Atmospheric Mercury Deposition Impacts of Future Electric Power Generation

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Outline

- Emissions Scenarios
- “Receptors” Studied
- Atmospheric Modeling
- Results

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U.S. Mercury Emissions *Scenarios*		
Area sources (residential fuel combustion, mobile sources…)	**Point sources** other than coal-fired electricity generation (smelters, incinerators…)	**Coal-fired electricity generation**
1996 data (U.S. EPA)	**1996 data (U.S. EPA)**	***Current:*** **1999 data (U.S. EPA)**

U.S. Mercury Emissions *Scenarios*		
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1996 data (U.S. EPA)	**1996 data (U.S. EPA)**	***Current:*** **1999 data (U.S. EPA)**
		Future: **2020 Projected Baseline (U.S. EPA)**

U.S. 2020 *baseline inventory* for mercury emissions from coal-fired power plants:

- estimated emissions from U.S. facilities if no new regulatory limitations were imposed beyond existing programs to cap and trade emissions of *sulfur dioxide* and *nitrogen oxides*.

- generating capacity estimated based on economic and demographic factors

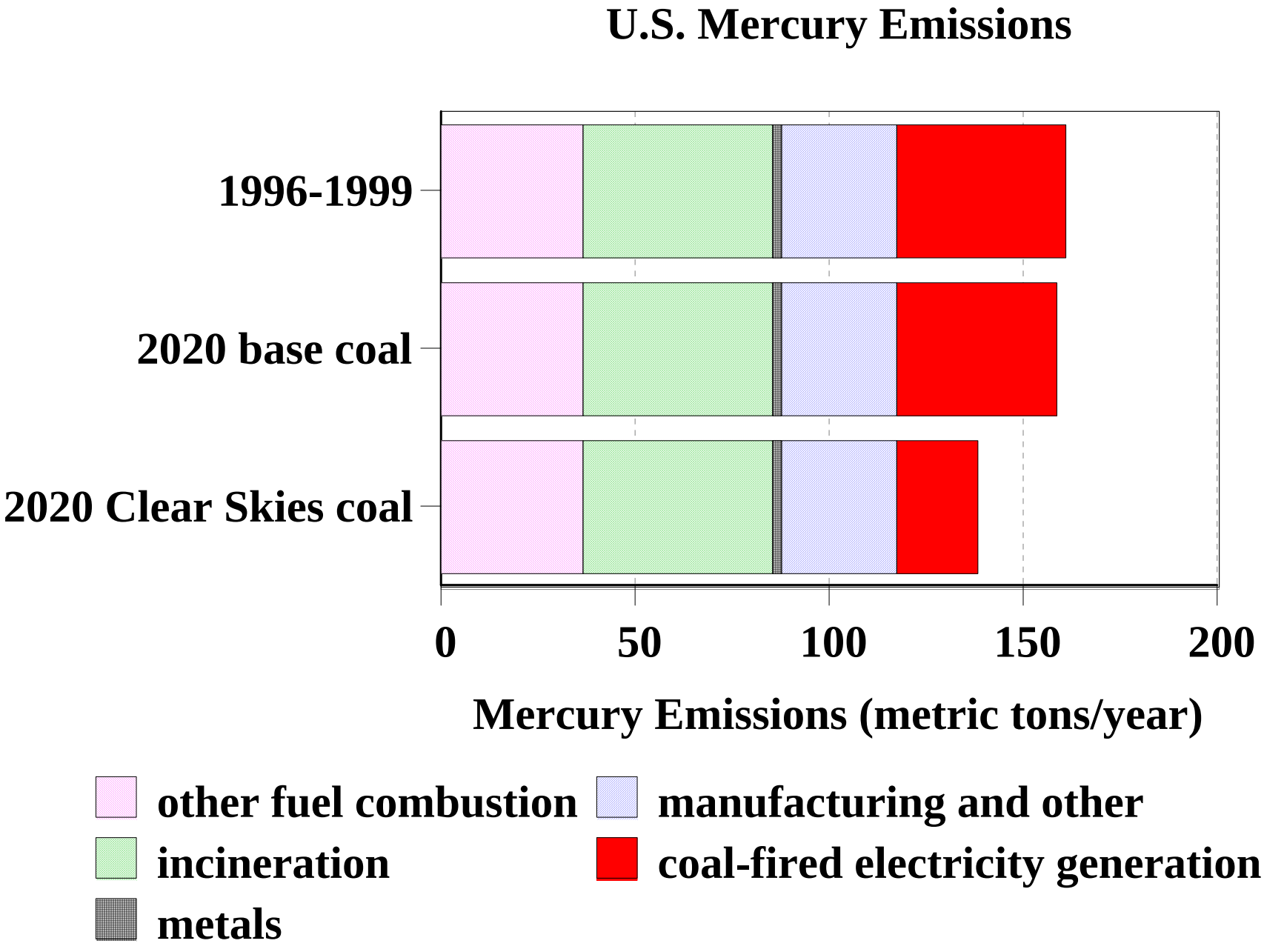
U.S. Mercury Emissions *Scenarios*		
Area sources (residential fuel combustion, mobile sources…)	**Point sources** other than coal-fired electricity generation (smelters, incinerators…)	**Coal-fired electricity generation**
1996 data (U.S. EPA)	**1996 data (U.S. EPA)**	***"Current":* 1999 data (U.S. EPA)**
		***Future:* 2020 Projected Baseline (U.S. EPA)**
		***Future:* 2020 *Clear Skies* (U.S. EPA)**

U.S. 2020 *Clear Skies* inventory for mercury emissions from coal-fired power plants:

- Projected emissions in 2020 from U.S. facilities if the proposed *Clear Skies* legislation is adopted and implemented.

- Presumptive cap of 14 metric tons of mercury emissions in 2018 versus the base 1999 U.S. emissions of about 43 metric tons.

- In the 2020 Clear Skies scenario used here [supplied by the EPA], the total mercury emissions are actually 21 metric tons due to provisions in the proposed legislation allowing “banking” of early excess emission reductions that can be used later under a trading program.


U.S. Mercury Emissions
1996-1999
2020 base coal
2020 Clear Skies coal
0
50
100
150
200
Mercury Emissions (metric tons/year)
other fuel combustion
manufacturing and other
incineration
coal-fired electricity generation
metals

Canadian Mercury Emissions *Scenarios*		
Area sources (residential fuel combustion…)	**Point sources** other than coal-fired electricity generation (smelters, incinerators…)	**Coal-fired electricity generation**
1995 data from Environment Canada	**2000 NPRI data used to update 1995 data from Environment Canada**	***Current:*** **2000 NPRI**

Canadian Mercury Emissions *Scenarios*		
Area sources (residential fuel combustion…)	**Point sources** other than coal-fired electricity generation (smelters, incinerators…)	**Coal-fired electricity generation**
1995 data from Environment Canada	**2000 NPRI data used to update 1995 data from Environment Canada**	***Current:*** **2000 NPRI**
		Future: **National Energy Board 2020 "Supply Push"**

Canadian National Energy Board 2020 *Supply Push scenario* for coal combustion at coal-fired power plants:

- technology advances slowly
- limited action with respect to the environment.

Canadian Mercury Emissions *Scenarios*		
Area sources (residential fuel combustion…)	**Point sources** other than coal-fired electricity generation (smelters, incinerators…)	**Coal-fired electricity generation**
1995 data from Environment Canada	**2000 NPRI data used to update 1995 data from Environment Canada**	***Current:*** **2000 NPRI**
		Future: **National Energy Board 2020 "*Supply Push*"**
		Future: **National Energy Board 2020 "*Techno-Vert*"**

Canadian NEB 2020 *Techno-Vert scenario* for coal combustion at coal-fired power plants:

- technology advances rapidly

- broad action with respect to the environment, including preference for environmentally-friendly products and cleaner-burning fuels.

