

# **CLEANING UP:**

### TAKING MERCURY-FREE CHLORINE PRODUCTION TO THE BANK



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STOP SEAFOOD CONTAMINATION

### **EXECUTIVE SUMMARY**

"Chlorine production is currently among the major industrial sources of mercury releases to the environment." Of the serious environmental challenges posed by the industrial age, few lend themselves to clear, achievable solutions quite the way that mercury pollution in the chlorine industry does. In 1894, the industry discovered the unique qualities of mercury for creating an electrolytic cell to split salt molecules, revolutionizing the production of chlorine around the same time internal combustion engines were first invented. As revolutionary as it may have been, it is not revolutionary anymore. Depending on mercury to make chlorine is like depending on the Model-T for modern commerce. Inefficient, to say the least.

Because of this archaic technology, chlorine production is currently among the major industrial sources of mercury releases to the environment. Two other approaches that do not use mercury have been widely adopted. Yet many companies still rely on this 110-year-old process, even though it creates numerous tons of mercury wastes with associated disposal and cleanup problems, pumps up corporate electric bills unnecessarily, and in some cases turns neighboring communities against the companies. Today in the United States, five mercury-cell chlorine plants continue to rely upon this technology, releasing tons of mercury unnecessarily. We call them the "Filthy Five."

Conversely, more than one hundred facilities just like these five mercurycell chlorine plants waded through the industrial inertia and converted to better technologies. These plants began putting mercury and its associated

challenges behind them as early as 1974. In doing so, they likely saved themselves millions of dollars in costs for fines, upgrades, cleanups, and other expenses that dogged their competitors.

In the seventies, technology using a diaphragm to create the electrolytic cell came into vogue, though it too had been invented in the previous century. Many plants switched to diaphragm-cell technology, while others did not. Around the same time, an even better method using membrane-cell electrolysis was being developed, increasing efficiency and still allowing the production of chlorine and caustic soda without the use or release of mercury. Many facilities soon began to shift to membrane-cell technology, as is shown in this report. In fact, some that had already undergone a shift to diaphragm technology saw the benefits

of membranes and shifted a second time. Other facilities, however, sat out even this second revolution, sticking with mercury in spite of its associated costs.

Globally, the chlorine industry had largely moved to mercury-free technology by the turn of the 21<sup>st</sup> century. In the United States, the industry reported that by 2004, 90 percent of its chlorine was produced using mercury-free technology and no new mercury-cell plant has been built since 1970. Oceana's Campaign to Stop Seafood Contamination targets the plants responsible for the remaining 10 percent.



This report details the successes of companies that have shifted and compares their successes to the lagging facilities in the United States that have remained in the 1894 technological rut. For each plant, Oceana looks at the likely costs of its mercury use and the financial benefits of moving away from mercury. We also tackle some of the prevailing arguments for not shifting – arguments that have been challenged by at least 115 similar facilities around the world. Compiling all of this history in one place clearly shows that the remaining mercury-cell plants are causing a major mercury problem with a clear, achievable solution that should be immediately implemented to benefit the environment and public health.



- If the Filthy Five eliminate mercury use in chlorine production, nearly 4,400 pounds of reported mercury releases would be eliminated every year. This does not include mercury that is "lost" and not monitored at the plants.
- At least 115 plants around the world have shifted or plan to shift to mercury-free technology since 1974. At least thirty-six of those plants shifted to diaphragm technology first and then upgraded to membrane-cell technology a short time later.
- Plants that have shifted to membrane-cell technology generally have achieved increases in energy efficiency between 25 and 37 percent per ton of chlorine produced. Since electricity can make up as much as half of total production costs, increasing efficiency can vastly improve a plant's profitability.
- Assuming a 25 percent increase in energy efficiency, if each of the Filthy Five converted, their total savings from energy efficiency could amount to \$98.6 million over five years.
- Improved energy efficiency would also reduce greenhouse gas emissions. If the Filthy Five were to switch to mercury-free membrane-cell technology, the corresponding decrease in energy consumption would save enough electricity to power 40,200 average homes.
- Since membrane cells are smaller than mercury cells, allowing more cells to operate in a given space, many plants choose to increase their capacity when they shift. Increases on the order of 25 percent are common. If just four of the "Filthy Five" plants made such a change, their collective sales would increase by more than \$302 million over five years and they would save nearly another \$14.6 million due to the increased energy efficiency over five years. Expansion of the largest plant, Olin's Tennessee plant, is not assumed in this estimate.
- There is no need to use mercury to create "mercury-grade," also called "rayon-grade," caustic soda, despite industry arguments. Rayon manufacturing at plants in India clearly shows that membrane-grade caustic can be used effectively. In addition, rayon textiles have not been manufactured in the United States for nearly a decade.
- Many household products made using chlorine or caustic soda contain traces of mercury. These include toothpaste, soap, shampoo, bleach and even soft drinks. When mercury is used to make caustic soda it is often found as a contaminant in the final product, and this may be the source of some of the residues.

Based on these findings, two conclusions become apparent. First, it is clear that shifting to membrane-cell technology is both achievable and affordable, and second, that it is a necessary step to stop mercury releases and protect public health and the environment.

### **INTRODUCTION**

Mercury has been used in chlorine and caustic soda production for more than one hundred years. Technology that eliminates the need to use mercury in chlor-alkali production has been readily available for just as long. Yet, in the United States, five chlor-alkali plants have still not committed to stop using the outdated mercury-cell technology to produce their products. In 2005, these five plants reported emissions of more than 4,400 pounds of mercury into the air.<sup>1</sup> On average, these plants release more than four times the average amount of mercury released from a typical power plant; earning them the title "The Filthy Five" (See Figure 1).

Unlike coal-fired power plants in which mercury emissions can only be reduced, technology can completely eliminate mercury pollution from chlor-alkali production. Thus, the release of tons of mercury to the environment reported by these companies, not to mention the many more tons "lost" by mercury cell chlorine plants, is entirely unnecessary.

Mercury is a dangerous neurotoxin that can accumulate in fish when released to the environment. According to the *Madison Declaration on Mercury Pollution*, a consensus of over 1,100 scientists released in March 2007, about two-thirds of the mercury in the environment is attributable to human activities, such as chlor-alkali production.<sup>2</sup>

Most human exposure to mercury is dietary, resulting from consumption of fish or seafood.<sup>3</sup> Once mercury builds up in the body, it can cause a variety of health problems that can be both subtle – such as numbness in fingers<sup>4</sup> – and quite serious – such as an increased risk of heart disease.<sup>5</sup>

The greatest concern about mercury surrounds its effects on the early development of the fetus and on later childhood development. Methylmercury can travel across the placenta from the mother to the fetus, meaning exposure to the dangerous poison often begins in the womb during a baby's most vulnerable developmental period. Not only does it take lower levels to harm a developing fetus than it would an adult, but mercury levels are also magnified in the womb.<sup>6</sup> Mercury can irreversibly impair children's brain functions as they grow.<sup>7</sup> Infants and children exposed to high doses of mercury may have problems with attention span, language, visual-spatial skills, memory and coordination. Very high levels of exposure in children can lead to brain damage, speech problems, seizures, blindness and mental retardation.<sup>8</sup>

"Once mercury builds up in the body, it can cause a variety of health problems including some that are subtle, such as numbness in fingers. Others can be quite serious, like increasing the risk of heart disease."

An Environmental Protection Agency (EPA) scientist has estimated that one in six women has enough mercury in her blood to pose neurological risks to her developing baby.<sup>9</sup> This means that hundreds of thousands of newborns each year in the United States may be exposed to enough mercury to hinder nervous system development.

While there are a variety of industrial sources of mercury, all of which need to be reduced, this report focuses on the problem of mercury releases from chlorine, or chloralkali, production. This analysis has identified 115 plants that already have switched or are in the process of switching to technology that neither uses nor releases mercury (See Table 3). It then goes on to focus on the five remaining mercury-cell chlor-alkali plants in the United States that have not committed to stop using mercury, and tallies the benefits against the cost of switching to membrane-cell technology. The final section of this report addresses the industry's argument that it is necessary to produce caustic soda (a co-product in chlor-alkali manufacturing) using the mercury process. As it turns out, industries in the United States that require this quality of caustic soda are dwindling, and viable alternatives exist.

#### [FIGURE 1]



#### MERCURY-CELL CHLORINE PLANTS EMIT MORE MERCURY THAN POWER PLANTS (2005)

### PLANTS THAT HAVE CONVERTED ILLUSTRATE BENEFITS OF CONVERSION

YEAR	# BY DATE	
1974	10	
1975	30	
1976	36	
1977	37	
1978	39	
1980	40	1
1982	41	
1983	42	
1984	46	
1985	51	
1986	55	
1988	56	
1989	60	
1990	61	
1991	63	
1993	67	
1994	67	
1997	69	
1998	75	
1999	81	
2000	82	
2001	85	
2002	89	
2003	91	
2004	95	
2005	98	
2006	104	
2007	109	
2008	110	
2010	113	
2012	115	

STOP

#### History of Mercury-Free Chlorine Production

Mercury-free technology has been readily available and installed around the world for decades. Many plants were constructed using either diaphragm or membrane-cell technology. However, many others were built to use mercury. Of those, more than one-hundred mercury-cell chlor-alkali plants already have switched or plan to switch to mercury-free technology. This analysis has identified 115 such facilities, making it the most comprehensive compilation of this information to date. However, some plants undoubtedly have been converted that were not identified in this analysis.

[FIGURE 2] Shifts to mercury free technology began in 1974 and continue to the present.



Source: Compiled by Oceana from a review of industry publications and news reports.

Although chlorine plants stop using mercury for a variety of reasons, including government-initiated bans on mercury-cell plants and environmental concerns, the economics of conversion are more attractive to the managers of facilities that consider them than one might think. While the up-front costs associated with installing mercury-free technology may appear to be high, there are many variables that balance out the cost of an upgrade, such as an increase in energy efficiency and the opportunity to increase capacity due to the shift.

Membrane-cell technology is the newest mercury-free technology, despite having been in use for over thirty years. It is now considered the best available technology for chlorine production, and currently most chlorine plants choose this technology when converting. Shifting to membrane-cell technology typically saves plants between 25 percent and 37 percent of their prior energy costs (Table 1). This is significant since electricity is a large portion, sometimes nearly half, of a chlorine facility's operating budget. In fact, individual mercury-cell chlor-alkali plants can consume as much electricity as small cities.

COMPANY NAME	LOCATION	YEAR CONVERTED	INCREASED ENERGY EFFICIENCY
Travancore Cochin Chemicals Ltd	Kochi, India	2006	37%
PPG	Beauharnois, Canada	1990	35%
Borregaard	Sarpsborg, Norway	1997	30%
Pioneer	St. Gabriel, Louisiana, USA	2008	29%
PPG	Lake Charles, Louisiana, USA	2007	25%
Westlake Chemicals	Calvert City, Kentucky, USA	2002	25%
Olin Chemicals	Niagara Falls, New York, USA	1990	25%
Associated Octel	Ellesmere Port, United Kingdom	1993	25%

[TABLE 1] Companies that shift to membrane cells increase energy efficiency.

Source: Compiled by Oceana from a review of industry publications and news reports.

Another benefit of mercury-free membrane cells is their ability to produce as much chlorine as a mercury cell in a smaller space. Most plants that have converted or are in the process of doing so have taken advantage of this fact by increasing their chlor-alkali capacity by 20 to 30 percent during their conversion, although others have increased chlorine capacity by up to 80 percent (Table 2). The corresponding increase in capacity obviously leads to an increase in sales potential. By increasing energy efficiency and increasing capacity, some plants have been able to pay off their conversion investments in fewer than five years.

COMPANY NAME LOCATION YEAR CONVERTED CAPACITY INCREASE DCM Shriram Consolidated Kota, India 80% 2005 Hydro Polymers Stenungsund, Sweden 2010 75% Westlake Chemicals Calvert City, Kentucky, USA 2002 68% Bihar Caustic & Chemicals Ltd. Rehla, India 2006 50% PPG 50% Kaohsiung, Taiwan 1988 Pioneer St. Gabriel, Louisiana, USA 2008 25% PPG Beauharnois, Canada 1990 25% Petkim Aliaga, Turkey 2000 25% LII Europe Frankfurt, Germany 2004 25% Vestolit 2007 Marl, Germany 20%

[TABLE 2] Companies shifting to mercury-free membrane technology also increase capacity.

Source: Compiled by Oceana from a review of industry publications and news reports.

Besides these direct benefits, conversion also brings indirect benefits to public and environmental health. For example, increasing energy efficiency reduces the plant's demand for fossil fuels and cuts down on its per unit generation of carbon dioxide, a greenhouse gas. Assuming no change in fuel type, a 25 percent decrease in fuel use results in a 25 percent decrease in greenhouse gas emissions. Minimizing mercury releases to the environment is another obvious benefit, although it is difficult to measure in dollars.

The world map (Figure 3A-3D) shows the global distribution of chlorine facilities that have converted. A number of examples are highlighted to demonstrate the details, such as timing and costs, of some of the conversions (See Table 3 for a full list).

#### **CANADA**

US-based PPG Inc. (owner of one of the Filthy Five) converted its Beauharnois mercurybased chlor-alkali facility, near Montreal to membrane technology in 1990 for \$40 million.<sup>10</sup> By converting, the plant increased capacity to about 88,000 tons of chlorine per year and increased its energy efficiency by 35 percent.<sup>11</sup>

#### **UNITED STATES**

More than 90 percent of the chlorine produced in the United States is made with mercury-free technology. This figure is growing since two mercury-based plants will have converted to membrane technology by 2008 and two others will have shut down since this figure was calculated. Yet the writing on the wall is clear for the remaining Filthy Five: mercury-based technology is outdated and unnecessary. In fact, Sen. Barak Obama (D-IL) introduced legislation in 2006 to ban the use of mercury in chlorine production. Sen. Obama's bill, the Missing Mercury in Manufacturing Monitoring and Mitigation Act aims to eliminate mercury use in chlor-alkali production by 2012. The bill has not yet been re-introduced in the Senate.

