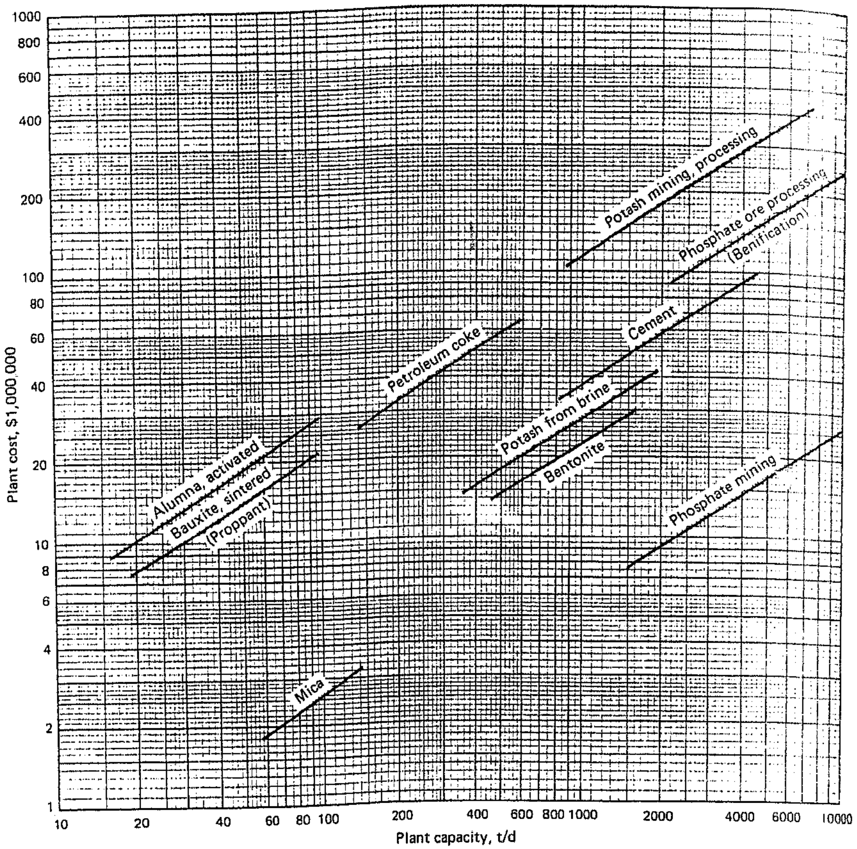
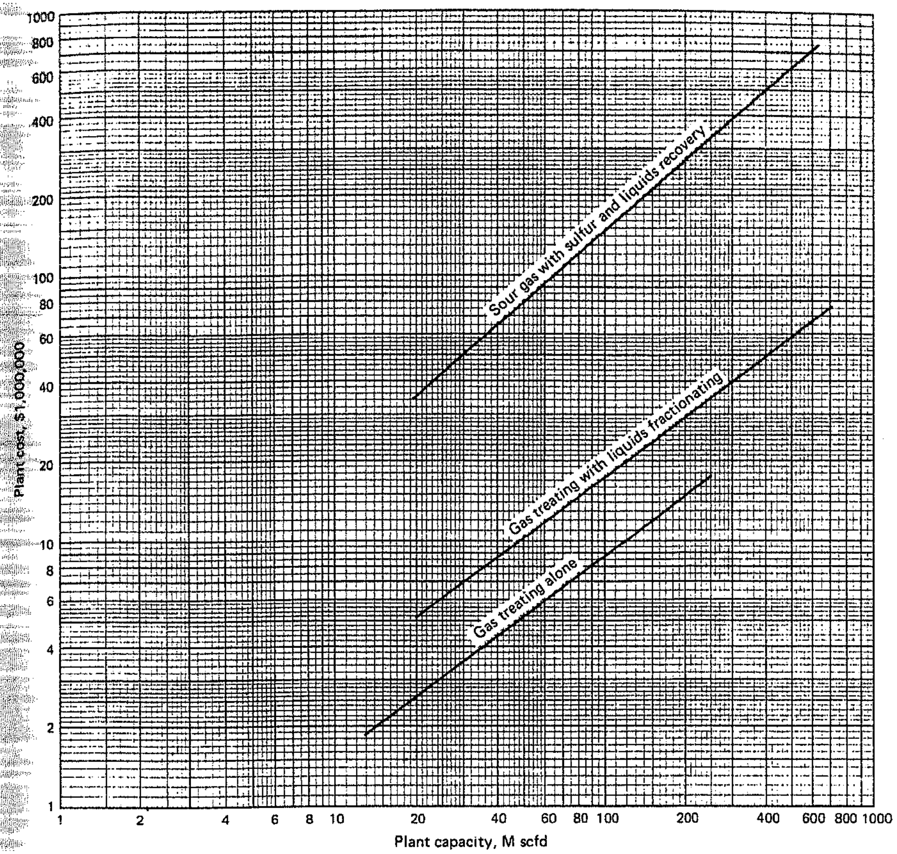
Plant Costs, Minerals



