Comparison of Technical and Socio-economic Factors for Chlor-alkali-based Products and Alternatives for Canada

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1. Introduction and Study Purpose

In 1992, the International Joint Commission (IJC) initially recommended 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 the means of reducing or eliminating other uses be examined." (IJC, 1992). In response to the IJC recommendations, the Canadian federal government has developed a Chlorine Action Plan, in which federal policy toward chlorine is defined as part of a broader Toxics Management Policy.

The Chlorine Action Plan has five components, one of which is socio-economic and public health studies of the use of chlorinated substances and their alternatives. The purpose of this study is to provide a comparison of socio-economic and technical factors of chlor-alkali products, and alternatives to these products in the context of the Canadian economy.

2. Methodology

The method employed in this study is to choose the major products and applications of the chlor-alkali industry, and generate a quantitative technical and socioeconomic description of that product, and of alternatives to that product, within the particular application studied. Two applications, pharmaceuticals and pesticides are not analysed quantitatively, but qualitatively.

Information and data collected for this study were drawn from three key sources: 1) publicly available databases; 2) literature reviews; and 3) interviews with, and questionnaires of, industry representatives. This information and data were collected for the following specific study objectives:

1) to provide a description of the markets for chlor-alkali products and alternatives to these products, including market trends.

2) to provide a technical comparison of the production processes and technical properties related to chlor-alkali products and alternatives to those products.

3) to determine the direct costs of substituting selected alternatives for chlor-alkali products, and to place these costs in context.

4) to develop socio-economic profiles of both chlor-alkali products and alternatives to those products.

Socio-economic data collected include: number and location of domestic producers; production and capacity; employment; revenues; imports and exports; and selected others in some cases. Costing and production data are based on 1993 levels, except where costs had significant annual variations, when five year (1988-1993) averages were used. The chlor-alkali products are classified into three broad categories: (a) the base commodities elemental chlorine, caustic soda, hydrochloric acid, ethylene dichloride (EDC), and vinyl chloride monomer (VCM); (b) polyvinyl chloride resin, compound, and final product (PVC); and (c) other chlorinated substances (e.g., solvents, refrigerants, flame retardants).

3. Selected Examples of Main Results

Both the basic commodities and the many chlorinated substances have many and varied applications. Even a summary of the main results is far beyond the scope of this short paper. Rather, a selection of representative results, from across the scope of the analysis, will be presented.

3(a) Base Commodities of Chlor-alkali Industry

The Canadian domestic market for chlor-alkali commodities exhibits an imbalance where the domestic production of caustic is roughly equivalent to domestic demand, but elemental chlorine production exceeds domestic demand and is exported. In 1993 chlorine exports (as elemental chlorine and EDC) accounted for 43% of the total domestic supply of chlorine. The trend indicates an increasing imbalance over time.

This deteriorating domestic balance results from the collapse of demand for elemental chlorine from the pulp and paper industry. Here, the demand for elemental chlorine is expected to decline from 32% of chlorine supply in 1988 (560 kilotonnes) to 3% (24 kilotonnes) in 2000. Annual chlorine capacity is expected to decrease from 1750 kilotonnes in 1988 to 1117 kilotonnes in 2000, a decline of 38%. Annual chlorine production is expected to decline from 1700 kilotonnes in 1988 to 930 kilotonnes in 2000, a decline of 43%. As a result of this trend the principal domestic use of elemental chlorine has become the production of EDC and VCM, with this demand expected to be relatively stable from 1988 to 2000. In 1993 the domestic demand for elemental chlorine for VCM production accounted for 21% of total elemental chlorine supply.

Based on 1993 production levels, an estimate of the annual value of domestic sales of base chlor-alkali products was $628 million. The value of domestic sales is dominated by the sales of caustic soda (58%), and VCM (33%). Domestic revenues include exports and imports, and are estimated at $760 million. Domestic revenues are also dominated by the sales of the same products, caustic soda (51%), and VCM (27%). Chlor-alkali commodities have an export surplus of $132 million, which is dominated by the contribution of elemental chlorine ($37million) and EDC ($70 million).

As of 1993 employment in the chlor-alkali industry was 2547, in ten plants. Currently, only seven plants are operating. Employment is expected to decline from 3123 in 1988 to 1989 in 2000, reflecting the plant closures caused by the declining domestic demand for elemental chlorine.