Occidental Chemicals owns and operates a former mercury-cell chlor-alkali plant in Mobile, Alabama. The company switched from mercury technology to membrane technology in 1991. Besides the elimination of mercury use and releases, the plant also reduced its hazardous waste generation by 94.5 percent. Hazardous waste can be quite costly for a company to either process on-site, or ship off-site for treatment or disposal. By reducing waste Occidental could be saving thousands of dollars every year. Natural gas usage at the plant was also reduced due to the switch and the company implemented additional waste minimization measures, saving Occidental nearly \$51,000 annually.<sup>12</sup>

One of the more recent conversions was at the Westlake Chemicals' plant in Calvert City, Kentucky. Westlake converted its 122,000 tons of chlorine per year capacity<sup>13</sup> chlor-alkali plant to mercury-free technology in 2002 for \$86.1 million.<sup>14</sup> The plant is now 25 percent more energy efficient<sup>15</sup> and its capacity has been expanded to nearly 205,000 tons of chlorine per year. <sup>16</sup> Most facilities see at least this level of increased energy efficiency after shifting away from mercury-free technology, if not more.

PPG Industries is in the process of converting its Lake Charles (Louisiana) facility to membrane technology. PPG decided to invest \$90 million and eliminate mercury from its processes at this plant by 2007.<sup>17</sup> With a capacity of about 275,000 tons of chlorine per year, PPG's facility is one of the largest to convert to mercury-free technology. The company expects the new technology to use 25 percent less electricity than the mercury-based process <sup>18</sup> while cutting the plant's natural gas consumption by two percent.<sup>19</sup> Mercury-free technology represents a powerful tool used by PPG, but the company still operates a mercurybased chlor-alkali plant in Natrium, West Virginia despite the company having already converted three other facilities in the United States and elsewhere in the world.

5 The most recently announced conversion plan comes from Pioneer Industries' Saint Gabriel (Louisiana) plant. Pioneer announced in January, 2007, that it will pay \$142 million to eliminate mercury in its processes at this facility and increase its 197,000 tons of chlorine per year capacity by 25% to 246,000 tons per year.<sup>20</sup> Like PPG, Pioneer expects a 29 percent increase in energy efficiency and the company expects the project to increase profitability by \$31 million annually due to increased sales and lower energy consumption costs. This project is expected to completely pay for itself in less than five years and is anticipated to be completed by the end of 2008.21 Pioneer still operates a mercury-based chlor-alkali facility in Canada.22



#### [FIGURE 3a]



#### **AUSTRIA**

Donau Chemie switched its Brückl (Bundesland Karnten) plant from mercury to membrane technology in 1999. It now has a capacity of about 60,100 tons of chlorine annually.<sup>23</sup> The most impressive part of this conversion was that it took place while the plant was operating at 80 percent production, thus avoiding major losses in sales that could have occurred had the plant shut completely for renovations.<sup>24</sup>

#### GERMANY

Vestolit's mercury-based chlor-alkali plant in Marl (Nordrhein-Westfalen) is expected to be converted to mercury-free technology by fall 2007. The \$96 million project will result in a 20 percent increase in capacity to approximately 286,600 tons of chlorine per year.<sup>25</sup>

#### NORWAY

S Borregaard ceased its mercury operations in Sarpsborg in 1997. This 40,000 tons of chlorine per year capacity plant upgraded to membrane technology for \$24 million. By switching technology, the plant improved in energy efficiency and saved nearly 30 percent on electrical costs. Additionally, the facility saved 25 percent in labor costs.<sup>26</sup> Through energy savings and other reduced costs, the plant paid for its conversion in five years.<sup>27</sup>

#### **SWEDEN**

In response to a Swedish government mandate for the phase-out of mercurycell chlor-alkali facilities by 2010, <sup>28</sup> Hydro Polymers will switch its plant in Stenungsund to membrane technology.<sup>29</sup> The plant now has an annual capacity of more than 126,000 tons of chlorine and upgrading the facility is expected to cost \$108.2 million.<sup>30</sup> By converting, Hydro expects to increase capacity to about 220,000 tons per year.<sup>31</sup> Switzerland has a similar mandate banning mercury-cell chlor-alkali facilities.<sup>32</sup>

#### UNITED KINGDOM

S Associated Octel's facility in Ellesmere Port (near Liverpool, England) was the first mercury cell chlor-alkali plant to switch to mercury-free technology in the United Kingdom. In 1993, the company upgraded its nearly 44,000 tons of chlorine capacity per year facility for \$17 million<sup>33</sup> (about \$30.6 million in 2006 dollars).<sup>34</sup> The switch resulted in a 25 percent reduction in power consumption.<sup>35</sup>

#### **CHINA**

The China National Chemical Construction Corporation upgraded its Lanzhou (Gansu Province) mercury-based chlor-alkali plant in 1985 to new membrane technology. This was the first import of membrane technology to China. The upgrade of the 10,000 tons of chlorine per year capacity plant cost \$2.04 million.<sup>36</sup>

#### **INDIA**

In 1986, India banned construction of new mercury-cell chlor-alkali plants and required that all new plants use membrane technology.<sup>37</sup> Since then, several companies, including Punjab Alkalies & Chemicals Ltd., Century Rayon Ltd., and NRC Ltd., have completely converted their facilities to mercury-free technology.<sup>38</sup> The Indian chlor-alkali industry expects to achieve a voluntary phase-out of mercury-cell chlor-alkali plants by 2012.<sup>39</sup> Currently 82 percent of India's chlor-alkali capacity is based on membrane technology.<sup>40</sup> Quigarat Alkalies and Chemicals Ltd. converted its last mercury-cell chlor-alkali plant in Vadodara (Gujarat) in 1989. Currently, the facility has capacity of slightly more than 137,000 tons of chlorine per year.<sup>41</sup> This company was the first in India to completely phase out mercury cells in its processes.<sup>42</sup>

OCM Shriram Consolidated converted its mercury-based chlor-alkali plant in Kota (Rajasthan) in 2005 for nearly \$77 million.<sup>43, 44</sup> By converting, the plant increased its capacity nearly 80 percent from close to 46,000 tons of chlorine per year to nearly 83,000 tons per year.<sup>45</sup>

Travancore Cochin Chemicals Ltd. began converting its mercury-cell chlor-alkali facility to membrane technology after it lost nearly 40 percent of its buyers for the particular grade of caustic soda produced at the plant.<sup>46</sup> The company raised capacity to nearly 58,000 tons of chlorine per year through its nearly \$5 million<sup>47</sup> investment. The system was commissioned completely in July 2006 and eliminated mercury in its processes. By upgrading, the plant reduced electricity consumption by 37 percent and the project is expected to pay for itself in less than five years.<sup>48</sup>

#### TAIWAN

PPG Industries (owner and operator of one of the Filthy Five) replaced a mercury-based plant in Kaohsiung City (Kaohsiung) in favor of membrane technology. The new facility cost \$38 million in 1988.<sup>49</sup> By building the new plant, PPG increased capacity by 50 percent to about 109,500 tons of chlorine per year. The upgrade was "in response to a government effort to phase out mercury cell operations."<sup>50</sup>







#### **AUSTRALIA**

In 1999, Orica, an Australian based chemicals company, announced it would be replacing a mercury-cell chlor-alkali facility with new membrane technology. The company's Laverton North (near Melbourne, Victoria) plant completed conversion in 2001<sup>51</sup> for \$63 million.<sup>52</sup> The conversion also created 200 new jobs in the area. Two other plants owned by Orica also converted from mercury to membrane technology in 2001.<sup>53</sup>

Australian Pulp and Paper Mills (APPM) switched its mercury-cell chlor-alkali facility in Burnie (Tasmania) to membrane technology after being decommissioned in 1988.<sup>54</sup> The upgrade cost \$14 million and the plant had a capacity of about 7,300 tons of chlorine annually at the start date.

#### EGYPT

(3) In 1993, Misr Chemical Industries began switching its mercury cell chlor-alkali facility in Alexandria to membrane technology. The contract was for \$96 million for the nearly 57,000 ton of chlorine per year capacity plant.<sup>55</sup>

#### JAPAN

The Chisso Corporation was a big producer of fertilizer in Japan in the first half of the 1900s.<sup>56</sup> From 1932-1964, the company dumped nearly 27 tons of mercury compounds into Minamata Bay with disastrous results.<sup>57</sup> More than 900 people died after eating contaminated fish

caught in the bay.<sup>58</sup> Since the Minamata Bay disaster, Japan has been vigilant against mercury emitting corporations and industries.

Japan had virtually eliminated mercury use in its chlor-alkali industry by 1986, following a government-initiated ban.<sup>59</sup> A total of 36 plants converted to the mercury-free diaphragm process between 1974 and 1977, with several more converting from mercury to membrane technology by 1986.<sup>60</sup> Most of the diaphragm facilities subsequently converted again to the more energy efficient membrane technology. As of 1999, nearly 95 percent of the industry utilized membrane technology to create their products. <sup>61</sup>

#### [Table 3]

### CONVERTED CHLOR-ALKALI PLANTS

YEAR	PLANT	TYPE	CITY	COUNTRY
1974	Asahi Glass	Diaphragm	Kita-Kyushu	Japan
1974	Central Chemical	Diaphragm	Kawasaki	Japan
1974	Kanegafuchi Chemical	Diaphragm	Takasago	Japan
1974	Mitsubishi Gas Chemical	Diaphragm	Naniwa	Japan
1974	Mitsui Toatsu	Diaphragm	Nagoya	Japan
1974	Nippon Soda	Diaphragm	Nihongi	Japan
1974	Sanyo Kokusaku Pulp	Diaphragm	Iwakuni	Japan
1974	Showa Enso	Diaphragm	Gushikawa	Japan
1974	Sumitomo Chemical	Diaphragm	Ohita	Japan
1974	Tsurumi Soda	Diaphragm	Tsurumi	Japan
1975	Ajinomoto	Diaphragm	Kawasaki	Japan
1975	Asahi Chemical Industry	Membrane	Nobeoka	Japan
1975	Asahi Glass	Diaphragm	Chiba	Japan
1975	Asahi Glass	Diaphragm	Kashima	Japan
1975	Chiba Chlorochemicals	Diaphragm	Chiba	Japan
1975	Denki Kagaku Kogyo	Diaphragm	Ohme	Japan
1975	Hokkaido Soda	Diaphragm	Tomakomai	Japan
1975	Kanto Denka Kogyo	Diaphragm	Mizushima	Japan
1975	Mitsubishi Chemical	Diaphragm	Kurosaki	Japan
1975	Mitsubishi Monsanto	Diaphragm	Yokkaichi	Japan
1975	Mitsui Toatsu	Diaphragm	Ohmuta	Japan
1975	Nihon Vinyl Chloride	Diaphragm	Chiba	Japan
1975	Osaka Soda	Diaphragm	Amagasaki	Japan
1975	Osaka Soda	Diaphragm	Matsuyama	Japan
1975	Ryonichi	Diaphragm	Mizushima	Japan
1975	Shin-etsu Chemical	Diaphragm	Naoetsu	Japan
1975	Showa Denko	Diaphragm	Kawasaki	Japan
1975	Tekkosha	Diaphragm	Sakata	Japan
1975	Tokuyama Soda	Diaphragm	Tokuyama	Japan
1975	Toyo Soda	Diaphragm	Nanyo	Japan
1976	Hodogaya Chemical	Diaphragm	Kohriyama	Japan
1976	Kureha Chemical Industry	Diaphragm	Nishiki	Japan
1976	Nikkei Kako	Diaphragm	Kanbara	Japan
1976	Sumitomo Chemical	Diaphragm	Kikumoto	Japan
1976	Toa Gosei Chemical	Diaphragm	Tokushima	Japan
1976	Toyo Soda	Diaphragm	Yokkaichi	Japan
1977	Nankai Chemical	Diaphragm	Tosa	Japan

Source: Compiled by Oceana from a review of industry publications and news reports.

[Table 3-Converted Chlor-Alali Plants Cont.]

YEAR	PLANT	TYPE	CITY	COUNTRY
1978	Prince Albert Pulp Co	Membrane	Saskatoon	Canada
1978	Asahi Glass	Membrane	Osaka	Japan
1980	Nippon Carbide	Membrane	Uozu	Japan
1982	Olin Chemicals	Diaphragm	McIntosh	USA
1983	Kashima Chlorine & Alkali	Membrane	Kashima	Japan
1984	Kansai Chlor-Alkali	Membrane	Osaka	Japan
1984	Mitsui Toatsu Chemical	Membrane	Osaka	Japan
1984	Toa Gosei Chemical	Membrane	Tokushima	Japan
1984	Billerud	Membrane	Skoghall	Sweden
1985	China National Chemical Construction Corp	Membrane	Lanzhou	China
1985	Hokkaido Soda	Membrane	Horobetsu	Japan
1985	Mitsubishi Chemical	Membrane	Mizushima	Japan
1985	Osaka Soda	Membrane	Kokura	Japan
1985	Toa Gosei Chemical	Membrane	Nagoya	Japan
1986	Kanto Denka Kogyo	Membrane	Shibukawa	Japan
1986	Nankai Chemical Industry	Membrane	Wakayama	Japan
1986	Nippon Soda	Membrane	Takaoka	Japan
1986	Okayama Chemical	Membrane	Mizushima	Japan
1988	PPG	Membrane	Kaohsiung	Taiwan
1989	АРРМ	Membrane	Burnie	Australia
1989	Gujarat Alkalies and Chemicals Limited	Membrane	Vadodara	India
1989	Tohoku Tosoh	Membrane	Sakata-shi	Japan
1990	PPG	Membrane	Beauharnois	Canada
1990	Olin Chemicals	Membrane	Niagara Falls	USA
1991	Novacke Chemicke Zavody	Membrane	Novaky	Slovakia
1991	Occidental Chemicals	Membrane	Mobile	USA
1993	Misr Chemical Industries	Membrane	Alexandria	Egypt
1993	Associated Octel	Membrane	Ellesmere Port	United Kingdom
1993	Century Rayon	Membrane	Thane	India
1994	TKI Hrastnik	Membrane	Celje	Slovakia
1997	Borregaard	Membrane	Sarpsborg	Norway
1997	Societe Nationale de Cellulose & de Papier Alfa	Membrane	Kasserine	Tunisia
1998	Orica	Membrane	Yarwun	Australia
1998	Punjab Alkalies & Chemicals	Membrane	Nangal	India
1998	P.T. Sulfindo Adiusaha	Membrane	Merak	Indonesia
1998	Micro-Bio Ltd.	Membrane	Fermoy	Ireland
1998	Solvay POR-PQ	Membrane	Povoa de Santa Ir.	Portugal
1998	Akzo Nobel Chem	Membrane	Skoghall	Sweden

Source: Compiled by Oceana from a review of industry publications and news reports.