Size exponents:
Assumed to be 0.64

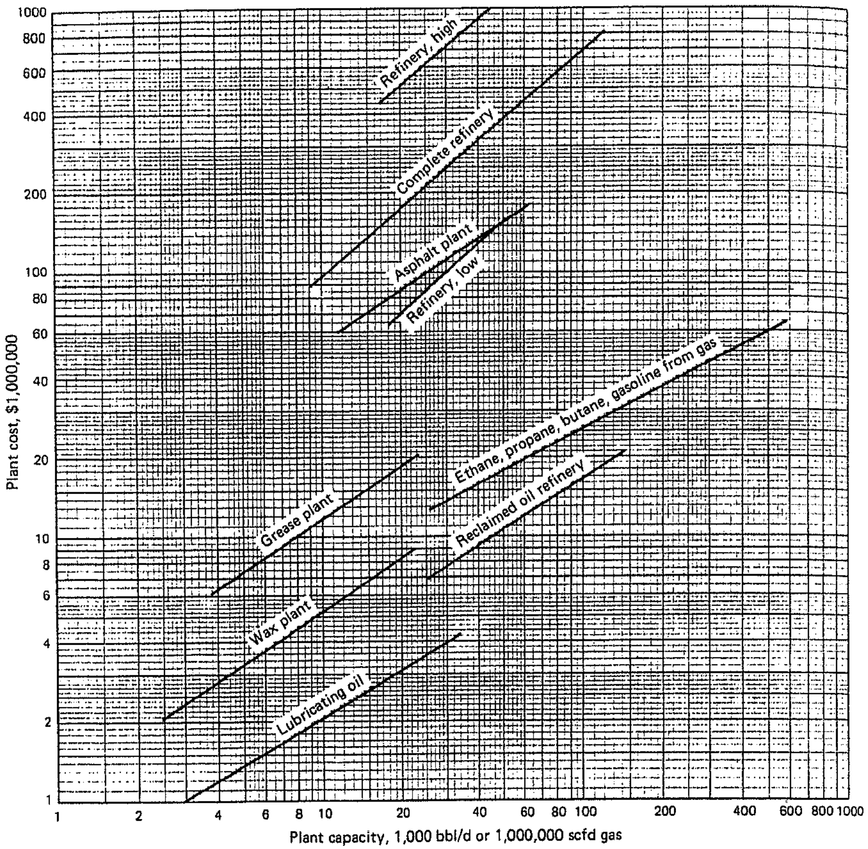
Plant Costs, Natural Gas Purification



Size exponents

Gas treating alone	0.75
Gas treating with liquids fractionation	0.75
Sour gas treating with sulfur recovery and liquids fractionation	0.84

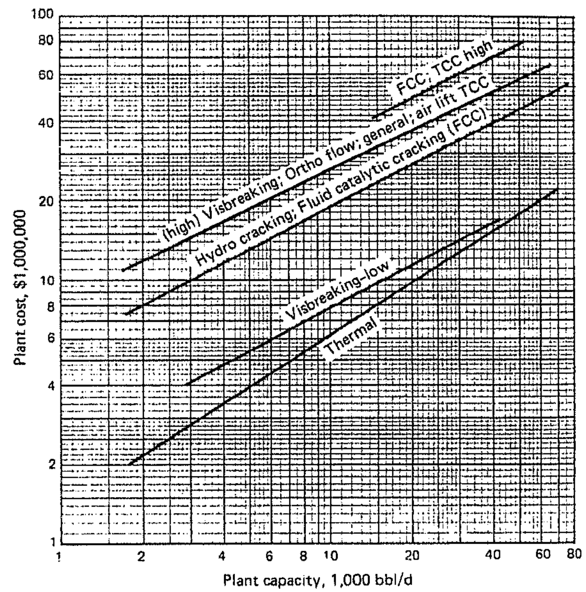
Petroleum Plant Costs, Complete Plants



Size exponent		Raw materials
Complete refinery	0.86	
Gas processing	0.52	Recovery of "light ends"
Wax plant	0.64*	
Lube plant	0.59	
Grease plant	0.64*	
Re-refined oil	0.64*	Reclaimed motor oil

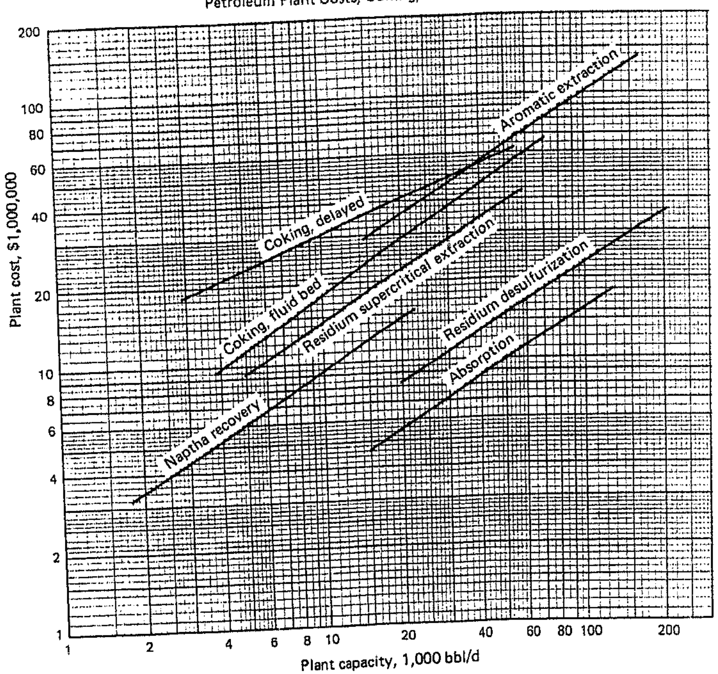
*Assumed

Petroleum Plant Costs, Cracking



Size exponent	
Ortho flow; general; air lift TCC	0.49
Hydro cracking; fluid catalytic cracking (FCC)	0.53
Visbreaking	0.54
Thermal	0.65

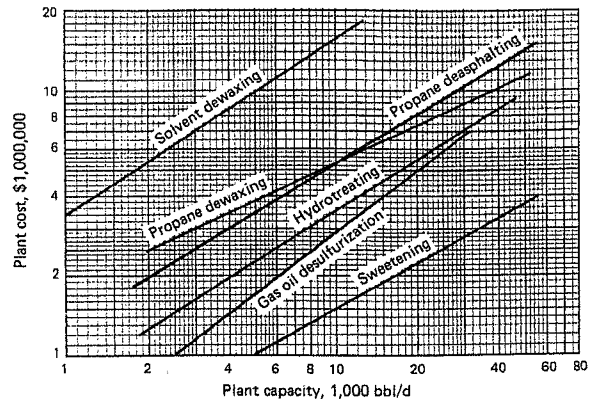
Petroleum Plant Costs, Coking, Extraction, Etc.



