Fluorescent Bulbs and Mercury

A spatial life cycle emissions assessment

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Yale School of Forestry & Environmental Studies
Environmental Engineering

Fluorescents and the Public

PHILIPS
sense and simplicity

WAL★MART
Save money. Live better.™

18 SECONDS.ORG
CHANGE A BULB. CHANGE EVERYTHING.

WHAT ARE CFL BULBS & WHY SWITCH ?

United States

CFL LIGHTBULBS PURCHASED SINCE 1/1/07:

145,132,366

VIEW STATE RANKING

EQUIVALENCY:

DOLLARS SAVED: $4,285,091,159

CARS OFF THE ROAD: 1,029,592

POUNDS OF COAL SAVED: 15,108,686,214

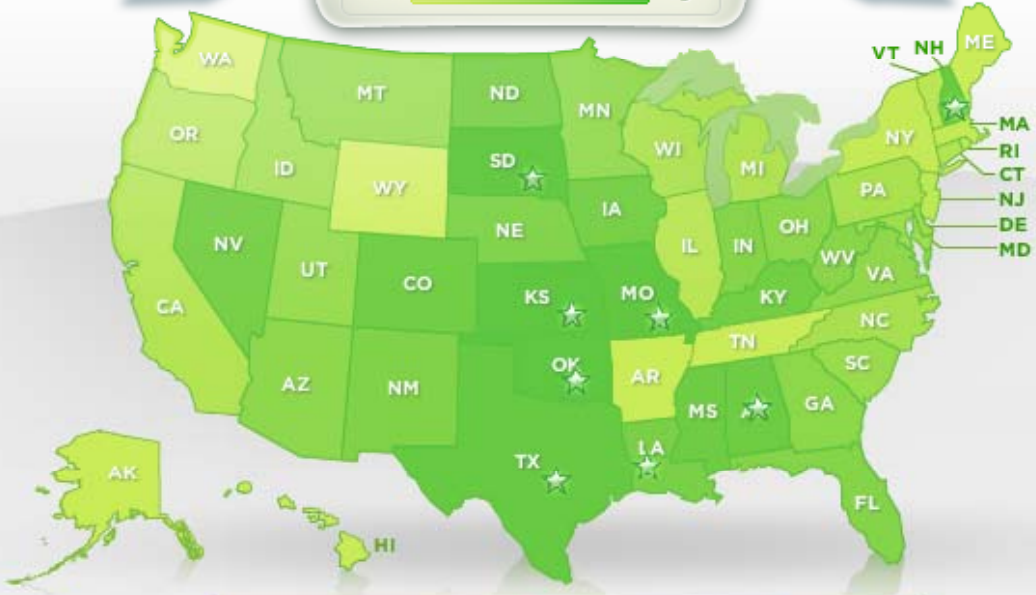
POUNDS OF CO2 PREVENTED: 64,665,176,995

CHANGE A BULB, CHANGE EVERYTHING

It only takes **18 seconds** to change a light. Save energy and cash now by switching to Energy Star CFL bulbs, available nearly everywhere light bulbs are sold.

HOW ENLIGHTENED IS YOUR AREA?

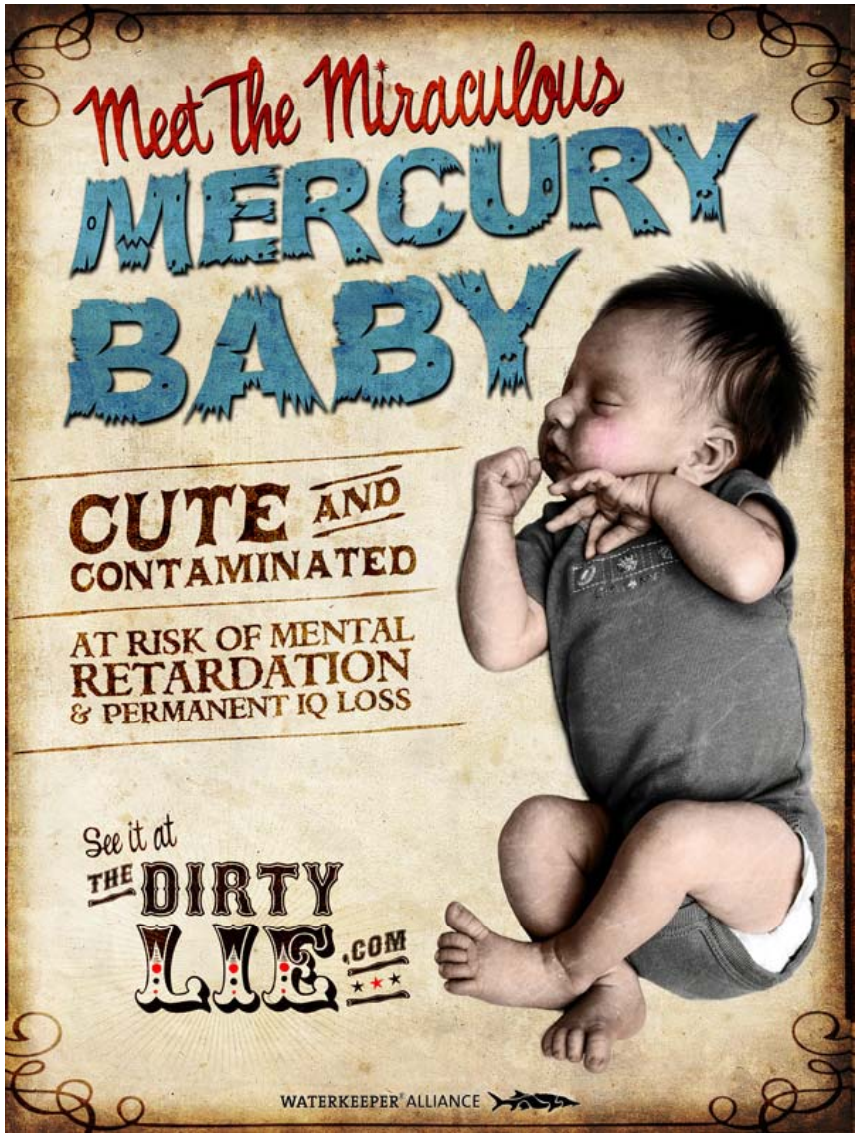
low — high



SELECT YOUR STATE OR ENTER ZIP FIND IT

The typical home has more than 40 sockets for light bulbs.