#### [Table 1-Converted Chlor-Alali Plants Cont.]

YEAR	PLANT	TYPE	CITY	COUNTRY
1999	Donau Chemie	Membrane	Brueckl	Austria
1999	Bayer	Membrane	Dormagen	Germany
1999	Dow	Membrane	Schkopau	Germany
1999	Clariant	Membrane	Gersthofen	Germany
1999	Erkimia	Membrane	Tarragona	Spain
1999	HoltraChem Manufacturing	Membrane	Riegelwood	USA
2000	Petkim	Membrane	Aliaga	Turkey
2001	Solvay SA	Membrane	Jemeppe	Belgium
2001	Elektro Chemie	Membrane	Bitterfield	Germany
2001	Oltchim	Membrane	Rimnicu Vilcea	Romania
2002	Orica	Membrane	Laverton North	Australia
2002	Orica	Membrane	Botany Bay	Australia
2002	Uniteca	Membrane	Estarreja	Portugal
2002	Westlake Chemicals	Membrane	Calvert City	USA
2003	Bayer	Membrane	Leverkusen	Germany
2003	BASF Aktiengesellschaft	Membrane	Ludwigshaven	Germany
2004	NRC Ltd.	Membrane	Thane	India
2004	LII Europe	Membrane	Frankfurt	Germany
2004	The Andhra Sugars Ltd.	Membrane	Kovvur	India
2005	ENIP	Membrane	Skikda	Algeria
2005	DCM Shriram Consolidated	Membrane	Kota	India
2005	SayanskKhimPlast	Membrane	Sayansk	Russia
2006	Arkema	Membrane	St. Auban	France
2006	Bihar Caustic & Chemicals Ltd.	Membrane	Rehla	India
2006	Chemplast Sanmar	Membrane	Mettur	India
2006	Grasim Industries	Membrane	Nagda	India
2006	Solvay	Membrane	Bussia	Italy
2006	Akzo Nobel	Membrane	Delfzijl	Netherlands
2006	Travancore Cochin Chemicals Ltd.	Membrane	Kochi	India
2007	Vestolit	Membrane	Marl	Germany
2007	Dhrangadhra Chemical Works	Membrane	Sahupuram	India
2007	Syndial S.p.A.	Membrane	Porto Marghera	Italy
2007	PPG	Membrane	Lake Charles	USA
2007	Syndial S.p.A.	Membrane	Porto Marghera	Italy
2008	Ineos Capital	Membrane	Wilhelmshaven	Germany
2008	Pioneer	Membrane	St. Gabriel	USA
2010	Vinnolit	Membrane	Gendorf	Germany
2010	Vinnolit	Membrane	Knapsack	Germany
2010	Hydro Polymers	Membrane	Stenungsund	Sweden
2012	Spolchemie	Membrane	Usti nad Labem	Czech Republic

Source: Compiled by Oceana from a review of industry publications and news reports.

#### **CHOOSING PROFITS OVER POISON**

Because of the environmental and economic benefits of the newer technology, some countries are banning mercury use in chlor-alkali production. Over one hundred facilities and some entire countries have decided to switch to mercury-free technology.

Unfortunately, the United States continues to allow the use of mercury in chlor-alkali facilities while some of its biggest competitors in the world market (including Japan, India and ultimately Europe) will reap the benefits of switching to mercury-free technology. While other countries have banned or are banning mercury-cell chlor-alkali production, the US has refused to mandate a phase-out of this antiquated technology, instead favoring voluntary approaches that will lead to slight reductions in mercury releases, if any.<sup>62</sup> The United States government should follow the lead of its Japanese and Indian counterparts and phase out mercury use in chlor-alkali facilities.





## AND THEN THERE WERE FIVE...

When Oceana began its Campaign to Stop Seafood Contamination in 2005, there were nine chlor-alkali facilities in the United States that still used mercury to manufacture their products. Today, five of those nine still have not committed to stop using mercury-cell technology. Two plants, PPG's Lake Charles, Louisiana plant and Pioneer's St. Gabriel, Louisiana plant, have committed to switching to mercury-free technology. Two others, Occidental Chemical's Delaware City, Delaware facility and its Muscle Shoals, Alabama facility, were shuttered rather than upgraded.

While coal-fired power plants are considered the primary source of mercury released to the environment, these chlorine factories rival their mercury releases. The Filthy Five, on average, report emitting four times more mercury to the air than the average power plant (Figure 1).<sup>63</sup>

Here we compare these five plants to their counterparts that already have switched to gain insight into the benefits of making the change. Each of the "Filthy Five" is compared to a plant that has previously converted in order to estimate the likely cost of conversion. Then the costs of continuing to use mercury are considered. These often include technological fixes to minimize mercury releases, fines in response to environmental violations, treatment and disposal of mercury-containing hazardous waste, treatment to remove mercury from hydrogen produced in the process, cleanup of mercury contamination, and more. While these figures were not all available for every plant, we compile as many as possible for each. Once those costs are determined, we look at the benefits of shifting in similar terms. These tend to include cost savings from increased energy efficiency, potential increases in capacity, and savings associated with the more efficient use of hydrogen for power generation. In each case, it turns out that companies' mercuryrelated expenses are comparable to the costs of switching to mercury-free technology. Furthermore, when the benefits of switching are factored in, it is clear that switching can be a good business decision.

"The Filthy Five, on average, report emitting four times more mercury to the air than the average power plant."

In this analysis, to be conservative, Oceana uses assumptions that underestimate the costs of mercury use and the benefits of shifting. Also there are many costs that were not included simply because they are not public knowledge, such as costs associated with legal proceedings and purchasing mercury itself. As a result, the figures presented here clearly underestimate the benefits of shifting to membrane-cell technology. Each of the assumptions made in this report, including the cost of electricity and the amount of electricity consumed by each plant, is described in detail in the Methods section (Appendix 1).

### ASHTA CHEMICALS

#### Ashtabula, Ohio

Ashta Chemicals owns and operates one of the five remaining chloralkali facilities in the United States that still has not committed to stop using mercury in its processes. In 2005, the plant, located in Ashtabula, Ohio, reported emitting 813 pounds of mercury into the air, making it the third largest mercury air polluter in the state.<sup>64</sup> Even though mercuryfree technology has been readily available since the early 1970s, in the nineteen years between 1987 and 2005, the Ashta plant reported emitting more than 27,000 pounds of mercury into the air.<sup>65</sup>

#### **PROJECTED COST OF SWITCHING**

To better understand what might be involved in a conversion at the Ashta

facility, which has an estimated chlorine capacity of 44,000 tons per year,<sup>66</sup> we compare it to a similarly-sized facility that already has converted. A plant in Ellesmere Port, United Kingdom, (with a capacity of about 44,000 tons of chlorine per year) converted from mercury-cell technology to membrane technology in 1993. The upgrade at the Ellesmere plant cost \$17 million.<sup>67</sup> Using Ellesmere as a reference, the expected costs of converting the Ashta facility to mercury-free technology would be in the same range. Adjusting for inflation, the Ashta plant conversion would be expected to cost \$30.6 million.<sup>68</sup>

The EPA has estimated that switching from mercury-cell to membrane-cell technology would cost between \$100,000 and \$200,000 per ton of chlorine produced per day.<sup>69</sup> Using this estimator

and adjusting for inflation, converting a facility of Ashta's size would be expected to cost between \$19.2 million and \$38.4 million in 2006 dollars.<sup>70</sup> The \$30.6 million estimate from Ellesmere falls easily within EPA's estimated range.

While \$30.6 million is no small amount, the costs of mercury use and the benefits of switching help to put it in perspective, as discussed below.

#### **COSTS OF NOT SWITCHING**

Using mercury has considerable downsides for companies. Here we look back at costs that Ashta has incurred in the past due to mercury use. If Ashta had switched to mercury-free technology in the past, these costs would have been avoided. Since these costs rival the cost of switching itself, they raise the question of whether sticking with mercury has been a good business decision for Ashta. They also argue for switching now, since it is possible that additional costs along these lines could come into play in the future.

#### **Penalties for Violations**

In 1992, EPA's Great Lakes Initiative required the plant to reduce the amount of mercury in the wastewater being discharged to Lake Erie. Ashta claimed that the initiative required a level of mercury discharge nearly 1.000 times lower than its technology could achieve. In order to fulfill the mandate. Ashta spent nearly \$10 million and added technology to reduce mercury in its wastewater. While the newly invented system saved the company money by reducing sludge generated by the previous treatment system, the project never paid for itself,71 nor did it achieve its intended results.

Three years later (1995), the company reported that it had discharged five pounds of mercury directly into the lake – in violation of the Great Lakes Initiative.72 Ohio Attorney General Jim Petro sued Ashta for violating its water permit and fined the company \$1.5 million. Instead of paying the fine and to avoid having to admit any wrongdoing, Ashta agreed to invest \$6.9 million to install additional pollution control systems. Even though the additional systems have an estimated maintenance cost of \$482,500 annually73 and eliminate the five pounds of mercury that would otherwise be discharged annually into Lake Erie, the plant still reported emitting more than 800 pounds of mercury into the air in 2005.74

In 2001, EPA filed an administrative complaint against Ashta for a series of violations, some related to mercury use. These included violating emissions limits, failing to properly operate and maintain an emissions control system, and failing to maintain mercury emissions records. Ashta agreed to pay thousands of dollars in fines associated with these violations.<sup>75</sup>

#### **Pollution Control Costs**

Ashta uses its excess hydrogen in fuel cells to create electricity,<sup>76</sup> but using hydrogen from a mercury-cell chlorine plant has several associated drawbacks and costs. The first is that hydrogen must be filtered prior to use due to high mercury content. As much as one percent of a plant's mercury air emissions can be attributed to

"ASHTA's \$29.7 million dollars in mercury-related costs would have nearly paid for the estimated \$30.6 million conversion."

hydrogen use, even after treatment.<sup>77</sup> While Ashta plans to install additional filters to reduce mercury emissions from its fuel cell, this system is in the preliminary stages of development and projected costs are unknown.<sup>78</sup> This is an example of an additional cost that should go in the "Costs of Not Switching" column as a result of mercury contamination of hydrogen that is not included in our calculations.

### Hazardous Waste Treatment and Disposal

Ashta Chemicals has spent millions of dollars on mercury control technology

and penalties for violations related to mercury pollution since the company took ownership of the plant in 1992. That year, the EPA banned the disposal of solid waste containing mercury from chlor-alkali plants in non-hazardous waste landfills in the United States. In response, according to news reports, Ashta "contributed \$100,000 or so" to the Chlorine Institute, an industry trade group, to research ways to implement the new EPA mandate.79 Part of the Chlorine Institute's recommendation was that chlorine manufacturers should build reprocessing facilities to recycle the mercury in their hazardous waste. Rather than following the Institute's recommendation to build a recycling center, Ashta used a "legal loophole" to ship its waste to Canadian landfills.80

#### Summary of Costs

Ashta clearly did not save money by sticking with mercury-cell technology. It spent \$29.7 million (2006 dollars) since 1992, on mercury-related needs such as research and development, waste disposal, and building and maintaining pollution control technology. That does not include expenditures for hazardous waste disposal, hydrogen filtration, litigation, mercury permitting, or the purchase of mercury itself. In total, its expenditures would exceed the expected conversion cost of about \$30.6 million. If Ashta had instead put its money into conversion back in 1992, as many other plants did, it could have prevented the release of more than 27,400 lbs of mercury to the environment since that time, and the continued release of 800 pounds of mercury to air annually.

"If ASHTA had put its money into conversion back in 1992, as many other plants did, it could have prevented the release of more than 27,400 pounds of mercury to the environment since that time."

#### **BENEFITS OF SWITCHING**

Based on comparisons with the companies that have switched, Ashta could achieve considerable financial benefits. These include increased fuel efficiency, increased capacity and decreased waste management costs.

#### [ 🗸 ] Energy Savings

Switching to membrane-cell technology can be a major cost-saver for a facility because this technology is much more energy efficient than mercury-cell technology. Some plants have seen as much as a 37 percent reduction in electricity consumption per unit of chlorine produced.<sup>81</sup>

Given Ashta's estimated size, the plant consumes the amount of electricity<sup>82</sup> needed to power more than 10,770 average homes.<sup>83</sup> When the Ellesmere Port (UK) facility converted, the plant improved energy efficiency by 25 percent<sup>84</sup> – a similar savings from Ashta would be enough to power nearly 2,700 average sized homes. Since electricity may be as much as half of total production costs at chlor-alkali plants, reducing consumption by even a small percentage can vastly improve a plant's profitability.<sup>85</sup> If Ashta were to switch to membrane technology, the company could achieve an estimated \$6.5 million in energy savings over five years.

#### [ 🗸 ] Increased Capacity

In addition to the energy savings, some facilities also take advantage of additional space created by membrane-cell technology to increase their product output. Increasing capacity can add an additional profit center to the equation, allowing for a quicker return on the conversion investment. While some facilities have chosen to increase capacity by up to 80 percent,<sup>86</sup> most choose to increase capacity about 25 percent, and others choose not to increase capacity at all.<sup>87</sup> By increasing capacity and decreasing power use, some facilities have paid-off their conversions in less than five years.<sup>86</sup> If Ashta were to increase capacity by 25 percent, the company could increase sales by nearly \$39 million over five years. Even better, because the manufacturing process would be more efficient, Ashta would earn \$1.6 million in extra profits due to saved electricity costs.

#### [ </ ] Increased Hydrogen Efficiency

As mentioned previously, Ashta uses excess hydrogen to create electricity. Besides the additional cost of filtering the hydrogen associated with mercury use, shifting to membrane-cell technology also provides an advantage in improving hydrogen efficiency. First, a plant that ties its shift to an expansion, as most do, would generate more hydrogen. This increases the amount of hydrogen on hand for use as fuel, and subsequently increases the amount of electricity that the plant could self-generate. Second, since membrane-cell plants use less electricity per unit produced, electricity generated from hydrogen would be used more efficiently. It has been suggested that hydrogen could fuel up to 20 percent of a chlorine plant's total electrical needs.<sup>89</sup> Once again, the use of mercury incurs a cost that may not be entirely apparent, but that adds another positive dollar figure to the benefits of switching. This amount, however, is not estimated or included in our final tally and is another factor that renders our "benefits of switching" estimates conservative.