Size exponent		Operation
Coking, delayed	0.42	Thermal cracking; coke production
Coking, fluid bed	0.64	Thermal cracking; coke production
Aromatics extraction	0.64*	Liquid extraction of aromatics
Residium supercritical extraction	0.64*	High pressure, temperation extraction
Naptha recovery	0.64*	Distillation, desulfurization, etc.
Residium desulfurization	0.64*	Hydrogenation
Absorption	0.64*	

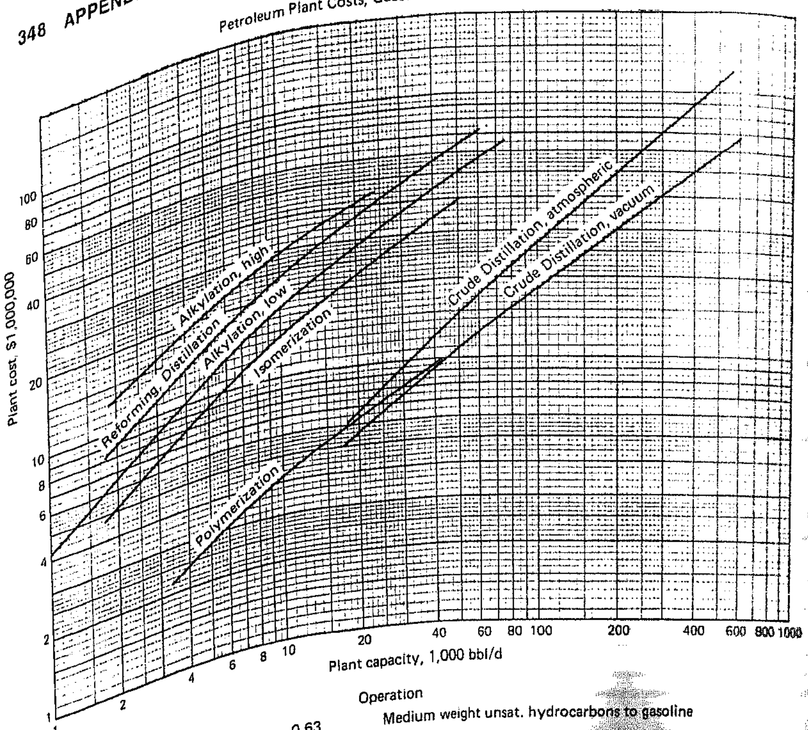
*Assumed

Petroleum Plant Costs, Sulfur Removal; Extraction



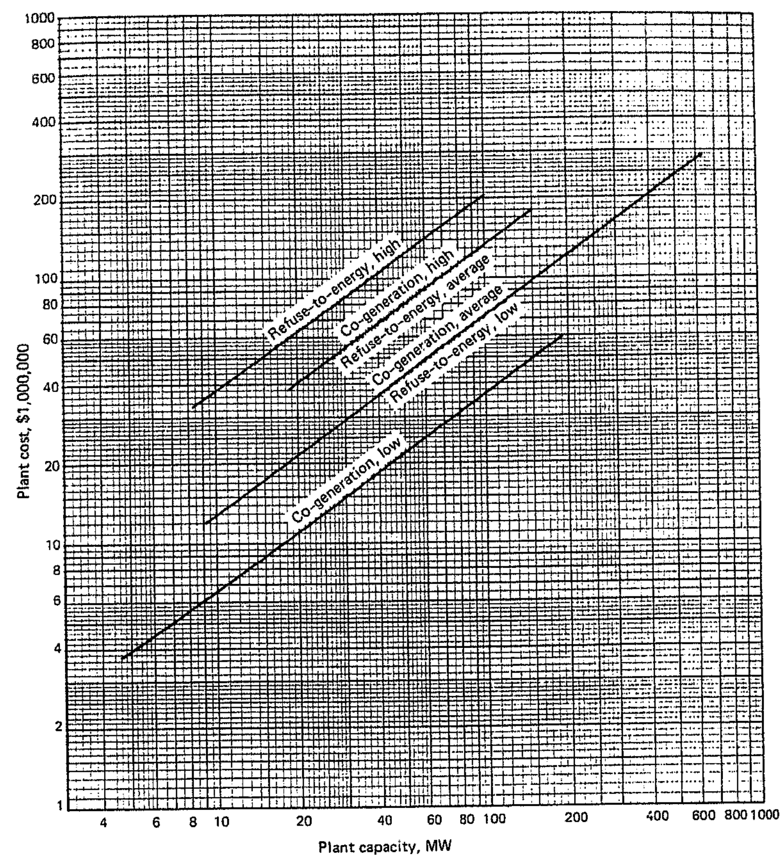
Size exponent		Operation
Desulfurizing		
Hydrotreating	0.64	Hydrogen treating of lube oils, naptha
Sweetening	0.57	Treatment of gasoline to remove mercaptans, sulfides
Gas oil desulfurization	0.78	Hydrogen treatment of gas oils
Extraction		
Propane deasphalting	0.61	Propane liquid extraction of vacuum distilled crudes
Propane dewaxing	0.47	Propane addition, filtration, stripping of diesel, etc. oils
Solvent dewaxing	0.66	Solvent extraction of lube oils

