

TURNING UP THE HEAT: ELIMINATING MERCURY THERMOSTATS FROM THE MARKETPLACE



**New England Zero Mercury Campaign
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Executive Summary

Thermostats that contain mercury contribute to local, regional and global mercury pollution when they are handled and disposed of improperly. Each year an estimated 1,000-2,000 pounds of mercury from thermostats are disposed of haphazardly or illegally throughout New England in landfills, incinerators, and construction and demolition dumps. As a result, the widespread use of electromechanical thermostats with mercury switches poses a significant threat to human health and the environment. This report challenges New England states to recognize the risks of mercury-switch thermostats, as well as the benefits of non-mercury, energy efficient alternatives, and develop the regulations necessary to prevent the sale and haphazard disposal of mercury containing thermostats.

In 1998, the New England Governors committed to virtually eliminating human-caused releases of mercury into the environment. While each New England state has taken significant steps to reduce mercury emissions consistent with the regional Mercury Action Plan, much more needs to be done. The problem of mercury pollution remains. In 2004, scientists at the Environmental Protection Agency estimated that 1 in 6 women of childbearing age in the United States have unsafe mercury levels in their bodies. This translates to over 630,000 babies born at risk for mercury exposure each year.

Because cost-effective and energy efficient alternatives are available, New England states should take immediate action to ban the sale of mercury thermostats in order to facilitate ending the production of this obsolete, toxic product. The availability of functionally equivalent or superior non-mercury thermostats was thoroughly assessed and demonstrated by the Lowell Center for Sustainable Production, under contract for the Maine Department of Environmental Protection.¹ Based on this information, Maine recently joined four other states in phasing out sales of mercury thermostats by January 1, 2006.

Further, states should also require that existing mercury thermostats – as well as all mercury-containing products – are not disposed of in landfills, incinerators, construction and demolition sites, or otherwise improperly or haphazardly handled. Additionally, states should require thermostat manufacturers to take responsibility for their toxic products, and ensure that a very high percentage of mercury thermostats are collected and recycled when removed from use.

Fulfilling the New England Governors' pledge to "virtually eliminate" anthropogenic mercury releases to the environment means taking action to control each and every source – and comprehensively addressing the problems posed by mercury-switch thermostats is a necessary step in that process. In summary, based on the findings of numerous recent studies from both government and industry sources, the New England Zero Mercury Campaign strongly recommends the following:

- Phase out the sale of mercury thermostats.
- Ban the disposal of all mercury-containing thermostats into the solid waste stream.
- Require manufacturers to establish and finance effective and aggressive collection systems to ensure that at least 90% of mercury thermostats removed from service are collected and recycled. Failure to meet this target should result in manufacturers establishing a bounty system to ensure that the capture rate is met.
- As part of the collection systems, wholesalers should be required to have collection bins, and manufacturers should be held responsible for establishing and funding collection sites at retail outlets where thermostats are sold and at municipal program sites that accept household hazardous waste.
- Developers should use mercury-free, energy efficient thermostats in building plans.
- Require all government agencies and low-income housing facilities to purchase only mercury-free thermostats for use in new buildings or renovations.

Introduction

Elimination of mercury-switch thermostats from the marketplace and creation of manufacturer take-back programs for proper management and recycling should be a high priority. Thermostats represent the largest amount of mercury in household products, and—unless the necessary steps are taken—will remain a significant source of mercury in the municipal waste stream and continue to contaminate New England’s environment. A single mercury thermostat typically contains between three to five grams of elemental mercury. Because mercury is a persistent, bioaccumulative toxin in very small amounts, releases of mercury from thermostats contribute to local, regional and global mercury pollution.

Mercury is a potent neurotoxin that has historically been used in manufacturing processes and products without concern for its impacts on human health, fish and wildlife, or the environment. It is highly toxic, and accumulates in the environment as it moves up the food chain. Even in small quantities, mercury can cause significant health and ecological problems. Exposure to methylmercury (the form of mercury that bioaccumulates in fish) can cause severe damage to the functioning and development of the central nervous system, and is particularly harmful for fetuses and young children.

