A Technical and Socio-Economic Comparison of Options to Products Derived From the Chlor-alkali Industry

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Introduction

This final report forms part of the Canadian government's Chlorinated Substances Action Plan. This Plan was developed in response to a 1992 recommendation from the International Joint Commission, that the United States and Canadian Governments, "in consultation with industry and other affected interests, develop timetables to sunset the use of chlorine and chlorine containing compounds as industrial feedstocks, and that means of reducing or eliminating other uses be examined". The purpose of this report is to provide descriptive background information which describes and assesses the relative economic importance of chlor-alkali industry products, their applications, and alternatives to the use of these products.

Material and Methods

The scope of chlor-alkali products investigated falls into three broad categories:

1. **base commodities** produced by the chlor-alkali industry (e.g., elemental chlorine, caustic soda, hydrochloric acid);
2. **polyvinyl chloride (PVC) resin products** (e.g., pipe, siding, windows, flooring, wire & cable, bottles, film & sheet); and
3. **other chlorinated substances** (e.g., household bleach, chlorinated solvents, refrigerants, flame retardants, etc.).

The study provides a socio-economic examination and direct replacement cost analysis of options in 28 chlorine and derivative applications which account for approximately three-

quarters of the net domestic consumption of chlorine contained in products derived from the chlor-alkali industry. Although the majority of the study focuses on the chlorine tree, a direct replacement cost analysis was also provided for caustic soda since it is a co-product of elemental chlorine production.

The market position and technical characteristics of options are compared for each chlor-alkali product studied in the report. Three principal economic variables are used to characterise and compare chlor-alkali products and options to those products:

1. direct replacement cost;
2. domestic revenues; and
3. manufacturing employment.

These economic variables are placed in context through the use of aggregates pertinent to the total size of the economy. The aggregate measures are, respectively: gross domestic product (GDP), domestic revenues of industries that use chlor-alkali products (end-use revenues) and total manufacturing employment.

The general approach in this study was to define where chlor-alkali derived products are used and identify options to the use of these products, which had a competitive position in the marketplace, either domestically or internationally.[1] The reference year for quantity data used in the analysis is 1993, while calculations of cost and revenue data for products with volatile prices are based on average prices for the period 1988 to 1993. In early 1995, when the study was initiated, 1993 was the latest year for which final economic statistics were available. A comparison of the technical characteristics of products derived from the chlor-alkali industry and options is provided.

The direct replacement cost analysis involves the development of models of substitution for primary producers, manufacturers, municipalities, household consumers or other economic entities which would directly incur the costs of adopting the various options. Only direct capital and operating costs are included in the analysis. Direct replacement costs are calculated from capital costs, annualised at a rate of 9% over 20 years, added to annual incremental operating costs. These total annualized costs are compared to end-use revenues for selected applications of study. End-use revenues refer to the domestic revenues[2] of sectors or industries which use chlor-alkali products. Employment data is also compared.

Information for this study was collected from literature sources, industry participants and associations, and consultants. Environment Canada co-ordinated a stakeholder review process for the report in order to ensure that relevant information and perspective from

[1] In some cases (e.g., water treatment), the identified options include smaller quantities of chlor-alkali industry products. In a few cases, the consultant's best judgment was used in selecting options to chlor-alkali based products which are not currently in the marketplace. These options are found in PVC flexible sheet used in vehicle trim and swimming pool liners, PVC wire & cable, and polychloroprene.

[2] Domestic revenues are defined as the revenues generated by shipments of domestically produced goods. Domestic sales are defined as the domestic consumption of goods. Domestic revenues equal domestic sales plus the trade balance. The trade balance is calculated as the value of exports minus imports.

industry participants, environmental non-government organisations (ENGO) and other stakeholders was incorporated in the study.

Results and Discussion

The total annual direct replacement costs for the chlor-alkali products assessed in this study is $1.9 billion for the low cost estimate and $4.3 billion for the high cost estimate. For selected products where end-use revenues could be identified and quantified, the total low and high direct replacement costs account for 0.7% and 1.7% of end-use revenues respectively. In this analysis of selected products, the total end-use revenues identified are $170 billion, accounting for roughly 24% of GDP in 1993 ($712 billion). In the context of the entire economy, the low and high direct replacement costs represent 0.3% and 0.6% of GDP in 1993, respectively. Table 1 summarises the key results of this study.

Table 1: Overall Summary of Results

	Direct Replacement Cost ($ million/yr)		Domestic Revenues ($ million/yr)		Employment	
	Low	High	Chlor-alkali	Product or Sector Options	Chlor-alkali	Product or Sector Options
Base Commodities	618	1495	485	1675	1305	4356
PVC	553	2171	2072	31138	6908	173931
Other Chlorinated Substances	681	681	133	2057	475	4099
Total	1852	4347	2690	34870	8688	182386

The low estimate for direct annualised replacement costs is dominated by two applications: chlorinated refrigerants and PVC flooring. The identified options are hydrofluorocarbon refrigerants ($481 million) and polyolefin sheet flooring ($336 million), respectively. The high estimate is dominated by costs for four applications: chlorine and chlorine dioxide use in chemical pulp production, PVC siding, chlorinated refrigerants and PVC flooring. The options identified are, respectively: totally chlorine free (TCF) pulp bleaching ($986 million), clay brick facing ($1,253 million), hydrofluorocarbon refrigerants (same as low cost estimate - $481 million), and a combination of ceramic tile and carpet flooring ($426 million).

