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Program assessment at the 20 year mark: experiences of Massachusetts companies and communities with the Toxics Use Reduction Act (TURA) program

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ABSTRACT

The Toxics Use Reduction Act (TURA) model is widely cited as an effective blend of mandatory and voluntary components, and is considered a model nation-wide and internationally. There is ample documentation of the reductions in toxic chemical use achieved by Massachusetts facilities under TURA. The present study was designed to gather other information about the experience of these facilities. Through an online survey and telephone interviews, the study investigated how these facilities are achieving toxics use reduction, how TURA affects internal company dynamics, what benefits and difficulties facilities experience, and how their experiences in the program have changed over time. Survey results indicate that the benefits experienced most frequently by facilities subject to TURA requirements are increased management attention to environmental practices; improved worker health and safety; and financial savings. Most frequently cited obstacles to TUR implementation are technical feasibility problems; financial costs; concerns about product quality; and customer requirements. Survey results also indicate that the TUR planning process is most useful in the first and second planning cycles, although most respondents indicated that they sometimes identify useful TUR options in subsequent planning cycles as well. Over all, the results indicate that facilities are continuing to experience significant benefits from the TURA program, while they also continue to face some challenges. These results provide a snapshot of the experience of Massachusetts facilities 20 years since the inception of the TURA program. They also provide baseline information that will be useful for later evaluations of the effects of statutory changes to TURA adopted in 2006 and implemented in subsequent years. The study also included a preliminary assessment of the experience of Massachusetts municipal agencies, community organizations, small business associations and others that receive assistance from the TURA program.

1. Introduction

Enacted in 1989, the Massachusetts Toxics Use Reduction Act (TURA) has been in effect for two decades. TURA regulates industrial facilities that use large quantities of chemicals listed on the TURA list of Toxic or Hazardous Substances (MGL c. 21I).

Facilities subject to TURA are required to report annually to the state on their use of toxic chemicals; pay an annual fee; and carry out Toxics Use Reduction (TUR) planning every two years. TUR plans must be certified by a TUR Planner trained and certified by the state. Amendments to TURA adopted in 2006 created additional flexibility in the planning process, and provided new options for the program to focus on the substances of highest concern, among other changes. TURA program services include training, grant programs, technical assistance, demonstration sites, and other activities. These services are provided by three implementing agencies: the Massachusetts Department of Environmental Protection (MassDEP); the Toxics Use Reduction Institute (TURI); and the Office of Technical Assistance and Technology (OTA). The implementing agencies work in concert with an Administrative Council, representing six state agencies; an Advisory Committee, a stakeholder group; and a Science Advisory Board.

The TURA model is widely cited as an effective blend of mandatory and voluntary components, and is considered a model nation-wide and internationally. Recently, it has served directly as a model for initiatives to promote the adoption of safer alternatives to toxic chemicals in the states of New York, California, and Connecticut, and in the Canadian province of Ontario (Meer et al., 2003; Wilson, 2006; Wilson et al., 2008; State of California, 2008; CalEPA, 2008; State of Connecticut, 2010; Ontario Ministry of the Environment, 2008). In this context, it is important to evaluate

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the program's activities and to identify lessons that may be applicable in other jurisdictions.

The effectiveness of the TURA program in reducing the use of toxic chemicals is well documented. The TURA program issues annual reports providing detailed information on toxics use and reductions in the state. These reports are made possible by Massachusetts' unique, publicly searchable database of toxics use information submitted by companies to the state each year. Over the period 1990 to 2005, facilities in a "1990 Core Group" (all sectors and chemicals that were subject to TURA program requirements over the full sixteen-year period) reduced their use of toxic chemicals by 40% and their on-site releases by 91%. Over the period 2000 to 2008, facilities in a "2000 Core Group" reduced toxic chemical use by 20% and on-site releases by 52%[1] (MassDEP 2008, 2010).

The goal of the present study was to gather information on aspects of the program that are not reflected in the state's annual reports on toxics data. The study was designed to generate information on the experiences of Massachusetts companies and communities, in order to identify areas of opportunity and to provide information for other states undertaking similar programs. It was also designed to provide baseline information on positive and negative aspects of the program prior to statutory changes to TURA that were adopted in 2006 and are being implemented in subsequent years.

Through online survey questions and telephone interviews, the study investigated how facilities subject to TURA requirements are achieving toxics use reduction; how TURA program requirements and services affect internal company dynamics; what benefits and challenges facilities experience; and how their experiences in the program have changed over time. The study also included a preliminary assessment of the experience of Massachusetts municipal agencies, community organizations, small business associations and others that receive assistance from the program under its mandate to provide information and assistance to Massachusetts communities.

This article begins with a brief overview of existing literature on the effectiveness of pollution programs in general, and on the experience of the TURA program in particular. It then presents the findings of the survey and interviews that were conducted for this study; explores some of the lessons that may be drawn from these results; and suggests possible directions for future research.

1.1. Literature review

1.1.1. Evaluation of pollution prevention programs

A variety of studies have assessed the effectiveness of government pollution prevention programs. Studies have examined state and federal programs within the US, as well as a variety of programs in other parts of the world. These studies have examined the effectiveness of pollution prevention and cleaner production programs in reducing toxic emissions. They have also assessed the extent to which pollution prevention innovations have spread from one facility to another; the ability of companies to sustain pollution prevention innovations after an assistance program has ended; the ability of demonstration sites to motivate broader change; and the organizational impacts of demonstration projects both within and outside the demonstration facilities, among other questions (Vidovic and Khanna, 2007; Sarmiento, 2004; Van Berkel, 2004). A 2003 study of state pollution prevention programs in the US, conducted by the US Environmental Protection Agency and the National Pollution Prevention Roundtable, estimated the total amount of pollution prevented by these programs as well as total financial savings resulting from pollution prevention efforts (Spektor and Roy, 2003).

A special issue of the *Journal of Cleaner Production* in 2008 considered opportunities and challenges facing pollution prevention programs in the US. The editors of the issue, in their overview, identify key challenges facing pollution prevention programs going forward. These include diminishing public sector support; competing priorities in the private sector; and challenges in documenting progress (Miller et al., 2008).

1.1.2. Studies of the TURA program

Studies of the TURA program in particular have examined the program's effectiveness in reducing toxics and in addressing worker health and safety; the value of the publicly available TURA data; the program's role in reducing use of specific categories of chemicals, such as carcinogens and asthmagens; and lessons that can be derived from the TURA program for other jurisdictions, among other themes.

A variety of scholarly and advocacy publications related to reforming chemicals policy at the state, national, or international level make reference to the TURA program as a useful model for protecting public health while promoting economic development. For example, physician Samuel Epstein discusses the TURA program as part of a broader exploration of legislative options for reversing the cancer epidemic (Epstein, 2000); and a 2007 publication on "solutions to cancer" showcases the TURA program as a positive example of how policy changes can reduce public exposure to carcinogens (Armstrong et al., 2007).