In the 1990s, studies of fish in waterbodies in Canada and the Northeastern states indicated that they contained unexpectedly high amounts of methylmercury, making their consumption dangerous, especially for pregnant women, young children and wildlife such as minks and loons. The U.S. Environmental Protection Agency’s 1997 Mercury Study Report to Congress determined that there is a “plausible link” between the high mercury levels in fish and pollution from human activities. The Eastern Canadian Premiers and New England Governors responded to this environmental health threat by adopting the Mercury Action Plan in 1998, aimed at properly managing old mercury-containing products and minimizing the production of new ones with the ultimate goal of “virtual elimination” of anthropogenic mercury releases.

Thermostats have historically contained mercury switches to automatically maintain building temperatures at a set level by triggering furnace operation when the temperature drops. The mercury switch is comprised of a glass bulb filled with an inert gas and a small pool of mercury that can freely move from one end of the bulb to the other. Attached to the glass bulb is a bi-metal coil that expands and contracts as room temperature changes. As the coil shifts, the glass bulb tilts, causing the mercury to move to one end of the bulb, where it closes an electrical circuit, or to the other end, where it opens an electrical circuit, thereby triggering the heating and/or cooling equipment to turn on and off.²

According to the National Electrical Manufacturers Association (NEMA), there are more than 50 million mercury thermostats in homes across the United States.³ It is estimated that nearly 30,000 pounds of mercury were used in thermostats sold across New England in 2001 (see Table 1).

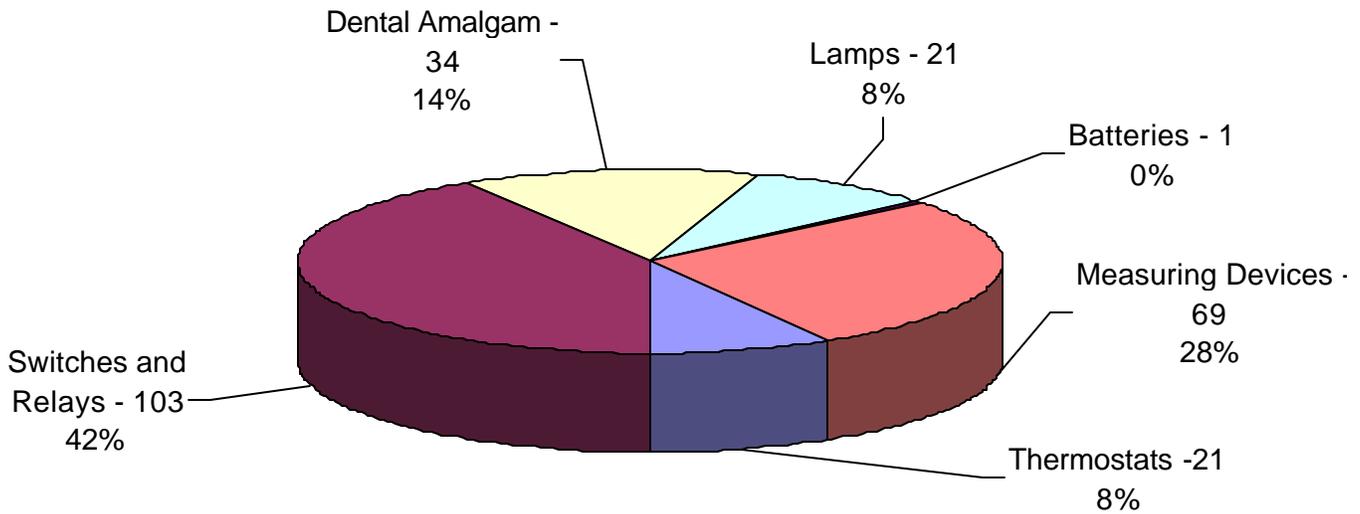
Table 1: Estimated Amount of Mercury in Thermostats Sold in New England, 2001