Petroleum Plant Costs, Gasoline Production, Distillation



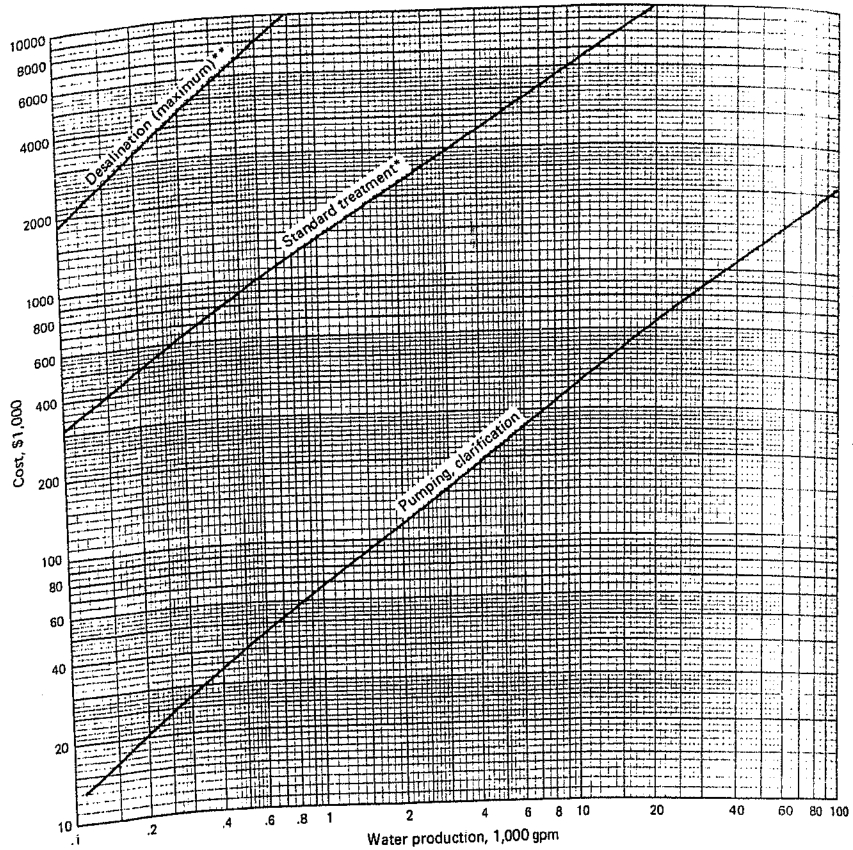
Size exponent		Operation
Alkylation, low	0.63	Medium weight unsat. hydrocarbons to gasoline
Alkylation, high	0.49	
Distillation, vacuum	0.73	Crude oil fractionation
Distillation, atmospheric	0.87	
Isomerization	0.64	Hydrogenation to upgrade pentane, hexane, etc.
Polymerization	0.61	Conversion of olefinic streams into higher octane
Reforming, Distillation	0.63	Dehydrogenation of paraffins, etc. into cycle compounds
		General distillation

Plant Costs, Power from Refuse, Co-generation



Size exponent 0.75

Water (Drinking) Preparation Plants



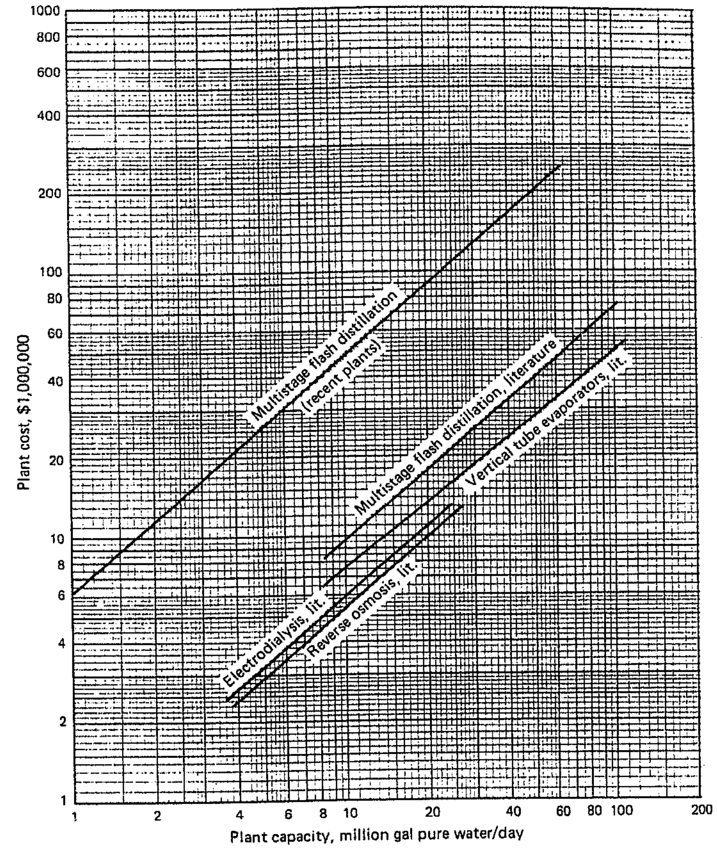
Size exponents

Desalination	0.89
Standard treatment	0.65
Pumping, clarification	0.74

*Standard treatment: floculation, clarification, filtration, chlorination.