A program evaluation sponsored by the TURA program and completed in 1997 found that the TURA program had been effective in reducing Massachusetts facilities' use of toxic substances while providing opportunities for facilities to achieve financial benefits. It also identified areas for improvement (see Section 4.9, below) (Becker and Geiser, 1997).

A 2006 study by OTA of the effectiveness of OTA's on-site technical assistance visits found that visited companies reduced their toxics use by an average of 9% more after being visited, than before (Reibstein, 2008).

Roelofs et al. (2000) reviewed published case studies of toxics use reduction by Massachusetts companies, and interviewed TURA program staff, in order to better understand the relationship between TURA program activities and the broader goal of improving worker health and safety. The authors found that "in almost 50 percent of the cases analyzed, improved worker health and safety was cited as a benefit of the toxic use reduction projects." However, they found that worker health and safety was usually not an explicit focus of the TUR efforts, creating the possibility that new hazards could be created or opportunities to protect workers could be missed. They recommended increased efforts to integrate worker protection with pollution prevention efforts.

Campbell and Levenstein (2001) draw upon interviews with Toxics Use Reduction Planners to evaluate the successes and limitations of the TURA program in effecting change within facilities. They identify types of planners, ranging from "active planners" who act as leaders within facilities and effect significant change, to "resistant planners" who do not promote true toxics use reduction. They argue that the successes of the TURA program have been limited by significant variation among companies in the amount of effort devoted to TUR planning, and by a lack of clear quality standards specified by the state for TUR plans.

[1] These figures are production-adjusted. Production-adjusted figures reflect changes in the amount of toxic chemicals used per unit of product. In the period 1990 to 2005, total manufacturing production in Massachusetts increased. The raw (non production-adjusted) toxics use reduction figures for that period, are a 35% reduction in toxic chemical use and a 90% reduction in on-site releases. In the period 2000 to 2008, total manufacturing production in Massachusetts declined. The raw toxics use reduction figures for that period, are a 37% reduction in use and a 62% reduction in on-site releases.

Advocacy organizations have used the TURA data as a way to evaluate the program's performance. For example, in 2001 the Massachusetts Public Interest Research Group (MassPIRG) analyzed the TURA data and argued that insufficient progress was being made in reducing the most highly toxic chemicals, particularly persistent, bioaccumulative toxic (PBT) chemicals. In the same year the Environmental League of Massachusetts analyzed trends in use of carcinogens and found that companies were making progress in reducing use of these chemicals (Champness, 2001).

O'Rourke and Lee (2004) note that TURA embodies several principles that have been proposed as best practice for environmental regulation, including focusing on performance outcomes, using mandatory planning mechanisms, and supporting innovation through technical assistance and peer mentoring. They also identify areas in which the TURA program could be strengthened, including increasing its work with small facilities. They suggest that in the absence of public pressure for more progress, the TURA program "will likely face a plateau of effectiveness." Such a plateau could result when all firms that are willing to innovate have done so, and less-motivated firms simply continue to submit TUR plans without acting on them. They offer several suggestions for ways to move beyond a possible plateau, including empowering the public to put pressure on firms that have not made progress; using TURA data to compare firms with one another and identify leaders and laggards; and using information generated under TURA to inform development of new regulations.

1.1.3. TURA as a model for other jurisdictions

State governments and other jurisdictions have studied the TURA program in detail as part of efforts to replicate the program's successes.

In 2006, University of California researchers wrote a report urging a reform of chemicals policy in California (Wilson, 2006). The report argues that deficiencies in federal regulation are a liability for the state and evaluates several state chemicals policies, including TURA, as potential models for California. The authors note that:

> "TURA is unique among U.S. environmental statutes in that it requires firms to report their use of hazardous chemicals rather than their releases of chemical pollutants, and it requires firms to evaluate their operations and plan for process improvements. It is the only statute that includes an institute – to provide ongoing technical assistance, training, and research for Massachusetts businesses in toxics use reduction strategies. Together, these approaches have motivated continual innovation by firms in strategies to reduce their use of hazardous chemicals. … We believe that California can learn from (and build on) the 16 years of experience by government and industry in Massachusetts under TURA." (Wilson, 2006)

The report also notes limitations of TURA. TURA program requirements do not apply to smaller firms (those that do not meet the relevant chemical reporting thresholds, or have fewer than ten employees). Collectively, firms not captured under TURA could use significant amounts of toxic chemicals. In addition, companies are not required to implement TUR plans, and the state has only a limited ability to motivate implementation. TURA also does not require companies to evaluate the toxicity of, or disclose information about, chemicals in products. The report suggests that California expand and improve upon the TURA model in a number of ways, including establishing a system for evaluating all chemicals, rather than relying on a pre-existing list of toxic chemicals (Wilson, 2006). As of filing year 2008, the TURA list of Toxic or Hazardous Substances included 1422 substances, of which 147 were reported (MassDEP 2010).

Subsequently, the government of California sponsored a series of reports and convened a high-level working group to consider options for chemicals policy reform in the state. The reports featured detailed consideration of the TURA program as a key model for new initiatives in California (State of California, 2008; CalEPA, 2008; Wilson et al., 2008).

The government of the Canadian province of Ontario has studied the TURA program in detail as part of its effort to replicate the TURA model, including extensive consultation between Ontario government employees and TURA program staff. Among other activities, the Ontario government produced a detailed report on the Massachusetts model (Ontario Ministry of the Environment, 2008).

2. Methods

In 2008, TURI contracted with Abt Associates Inc. to conduct an online survey and telephone interviews with TURA filers and planners. In addition, TURI conducted a preliminary online survey of individuals that have worked with TURI's community program, and contracted with a consultant to conduct telephone interviews with recent recipients of TURI community grants.

2.1. Online survey and telephone interviews with TURA filers

TURA filers are companies that are subject to TURA requirements (reporting, planning, and fee). Companies are subject to TURA requirements if they have ten or more employees,[2] use more than the TURA threshold amount of one or more listed toxic chemicals, and are in TURA covered sectors. Abt Associates distributed an online survey to all 561 facilities that filed a toxics use report under TURA in 2006.[3] Of these facilities, 196 responded to the survey (35%).[4]

The survey was also distributed to all Toxics Use Reduction Planners (TUR Planners) who were registered with the program as of January 2008. There are two types of TUR Planners: Limited Practice Planners, who are certified to work only with one facility; and General Practice Planners, who are certified to work with multiple facilities. Respondents who identified themselves as General Practice Planners had the option to answer a separate set of questions based on the range of their professional experience, without reference to a specific facility. Thirty-six General Practice Planners answered these questions.