State	Mercury sold in thermostats, pounds
CT	347
MA	647
ME	130
NH	126
RI	107
VT	62
US Total	28,689

Notes: Estimated amount of mercury sold in thermostats in New England states based on population distribution, using 2000 United States Census data⁴. Total amount of mercury sold in thermostats in US in 2001 provided by Northeast Waste Management Officials Association.⁵

Nationwide, the total amount of mercury in thermostats annually sold is estimated to range from 14.3 tons to 21 tons of mercury. While there is a considerable discrepancy between these two estimates, the Northeast Waste Management Officials Association has confirmed that their estimate of 14.3 tons per year under-reports the actual amount of mercury—as some mercury used in thermostats was reported in the “switch” category.⁶ According to the chart below, EPA estimates that 8% of the mercury consumed in the U.S. goes into the production of electromechanical mercury-switch thermostats.

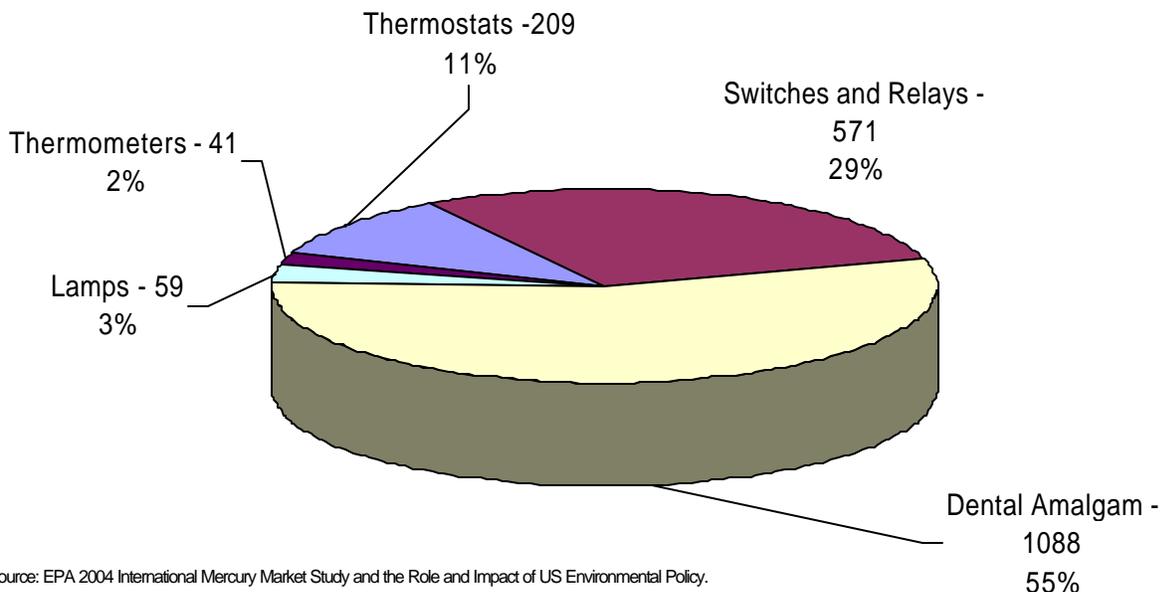
Figure 1: Estimated Annual Consumption of Mercury in Products⁷
 Total Annual Consumption = 276 tons



Source: EPA 2004 International Mercury Market Study and the Role and Impact of US Environmental Policy.

The U.S. Environmental Protection Agency has estimated that 21 tons of mercury is used annually for the production of thermostats (see Figure 1). Furthermore, the Agency estimates that mercury thermostats currently in homes and businesses contain a reservoir of over 200 tons of mercury that will be disposed of across the country in the next few decades (see Figure 2).⁸

Figure 2: Estimated Mercury Reservoirs in Products⁹
 Total Mercury Reservoir = 1968 tons



Source: EPA 2004 International Mercury Market Study and the Role and Impact of US Environmental Policy.