Fluorescents and the Public



Purpose

Quantify net atmospheric emissions of mercury resulting from the replacement of one 60W incandescent with one fluorescent bulb, by state and country

Life Cycle Inventory (LCI), covering

1. Manufacturing
2. Use
3. Recycling and Disposal

Mercury Sources in U.S.

The major sources of atmospheric mercury in the United States are:

Utility boilers	32.8%
MSW combustors	18.7%
Commercial/Ind boilers	17.9%
Medical waste incinerators	10.1%
Chlor-alkali	4.5%
…	…
Fluorescent lamps	1.0%

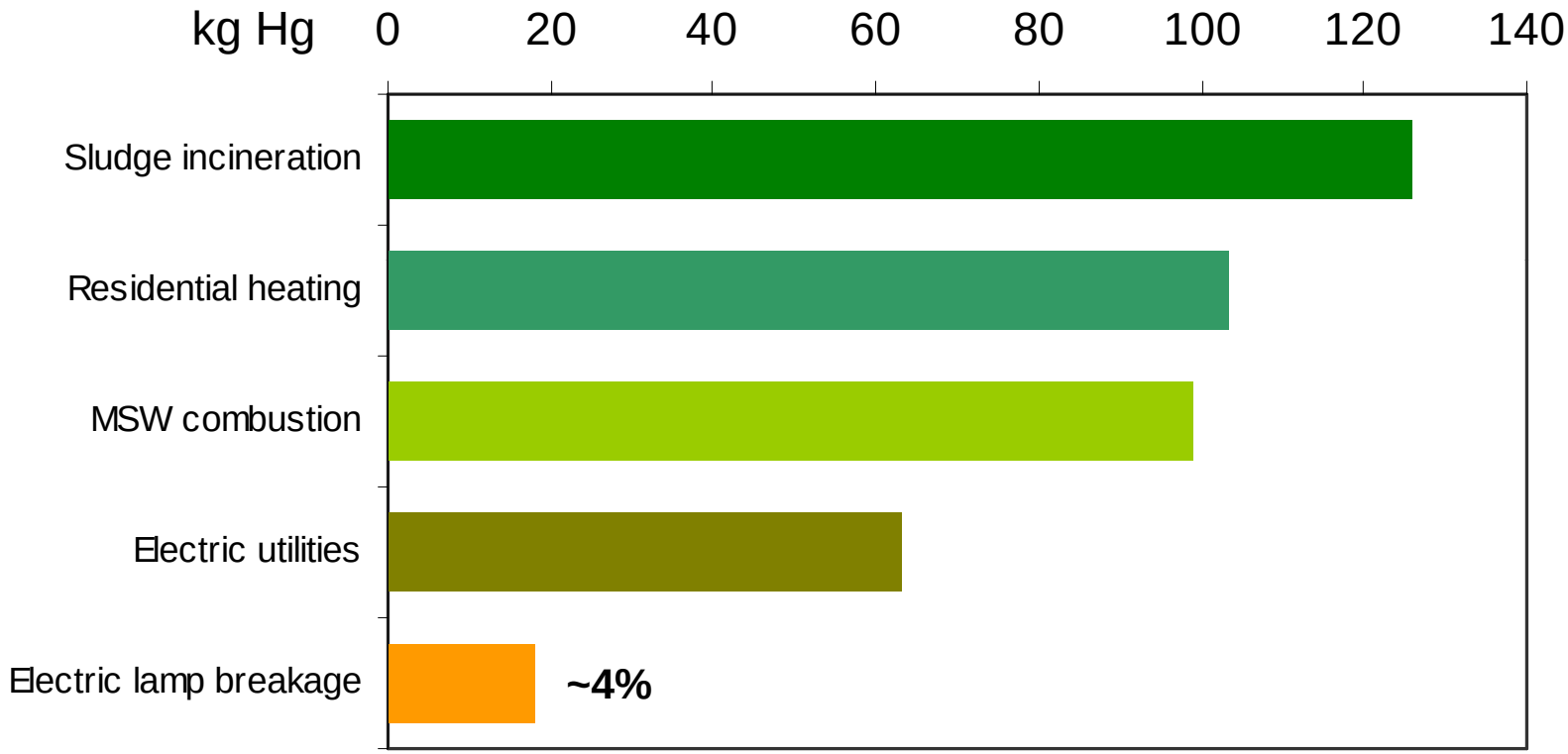
Total Emissions:

144 Mg/yr

Mercury Study Report to Congress

Volume II: An Inventory of Anthropogenic Mercury Emissions in the United States

Mercury Sources in CT

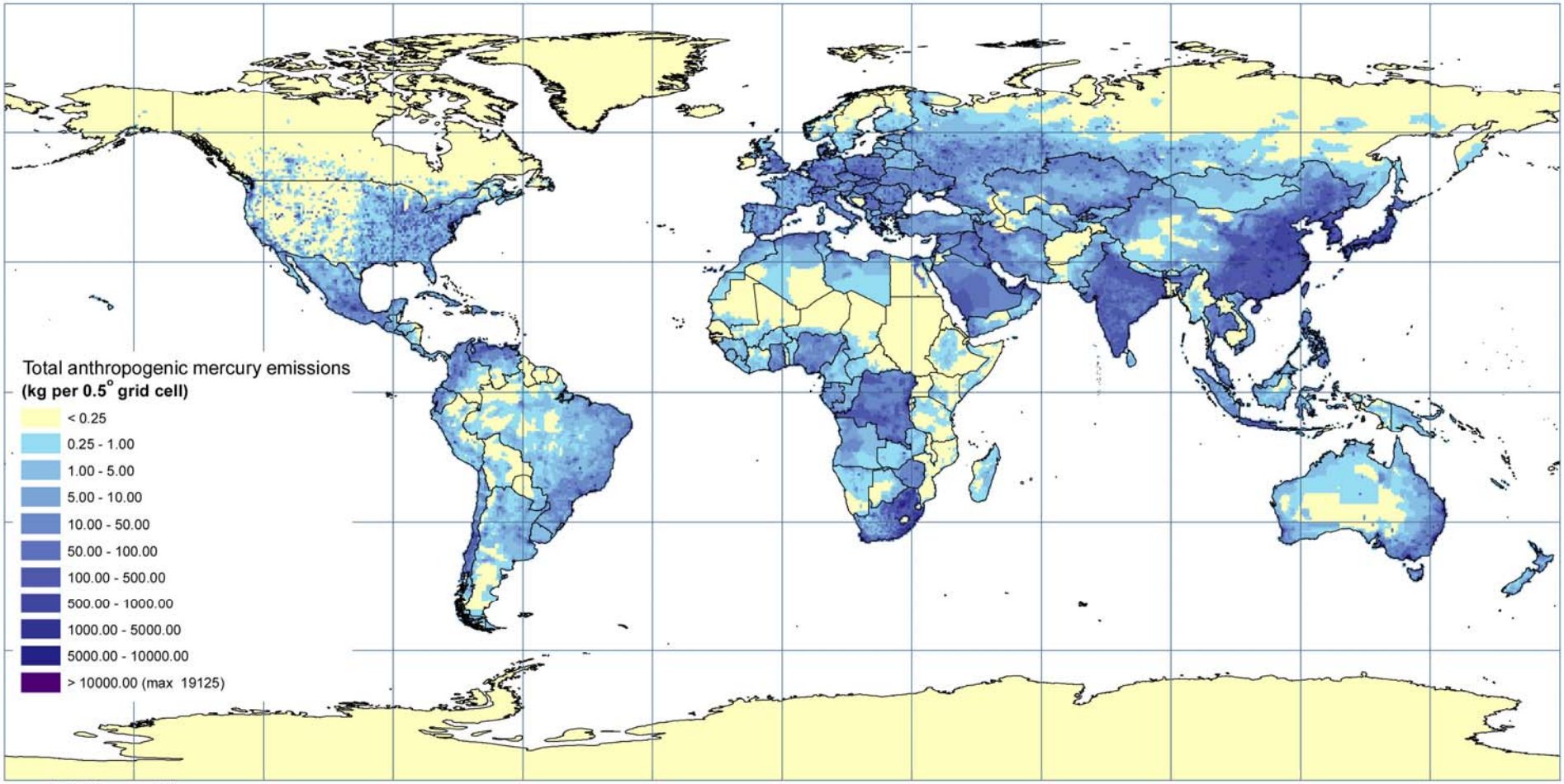


Source: *NESCAUM*

Total Emissions:
450 kg/yr

Spatially Distributed Inventories of Global Anthropogenic Emissions of Mercury to the Atmosphere, 2000