Abt Associates conducted in-depth telephone interviews with a subset of 18 of the survey respondents. These interviews provided additional detail to supplement the information gathered through the online survey. Both the survey and telephone interview results were anonymous (identity known to Abt Associates, but not to TURI).

2.2. Online survey and telephone interviews with community organizations

To supplement the survey of TURA filers and planners conducted by Abt Associates, TURI staff conducted a brief online survey for individuals and organizations that have worked with TURI's community outreach program, as well as past recipients of TURI community grants. The survey posed questions about benefits

[2] The ten-employee threshold can be eliminated in some cases, but this provision has not been implemented to date.

[3] The full set of survey questions is available from the author upon request.

[4] The survey was also distributed to facilities that last filed under TURA in earlier years, going back to 2000. Only nine such facilities responded, so their responses cannot be considered representative of the larger population of facilities that filed in earlier years. These facilities' responses are not included in any of the quantitative results, but this article does reflect some of these facilities' responses to the survey's open-ended questions.

Table 1
Number of employees.

Number of employees	Total survey population	Respondents
>10 and <50	38%	34%
>50 and <100	23%	21%
>100 and <500	32%	31%
>500	7%	8%
Not specified		6%

Table 2
Number of years reporting under TURA.

Number of employees	Total survey population	Respondents
1–5 years	27%	34%
6–10 years	16%	18%
11–16 years	50%	45%
Not specified[a]	7%	3%

[a] Number of years in the TURA program is not specified for some facilities due to changes in company name or other identifying information.

gained from the TURA program, challenges in implementing toxics use reduction projects, and suggestions about how the TURA program can serve communities most effectively.

The online survey was sent to 350 individuals. Responses were received from 62 individuals. Of these, fourteen responded on behalf of an organization that had received a grant from TURI at some point in the period 1998–2007, while the others provided information on other aspects of TURI's community outreach activities.

TURI also contracted with a consultant to conduct interviews with representatives of organizations that had received a TURI community grant in fiscal year 2006, 2007, or 2008. The interviews included questions about the organization's experience working with TURI, the role of the TURI grant in the development of the organization's agenda and activities, the organization's ability to raise funds prior to and after receipt of a TURI grant, and media recognition of the organization's work. These interviews were conducted with fourteen grant recipients (not necessarily overlapping with the fourteen grant recipients who responded anonymously to the online survey, and who may have received a grant in an earlier year).

3. Results

3.1. TURA filers and planners: Profile of respondents

3.1.1. Number of employees

Just over a third (34%) of respondents were from facilities with 10–50 employees; 21% were from facilities with 50–100 employees; 31% from facilities with 100–500 employees; and 8% from facilities with more than 500 employees. These percentages are similar to those found in the full population of 561 facilities that filed under TURA in 2006, as shown in Table 1.

3.1.2. Years of reporting under TURA

Just over a third of respondents (34%) had been reporting under TURA for five years or less; 18% had been reporting under TURA for six to ten years; and 45% had been reporting for 11–16 years. Again, this breakdown is similar to that of the total population of facilities that filed under TURA in 2006, as shown in Table 2.

3.1.3. Industrial sectors represented

Table 3 compares the industrial sectors represented in the total filing population in 2006 with the breakdown of sectors represented by the survey respondents. The largest percentage of filers in 2006 (17%) were in the chemical manufacturing sector, followed by the fabricated metal manufacturing and computer and electronic manufacturing sectors. It is worth noting that the chemical manufacturing sector accounts for the largest volume of chemical use (64% of total chemical use by volume in 2006) (MassDEP, 2009a).

For most sectors, the percentage of survey respondents was similar to the percentage in the total survey population, with some exceptions. The computer and electronic product manufacturing sector was underrepresented, the plastics and rubber manufacturing sector was slightly overrepresented, and facilities classified as "other" were overrepresented in the respondent population.

3.2. How facilities are reducing toxics

The TURA data make it possible to determine the rate at which Massachusetts facilities are reducing their use of toxic chemicals. The survey allowed respondents to augment this information by providing detailed information on how facilities are achieving these reductions. This section presents information provided by respondents on their use of individual TUR techniques, and on focus areas that emerged from respondents' answers to open-ended questions.

3.2.1. TUR techniques

TURA defines six toxics use reduction techniques: improved operations and maintenance; input substitution; recycling, reuse, or extended use of toxics; product reformulation; production unit modernization; and production unit redesign or modification (MGL c. 21I). The quantitative portion of the survey asked respondents which of these techniques their facility employed frequently. In addition, respondents had the opportunity to provide open-ended responses describing their toxics use reduction efforts in more detail.

Table 3
Industrial sectors represented.

Sector	Total survey population[a] – percentage (of 561)	Survey respondents – percentage (of 196)
Chemical manufacturing	17%	15%
Fabricated metal product manufacturing	12%	14%
Computer & electronic product manufacturing	12%	3%
Nonmetallic mineral product manufacturing	7%	5%
Paper manufacturing	6%	5%
Utilities	5%	6%
Primary metal manufacturing	4%	2%
Textile mills	4%	4%
Food manufacturing	4%	2%
Plastic & rubber products manufacturing	4%	7%
Miscellaneous manufacturing	3%	4%
Electrical equipment	3%	3%
Personal and laundry services	2%	1%
Petroleum & coal products manufacturing	2%	1%
Transportation equipment manufacturing	2%	1%
Merchant wholesalers, nondurable goods	2%	3%
Other	9%	26%

[a] Source: Massachusetts Department of Environmental Protection, *2006 Toxics Use Reduction Information Release* (February 2009), p. 20. Available at: http://www.mass.gov/dep/toxics/priorities/06relfin.pdf

Table 4
Toxics Use Reduction techniques employed.

TUR Technique	Percentage (of 196 respondents)	Examples[a]
Improved operation & maintenance	63%	Installation of a temperature-controlled storage room to extend the shelf life of raw materials.
Input substitution	46%	Replacement of all uses of n-hexane with safer substances. "It took a long time to find and approve all the new formulations, but the replacement is now complete." Facility was able to stop reporting under TURA as a result.
Recycling, reuse, or extended use of toxics	46%	Implementation of a zero-discharge nickel/chrome recycling system.
Product reformulation	34%	Reformulation initiatives to (a) reduce phenol in resins from 17% to 6%, and (b) reduce use of formaldehyde. As a result, the facility dropped below the TURA reporting threshold for formaldehyde.
Production unit modernization	29%	Creation of "a new vapor etch machine that cut chemical use by 80 percent."
Production unit redesign or modification	28%	Moved parts washing from manual, solvent-based to mechanized, aqueous-based process.
Don't know	7%	

[a] Examples are drawn from open-ended responses.

