

IHS CHEMICAL

Chlor-Alkali Process Summary

Process Economics Program Review 2016-12

September 2016

ihs.com

PEP Review 2016-12

Chlor-Alkali Process Summary

Ron Smith

Sr. Principal Analyst



PEP Review 2016-12

Chlor-Alkali Process Summary

Ron Smith, Sr. Principal Analyst

Abstract

In this process summary, we review current chlor-alkali production processes and present key features and production economics of four competing processes: (1) mercury cell, (2) diaphragm cell, (3) membrane cell, and (4) membrane cell with oxygen depolarized cathode (ODC), in four major global regions. The process economics include estimated capital costs, variable costs, direct costs, plant cash costs, and full production costs in second quarter 2016 (snapshot economics). We also present carbon footprint and water consumption comparison data for the four competing processes. A brief market overview summarizes the global supply and demand and end-use markets and demand drivers. The status of chlor-alkali process licensors and their offerings are also discussed.

The second quarter 2016 snapshot economics are obtained by using unit price of raw materials, by-products, utilities, labor, and construction cost at the time. To take into account of the fluctuation of prices, this review highlights a new iPEP Spectra™ cost module, developed by the IHS Chemical Process Economics Program (PEP), in which production economics are presented in a time series from 2000 to second quarter 2016, quarterly. The iPEP Spectra™ data module is written in Microsoft Excel pivot tables, which provides a powerful interactive tool to allow our clients maximum flexibility in selecting competing technology and production location and comparing production cost at various levels, such as variable costs, cash costs, or full production costs, as well as margins. The cost module is attached with this process summary on the PEP website. An iPEP Spectra™ historical economics comparison provides a more comprehensive way to compare economics of competing technologies over a long period of time, leading to a more valid investment decision.

Contents

1	Executive summary	4
2	Introduction	5
	Technology	7
	Processes	8
	Process economics comparison	9
	Production costs	10
	Comparison of carbon emissions	10
	Comparison of water consumption	12
	Historical economics comparison—iPEP Spectra™ analysis	13
	Cash costs for production of chlorine by four competing technologies in the US Gulf Coast	13
	Cash costs for production of chlorine by membrane cell technology in four world regions	14
3	Market overview	15
	Chlorine	16
	Caustic soda	18
4	Chlor-alkali production processes	24
	Process chemistry	24
	Commercial processes	25
	Chlorine (caustic soda by-product) by electrolysis of NaCl in mercury cells	26
	Chlorine (caustic soda by-product) by electrolysis of NaCl in diaphragm cells	27
	Chlorine (caustic soda by-product) by electrolysis of NaCl in membrane cells	28
	Chlorine (caustic soda by-product) by electrolysis of NaCl in membrane cells with oxygen depolarized cathodes (ODCs)	30
	Comparison of key features	31
	Cell room	32
	Cooling and drying	32
	Chlorine compression and liquefaction	32
	Storage and loading	32
	Caustic handling, evaporation, storage, and loading	32
	Hydrogen handling	33
5	Process economics	35
	Unit consumptions and variable costs	35
	Capital costs	35
6	Historical economics comparison—An iPEP Spectra™ analysis	38
	Historical prices	38
	Chlorine	38
	Caustic soda (dry basis)	39
	Rock salt	40
	Electricity	41
	Plant cash costs by region	42
7	Detailed process economics	48
8	Cost basis	56
	Capital investment	56
	Production costs	56
	Effect of operating level on production costs	57
	Appendix A—Cited references	58

Tables

Table 1 World top producers of chlorine	22
Table 2 Comparison of three main electrolytic technology capex and opex economic characteristics	33
Table 3 Basic comparison of detailed energy use for conventional chlor-alkali technologies	33
Table 4 Variable costs of chlorine (caustic soda by-product) by electrolysis of NaCl	35
Table 5 Capital costs for worldscale chlorine (and caustic) production processes	36
Table 6 Summary of updated replacement cost economic attributes of four types of worldscale chlorine plants at full capacity	36
Table 7 Mercury cell versus ODC technology economics	37
Table 8 Chlorine (caustic soda by-product) production costs by electrolysis of NaCl in mercury cells	48
Table 9 Chlorine (caustic soda by-product) production costs by electrolysis of NaCl in diaphragm cells	50
Table 10 Chlorine (caustic soda by-product) production costs by electrolysis of NaCl in membrane cells	52
Table 11 Chlorine (caustic soda by-product) production costs by electrolysis of NaCl in ODC cells	54

Figures

Figure 1 Comparison of total fixed capital investments by technology	9
Figure 2 Comparison of production costs by technology	10
Figure 3 Comparison of CO ₂ emissions	12
Figure 4 Comparison of water consumption	13
Figure 5 Historical cash cost comparisons for chlorine production by four competing processes in the US Gulf Coast, \$/ton	14
Figure 6 Historical cash costs for chlorine production by the membrane cell process in four world regions	14
Figure 7 World chlor-alkali demand versus GDP	15
Figure 8 Global chlorine production by feedstock	17
Figure 9 Global current demand for chlorine by end use	17
Figure 10 Historical and future demand for chlorine by world region	18
Figure 11 World caustic soda supply, demand, and industry operating rate	20
Figure 12 2015 global demand for the use of caustic by end use	20
Figure 13 Historical and future demand for caustic by world region	21
Figure 14 Total 2015 chlorine production capacity by world region	21
Figure 15 2015 chlorine plant capacity by region and technology	22
Figure 16 Block flow diagram for the mercury cell process	26
Figure 17 Block flow diagram for the diaphragm cell process	27
Figure 18 Block flow diagram for the membrane process	29
Figure 19 Conventional membrane cell configuration	31
Figure 20 Historical chlorine prices by major world region	38
Figure 21 Annual world nominal chlorine price	39
Figure 22 Historical caustic soda prices by major world region	40
Figure 23 Historical rock salt prices by major world region	40
Figure 24 Historical electricity prices by major world region	42
Figure 25 Historical and projected nominal annual world caustic soda price	42
Figure 26 Historical chlorine plant cash costs for four competing processes, USGC	43
Figure 27 Historical chlorine plant full production costs for all competing processes, USGC	43
Figure 28 Historical chlorine cash cost margin spreads for all competing technologies, USGC	44
Figure 29 Historical chlorine cash cost for four competing processes in China	44
Figure 30 Historical chlorine full production cost for four competing processes in China	45
Figure 31 Historical chlorine plant cash margin spread for all competing processes in China	45
Figure 32 Historical membrane cell cash cost by major world region	46
Figure 33 Comparison of plant cash cost of chlorine produced by Bayer ODC Cell electrolysis in major world regions	46
Figure 34 Membrane cell technology cash cost by major world region	47

IHS Customer Care:

Americas: +1 800 IHS CARE (+1 800 447 2273); CustomerCare@ihs.com
Europe, Middle East, and Africa: +44 (0) 1344 328 300; Customer.Support@ihs.com
Asia and the Pacific Rim: +604 291 3600; SupportAPAC@ihs.com