For both Canadian 2020 scenarios:

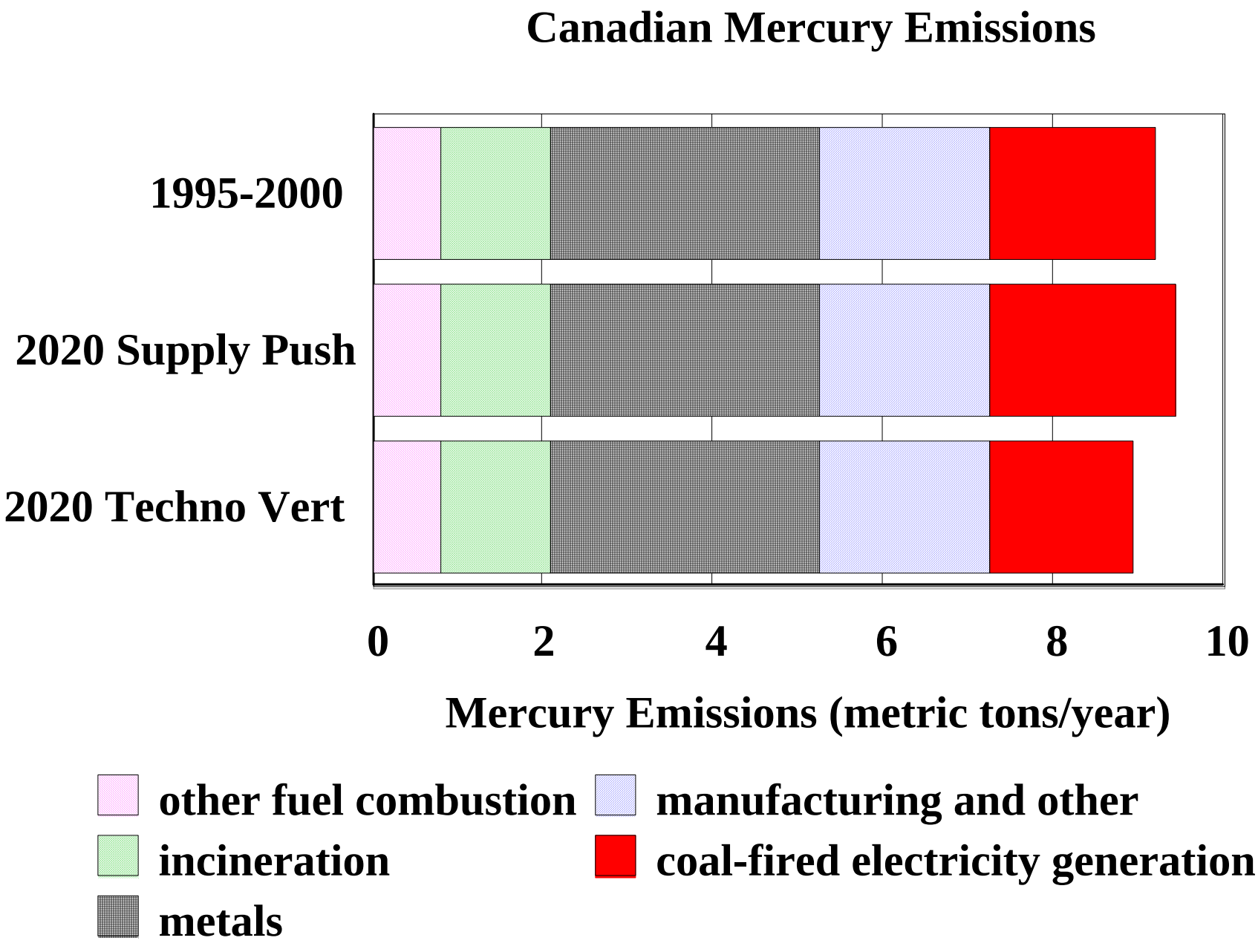
- **the same *emissions factors***

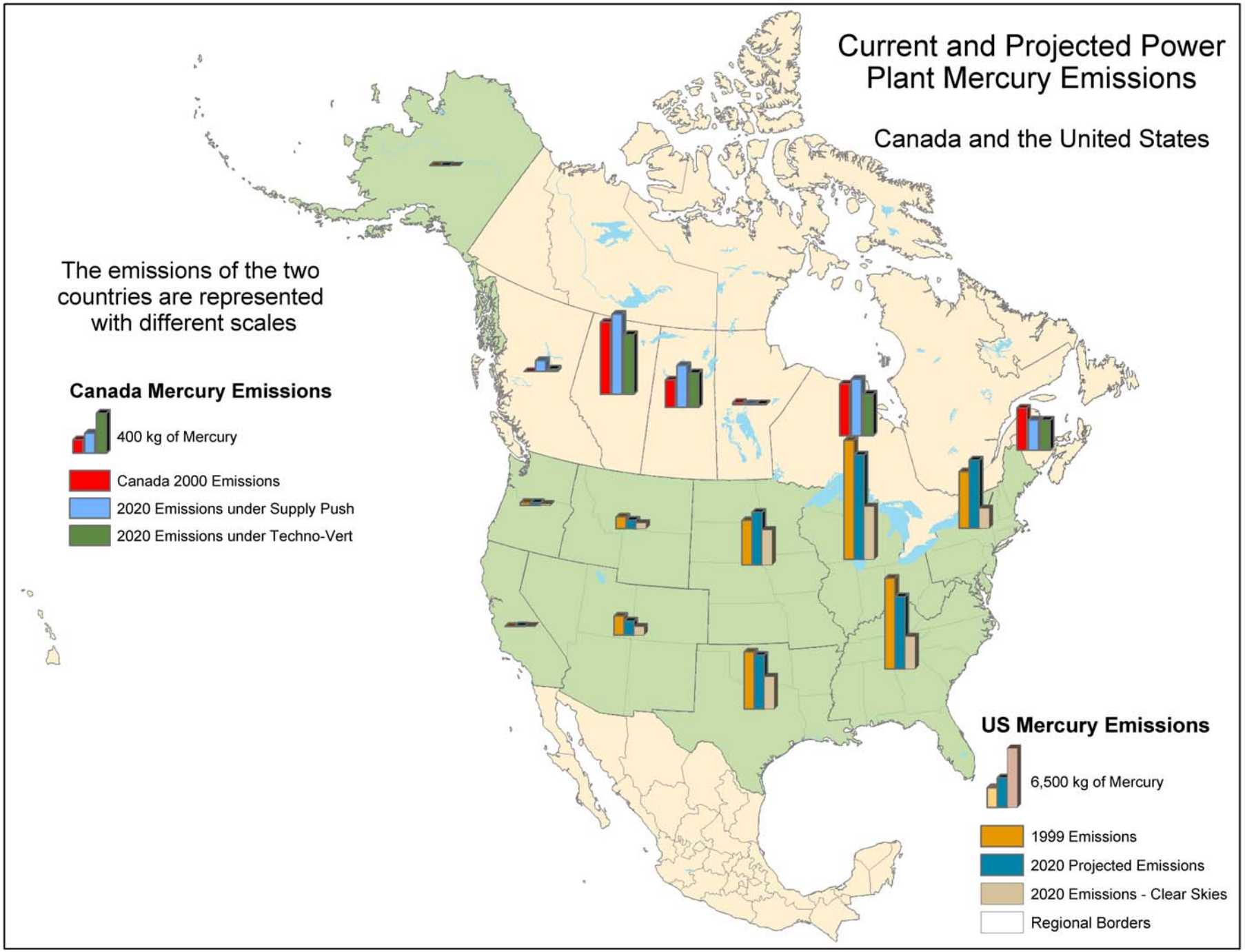
  (amount of mercury emitted per ton of coal burned)

