Toxics Use Reduction and Resource Conservation:
Competitiveness Impacts for Massachusetts Businesses

Massachusetts Toxics Use Reduction Institute (TURI) and
Massachusetts Office of Technical Assistance and Technology (OTA)

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The Toxics Use Reduction Institute is a multi-disciplinary research, education, and policy center established by the Massachusetts Toxics Use Reduction Act of 1989. The Institute sponsors and conducts research, organizes education and training programs and provides technical support to help Massachusetts companies and communities to reduce the use of toxic chemicals.

The Massachusetts Office of Technical Assistance and Technology (OTA) provides a range of free, non-regulatory, confidential assistance services to Massachusetts businesses. OTA is staffed by chemists, engineers and public health experts who can assist businesses in pollution prevention and toxics use reduction.

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Toxics Use Reduction and Resource Conservation: Competitiveness Impacts for Massachusetts Businesses

Introduction

The Massachusetts Toxics Use Reduction Act (TURA) program works with Massachusetts businesses and communities to reduce the use of toxic chemicals. The TURA program is designed to help protect workers, public health, and the environment while also promoting the competitiveness of Massachusetts businesses.

The economic benefits of pollution prevention in general, and of TURA program activities in particular, have been documented in a variety of publications.[1] This overview summarizes and updates selected TURA program resources on the business impacts of toxics use reduction and resource conservation.

Many businesses are saving on their annual operating costs as a direct result of toxics use reduction or resource conservation efforts. There are also cases in which businesses choose to make changes that actually increase their annual operating costs. This document presents examples of both experiences, notes the individual business factors that have influenced their decisions, and considers the competitiveness benefits these businesses have experienced.

This overview includes information about very small, family-owned businesses, small to medium-sized businesses, and multinational businesses with thousands of employees. It includes a number of sectors, ranging from local, service-oriented sectors such as garment cleaning and auto repair to manufacturing sectors such as coatings and plating formulations, biotechnology and medical devices, and electronics.

TURA is implemented jointly by three entities: the Massachusetts Department of Environmental Protection (MassDEP), the Office of Technical Assistance and Technology (OTA), and the Toxics Use Reduction Institute (TURI). Both OTA and TURI provide a variety of services to help Massachusetts businesses reduce their use of toxic chemicals. OTA provides on-site, confidential technical assistance to businesses. TURI provides services including training, research, grant programs, demonstration events, and laboratory and library resources. The businesses highlighted in this report have worked with OTA and TURI in a variety of ways; some have received grants, some have been involved in collaborative research projects, and many have been showcased in a demonstration event or a TURA program case study. This document provides additional information on these businesses' experiences with the competitiveness impacts of toxics use reduction.

Garment Cleaning

Beginning in 2008, TURI began providing an average of one to two grants per year to small, family-owned garment cleaning businesses, making it possible for them to invest in professional wet cleaning equipment and eliminate the use of the toxic solvent perchloroethylene.

Based on the experiences of a number of garment cleaners in California that had made the switch[2], TURI expected that the Massachusetts cleaners would benefit financially as well as enjoying a safer, healthier working environment. To test this hypothesis, TURI worked with each of these small

businesses to assess costs before and after the conversion to professional wet cleaning.

TURI conducted a formal financial analysis for five of these cleaners. Based on this analysis, over a 15-year period, the net present value associated with the investment in wet cleaning ranged from just over $28,000 to just under $475,000.[3] Table 1 shows the change in resource costs and operating costs and the 15-year net present value of the financial benefits enjoyed by each facility.

Table 1: Capital Investments, Savings, ROI and 15-year NPV at five garment cleaning facilities

Facility	Capital investment[b]	Savings - annual labor costs	Savings - monthly operating costs	Savings - monthly resource costs	ROI/ ROI discounted[d]	15 year NPV
SH[a]	$51,880	$26	($432)[c]	$414	4.3/2.6	$136,725
Ace	$33,981	$5,835	$181	($81)[c]	2.6/1.4	$48,715
K&Q	$63,146	$5,134	$80	$86	1.0/0.3	$28,084
AB	$33,512	$2,053	$425	$429	5.3/3.3	$111,074
KMK	$38,151	$22,047	$683	$1,083	18.8/12.4	$474,577
Average					**5.7/3.6**	**$159,835**

Source: Onasch J, Jacobs M, Biddle E. 2017. "From Perchloroethylene Dry Cleaning to Professional Wet Cleaning: Making the Health and Business Case for Reducing Toxics." *Journal of Environmental Health* 79:6 (January/February 2017 E-Journal Bonus Article).

[a] This facility experienced savings of about $1,400 per month on claims for damaged garments.

[b] These investments were offset by TURI grants of: $18,000, $17,000, $17,000, $8,500, and $15,000, respectively. However, the TURI grant is not factored into the calculation of ROI and NPV.