#### [ / ] Elimination of Mercury Waste Disposal Costs

Besides the hundreds of pounds of mercury emitted into the air from Ashta every year, the plant also has sent thousands of pounds of mercury contaminated waste to landfills and reprocessing plants for disposal. A European study estimates that an average sized plant could be spending between €300,000 and €500,000 annually in costs associated with mercury waste disposal,<sup>90</sup> which is the equivalent of spending between \$400,000 and \$663,000<sup>91</sup> in 2006 dollars annually.<sup>92</sup>

#### [ / ] Eliminating Mercury Monitoring and Maintenance

Despite Ashta's best efforts to reduce mercury emissions, mercury still escapes from equipment and poses a threat not only to the environment, but also to the workers. While properly maintaining mercury cells can reduce releases, plants still need to monitor mercury levels in various media. This includes testing workers,93 sometimes weekly.94 A European study of mercury-cell chlorine plants estimated that an average plant could be expected to pay about €300,000 annually in costs associated with mercury monitoring and maintenance.95 Using this estimate and reducing it by about 25% due to

the small size of the plant<sup>96</sup> suggests that Ashta could be spending about \$300,000<sup>97</sup> annually on monitoring and maintenance in 2006 dollars.<sup>98</sup>

#### [ / ] Eliminating Wastewater Treatment for Mercury

While Ashta has already invested in new technology to remove mercury from its wastewater,<sup>99</sup> it still reported spending \$482,500 annually (in 2004 dollars) to run its mercury treatment process. Based on this rate of spending and adjusting for inflation, it is likely that the plant will spend at least \$3.4 million over a fiveyear period in order to remove the mercury.<sup>100</sup>

#### **FINAL TALLY**

If Ashta had converted its facility to mercury-free technology in 1992, the project would most likely have already paid for itself and the company would now be reaping the benefits of the conversion. Although Ashta has already paid nearly \$29.7 million (in 2006 dollars) to keep up with environmental regulations, these costs will continue to accrue. By keeping ahead of the regulations and switching to mercury-free technology now, Ashta could avoid costly endeavors that may never pay for themselves, while at the same time reducing energy consumption, increasing capacity, and improving hydrogen fuel cell efficiency.

Over five years, shifting to the membrane-cell process could save the company about \$6.5 million in electricity costs, \$3.4 million from eliminating maintenance costs associated with wastewater treatment, \$2 million to \$3.3 million from hazardous material disposal, and an additional \$1.5 million for monitoring mercury. If the company chose to increase the plant's capacity along with the conversion, as many companies do, there would be an additional savings in electricity consumption by \$1.6 million due to energy efficiency and a projected increase of nearly \$39 million in sales over five years. Conversion to membrane-cell technology would benefit this company's finances and public image, as well as the environment and public health.

Cost to Switch:	\$30.6 míllíon
Costs of Using Mercury	\$29.7 million
Benefits (Over 5 years)	
Energy Savings	\$6.5 míllíon
Water Treatment	\$3.4 míllíon
Waste Dísposal	\$2 to \$3.3 míllíon
Monitoring	\$1.5 míllíon
Capacity Increase (Over 5 yea	ars)
Sales	\$38.8 míllíon
Energy Savings	\$1.6 míllíon

Note: Capacity increase estimates assume a 25 percent increase in capacity unless otherwise noted.

### **OLIN CORPORATION**

#### Charleston, Tennessee

The Olin Corporation generates a considerable amount of mercury pollution from the two mercury-cell chlor-alkali plants it continues to operate. In 2005, Olin's Charleston, Tennessee plant reported emitting 1,250 pounds of mercury into the air, making it the number one mercury air polluter in the state.<sup>101</sup>

Additionally, this plant reported emitting nearly three times more mercury into the air than Tennessee's top mercury-emitting coal-fired power plant in 2005.<sup>102</sup>

#### **PROJECTED COST OF SWITCHING**

With an estimated capacity of 270,000 tons of chlorine per year,<sup>103</sup> Olin's Tennessee facility is more than twice the size of its Georgia facility and is the largest plant considered in this report. To compare Olin's facility to one that has already switched, it is necessary to identify a larger-than-average plant that has switched to membrane-cell technology.

PPG Industries' chlor-alkali facility in Lake Charles, Louisiana, has a similar capacity to Olin's Tennessee plant and thus serves as the best example for comparison, as it has nearly finished converting from a mercury-cell process to membrane-cell technology. The Louisiana plant has a capacity of 275,000 tons of chlorine per year, making it just slightly larger than Olin's plant.<sup>104</sup> The upgrade to mercury-free membrane-cell technology should be completed by mid-2007 and was projected to cost \$90 million in 2005. It is reasonable to expect a conversion at Olin's Tennessee plant to fall in the same range. Adjusting for inflation puts the cost to convert Olin's Tennessee plant at about \$112 million in 2006 dollars.<sup>105</sup>

To get another perspective, the EPA estimates that switching from mercury-cell to membrane-cell technology would cost between \$100,000 and \$200,000 per ton of chlorine produced per day.<sup>106</sup> Adjusting for inflation, the conversion of a facility of Olin's size would be expected to cost between \$117.8 million and \$235.7 million in 2006 dollars.<sup>107</sup> The estimate for converting based on the PPG experience suggests that the true cost would be near the low end of this range. The EPA formula is expected to be more accurate for an average sized plant than for an extremely large plant due to the economies of scale realized during a conversion. Combining the PPG experience and the EPA estimate, it appears that \$117.8 million is a reasonable cost estimate for Olin's Tennessee plant.







While \$117.8 million is no small amount, the costs of mercury use and the benefits of switching help to put it in perspective, as discussed below.

#### **COSTS OF NOT SWITCHING**

Using mercury has considerable downsides for companies. Here we look back at costs that Olin's Tennessee Plant has incurred in the past due to mercury use. If Olin had switched to mercury-free technology, these costs would have been avoided. Since these costs rival the cost of switching itself, they raise the question of whether sticking with mercury has been a good business decision for Olin. They also argue for switching now, since it is possible that additional costs along these lines could come into play in the future.

#### **Penalties for Violations**

Olin's mercury-cell chlor-alkali plant in Tennessee has certainly had its share of fines and required environmental upgrades. In 1988, mercury was spilled at the plant while a pipe was being replaced, and in 1994, six years after the incident, the company paid a \$1 million fine to "avoid a lengthy and costly trial."<sup>108</sup> This amount is equal to about \$1.36 million in 2006 dollars.

Then in 2004, a worker used duct tape to seal a canister of hazardous waste: a violation of the Tennessee Hazardous Waste Management Act and one of Olin's eight violations of the Act since 2001. Additionally, the plant had two mercury-related violations in 2003 concerning its storm water discharges, forcing Olin to spend \$120,000 to upgrade its storm water system.<sup>109</sup> This amount is equal to about \$170,000 in 2006 dollars.

#### **Pollution Control Costs**

Olin has had a troubled legacy with mercury pollution from chloralkali production, which continues to this day. The company testified in 1970 that it had spent more than

\$200.000 in six months to reduce mercury discharges into the Niagara River from its Niagara Falls, New York, mercury-cell chlor-alkali plant, and that the company planned on spending more than \$1.4 million over the remainder of the year to complete the job.<sup>110</sup> Then in 1979, Olin was charged \$70,000 for falsifying documents pertaining to releasing mercury into the Niagara River from the same plant.<sup>111</sup> While these costs from the Niagara Falls plant are not included in our tally, costs may have been mounting from mercury use at Olin's Tennessee facility for decades. In 1990, Olin's Niagara Falls facility stopped using mercury in favor of mercury-free technology.

Despite previously installed mercury controls, the EPA issued a new rule in 2003 requiring a reduction of mercury air emissions by 2007.<sup>112</sup> According to the plant manager in Charleston, the company has already spent \$54 million over the past eight years on additional technology for personnel and environmental safety programs.<sup>113</sup> This included \$2.6 million in additional emissions control equipment. Even with the added upgrades, the company still expects to be emitting 1,084 pounds of mercury into the air annually in 2008.<sup>114</sup> Olin will most likely retain its position as the number one mercury emitter in the state in spite of these and other investments.<sup>115</sup>

Even though some mercury air pollution will be prevented, carbon-based systems trap mercury in a filter, which then may be relocated into a landfill or recycled, at a greater cost to the company. While capturing mercury is better than allowing it to simply vent into the air, mercury may still escape from these filters by either evaporating after disposal in landfills or through spills which may allow mercury to leach into the environment. The mercury does not simply go away.

#### Hazardous Waste Treatment and Disposal

In 1992, EPA banned disposal of mercury-laden hazardous waste in regular landfills. Olin spent \$4.5 million (\$8 million in 2006 dollars) at its Charleston plant to build a mercury recovery unit to comply with the EPA ruling.<sup>116</sup> In 2005, Olin's Tennessee reprocessing facility treated more than 31,000 pounds of mercury-laden waste, which included some waste from Olin's Augusta, Georgia mercury-cell chlor-alkali plant.<sup>117</sup>

#### **Hydrogen Filtration**

Although all plants treat and cool their hydrogen to remove as much mercury as possible, still nearly one percent of their total air mercury emissions come from the cleaned hydrogen that escapes. As a result, Olin plans to install additional filters to remove more mercury from hydrogen escaping the plant.<sup>118</sup> Hydrogen filtration and the resulting mercury waste management costs can be completely avoided by switching to mercury-free technology. Plants in Europe have been known to spend nearly \$500,000<sup>119</sup> on systems to treat hydrogen, as filters in these carbon-based systems need to be replaced every two to three years.<sup>120</sup>

#### Summary of Costs

The continued use of mercury has required that Olin spend more than \$64.2 million (2006 dollars) in treatment systems, fines, and other mercury-related costs in Tennessee. This includes costs described above in 2006 dollars, including the fine (\$1.36 million), upgrades to manage mercury releases (\$54 million), the wastewater upgrade (\$170,000), hazardous material management (\$8 million), and hydrogen filtration (\$707,000).<sup>121</sup> Other costs not included in this estimate include those related to legal and consulting fees, mercury permitting, and purchasing mercury. Despite having spent millions of dollars on control technology, the plant still reports emitting over 1,250 pounds of mercury pollution into the air annually and workers are tested weekly for high mercury levels. With each passing year, Olin will have to spend even more to control mercury pollution, while that \$64 million would have gone a long way toward paying for

the conversion to mercury-free technology. Switching would also provide substantial financial benefits to the company, not to mention to the environment and public health.

#### **BENEFITS OF SWITCHING**

Based on comparisons with the companies that have switched, Olin could achieve considerable financial

electricity<sup>123</sup> needed to power more than 66,100 average homes annually<sup>124</sup> – more homes than one will find in Clarksville, Tennessee.<sup>125</sup> Conversely, converting plants results in great gains in energy efficiency. For instance, PPG's Lake Charles, Louisiana facility expects to use 25 percent less electricity while producing the same



benefits at its Tennessee plant. These include increased energy efficiency, increased capacity, and decreased wastewater treatment costs.

#### [ 🗸 ] Energy Savings

Electricity is considered a raw material in the chlor-alkali industry and in some cases represents up to half of a plant's total operating costs.<sup>122</sup> For instance, given Olin's estimated size, the plant consumes the amount of amount of chlorine and caustic soda.<sup>126</sup> If Olin were to reduce its electricity consumption by a similar percentage, it would save enough electricity to power 16,525 average homes. It could be estimated that such a decrease in electricity consumption would save the company nearly \$8 million annually or nearly \$40 million over five years.

#### [ 🗸 ] Increased Capacity

Although newer technology allows increased capacity of chlor-alkali

products, Olin may opt not to increase capacity in this facility due to its large size. However, even increasing capacity at the Tennessee facility by a mere 10

"The continued use of mercury has required that Olin spend more than \$64.2 million (2006 dollars) in treatment systems, fines. and other mercury-related costs in Tennessee. [This] would have gone a long way toward paying for the conversion to mercury-free technology."

percent (when 25 to 30 percent increases in capacity are fairly regular) would provide quite a boost of chlor-alkali products in the market due to the plant's large size. Olin has been known to increase capacity by large quantities in the past, despite market conditions being less than favorable.<sup>127</sup> By capitalizing on energy savings, and possibly opting to increase capacity, switching to membrane-cell technology could prove to be quite profitable. If Olin were to increase capacity by even 10 percent, the company could increase sales by nearly \$17 million annually (or \$85 million over five years.) Even better, because the manufacturing process would be more efficient, Olin would earn \$800,000 in extra profit each year (\$4 million over five years) due to saved electricity costs.

#### [ 🗸 ] Eliminating Mercury Waste Management Costs

Olin spent \$4.5 million to build a waste treatment facility at its Tennessee plant where mercury-laden hazardous waste is reprocessed,<sup>128</sup> while switching to mercury-free technology could have reduced hazardous waste by 94.5 percent, as demonstrated by OxyChem's Mobile, Alabama plant which converted in 1991.<sup>129</sup> By eliminating future mercury waste, Olin could be saving many thousands of dollars in operation and maintenance costs related to the operation of its reprocessing facility.

#### [ 🗸 ] Eliminating Mercury Monitoring and Maintenance

Despite Olin's best efforts to reduce mercury emissions, mercury still escapes from equipment and poses a threat not only to the environment, but also to the workers. While maintaining mercury cells properly can reduce releases, plants still need to monitor mercury levels in various media. This includes testing workers,<sup>130</sup> sometimes weekly.<sup>131</sup> A European study estimates that a plant less than half the size of Olin's could be spending €300,000 annually in costs associated with mercury monitoring and maintenance.<sup>132</sup> Because of the size of Olin's Tennessee plant, the European estimate should be increased by about 25 percent,<sup>133</sup> which would lead to the equivalent of spending about \$469,000<sup>134</sup> in

2006 dollars annually.<sup>135</sup>

#### [ 🗸 ] Eliminating Wastewater Treatment for Mercury

Besides emitting mercury into the air, mercury-cell chlorine plants generally also discharge the chemical into nearby waterways.<sup>136</sup> One of the Filthy Five, Ashta Chemicals, was required to invest in additional controls at a considerable cost. Ashta developed new technology to remove mercury from its wastewater in 1993 at a cost of \$10 million; <sup>137</sup> however, even this technology did not eliminate all of the mercury in the plant's wastewater, Ashta continued to discharge five pounds of mercury into Lake Erie in 1995 and 1996.<sup>138</sup> By 2004, the company had spent another \$6.9 million

to install additional wastewater treatment systems to eliminate its mercury releases.<sup>139</sup> If Olin had to completely eliminate mercury in its wastewater

discharge, it could expect a costly process similar to that of Ashta. This possible cost has not been included in the final tally.