- **and the same *speciation* profile**

  [fraction of emissions as Hg(II), Hg(0), and Hg(p)]

…as the current emissions inventory


Canadian Mercury Emissions
1995-2000
2020 Supply Push
2020 Techno Vert
0
2
4
6
8
10
Mercury Emissions (metric tons/year)
other fuel combustion
manufacturing and other
incineration
coal-fired electricity generation
metals


Current and Projected Power Plant Mercury Emissions
Canada and the United States
The emissions of the two countries are represented with different scales
Canada Mercury Emissions
400 kg of Mercury
Canada 2000 Emissions
2020 Emissions under Supply Push
2020 Emissions under Techno-Vert
US Mercury Emissions
6,500 kg of Mercury
1999 Emissions
2020 Projected Emissions
2020 Emissions - Clear Skies
Regional Borders

The U.S. and Canadian Future Scenarios used in this analysis are not really comparable…

- **…the 2020 U.S. *Clear Skies* scenario envisions enhanced pollution control (e.g., scrubbers) at some coal-fired power plants,**

- **…but additional pollution control is *not* considered in *these* particular 2020 Canadian scenarios.**

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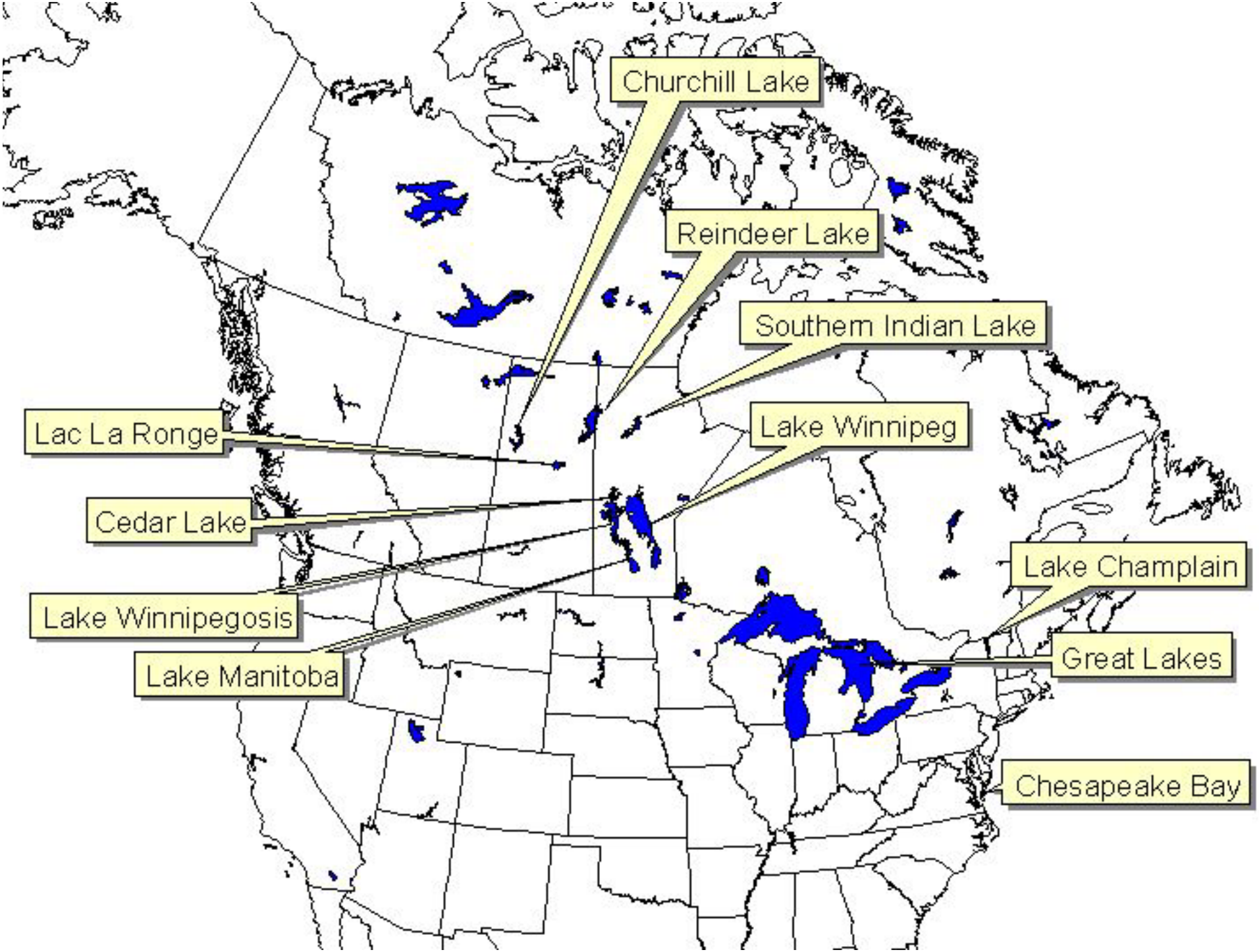
Churchill Lake
Reindeer Lake
Southern Indian Lake
Lac La Ronge
Lake Winnipeg
Cedar Lake
Lake Champlain
Lake Winnipegosis
Great Lakes
Lake Manitoba
Chesapeake Bay

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Modeling methodology described in a forthcoming publication:

Modeling the Atmospheric Transport and Deposition of Mercury to the Great Lakes

Accepted for Publication by *Environmental Research*,
for the special issue of the journal devoted to papers from the
Workshop on An Ecosystem Approach to the Health Effects of Mercury in the Great Lakes Basin, Windsor, Ontario, Feb 2003.

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Three “kinds” of atmospheric mercury:

- **Elemental mercury – Hg^0**

  Minimal local and regional deposition

- **Reactive Gaseous Mercury (RGM) – Hg(II)**

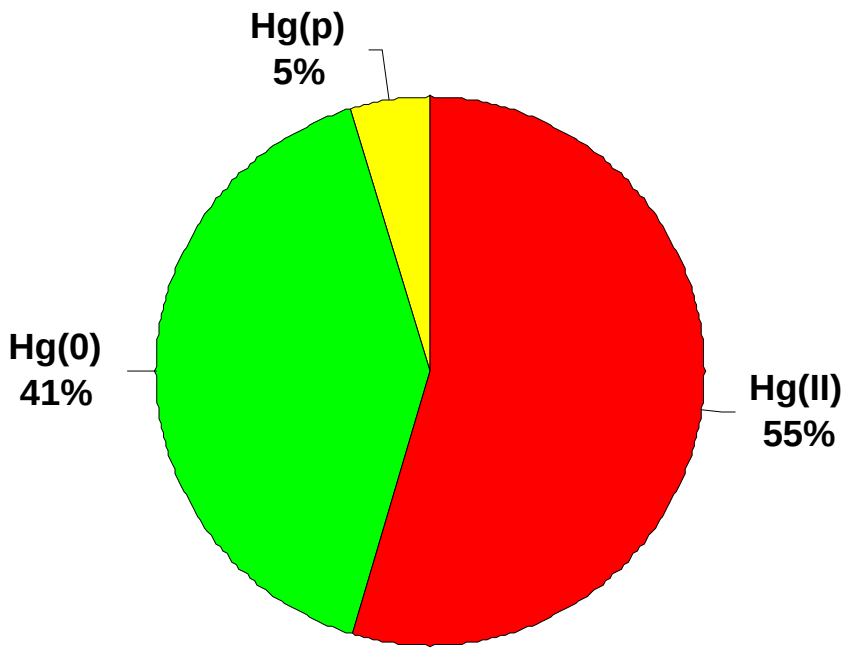
  Enhanced local and regional deposition