[c] Parentheses denote a cost increase.

[d] Discount rate set at 5%.

Decorative Chrome Plating

The market for decorative chrome plating in the United States has declined as manufacturing has shifted overseas. Some Massachusetts businesses have been able to weather changing global markets in part through the strategic application of toxics use reduction techniques.

Two Massachusetts businesses that perform decorative chrome plating used toxics use reduction techniques to reduce their use of hexavalent chromium, a known human carcinogen. One adopted a modernized plating line for hexavalent chromium and nickel, along with a number of other facility upgrades, and experienced substantial savings. The other made a variety of changes that reduced toxic chemical use, including the addition of a trivalent chromium plating line. Some costs rose while others declined; over all, the changes yielded savings and improved competitiveness.

Columbia Manufacturing[4] in Westfield, MA, manufactures furniture for use in schools. In 2001, Columbia undertook a major facility upgrade, installing a new plating line as well as a closed-loop water treatment system. These changes vastly increased Columbia's efficiency, yielding large reductions in the use of hexavalent chromium and nickel compounds and saving 147,000 gallons of water per day. The changes also tripled Columbia's plating capacity, enabling the facility to remain competitive nationally. Business representatives credit these improvements with keeping Columbia Manufacturing in business.

Over the period 2001 to 2015, Columbia calculated that its cumulative savings were $3,850,000 for nickel, $800,000 for chromium trioxide, and $3,000,000 for water and sewer costs. Converting these cumulative figures to annual savings, the estimated annual savings were approximately $275,000 for nickel, $57,000 for chromium trioxide, and $214,000 for water and sewer costs. Per-gallon costs for water and sewer continue to rise, so these savings continue to increase. Columbia also undertook a variety of energy efficiency measures, including eliminating unused and underutilized space and other energy-saving initiatives. Since 2008, Columbia has reduced its thermal energy cost by $500,000 annually through these measures.

Independent Plating[5] in Worcester, MA, finishes predominantly steel tubing and wire products for a variety of products including school furniture, retail displays, medical devices and law enforcement tools. Although Independent Plating's business has declined by approximately 30% over the past 20 years as manufacturing in New England has shifted offshore, the company has been able to reduce use of individual toxic chemicals by 50%-100%.

Independent Plating has undertaken a number of toxics use reduction initiatives over time. The facility eliminated all its cyanide plating baths by converting to alkaline-based chemistry and discontinuing brass plating. As a result, the facility eliminated its use of cyanide compounds by 2012, a reduction of 2,200 pounds per year. This yielded additional savings through the elimination of the cyanide destruction system in the facility's wastewater treatment.

Starting in 2004, Independent Plating also reduced its use of virgin hydrochloric acid (HCl) by careful planning and timing of pickling bath neutralization in wastewater treatment. This eliminated 150,000 pounds per year of HCl and yielded annual savings of approximately $15,000.

In 2010, the facility eliminated the handling of liquid hydrofluoric acid, a highly toxic chemical, by shifting to ammonium bifluoride. This led to a reduction of 15,000 pounds per year and savings of $8,500 per year.

The facility was also an early adopter of safer, water-based alkaline cleaners as a replacement for organic solvents for cleaning applications.

In 2012, with assistance from a TURI grant, Independent Plating converted its largest nickel chrome plating line from hexavalent to trivalent chromium. This change made it possible to offer a trivalent option to customers while reducing the use of both hexavalent chromium and sodium bisulphite. From a performance and productivity perspective, Independent Plating identified both benefits and challenges associated with use of a trivalent chromium system. Benefits included improved product quality and increased throughput. Challenges included color, technical capabilities, and bath control.

Independent Plating achieved reductions in its use of hexavalent chromium compounds and reduced its hazardous waste generation, but chemical purchasing costs for the trivalent chromium system are higher than those for the hexavalent chromium system. In 2015, chemical purchasing costs for the trivalent chromium system totaled $16,500, whereas chemical purchasing costs for an equivalent hexavalent chromium system totaled just $765.

Anodes for the trivalent system also cost more than those used in the hexavalent system. The trivalent system uses 24 anodes, which are recoated every four years at a cost of $1,000 per recoating. Thus, the annual recoating cost is $6,000. In contrast, the hexavalent system uses twelve anodes, which are not recoated, but must be disposed of occasionally. The anodes were purchased at $219 each in 2006, and are assumed to last 13 years, for a total annual cost of $202.

The trivalent chromium system eliminates certain waste treatment and waste disposal costs

associated with the hexavalent chromium system. The hexavalent chromium system requires purchase of sodium bisulfite to chemically reduce the waste stream. The total purchase cost is estimated at $516 annually.

Each pound of hexavalent chromium used in the system generates 13.3 lb. of sludge. The system is estimated to generate 4,655 lb. sludge annually, for a total disposal cost of $815 annually.