Another way to estimate the costs of wastewater treatment is to use a European study. The study estimates that a plant could spend between  $\in 2$  and  $\in 3$  per metric ton of capacity per year for wastewater treatment associated with mercury contamination. For a plant of Olin's size, this would be the equivalent of spending between \$651,000 and \$977,000<sup>140</sup> annually on wastewater treatment in 2006 dollars. Over five years, this would add up to \$3.3 to \$4.9 million.

#### **FINAL TALLY**

If Olin had converted its Tennessee facility to mercury-free technology in 1988, the company could have prevented over \$64 million in costs related to mercury according to the analysis above. Worse yet, many of these costs will continue to accrue. By keeping ahead of the regulations and switching to mercury-free technology, Olin could avoid costly endeavors that may never pay for themselves, while at the same time reducing energy consumption and possibly increasing capacity.

Over five years, shifting to the membrane-cell process could save the company about \$40 million in electricity costs, \$2.3 million from eliminating monitoring and maintenance costs associated with mercury use, and between \$3.3 million and \$4.9 million in estimated wastewater treatment costs. If the company chose to increase capacity along with the conversion, as many companies do, there would be an additional \$4 million in savings due to the increased energy efficiency and a projected increase of \$85 million in sales over five years based on just a 10 percent capacity increase. These benefits, when added to the prior costs of using mercury, nearly equal the cost to convert, without even considering the potential benefits of additional capacity. This suggests that conversion to membrane-cell technology would be good for this company, in addition to being good for the environment.

"If Olin had converted its Tennessee facility to mercury-free technology in 1988, the company could have prevented over \$64 million in costs related to mercury..."

Cost to Switch:	\$117.8 million
Costs of Using Mercury	\$64.2 million
Benefits (Over 5 years)	
Energy Savings	\$40 million
Monitoring	\$2.3 million
Wastewater Treatment	\$3.3 to 4.9 míllíon
Capacity Increase (Over 5 yea	ars)
Sales	\$84.9 million
Energy Savings	\$4 million

Note: Capacity increase estimates for Olin, TN assume a 10 percent increase in capacity.

#### OLIN CORPORATION Augusta, Georgia

Olin's Augusta, Georgia facility is the smaller of the company's two mercury-cell chlor-alkali plants. In 2005, this plant reported emitting 824 pounds of mercury

into the air, making it the third largest source of mercury air pollution in the state. The plant's reported emissions increased by more than 10 percent between 2004 and 2005, and its mercury discharges into the Savannah River increased by 34.6 percent as well.<sup>141</sup> Rather than continuing to increase its mercury emissions each year, the plant could eliminate hundreds of pounds of toxic mercury releases from our environment every year by switching to mercury-free technology.

#### **PROJECTED COST OF SWITCHING**

Although Olin's Georgia plant is smaller than its Tennessee plant, it is not a small facility. With an estimated capacity of 120,000 tons of chlorine per year, this facility is the second largest mercury-cell chlor-alkali plant

in the United States that has not committed to stop using mercury.<sup>142</sup> Nevertheless, a facility of similar size switched to mercury-free technology in 2002. The Westlake Chemicals facility in Calvert City, Kentucky took two years to convert to mercury-free technology at a cost of \$86 million, according to company documents.<sup>143</sup> An Augusta City Commissioner also stated that Olin could expect to spend about \$90 million for the conversion of the Augusta, Georgia facility to mercury-free technology.<sup>144</sup>

To get yet another perspective, the EPA estimated that switching from mercury-cell to membrane-cell technology would cost between \$100,000 and \$200,000 per ton of chlorine produced per day.<sup>145</sup> Adjusting for inflation, converting a facility of Olin's

size could be expected to cost between \$52.4 million and \$104.7 million in 2006 dollars. The suggested \$90 million figure is at the higher end of the EPA's estimated range. Thus, a \$90 million conversion estimate is not unrealistic.

While \$90 million is no small amount, the costs of mercury use and the benefits of switching help to put it in perspective, as discussed below.

#### COSTS OF NOT SWITCHING

Using mercury has considerable downsides for companies. Here we look back at costs that Olin's Georgia Plant has incurred in the past due to mercury use. If Olin had switched to mercury free technology in the past, these costs would







have been avoided. These costs argue for switching now, since it is possible that additional costs associated with mercury use could come into play in the future.

#### Pollution Control Costs (Hydrogen)

Olin uses excess hydrogen generated in the chlor-alkali process to create electricity. In 1968, the company built an electric generator that burns hydrogen to produce 1.5 megawatts (MW) of electricity.<sup>146</sup> Environmental regulations passed in 1974 required Olin to filter its hydrogen prior to use in order to remove mercury contamination. As much as one percent of a plant's mercury air emissions can be attributed to hvdrogen use, even after such treatment.<sup>147</sup> European plants have reported spending nearly \$500,000 on systems to treat hydrogen,<sup>148</sup> and filters in these carbon-based systems need to be replaced every few years.149 Meanwhile, Olin could lower the costs and alleviate the mercury releases by producing and using mercury-free hydrogen, if the company converted its facility.

#### Hazardous Waste Treatment and Disposal

Chlor-alkali products made using mercury generally contain trace amounts of mercury as a contaminant. Waste generated through the chloralkali process also includes mercury at even higher levels. In 1992, Olin spent \$4.5 million at its Charleston, Tennessee plant to build a mercury recovery unit to treat mercury-laden hazardous waste.<sup>150</sup> This reprocessing plant treats wastes generated in Tennessee and from Olin's Georgia facility hundreds of miles away. This expense was attributed to the Tennessee plant and is not counted in the final tally here.

#### **Mercury Cleanup Costs**

Another cost associated with Olin's use of mercury is the cost of cleaning up the highly contaminated channel that leads from its water discharge pipe to the river. The exceedingly high levels of mercury in the channel were discovered by a high school student conducting a research project for her science class in 2006. Soon thereafter, Olin conducted its own tests on the channel, which confirmed the student's findings. Unfortunately, the company has proposed to simply cover up the toxic mud with "clean" dirt, an insufficient response due to the risk of the contaminated mud re-entering the water. Insufficient as it may be, this minimal response alone would cost the company \$1 million.<sup>151</sup> Olin dealt with a similar problem at its McIntosh, Alabama chlor-alkali facility, where despite capping a mercurycontaminated landfill, the EPA required the company to spend \$10 million in additional cleanup costs.152 Similarly, in Augusta EPA may require a more effective channel cleanup. If it falls in the same range as the landfill, it may cost Olin closer to \$13 million in 2006 dollars.<sup>153</sup> In 1982, Olin stopped using mercury in favor of mercury-free technology at its McIntosh facility.

#### **Summary of Costs**

The continued use of mercury has cost Olin over the years. Some of the \$4.5 million cost of the treatment facility in Tennessee covers waste treatment for the Georgia facility; however, these costs were not counted here as they were attributed to the Tennessee facility. The cost of the anticipated channel cleanup will be at least another million dollars and possibly as much as \$13 million. Other costs not included in this estimate include those related to legal and consulting fees, treatment of hydrogen, mercury permitting expenses and purchasing mercury itself.

"In 2005, this plant reported emitting 824 pounds of mercury into the air, making it the third largest source of mercury air pollution in the state."

#### **BENEFITS OF SWITCHING**

Based on comparisons with the companies that have switched, Olin could achieve considerable financial benefits at its Georgia plant. These include increased fuel efficiency, increased capacity, and decreased waste management costs among others.

#### [ 🗸 ] Energy Savings

The amount of electricity consumed in chlor-alkali production is extremely high. For instance, it is estimated that Olin's Georgia facility consumes enough electricity<sup>154</sup> to power nearly 29,400 average homes annually,<sup>155</sup> several thousand more than those found nearby in Marietta.<sup>156</sup> Meanwhile, membrane-cell technology "If Olin were to switch to membrane-cell technology, the company could save more than \$17.6 million in energy costs over five years." uses less electricity: when Westlake Chemicals switched its facility in Calvert City, Kentucky, to membrane-cell technology, the plant improved energy efficiency by 25 percent.<sup>157</sup> Similar savings for Olin's Augusta plant would save enough to power 7,350 average homes. If Olin were to switch to membrane-cell technology, the company could save more than \$17.6 million in energy costs over five years.

#### [ 🗸 ] Increased Capacity

Plants often opt to increase capacity while switching to membrane-cell technology. For example, when Westlake Chemicals converted its Calvert City, Kentucky plant to membrane-cell technology, the facility increased capacity by an estimated 68 percent from 122,000 tons of chlorine per year<sup>158</sup> to 205,000 tons of chlorine per year.<sup>159</sup> For a similar increase, Olin's estimated chlorine capacity of 120,000 tons per year<sup>160</sup> would increase to approximately 201,600 tons per year. Such a large capacity increase is unique, since many converting or converted plants increase their capacity by a percent similar to their increases in energy efficiency (25 to 30 percent). Either way, increasing capacity can substantially decrease payback time for switching technology. If Olin were to increase capacity by just 25 percent, the company could increase sales by more than \$19.7 million annually or \$98.5 million over five years. Even better, because the manufacturing process would be more efficient, Olin would earn \$880,000 in extra profits each year (\$4.4 million over five years) from the increased sales due to saved electricity costs.

#### [ 🗸 ] Eliminating Mercury Waste Management Costs

Besides the hundreds of pounds of mercury reported as emitted into the air from Olin's Augusta plant every year, the plant also has sent thousands of pounds of mercury contaminated waste to landfills and reprocessing plants for disposal. A European study on mercury-cell chlorine plants estimated that a plant of Olin's size could be expected to spend between €300,000 and €500,000 annually in costs associated with disposal of mercury waste;<sup>161</sup> or about between \$400,000 and \$663,000<sup>162</sup> annually on hazardous waste disposal in 2006 dollars.<sup>163</sup> This could be savings if the plant switched to mercury-free technology.

#### [ 🗸 ] Eliminating Mercury Monitoring and Maintenance

Despite Olin's best efforts to reduce mercury emissions, mercury still escapes from the plant and poses a threat not only to the environment, but also to the workers inside. While maintaining mercury cells properly can reduce releases, plants still need to monitor mercury levels in various media. This includes testing workers,<sup>164</sup> sometimes weekly.<sup>165</sup> A European study estimates that a plant about the size of Olin's could be spending €300,000 annually in costs associated with mercury monitoring and maintenance;<sup>166</sup> or about \$400,000<sup>167</sup> in 2006 dollars annually.<sup>168</sup>

#### [ / ] Eliminating Wastewater Treatment for Mercury

Besides emitting mercury into the air. mercury-cell chlorine plants generally also discharge the chemical into nearby waterways.<sup>169</sup> One of the Filthy Five, Ashta Chemicals, was required to invest in additional controls at a considerable cost. Ashta added additional water treatment systems to remove mercury from its wastewater in 1993 at a cost of \$10 million; 170 however, even this technology did not eliminate all mercury in the plant's wastewater, Ashta continued to discharge five pounds of mercury into Lake Erie in 1995 and 1996.171 By 2004, the company had spent another \$6.9 million to eliminate the five pounds of mercury being discharged by installing extra pollution control systems.<sup>172</sup> If Olin had to completely eliminate mercury in its wastewater discharge, it could expect a costly process similar to that of Ashta. This possible cost has not been included in the final tally.

A European study offers additional insight to the costs associated with eliminating mercury in wastewater. The study estimates that a plant could spend between €2 and €3 per metric ton of capacity per year for wastewater treatment associated with mercury contamination. For a plant Olin's size, that would be the equivalent of spending between \$289,000 and \$434,000<sup>173</sup> annually on wastewater treatment in 2006 dollars.<sup>174</sup>

#### Other Considerations

Some have speculated that Olin would close its Georgia facility if required to switch to mercury-free technology.<sup>175</sup> However, such fears may be unfounded since the company recently spent \$4 million to increase its bleach production.<sup>176</sup> The company has said that mercury is not used in bleach production;177 thus, this investment will not be lost if the plant converts to mercuryfree technology. However, while mercury is not needed for bleach production, it is present in some bleach products,178 possibly because chlorine and caustic soda processed from mercury-cell chlorine plants is contaminated with mercury.<sup>179</sup>

#### **FINAL TALLY**

Olin has spent millions of dollars upgrading its Augusta facility, yet the facility still emits hundreds of pounds of mercury into the air every year. Olin could eliminate mercury use at this facility by using membrane-cell technology that also would reduce energy use and increase product capacity. By switching to mercuryfree technology, Westlake Chemicals decreased power consumption by 25 percent and increased capacity of its products by 68 percent; benefits that could be seen by Olin if it chooses to switch its Augusta plant. Eliminating mercury in its chlor-alkali production would be beneficial to Olin's business and the environment.

Cost to Switch:	\$90 million
Costs of Using Mercury	\$1 million
Potential Additional Cleanup	s \$12 million
Benefits (Over 5 years)	
Energy Savings	\$17.6 million
Waste Dísposal	\$2 to 3.3 million
Monitoring	\$2 million
Wastewater Treatment	\$1.4 to 2.2 million
Capacity Increase (Over 5 yea	ars)
Sales	\$98.5 million
Energy Savings	\$4.4 million
	Costs of Using Mercury Potential Additional Cleanup Benefits (Over 5 years) Energy Savings Waste Disposal Monitoring Wastewater Treatment Capacity Increase (Over 5 years) Sales



PPG owns and operates one of the five remaining chlor-alkali facilities in the United States that continue to report emitting hundreds of pounds of mercury pollution annually without committing to stop using mercury. In 2005, PPG's Natrium, West Virginia plant reported pumping 400 pounds of mercury into the air,<sup>180</sup> nearly twice as much as the average power plant.<sup>181</sup> Readily available mercury-free technology, if installed, could benefit the plant dramatically.

