Assessing the effect of EISA and EPA regulations on mercury inventory from residential lighting

Huimin Tan, Advisor: Ines Azevedo

Department of Engineering and Public Policy, Carnegie Mellon University

Background Information

Lighting constitutes a large share of electricity consumption, and many current lighting technologies are highly inefficient. Improved technology for lighting holds great potential for energy, emissions and cost savings.

- Fluorescent technologies are seen as promising alternatives to incandescent lamps, since they last longer, have higher efficacy and are more efficient.
- Fluorescent replacements lead to reduced mercury emissions from power plants during the use of the bulb. However, concerns exist that the net mercury emission throughout the lifetime of the bulb may increase as the result of the mercury content in the bulb.

The present analysis examines the impact of recent U.S. mercury-related regulations on residential lighting demand growth over the next ten years, in terms of electricity consumption and mercury inventory.

Recent mercury-related regulations

Recent lighting energy efficiency-related regulations and utility emission standards both impact mercury mass through the use of lamps.

- The Energy Independence and Security Act of 2007 (EISA) has established requirements for the maximum wattages at different four ranges of lumen output. This indirectly translates into a "phase-out" of incandescent lamps.

Light Output Range (Lumens)	Future Maximum Rated Wattage (Watts)	Effective Date
1,490-2,600	72	January 1, 2012
1,050-1,489	53	January 1, 2013
750-1,049	43	January 1, 2014
310-749	29	January 1, 2014

- In 2011, EPA issued the "maximum achievable control technology" (MACT) standards for mercury pollution from power plants. The standards establish mercury emission limits for both existing and new coal-fired or oil-fired power plants.

Subcategory of power plant	Mercury emission limit for new sources (lb/GWh)	Mercury emission limit for existing sources (lb/GWh)
Coal-fired unit not low rank virgin coal	1.3E−2	1.3E−2
Coal-fired unit low rank virgin coal	4.0E−2	4.0E−2
Liquid oil-fired unit	1.0E−4	2.0E−3

Data

Data is obtained from EPA eGRID 2007, 2010 U.S. Lighting Market Characterization, and EIA Annual Energy Outlook 2012. eGRID 2007 provides nationwide power plant-specific electricity generation and emissions rates for mercury. 2010 U.S. Lighting Market Characterization provides average number of lamps, average daily operating hours, and average wattage and efficacy by lamp type in the residential sector. Annual Energy Outlook 2012 provides U.S. household units, average house square footage and electricity grid mix.

Assumptions

The power plant stock is assumed to be static over the next ten years. The mercury intensity of coal and efficiency of mercury control technology are assumed to remain the same throughout 2022. The inventory of residential incandescent lamps is assumed to be composed of equal number of lamps in 40W, 60W, 75W, and 100W, 95% of which burn out at end of their lifetime (~1,000 hours) while the remaining 5% are replaced prior to their burn-out dates due to retrofits. The stock of incandescent lamps as of the base year is assumed to be composed of equal amount of brand-new, half-year old, and one-year old lamps. All the incandescent lamps subject to EISA maximum wattage requirements are assumed to replaced by CFLs, though they can possibly be replaced by LEDs as the technology evolves. A 20% national CFL recycling rate is applied to calculate the total mercury mass from CFLs, assuming 25% out of the 5mg mercury contained in each non-recycled CFL would be released to the environment.

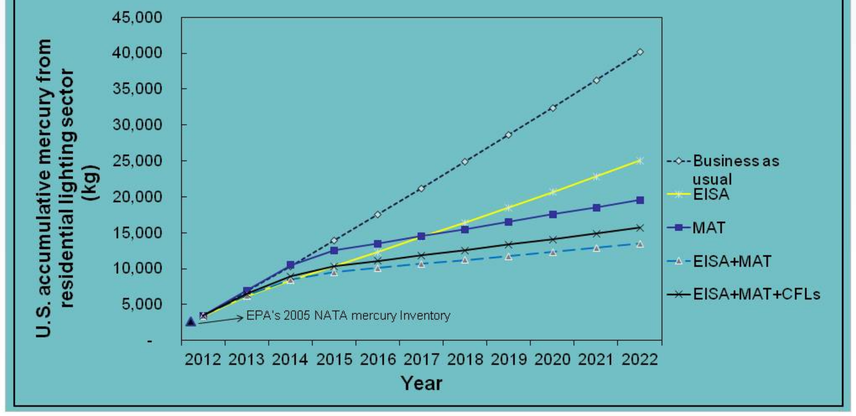
Policy scenarios

The analysis examines the influence of EISA and MACT on mercury mass from lighting under four policy scenarios over the period of 2013 to 2022:

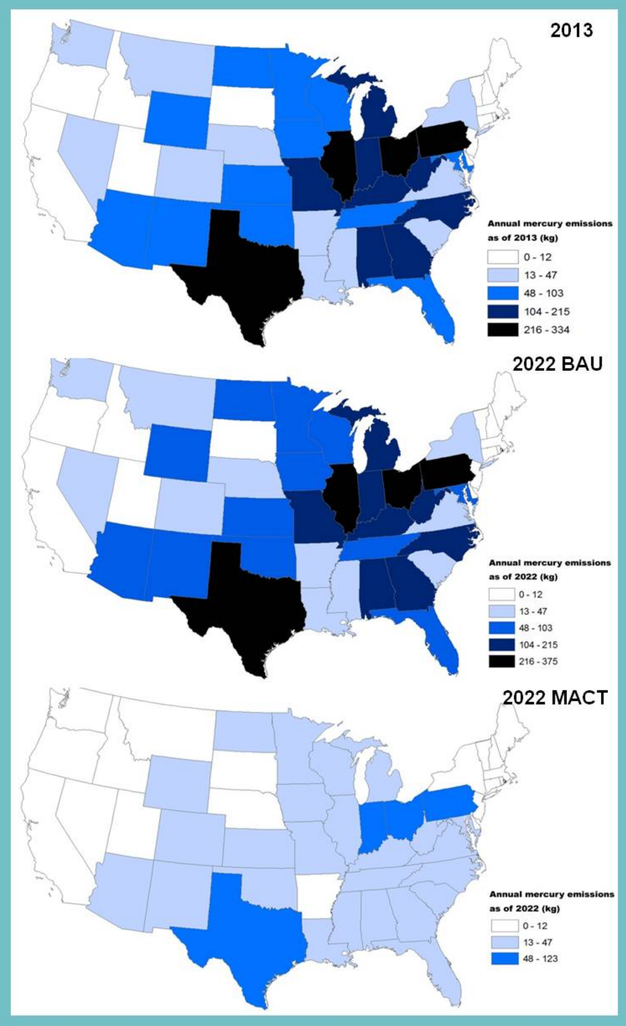
Business-as-usual scenario	Projected mercury emissions inventory of residential lighting (in particular, incandescent lamps), based on the growth of residential households and lighting demand.
EISA scenario	Projected mercury emissions from residential lighting, accounting for change in lamp stock composition as the lamp maximum wattage requirements set by EISA 2007 takes into effect in 2013.
MACT scenario	Projected mercury emissions from residential lighting, accounting for the mercury emission limits for existing coal-fired power plants set by MACT that will take into effect in 2015. This scenario is generated through a bounding analysis, assuming lighting is entirely powered by oil-fired generators or coal-fired generators.
EISA + MACT scenario	Projected mercury emissions from residential lighting, accounting for both the maximum wattage requirement and mercury emission limits.

Results

Projected mercury mass from **power plants** under different policy scenario:



Mercury mass from coal-fired power plants will substantially decrease over the next ten years, as a result of MACT:



- The mercury mass profiles look different by state, depending on the electricity grid mix of each state. TX and OH remain one of the biggest contributors to mercury emissions from power plants, despite of MACT.
- Mercury mass can be reduced by 44% by 2022 in EISA scenario and 73% in MACT scenario. EISA+MACT scenario will generate the most mercury mass reductions, 85% by 2022.
- Mercury mass from power plants are about 20 times as many as that released from CFLs.

Funding sources: This work was supported by the center for Climate and Energy Decision Making (SES-0949710), through a cooperative agreement between the National Science Foundation and Carnegie Mellon University.