Table 5
Reduction or elimination of toxic solvents in cleaning applications: selected examples.

Sector	Years in TURA	Approach to reducing solvent use
Electronic & electrical equipment & components	5	*Elimination of a cleaning step*: Facility eliminated the washing of circuit boards, thus eliminating the use of solvents.
Electrical & electronic equipment & components	8	*Process change*: Facility switched from parts washing using a manual, solvent-based system to a mechanized, water-based process.
Fabricated metal products	8	*Process change*: Facility eliminated vapor degreasing entirely.
Fabricated metal products	16	*Equipment upgrade*: A facility that has been in the TURA program since 1990 purchased new closed-loop vapor degreasers in 2001. The purchase allowed the facility to reduce its consumption of trichloroethylene from more than 10 tons to less than 1 ton per year.
Fabricated metal products	16	*Reduction of a substance used below TURA threshold*: Facility replaced methylene chloride with a safer cleaning chemical. The respondent noted that this reduction was not reflected in the facility's annual reporting because methylene chloride use was already below reportable levels.

The largest number of respondents (63%) indicated that they have made use of improved operations and maintenance. The next most commonly selected techniques (each selected by 46% of respondents) were input substitution and recycling, reuse or extended use of toxics. Product reformulation, production unit modernization, and production unit redesign or modification were selected by 34%, 29%, and 28% of respondents respectively. These results indicate that facilities are making use of all six of the techniques, although some are used more frequently than others. Table 4 shows the frequency with which each technique is being used, along with an example of each technique as reported in open-ended responses.

Several additional themes emerged in the open-ended responses. Respondents provided detailed information on facilities' work to reduce the use of toxic solvents; efforts to reduce or eliminate the use of lead and other toxic substances targeted by the European Union's Restriction of Hazardous Substances (RoHS); integration between TUR activities and other management systems; and conservation of energy and water, among other themes.

3.2.2. Reducing use of solvents

Several respondents provided examples related to solvent use in cleaning applications. For example, two facilities that have been in the program since its inception have implemented new TUR options in recent years to reduce solvent use. One eliminated its use of methylene chloride even though its use was already below TURA reporting thresholds; the other reduced solvent use by purchasing a closed-loop vapor degreasing system. Table 5 shows examples of reduction or elimination of solvents in cleaning.

Others described efforts to reduce or eliminate solvent use in formulations. For example, one facility adopted a high volume, low pressure (HVLP) spray system, along with low hazardous air pollutant (HAP) coatings. Another respondent explained that the facility develops aqueous coatings instead of solvent-based coatings wherever possible. One barrier is that "many customers have a specific coating already formulated… which may prevent this from happening."

In some cases, reformulation requires coordination up and down the supply chain. For example, a facility wishing to reduce its use of a solvent in a purchased product may need to communicate with upstream suppliers in order to obtain a reformulated product. In other cases, a formulator may need to communicate with customers downstream in order to ensure that a reformulated product meets their specifications.

3.2.3. Reduction in lead use

A number of respondents noted that they have used TUR techniques to reduce their use of lead and other hazardous substances in order to comply with the European Union's Restriction of Hazardous Substances (RoHS).

For example, a facility that manufactures audio and video equipment began a lead reduction program in 2001. The effort was motivated by the RoHS requirements, and the facility used TUR planning as a tool to achieve this goal. Among other changes, the facility purchased new wave soldering equipment to replace an older system that relied on lead. The facility planned to eliminate lead-containing products at the end of product life cycles (usually about five years). The respondent commented that an advantage of TURA is that it encourages businesses to make environmental improvements according to their own business plan and schedule.

Facilities whose products are exempt from RoHS or are not sold in the European Union also described their efforts to reduce the use of lead and other hazardous substances. For example, one facility purchased a more efficient solder machine. This change enabled the facility to reduce lead use steadily from nearly 400 pounds in 2003 to just 30 pounds in 2007.

3.2.4. Integration of TUR activities with other management systems

Some respondents emphasized the relationship between their TUR activities and activities under other management systems such as an Environmental Management System (EMS) or Lean Six Sigma.

One respondent explained, "This facility employs Lean Six Sigma techniques in an attempt to continually improve our process safety, quality, energy efficiency, reduced waste generation and to limit the use, handling and exposure to toxic chemicals. We use the TURA process to feed potential projects into this existing process. Several projects are completed annually that reduce chemical usage, reduce chemical exposure, reduce waste generation, improve product quality, improve energy efficiency or improve the overall safety of the facility. Generally the barriers faced in the implementation of these projects are minimal due to the fact that the Lean Six Sigma process and Continuous Improvement is supported at the highest levels within the organization."

3.2.5. Energy and water conservation

The toxics use reduction planning process can also be used to identify opportunities for conservation of other resources, such as energy and water. A number of respondents described ways in which facilities have been using the TUR planning process to generate options for conserving water and energy.

For example, a facility that has been in the TURA program since its inception installed a steam generator in 2006 in order to reduce natural gas use. This project was included in the facility's 2006 TUR Plan, and the respondent pointed to it as "feeding into our system from the TURA process."

Another facility that has been in the TURA program since its inception, and has eliminated or significantly reduced several TURA listed substances, is also working now to reduce its use of water. The facility uses 140 million gallons of cooling water annually. The facility has hired a fluid management contractor to examine options for reducing toxics and cutting costs in general. Any savings achieved through water use reductions are divided with the contractor.

One respondent noted, "One of the primary benefits of being involved with TURA Program has been using the planning tools to achieve other goals outside the program. We have conserved energy, water, and reduced the volume of solid waste generated by our facilities. We have saved money and resources while operating in a positive environmental manner."

3.2.6. Capital investments

The survey asked respondents whether their facility had made capital expenditures as a result of implementing TUR projects in the period 2000–2006. Capital investments may include investments in equipment, buildings, or other fixed assets.

Of 196 respondents, 77 (39%) indicated that their facility had made one or more TUR-related capital expenditure. These 77 respondents provided detailed information on a total of 125 capital expenditures.

The largest number of these investments was for production equipment. In this category, respondents listed a wide range of examples. These included: purchase or modification of mixing tanks, chemical bath tanks, and acid tanks; replacement of mixer equipment; modifications such as enclosing a mixer or adding a furnace exit curtain; installation of a high volume, low pressure (HVLP) spray system; installation of diameter control equipment; purchase of a new boiler or other new equipment; purchase of a pointing machine; adoption of a reverse osmosis skid system for water purification; and adoption of closed-loop vacuum vapor degreasers. Other capital expenditures selected by a number of respondents were for facility modification; emission control; instruments and controls; and ancillary process equipment (See Table 6).

Most of the capital investments (74%) were under $100,000. A third of them were under $10,000. This cost information may be useful in identifying areas in which grants or loans could help small facilities to achieve toxics use reduction.