#### PROJECTED COST OF SWITCHING

PPG's Natrium, West Virginia facility could be considered a hybrid, with one portion of the plant using mercury and the other portion using mercury-free

technology for chlor-alkali production. The newer portion uses diaphragm technology with an estimated capacity of 297,000 tons of chlorine every year,<sup>182</sup> whereas the older mercury-cell portion has 100,000 tons of chlorine capacity per year.<sup>183</sup> The rest of this section focuses only on the mercury portion of the facility. PPG's history of converting mercury-cell chlorine plants aids in arguing for the conversion of the company's Natrium facility. PPG converted its Beauharnois, Canada plant from mercury-cell chlor-alkali production to mercury-free technology in 1990.<sup>184</sup> Converting the plant in Canada and increasing capacity to 88,000 tons of chlorine per year<sup>185</sup> cost PPG \$40 million,<sup>186</sup> or about \$71.2 million in 2006 dollars.<sup>187</sup>

Although PPG's Natrium facility is larger than its Beauharnois facility was when it converted, costs would not be expected to be significantly more than \$71.2 million. The EPA estimates that it could cost a plant

\$100,000 to \$200,000 per ton per day of chlorine capacity to convert to mercuryfree technology.<sup>188</sup> Adjusting for inflation, the cost of converting PPG's Natrium facility should range between \$43.6 million and \$87.3 million.<sup>189</sup> The \$71.2 million figure falls well within this range.

PPG has converted other facilities at much higher costs. For example, PPG spent nearly \$200 million in the early 1980s to partially install mercury-free technology at its Lake Charles, Louisiana facility<sup>190</sup> (which is now switching completely to the membrane-cell technology at a cost of \$90 million) and at the Natrium, West Virginia plant. Since PPG has spent hundreds of millions of dollars in the past in upgrades, a conversion cost of \$71.2 million should not warrant sticker-shock for the company. Even though this is no small price, the costs associated with not switching the antiquated facility have been mounting in recent years.



STOP SEAFOOD



#### **COSTS OF NOT SWITCHING**

Using mercury has considerable downsides for companies. Here we look back at costs that PPG's West Virginia plant has incurred in the past due to mercury use. If PPG had switched to mercury-free technology in the past, these costs would have been avoided. Since these costs rival the cost of switching itself, they raise the question of whether sticking with mercury has been a good business decision for PPG. They also argue for switching now, since it is possible that additional costs along these lines could come into play in the future.

#### **Pollution Control Costs**

To control air mercury releases, PPG had to install multi-million dollar air pollution controls at its Natrium facility. In 2005, the company announced it had spent nearly \$4 million installing additional emission controls,<sup>191</sup> or \$5 million in 2006 dollars. Unfortunately, even with this technology in place, mercury will continue to be released from the plant.

Mercury from PPG's facility not only affects the land and air, but it contaminates waterways as well. PPG has been in a legal battle since 2005 concerning its mercury discharges into the Ohio River (See Box 1). The West Virginia Environmental Quality Board (EQB) required that PPG reduce mercury discharges into the river; however, the company claimed it could not reach the lower limits and would be forced to close if such a limit was enforced. The company has appealed this decision, hanging the issue up in court.<sup>192</sup> PPG has been involved in similar permit disputes dating back to 1988.<sup>193</sup> Countless hours and dollars have been spent by PPG to allow

the plant to continue to release high mercury loads to the river, though those costs are not included in this analysis.

To get an idea of the possible expense associated with complying with the current permit, we can look to another one of the Filthy Five plants. Ashta's mercury-cell plant in Ashtabula, Ohio was ordered to reduce its mercury discharges to the same level as PPG and spent about \$16.9 million to install technology to eliminate mercury discharges.<sup>194</sup> If PPG is to reduce its mercury discharges into the Ohio River as its permit requires, the company may have to pay for additional pollution controls as Ashta already has done. However, installing similar technology would cost approximately \$27.5 million in 2006 dollars, not to mention the corresponding annual upkeep of nearly \$500,000.195

### Hazardous Waste Treatment and Disposal

Since PPG's waste is contaminated with mercury, it must be treated as a hazardous waste. In 1992, the United States Environmental Protection Agency mandated that the mercurycell chlor-alkali plants could no longer dispose of solid waste containing mercury in regular landfills. Several facilities decided to build mercury reprocessing facilities to avoid shipping and disposal costs associated with using hazardous waste landfills. PPG built a reprocessing facility in Lake Charles, Louisiana, near another chlorine plant owned by the company, which is where its Natrium plant ships its mercury-laden hazardous waste. The reprocessing plant cost \$5 million in the early 1990s<sup>196</sup> (\$8.8 million in 2006 dollars), and processes waste for

the West Virginia plant.<sup>197</sup> Meanwhile, since PPG's chlor-alkali facility in Lake Charles, Louisiana, is converting from mercury to membrane-cell technology, the company may need to continue to operate the reprocessing facility just to treat the waste generated in West Virginia. Conversion of the Natrium facility would eliminate both the treatment and facility operating costs for the company.

#### **Summary of Costs**

By not converting to mercury-free technology, PPG has spent millions of dollars on pollution control systems and fines, while continuing to emit more than 400 pounds of mercury into the air annually. If PPG had paid upfront the reported amounts here, including research, development, building and maintenance of pollution control technology, and waste disposal, it would have spent more than \$13.8 million in 2006 dollars just for these mercury-related expenses. Another nearly \$27.5 million could be facing PPG if the company is required to reduce mercury discharges into the Ohio River. Other costs not included in this estimate include those related to worker safety, energy costs and work time spent on litigation, and mercury permitting. The more-than \$13.8 million spent on upkeep related to mercury use and possible \$27.5 million in additional pollution control would have gone a long way toward paying the \$71.2 million estimated costs to switch to mercury-free technology. That switch would also provide substantial financial benefits to the company, not to mention to the environment and public health.



#### WEST VIRGINIA RIVERS COALITION

SEEKING THE CONSERVATION & RESTORATION OF WEST VIRGINIA'S EXCEPTIONAL RIVERS & STREAMS.

#### **Mercury Pollution Persists**

In 2005, the Appalachian Center for the Economy and the Environment, on behalf of West Virginia Rivers Coalition, appealed a pollution permit issued to PPG Industries, which allowed the company to continue dumping excessive amounts of mercury into the Ohio River – already the company's practice for more than a decade!

In the summer of 2006, the West Virginia Environmental Quality Board (EQB) ordered PPG to immediately comply with stricter limits and use a more sensitive method for detecting how much mercury it is actually releasing into the river.

However, PPG then appealed EQB's order to the circuit court. Unfortunately, the circuit court judge granted a partial "stay" of the EQB's decision, thereby allowing the company to continue releasing excessive levels of mercury into the river, possibly until 2013.

The circuit court's decision to allow PPG to continue releasing levels of mercury above the state's limits followed a decision by the Ohio River Valley Water Sanitation Commission (ORSANCO) making PPG and other companies potentially eligible for a "mixing zone."

ORSANCO, a commission that recommends water quality rules for the Ohio River, had not previously allowed PPG to receive a mixing zone. But, in the fall of 2006, the commission voted to change its mixing zone rules—making PPG potentially eligible for a mixing zone. Mixing zones are areas where higher amounts of mercury and other toxins are released into a river with the expectation that the pollution will become diluted as it moves downstream.

ORSANCO's mixing zone rule change may now allow an unknown number of companies to pollute excessively into the next decade. The commission boldly adopted the new rule without actually knowing how many pollution permits may be affected by the change.

Significant amounts of research indicate that mercury causes serious and widespread health effects.

There are fish consumption advisories for every water body in West Virginia because of mercury contamination. The U.S. Environmental Protection Agency stated that in 2004 PPG released about 1,200 pounds of mercury into the air and more than 30 pounds into the Ohio River.

A recent review of PPG's records indicated that the company is still releasing mercury at high levels; in fact, in August, 2006, the company dumped 47 times the average monthly limit allowed by West Virginia's water quality rules.

WVRC will continue to explore options that will require PPG to become mercury free, or at least become a responsible pollution permit holder. 198

#### **BENEFITS OF SWITCHING**

Based on comparisons with the companies that have switched, PPG could achieve considerable financial benefits by doing so. These include increased fuel efficiency, increased capacity and decreased waste management costs.

#### [ 🗸 ] Energy Savings

Mercury-cell chlor-alkali production consumes tremendous quantities of electricity and is the most energy intensive way to create chlorine and caustic soda. For example, given PPG's estimated size, the mercury portion of the plant consumes the amount of electricity<sup>199</sup> needed to power nearly 25,000 average homes annually,<sup>200</sup> nearly as many homes as in the state's capital, Charleston.<sup>201</sup> Meanwhile, membrane-cell technology is more energy efficient. When PPG's Beauharnois plant converted, it increased energy efficiency by 35 percent.<sup>202</sup> However, an increase in energy efficiency of about 25 percent is typical. Achieving a 25 percent increase in energy efficiency at PPG Natrium would save enough electricity to power more than 6,100 homes. Assuming a 25 percent savings, if PPG were to switch to membrane-cell technology, the company could save nearly \$14.7 million in energy savings over five years.
## [ 🗸 ] Increased Capacity

In addition to increases in energy efficiency, plants tend to increase capacity while installing new membrane-cell technology. When PPG's Beauharnois facility converted, it increased its capacity by 25 percent to 88,000 tons of chlorine per year.203 If PPG were to expand its Natrium facility by a similar percentage to Beauharnois, Natrium would increase its estimated capacity to 125,000 tons of chlorine per year.204 This would result in an estimated increase in sales of \$82.2 million over five years. Even better, because the manufacturing process would be more efficient, PPG would earn \$3.7 million in extra profits over five years from the increased sales due to lower electricity costs.

### [ ✓ ] Eliminating Mercury Waste Management Costs

Besides the hundreds of pounds of mercury emitted to the air from PPG's Natrium plant every year, the plant also has sent thousands of pounds of mercury contaminated waste to landfills and reprocessing plants for disposal. A European study on mercury-cell chlorine plants estimated that a plant about the same size as PPG's could be expected to pay between €300,000 and €500,000 annually in costs associated with disposal of hazardous waste containing mercury,<sup>205</sup> the equivalent of spending between about \$400,000 and \$663,000<sup>206</sup> annually on hazardous waste disposal in 2006 dollars.<sup>207</sup> This comes to \$2 million to \$3.3 million over five years.

### [ / ] Eliminating Mercury Monitoring and Maintenance

Despite PPG's best efforts to reduce mercury emissions, mercury still escapes, posing a threat not only to the environment, but also to the "With the tremendous strides made lately, it is becoming difficult to imagine the construction of any new plants utilizing technologies other than the new membrane cell designs...We will be able to take good advantage of membrane cells in their present state of development."

> Paul J. Kienholz, PPG Industries' chlor-alkali business manager, 1983<sup>213</sup>

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## MORE THAN 20 YEARS LATER, PPG CONTINUES TO USE OUTDATED MERCURY TECHNOLOGY.

workers. While maintaining mercury cells properly can reduce releases, plants still need to monitor mercury levels in various media. This includes testing workers,<sup>208</sup> sometimes weekly.<sup>209</sup> A European study estimates that a plant about the same size as PPG's could be spending €300,000 annually in costs associated with monitoring workers and maintaining mercury cells,<sup>210</sup> the equivalent of spending about \$400,000<sup>211</sup> in 2006 dollars annually.<sup>212</sup> This comes to about \$2 million over five years

## **FINAL TALLY**

PPG already has shown that it has the ability to shift to membrane-cell technology at its Natrium facility as it has done so already at several other plants. Mercury use not only damages the environment and poses a health risk to employees, but it also costs the company by consuming large quantities of electricity and requiring the utmost care in dealing with hazardous waste created in the process. By using the company's own Beauharnois facility as a model, it could be estimated that switching to membrane-cell technology could increase energy efficiency at the Natrium plant by 35 percent and increase capacity by 25 percent. Here we assume only a 25 percent increase in energy efficiency. Until PPG converts its Natrium facility to mercuryfree technology, hundreds of pounds of mercury will continue to be emitted into the air annually and thousands of dollars will continue to be spent unnecessarily to maintain a wasteful technology.

Cost to Switch:	\$71.2 million	
Costs of Using Mercury	\$13.8 míllíon	
Potential Water Treatment Bill	\$27.5 million	
Benefits (Over 5 years)		
Energy Savings	\$14.7 million	
Waste Dísposal	\$2 to 3.3 million	
Monitoring	‡2 míllíon	
Capacity Increase (Over 5 years)		
Sales	\$82.2 million	
Energy Savings	\$3.7 million	

# **ERCO WORLDWIDE**

## Port Edwards, Wisconsin

ERCO Worldwide operates one of the last five mercury-cell chlor-alkali plants in the United States that has not committed to stop using mercury. While

the company is owned by Superior Plus Income Fund, based in Calgary, Canada, ERCO itself is based in Toronto and this plant is located in Port Edwards, Wisconsin. In 2005, this facility reported emitting 1,118 pounds of mercury into the air,<sup>214</sup> and the company readily admits it is the largest source of mercury pollution in Wisconsin.<sup>215</sup> The plant emits more than a guarter of Wisconsin's mercury air pollution.<sup>216, 217</sup>

## **PROJECTED COST OF SWITCHING**

Despite the large quantity of mercury the company reported releasing from the plant, ERCO's Port Edwards facility is the second smallest chloralkali plant still using mercury in the United States. With an estimated

chlorine production capacity of 97,000 tons per year, ERCO's plant is slightly larger than Ashta Chemical's facility in Ohio.<sup>218</sup> Unlike the other four plants, comparison of the ERCO facility to another, already converted, chlor-alkali plant is unnecessary. The facility already spent nearly \$1 million on a feasibility study to determine how to switch from mercury-cell to mercury-free technology and some of the results from this study have been made available to the public.<sup>219</sup> While ERCO was prepared to invest between \$50 million and \$100 million for membrane-cell technology, the actual cost of the conversion was estimated to be closer to \$85 million.<sup>220</sup>

The \$85 million conversion proposal was dependent on a special electric rate and approval of the company's board, but the plant did not receive the special electric rate and its board has not yet

approved the conversion.<sup>221</sup> There are a number of possibilities ERCO could explore to reduce expenses related to energy consumption that could allow it to convert. Even if ERCO does not receive a preferential electricity rate, the plant would still save money due to the increased energy efficiency and increased capacity, and should still proceed with a conversion to mercury-free technology.

# COSTS OF NOT SWITCHING

The Port Edwards plant has had four different owners since it was built, making it difficult to compare past mercury-related expenses that ERCO has incurred, to the costs of switching, as we have for the other companies. In 2005, ERCO Worldwide, a subsidiary of Superior Plus, purchased the chlor-alkali plant in Port Edwards from Occidental Petroleum Corporation.<sup>222</sup> Occidental

ORT EDWARDS PLAN

STOP

purchased the plant from Vulcan Chemicals in 2004.<sup>223</sup> Vulcan Chemicals purchased the facility from BASF Wyandotte Corporation in 1980.<sup>224</sup> The facility was built in 1967.<sup>225</sup> The high turnover rate for this facility makes it difficult to attribute upgrades and violations of environmental regulations to the present owner.