Overall, the following can be stated:

- the chlor-alkali industry in Canada is small to medium sized;
- there are currently available alternatives to chlor-alkali products, but usually at additional costs;
- the alternatives provide or can provide comparable employment opportunities;

- compared to overall revenues or relevant market size, and normal business cycle fluctuations, the additional costs are often not unduly large, although there are exceptions. This cost significance varies depending on whether the application is an end-use or an intermediate input;

- Direct negative and positive employment effects do not appear large in relative terms and tend to counteract one another;

- As an approximate measure of significance, the direct replacement costs calculated as the high estimate for all applications studied, is less than 1% of GDP in 1993.

Tables 2 through 5 list the direct replacement costs by product and application, and provide some comparison to end-use revenues or total market value.

Table 2: Direct Replacement Costs Compared to End-Use Revenues

(Selected Applications of Base Commodities)

Base Commodity Chlor-Alkali Products and Applications	Direct Replacement Cost (Low) ($ million/yr)	Direct Replacement Cost (High) ($ million/yr)	End-Use Revenues ($ million/yr)	Cost/Revenues (low) (%)	Cost/Revenues (high) (%)
Electrolytic Caustic					
Chemical pulp	70	70	7692	0.9%	0.9%
Newsprint and Mechanical papers	17	17	6006	0.3%	0.3%
Aluminum Smelting and Refining	10	10	5294	0.2%	0.2%
Soaps and Detergents	9	9	1602	0.6%	0.6%
Metal Mining (Gold)	6	6	2093	0.3%	0.3%
Petrochemicals (tar sands)	3	3	2057	0.1%	0.1%
Elemental Chlorine					
Pulp Bleaching	89	966	7692	1.2%	12.6%
Water Treatment	76	76	2297	3.3%	3.3%
Wastewater Treatment	17	17	985	1.7%	1.7%
Titanium Dioxide	61	61	177	34%	34%
Hydrochloric Acid					
Steel Pickling	46	46	10100	0.5%	0.5%
Choline Chloride	199	199	79	252%	252%
Total	604	1481	38382[3]	1.6%	3.9%

[3] Total does not equal the sum, since chemical pulp bleaching appears more than once and is not double-counted.

Table 3: Direct Replacement Costs Compared to Total Market Value

(PVC Products)

Product Markets	Direct Replacement Cost (Low) ($ million/yr)	Direct Replacement Cost (High) ($ million/yr)	Total Market Value ($ million/yr)	Cost/Total Market Value (L) (%)	Cost/Total Market Value (H) %
Water and Sewer Pipe	49	71	1280	4%	6%
Other Pipe	(5)	25	668	(1)%	4%
Siding	80	1253	823	10%	152%
Window Profiles	(118)	55	1200	(10)%	5%
Flooring	338	426	3000	11%	14%
Wire and Cable PVC Compound	181	181	1600	11%	11%
Food Wrap	(9)	(9)	84	(11)%	(11)%
Plastic Bottles	(2)	3	225	(1)%	1%
Thermoformed Packaging	6	6	104	6%	6%
Vehicle Trim	25	60	497	5%	12%
Swimming Pool Liners	8	100	154	5%	65%
Total	553	2171	9635	6%	23%

Table 4: Direct Replacement Costs Compared to End-Use Revenues

(Selected PVC Products)

End-Uses	Direct Replacement Cost (Low) ($ million/yr)	Direct Replacement Cost (High) ($ million/yr)	Value of End-Use Sales ($ million/yr)	Cost/End-Use Revenue (Low) (%)	Cost/End-Use Revenue (High) (%)
Municipal Water Revenues (pipe)	49	71	3283	1.5%	2.2%
Transportation Equipment (vehicle trim)	25	60	64113	0.04%	0.1%
Residential Construction (siding)	48	752	42884	0.1%	1.8%
Residential Construction (windows)	(71)	33	42884	(0.2)%	0.1%

Residential Construction (flooring)	203	256	42884	0.5%	0.6%
Residential Construction (wire & cable compound)	10	10	42884	0.02%	0.02%
Total Residential Construction	190	1050	42884	0.4%	2.4%
Total	264	1181	110280[4]	0.2%	1.1%

Table 5: Direct Replacement Cost Compared to End-Use Revenues

(Selected Applications of Other Chlorinated Substances)

End-Uses And Chlorinated Substances	Direct Replacement Cost ($ million/yr)	End-Use Revenues ($ million/yr)	Cost/Revenues (%)
Household Bleach (Sodium hypochlorite)	56	94	60%
Dry Cleaning (Tetrachloroethylene)	43	740	6%
Steel Pipe And Tube (Trichloroethylene	3	1563	0.2%
Aeronautics (Trichloroethylene)	2	4796	0.04%
Auto And Auto Parts (Trichloroethylene)	2	64113	<0.01%
Paint Stripper (Dichloromethane)	27	37	73%
Polyurethane Foam (Dichloromethane)	2	150	1.2%
Plastics (Flame Retardant)	13	1602	0.8%
Fabricated Metal Products (Short Chain Chlorinated Paraffins)	1	15404	0.01%
Commercial Refrigeration (CFC, HCFC)	66	342	19%
Domestic Appliances (CFC, HCFC)	4	917	0.4%
Transportation Equipment (CFC, HCFC)	35	64113	0.05%
Auto And Auto Parts (Polychloroprene)	24	64113	0.04%
Total	278	88195[5]	0.3%

[4] Total does not equal the sum of the figures in the column to avoid double-counting.
[5] The total for end-uses revenues does not equal the sum of the figures contained in the column, since steel tube is part of fabricated metal products and transportation (and auto and parts) equipment appears three times.