- **Particulate Mercury – Hg(p)**

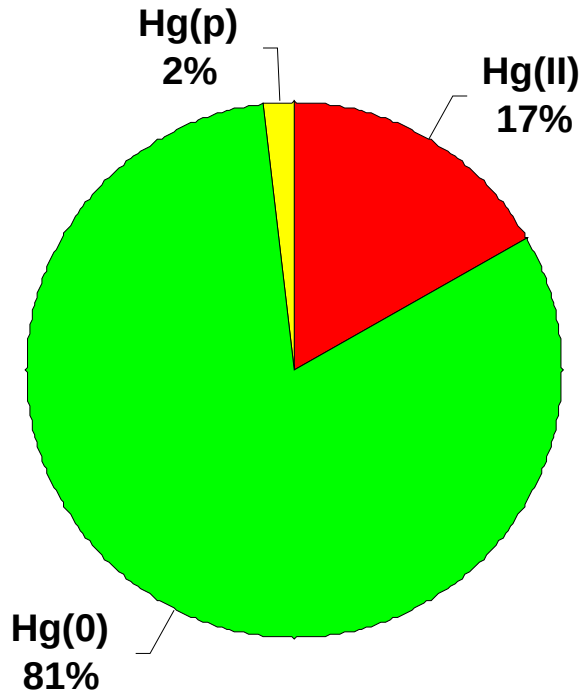
  Moderate local and regional deposition

Typical Speciation Profiles of Mercury Emissions From Coal-Fired Electricity Generation Facilities

Without Wet Scrubber



With Wet Scrubber



(and similar difference with dry scrubbers)

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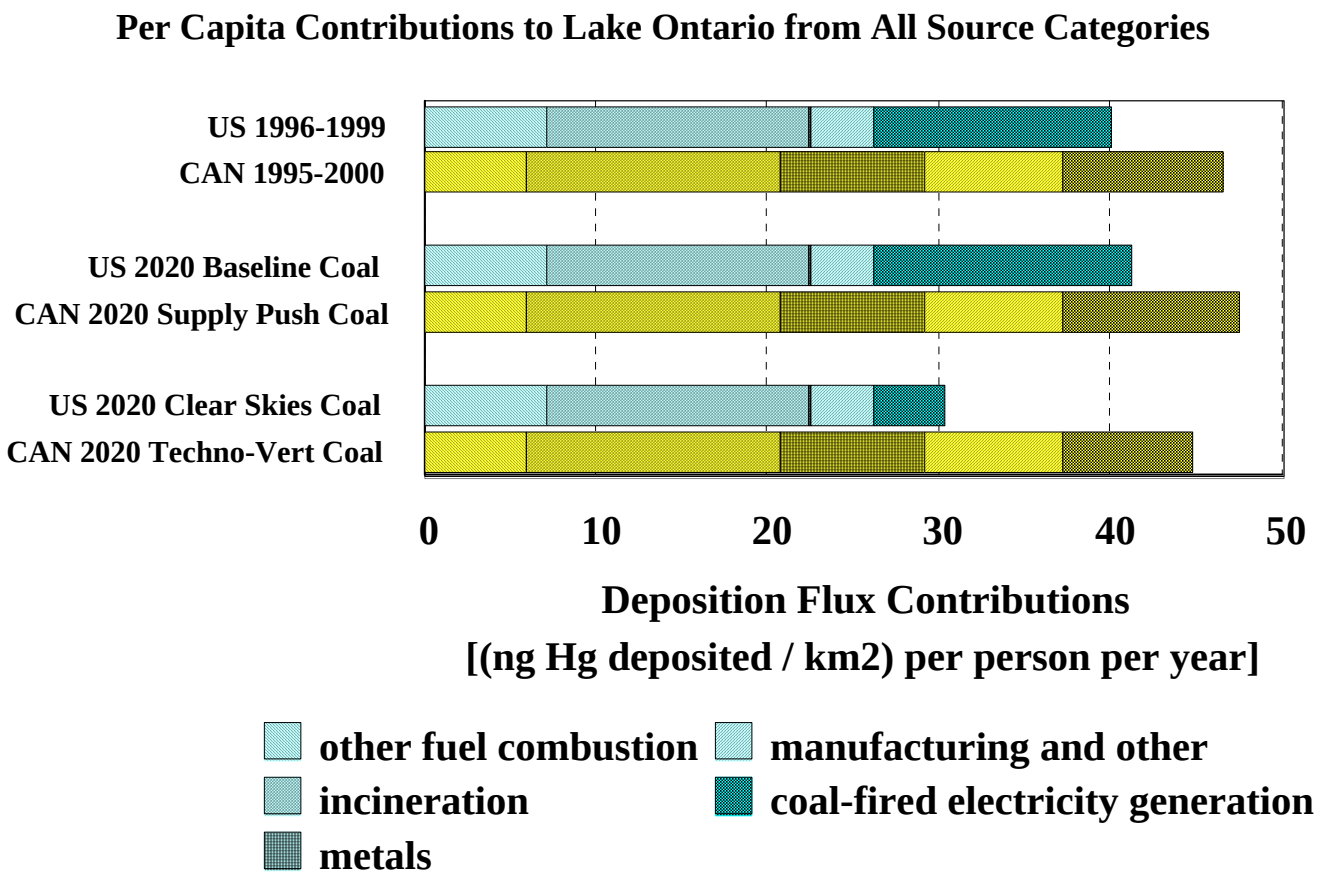
Mercury Emissions from Coal-Fired Electricity Generation are not the only emissions impacting these receptors…



U.S. data shown with "blue" shading; Canadian data shown with "yellow" shading. The only category with emissions changes in 2020 is "coal-fired electricity generation"; all other source categories were held constant at their "current" baseline

The receptors fell into two groups:

Figure 5. Deposition Flux from Coal-Fired Electricity Generation to "U.S. influenced" receptors