Table 2 shows the cost comparison between hexavalent and trivalent chromium plating at this facility.

Table 2: Hexavalent vs. trivalent chromium plating: annual operating costs at Independent Plating

Category of expense	Hexavalent system	Trivalent system
Plating chemistry	$765	$16,500
Anodes	$202	$6,000
Sodium bisulfite purchase	$516	$0
Sludge disposal (approx. 4,655 lb/yr)	$815	$0
Total	**$2,296**	**$22,500**

Source: Charles Flanagan, Independent Plating, personal communication, April 2016 and August 2017.

Business benefits of the trivalent plating line include the ability to meet the demands of customers seeking a safer alternative to hexavalent chromium. Several of Independent Plating's customers were able to qualify their products for green certifications and LEED points as a result of the shift to trivalent chromium plating. This has provided a competitive advantage to both Independent Plating and its customers.

Independent Plating finds that the changes it has undertaken have significantly improved the health and safety environment in the plant. Taken as a whole, the reduction in chemical use has also reduced costs and improved margins.

Table 3 provides summary information on the experiences of the two facilities.

Table 3: Savings and costs at two facilities offering decorative chrome plating				
Facility	**Project**	**Capital investments**	**Annual savings (costs)**	**Other business factors**
Columbia Manufacturing	Facility upgrade; installation of new plating line; closed-loop water treatment system	$4,000,000 (approximate)	$1,046,000	New plating line tripled plating capacity; helped the company to remain competitive and stay in business.
	Energy efficiency		$500,000	
Independent Plating	Elimination of cyanide plating baths		Savings (amount not quantified)	Savings included elimination of cyanide destruction in wastewater treatment.
	Hydrochloric acid reduction		$15,000	
	Elimination of organic solvents for cleaning		Savings (amount not quantified)	
	Substitution of ammonium bifluoride for liquid HF		$8,500	Improved occupational safety
	Addition of trivalent chromium plating line	$46,800[a]	($20,204)[b]	Use of trivalent chromium has allowed several customers to qualify their products for green certification and LEED points.

Sources: Information on original investments: OTA and TURI. 2015. "Columbia Manufacturing, Inc.: Plating Operations Achieve Zero Wastewater Discharge"; OTA and TURI. 2012. "Trivalent Chromium Plating Conversion Case Study: Independent Plating, Worcester, Massachusetts." Updated information on savings/costs: Ali Salehi, Columbia Manufacturing, personal communication, December 2016; Charles Flanagan, Independent Plating, personal communication, April 2016 and August 2017.

[a] Partially offset by $15,000 TURI grant.

[b] Parentheses denote a cost increase.

Medical Diagnostics and Biotechnology

Two businesses in the medical diagnostics and biotechnology sectors are featured in this section. One, a large business, worked with TURI on basic research to develop safer alternatives for a chemical targeted for regulation in the European Union. The other, a small startup, worked with OTA and TURI to adopt cost-saving TUR techniques.

Siemens Healthineers[6] is the separately managed healthcare business of Siemens AG, enabling healthcare providers worldwide to meet their current challenges and to excel in their respective environments. A leader in medical technology, Siemens Healthineers is constantly innovating its portfolio of products and services in its core areas of diagnostic and therapeutic imaging and in laboratory diagnostics and molecular medicine. Siemens Healthineers is also actively developing its digital health services and enterprise services. To help customers succeed in today's dynamic healthcare marketplace, Siemens Healthineers is championing new business models that maximize opportunity and minimize risk for healthcare providers.

In fiscal year 2016, which ended on September 30, 2016, Siemens Healthineers generated revenue of $15.9 billion and net income of over $2.7 billion

and has about 46,000 employees worldwide. Further information is available at www.siemens.com/healthineers.

Siemens Healthineers has multiple facilities in Massachusetts, including facilities in towns of Beverly and Walpole as well as the headquarters of its Point of Care business unit in the town of Norwood. The Beverly, Norwood and Walpole facilities currently employ approximately 20,300 and 700 workers, respectively. The company has announced plans to expand the Walpole facility, adding another 400 to 700 employees.[7]

In 2015, Siemens Healthineers responded to a TURI request for proposals and asked for assistance improving one of its diagnostic products, the Stratus® CS Analyzer. The Stratus CS Analyzer for acute care diagnostics provides quantitative cardiac assays for fast, accurate testing of patients with suspected myocardial ischemia (reduced blood flow to the heart). It can be used either in the laboratory or at the point of care.[8]

The Stratus CS contains a chemical in the family of octylphenol ethoxylates (OPEs), used as a surfactant (a chemical that reduces the surface tension of a mixture). The OPEs have been identified as a Substance of Very High Concern (SVHC) under the European Union's Registration, Evaluation and Authorization of Chemicals (REACH) regulation. This designation is a signal that these chemicals will face restrictions for use in the EU in the future. Working to stay ahead of the regulatory curve and use substitutes that are safer for people and the environment, Siemens Healthineers requested assistance in identifying a surfactant that would work as well as the OPEs for its specific applications in medical diagnostics.[9]

TURI provided funding to support a partnership between Siemens Healthineers and a researcher at the University of Massachusetts Lowell. Working together, the team was able to identify an alternative with equally good technical performance. The team is now conducting further tests to minimize chances that the alternative has any unanticipated adverse health effects or environmental impacts.