Although waste thermostats from businesses are generally classified as hazardous waste, the mercury they contain (and the mercury in household thermostats) usually ends up being released directly to the environment as a result of waste incineration, or indirectly through disposal in the solid waste stream at landfills and construction and demolition dumps. Recycling options in New England have been inconvenient, poorly publicized, not generally offered to the public, and without incentives to foster participation by contractors. Each year, an estimated 1,651 pounds of mercury from thermostats is removed from New England residences (see Table 2), most of which is thrown into landfills, construction and demolition waste sites, or incinerated.

Table 2: Current Estimate of Mercury in Thermostats in New England Residences, 2002

State	Housing Units	Total Thermostats	Mercury Thermostats (83%)	Amount of Mercury (lbs)	Annual Replacement (lbs)*
CT	1,402,643	2,103,965	1,746,291	11,539	385
MA	2,649,029	3,973,544	3,298,041	21,793	726
ME	664,613	996,920	827,444	5,468	182
NH	561,178	841,767	698,997	4,617	154
RI	443,761	665,642	552,482	3,651	122
VT	299,570	449,355	372,965	2,465	82
NE Total	6,020,794	9,031,193	7,495,890	49,533	1,651

Notes: Estimates are based on conservative assumptions from a 2004 Maine DEP report, A Plan to Improve the Collection of Mercury Thermostats,¹⁰ This table does not include thermostats in commercial or public buildings – which also constitute a significant reservoir of mercury. As a result, the total amount of mercury currently in use in thermostats across New England is likely to be much higher than this Table indicates. See Appendix for detailed methodology.

Manufacturers are only required to report their sales to the Northeast Waste Management Officials Association (NEWMOA) every three years (2004 data was not yet available at time of writing). Since 2001, Connecticut is the only state in New England whose law prohibiting the sale of mercury-added thermostats has taken effect. Therefore, it is difficult to estimate sales reduction, since data are not readily available.

About 1.8 million mercury-switch thermostats are brought out of service each year in the U.S., according to the EPA.¹¹ If one assumes that almost every residential unit in the United States contains at least one mercury thermostat, the potential for mercury pollution just from the improper management of existing mercury thermostats becomes clear. There are 115,904,641 residential units in the U.S.¹² With each mercury thermostat containing at least 3 grams of mercury, there are 347,713,923 grams, or 765,890 lbs of mercury in residential units alone.

Because of environmental concerns and limitations of the technology, mercury-switch thermostat applications are increasingly being limited to residential and light commercial use. While still widely used in some office buildings and schools, that type of use is declining rapidly. This is due to several factors, including the need for integration of systems including lighting, heating, ventilation, fire, and security that require more sophisticated technologies.¹³ As a result, annual sales and revenues for mercury thermostats are steadily declining over time.¹⁴

There is a significant reservoir of mercury in thermostats which will eventually be released into the environment –through building fires, demolition, and disposal –unless states adopt policies that require new thermostats to be mercury free, ban the disposal of mercury thermostats into landfills or incinerators, and mandate collection and recycling programs.

Alternatives to Mercury Thermostats

Programmable digital thermostats are a viable alternative to mercury thermostats. They are readily available, contain no mercury, and are more cost effective than mercury thermostats. A digital thermostat can be programmed to turn down the heat when people are sleeping or away at work, and then turn it back up when more heat is needed. This additional function can save large amounts of energy compared with a mercury thermostat that maintains a single setting.

Claims have been made by manufacturers and retailers that setback thermostats can save up to 30 percent in utility costs.¹⁵ According to the U.S. EPA, installing a programmable, “Energy Star” approved thermostat in your home can save you about \$100 a year.¹⁶ Although programming the thermostat is no more difficult than adjusting a digital watch, microwave, or alarm clock, many electronic thermostats are “smart” – meaning they come pre-programmed with energy efficient settings. This way, even those who are not adept at working digital gadgets can immediately start accruing cost savings and environmental benefits from their non-mercury thermostat.

