



## Greenhouse Gas Emissions and Hydropower


13th Annual Waterkeeper Alliance Conference  
Northwestern University  
Evanston, Illinois  
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## Historical Background

- Science of reservoir emissions still very young
  - > Early reports from HQ and others showed virtually no emissions
  - > Reports from Brazil showing substantial methane emissions
  - > Serious debates began at World Commission on Dams
- Conflicts between utility and independent researchers
  - > Brazil – Pinguilli Rosa v. Fearnside
- Northern reservoirs
  - > Most research funded by Hydro-Québec
  - > Concerns about independence
- Sumarized in *Fizzy Science* (IRN 2007)
  - > Recommendation: IPCC Special Report
  - > Not acted upon



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## GHG and hydropower

- Not easy to get the facts straight
  - > Subtle measurements and calculations over enormous areas
- Policy consequences in three areas
  - > National emissions inventories (Kyoto)
  - > CDM eligibility
  - > Debates about new projects
    - HQ:
      - Eastmain 1A/Rupert Diversion
      - La Romaine, Plan Nord
    - Nalcor
      - Lower Churchill
  - > “projects displace coal with near-zero emissions hydropower, and so should be built”

3



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## Important questions

1. What **are** the GHG emissions from reservoirs?
2. What is the net GHG benefit when hydropower is exported from Canada to the US?

4



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## Reservoir emissions

- Focus here on new hydropower reservoirs in temperate/boreal regions
- Conflict diminishing
  - > QC: in-depth research funded by HQ
  - > Academic freedom for researchers
    - But HQ also publishes conference papers (not peer-reviewed)
    - Conclusions not necessarily the same

5



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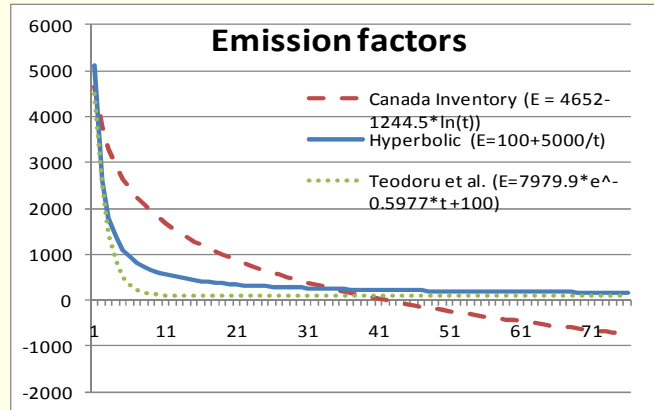
## What do we know?

- Known knows
  - > Initial emissions very high (CO<sub>2</sub> and CH<sub>4</sub>) due to decomposition of flooded organics, with rapid decline (5-10 yrs)
  - > Long-term emissions stabilize but do not stop
  - > Type of flooded terrain affects both early-year emissions and long-term **net** emissions
- Known unknowns
  - > Operating regimes affect emissions, but no data available
  - > How much energy should be attributed to the individual reservoir (denominator)

6

## Evolution of modelling

- Models showing emissions falling to zero now largely discredited



7

## HQ paper

- Net GHG Emissions at EM-1 Reservoir<sup>1</sup>
- Data from pre-flooding and 1<sup>st</sup> 4 yrs
- Results:

	kT C/yr	kT CO2- eq/yr	G CO2- eq/kWh
<b>Early years</b>	500	1,600	600
<b>Long term</b>	100	329	50
<b>Long term average</b>	158	519	80

- Roughly 20% of GHG emissions of gas combined cycle (380 g/kWh)
- Much higher than earlier estimates, which predicted emissions declining to zero