Total Hg, point sources + distributed sources, 0.5° grid

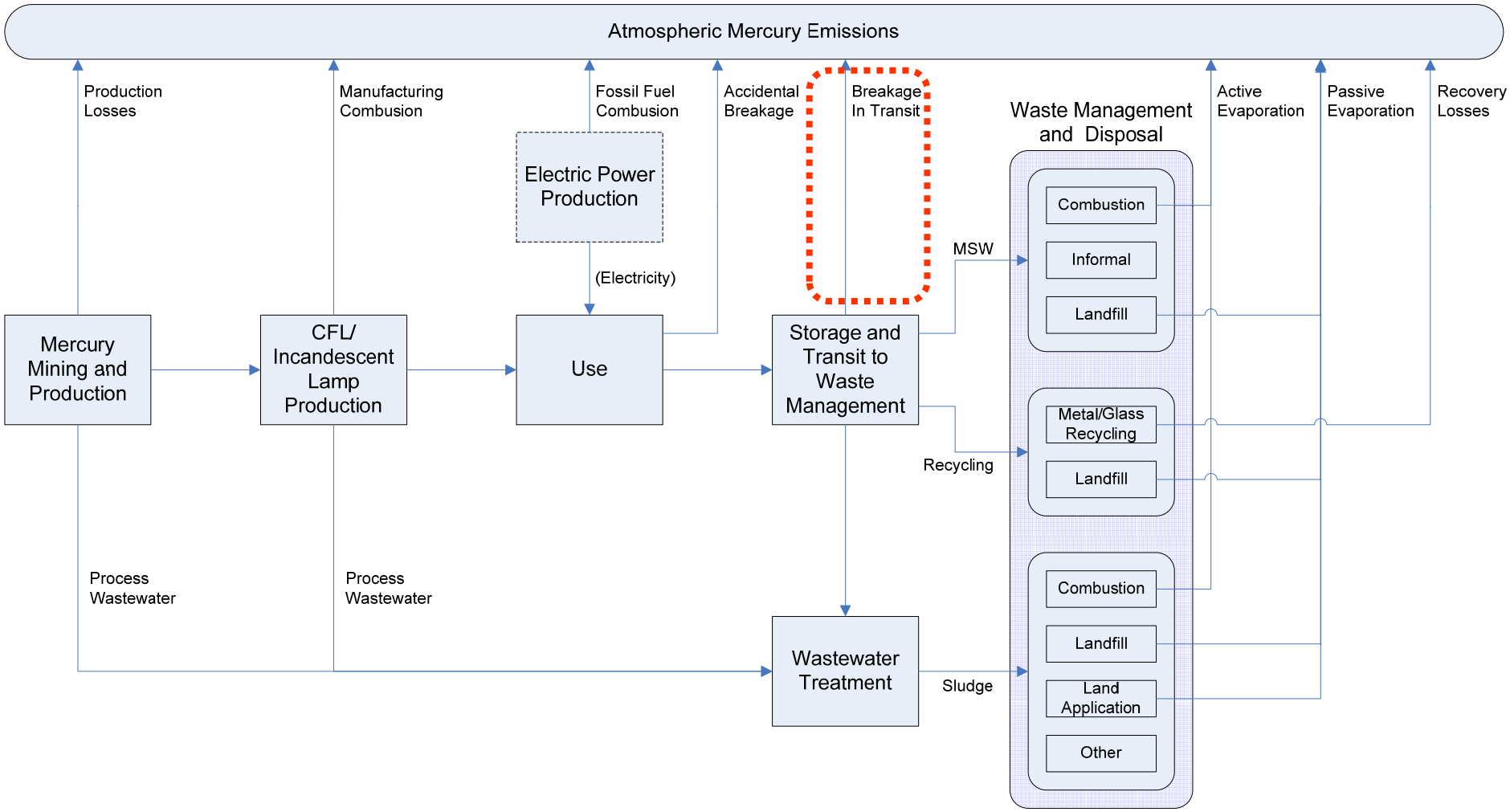


unprojected (geographic)

citation:
Pacyna, J., S. Wilson and F. Steenhuisen. 2005.
Spatially Distributed Inventories of Global Anthropogenic Emissions of Mercury to the Atmosphere.
(www.amap.no/Resources/HgEmissions/HgInventoryMain.html)

S. Wilson (AMAP), F. Steenhuisen (Arctic Centre, RuG), J. Pacyna (NILU)

The Hg – Fluorescents Life Cycle



Mass Balance on Mercury

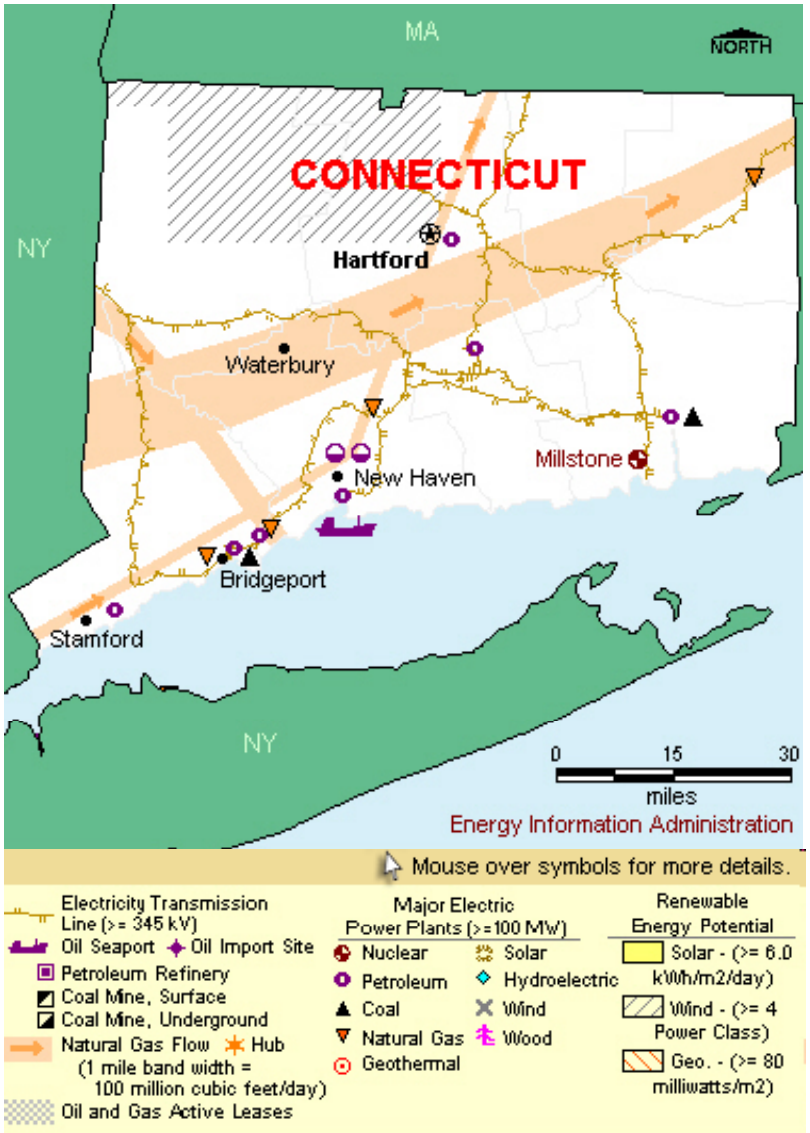
Coal coming in ← Electric Power Production ← *Electricity coming out*

Coal heat content
Coal washing
Coal Hg content

Conversion efficiency
Pollution control
Volatilization fraction

Electricity mix
Trans & dist losses
Grid transfers
Reduced demand from lighting efficiency