**See Desalination graph

Plant Costs, Desalination

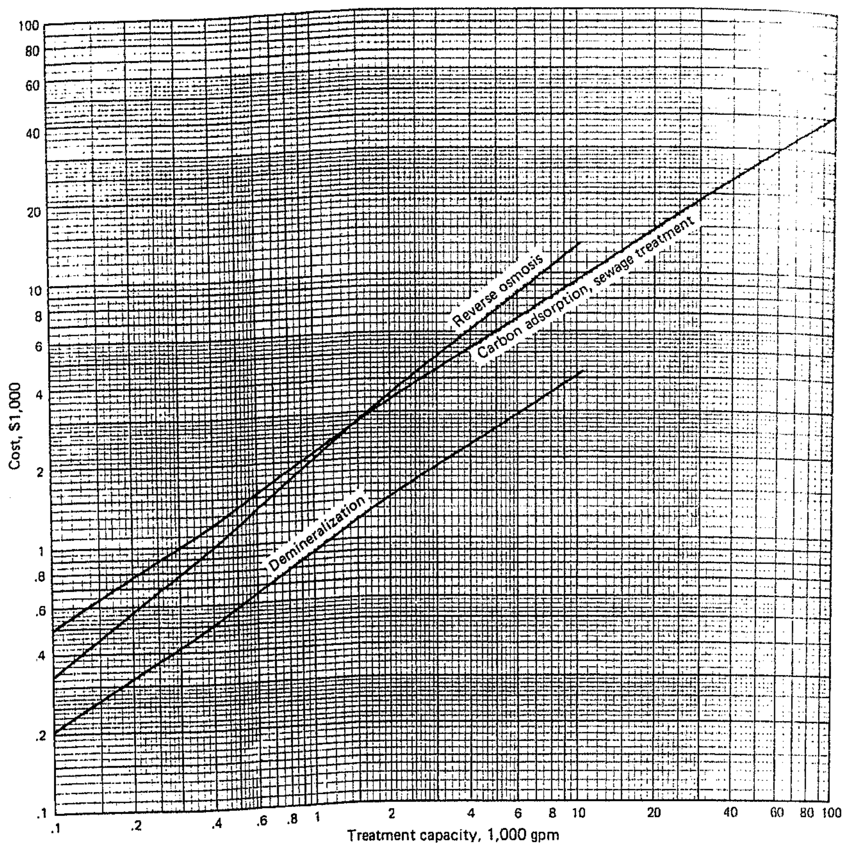


Size exponent

Multistage flash distillation, electrodialysis, reverse osmosis	0.89
Vertical tube evaporators	0.82

Wastewater or Sewage Treatment

Secondary sewage processing: filtration, activated sludge



Size exponent	
Carbon adsorption, sewage treatment	0.64
Reverse osmosis	0.79
Demineralization	0.65

Factors for sewage treatment

Primary: 0.33 (filtration alone)

Tertiary: 2.0 (secondary plus chemical treatment of filtrate)

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Guthrie, Kenneth M. 1974. *Process Plant Estimating, Evaluation, and Control*. Craftsman Book Co., Solana Beach, CA: 125–180, 334–353, 369–371.

Guthrie, Kenneth M. 1970. Capital and operating costs for 54 chemical processes. *Chemical Engineering* (June 15):140–156.

Kharbanda, O. P. 1979. *Process Plant and Equipment Cost Estimation*. Craftsman Book Co., Solana Beach, CA.

Process Economics International. 1979–1980. Vol. 1 (2).

APPENDIX 3

MANUFACTURING COST

DATA PRESENTED

There are far less data in the literature on manufacturing cost than on the other components of cost estimating, primarily because it is a more complex and site, process, or company-specific cost. Some data do exist, however, and they are presented in the following pages. Most of the data are quite old, and difficult to easily update, although an attempt has been made to convert data to early 1987, or CE Index 320 values.

Section 1 presents manufacturing cost versus plant capacity curves of Guthrie (1974), with the percent breakdown into major cost components when available by Kharbanda (1979). The original Guthrie data were probably quite accurate as a first, general approximation, but they are old, and may have suffered badly by attempts to extrapolate them to the present time. The percent breakdown tables were undoubtedly based upon one single plant or process and location, and may be far from typical. Both sets of data at best should only be used for order-of-magnitude or "ballpark" estimates.

Section 2 gives some detailed manufacturing raw material and utility estimates from *Chemical Engineering* (1973/1974), which also probably were quite accurate when published. The processes may have changed considerably since that time, but at least these values should still be useful for conservative first approximations.

Section 3 provides more of the percent breakdowns of Kharbanda (1979), but now with the single plant size operating cost also estimated. In Section 4 Kharbanda has tabulated (or calculated) the raw materials and utilities required for many processes. As noted previously, the accuracy is probably very poor, but in many cases provides initial rough estimates that are better than nothing, and in other cases it is useful to doublecheck the figures quoted by vendors or others.