ChemGenes[10] in Wilmington, MA is a small biotechnology firm with 32 employees. In 2007, following up on advice provided by OTA, ChemGenes invested in a new chromatography system, making it possible to decrease its annual use of chloroform by over 50,000 lb (a 61% reduction) and its annual use of hexane by 23,000 lb (a 42% reduction). Both chloroform and hexane are toxic solvents.

Adoption of the new chromatography system led to savings on chemical purchasing, hazardous waste disposal and other associated costs. After accounting for $65,000 of capital expenses for the new chromatography system and $20,000 for R&D and associated quality testing, ChemGenes achieved a substantial net savings. Over the period 2007 to 2012, cumulative savings exceeded $215,000, or about $43,000 per year. These savings have continued to accrue in subsequent years. These savings helped ChemGenes to grow, and the business hired four new staff members. The success of this project also created momentum for a second toxics use reduction endeavor.

ChemGenes' second project was the installation of a solvent recovery system. The system required an up-front expenditure of $26,000; this cost was partially offset by a $15,000 grant from TURI. Over the period 2013-2015, the new solvent recovery system resulted in an annual average reduction of 959 liters of hexane and 1,107 liters of ethyl acetate. This allowed substantial savings in chemical purchase costs as well as reduced costs for transportation, insurance and disposal of hazardous waste. These savings were partially offset by additional annual operating costs related to maintenance, quality control and other activities. Net savings are estimated at $3,912 annually. These savings are expected to last for the life of the equipment.

Table 4 provides summary information on the experience of ChemGenes.

Table 4: Annual savings at ChemGenes

Project	Capital investments	Annual savings (approximate)	Other business factors
New chromatography system	$85,000	$43,000	• Savings from first project provided momentum and financing for a second project. • Savings facilitated business growth.
Solvent recovery system	$26,000[a]	$3,900	
Total annual savings[b]		**$46,900**	

Source: Information on original investments: OTA and TURI. 2016. "ChemGenes Corporation: Toxics Use Reduction Case Study." Updated information on savings: Anuj Mohan, ChemGenes, personal communication, January 2016.

[a] Partially offset by $15,000 TURI grant.

[b] Since the second project began to produce savings in 2013, this total is for 2013 and subsequent years.

Paints and Coatings

The TURA program has published case studies of two businesses in the paints and coatings sector. One business protected a key product line through a series of toxics use reduction measures. The other decided to switch to a safer chemical even though this increased its chemical purchasing costs.

Stainless Steel Coatings,[11] in Lancaster, MA, manufactures STEEL-IT®, an industrial coating used in corrosive and high-impact applications. The coating is used by a number of industrial sectors, including food processing and packaging, pharmaceutical manufacturing, and motorsports, among others.

Stainless Steel Coatings undertook several chemical substitutions, including eliminating the use of hexavalent chromium in one of its key products, a primer that is used with a polyurethane coating. In the process of responding to requirements under REACH, the company found out that one of its existing ingredients, zinc-bis-triorthophosphate (ZBZ), contained small amounts of hexavalent chromium. Stainless Steel Coatings was able to eliminate ZBZ by adopting a magnesium-based alternative for use in the primer.

The alternative was more expensive than the hexavalent chromium containing product. However, overall costs were reduced because a smaller amount of the replacement chemical was required in the formulation. Net input costs were equivalent after the substitution.

If Stainless Steel Coatings had not identified the magnesium-based alternative, its options would have been to adopt an inferior anticorrosive or discontinue the primer. Discontinuing the primer could have led to an estimated loss of 8 to 10% of gross revenue. Thus, toxics use reduction was a key factor in preserving a competitive position in European markets and maintaining a valued product line.

The business also changed its production schedules to group batches more efficiently, reducing the need to clean production vats between batches. The change in production scheduling reduced Stainless Steel Coatings' annual hazardous waste costs by $15,160.

The company also undertook energy efficiency improvements, and was able to take advantage of several energy conservation assistance programs that provided subsidies. Stainless Steel Coatings undertook improvements costing approximately $10,000; the company covered 30% of the cost, while the balance was covered by National Grid subsidies. These changes yielded annual energy savings of $1,440. Measurements taken in the facility also showed that after the energy efficiency upgrades, lighting output in the facility was increased by 10 to 12%, a notable benefit in a factory setting.