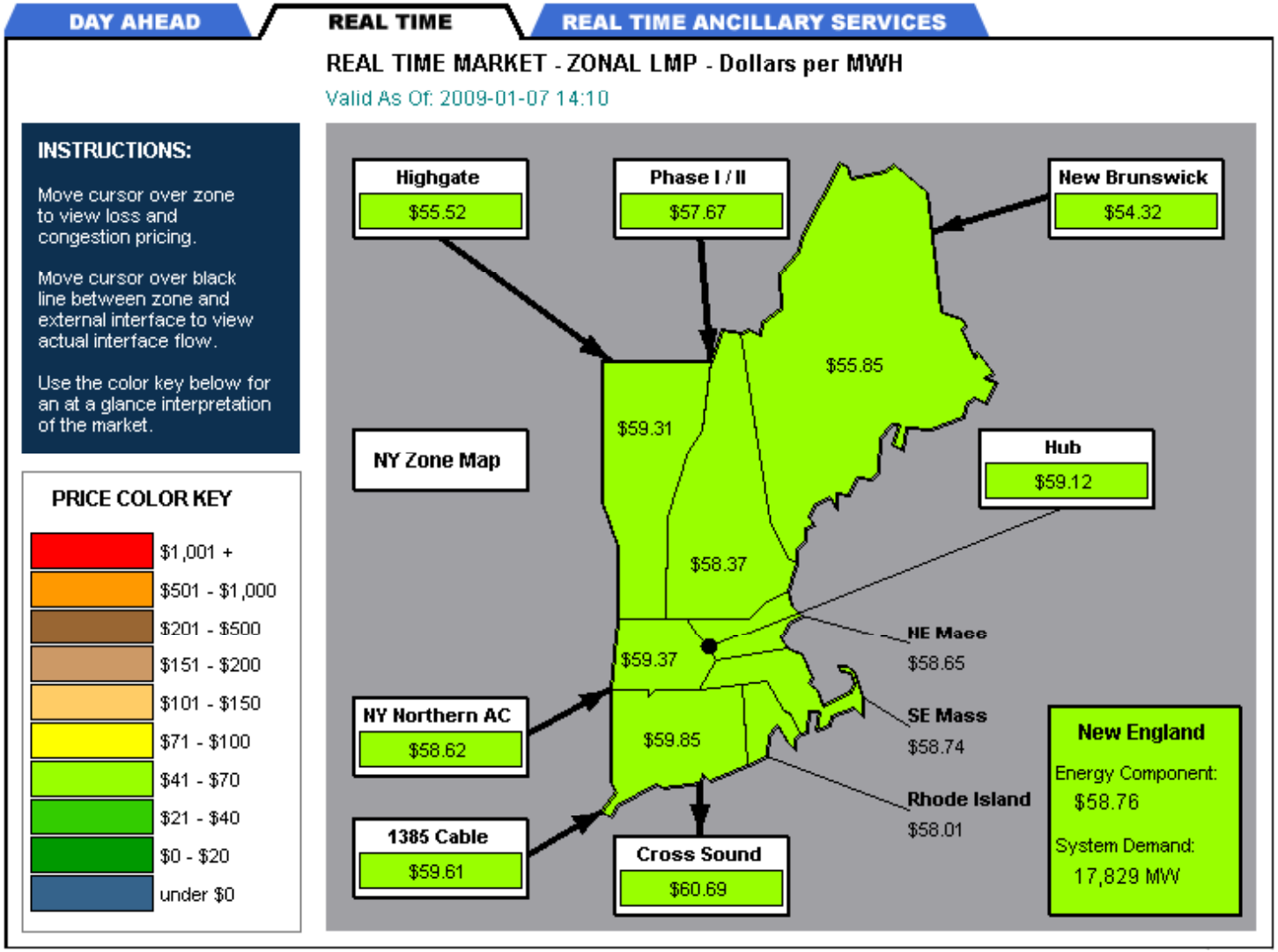
Results for Connecticut



- **1.5 mg** net reductions in mercury emissions from fluorescent switching
- **13%** coal-based electricity
- **24 MJ/kg** coal heat content
- ISO-NE is a net importer of Canadian electricity (~3.7%)
- Low output emissions rate from eGRID (37th in the U.S.)
- New emissions limits for mercury in CT in 2008

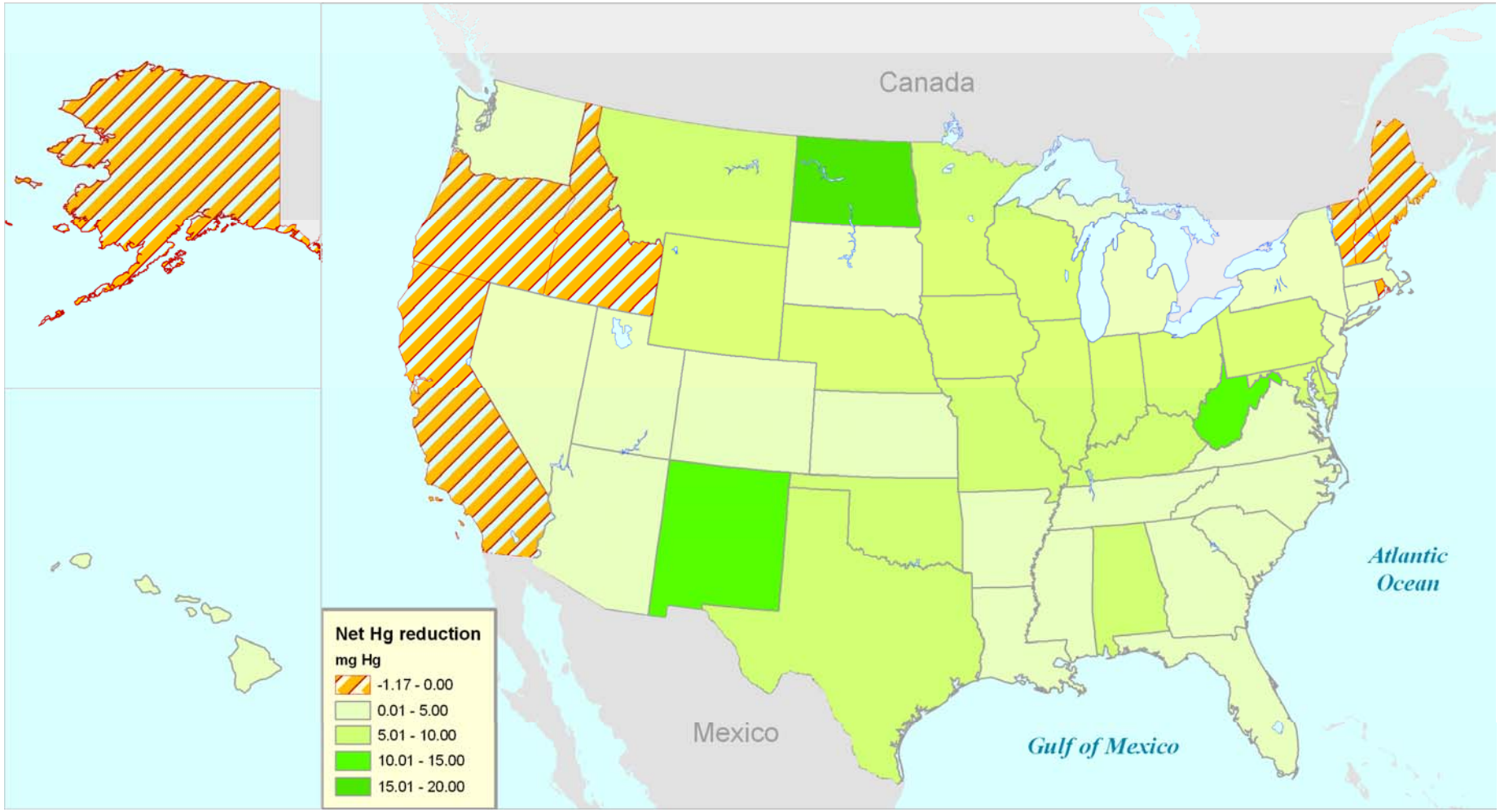
http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=CT