3(b) Costs of Substitution - Caustic Soda

Alternatives to electrolytic caustic considered are chemical caustic (produced using the lime-soda process), soda ash, lime, and saltcake. The cost of substitution for electrolytic caustic is estimated based on 100% substitution with chemical caustic. This is produced through the lime-soda process, where soda ash is reacted with slaked lime. Currently, there are no facilities in Canada producing merchant chemical caustic. The total costs of substitution are estimated at $45 million in annual operating costs, and $731 million in capital costs, resulting in an estimated annual cost of $119 million (using an 8% interest rate and a 20 year life, which is used throughout the study).

To place these costs in context they can be compared to the total revenue generated by the industries which use electrolytic caustic (chemical pulp, newsprint and mechanical papers, primary aluminum smelting and refining, soaps and detergents, metal mining - gold, and petrochemicals - oil sands). In all these industries the costs of substitution would be less than 1% of total annual revenues.

3(c) Costs of Substitution - Pulp and Paper

Costs of converting Canadian chemical pulp mills to ECF and TCF, given the bleaching sequences of 1993, were estimated using secondary data and detailed assumptions. These costs should be seen as rough estimates due to the necessary simplifying assumptions used. A more accurate cost estimate would involve detailed engineering studies of all 44 Canadian pulp mills, a task beyond the scope of this study.

In the base year for the study (1993), 7 of 44 chemical pulping mills were producing totally ECF pulp. At the current time (1995), this number has increased to 20. Based on pulp production weighted-average chlorine dioxide substitution, 66% of chemical pulp was produced by chlorine dioxide bleaching in 1993, increasing to 85% in 1995. By 2000 it is expected that almost all pulp produced in Canada will be ECF pulp. The main reason for this change is regulation; of dioxins and furans at the federal level, and of adsorbable organic halides (AOX) at the provincial level.

TCF pulping has a negligible market share in Canada, both in 1993 and currently. At the present time, no Canadian mills are planning to convert to TCF pulping.

The costs of total substitution to ECF pulping, from the 1993 base year mill configuration, are estimated at $20 million in annual operating cost savings, and an additional $760 million in capital costs. Annualizing capital costs gives an estimated annual cost of substitution to ECF pulp of $57 million per year. This represents about 0.75% of the 1993 value of domestic chemical pulp production ($7.7 billion; derived as 12308 kilotonnes of chemical pulp production, times a price per tonne of $625 deduced from pulp export quantities and value).

The costs of total substitution to TCF pulping from the 1993 base year mill configuration are estimated at $620 million in annual operating costs, and $2.5 billion in capital costs. Annualized, these total costs amount to $871 million. This is about 11.3% of the value of domestic chemical pulp production.

3(d) Costs of Substitution - Water and Wastewater Treatment

Elemental chlorine has been the primary disinfectant for water since the advent of public water supply. 16.5 kilotonnes of elemental chlorine were used in water treatment in Canada in 1993 (about 1 to 2% of total chlorine supply, and 69% of water treatment plants). Two alternatives to the use of elemental chlorine were assessed. These were ozonation for water supply, and ultraviolet radiation for wastewater treatment.

The number of plants using alternate water treatment technology is small, but growing, with ozonation being the most common new technology, used in 30 plants or 1% of the total. The principal explanation for this slight trend is potential health concerns related to the known formation of chlorination by-products. Similarly, UV radiation has displaced chlorine in a small but growing number of wastewater treatment plants (from 40 plants or 2% in 1993, to 70 plants in 1995). The principal explanation here is environmental concerns related to the toxicity of chlorinated effluents, which have been declared toxic under the Canadian Environmental Protection Act (CEPA).

The substitution costs for ozonation were estimated at $490 million in capital costs and $23 million/year in additional operating costs. Annualized capital costs are $50 million/year, bringing total additional annual costs, including operating, to $73 million. This cost represents about 3% of water supply revenues. This is conservative because water rates in Canada do not recover full costs.

The substitution costs for UV radiation are $154 million in capital costs, with no additional operating costs. Annualized, this costs amounts to $16 million/year. This represents about 2% of wastewater revenue, and is again conservative.

3(e) Costs of Substitution - Titanium Dioxide and Hydrochloric Acid

The study described two processes used to produce the white pigment titanium dioxide - the chloride process and the sulphate process. Approximately 70% of titanium dioxide manufactured in Canada uses the chloride process, and the sole manufacturer is considering expanding this process by 20%. This increasing market share is principally in response to environmental concerns regarding the sulphate process.