#### **Pollution Control Costs**

ERCO estimates that it will need to spend \$5 million to comply with new air requirements going into effect in December, 2007.<sup>226</sup> The new requirements only mandate that ERCO reduce its mercury air emissions by 30 to 40 pounds of mercury per year which means the plant is likely to remain the largest mercury polluter in the state.<sup>227</sup> Switching to mercury-free technology, however, could prevent ERCO from paying for these controls that will not pay for themselves.

#### **BENEFITS OF SWITCHING**

Based on comparisons with the companies that have switched, as well as ERCO's own analysis, the company could achieve considerable financial benefits from switching. These include increased energy efficiency, increased capacity, and decreased waste management costs.

## [ 🗸 ] Energy Savings

Energy is consumed at staggering rates in the chlor-alkali industry, and the ERCO plant is no exception. The company has stated that it consumes about 270,000,000 kilowatt-hours of electricity annually.228 In fact, ERCO's Port Edwards plant consumes enough electricity to power more than 25,300 average homes annually,229 or a city nearly the size of Oshkosh, Wisconsin.230 Membrane-cell technology would increase energy efficiency by 30 percent, according to the company. Such an improvement in energy efficiency would save enough energy to power 7,600 homes, the equivalent of a small town in Wisconsin. Since electricity accounts for such a large proportion of a plant's operating costs,<sup>231</sup> switching to energy efficient technology could help stabilize everincreasing electrical costs. If ERCO were to switch to membrane-cell technology, the company could save nearly \$20 million in energy savings over five years.

## [ 🗸 ] Increased Capacity

Another way ERCO expected to increase the profitability of conversion was to increase capacity at the plant. While upgrading to membrane-cell technology, ERCO planned to increase capacity at their facility by 20 to 30 percent,<sup>232</sup> which would lead to a capacity of 116,000 to 126,000 tons of chlorine per year. In doing so, the company would be diversifying the plant to maximize profitability through energy savings and increased selling power. An increase in ERCO's capacity of 25 percent would increase sales by nearly \$83.2 million over five years. Even better, because the manufacturing process would be more efficient. ERCO would earn \$4.9 million in extra profits over five years due to savings in electricity.

## [ 🗸 ] Eliminating Mercury Waste Management Costs

Besides the hundreds of pounds of mercury emitted into the air from ERCO's Port Edwards plant every year, the plant also has sent thousands of pounds of mercurycontaminated waste to landfills and reprocessing plants for disposal. A European study on mercury-cell chlorine plants estimated that a plant about the size of ERCO's could be expected to pay between €300,000 and €500,000 annually in costs associated with disposal of hazardous waste containing mercury<sup>233</sup> the equivalent of spending between \$400,000 and \$663,000<sup>234</sup> annually on hazardous waste disposal in 2006 dollars.235

#### [ ✓ ] Eliminating Mercury Monitoring and Maintenance

Despite ERCO's best efforts to reduce mercury emissions, mercury still escapes – posing a threat not only to the environment, but also to the workers. While maintaining mercury-cells properly can reduce releases, plants still need to monitor mercury levels in various media. This includes testing workers.236 sometimes weekly.237 A European study estimates that a plant about the same size as ERCO's could be spending €300,000 annually in costs associated with monitoring workers and maintaining mercury cells,<sup>238</sup> the equivalent of spending about \$400,000239 in 2006 dollars annually.240

#### [ 🗸 ] Eliminating Wastewater Treatment for Mercury

Besides emitting mercury into the air, mercury-cell chlorine plants generally also discharge the chemical into nearby waterways.<sup>241</sup> One of the Filthy Five, Ashta Chemicals, was required to invest in additional controls at a considerable cost. Ashta developed new technology to remove mercury from its wastewater in 1993 at a cost of \$10 million;<sup>242</sup> however, even this technology did not eliminate all of the mercury in the plant's wastewater, Ashta continued to discharge five pounds of mercury into Lake Erie in 1995 and 1996.<sup>243</sup> By 2004, the company had spent another \$6.9 million to install additional wastewater treatment systems to eliminate its mercury releases.<sup>244</sup> If ERCO had to completely eliminate mercury in its wastewater discharge, it could expect a costly process similar to that of Ashta. This possible cost has not been included in the final tally.

A European study offers additional insight to the costs associated with eliminating mercury in wastewater. The study estimates that a plant could spend between  $\in 2$  and  $\in 3$  per metric ton of capacity per year for wastewater treatment associated with mercury contamination. For a plant ERCO's size, that would be the equivalent of spending between more than \$234,000 and \$351,000<sup>245</sup>

Cost to Switch:	\$85 million
Costs of Using Mercury	\$5 míllíon
Benefits (Over 5 years)	
Energy Savings	\$19.8 million
Waste Dísposal	\$2 to 3.3 million
Monitoring	\$2 million
Wastewater Treatment	\$1.2 to 1.8 million
Capacity Increase (Over 5 years)	
Sales	\$83.2 million
Energy Savings	\$4.9 million

annually on wastewater treatment in 2006 dollars, or \$1.2 to \$1.8 million over five years.<sup>246</sup>

## **FINAL TALLY**

ERCO is a company which has itself advocated a shift to mercuryfree technology. Mercury use not only damages the environment and poses a health risk to employees, but it also costs the company by consuming large quantities of electricity and requiring special care in dealing with hazardous waste created in the process. The company's own analysis shows that the plant

could be saving millions of dollars annually from reduced electrical consumption as well increasing sales of its products. Until ERCO converts its facility to mercury-free technology, hundreds of pounds of mercury will continue to be emitted into the air annually and thousands of dollars will continue to be spent unnecessarily on a wasteful technology.

STOP

# CONCLUSION

If the Filthy Five were to convert to mercury-free technology, reported mercury releases to the air would decrease by more than two tons every year. Additional, unreported releases also would be eliminated. While these companies have collectively spent tens of millions of dollars to clean up their acts, hundreds of pounds of mercury are still being dangerously emitted every year. Fortunately, mercury-free technology readily exists and is not only good for the environment, but good for business as well. Previously converted plants similarly-sized to the Filthy Five have increased energy efficiency as much as 37 percent, increased capacity as much as 80 percent, decreased hazardous waste by 94.5 percent, reduced employee health risks, improved corporate image and eliminated thousands of pounds of reported mercury air releases every year.

When a plant does make the shift, it is important that any contamination in the area is cleaned up in a manner that protects public and environmental health. Mercury that is no longer needed should be permanently stored in a secure facility to prevent release, and should not be exported or sold. The Filthy Five should follow the lead of the 115 plants that are already on the right track, to eliminate mercury in their processes for the benefit of their business, public health, and the environment.

# "MERCURY GRADE" CAUSTIC IS UNNECESSARY

## THE USES OF CAUSTIC SODA

Industry sources have argued that it is necessary to continue to use mercury cells because the other two production methods make caustic soda of insufficient purity for the production of rayon.<sup>247</sup> Caustic soda is used in a wide variety of products and processes, such as soap and bleach manufacturing, textiles, oil drilling, petroleum refining, water treatment (pH regulation and regeneration of ion exchange resins), aluminum production, and pharmaceuticals. Even agricultural fertilizers can be created from or benefit from the use of caustic soda.<sup>248</sup>

While chlorine quality is not as variable, each of the three production methods – mercury, diaphragm, and membrane – produces caustic with slightly different qualities. All three grades of caustic soda are fairly transferable for most uses. Caustic made using mercury, as we discuss below, does tend to have the lowest salt content. However, it is also the only variety that is contaminated with mercury. Products manufactured using caustic soda from mercury-cell chlor-alkali may contain trace levels of mercury as well. This can be especially problematic for the consumer using the products, and it can also result in mercury releases from the plants that purchase this type of caustic soda.

"The mercury cell produced Caustic Soda is typically referred as Mercury Cell Grade, or more commonly, Rayon Grade. Most production of rayon fiber is dependent on the availability of the high purity Rayon Grade Caustic Soda solution. Another very common use of this high purity caustic solution is for DI water exchangers. The DI unit resin literature often specified Rayon Grade Caustic Soda only for regeneration. One must remember that this literature was published prior to the availability of membrane cell produced solutions."

-Quote from Olin Corp.'s website indicating the "need" for Rayon-grade Caustic Soda.249



OLIN FAILS TO MENTION RAYON IS NO LONGER PRODUCED IN THE UNITED STATES.







## Mercury-Cell Caustic Soda

Mercury-cell chlor-alkali plants produce what is called "Rayon-grade" caustic soda. This is considered to be the highest grade of the chemical because it has low salt content, below 50 parts per million (ppm).<sup>250</sup> It also contains traces of mercury (up to 1 ppm in some cases) due to the use of mercury in its production.<sup>251</sup> This type of caustic soda is commonly referred to as rayon-grade because it is used in the production of the human-made fiber, rayon. Rayon-grade caustic soda is the most expensive type of caustic soda to produce,<sup>252</sup> and is typically the most expensive to purchase.<sup>253</sup>

## Membrane-Cell Caustic Soda

Membrane cells create "membrane-grade" caustic soda. Membrane-grade is the cheapest grade to produce,<sup>254</sup> and is usually less expensive than rayongrade caustic soda.<sup>255</sup> Membrane-grade caustic soda usually contains higher levels of salt (up to 100 ppm in some facilities).<sup>256</sup> Some processes have been known to use both rayon-grade caustic soda and membrane grade caustic soda interchangeably. Other processes have replaced rayon-grade with membranegrade caustic soda due to the excessive levels of mercury in the mercury-cell product. Membrane-grade, of course, contains no mercury.

## Diaphragm-Cell Caustic Soda

The lowest quality of caustic soda by far is created from diaphragm cells. "Diaphragm-grade" caustic soda is slightly more expensive to produce than membrane-grade caustic soda<sup>257</sup> and is usually the least expensive to purchase.<sup>258</sup> Salt content is quite high in this product (up to 1.1 percent of total weight, or 11,000 ppm) and the product is so weak that it must be concentrated prior to use.<sup>259</sup> An extra step can be used to reduce salt in diaphragm-grade caustic soda resulting in a "purified grade" of caustic soda which still has significant amounts of salt in the product (about 0.2 percent of total weight in some facilities.) Of course, caustic soda produced using a diaphragm cell does not contain mercury.<sup>260</sup>

## MEMBRANE-GRADE IS THE NEW "RAYON-GRADE"

Membrane-grade caustic soda is increasingly replacing rayon-grade caustic because of its high quality, lower price, and lack of mercury contamination. Its near-universal use virtually eliminates the need for mercury-cell chlor-alkali facilities. The suggestion that "mercury-grade" caustic is needed for rayon production is difficult to justify, considering the global trends in the use of membrane quality caustic.

#### **Rayon Production**

Rayon, the first fiber manufactured by humans, is created by taking cellulose from wood pulp and treating it with caustic soda. Few impurities (salt and other minerals) are tolerated, as they may sacrifice the quality of rayon produced. Quality rayon is used to create a variety of products, including yarns, fabrics, textiles, apparel, and even tires, conveyer belts, and hoses.<sup>261</sup>

Despite the fabric's ability to be used in many applications, it has fallen out of favor in the global fabric market. In recent years, global synthetic fabric (such as nylon and polyester) production has been steadily increasing at the expense of rayon production, which has consistently been decreasing by about 2 percent per year from 1978 to 2002.<sup>262</sup> Even though nylon and polyester are more popular than rayon, they may not fully substitute for rayon. It is argued now, however, that acetate filament yarn is a viable substitute for rayon yarn.<sup>263</sup>

In the United States, rayon manufacturing began with the American Viscose Company in 1910.<sup>264</sup> The last textile rayon manufacturer in the United States closed in 1997,<sup>265</sup> and all rayon production ended in the United States in 2005.<sup>266</sup> Currently there are no rayon producers in the United States, suggesting that rayon-grade caustic soda has a limited market in the U.S.<sup>267, 268, 269</sup>

Cellulose used in rayon production is made in the United States and this process is likely still using mercury-grade caustic soda . For instance, Rayonier Inc. in Jesup, Georgia, produces cellulose fibers used in "high-tenacity rayon yarn for tires and industrial hoses," among other applications. Other uses for Rayonier's fiber include cigarette filters, medicinal purposes, food castings, and cosmetics. According to the company, nearly 60 percent of its products are exported to Asia, Europe, and Latin America.<sup>270</sup>

Rayonier releases surprising levels of mercury from its processes. The plant reported emitting 15 pounds of mercury into the air and 18 pounds of mercury into the Altamaha River in 2005.<sup>271</sup> This mercury may be the result of contamination of the company's caustic soda, suggesting that it might have been purchased from one of the Filthy-Five. The plant is located less than 200 miles from Olin's Georgia facility. If caustic is the source of the problem, it is an



easy one to solve because further evidence suggests that the entire rayon-making process can be done with membrane grade caustic.

