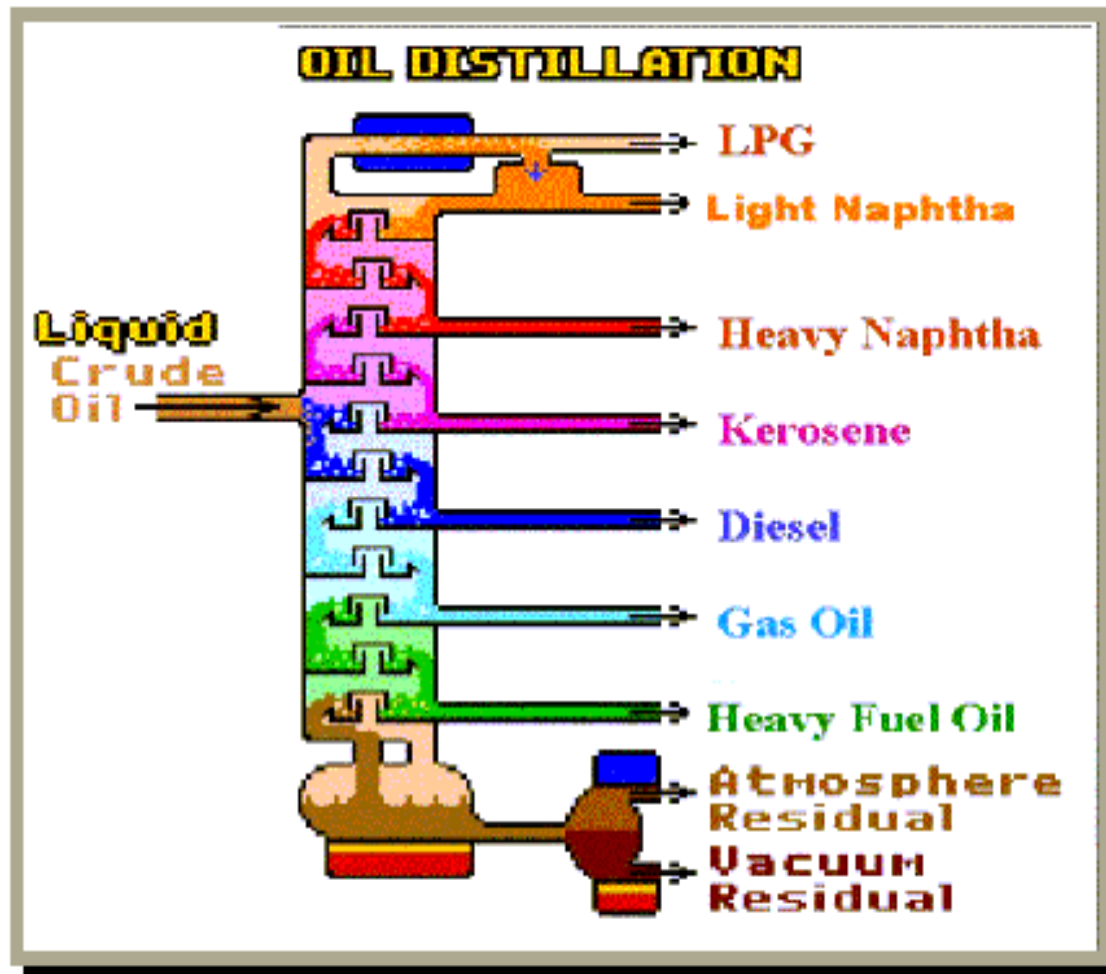
High Versus Low ON

- Higher performance engine has a higher compression ratio and requires higher octane gasoline.
- The design of the engine (its compression ratio) determines the octane number of the gasoline that should be used.
- Using a gasoline of octane which is higher than the required, does not clean the engine or improve the engine performance and reduce pollution, but only costs more.

The Need for ON Enhancement

- The RON of the fractions of atmospheric distillation:
 - 60-70 for light naphtha
 - 40-60 for medium and heavy naphtha
- Cannot be used directly as the RON requirements for gasoline engines are 90 to 98
- Different refinery products are used for gasoline blending
- Additives are also used (TEL, MTBE,..)