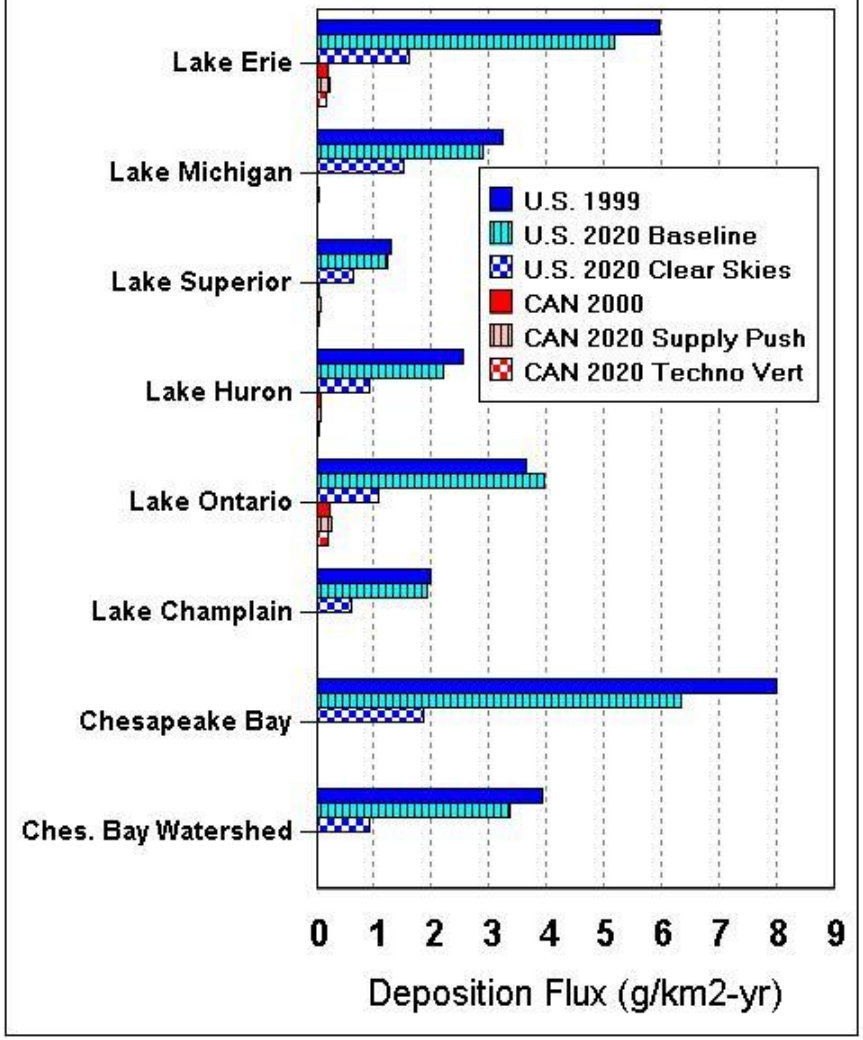
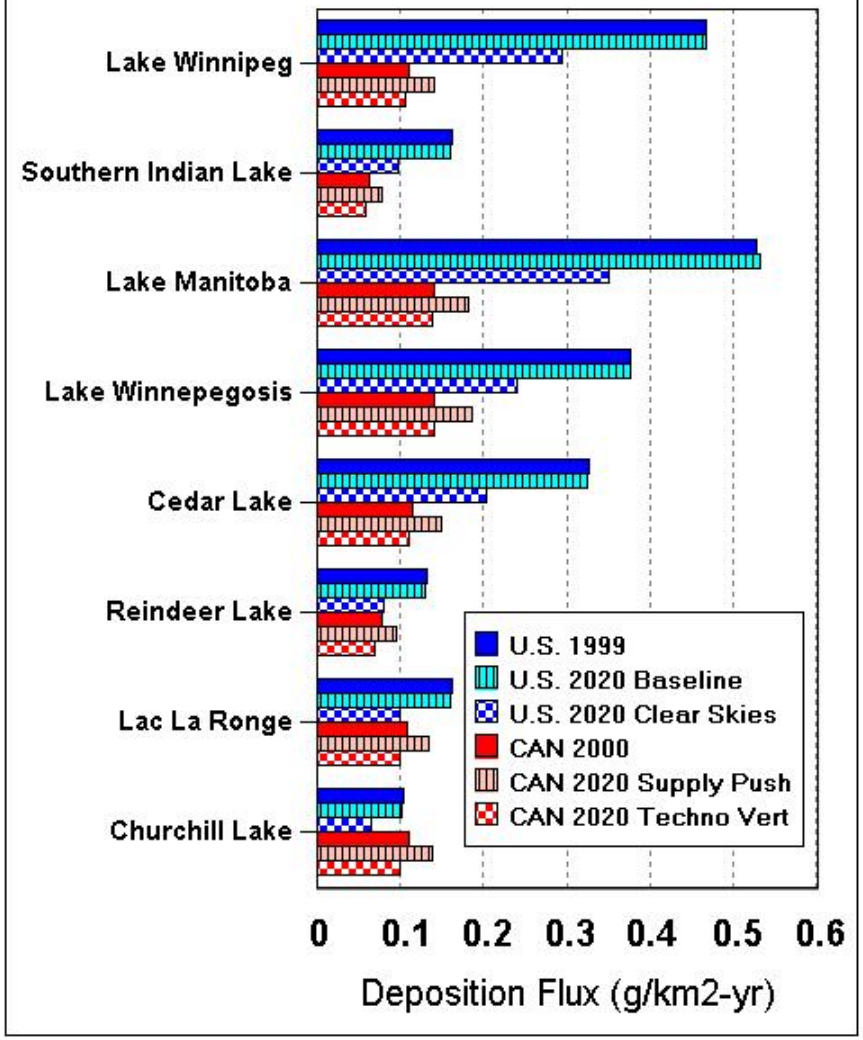
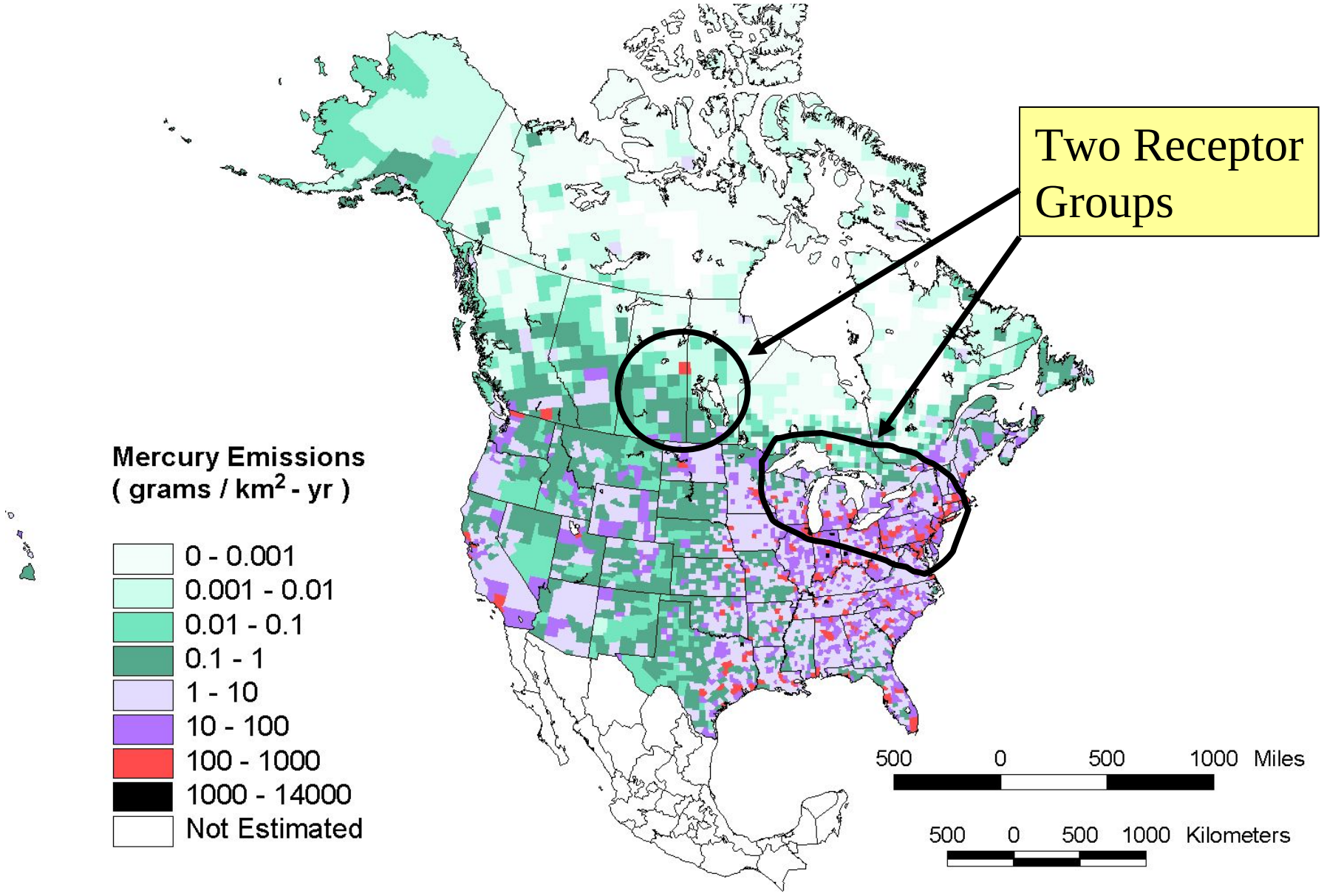