Franklin Paint[12] is a manufacturer of road paint located in Franklin, Massachusetts. In addition to its 28 permanent employees, Franklin Paint supplements its workforce with up to an additional 30 temporary workers during the busy summer months.

Franklin Paint has reformulated its road paint formulations to eliminate the use of lead and chromium pigments. It has also substituted ethanol for methanol, and eliminated the use of xylene and reduced the use of toluene by substituting with acetone. The business has made a variety of improvements related to reducing ergonomic hazards, and has undertaken energy conservation initiatives.

Switching from methanol to ethanol increased Franklin Paint's chemical purchasing costs. Ethanol has a higher price per gallon than methanol and higher quantities of ethanol must be used in the formulation. Prices of inputs such as methanol and ethanol vary widely over time, and Franklin Paint has not tracked the price differential by year. However, Franklin Paint did calculate a point estimate of the cost differential in 2016 at approximately $123,000.

Franklin Paint also upgraded its lighting fixtures for a total cost of $43,257. An incentive from the energy utility and other adjustments lowered the company's up-front cost to $18,024. These changes yielded energy cost savings of $7,472/year and savings in energy-related operations and maintenance costs of $1,265/year, for a total of $8,737 in annual savings.

Company representatives emphasize that they made the formulation change because "it was the right thing to do." In addition to being safer for the environment, the formulation change improved the paint quality because ethanol dries more slowly than methanol, reducing the likelihood of the paint "skinning" that can cause blockages in painting equipment. This improvement, in turn, reduces labor time for users of the paint.

These product performance improvements did not translate directly into financial benefits for Franklin Paint. However, Franklin Paint's business grew substantially as a result of a suite of product improvements and good management practices, many of them unrelated to toxics use reduction. Franklin Paint distinguishes itself in the road paint market by ensuring its paint is of the highest quality on a number of metrics. Over the five-year period 2010 to 2015, it grew from a $12 million to a $17.5 million business.

Table 5 provides summary information on the experiences of the two facilities.

Table 5: Savings and costs at two facilities in the paints and coatings sector				
Facility	**Project**	**Capital investments**	**Annual savings (costs)**	**Other business factors**
Stainless Steel Coatings	Elimination of hexavalent chromium through adoption of magnesium based compound	n/a	No change in costs	• Retained high-quality, primer product valued at 8-10% of sales; maintained competitiveness in EU • Improved lighting in facility
	Improved production scheduling	n/a	$15,160	
	Energy efficiency	$10,000 ($3,300 after subsidies)	$1,440	
Franklin Paint	Switch from methanol to ethanol	n/a	($123,000)[a]	• Improved product quality (less skinning of paint during use) • Business grew by over 45% over 5 years due to a range of other factors
	Lighting upgrade (energy efficiency)	$43,257 ($18,024 after subsidies and adjustments)	$8,737	

Sources: Background information: OTA and TURI. 2015. "Franklin Paint Company: Toxics Use Reduction and an Integrated Contingency Plan." TURA program case study. Updated information on costs and savings: Lawrence Boise and and Steven Schultz, Franklin Paint, personal communication, February 2016; OTA and TURI. 2015. "Stainless Steel Coatings, Inc: Toxics Use Reduction, Energy Efficiency, and Worker Safety." TURA program case study. Updated cost and savings information: Robert Audlee, Stainless Steel Coatings, personal communication, March 2017.

[a] Parentheses denote a cost increase. The figure shown here is the 2016 estimate of the annual chemical purchasing cost increase.

Electronics Manufacturing

This section highlights one individual manufacturer and one collaborative project that brought together multiple businesses in the electronics supply chain.

Analog Devices (ADI)[13] is a world leader in the design, manufacture, and marketing of a broad portfolio of high performance analog, mixed-signal, and digital signal processing integrated circuits used in virtually all types of electronic equipment. ADI products play a fundamental role in converting, conditioning, and processing real-world phenomena such as temperature, pressure, sound, light, speed, and motion into electrical signals to be used in a wide array of electronic devices. ADI serves markets such as aerospace and defense, energy, healthcare, motor and power control, and more.

ADI currently employs 15,000 employees worldwide with corporate headquarters located in Norwood, MA, and manufacturing sites located in California, Washington, Ireland, Philippines, Malaysia and Wilmington, MA. The ADI Wilmington manufacturing site employs over 2,000 people (employees and contractors) and is made of up of 7 buildings (roughly 600,000 square feet) on 65 acres.