ISO-NE Grid Transfers



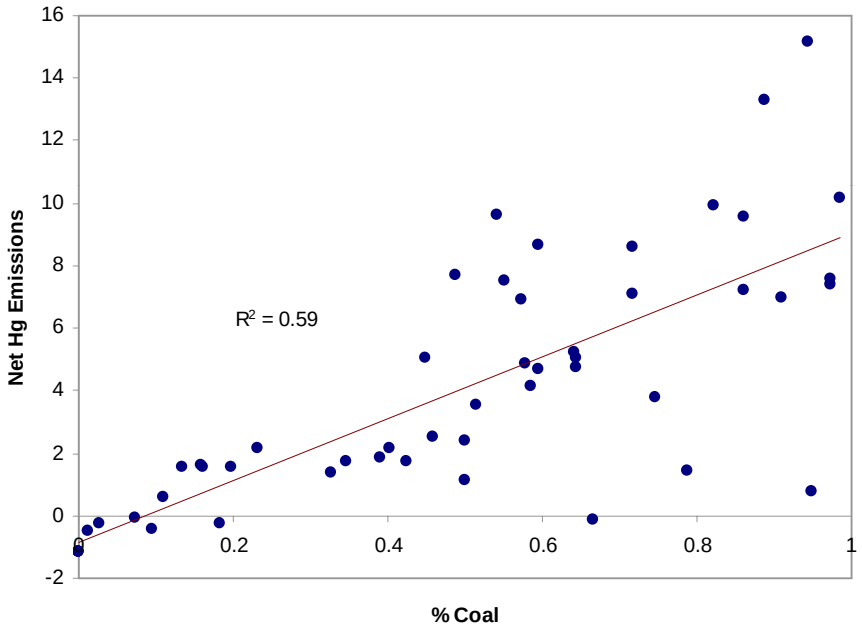
http://www.iso-ne.com/portal/jsp/lmpmap/Index.jsp

U.S. Results


Canada
Mexico
Atlantic Ocean
Gulf of Mexico
Net Hg reduction
mg Hg
-1.17 - 0.00
0.01 - 5.00
5.01 - 10.00
10.01 - 15.00
15.01 - 20.00

Issues with U.S. Analysis

- Inter-grid transfers
- Coal washing and transfers are difficult to track
- International electricity transfers on border states
- Cannot account for differences in recycling rates among states; used national average
- Lightbulbs produce heat, too…

