

MEMORANDUM

To: MassSave Appliance Rebate Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) Consultants

From: The Residential Evaluation Team

Subject: Program Assessment - Tube TV Recycling - Final

Date: March 24, 2015

The goal of this study was to assess the feasibility of expanding the MassSave Appliance Rebate program to offer rebates for recycling operable but old, inefficient tube televisions (CRT-TVs).

The Massachusetts Program Administrators Appliance Rebate program is aimed at helping residential customers reduce their energy usage by recycling old inefficient appliances. Already the program covers refrigerators and freezers and CRT-TVs might be an additional energy savings opportunity. Implementation of this program would include removal of the units and potentially, in some cases, voucher for the incremental cost of replacing the unit with a new, efficient television.

To save on survey costs, the Evaluation Team collected television data from 150 Massachusetts homes in conjunction with the lighting market assessment study. Out of 150 houses, the team identified 370 TVs, measuring the size and recording the technology type of each unit. We also collected additional self-reported usage information such as the average hours of daily use, estimated purchase date, and the willingness of the customer to replace the unit if offered with free removal for secondary TVs and a \$50 voucher for primary TVs.

The Evaluation Team found that out of the 370 TVs recorded, 20% were CRT-TVs, targets for replacement, with the remaining 80% consisting of LCD/LED, plasma, or rear projection TVs (all considered efficient). While our team observed a reasonably high saturation of CRT-TVs, our research indicated that the remaining CRT-TVs were underutilized, small, and being naturally replaced by users. For these reasons, the Evaluation Team does not recommend expanding the existing recycling program at this time. The analysis that follows presents the rationale behind our recommendation.

TV penetration and usage in the Massachusetts market

TV screen size is one of the most important factors for determining energy consumption. As TV screen size increases energy consumption increases as well. Thus, there is a greater savings opportunity as TV size increases. . Table 1 shows the distribution of TVs by size. Of the TVs surveyed, only 1% of CRT-TVs were shown to be larger than 40" and almost half (48%) were smaller than 20". In contrast, most LCD/LED TVs were between 30" and 50", with plasma and rear projection TVs even larger than that.

Table 1: Distribution of active TVs by size and type

| | All TVs | CRT | LCD/LED | Plasma | Rear Projection | |
|-------------------------------|---------|-----|---------|--------|-----------------|-----|
| Sample size (total TVs) | 370 | 73 | 279 | 13 | 5 | |
| Percent of total TVs | 100% | 20% | 75% | 4% | 1% | |
| Screen Size Range (inches) | 10-20 | 16% | 48% | 9% | 8% | 0% |
| | 20-30 | 18% | 38% | 13% | 15% | 0% |
| | 30-40 | 28% | 12% | 33% | 8% | 20% |
| | 40-50 | 29% | 0% | 34% | 62% | 60% |
| | 50-60 | 8% | 0% | 10% | 8% | 20% |
| | 60+ | 1% | 1% | 1% | 0% | 0% |

A more obvious driver of energy consumption is the average amount of time a TV is turned on. The survey also collected user reported data on the average daily use of each TV. Table 2 shows that the majority of CRT-TVs were used for one hour or less, confirming user responses that these were in fact secondary TVs. On average, CRT-TVs were also the least utilized of each of the TV types with an overall average use of 2.1 hours. In contrast, LCD/LED TVs were used for an overall average of 3.6 hours per day. Additionally, 11% percent of all TVs surveyed were LCD/LED TVs used for 4 hours per day.

Table 2: TV usage shown as percentage of all TVs surveyed

| Time used (hrs) | All TVs | CRT | LCD/LED | Plasma | Rear Projection |
|-------------------|---------|------|---------|--------|-----------------|
| 0 | 10% | 5% | 4% | 1% | 1% |
| 1 | 31% | 7% | 24% | 0% | 0% |
| 2 | 12% | 2% | 9% | 1% | 0% |
| 3 | 11% | 2% | 8% | 1% | 0% |
| 4 | 12% | 1% | 11% | 1% | 0% |
| 5 | 6% | 1% | 5% | 0% | 0% |
| 6 | 3% | 1% | 2% | 0% | 0% |
| 7 | 3% | 1% | 2% | 0% | 0% |
| 8 | 4% | 0% | 4% | 0% | 0% |
| 9 | 1% | 0% | 1% | 0% | 0% |
| 10 | 1% | 0% | 1% | 0% | 0% |
| 11 | 0% | 0% | 0% | 0% | 0% |
| 12 | 6% | 1% | 5% | 0% | 0% |
| 12+ | 1% | 0.3% | 0.3% | 0% | 0% |
| Average use (hrs) | 3.3 | 2.1 | 3.6 | 2.8 | 4.2 |