METHODS OF USE

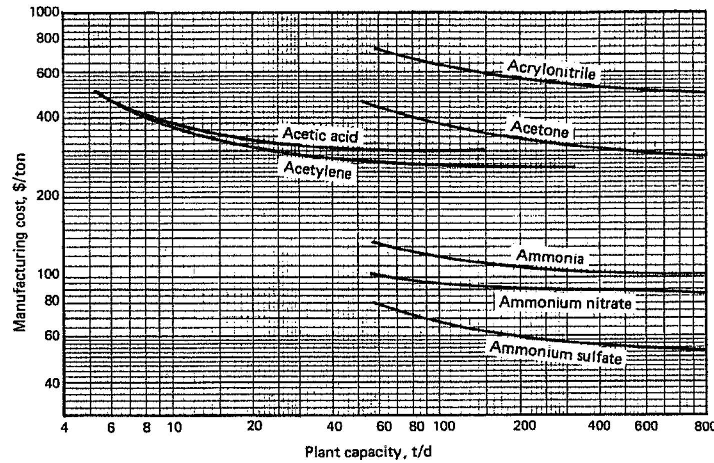
Since each of the four sections of data overlap each other, are from different authors, and present limited lists of chemicals, each must be separately examined to make a manufacturing cost estimate. For example, ammonia is found in three of the four section's figures and tables. In cases such as this the data may not be consistent and you will have to make your best guess as to which to use and not use. This will complicate your study, but often there is some component of the information you know or feel more confident of, and this will aid in your selection. For instance, you may have heard that the average U.S. ammonia plant now uses 32 million Btu of fuel per ton of ammonia, and that the

newest plants consume less than 25 million. This can allow you to somewhat adjust and evaluate the data from the three sections.

In other cases, merely knowing the current competitive selling price can allow you to adjust this data somewhat, assuming that the present manufacturers must make at least some profit on the product. This concept can lead you to further examine various alternative raw materials, processes, and producers, to see where the competitive advantages exist, which may influence and assist in your cost estimates and recommendations.

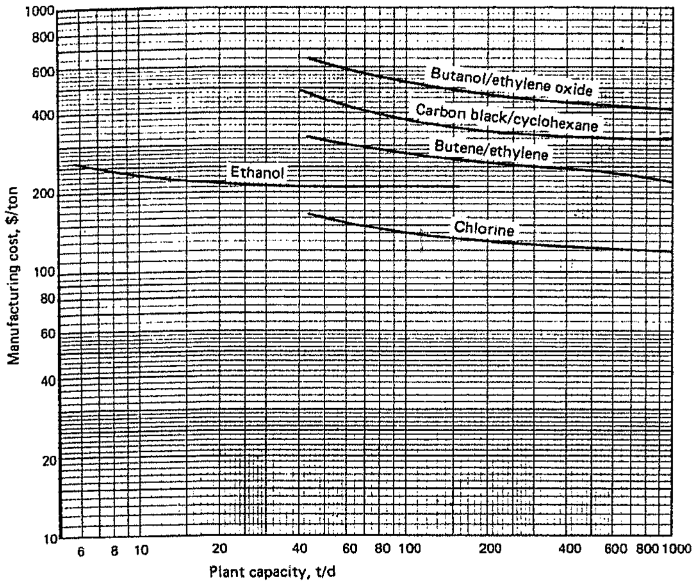
SECTION 1. MANUFACTURING COST VS. PLANT CAPACITY (1); PERCENT COST BREAKDOWN (3)

Manufacturing Cost, A



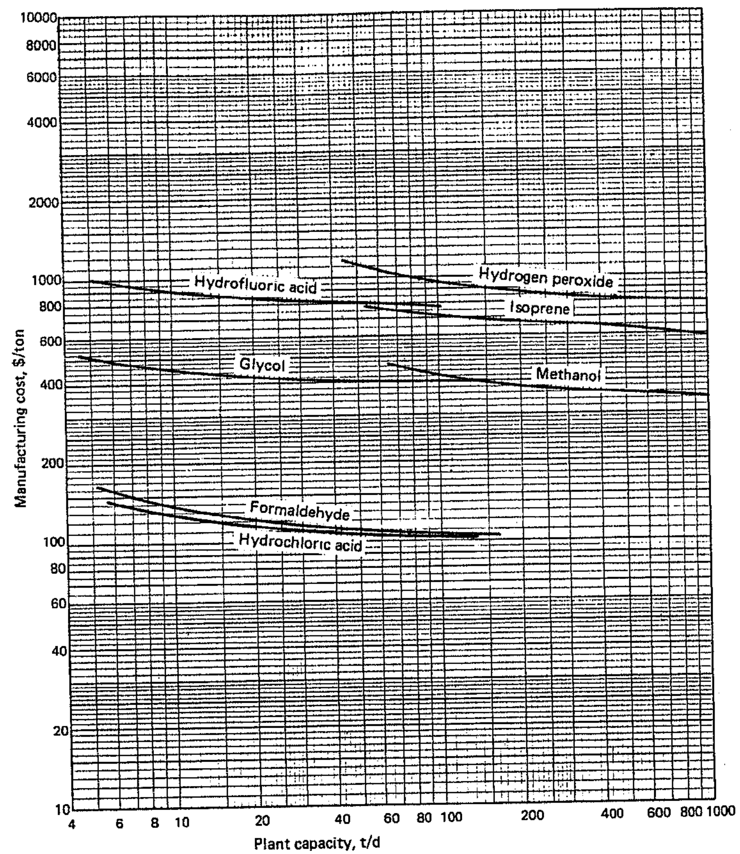
		Manufacturing cost, %			
	Plant capacity, t/d	Raw materials	Depreciation	Utilities, labor	Raw materials
Acrylonitrile	85	37	46	17	Propylene, NH_3
Acetone	70	74	6	20	Isopropanol; vapor
	70	84	6	10	; liquid
Acetic acid	70	51	24	25	Acetaldehyde, ethanol
	140	32	46	22	Methanol
Acetylene	50	15	45	40	Hydrocarbons
Ammonia	1000	36	50	14	Methane @ $1.25/MM btu
Ammonium nitrate	700	77	15	8	Ammonia