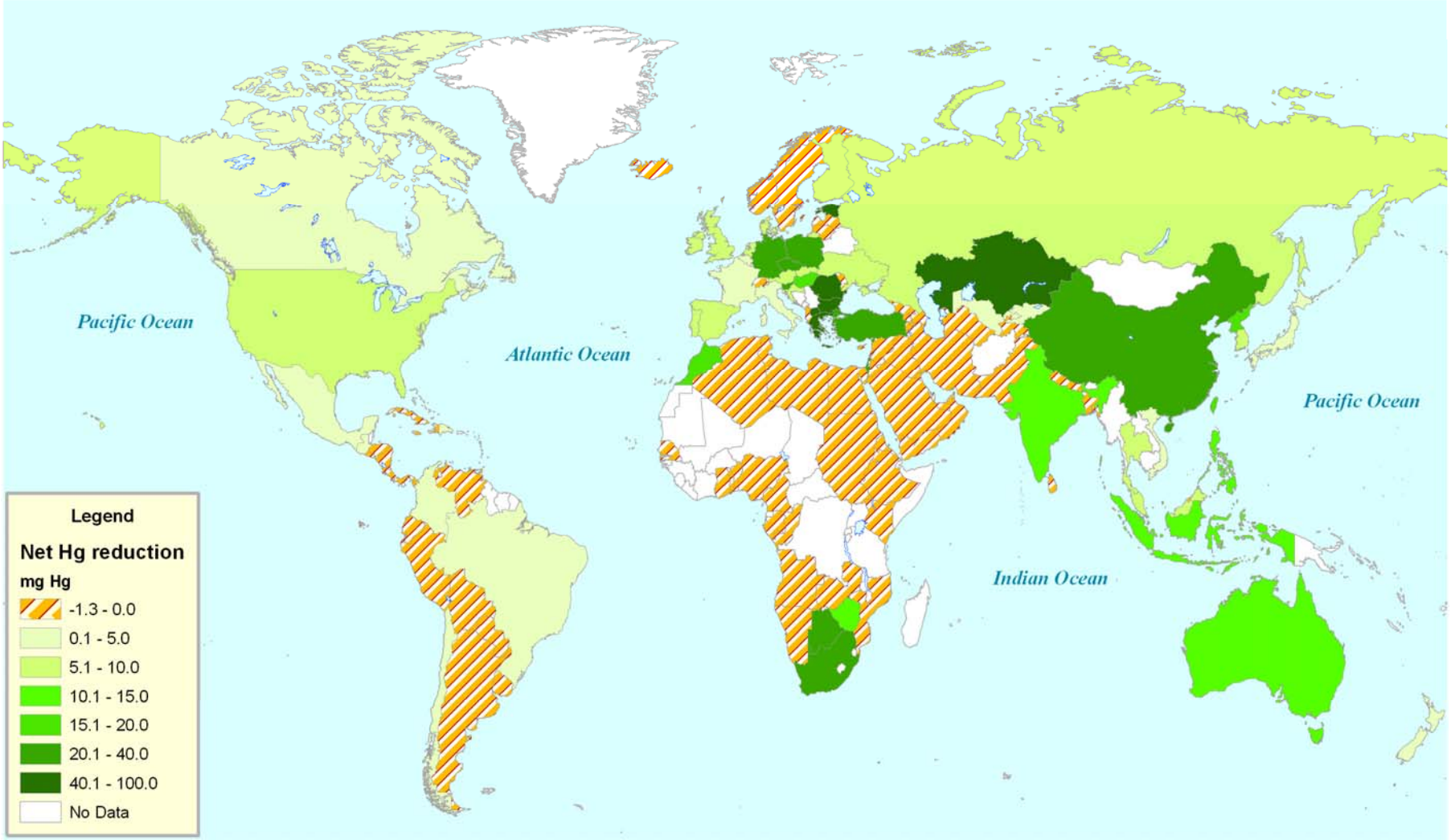


Percentage of coal-fired electricity accounts for 60% of variation in net Hg emissions

U.S. Policy Modeling

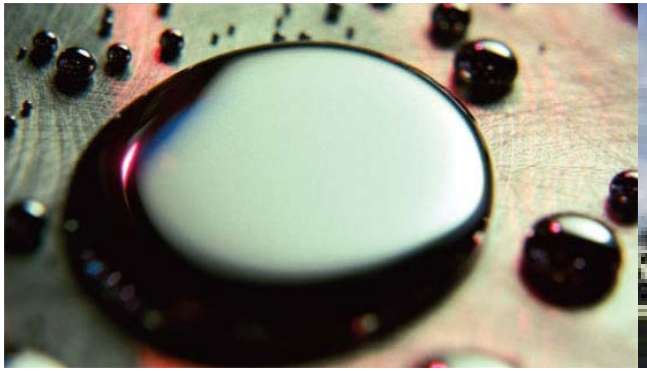
	Hg emissions avoided
• Scenario 1- Ban incandescents by 2012	**25 Mg**
• Scenario 2- Use MACT for Hg in all U.S. power plants in 2012	**56 Mg**
• Scenario 3- Increase fluorescents recycling rate to 80%	**2 Mg**
• Scenario 4- Implement proposed renewable energy portfolio standard	**5 Mg**

World Results

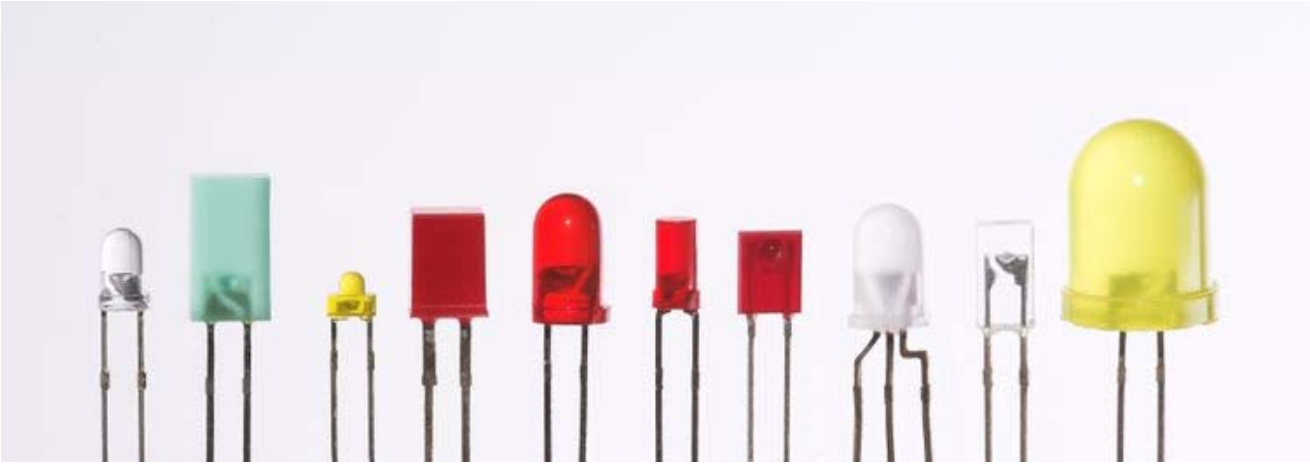


World Results

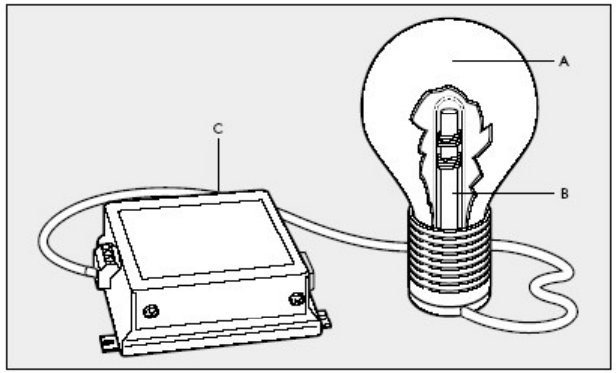
- Major improvements in net mercury emissions from using CFLs in Estonia, Bulgaria, Romania, Greece, China, Kazakhstan, Botswana
- Coal quality is one of the major factors
- Places where net benefits are high often lack proper recycling systems
- Difficult to assess country-level recycling rates, manufacturing controls, pollution abatement equipment



