CH2356 Energy Engineering

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Energy Saving Measures in Petrochemical Industries

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Petrochemical Industry

- **The most important building blocks of the petrochemical industry** are olefins (ethylene, propylene, butylenes and butadiene) and aromatics (benzene, toluene, xylenes) produced from hydrocarbon feedstocks such as ethane, naphtha, gas oil or aromatic mixtures from catalytic reforming in refineries.

Petrochemical Production Processes

- Involves the following steps:
  - Supply and preparation of the raw materials.
  - Synthesis of the crude product from the raw materials via one or more chemical reactions (pyrolysis, alkylation, hydrogenation, etc.)
  - Separation and refinement of the desired product from the crude product stream (e.g. distillation, filtration and evaporation)
  - Storage, packaging and shipment of the product
  - Abatement of emissions and waste streams

Chemical Reactions

According to U.S.-EPA (1993), between 30 and 35 types of chemical reactions are used to produce 176 high-volume chemicals.

Table 3.1 Chemical reaction types.

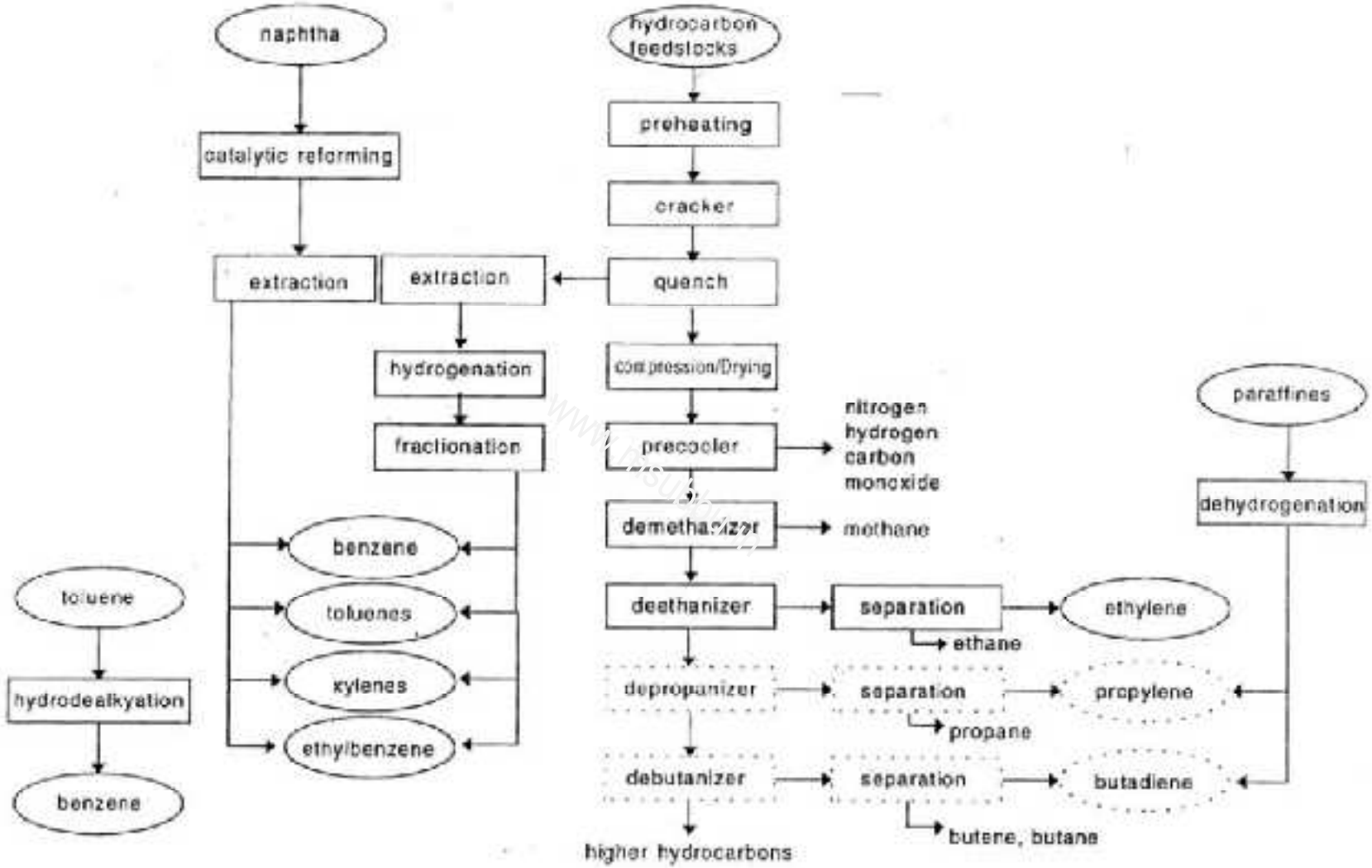
Reaction type	Number of chemicals [1]	Reaction type	Number of chemicals[1]
1 Pyrolysis	7	16 Oxidation	4
2 Alkylation	13	17 Hydrodealkylation	2
3 Hydrogenation	13	18 Isomerization	3
4 Dehydration	5	19 Oxyacetylation	1
5 Hydroformylation	6	20 Oligomerization	7
6 Halogenation	23	21 Nitration	3
7 Hydrolysis/Hydration	8	22 Hydrohalogenation	2
8 Dehydrogenation	4	23 Reduction	1
9 Esterification	12	24 Sulfonation	4
10 Dehydrohalogenation	1	25 Hydrocyanation	2
11 Ammonolysis	7	26 Neutralization	2
12 Reforming	4	27 Hydrodimerization	1
13 Oxyhalogenation	1	28 Miscellaneous	6
14 Condensation	12	29 Nonreactor processes[2]	26
15 Cleavage	2		