## Rayon Producers in India use Membrane-Grade Caustic

India, the source of 20 percent of United States rayon imports, demonstrates that membrane grade caustic soda can be used to make rayon. India has the second highest rate of membrane-cell chloralkali capacity in the world, behind Japan. Nearly 82 percent of chloralkali products are manufactured using mercury-free membranecell technology in India.<sup>272</sup> The country reports that it is phasing out mercury-cell chlor-alkali plants by 2012.<sup>273</sup>

Currently, at least six membranecell chlor-alkali facilities in India are producing "rayon-grade" caustic soda without using mercurycell technology. Indian Rayon, Tata Chemicals, Century Rayon, Gujarat Alkalies, Travancore Cochin Chemicals, and Grasim have built membrane-cell chloralkali facilities that produce caustic soda for production at their own rayon facilities or to be sold to other companies, including rayon producers.<sup>274</sup>

- Tata Chemicals commissioned a new membrane-cell chloralkali facility in 2001 with technology from Italy to "produce rayon grade caustic soda, liquid chlorine, hydrochloric acid, and sodium hydrochloride."<sup>275</sup>
- Gujarat Alkalies and Chemicals Limited makes "ultra high purity caustic soda" using membrane-cell technology at their Dahej, India facility for many manufacturing uses, including rayon production.<sup>276</sup>
- Travancore Cochin Chemicals Limited shut down its mercurycell chlor-alkali facility in Kerala, India, and upgraded to membrane-cell technology at the same site. The plant now produces "rayon grade caustic soda," according to the Indian government.<sup>277</sup>
- Grasim is a world leader in rayon production, representing nearly 23 percent of the global market share.<sup>278</sup> The company operates a membrane-cell chlor-alkali plant in Nagda, India, and considers the caustic soda to be rayon-grade.<sup>279</sup>
- Indian Rayon and Industries Limited built its membranecell chlor-alkali facility in 1997 and according to the Indian government, "30 percent of caustic soda is for self-consumption and [the] remaining is for sales."<sup>280</sup>
- Century Rayon's facility in Kalyan is the biggest rayon facility in India<sup>281</sup> and recently expanded its membrane-cell chlor-alkali plant to produce 57 percent more caustic soda.<sup>282</sup>

Although it is not clear whether all of these facilities started out using mercury-cell technology, they are clearly producing caustic soda that is of sufficient quality for making rayon without using mercury.<sup>283</sup>

Given that there are no rayon manufacturers in the United States and that rayon is being made with membrane grade caustic soda elsewhere in the world, there is little reason for the Filthy Five to continue using mercury in their processes. Additionally, there are many processes where it has been necessary to stop using mercurytainted caustic soda and it has been replaced by mercury-free alternatives to prevent mercury contamination in the final product or in the waste streams.

### HOUSEHOLD PRODUCTS

Caustic soda is used to produce a wide variety of products. Unfortunately, products made using caustic soda from mercurycell plants may end up containing some level of mercury. Household products that are made directly with caustic or use caustic soda in a part of their production include bleach, toothpaste,<sup>284</sup> soap, shampoo,<sup>285</sup> drain cleaners,<sup>286</sup> and even soft drinks.<sup>287</sup> Each of these may contain trace amounts of mercury (See Table 4).<sup>288</sup> While there may be other sources of mercury contamination for some of these products, it is worth investigating the sources of mercury, especially since caustic soda from mercury-cell plants is known to be contaminated and is so easily replaced with a mercury-free alternative.

STOP SEAFOOD CONTAMINATION

PRODUCT	MERCURY LEVEL (PPB)
Soap/Shampoo	25
Bleach	6.17
Soft Drinks/Drink Mixes	6.07
Toothpaste	3.8
Laundry Detergent	2.49
Toilet Tissue	1.5

#### [TABLE 4] Mercury is found in many household products.

Source: Adapted from National Association of Clean Water Agencies. 289

#### Bleach

While bleach itself is not made with mercury, it is produced by mixing caustic soda (NaOH) with chlorine (Cl), both of which may be contaminated with mercury. When these chemicals are produced in mercury-cell chlor-alkali plants, some trace amount of mercury is left in the final bleach product. Boston University's Mercury Wastewater Reduction Program identified a number of products that contain mercury as a contaminant, including bleach and laboratory reagents.

Not surprisingly, some bleaches are mercury-free. These are likely made with chlor-alkali products from mercury-free plants. Other bleaches contain elevated levels of mercury, indicating they may be made from products from mercury-cell chlor-alkali plants. Boston University's Mercury Wastewater Reduction Program found that "germicidal" Clorox bleach contains about 136.2 ppm mercury and Clorox Ultra bleach contains 6.63 ppm mercury, whereas Austin's A-1 Bleach and Spectrowax Elite Bleach are guaranteed to be mercury-free.<sup>290</sup> The Program is designed to reduce laboratory related mercury discharges, particularly from pouring products like bleach down drains. However, since bleach is a popular household product for cleaning sinks, toilets, and clothes, there is no doubt mercury from bleach is making its way into water sources. By eliminating mercury use at chlor-alkali plants, this source of water pollution could be eliminated.

#### Paper Mills

Like rayon production, paper production uses caustic soda to extract pulp from wood. Nearly 20 percent of all United States caustic soda production goes to the pulp and paper industry.<sup>291</sup> Although caustic soda is filtered to remove mercury prior to being sold, trace amounts remain. Effluent from paper mills occasionally contains trace amounts of mercury, possibly from sources other

than caustic soda (such as sulfuric acid),<sup>292</sup> but rayon-grade caustic soda undoubtedly contributes to mercury releases from these plants.

Some paper mills have documented increased discharges of mercury from wastewater systems and have switched to using caustic soda produced by mercury-free chlor-alkali plants. For example. a paper mill concerned about mercury pollution, International Paper's Erie Facility, looked into the manufacturing process of the caustic soda it was purchasing. The company concluded that the caustic soda was not made using the mercury process, suggesting that the paper production does not require mercury-grade caustic soda.<sup>293</sup> Potlatch Corporation (another paper company) similarly does not use caustic soda from mercury-cell chlor-alkali plants in its Cloquet, Minnesota facility.294 At this plant, mercury discharges had increased in conjunction with an increase in caustic soda use in the water treatment system. Upon further research, the caustic soda used was found to be produced at a mercury-cell chlor-alkali facility. It contained mercury levels between 74 ppb and 89 ppb.<sup>295</sup> The paper mill replaced its mercury-cell caustic soda with membrane-grade caustic and subsequently reduced its mercury discharges. Not only does this example show that paper mills do not need mercury-grade caustic soda, but also that they are actually better off without it.

"By eliminating mercury use at chlor-alkali plants, mercury levels in household products could be reduced."



### Water Treatment

Mercury-grade caustic soda is also known for its use in water treatment to regulate pH levels, soften water, neutralize effluent from sewage treatment, and regenerate ion membranes.<sup>296</sup> Unfortunately, trace levels of mercury can be left in treated water from contaminated caustic soda produced at mercurycell plants. When mercury from caustic soda makes its way into aquatic systems, it can result in human exposure, usually through fish consumption.

Fortunately, mercury-grade caustic soda is not necessary in water treatment. The State Line Power Station in Indiana had been using mercury-grade caustic soda to treat its wastewater. After switching to membrane-grade caustic soda, the power station saw about a 50 percent reduction in the mercury discharge from its wastewater.<sup>297</sup> It is unclear how many other power stations have switched to membrane-grade caustic soda for similar reasons.

## Caustic Potash (KOH)

Several of the Filthy Five produce a chemical called potassium hydroxide, or caustic potash. Olin's Tennessee plant, Ashta's Ohio facility, and ERCO Worldwide's Wisconsin plant have a cumulative estimated capacity of 323,200 tons of caustic potash per year, with Olin's plant representing about half of this amount.<sup>298</sup> Caustic Potash has many end uses, including creating potassium carbonate (used in glass manufacturing), manufacturing pharmaceuticals, fertilizers, soaps, pesticides, batteries, and photographic products. Caustic potash made from mercury-cell chlor-alkali plants may contain levels of mercury up to three times higher than caustic soda produced in mercury cell plants, putting its end uses at risk of mercurv contamination.<sup>299</sup> Due to the nature of the products created using caustic potash, there is potential for elevated mercury levels on land, in water, and even in people.



## The End of "Rayon-Grade" Caustic Soda?

Membrane-grade caustic soda is replacing so-called "rayon-grade" caustic soda, even for a process that is said to require the highest purity of caustic soda: rayon production. As shown in this report, there are few, if any, manufacturing or end purposes that still require rayon-grade caustic soda. There are no rayon manufacturers in the United States and water treatment can be done with other grades of caustic soda. For those still making rayon, mercury-grade caustic soda is being replaced in many cases by high quality membrane-grade caustic soda. Since mercury-grade caustic soda contains trace amounts of mercury, the use of this product contributes to mercury pollution problems, whereas membrane grade caustic soda prices are so similar that customers purchasing mercury-grade caustic soda can easily substitute it for membrane-grade caustic soda without seeing higher costs.<sup>300</sup> By switching to mercury-free technology, the Filthy Five could produce high quality caustic soda while protecting public health and the environment.

# CONCLUSION

This report concludes that shifting to mercury-free technology is achievable and that the continued use of mercury and release of mercury to air, water and land are entirely unnecessary. Further, it shows that shifting to membrane-cell technology is feasible and in fact has been done by a large number of facilities. Mercury-grade caustic, which the industry claims is a reason to continue using and releasing mercury, turns out to be unnecessary as well.

Based on this analysis, Oceana recommends that the five remaining mercury based facilities considered in this report immediately commit to shifting to mercury-free technology to put an end to the use of this antiquated and harmful technology.

# **Appendix: Methods**

Estimates in this report are designed to provide a conservative look at the costs and benefits of shifting to membranecell technology. Below are explanations of estimation methods and assumptions made. The authors would be happy to discuss this approach with anyone interested.

### **Costs and Benefits Figures**

Due to the international context of this report, some financial data in this report come from international sources. All amounts reported in foreign currencies were converted to and are represented as United States Dollars based on the exchange rate at the date that the figure was published.

Prices associated with installation of technology have been adjusted for inflation to 2006 dollars, where stated in the report, using the Bureau of Labor Statistics Producer Price Index.<sup>301</sup> Fines paid for violations and costs of operations have been adjusted for inflation to 2006 dollars using the Bureau of Labor Statistics Inflation Calculator, which is based on the Consumer Price Index.<sup>302</sup>

### **Electrical Cost Estimates**

Estimation of energy cost savings is challenging as special electric rates may apply to these facilities since they are such large electric consumers. Rates granted by local utility companies are extremely difficult to determine, if they are even available to the public at all. Additionally, some plants produce a portion of their own electricity,<sup>303</sup> complicating such estimation. In spite of these variables, it is possible to place an estimated dollar figure on the cost savings from energy efficiency which helps to demonstrate the magnitude of benefits afforded by a switch to membrane-cell technology. The following equation was used to estimate electrical costs prior to converting to membrane-cell technology:

#### Capacity x Operating Rate x Power per Unit Chlorine x Cost per Unit Power = Total Cost

**Capacity** – This variable is simply the capacity in electrochemical units (ECU) of the plant being considered. These values are reported by chlor-alkali companies and other industry sources.<sup>304</sup>

**Operating Rate** – Currently, operating rates in the chlor-alkali industry are fairly high, thus we assume a 90 percent operating rate in making cost estimates for the future.<sup>305</sup>

**Power per Unit of Chlorine Produced** – For this purpose, we assume that it takes approximately 2.9 MWh (2,900 kWh) of electricity per ton of chlorine capacity.<sup>306</sup> However, this assumption is likely to be low, considering that Olin's own website claims that it takes 3,600 kWh (3.6 MWh) to create one metric ton of caustic soda (or about one ton of chlorine).<sup>307</sup> Since this figure is approximately 24 percent higher than the assumed cost, it is possible that electrical costs and savings from increased efficiency are considerably higher than reported here.

**Cost per Unit of Power** –Additionally, we assume a \$45 per MWh cost for electricity, based on an electric rate request from ERCO Worldwide.<sup>308</sup> However, this figure is likely to be an underestimate as well. ERCO Worldwide requested this special electric rate to replace their current electric rate of \$49 per MWh;<sup>309</sup> which is obviously higher than the amount we assumed. Similarly, the national average electricity cost for manufacturers according to the Department of Energy is \$57.30 per MWh (5.73 cents per kWh),<sup>310</sup> again much higher than what we assumed. SRI consulting also cites U.S. electric costs in the \$50 range.<sup>311</sup>

Due to the use of conservative assumptions in both the power per unit of chlorine produced, and the cost per unit of power to estimate the benefits of switching, the actual benefits could be much higher than what is estimated here.

In addition to this approach, every effort was made to find and use actual industry reported electrical use figures. Where such reports were found, as in the cases of ERCO, those figures were used instead of this calculation.

### **Energy Cost Savings Estimates**

An increase in energy efficiency of 25 percent per unit is typical and has been assumed to determine cost savings for four of the five facilities. However, companies shifting to membrane-cell technology have observed increases in energy efficiency ranging from 25 percent to as high as 37 percent. ERCO conducted an economic analysis of its conversion to membrane-cell technology in which it anticipated a 30 percent increase in energy efficiency. The 25 percent figure is applicable to the greatest number of facilities and appears to be, again, a conservative choice.

Cost savings determined using this approach are not guaranteed, but can be used to estimate possible savings. The actual savings are likely to be higher due to the conservative assumptions made.

#### Capacity, Capacity Increases and Increased Product Sales

To estimate the benefits of potential increases in capacity, the original plant capacities were determined from chloralkali companies as well as industry sources.<sup>312</sup> Plant capacities reported in terms of caustic soda were converted into estimated tons of chlorine per year for comparison purposes using the ratio of one ton of chlorine is produced for every 1.1 tons of caustic soda.<sup>313</sup> Additionally, all weights reported in metric tons were converted to short tons (tons) using the ratio of 1 metric ton to 1.1023 tons.<sup>314</sup>

Estimated increases in product sales are based on an assumed capacity increase, an assumed operating rate for the plant, and the current price of chlorine, caustic soda, and caustic potash as follows:

#### Increased Sales of Chemical = Increased Capacity of Chemical x Operating Rate x Price per Ton

This is estimated for the three primary chemicals produced, chlorine, caustic soda, and caustic potash. The three estimates are then added to get the final additional sales figure.

**Increased Capacity** – For the purposes of this report, we consider the benefits of a 25 percent capacity increase for all plants except for Olin, Tennessee. Plants shifting to membrane-cell technology from mercury-cell technology have increased their capacities as much as 80 percent. However, 25 percent is the most common increase seen as shown in the report. Actual expansions may be larger or smaller and the benefits would vary accordingly. In the case of Olin, Tennessee, due to the size of the plant, we chose a more conservative expansion so as not to over-state the benefits. In Olin's case we looked at the benefits of a 10 percent expansion at the Tennessee plant.

**Operating Rate** – Currently, operating rates in the chlor-alkali industry are fairly high, thus we assume a 90 percent operating rate in making cost estimates for the future

**Price per Ton** – Here we estimate the price of each product based on current pricing trends. We assume \$335 per ton of chlorine, \$360 per ton of caustic soda,<sup>315</sup> and \$14 per hundredweight (cwt) for caustic potash<sup>316</sup> or \$280 per ton based on industry reports. While prices of these products do vary, these prices are not highs for any of the commodities and are at the low end of recent prices. Additionally, this approach allows an estimate of increased sales due to plant expansion assuming current market conditions. Despite probable increases in prices, the lower reported prices provide conservative estimate of possible sales.

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