Manufacturing Cost, B, C, E



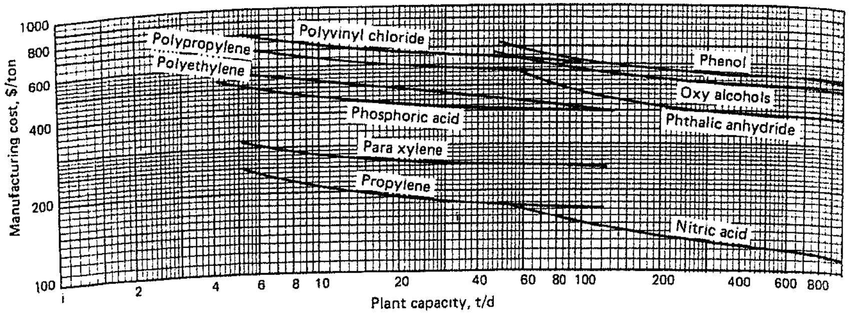
	Manufacturing cost, %				
	Plant capacity, t/d	Raw materials	Depreciation	Utilities, labor	Raw materials (process)
Butanol	70	68	9	23	Ethanol
Ethylene oxide	85	48	33	19	Ethylene, (SD)
	85	68	18	20	Ethylene, (Shell)
Carbon black	110	27	50	23	Oil
Cyclohexane	140	92	5	3	Benzene, H_2
Butene	140	32	54	14	Butane
Ethylene	280	25	45	30	Ethane; naptha
	825	13	44	43	Propane; naptha
Ethanol	280	57	24	19	Ethylene

Manufacturing Cost, F, G, H, I, M



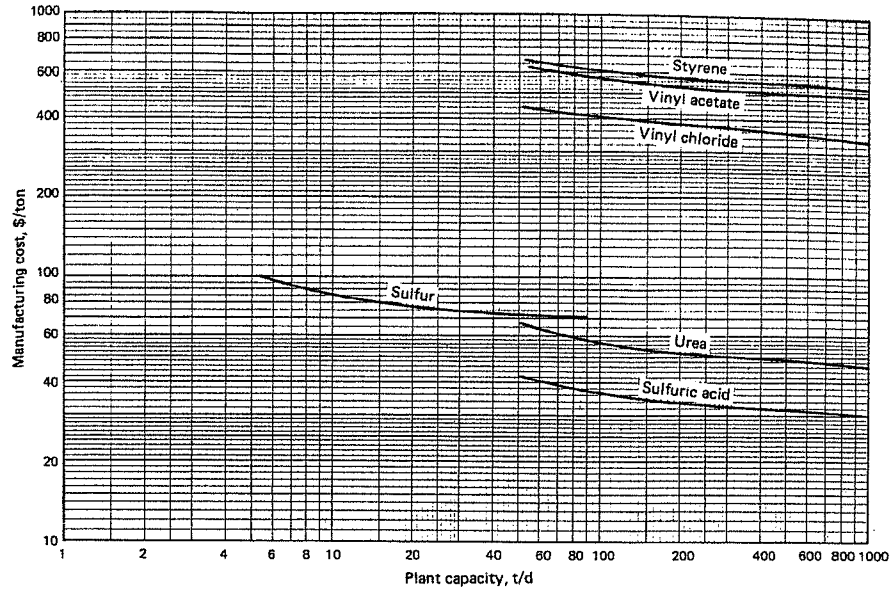
	Manufacturing cost, %				
	Plant capacity, t/d	Raw materials	Depreciation	Utilities, labor	Raw materials
Isoprene	140	42	44	14	Propylene
	140	50	25	25	Methanol
Methanol	200	22	44	34	Methane
Glycol	110	90	4	6	Ethylene oxide
Formaldehyde	140	59	23	18	Methanol

Manufacturing Costs, N, O, P



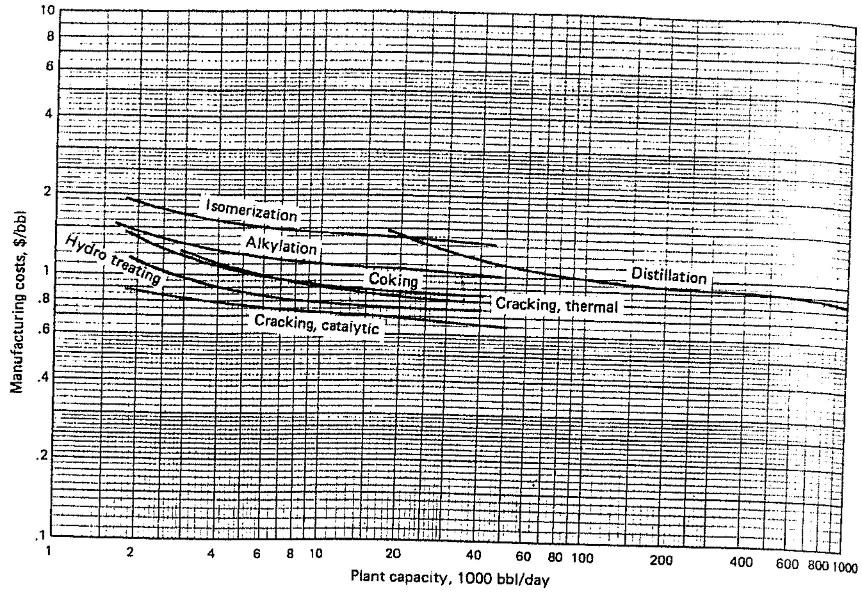
	Plant capacity, t/d	Manufacturing cost, % Raw materials	Depreciation	Utilities, labor	Raw materials (process)
Polyvinyl chloride	70	59	24	17	Vinylchloride; (suspension; emulsion)
Phenol	140	43	35	22	(Modified Raschig)
	140	33	35	32	Cumene
Phthalic anhydride	40	38	50	12	o-xylene
	40	53	41	6	Fluid bed; naphthalene
p-xylene	70	34	50	16	(Fractionation)
Propylene	70	77	13	10	Propane
Nitric acid	300	53	36	11	Ammonia