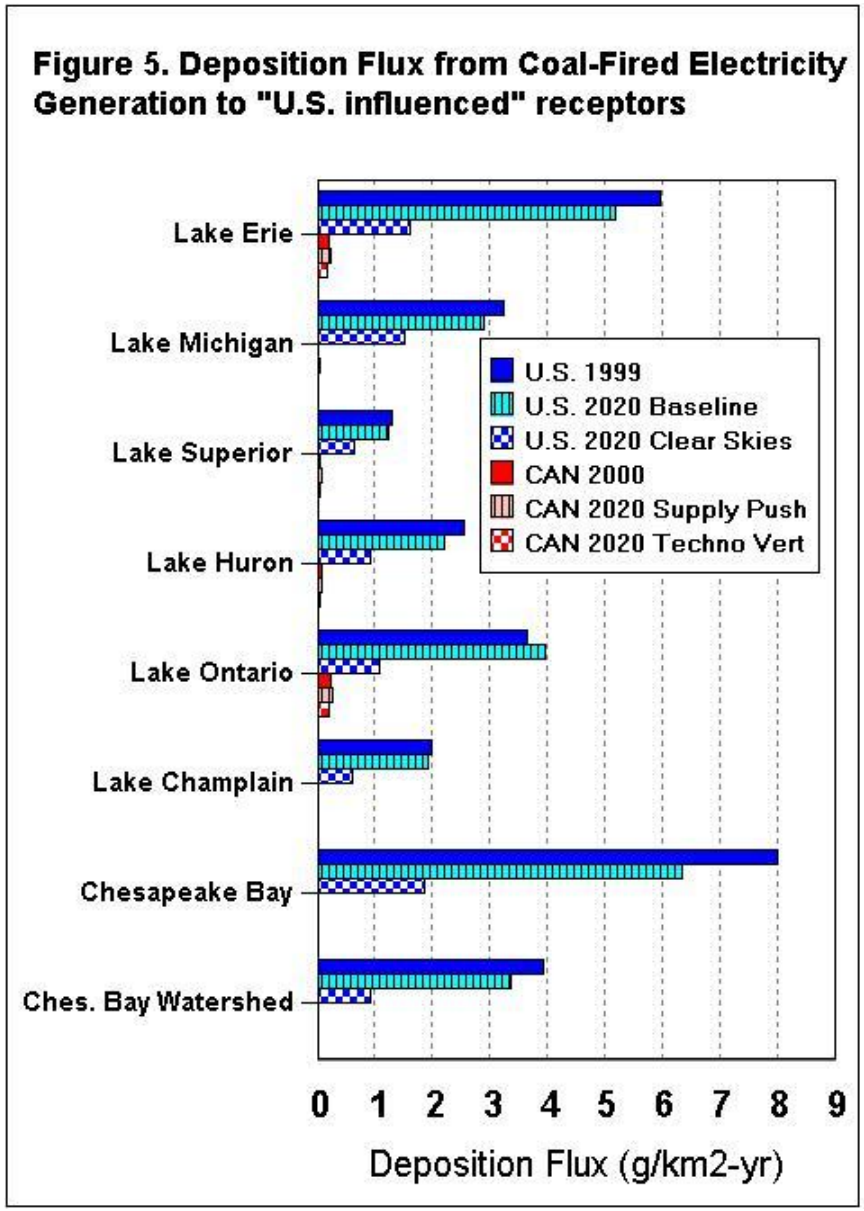
Figure 6. Deposition Flux from Coal-Fired Electricity Generation to "Canada & U.S. influenced" receptors

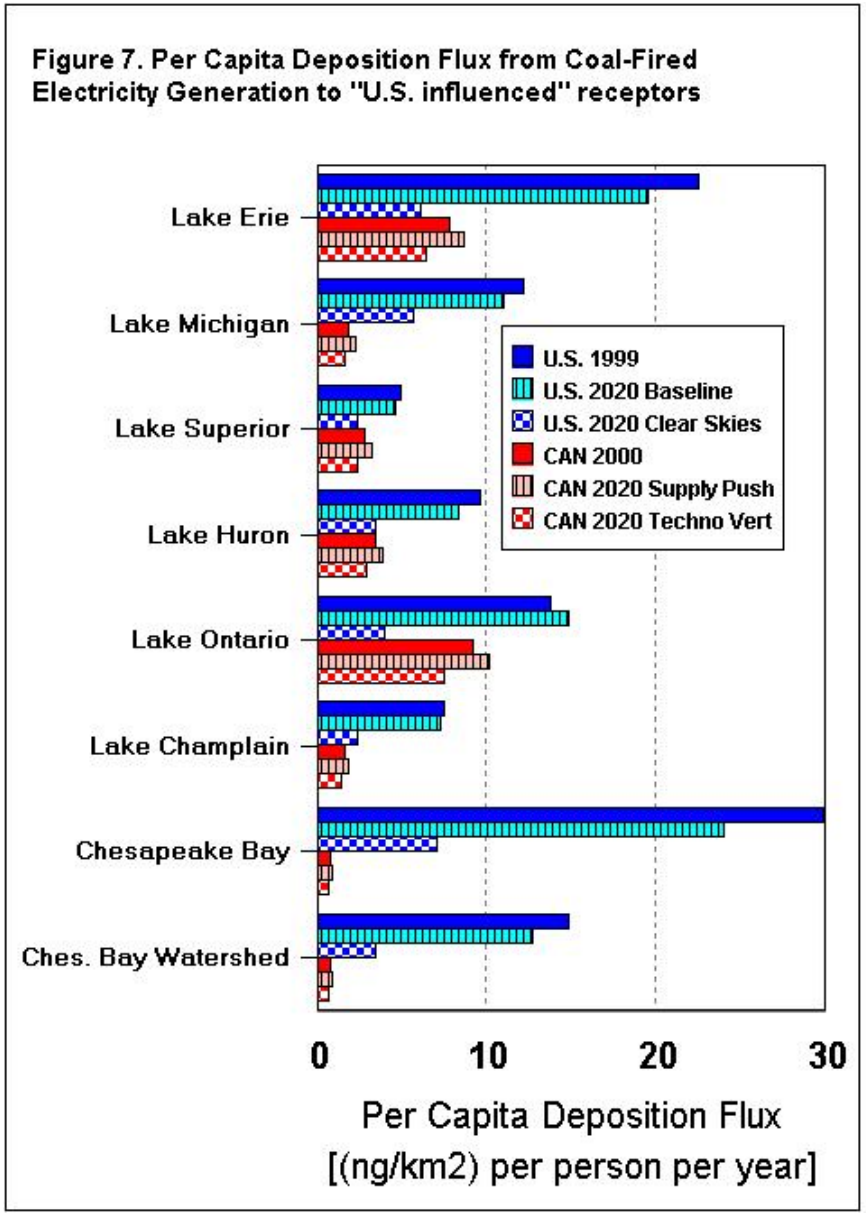


Anthropogenic Mercury Emissions from Sources in the U.S. and Canada (~1995-1996)