Emerging Lighting Technologies



Solid state LEDs



Electrode-less lamps

Organic LEDs

What about LEDs?

1. Desktop computers have been shown to require most of their life cycle energy in manufacturing, not in use

   81% for manufacturing

   19% for operation

   As opposed to refrigerators:

   11% for manufacturing

   89% for operation

Williams, E. *Environ. Sci. Technol.* **2004**, *38*, 6166-6174

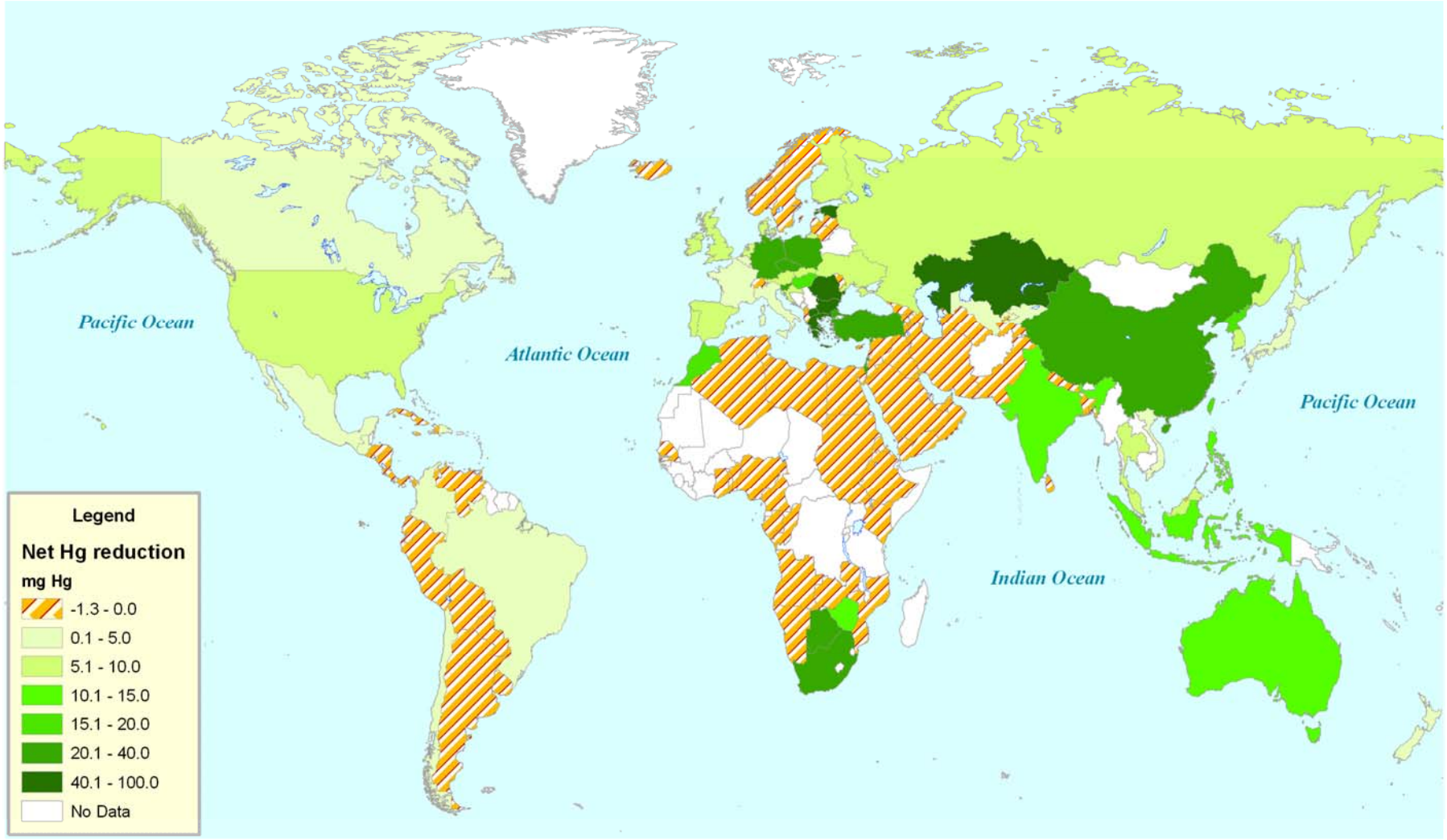
What about LEDs?

2. The manufacture of LEDs is similar to that of computer components in many ways:
   - Very high purity requirements
   - Boutique materials (such as gallium, indium)
   - High temperature and pressure processes
   - Several washing and purification steps
   - Clean room manufacturing

What about LEDs?

3. Are the benefits of LEDs in terms of energy efficiency and long lifetimes in the use phase lessened or negated by the energy costs of manufacturing?

Questions?


Pacific Ocean
Atlantic Ocean
Pacific Ocean
Indian Ocean
Legend
Net Hg reduction
mg Hg
-1.3 - 0.0
0.1 - 5.0
5.1 - 10.0
10.1 - 15.0
15.1 - 20.0
20.1 - 40.0
40.1 - 100.0
No Data