Manufacturing Costs, S, U, V

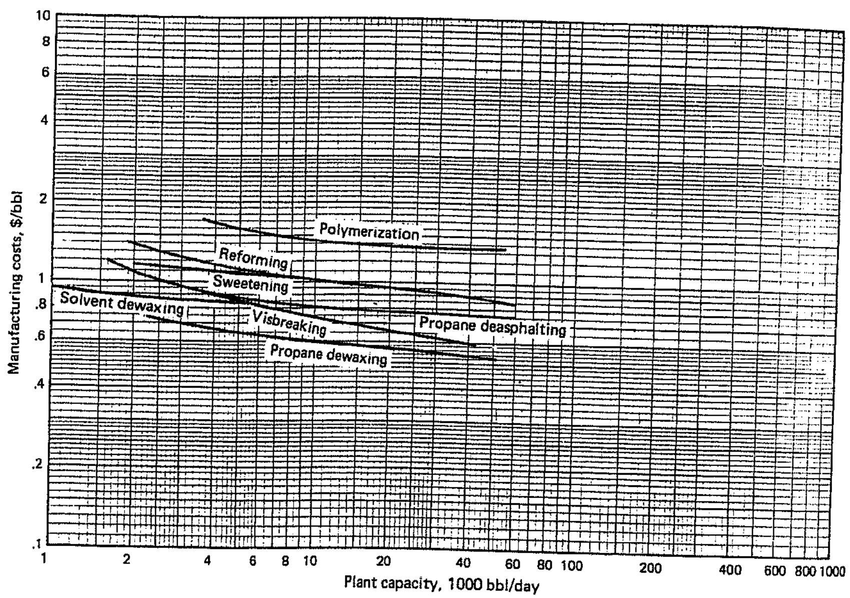


	Plant capacity, t/d	Manufacturing cost, % Raw materials	Depreciation	Utilities, labor	Raw materials
Styrene	140	68	14	18	Ethyl benzene
Sulfur	150	0	59	41	H_2S - rich gas
Urea	300	66	19	15	Ammonia, CO_2
Vinyl acetate	70	70	21	9	Acetic acid, acetylene
Vinyl acetate	70	49	42	9	Ethylene
Vinyl chloride	140	80	10	10	Acetylene, HCl
Vinyl chloride	140	71	15	14	Ethylene, Cl_2

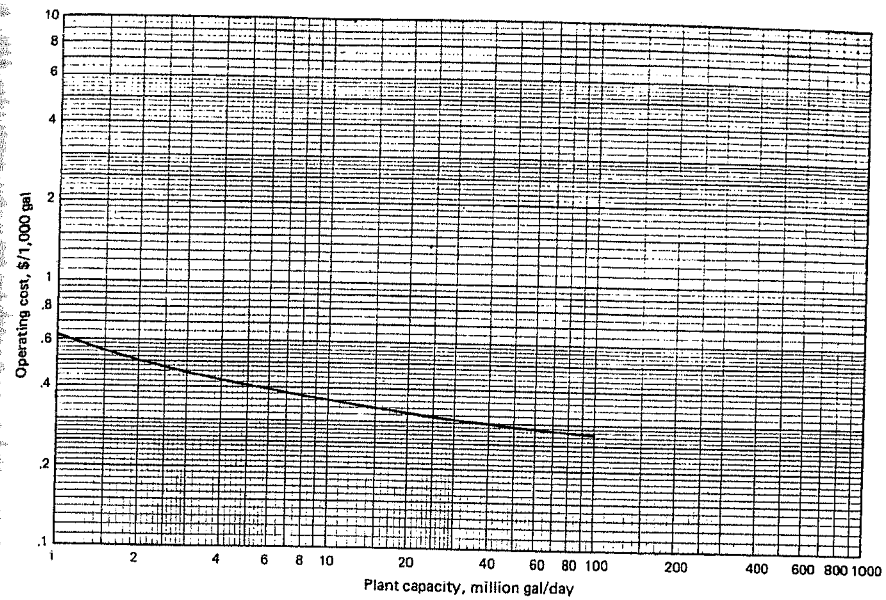
Manufacturing Costs, Petroleum Plants



Manufacturing Costs, Petroleum Plants



Operating Cost, Wastewater Treatment



Curve: Primary, secondary treatment, sludge handling, chlorination

Factors	
Sand filtration	0.27
Activated carbon	0.62
Electrodialysis	1.08

Manufacturing Costs

SECTION 2. DETAILED REQUIREMENTS PER TON OF PRODUCT

1. Acetaldehyde 225 t/d (75,000 t/yr) (*Hydrocarbon Process* 1967)

	One Stage (Oxygen)	*Two Stages (Air)*
Raw materials:		
Ethylene	1,340 lb	1,340 lb
Oxygen (99.5%), scf	9,460	—
Air, scf		54,000
HCl (as 20° Be acid), lb	30	80
Catalyst, $	2.75	2.75
Utilities:		
Electricity, KW hr	45	270
Steam (150 psig), M lb	2.4	2.4