Table 6
Capital expenditures.

Type of Expenditure	Responses	Percentage (of 77 respondents)[a]	Example
Production equipment	60	78%	Installation of high volume, low pressure (HVLP) spray system
Facility modification	16	21%	Creating a hard piped reuse system
Emission control[b]	12	16%	Redesign of exhaust system
Instruments and controls	12	16%	Improved wastewater control
Ancillary process equipment	11	14%	Automated mixing equipment
Other	7	9%	Investment in piping and pumps
Product testing equipment	6	8%	R & D test equipment
Don't know	1	1%	n/a
Total responses	125	n/a	

[a] Percentages do not total 100% because some respondents provided information on multiple expenditures.
[b] The activities reported under the category of emissions control do not necessarily meet the definition of toxics use reduction. However, these items indicate that the facility has used the TUR process to consider all the facility's operations.

3.3. Benefits of TUR planning and implementation

Both in the quantitative portion of the survey and in open-ended responses, respondents described a variety of benefits from TUR planning and implementation of TUR projects. The benefits cited by the largest number of respondents were "increased management attention to environmental practices" (55%), "improved worker health and safety" (51%), and financial savings (41%). The full set of responses to this question is shown in Table 7. In open-ended responses, respondents provided additional insight into these benefits.

3.3.1. Organizational benefits of TURA

The organizational benefits of TUR planning and plan implementation affect every level of the organization, from management to shop floor employees. Regarding increased management attention to environmental practices, one respondent explained that "TURA is a great reason to make sure management and others are involved, and it facilitates routine business discussion."

Consultation with employees is a required component of the TUR planning process. Respondents described experiences in which employees generated ideas that both protected employee health and improved efficiency.

For example, a facility that has been in the TURA program since 1990 installed a bulk caustic solution tank in 2007. The idea was generated by shop floor employees who worked directly with the caustic solution. Prior to the toxics use reduction project, employees worked directly with 30-gallon drums of caustic solutions. The process was labor intensive and involved exposure of workers to toxic chemicals. Now the entire process is automated. By eliminating the need to handle 2500 or more drums per year, the facility has saved $70,000 annually in raw material costs.

Respondents also cited benefits related to improved morale. One respondent noted that toxics use reduction had improved morale by making the facility's cleaning processes more efficient. This was described as a "great morale booster—cleaning is not a desired task."

3.3.2. Health and environmental benefits

Several respondents described examples of improvements in worker health and safety resulting from TUR implementation. For

Table 7
Benefits experienced as a result of implementing TUR projects in the period 2000–present.

Benefit	Responses	Percentage (of 196 Respondents)
Increased management attention to environmental practices	108	55%
Improved worker health and safety	99	51%
Financial savings	81	41%
Compliance with other state or federal regulations	64	33%
Improvements in production efficiency	57	29%
Improved product marketing	41	21%
Improvements in product quality	33	17%
Improvements in technology and physical infrastructure	30	15%
Compliance with international standards	22	11%
Improved worker–management relations	21	11%
Other	18	9%
Improved community relations	16	8%
Retention of a product line	12	6%

example, one facility switched to hard piping of the facility's wash-water reuse system. TUR, worker safety, and productivity were all incentives for implementing the project. The facility had previously reused wash water by pumping it into drums, which were moved back to the front of the line for reuse. Hard piping and automating the system saved time and labor, and reduced exposures for shop floor workers by reducing the possibility of leaks or spills.

Another respondent described the facility's experience in eliminating cyanide and PCBs, and reducing use of TCE, methylene chloride, anhydrous ammonia, and a VOC lacquer. The respondent noted that eliminating cyanide alone has significantly improved worker health and safety at the facility.

3.3.3. Financial benefits

TURA program requirements are designed to allow facilities maximum possible flexibility in achieving their TUR goals. While facilities are required to complete a TUR plan and to conduct a financial analysis of their TUR options, they are not required to implement any specific TUR option. Thus, when facilities do implement TUR options, they frequently select options that offer direct financial savings as well as health, environmental and other benefits. Eighty-one respondents (41%) indicated that their facility achieved financial savings as a result of implementing TUR options in the period 2000–2006.

For example, a facility that has been in the TURA program for four years installed new cutting presses that allow for tighter patterns, reducing the quantity of scrap fiberglass that is sent out for disposal by about one ton per week. This change reduced operating costs by reducing both raw material and disposal costs, while improving productivity. Through this and other TUR projects, as well as changes in energy use, the facility reduced annual operating costs by more than $25,000.

3.3.4. Professional benefits for TUR planners

Most general practice planners that responded to the survey indicated that they also work with facilities that are not TURA filers. Of these planners, 83% indicated that their knowledge of TUR is an asset for their work with non-TURA filers.

3.4. Challenges faced in TUR project implementation

The survey gave respondents the opportunity to provide additional information on what challenges or barriers they face as they make decisions about what TUR projects to implement. As shown in Table 8, the challenges cited by the largest number of respondents were technical feasibility problems (62%); financial costs (55 percent); concerns about product quality (49%) and customer requirements (45%). In their open-ended responses and in the telephone interviews, respondents provided additional detail on concerns about product quality, and the role of customer requirements.

3.4.1. Concerns about product quality

Regarding product quality, one respondent provided the following example: "We tried to use high-grade zinc with low lead content instead of prime western zinc with about 1% lead content in our galvanizing process. The zinc coating quality is not as good using the high-grade zinc. As a matter of fact, the quality was so poor that management decided to go back to the prime western zinc until we can come up with another solution."

3.4.2. Customer requirements

Customer requirements may result from specifications (e.g. military specifications) that are difficult to change; unique functional requirements; or simply a preference for a familiar option. For example, one respondent noted that "The medical industry has a lot of product requirements and exemptions, and getting changes approved is difficult." Another commented that, "Our facility does custom formulations or required formulations for clients; customer decisions often veto substitution options." Another respondent identified customer requirements as "the biggest barrier to phase out lead. Leaded glazes are superior in quality and performance, and customers still want the leaded glaze, although recent stories about lead in toys and paints have helped dull demand." Yet another noted that the facility had had difficulty replacing cadmium because Department of Defense clients specified the inclusion of cadmium in airplane and parachute parts, and disallowed the zinc-tin or zinc-cobalt alloys that were offered as replacements.

3.4.3. Institutional challenges

Some respondents noted that management at their facility places greater emphasis on short-term costs than on long-term benefits, or simply consider TUR to be a low priority. Perceived lack of sufficient benefits was cited as a barrier by 29% of facility respondents and 28% of general practice planners. Nine percent of facility respondents and 28% of general practice planners indicated

Table 8
Barriers to implementing TUR projects in the period 2000–present (facility respondents).