Water is a vital resource in semiconductor manufacturing, and the Wilmington manufacturing facility has undertaken several water conservation projects. Some examples of the facility's water reduction activities include: reclaiming process and scrubber water; new controls, tightened chemical treatment ranges and optimized pH control on the wastewater treatment systems; improved efficiencies in the reverse osmosis water treatment

systems; increased reclaim water used in scrubbers and cooling towers; the implantation of flow and water quality meters; and additional water treatment to maximize water reclaim. As a result, ADI has saved approximately 90 million gallons of water cumulatively, reduced its use of water treatment chemicals, and achieved savings of hundreds of thousands of dollars over the course of a decade.[14]

Within this larger suite of water conservation initiatives, ADI was able to share detailed information on one sample project. This project focused on reducing the need for chemical regenerations of the Wilmington facility's deionized water reclaim system's ion exchange resins. These resins serve to remove ions from the incoming water supply before that water is used again in the manufacturing process. ADI found that slightly adjusting the pH of influent water prior to the reverse osmosis step in the process greatly reduced the degradation of the ion exchange resin. As a result, the facility was able to reduce resin regenerations from approximately 12 times per year to approximately 1 to 2 times per year.[15]

This change led to an annual savings of 1,100 gallons each of HCl and NaOH, and approximately 150,000 gallons of water. The project resulted in an annual savings of $35,000 in chemical purchase costs, water, and RO membrane maintenance costs. In addition, ADI estimates that the project has resulted in labor maintenance savings totaling over 100 person-hours annually.[16]

In addition to the water conservation projects outlined above, ADI has been able to reduce electricity usage by more than 16 million KWH per year through energy conservation initiatives.[17]

ADI has received wide recognition for its environmental performance, including inclusion in *Newsweek* magazine's listing of "Top Green Companies" in the US[18] and in the 2017 Global 100, a list of the "100 Most Sustainable Corporations in the World" developed by *Corporate Knights*.[19] Representatives of Analog Devices note that the company's good environmental performance provides market advantage with customers that prefer socially-responsible companies, and note that the TURA program has helped the business to attain many of these achievements.[20] Company representatives also note that the success of early resource conservation projects, as well as public recognition received for these projects, helped to build momentum for additional improvements over time.

Table 6 summarizes key aspects of ADI's experience with water conservation projects in particular.

Table 6: Savings from conservation of water and water-treatment chemicals at Analog Devices

Project	Savings	Other business factors
Multiple projects (over 10 years)	Hundreds of thousands of dollars saved over 10-year period	• Business has also achieved large energy savings. • Business has received public recognition for environmental performance, and considers good environmental performance to produce market advantage. • Early projects built momentum and enhanced staff morale for additional projects.
Sample project – Change in water pretreatment system	Saved $35,000 plus 100 person-hours annually	

Sources: Toxics Use Reduction Institute (TURI) and Analog Devices. 2015. "Innovative Solutions to Conservation: New Approach to High Purity Water Treatment." TURI Case Study. Additional information provided by Elizabeth Tshudy, Analog Devices, personal communication, January 2016.

The **New England Lead-Free Electronics Consortium**,[21] convened and coordinated by TURI, brought together more than 25 businesses both within and outside Massachusetts to work collaboratively. Participating Massachusetts facilities included Analog Devices, American Power Conversion, BTU International, Cobham DES-M/A-COM, EMC, Hadco Corporation, International Rectifier, Raytheon, Schneider Electric, Skyworks, Solectron, Teradyne, Texas Instruments, and Textron. Over the period 2001 to 2011, the businesses worked together to test a range of lead-free materials for use in electronics applications.

The Consortium was able to show that lead-free electronics assembly produced results that were equal to or better than what had been achieved with lead, and that lead-free options were also effective for rework (repair) applications. The Consortium's research generated information that helped the participating companies make the transition to lead-free electronics assembly and repair.[22] Participating businesses cited a number of advantages to the work they completed through the Consortium. One business representative noted that the experience of building the equipment for testing provided competitive advantage; another noted increased speed to market; and another noted that resource pooling through Consortium made it possible to complete more testing than any single company could have taken on.[23] This work enabled Consortium members to proactively address emerging European Union regulations governing lead and other toxic materials in electronics, and thus secure their continued competitiveness in global markets.

Auto Repair and Auto Body

Auto repair and auto body shops use a variety of solvents and other toxic chemicals for parts cleaning and other tasks. This can lead to worker exposures on a routine basis. These exposures often affect workers who may lack access to training and appropriate personal protective equipment. TURI and OTA provide a range of services to auto shops. Two examples are featured here.

Mike's Auto Body,[24] in Fall River, MA, is both an auto body and a mechanical repair facility. Mike's Auto Body undertook changes in several areas: wheel weights, paint gun washing, brake cleaning and degreasing, and wheel cleaning. Some of these changes increased costs while others decreased costs. Taken together, the changes yielded net annual savings. A grant from TURI helped Mike's Auto Body to make some initial investments and eased the risks that may be associated with trying new products.