The costs of total substitution from chloride-process to sulphide-process production, using 1993 production, are estimated at $213 million in capital and an additional $32 million in annual operating costs. Annualizing the capital costs brings the total annual cost to $54 million, which is about 30% of the revenues derived from domestic titanium dioxide production (about $177 million).

The analysis of the use of HCl was restricted to steel pickling, which is the largest single end use application. The alternative considered is sulphuric acid. The trend is towards an increasing use of HCl, due to waste disposal problems with sulphuric acid, and an inability to regenerate that acid. In contrast to sulphuric acid, up to 95% of HCl can be regenerated.

The study assumes that HCl in steel pickling is replaced by sulphuric acid. The capital costs are $2 million, and the annual operating costs are reduced by $2 million. Annualizing the capital costs results in an overall costs savings of about $1.8 million/year. This represents less than 0.1% of total revenues from steel production.

3(f) Costs of Substitution - PVC Products and Applications

In the case of PVC products the costs of substitution are primarily operating costs, defined as annual changes in material costs, rather than changes in production technology. The following summarizes these costs in $millions (CDN) for a range of alternatives:

Application	Alternative	Annual Oper.	Capital	Total Annual
Water Pipe	HDPE	20	0	20
	Ductile Iron	26	0	26
Wastewater Pipe	HDPE	29	0	29
	Concrete	65	0	65
Drainage Pipe	HDPE	-3	0	-3
	Concrete	-3	0	-3
Plumbing (DWV)	ABS	0	0	0
Industrial 8"Ducting	HDPE	-5	0	-5
Siding	Aluminum	80	0	80
	Clay brick	1253	0	1253
Window Profiles	Wood	-118	0	-118
	Aluminum	55	0	55
Flooring	Ceramic Tile	485	0	485
	Carpet	321	0	321
	Rubber	900	0	900
	Hardwood	1715	0	1715
Wire and Cable	XLPE and TPE	127	2.3	127
Food Wrap	PE	-9.4	0	-9.4
Bottles	HDPE	-2.6	10	-1.6
	PET	1.7	13.7	3
Rigid Sheet	OPS/PET	6.1	0	6.1
Flex Sheet-Cars	Fabric	30	0	30
	Leather	350	0	350
Flex Sheet-Pools	TPE	13	0	13
	Concrete	100	0	100

Putting some of these costs in context yields the following. The costs of substituting for PVC pipe in the municipal pipe market represents from 4 to 7% of municipal pipe purchases, and 1 to 3% of total revenues from water and sewer rates. Other comparisons for the PVC applications are not yet available.

3(g) Costs of Substitution - Other Applications

Several other applications were also analysed and the cost data summary follows ($millions CDN).

Application	Alternative	Annual Oper	Capital	Total Annual
Flame Retardants	Non-Cl (Br;P;ATH)	13.4	0	13.4
Metal Working Fluids	Overbased Sulphonate	1	0	1
Polychloroprene	Three Non-Cl Products (NBR; EPDM; other)	45	0	45
Dry Cleaning	30% wet;70%hydrocarb	18	231	42
Refrigerants	HFC	481		481
Household Cl-Bleach	Stab. Hydrogen Per	56	0	56
Degreasing Agents	60%aqueous;40%hydrocar	7	52	12
Methylene Chloride				
(paint remover)	Hydrocarbon	3.7	0	3.7
(blowing agent)	Injected CO2	-1.7	5.5	-1.1
Choline Chloride	Choline Bitartrate	199	0	199

The dry cleaning costs represent about 6.0% of the total annual revenues of dry cleaning. The cost of substitution in choline chloride may make the single producer uncompetitive. Other contextual comparisons are not yet available.

4. Preliminary Findings and Conclusions

1) There are alternatives to chlor-alkali products already in the marketplace, and there are others that can be developed.
2) These alternatives provide or can provide comparable employment opportunities.
3) There are usually higher costs involved in immediate substitution.
4) Compared to overall revenues or relevant market size, and normal fluctuations, these costs are often not unduly large, although there are exceptions.
5) The relative cost significance varies depending on whether the application is an end-use or an intermediate input.
6) Direct negative and positive employment effects do not appear large in relative terms, and tend to counteract one another.
7) First-cut estimate of impact on GDP of eliminating chlor-alkali products is less than 1%. (Based on estimated total substitution costs of from, low of $1,771 million to high of $5,680 million, compared to 1993 Canadian GDP at market prices of about $712,000 million).