Barrier	Responses	Percentage (of 196 Respondents)
Technical feasibility problems	121	62%
Financial costs too high	107	55%
Concerns about product quality	97	49%
Customer requirements	88	45%
Lack of sufficient expected benefits	56	29%
Project considered too time consuming	37	19%
Project considered low priority for management	18	9%
Lack of support from supply chain partners	16	8%
Regulatory environment	14	7%
Other	13	7%
Lack of organizational support for implementation	13	7%

that TUR projects were given a low priority by management. For some facilities, plant policies and procedures are dictated by parent companies, limiting the facility's ability to take the initiative in reducing toxics.

Other respondents considered other management systems to be more useful than TUR in achieving environmental health and safety goals. Finally, a few respondents simply stated that they see toxics use reduction as antithetical to their company's goals. For example, one respondent stated: "Our company is in the business of selling chemicals. The TURA program essentially reduces our business. A company that survives by selling both toxic and non-toxic chemicals should not have to provide a TURA plan."

3.5. Changes in facilities' experiences over time

One of the goals of the program assessment was to determine how facilities' experiences in the program have changed over time. The early years of the program were characterized by facilities identifying "low-hanging fruit" – opportunities to reduce toxics through simple changes in production systems. These changes often produced financial savings as well. The survey posed questions about how facilities' experiences with TUR planning and other aspects of the program have changed over time.

The survey asked respondents to indicate how often the first, second, and subsequent TUR planning cycles lead to the discovery of new TUR opportunities or options. Respondents were asked about planning years 2000–2006, which pre-date the alternative planning provisions of the 2006 amendments. Thus, responses to this question provide information about the baseline prior to the implementation of the 2006 amendments.

Some respondents indicated that they find that planning is no longer as useful as it was earlier in the program. Others indicated that they do continue to identify new options over time. Seventy percent of respondents "always" or "usually" found new TUR opportunities or options when doing a TUR plan the first time. While a facility's first and second plans are most likely to produce significant insights into the production process, nearly all respondents indicated that they sometimes identify useful TUR options in subsequent planning cycles as well.

Some respondents offered suggestions about how the TURA program could increase the effectiveness of planning and encourage facilities to learn from one another's experiences. One general practice planner recommended shifting the perspective of the planning periodically: "Usually, if we re-metric … we can find other options that are not readily apparent." Another respondent noted that additional regulatory motivators become increasingly important after the first two planning cycles.

3.6. Value of TURA program services

TURA program services and resources include training sessions, conferences, workshops, compliance assistance, on-site visits, written and online materials, demonstration sites, grant programs, and laboratory and library services. In addition, the program provides an annual 40-h course to train new TUR planners. These services are available to all Massachusetts businesses and individuals, regardless of whether they are subject to TURA program requirements. This section summarizes survey results on the value of these services and resources to TURA filers and planners.

Of the respondents using program services, 90% or more considered the program websites, training sessions, conferences, workshops, and the TUR planner course to be "very" or "somewhat" useful. The program's written resources, compliance assistance, and library and reference services were rated as "very" or "somewhat" useful by more than 80% of the respondents on behalf of individual facilities, and by 93, 88, and 91% of general practice planners, respectively.

Of those who received site visits, 74% of respondents on behalf of individual facilities and 90% of general practice planners found the visits to be "very" or "somewhat" useful. Cleaner technology demonstration sites and laboratory services were ranked as "very" or "somewhat" useful by over 65% of respondents on behalf of individual facilities, and over 70% of general practice planners. In general, respondents on behalf of individual facilities and general practice planners provided similar assessments of the relative usefulness of each program service, with a slightly higher proportion of general practice planners categorizing each service as useful.

3.7. Community survey results

3.7.1. Benefits and challenges

Survey respondents described economic as well as health and environmental benefits from implementation of community toxics use reduction projects. These include marketing benefits for small businesses, such as landscaping and janitorial services; provision of training to municipal employees and boards; and long-term savings from reducing hazards to water supplies.

Respondents also commented on ways in which the grant program provided them with access to scientists and professionals with specialized expertise, media outlets, and opportunities to leverage additional support. Unique resources offered through the grant program included technical support, training, and materials; education and hands on training that would have not been available otherwise; and assistance with media outreach.

Most grant recipients did not describe major implementation challenges. Some mentioned difficulties associated with carrying out the project in the allotted time, coordinating all the partners and activities involved in the project, or addressing regulatory and institutional barriers.

3.7.2. Project longevity and leveraging of additional support

One of the goals of the community grants is to help begin projects that can continue independently after the grant period has ended. Of the fourteen projects discussed in the online survey, eleven continued after the grant period ended. Only three had received funding prior to the TURI grant.

The telephone interviews gathered additional information on the role of TURI grants in project development and future funding prospects. The fourteen grant recipients participating in the telephone interviews (not necessarily overlapping with the online survey respondents) received, collectively, a total of just over $190,000 in TURI grant funds. In a number of cases, the TURI grant served as seed money, making it possible for the organization to raise significant additional amounts of funding after receipt of the TURI grant. The interviewees reported a total of $1,458,000 in non-TURI grants received after receipt of the TURI grant (a leverage factor of 7.5).

For example, the respondent on behalf of the Regional Environmental Council (REC) of Central Massachusetts, a community environmental justice organization, indicated that prior to applying for and receiving a grant from TURI, the organization focused primarily on more traditional environmental issues, such as recycling. A series of grants from TURI helped the organization to develop expertise in toxics and health, areas that are now an important focus of the organization. REC later leveraged this expertise to apply successfully for larger grants from Federal, state, and city sources. The respondent indicated that "The TURI grants helped us to break new ground and develop the confidence needed to get additional funding."

In another example, the Vietnamese-American Institute for Development (Viet-AID), a community development organization, received grants from TURI in fiscal years 2007 and 2008 to educate Vietnamese floor finishers about hazards of, and safer alternatives to, certain floor finishing materials. Earlier outreach efforts had been unsuccessful, but with the additional staff time and resources that were made possible by the TURI grant, Viet-AID was able to educate a large number of floor finishers. Building on the expertise and track record developed under the TURI grant, Viet-AID later applied successfully for U.S. EPA support.

4. Discussion

The survey and interview results are of potential value both for planning within the TURA program, and for other jurisdictions that wish to replicate TURA program elements. This section provides brief comments on some of the themes that emerge from the results presented above.

4.1. Benefits of TUR planning and plan implementation

One question motivating the study was to determine whether the TURA program continues to be useful twenty years after its original adoption. The survey results indicate that facilities are continuing to reap significant benefits from the TUR program, including organizational benefits as well as improved worker health and safety and financial savings.