Source: U.S. EPA (1993), based on a source from the early 1980s.

[1] Ranking by amount of production for each chemical reaction type.

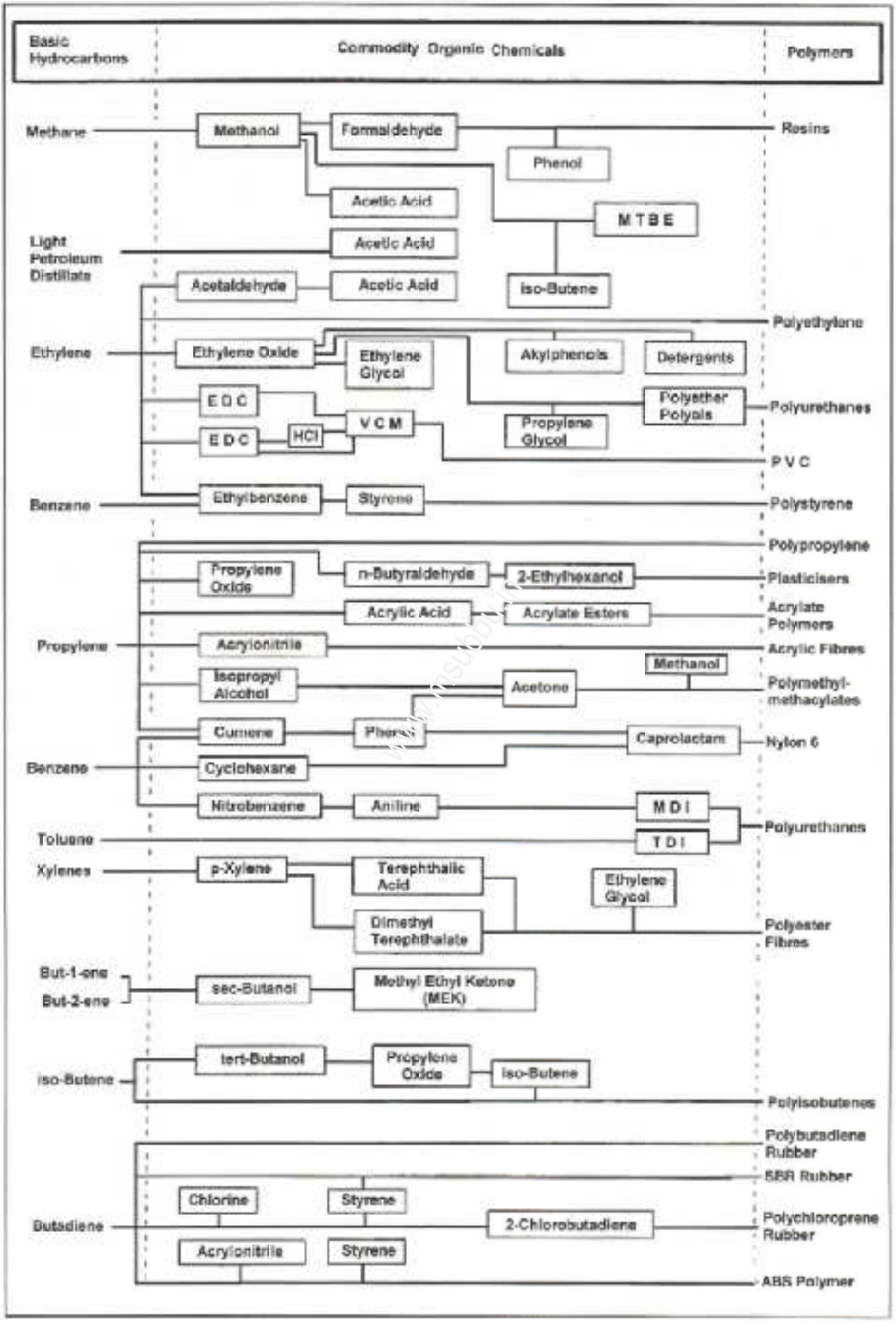
[2] Produced by air oxidation, distillation, or other non-reactor processes not covered in the U.S. EPA study.

Figure 3.2 Process blocks for the production of petrochemical building blocks.