Table 3: Price Ranges of Thermostat Types¹⁷

Thermostat Variety	Price Range
Electromechanical – With Mercury Switches	\$17.97 - \$34.15
Electromechanical – Without Mercury Switches	\$15.21 - \$38.84
Electronic – non-programmable	\$18.00 - \$76.75
Electronic – programmable	\$29.00 - \$151.45

Industry Claims

Industry has consistently claimed that mercury thermostats are more reliable and have a longer life than electronic thermostats. Yet in a 2004 decision affirming the Maine Department of Environmental Protection’s denial of the industry’s request for exemption from Maine’s ban on sale of mercury thermostats, the Maine Board of Environmental Protection wrote:

“The Frost and Sullivan market survey contradicts [the thermostat industry’s] reliability claims for mercury thermostats.¹⁸ That study says that the life span of mechanical thermostats can reach the 15-year mark, while “electronic devices are estimated to last longer as they do not contain moving parts that wear out, therefore maintaining their reliability.”¹⁹ According to Frost and Sullivan:

"The average life for most thermostats is somewhere between 10 and 15 years depending on the application of the device and factors such as cleanliness of the environment. A thermostat can be kept working for over 20 years, however its reliability will be greatly diminished. This certainly is the case with electromechanical thermostats, where mechanical parts get worn out over time, reducing reliability."²⁰

State Legislative Action on Mercury Thermostats

There are several states that have taken action to address the sale and/or disposal of mercury thermostats. Additional states are expected to follow suit within the next 2 years.

California: In 2004, California became the fifth state to ban the sale of mercury-added thermostats for most uses after January 1, 2006. There are no collection or disposal requirements in the law. (Chapter 6.5 of Division 20 of the Health and Safety Code of California, Article 10.2.1)

Connecticut: In 2002, Connecticut passed a comprehensive mercury products bill which phased out the sale of mercury-containing products. Products containing greater than one gram of mercury (including thermostats) were banned for sale after July 1, 2004. Connecticut requires manufacturers to set up collection systems for these mercury products sold after July 1, 2003. (Connecticut General Statute Chapter 446, Section 22a-617)

Maine: In 2001, Maine banned the sale of mercury thermostats (effective January 1, 2006). In December 2002, the National Electrical Manufacturers Association applied to the Maine DEP for an exemption from the sales ban. DEP denied the exemption, and the decision was affirmed on appeal to the Board of Environmental Protection on May 6, 2004. (38 Maine Revised Statutes Annotated § 1661-C, sub-§ 5)

On the specific point of reliability, Frost and Sullivan have this to say:

“One of the major problems encountered with the use of electromechanical thermostats is the lack of reliability. Over time, the mechanical parts used in electromechanical thermostats become dirty and begin to malfunction. The major issue when it comes to reliability is the ability of the thermostat to turn on and off at the set temperature. A thermostat that is working at a 3 to 4 degree difference from the set temperature will consume additional energy and will not provide a comfortable environment.

The electronic thermostat can provide these benefits as their design provides both reliability and comfort. The setting on an electronic thermostat has a margin of error of +/- 1 degree and in some thermostats the error can be as little as half a degree. End users have become more demanding and are expecting better results from their thermostat device. This idea has strengthened demand for electronic devices and, as price drops, demand is anticipated to be even greater.”²¹

Manufacturers also claim that mercury-added thermostats are more energy efficient than the non-mercury alternatives, but this claim appears to be based on a comparison between mercury switch thermostats and non-mercury models selected for their inefficiency. There are numerous non-mercury thermostat models on the market with energy efficiency ratings equal or superior to mercury switch thermostats. In fact, the EPA Energy Star Program, which was established to protect the environment by promoting energy efficient products including thermostats, does not include any mercury switch thermostats among the 125 thermostats that qualify for the Energy Star label. All of the Energy Star models are electronic programmable thermostats. These programmable alternatives generally save users both energy and money when compared with mercury switch thermostats.