A potential source of error in this analysis stems from user reported data. Our study indicated that the average TV was turned on for 3.3 hours/day. Nielsen publishes TV use data showing that average TV use in 2011 was 5.5hrs/day and rising and that use was 7.5hrs/day for primary TVs¹. Factoring this difference into our analysis, we have used our own surveyed data on TV type, size, and distribution with national TV use data for average daily and yearly use.

Energy Use and Savings of a TV Recycling Program

¹ Nielsen TV market insights. <http://www.nielsen.com/us/en/insights/reports.html>

Compiled in Table 3 are efficiency data shown as estimated annual energy use of TVs in 2006. Although CRT-TVs were at the time being replaced with LCD and plasma TVs, these new TVs were larger and contained more features, resulting in smaller gains in efficiency. Reported annual energy use is calculated from a Department of Energy (DOE) standard including on mode, standby mode, and off mode, as well as a data acquisition mode, if applicable.²

Table 3: Energy consumption televisions in 2006³

| | Estimated Annual Energy Use (kWh/yr) |
|-----------------|--------------------------------------|
| CRT | 244 |
| LCD/LED | 256 |
| Plasma | 679 |
| Rear Projection | 444 |

Since 2006, TV sizes have continued to grow in average size, but now efficiency gains have started to make an impact on energy consumption. For example, the average 40-50" TV in 2010 consumed 143kWh/yr compared to 60kWh/yr in 2015. Energy Star TVs represent the industry standard for energy efficiency of new televisions, and certified Energy Star TVs have been increasingly represented by LCD/LED TVs with the 2015 listing being comprised exclusively of LCD/LED TVs. Shown in Table 4, new televisions of all sizes have reduced their estimated annual energy use by about half since 2010.

Table 4: Estimated annual energy use of Energy Star TVs⁴ over time *exclusively LCD/LED TVs

| Screen Size Range (inches) | Energy Star Certified Estimated Annual Energy Use (kWh/yr) | | |
|----------------------------|--|------|-------|
| | 2010 | 2012 | 2015* |
| 10-20 | 40 | 29 | 23 |
| 20-30 | 57 | 42 | 35 |
| 30-40 | 97 | 80 | 47 |
| 40-50 | 143 | 106 | 60 |
| 50-60 | 174 | 127 | 81 |
| 60+ | 192 | 139 | 93 |

What Table 3 and Table 4 illustrate is that although CRT-TVs are inefficient, industry standards for new TVs did not represent a significant improvement until about 2010. Rather than using CRT-TVs as the standard for inefficient TVs, a more applicable constraint for a recycling program might be the replacement of any primary TV older than 2010. In our survey, data was collected on the year of TV purchase, but was supplied as a user estimate, leaving a range of years and some uncertainty production year and thus the efficiency of the TV. Still, the next section will include TVs older than 2010 as an estimate in their feasibility as targets for replacement.

² DOE estimated annual energy use.

http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/tv_tpnopr_usageanalysis.pdf

³ Television market industry research 2006.

http://www.energystar.gov/ia/partners/prod_development/revisions/downloads/tv_vcr/Preliminary_TV_Market_Research012006.pdf

⁴ ENERGY STAR Most Efficient 2015. <https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Most-Efficient-Televisions/kcm5-p3c5>

Feasibility of a TV Recycling Program

The feasibility of initiating a TV recycling program hinges on the potential energy savings, the cost of the program, and the willingness of the users to participate. The willingness of users to participate in a recycling program was evaluated only if the user had a CRT-TV. The survey was conducted with the incentive that a primary CRT would be removed for a \$50 voucher and a secondary CRT would be removed for free. Table 5 shows that the majority of responders were at least somewhat interested in the recycling program. The analysis that follows will consider only the percentage of users that were at least somewhat interested in the recycling program.