Comparing the present survey results with those of the program evaluation survey that was conducted a decade earlier can provide additional insight. The 1997 program evaluation found that the most frequently cited benefit of implementing TUR projects was cost savings (67% of respondents), followed by improvements in worker health and safety (66% of respondents). Both of these benefits were near the top of the list in the present survey as well, although the percentage of respondents reporting these benefits was smaller (41% and 51%, respectively). This is consistent with the experience of many facilities in identifying "low-hanging fruit" opportunities for toxics use reduction in the early years of the program. The benefit reported most frequently in the quantitative portion of the present survey, "increased management attention to environmental practices," which was chosen by 55% of respondents, appeared only in the open-ended responses in the 1997 survey so the percentages cannot be compared.

4.1.1. Organizational benefits

Complying with TURA can affect the internal dynamics within a facility in a variety of ways. One of those ways is increased management attention to environmental practices. The TURA planning requirements are designed to facilitate buy-in from every staffing level, including management. Other activities that can attract management attention include demonstration sites and opportunities for the facility to be honored as a leader.

TURA can also affect internal dynamics through its requirement that the planning process include consultation with employees. This requirement helps to ensure that employees have an opportunity to express concerns and provide suggestions, an opportunity that is not guaranteed by other regulations. The opportunity for employees to weigh in is not guaranteed by any federal statutes. The anecdotal information provided in open-ended survey responses and interviews indicates that some facilities are gaining substantial benifits from the employee consultation element of the planning process, achieving financial savings and improvements in health and safety as a result of employee-generated ideas. There may be scope for other facilities to learn from these successes in order to make the best possible use of this plan element.

4.2. Value of TURA program services

Some of the activities that respondents cited as most useful have been a focus of TURA program work. For example, reduction of lead use has been a focus of TURA program activities at both TURI and OTA. Among other activities, TURI has worked with Massachusetts businesses to create a consortium of facilities working to build and test prototypes of lead-free electronic circuit boards. Many respondents cited lead reduction as a key benefit of the TURA program for their facility.

Another example is the program's work to facilitate communication up and down the supply chain as a means of facilitating toxics use reduction for specific industry sectors. Supply chain communication has been particularly important for the work by manufacturers of electrical and electronic equipment to comply with RoHS requirements, in particular the reduction or elimination of lead.

4.3. Challenges faced in implementing TUR projects

The design of the TURA program, with its focus on voluntary implementation of TUR options, makes it possible for facilities to make business decisions about the most technically and financially viable options. Those options that are less viable from a technical or financial standpoint are set aside in favor of those that are most advantageous to the facility. Thus, even under ideal circumstances, some options will be rejected due to technical or financial barriers. However, the TURA program endeavors to help facilities overcome as many such barriers as possible. Thus, for example, the technical barriers cited by respondents indicate opportunities for assistance through research and technical support.

It is notable that while 41% of respondents cited financial savings as a benefit of TUR plan implementation, 55% cited financial costs as a barrier. These responses are not contradictory: in some cases, cost is the deciding factor against a project. This is consistent with facilities also gaining significant financial benefits from TUR implementation in some cases.

4.4. Opportunities for greater integration with other management systems

The survey results indicate that a number of respondents were interested in increased integration between TUR planning and other management tools. In the process of implementing the 2006 amendments, the TURA program has worked to integrate TUR principles into the broader environmental management systems (EMS) methodology. Going forward, it may also be useful to work toward the integration of TURA principles into Lean Six Sigma processes and other, similar management systems. It may also be useful to build the Global Reporting Initiative criteria into TURA reporting; these criteria are used increasingly by U.S. EPA and other state pollution prevention programs (U.S. EPA 2010).

4.5. Opportunities associated with alternative resource conservation planning

The 2006 amendments to TURA make it possible for facilities to conduct alternative resource conservation planning as an alternative to toxics use reduction planning under some circumstances. The survey focused on facilities' activities prior to these amendments going into effect. However, the survey responses indicate that even prior to the 2006 amendments, some facilities were using the TUR planning process to identify options for energy and water conservation, in addition to reducing toxics.

Going forward, with the implementation of the 2006 amendments, the TURA program has the opportunity to encourage and facilitate adoption of new energy- and water-saving techniques. The experiences of facilities that have already undertaken some activities of this kind indicate opportunities for progress by other facilities. Skills and capacity built through existing TURA program activities have helped to lay the groundwork for further progress in this area.

4.6. Opportunities to increase the usefulness of TUR planning

Most respondents indicated that the usefulness of the TUR planning process decreases with repeated planning cycles, although some useful TUR options continue to be discovered with repeated planning cycles. It is worth noting, however, that some facilities have found ways to make the planning process useful every time it is conducted, and some respondents offered specific suggestions about ways to ensure continued usefulness of the planning process. In this context, there are potential opportunities to help planners and facilities to ensure that the planning process is useful every time. This could include encouraging facilities to begin the planning process earlier in the year, and providing guidance on options for shifting the perspective of the planning process in each cycle.

4.7. Technological change and the role of TUR planning

In some instances, additional toxics use reduction occurs over time because new options become available due to the development of new materials and technologies. With repeated planning cycles, facilities have an opportunity to re-visit their use of toxic substances regularly and to take advantage of new alternatives as they become available.

The case of solvent reduction, substitution, and elimination provides a good case in point. Some of the facilities that have reported reductions in solvent use in the period 2000 to 2006 have been in the program for many years. Some had difficulty reducing their use of toxic solvents earlier in the program, but were able to do more in recent years due to technological advances.

Some facilities shifted from solvent-based systems to safer aqueous systems in the mid 1990s, while others found it difficult to make this shift. For facilities that have difficulty switching to an aqueous system, an alternative or intermediate solution is to move to a closed-loop system that minimizes potential exposures. Closed-loop vapor degreasing systems became available in the late 1990s; thus, some facilities that have reported reduction in solvent use in recent years have done so thanks to this new technology.

4.8. Role of capital investments in toxics use reduction

The survey results indicate that facilities are continuing to choose to make capital investments in toxics use reduction techniques. In all cases, facilities made a business decision in favor of these capital investments; the TURA program does not require facilities to make these investments.

It is interesting to note that most of the capital investments (74%) were under $100,000, and a third of them were under $10,000. These results indicate that facilities continue to identify toxics use reduction options that can be implemented with a relatively small up-front capital investment.

4.9. Improvements over time: progress since 1997

As noted in the introduction, the 1997 program evaluation identified a number of areas for improvement in the TURA program. These included addressing barriers related to product quality and customer requirements; rewarding firms that have made progress in TUR and focusing assistance on those that have been less successful; working with smaller quantity toxics users to ensure they make progress in tandem with larger firms; applying the principles of TUR planning to areas other than use of toxic chemicals, such as water and energy use; and analyzing health and environmental effects of toxics in consumer products during use and disposal.