The following table lists the major manufacturers of electromechanical thermostats. A breakdown of which manufacturers provided thermostats with and without mercury switches was unavailable.

Table 4: Manufacturers of Electromechanical Thermostats²²

Manufacturer	1999 Market share
Honeywell	66%
White-Rodgers	15%
Robertshaw	6%
Other	13%
Total	100%

State Legislative Action on Mercury Thermostats, continued

Rhode Island: In 2001, Rhode Island passed the Rhode Island Mercury Reduction and Education Law, which was later revised in 2003. The law was a comprehensive mercury products law that phased out the sale of mercury containing products. Products containing greater than one gram of mercury (including thermostats) were banned for sale after July 1, 2005. Under the law, mercury-containing products may not be disposed of in municipal waste systems. Manufacturers of mercury-containing products (including thermostats) must set up and finance collection systems to ensure that those products are recycled.

(RI General Laws 23-24.9)

Oregon: In 2001, Oregon became the first state in the nation to pass a law banning the sale of mercury thermostats (effective January 1, 2006), and requiring manufacturers of mercury-added thermostats to take responsibility for the collection of used thermostats. The law also requires the State Construction Contractors Board to provide an annual notice to contractors about the thermostat rules.

(Oregon Revised Statutes Chapter 455, Section 355)

Collection of Mercury Thermostats

Mercury thermostats have a long shelf life, so it is imperative that a system be put in place to ensure that these thermostats are collected in a comprehensive manner over a long period of time. For more than a decade, Honeywell has made some effort to recycle its mercury thermostats. In 1998, along with General Electric Co. and White-Rodgers, it created the Thermostat Recycling Corporation (TRC), a Rosslyn, Virginia-based nonprofit association.

While this action by industry to take responsibility for the toxic products they put on the market appears positive, manufacturers, for a time, used the program to justify continued sales of new mercury thermostats. At the same time, it became increasingly clear that TRC is far from solving the mercury thermostat collection problem. TRC currently recycles one to five percent of the mercury thermostats removed from service each year in the northeastern states.²³ In another example, Wisconsin recycles just under 5,100 mercury thermostats through the industry program, less than 3 percent of the estimated 180,000 discarded.²⁴ The extremely low capture rate found in the northeast generally reflect what is occurring nationally, according to Thermostat Recycling Corporation data. Although TRC claims to be a nationwide program, they report no collection in 10 states,²⁵ and few thermostat dealers in the northeast have been recruited to participate in this voluntary program.²⁶ Also, TRC only makes its services available to contractors that buy wholesale, not to the general public.

Table 5: Thermostat Recycling Corporation Collections, 2003²⁷

State	Thermostats Collected	Mercury collected, lbs
Connecticut	901	7.08
Maine	482	4.49
Massachusetts	1168	11.56
New Hampshire	398	3.47
Rhode Island	0	0
Vermont	194	1.59
NE Total	3,143	28.19

According to the NEWMOA 2001 study, the northeast region could potentially be collecting over 55,000 thermostats per year.²⁸ Yet this may be a conservative estimate, since individual states in New England have estimated much higher numbers.²⁹ Table 5 illustrates that TRC is only capturing a small percentage of available mercury from discarded thermostats in the New England states.

These numbers make a compelling case that recovery rates for mercury thermostats must be dramatically improved. States should act to require more effective industry-funded programs, with incentives for dramatically increasing the collection of mercury thermostats, through either providing discounts on purchases of new non-mercury thermostats when old ones are turned in or in the form of so-called “bounty programs” where the manufacturers pay a set fee for each recovered thermostat.