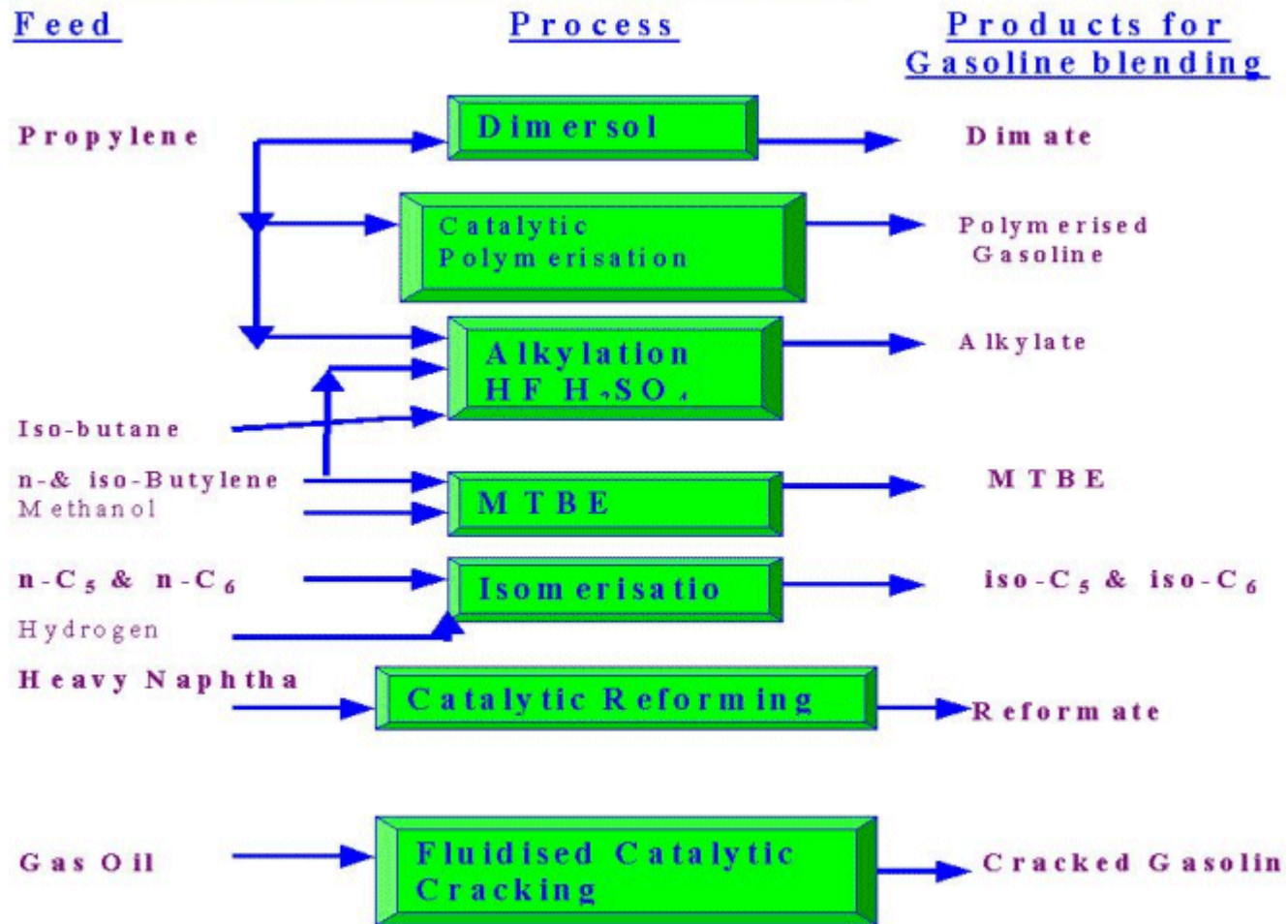
Crude Oil Distillation



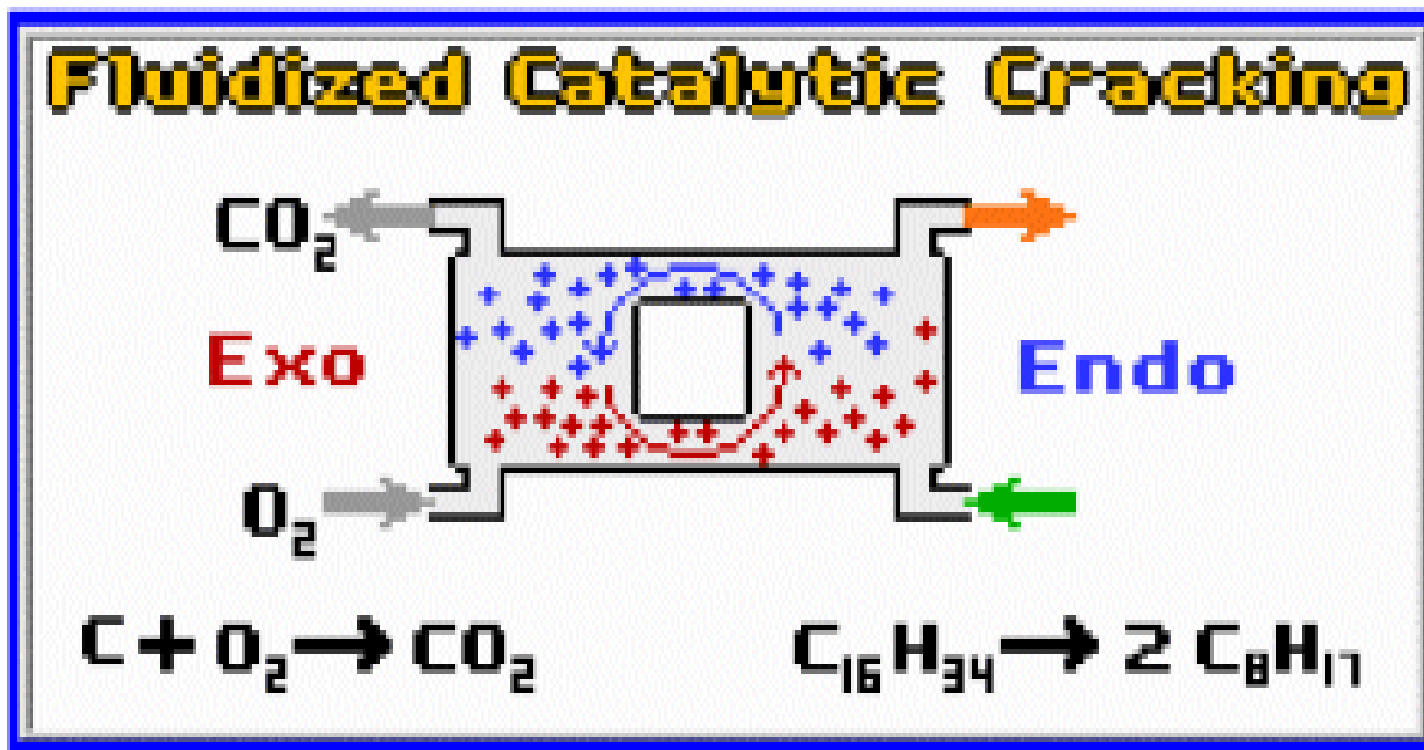
Components for Gasoline Blending

- **Catalytic Naphtha Reforming:** Saturated, low octane hydrocarbons converted into higher octane product containing about 60% aromatics.
- **Fluidized Catalytic Cracking (FCC):** Breaks larger hydrocarbons into a product containing 30% aromatics and 20-30 olefins
- **Isomerisation:** Straight chain HCs converted into branched isomers
- **Alkylation:** gaseous olefins streams reacted with isobutane to produce liquid high octane iso-alkanes
- The first two are most commonly used to produce gas blending high octane components