It is valuable to consider which of these recommendations have been pursued and where the remaining gaps may lie, as context for interpreting the other material presented in this article.

Many, though not all, of the 1997 recommendations have been followed.

- The program has addressed barriers related to product quality and customer requirements for specific industry sectors through a wide variety of activities, including demonstration sites, on-site technical assistance, university research, and supply chain initiatives. These activities are ongoing with variations to address industry needs that change over time.
- The program has continued to reward firms that make progress in TUR by showcasing their work in public events, publishing case studies, and other activities. The program has, however, done less to focus assistance on those companies that have underperformed.
- The 2006 amendments to TURA have addressed some of the recommendations directly. Under these amendments, facilities may use the toxics use reduction planning process to plan for conservation of other resources such as water and energy. In addition, the amendments create a higher hazard substance designation which makes it possible for the program to work with smaller firms in some cases. There continues to be additional scope for work with smaller firms, as many of them are still not covered by TURA.
- The recommendation that TURA work to assess the effects of toxic chemicals in products has been fulfilled to some extent in the TURA program's work on alternatives assessment; its grants to community organizations and university researchers; and individual research projects funded by outside agencies. However, there continues to be ample opportunity to better address the problem of toxic chemicals in products used in Massachusetts. One possible forum for addressing chemicals in products is for the TURA Administrative Council to coordinate action on this issue among multiple Massachusetts agencies.

5. Directions for future research

One weakness of the present study was that many respondents lacked institutional memory, making it difficult for them to answer some of the questions, especially those related to changes in costs or savings over time. Many respondents lacked detailed information on costs or savings associated with TUR implementation over a period of several years, and could comment only expenditures or savings within the past year. This made it difficult to draw robust quantitative conclusions about costs and savings over time. In the future, it will be useful to request financial information from facilities at shorter intervals.

Under the 2006 amendments to TURA, facilities have the option to do alternative resource conservation planning or develop an environmental management system (EMS) in place of regular TUR planning, or to incorporate TUR into an existing EMS. This option was created in order to ensure that repeated cycles of TUR planning continue to be useful for facilities. It will be important to survey facilities in future years to determine whether there are changes in

the rate at which facilities indicate that second and subsequent TUR planning cycles are useful.

The 2006 amendments also make it possible for the TURA program to designate "higher hazard substances." Facilities are subject to TURA reporting, planning, and fee requirements if they use more than 1000 pounds per year of a higher hazard substance. As of February 2010, four substances have been designated in this status; the program has the statutory authority to designate up to ten per year. This new provision means that beginning in reporting year 2009, new and smaller facilities will be subject to TURA program requirements. It will be important to assess the experiences of these new facilities entering the program, capturing their experiences early on and tracking changes over time.

It may also be of interest to take a closer look at the role of Toxics Use Reduction Planners in driving toxics use reduction at Massachusetts facilities. A future study could assess the significance of the planner certification program in the success of the TURA program, and could provide insights to other states considering creating such a program.

Unlike the 1997 evaluation of the TURA program, this study also includes some preliminary information on the experience of community organizations that have received grants or other assistance from the program. There is ample scope for further study of these organizations' activities, their effects on health and the environment in Massachusetts, and their experiences working with state agencies through the TURA program.

6. Conclusions

The results of the survey and interviews conducted with Massachusetts facilities indicate that facilities are continuing to experience benefits from the TURA program, including improved worker protection and financial savings as well as organizational benefits. Facilities also continue to face challenges, ranging from technical feasibility problems to limitations deriving from customer specifications. In combination with past studies of the TURA program, the present study adds to a comprehensive understanding of the program's effects on Massachusetts companies, and provides baseline information about the experience of TURA filers prior to the implementation of the 2006 amendments to TURA. It also provides useful information on the benefits of TURA program grants to community organizations. Results indicate that relatively small grants, combined with active support from TURA staff members, can make it possible for these organizations to build substantial projects and leverage significant additional support.

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Appendix

The following sample respondent profiles are based on online survey results as well as telephone interviews.

Sample respondent #1

The respondent's facility has been in the TURA program for eleven years.

In the online survey, the respondent noted that the facility has been able to stop reporting for two chemicals because of TUR project implementation. A variety of TUR planning elements were flagged as "very useful," including soliciting TUR ideas from employees. The respondent noted that other facilities outside Massachusetts have employed TUR techniques. The respondent also indicated that every TUR planning cycle has revealed areas of opportunity, and that Cleaner Technology Demonstration Sites sponsored by the TURA program have helped the facility to generate new ideas.

In the period 2000–2006 the facility made TUR-related capital expenditures in the range of $250,001–$500,000, and reduced annual operating costs by $100,001–$250,000 through TUR implementation in this same period. The capital expenditures included new production equipment (e.g., moving from 150 to 50 gallon acid bath tanks) and corresponding controls. However, the respondent noted that the savings in chemical costs, filing fees, and waste and wastewater disposal costs have "more than made up for" these expenditures in terms of annual savings.

The respondent indicated that with each TUR plan, staff members generate and undertake some new project. Recently they experimented with a new product to prolong solution life. An ion exchange project they attempted failed, but the respondent was glad TURA helped to generate the idea and said they learned something even with the failure. Most recently, filtration to help freshen the acid bath resulted in a 7–10% reduction in nitric acid use.

Sample respondent #2

The respondent's facility has been in the TURA program for three years. The respondent indicated in the online survey that all TUR elements were "very useful," and cited improved worker health and safety and financial savings benefits. The respondent noted that at this facility, an employee feedback form is distributed every three months to solicit TUR suggestions. Winners are declared for the best improvement ideas, and several successful projects have been proposed in this manner.

As an example of a TUR project, the respondent explained that in the facility's reclamation process, a series of chemical baths are used to strip a variety of coatings, including copper, from wafers. Previously, some of these baths would "boil over" with the reactions. Employees designed a new bath shape to save money, prevent spills, and reduce exposures to the chemicals.

Sample respondent #3

The respondent's facility has between 100 and 500 employees, and has been in the TURA program for 16 years. The respondent indicated in the online survey that the facility has eliminated use of two toxic chemicals through implementation of TUR projects; that the facility implemented TUR projects in plan years 2004 and 06; and that the facility experienced worker health and safety and financial savings benefits. The respondent reported total capital expenditures of $500,001–$1,000,000 over the period 2000–2006.

The facility found that there were many improvements it could make in the 1990's, but the respondent indicated that it has become more difficult to implement TUR over time. Even with annual planning meetings, the facility has more difficulty finding changes to make.

The respondent stated that a major benefit of TUR has been the removal of the facility from the "spotlight" of environmental regulators. Reporting to TURA has become easier since the facility has reduced its number of reportable chemicals from four to one.

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