Policy Recommendations

There are many steps that state governments can take to prevent mercury thermostats from entering the waste stream, and ultimately contaminating our environment. Here in New England, the states of Vermont, New Hampshire, and Massachusetts must follow the lead of their neighbors in addressing this significant source of mercury pollution. In order for the region as a whole to fulfill the New England Governors’ pledge to virtually eliminate mercury releases to the environment, all states must:

- **Phase out the sale of mercury thermostats.**
- **Ban the disposal of all mercury-containing thermostats into the solid waste stream.**
- **Require manufacturers to establish and finance effective and aggressive collection systems to ensure that at least 90% of mercury thermostats removed from service are collected and recycled. Failure to meet this target should result in manufacturers establishing a bounty system to ensure that the capture rate is met.**
- **As part of collection systems, wholesalers should be required to have collection bins, and manufacturers should be responsible for establishing and funding public collection sites at retailers where thermostats are sold and at sites of municipal collection programs that accept household hazardous waste.**
- **Developers should use mercury-free, energy efficient thermostats in building plans.**
- **Require all government agencies and low-income housing facilities to purchase only mercury-free thermostats for use in new buildings or renovations.**

Appendix

Calculations of Mercury in Thermostats in New England Residences and Waste Stream Amounts

Calculations in Table 2 are based on calculations and estimates made in *A Plan to Improve the Collection of Mercury Thermostats*, Maine Department of Environmental Protection, January 15, 2004 (Appendix 1). The following assumptions that were made in that report are employed here:

- Thermostats have a 30 year life span;
- There are on average 1.5 thermostats per home;
- 83% of all thermostats contain mercury;
- Most thermostats contain 3 grams of mercury.

The Maine report states that these numbers are thought to be conservative (for example, some estimates suggest that 90% of thermostats contain mercury, and some thermostats contain more than one ampoule of mercury and so would have closer to 6 grams).

Using these numbers, the calculations are as follows (the state of Connecticut will be used as an example):

1.) (# of Housing Units in the state) X (1.5 thermostats per household unit) = (# of residential thermostats)

eg: Using 2000 US Census data for Connecticut:

$$(1,402,643 \text{ housing units in CT}) \times (1.5) = \mathbf{2,103,965 \text{ residential thermostats in CT}}$$

2.) (# of residential thermostats) X (.83 thermostats that use mercury) = (# of mercury thermostats in the state)

$$\text{eg: } (2,103,965 \text{ residential thermostats in CT}) \times (.83) = \mathbf{1,746,291 \text{ mercury thermostats in CT}}$$

3.) $\frac{(\# \text{ of mercury thermostats}) \times (3 \text{ grams mercury per thermostat})}{454 \text{ grams per pound}}$ = pounds of mercury in residential thermostats

$$\text{eg: } \frac{(1,746,291 \text{ mercury thermostats}) \times (3 \text{ grams mercury per thermostat})}{454 \text{ grams per pound}} = \mathbf{11,539 \text{ pounds of mercury in CT residential thermostats}}$$

4.) Assuming the life of a thermostat is 30 years, each year 1/30th of the thermostats are replaced.

$\frac{(\text{Pounds of mercury in residential thermostats})}{30}$ = Pounds of mercury in residential thermostats replaced each year

$$\text{eg: } \frac{(11,539 \text{ pounds of mercury in CT residential thermostats})}{30} = \mathbf{385 \text{ pounds of mercury in residential thermostats replaced annually in CT}}$$

Since these assumed numbers are conservative, it is likely that the amount of mercury actually in use in thermostats and replaced each year is even higher than these numbers suggest. These calculations also do not include thermostats used in businesses, which is an additional significant reservoir of mercury.