Source: Phylipsen et al. (1998)

Figure 3.1 Pathways from basic hydrocarbons to polymers.



Source: EC-IPPC (2003)

Energy Consumption

- **Energy consumption of chemical industries**: Including feedstock, the chemical industry consumed 6,465 TBtu or 28% of all energy consumed by the manufacturing industry in the United States in 2002 (U.S. DOE, 2005c).

- **Petrochemical Industries** - the large volume organic chemical industry consumed approximately 70% of the total energy used in the chemical industry in US (2002).

Energy Saving Measures in Petrochemical Industries

Table 5.2 Summary of process specific measures included in this Energy Guide.

Process Specific Measures (Chapter 16)	
Process	**Measures**
Ethylene	More selective furnace coils
	Improved transfer line exchangers
	Secondary transfer line exchangers
	Increased efficiency cracking furnaces
	Pre-coupled gas turbine to cracker furnace
	Higher gasoline fractionator bottom temperature
	Improved heat recovery quench water
	Reduced pressure drop in compressor inter-stages
	Additional expander on de-methanizer
	Additional re-boilers (cold recuperation)
	Extended heat exchanger surface
	Optimization steam and power balance
	Improved compressors

Aromatics	Improved product recovery systems
Polymers	Low pressure steam recovery
	Gear pump to replace extruder
	Online compounding extrusion
	Re-use solvents, oils and catalysts
Ethylene Oxide / Ethylene Glycol	Increased selectivity catalyst
	Optimal design EO/EG-sections
	Multi-effect evaporators (Glycol)
	Recovery and sales of by-product CO_2
	Process integration
Ethylene Dichloride / Vinyl Chloride Monomer	Optimize recycle loops
	Gas-phase direct chlorination of ethylene
	Catalytic cracking EDC
Styrene	Condensate recovery and process integration
Tolnene diisocyanate	Recover exothermic heat
	Recuperative incinerators

Energy Efficient Measures in General

Steam Systems: (Chapter 7)	
Steam Supply	
Boiler feed water preparation	Flue gas heat recovery
Boiler process control	Blow down steam recovery
Reduction of flue gas quantities	Reduce standby losses
Reduction of excess air	Combined Heat and Power (CHP)
Improved boiler insulation	High temperature CHP
Boiler maintenance	Steam expansion turbines
Steam Distribution Systems and Steam End Use	
Improved distribution system insulation	Leak repair
Insulation maintenance	Flash steam recovery
Steam trap improvement	Return condensate
Steam trap maintenance	Improve efficiency at steam end use
Steam trap monitoring	
Furnaces / Process Heaters (Chapter 8)	
Control air-to-fuel ratio	Improve control
Improve heat transfer	Maintenance
Improve heat containment	Switch electric heaters to fuelled heaters
Heating, Cooling and Process Integration (Chapter 9)	
Reduce fouling in heat transfer equipment	Process integration
Regular checks of cooling water systems	Pinch analysis
Heat recovery	Total site pinch analysis

Electric Motors Systems (Chapters 10-13)	
Motor Systems	
Properly sized motors	Reduce voltage imbalance
High efficiency motors	Adjustable-speed drives
Improve power factor	Variable voltage controls
Pumps	
Pump system maintenance	Avoiding throttling valves
Pump system monitoring	Replacement of belt drives
Pump demand reduction	Proper pipe sizing
Controls	Adjustable-speed drives
High-efficiency pumps	Precision castings, surface coatings or polishing
Properly sized pumps	Improve sealings
Multiple pumps for variable loads	Curtailing leakage through clearance reduction
Impeller trimming	Use dry vacuum pumps
Fans and blowers	
Properly sized fans	Improved controls
Adjustable speed drives	High efficiency belts
Compressors and compressed air systems	
System improvements (pressure reduction)	Controls
Maintenance	Properly sized regulators
Monitoring	Properly size piping
Leak reduction	Heat recovery
Reducing the inlet air temperature	Adjustable speed drives
Maximize allowable pressure dew point	High efficiency motors
Improved load management	

Distillation (Chapter 14)	
Optimization of reflux ratio	Feed conditioning
Check required product purity	Upgrading column internals
Seasonal operating pressure adjustments	Stripper optimization
Reducing reboiler duty	Insulation
Enhanced distillation control	

Building Energy Efficiency Measures (Chapter 15)	
HVAC Systems	
Energy efficient system design	Fan modification
Recomissioning	Efficient exhaust fans
Energy monitoring and control systems	Use of ventilation fans
Non-production hours set-back temperatures	Cooling water recovery
Duct leakage repair	Solar air heating
Variable-air-volume systems	Building reflection
Adjustable-speed drives	Low-emittance windows
Heat recovery systems	
Lighting	
Turning off lights in unoccupied areas	Replacement of mercury lights
Lighting controls	High-intensity discharge voltage reduction
Exit signs	High-intensity fluorescent lights
Electronic ballasts	Daylighting
Replacement of T-12 tubes with T-8 tubes	