Table 5: Willingness of survey responders to participate in CRT-TV recycling program

| Willing to replace | CRT (primary) | CRT (secondary) |
|-----------------------|---------------|-----------------|
| Total CRT TVs | 19 | 54 |
| Not at all interested | 26% | 46% |
| Somewhat interested | 42% | 33% |
| Very interested | 32% | 20% |

Although the survey focused exclusively on recycling of CRT-TVs, we have also mentioned how energy savings might be achieved from the recycling of older models of LCD/LED TVs, plasma TVs, and rear projection TVs. Shown in Table 6 are the estimated savings of replacing old CRT-TVs with a new industry standard LCD/LED TVs. For primary CRT-TVs, this savings is estimated at 200kWh/yr while savings for secondary and other CRT-TVs is estimated at 70kWh/yr. Included in Table 6 is also an estimate of potential savings from inclusion of primary non-CRT-TVs older than 2010 in the recycling program, with estimated savings each of 150kWh/yr⁵. According to the EIA, the cost of residential electricity in Massachusetts for November 2014 was \$0.17/kWh⁶ meaning that energy savings of 200kWh/yr translate to about \$35/year in savings.

Table 6: Estimated energy savings for TV recycling program.

| Potential for recycling | Total TVs | % of Total TVs | Average Savings | |
|-------------------------|-----------|----------------|-----------------|--------------|
| | | | kWh/yr/TV | kWh/yr/house |
| CRT-TV (primary)† | 14 | 4% | 200 | 19 |
| CRT-TV (secondary)† | 29 | 8% | 70 | 14 |
| Other primary* | 23 | 6% | 150 | 23 |

†Data for users either somewhat or very interested. *Other primary TVs include LCD/LED, plasma, and rear projection TVs that are older than 2010 and identified as primary living space TVs

As shown in Table 6, about 12% of all TVs qualify for the recycling program as it stands with an additional 6% of TVs identified as older flat screen TVs and potentially valuable targets for recycling. Under the proposed recycling program, the average savings would be 33kWh/yr/house which could be boosted to 56kWh/yr/house if older primary flat screen TVs were included as well.

⁵ Estimated from survey data.

⁶ EIA average retail price of electricity by sector.

http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

The cost of recycling TVs under this program would hinge on the cost of disposal of the TVs as well as the voucher offered to replace them. Typical CRT recycling costs are currently around \$0.10/lb for fully intact TVs⁷. A large scale recycling program such as the one proposed here is estimated to cost about \$12 per (statistically larger) primary CRT-TV and about \$8 per smaller secondary CRT-TV with older LCD/LED TVs costing about \$10 to recycle.⁸

As discussed in Table 1, only 20% of all TVs surveyed were CRT-TVs, but these TVs were spread out over 34% of the homes surveyed. A removal program would thus be required to visit more homes in disposing of the old TVs.

An additional constraint limiting the removal of CRT-TVs is their weight. A CRT-TV of 27" can weigh up to 95lbs with larger TVs reaching 300-400lbs. As such, TV's larger than 27" would require two technicians and incur greater removal costs. As an estimate in program cost, these have been factored in to the disposal costs as \$2 per TV, a total value which is reflected in Table 7.

Table 7 shows the cost effectiveness of the recycling program including these costs and spreading them over the average household in the recycling program. There are positive savings immediately for TVs on which no voucher is paid, and although the voucher payment for replacement of a primary CRT-TV is negative in year 1, over a 5 year time period, it results in net positive savings.