The business adopted a lead-free wheel weight system. This system has higher annual costs for material purchasing, but it made it possible to reduce inventory, and staff find it user-friendly. Rather than having many loose sizes of lead wheel weights stored in the shop, the adhesive wheel weights come on a single roll, allowing the staff to measure the material as needed. This saves storage space and reduces clutter in the shop.

Mike's purchased a new gun washing unit. The new paint gun washer required an up-front capital investment, but is associated with a much lower annual cost due to lower hazardous waste disposal costs and significantly increased life of the gun washing fluid.

Mike's chose a new set of brake cleaning and degreasing products. The new, safer products cost less than the products Mike's had used previously, yielding an annual savings of over $1,500.

Finally, for wheel cleaning, Mike's switched from a product containing highly hazardous hydrogen fluoride (HF) to a safer product. The cost of this new, safer product is higher than the cost for the product containing HF, but is an important improvement for worker health and safety.

Table 7 provides a summary of these changes.

Table 7: Investments, costs and savings at Mike's Auto Body

Category of expense	Annual cost of original product	Capital investment[a]	Annual cost of new product[a]	Annual savings (costs)	Other business factors
Wheel weights	$175	$644	$730	($555)[b]	• Save space, reduce clutter; easy to work with
Paint gun washer	$700	$1,913	$30	$643	
Brake cleaning & general degreasing	$2,000	0	$475	$1,525	
Wheel cleaning	$300	0	$542	($242)[b]	• Important improvement for worker health/safety
Total annual savings				**$1,371**	

Source: Toxics Use Reduction Institute and Office of Technical Assistance. 2016. "Auto Body Shop Improves Work Environment by Going Green." TURA Program Case Study.

[a] Offset by TURI grant of $5,500. This grant was used both for capital investments and for up-front purchase of new consumable products. The grant is not factored into the calculation of savings.

[b] Parentheses denote a cost increase.

912 Auto Center,[25] located in Dorchester, MA, switched to water-based paints and a water-based paint gun washer and installed a new spray booth.

Use of the water-based gun washing system yielded annual savings of $3,357. Water-based paints cost more than the solvent-based paints but eliminated the need for a paint reducer; thus, there was no overall difference in costs after the conversion. 912 Auto chose to purchase new gun washing equipment with an up-front cost of $1,000, but this was optional; the water-based system could also have been used with the existing equipment.

The new spray booth required a capital investment of $60,000, and included a hot air pressure system to dry the water-based paint. The booth was purchased at the time that the facility moved to a new location, and a new spray booth would have been necessary even if the facility had remained with the solvent-based paint system; still, this purchase represented a major investment for the business, and was influenced by the owner's commitment to protecting worker health.

Table 8 provides a summary of these changes.

Table 8: Investments, costs and savings at 912 Auto Center			
Product	**Capital investment**	**Annual savings**	**Other business factors**
Water-based paints	n/a	No change in costs	• Eliminating paint reducer counterbalanced increased cost of the water-based paints. • Worker/owner no longer experiences dizziness while mixing paints.
Water-based gun washing solution	$1,000	$3,357	• Capital investment was optional; water-based system could also have been used with existing equipment. • Water-based system works more quickly (one wash instead of several washes).
Spray booth	$60,000	n/a	• New booth was necessary due to move to new facility; new booth also facilitated use of water-based paints.

Source: Office of Technical Assistance and Toxics Use Reduction Institute. [No date.] "Auto Body Shop Saves Money by Eliminating Solvent." TURA program case study.

Table 9 summarizes the experiences of the two auto shops featured here.

Table 9: Annual savings at two auto shops		
Facility	**Annual savings**	**Other business factors**
Mike's Auto Body	$1,371	• Facility undertook several TUR initiatives. Some increased costs and others yielded savings. Taken together, they yielded net annual savings.
912 Auto Center	$3,357	• Facility made a capital investment of $60,000 in a new spray booth associated with its move to a new location. • Worker/owner experienced direct health benefits.

Summary

The five small, family-owned ***dry cleaners*** featured here all achieved savings after a short payback period for the cost of the new wet cleaning equipment. In the case of this sector, TURI has continued to collect data on similar facilities and all have achieved savings.

The two facilities that undertook changes related to ***decorative chrome plating*** illustrate two different types of experiences. One achieved savings and boosted productivity through an overhaul of its equipment; the other achieved overall savings and competitiveness benefits through a variety of toxics use reduction initiatives.

In the ***medical devices and biotechnology*** sector, one facility is working with a UMass Lowell research team to achieve competitive advantages through product reformulation, staying ahead of the regulatory curve in the EU; the other, a small facility, achieved financial savings through TUR projects at its facility.

In the ***paints and coatings sector***, one business achieved financial savings and protected a key product line through a series of toxics use reduction measures, while another decided to switch to a safer chemical even though this increased its chemical purchasing costs.

In the ***electronics sector***, a business in the semiconductor industry achieved financial savings through resource conservation; and a consortium of businesses worked together to achieve competitive advantage and improved speed to market for lead-free electronics.