Endnotes

- ¹ Morose, Gregory, *A Review of Thermostat Energy Efficiency and Pricing*, Prepared for the Maine Department of Environmental Protection, Lowell Center for Sustainable Production, University of Massachusetts Lowell, May 12, 2003. The report is available at <http://www.maine.gov/dep/mercury/lcspfinal.pdf>.
- ² *ibid*, p.15.
- ³ All four industry claims are included in a chart labeled “Thermostat Comparison” (8/01) distributed by Paul Boudreau, Vice President, Corporate Relations, Honeywell, *Presentation to the Maine Mercury Advisory Committee*, August 30, 2001.
- ⁴ <http://www.census.gov/main/www/cen2000.html>
- ⁵ NEWMOA, 2005
- ⁶ Northeast Waste Management Officials Association (NEWMOA), *FACT SHEET; Mercury Use in Thermostats*, January, 2005.
- ⁷ United States Environmental Protection Agency, *International Mercury Market Study and the Role and Impact of US Environmental Policy*, 2004.
- ⁸ “EPA’s Draft Mercury Reduction Program,” Presented to the Great Lakes Bi-national Toxics Forum by Linda Barr, EPA Office of Solid Waste, November 30, 2004.
- ⁹ United States Environmental Protection Agency, *International Mercury Market Study and the Role and Impact of US Environmental Policy*, 2004.
- ¹⁰ Maine Department of Environmental Protection, *A Plan to Improve the Collection of Mercury Thermostats*, January 15, 2004. The report is available at <http://mainegov-images.informe.org/dep/rwm/publications/legislativereports/pdf/thermostatreport.pdf>
- ¹¹ Northeast Waste Management Officials Association, *Review of the Thermostat Recycling Corporation’s Activities in the Northeast*, p. 1, November 1, 2001.
- ¹² <http://www.census.gov/census2000/states/us.html>
- ¹³ Frost & Sullivan, *North American HVAC Thermostat and Temperature Control Markets*, May 2000, p.5-2
- ¹⁴ Frost & Sullivan, p.1-4
- ¹⁵ Frost & Sullivan, p.5-6; The Home Depot, *Save Energy, Save Money* advertisement flyer, p.36, 2001; features six mercury-free thermostats including the Honeywell Smart Programmable Thermostat: “Smart responses maximize comfort and savings by automatically adjusting start times for changing weather, Save up to 33% on energy costs,” Even Honeywell concedes this point. See chart labeled Thermostat comparison (8/01) distributed by Paul Boudreau, Vice President, Corporate Relations, Honeywell, *Presentation to the Maine Advisory Committee*, p.7, August 30, 2001.
- ¹⁶ http://www.energystar.gov/index.cfm?c=thermostats.pr_thermostats
- ¹⁷ Morose, 2003.
- ¹⁸ The reliability claims referred to by the board are set forth in the industry's letter of appeal dated September 11, 2003 from Ric Erdheim of the National Electrical Manufacturers Association to the Chair of the Maine Board of Environmental Protection. The Frost and Sullivan market survey relied on the board in responding to the industry's claims was submitted to the Maine Department of Environmental Protection in February 2003 in support of the industry's petition for exemption from 38 MRSA §1661-C(5), the Maine statute that bans the sale of mercury-added thermostats beginning January 1, 2006. See Frost & Sullivan, *North American HVAC thermostat and Temperature Control Markets* (May 2000).
- ¹⁹ Frost & Sullivan, *supra* n. 7 at p. 4-7.
- ²⁰ Frost & Sullivan, *supra* n. 7 at p. 5-5.
- ²¹ Frost and Sullivan, *supra* n. 7 at p. 7-5.
- ²² Frost and Sullivan.
- ²³ NEWMOA, 2001.
- ²⁴ Personal conversation with John Reindl, WI county official, email communication, Feb. 2005
- ²⁵ <http://www.nema.org/media/pr/20040220a.cfm>
- ²⁶ NEWMOA, 2001
- ²⁷ <http://www.nema.org/gov/ehs/trc/> Spreadsheet of TRC Collection Results: Jan 1998 – Dec. 2003
- ²⁸ NEWMOA, 2001
- ²⁹ Personal communication with John James, ME DEP, Feb, 2005