Table 7: Costs and savings of TV recycling program

| | Voucher (\$) | Disposal Cost (\$) | Savings/house (\$) | 5 year savings (\$) |
|---------------------|--------------|--------------------|--------------------|---------------------|
| CRT-TV (primary)† | \$50.00 | \$14.00 | -\$2.80 | \$9.89 |
| CRT-TV (secondary)† | \$0.00 | \$10.00 | \$0.37 | \$9.57 |
| Other primary* | N/A | \$12.00 | \$2.07 | \$17.71 |

†Data for users either somewhat or very interested. *Other primary TVs include LCD/LED, plasma, and rear projection TVs that are older than 2010 and identified as primary living space TVs

Clearly electricity would be saved by initiating a TV recycling program, whether it included only CRT-TVs or also older flat screen TVs. For a large program with high participation, these small individual savings could add up to large overall savings of electricity. The financial returns are more mixed; there are savings over 5 years but these will become increasingly an overestimate due to the natural turnover of TVs in use.

Conclusion

The findings of this survey indicate that a TV replacement and voucher program is feasible on a micro-scale but would depend on the overall size of the program to justify the macroscopic costs associated with organization and implementation. Overall, the TV market is changing rapidly and for of the following reasons we do not recommend the TV recycling program.

First, half of all CRT-TVs we found in use were smaller than 20" and on average they were used for half as much time as their newer counterparts. This is a reflection of the relatively fast turnover of the TV

⁷ CRT Glass Processing Update: Industry and Regulatory Developments. <http://kuusakoski.us/wp-content/uploads/2014/10/2014-CRT-White-Paper-Update.pdf>

⁸ AllGreen Massachusetts Electronic Waste Recycling

market in general. Sales of LCD TVs, the largest competitor of CRT-TVs and fully 75% of the TVs surveyed, first exceeded CRT-TVs only in 2007.⁹ The relative prevalence of LCD/LED TVs indicates that replacement has been rapid and that even for those consumers who have kept their old CRT-TVs, they increasingly purchase and favor the use of new LCD/LED TVs. The biggest effect of this turnover is the steady increase in sales of energy efficient TVs. The percentage of Energy Star energy efficient TVs sold per year has risen from 47% in 2003 to 79% in 2013.¹⁰ Each year consumers naturally replace a large fraction of old inefficient TVs with newer increasingly efficient ones.

With the progression of technology and the majority of consumers replacing their primary TVs within the 5 year time horizon used for this study, the effective useful life for an early retirement CRT-TV will be relatively short.

The goal of the MassSave program is the reduction of energy use by replacement of old inefficient appliances with new energy efficient models. This program works well for refrigerators, but is not so well transferrable to TVs for a few reasons. Refrigerators are by nature always turned on, consuming electricity. TVs in contrast are typically used less than 24hrs/day meaning that energy efficient savings have less “time online” to accrue savings. Additionally, TV use can vary depending on the user and purpose of the TV (primary, secondary, etc.). As was the case in this study, users were more inclined to use their less efficient CRT-TVs for shorter times each day than their more efficient primary TVs.

Recommendations:

- Refrain from the TV recycling program, or consider recycling all TVs older than 2010
 - Most CRT-TVs are small and are used infrequently meaning that there is not much savings from them. Full program implementation would be about 33kWh/house/yr on average.
 - Inclusion of other primary TVs older than 2010 would increase savings to 56kWh/house/yr
- Consider a follow up study to measure natural TV replacement in the Massachusetts market
 - Based on TV sales data and current TV breakdown, natural turnover appears to be replacing CRT-TVs with new efficient models
 - Future studies should be conducted in 4-6 years to measure whether CRT-TVs are indeed being replaced naturally
- An additional consideration is the end result of CRT-TVs. In fact, more than 50% of CRT-TV users are interested in a recycling program. Our data show that CRT-TV use is approximately half that of LCD/LED TVs indicating that most users probably have already replaced their primary TV but have not yet disposed of their old TVs. There are a variety of reasons to explain this phenomenon:
 - Difficulty: the TVs are heavy and cumbersome to remove

⁹ Global TV market research. <http://www.displaysearch.com/cps/rde/xchg/displaysearch/hs.xsl/6138.asp>

¹⁰ US shipment and sales of Energy Star TVs.

https://www.energystar.gov/index.cfm?c=partners.unit_shipment_data_archives

- Expense: E-recyclers like BestBuy and Goodwill have started charging or not accepting CRT-TVs respectively due to the mounting costs of disposal
- For these reasons, a TV recycling program might have the unspecified benefit of removing dangerous e-waste from circulation and preventing costly cleanups in the future