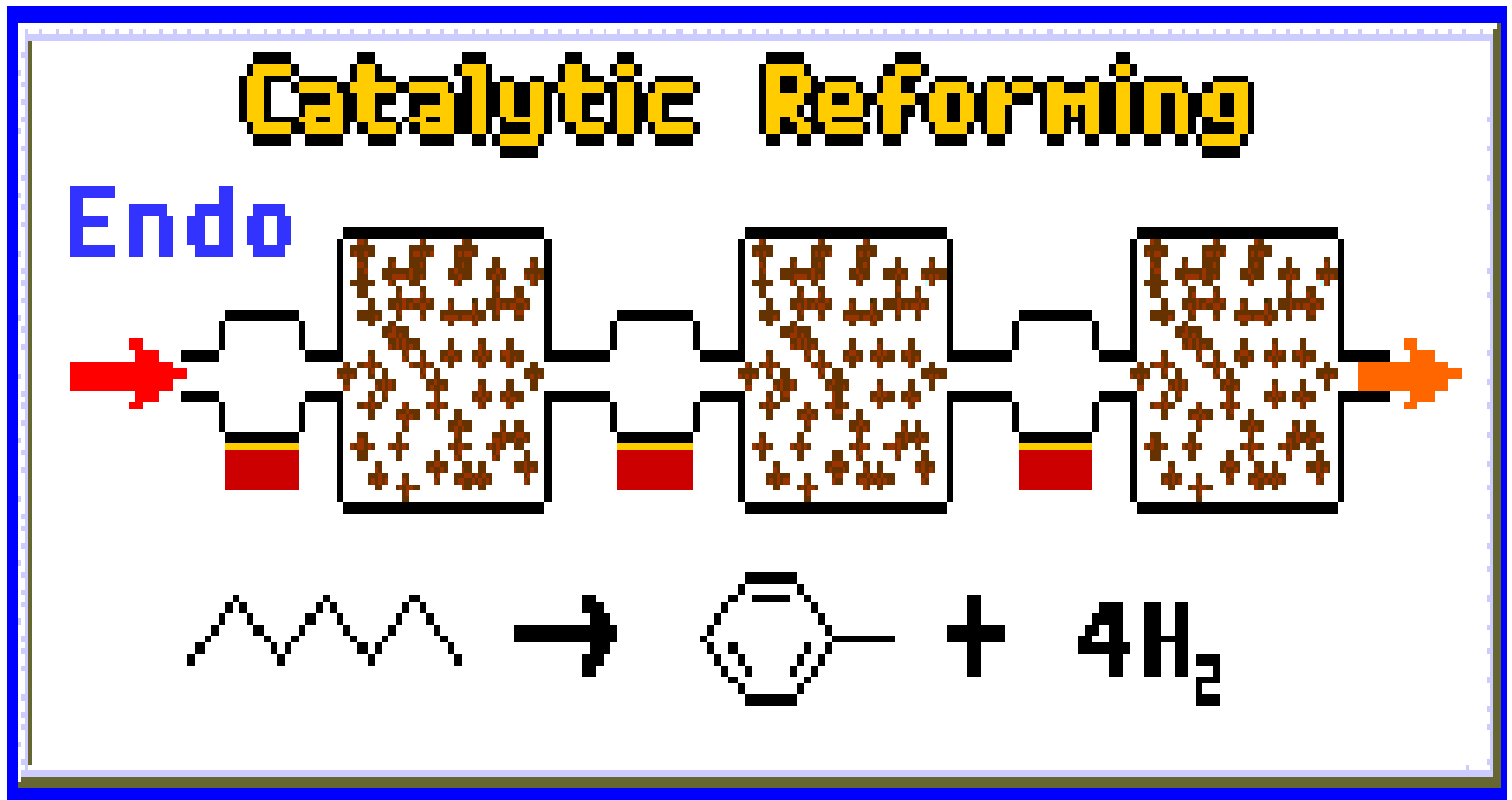
Products for Gasoline Blending



Fluidized Catalytic Cracking (FCC)



Catalytic Reforming



Impact of Gasoline on the Environment 1

Gasoline property	Desirable for engine	Impact on environment
Octane Number	Avoid engine knocking; increase fuel-air mix compression ratio, engine power & efficiency.	Octane enhancing compounds are generally not environ friendly : Lead additives are toxic air pollutants & poison catalytic converter catalysts. Benzene is carcinogenic. Aromatics produce more smoke & smog. Olefins form engine fouling gums, more smoke & smog

Impact of Gasoline on the Environment 2

Gasoline property	Desirable for engine	Impact on environment
Volatility	Sufficient light components to give adequate vaporization of fuel air mix for easy engine cold start.	<ul style="list-style-type: none">● Too many light components result in hydrocarbon loss & result in atmospheric pollution.● Too many heavy components contribute to chamber deposits & spark plug fouling causing release of unburnt hydrocarbons into the atmosphere.

Impact of Gasoline on the Environment 3

Gasoline property	Desirable for engine	Impact on environment
Sulphur Content	Not desirable at all	<ul style="list-style-type: none">● Sulfur compounds are corrosive, foul smelling, and increase sulfur dioxide & trioxide emissions.● Decrease catalytic converter efficiency.● Adversely affect ignition timing, leading to lower engine efficiency

Impact of Gasoline on the Environment 4

Gasoline property	Desirable for engine	Impact on environment
Olefins	Desirable for their octane value	<ul style="list-style-type: none">● Leads to deposits and gum formation and increased emissions of ozone forming hydrocarbons and toxic compounds.

Impact of Gasoline on the Environment 5

Gasoline property	Desirable for engine	Impact on environment
Aromatics	Desirable for their octane value	<ul style="list-style-type: none">● Increased engine deposits and tailpipe emissions including carbon dioxide.● Produces carcinogenic benzene in exhaust.

Impact of Gasoline on the Environment 6

Gasoline property	Desirable for engine	Impact on environment
Stability additives	Reduce valve deposits.	<ul style="list-style-type: none">● Affect carburetors resulting in higher H/C and CO emissions.

Considerations in Vehicular Pollution Control

- Quality of fuel and the vehicle should be considered together:
 - Quality of fuel: options are available, weigh benefits against risks.
 - Vehicle: introduce catalytic converters to fully benefit from lead phase out, qualified maintenance shops.

Considerations in Vehicular Pollution Control

- Environmental/traffic management issues
 - Raise public awareness
 - Vehicle emissions standards/ enforcement: high incompliance rate for the current limits (CO:5%, HC: 600 ppm), better to go from less to more stringent limits.
 - Improve monitoring of AQ and Vehicle emissions and improve enforcement of standards and regulations
 - Traffic managements: bridges and tunnels, parking, light railway, public transport, etc.