In the ***auto repair and auto body sector***, two small businesses achieved annual savings through TUR.

Table 10: Summary

Sector	Business	Type & size	Key project aspects
Dry cleaning	5 sample facilities	Local, family-owned ≤ 10 FTEs	• All facilities achieved annual savings. Average 15-year NPV was approximately $160,000.
Decorative chrome plating	Columbia Manufacturing	≤ 100 FTEs	• Annual savings over $1 million. New plating line tripled plating capacity; helped the company to remain competitive and stay in business.
	Independent Plating	≤ 50 FTEs	• Annual savings of $15,000 from HCl reduction; annual savings of $8,500 from HF substitution; annual costs of $20,000 from trivalent plating line. Savings from cyanide and cleaning solvents reduction not quantified. Ability to offer trivalent option to customers that prefer this option.
Medical devices & biotechnology	Siemens Healthineers	Multinational ≥ 1,000 FTEs in MA	• Identifying safer surfactant to replace chemical targeted for regulation in EU.
	ChemGenes	Startup ≤ 50 FTEs	• Annual savings of $46,900. Savings from initial project provided both momentum and financing for a second project. Savings facilitated business growth.
Paints & coatings	Stainless Steel Coatings	≤ 50 FTEs	• Financial savings: $15,160 annually for hazardous waste; $1,440 for energy. • Substituted safer compound without a change in costs, retaining product line valued at 8-10% of sales and maintaining competitiveness in EU.
	Franklin Paint	≤ 50 FTEs	• Financial cost: $123,000 annually. • Business grew over 65% over five years.
Electronics	Consortium including 14 Massachusetts facilities	Variety of business sizes/types, including multinationals	• Competitiveness benefits; increased speed to market; enhanced ability to test lead-free materials.
	Analog Devices	Multinational ≥ 3,000 FTEs in MA	• Financial savings: hundreds of thousands of dollars saved over 10-year period; sample project yielded annual savings of $35,000 plus 100 person-hours. • Positive environmental image; momentum for continuous improvement.
Auto repair & auto body	Mike's Auto Body 912 Auto Center	Local, family-owned Mike's: 17 FTEs 912: ≤ 10 FTEs	• Both facilities achieved annual savings. One made a substantial capital investment in equipment that was needed due to a change in shop location. Annual savings range between about $1,400 and $3,400.

The businesses discussed in this report provide a sampling of experiences, each with unique characteristics. Company size, business sector, market trends, and the efforts of both management and employees all contribute to the case-specific experiences of these businesses. To learn more about businesses that have worked with the TURA program to reduce toxics, the reader is encouraged to visit www.turi.org and www.mass.gov/eea/ota and browse the TURA program's case studies.

[1] See, for example: Toxics Use Reduction Institute. 1997. *Benefit-Cost Analysis of the Massachusetts Toxics Use Reduction Act.* TURI Methods and Policy Report No. 15. 1997; Massey, RI. 2011. "Program assessment at the 20 year mark: experiences of Massachusetts companies and communities with the Toxics Use Reduction Act (TURA) program." *Journal of Cleaner Production* 19, 505-516; National Pollution Prevention Roundtable (NPPR). *An Ounce of Pollution Prevention is Worth Over 167 Billion Pounds of Cure: A Decade of Pollution Prevention Results 1990 – 2000*. Washington, DC: NPPR; NPPR. [No date.] *National P2 Results Data System: 2010 to 2012.* Washington, DC: NPPR. For detailed information on individual projects, see http://www.turi.org/TURI_Publications/Case_Studies and http://www.mass.gov/eea/grants-and-tech-assistance/guidance-technical-assistance/agencies-and-divisions/ota/ota-publications/ota-case-studies/.

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[4] Information in this section is drawn from: Toxics Use Reduction Institute (TURI), Office of Technical Assistance and Technology (OTA), Massachusetts Department of Environmental Protection (MassDEP). 2015. "TURA 25th Anniversary Leaders Demonstrate Product Innovation, Quality and Safety: Massachusetts Companies Reduce Toxic Chemical Use, Waste and Emissions." Lowell, MA: TURI, available at http://www.turi.org/About/Toxics_Use_Reduction_Act2/TURA_25th_Anniversary_Leaders_Brochure; OTA and TURI. 2015. "Columbia Manufacturing, Inc: Plating Operations Achieve Zero Wastewater Discharge, " available at https://www.turi.org/TURI_Publications/Case_Studies/Metal_Finishing_and_Plating/Columbia_Manufacturing_Inc._-_Plating_Operation_Achieves_Zero_Wastewater_Discharge_OTA._2015, and Ali Salehi, personal communication, December 2016.

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Toxics Use Reduction and Resource Conservation:
Competitiveness Impacts for Massachusetts Businesses

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