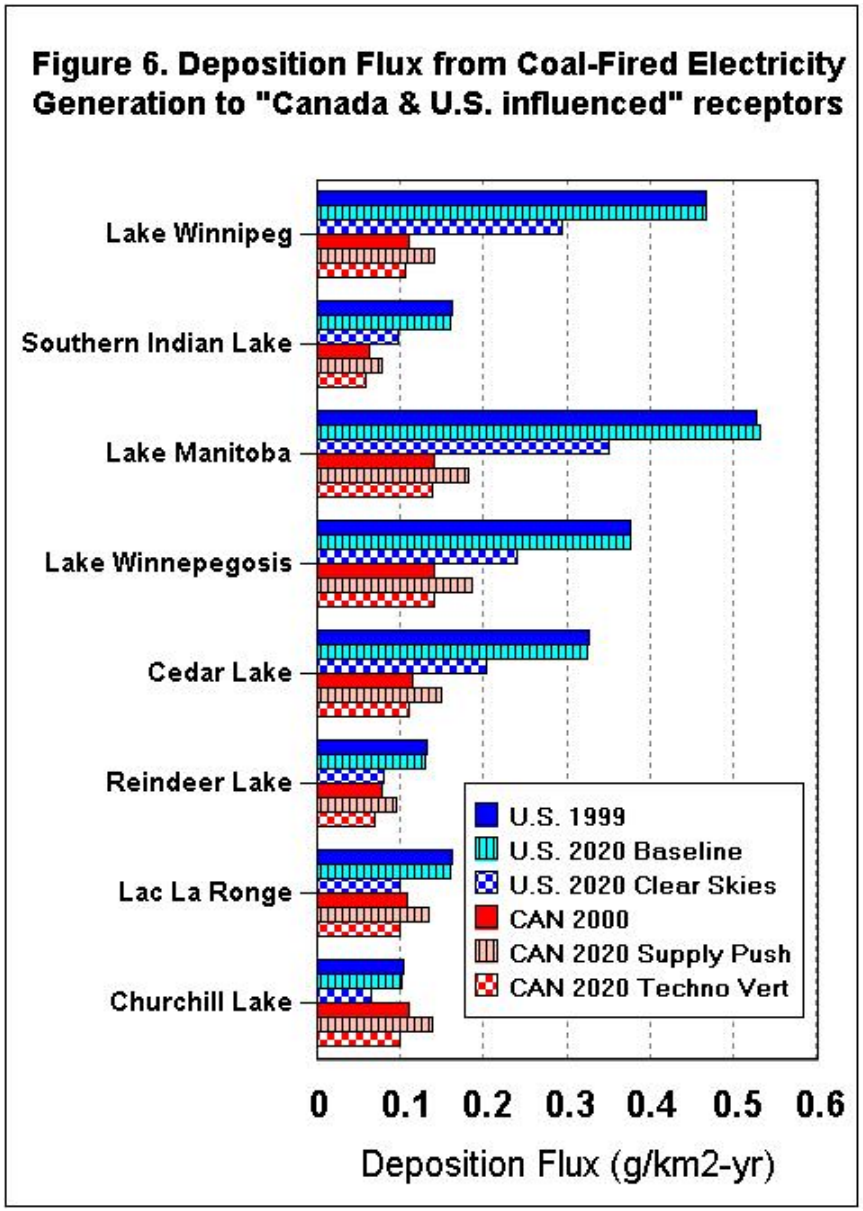


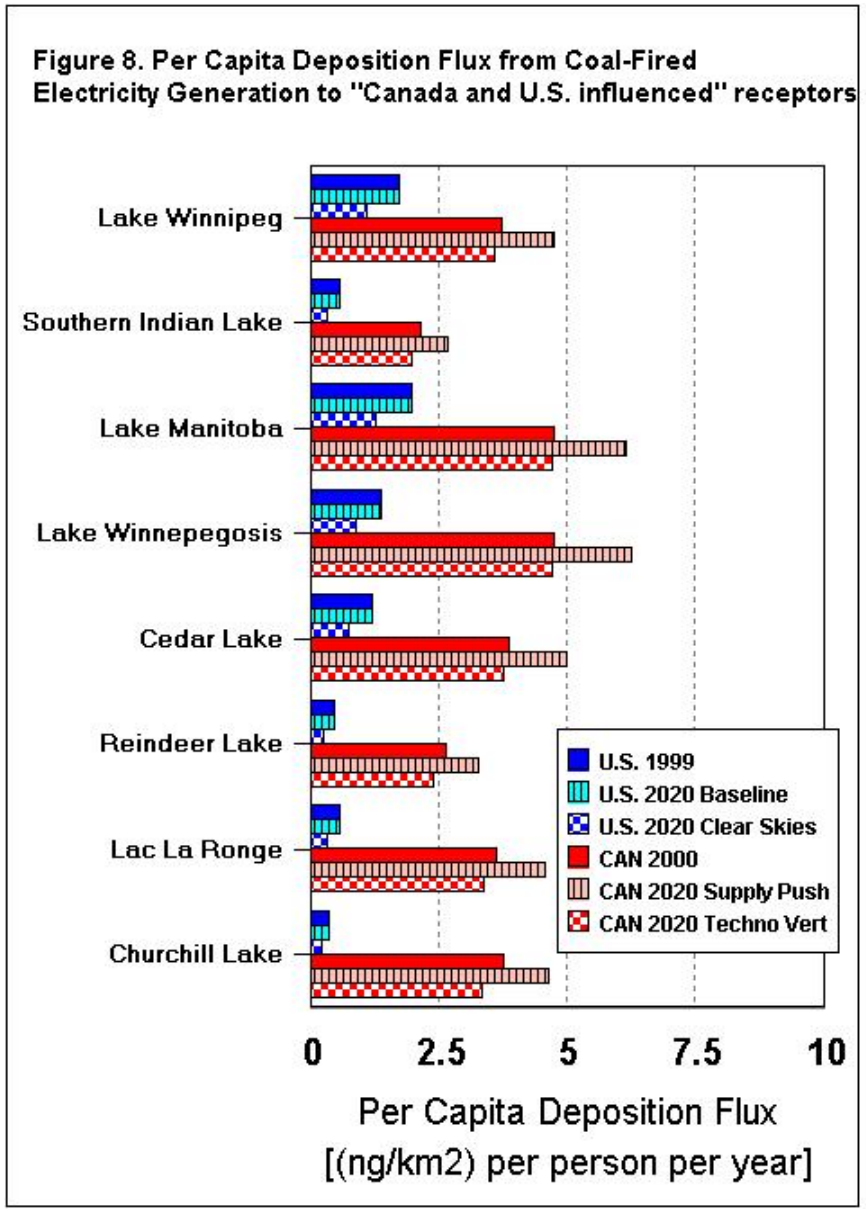
Even on a per-capita basis, U.S. emissions appear to be more important for the first group…





However, on a per-capita basis, Canadian emissions appear to be more important for the second group…





Some Limitations of this Study…

- **U.S. and Canadian anthropogenic emissions *only* [ignoring natural emissions and global sources]**
- ***Uncertainties* in emissions inventories, and in fate and transport modeling**
- **Future U.S. & Canadian scenarios not really comparable; many other scenarios that could be considered, including some with much deeper reductions in mercury emissions**

Summary and Conclusions

- **Deposition impact of *current* and *future* U.S. and Canadian mercury emissions examined with an atmospheric fate and transport model**

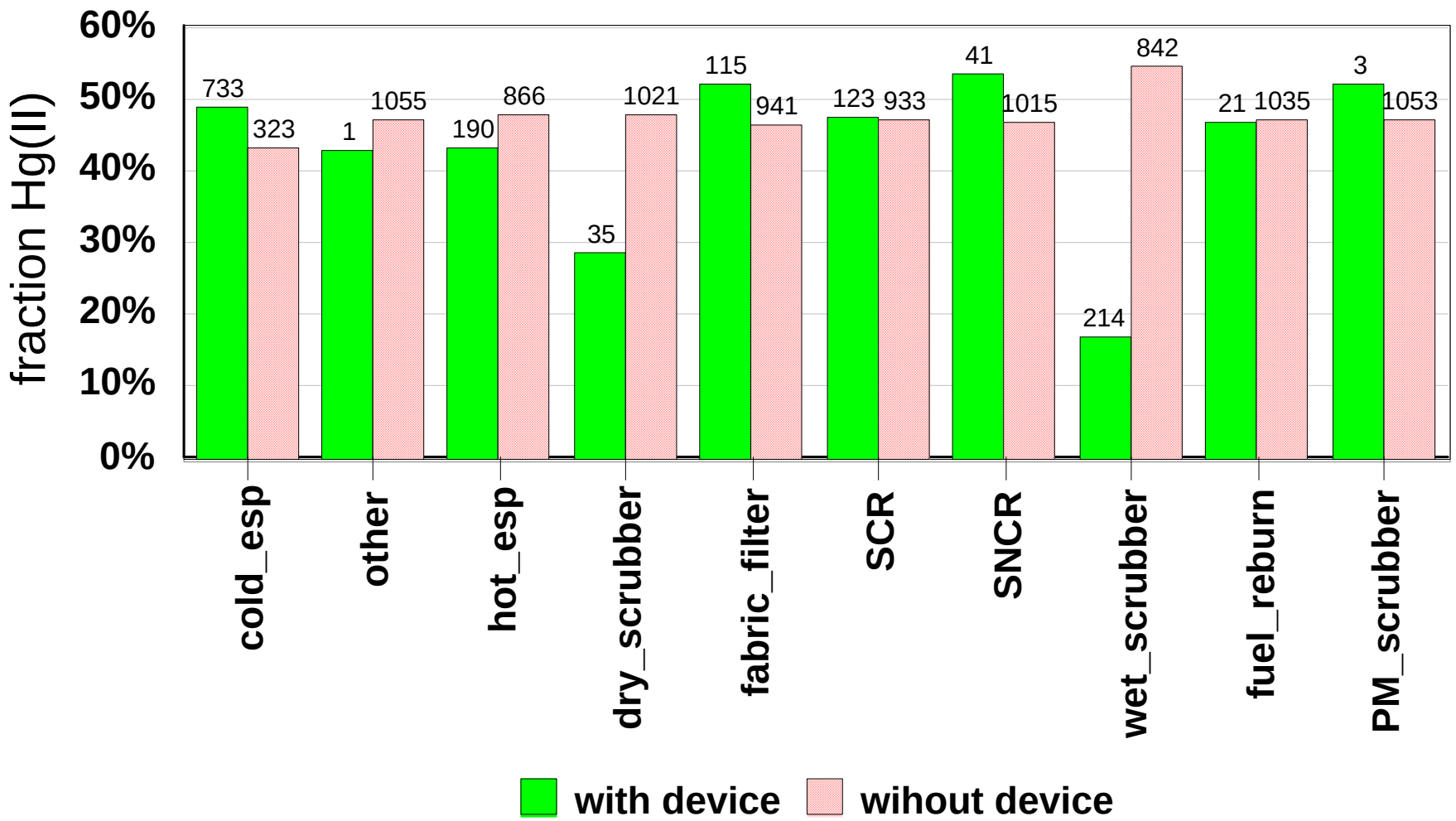
- **Receptors fell into two groups:**
  (1) Influenced primarily by the U.S.; *larger total flux*
  (2) Influenced by the U.S. and Canada; *smaller total flux*

- **Coal-fired power plants not the only contributors to atmospheric mercury deposition in the receptors studied**

- **Emissions from coal-fired power plants contribute significantly to deposition to all the receptors, and changes in the amounts and/or speciation profile of these emissions will result in changes in deposition.**

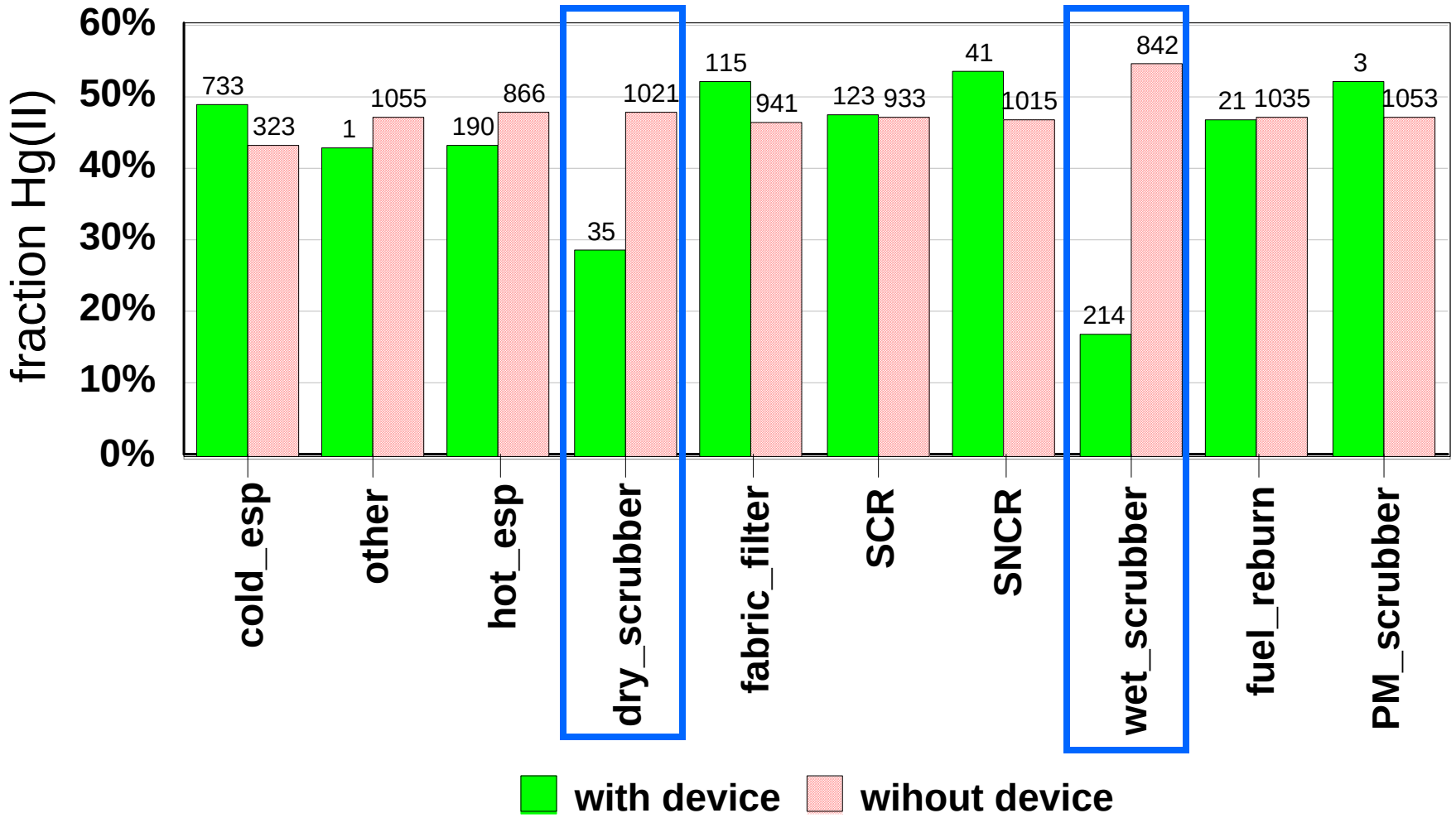
Extra Slides

Hg(II) fraction vs. air pollution control device for Hg(II) ("RGM") for mercury emissions from U.S. coal-fired electricity generation



numbers above bars are the number of records

Hg(II) fraction vs. air pollution control device for Hg(II) ("RGM") for mercury emissions from U.S. coal-fired electricity generation



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