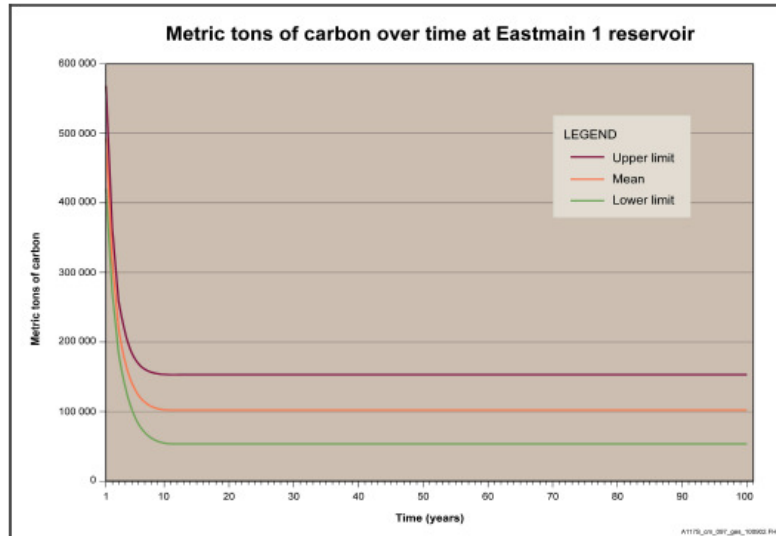
<sup>1</sup>[http://www.hydroforthefuture.com/docs/sizes/4cb733c207f1b/source/Tremblay\\_WEC-2010\\_FINAL-ANG\\_08-09-14-\\_2.pdf](http://www.hydroforthefuture.com/docs/sizes/4cb733c207f1b/source/Tremblay_WEC-2010_FINAL-ANG_08-09-14-_2.pdf)

8

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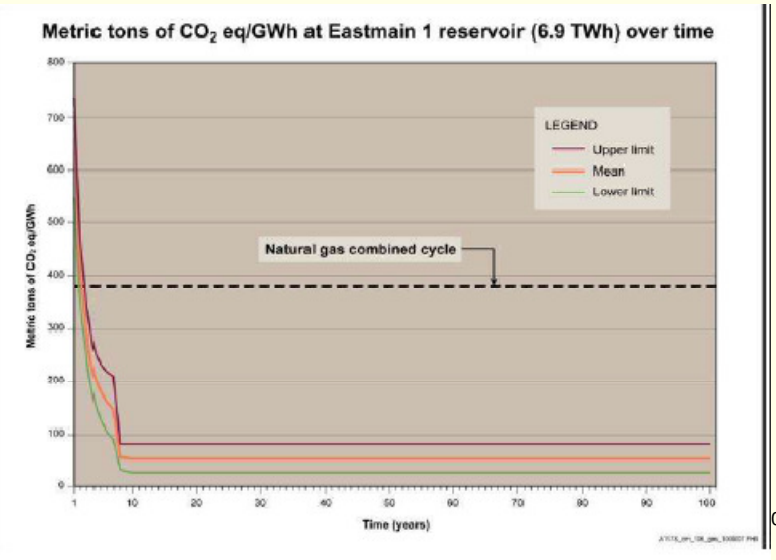
## HQ Study – Total Emissions



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## HQ Paper results




  
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## HQ paper (cont.)

- But incorrect figures for per kWh emissions
  - > wrong denominator (6.9 TWh)
  - > Energy production from EM-1 just 2.7 TWh/yr
  - > Rises to 5 TWh with Rupert Diversion, but higher emissions too

	kT C/yr	kT CO <sub>2</sub> -eq/yr	g CO <sub>2</sub> -eq/kWh
<b>Early years</b>	500	1,600	600
<b>Long term</b>	100	329	121
<b>Long term average</b>	158	519	192

- 50% of cumulative NGCC GHG emissions 11


  
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## Electricity Trade and GHG Emissions<sup>1</sup>

- Very interesting paper in peer-reviewed academic journal
- Estimate total GHG impacts of cross-border electricity trade
- Sophisticated method
  - > Determine marginal generator for each hour
  - > Calculate GHG implications of each kWh imported and exported
- But undermined by inappropriate assumptions and methodological choices

<sup>1</sup><http://discover-decouvrir.cisti-icist.nrc-cnrc.gc.ca/dcvr/ctrl?action=shwart&aix=1&aid=16952071>


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## Electricity trade

- Authors' conclusions
  - > Net GHG benefit of 524g CO<sub>2</sub>-eq/kWh
- BUT:
  - > Wrong methodology for choosing marginal generation. Brings benefit down to **63 g**
  - > Inconsistent use of "life cycle" assessment
  - > Uses hydropower GHG emissions of **11 g/kWh** – clearly inappropriate
  - > Back-of-the-envelope recalculation: **net benefit probably well under 50 g/kWh exported.**

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## Conclusions

- Best estimate of hydropower emissions = about 50% of current gas combined cycle emissions
- But, over the long term, fossil efficiencies will almost certainly improve
  - > Technological improvements
  - > Waste heat recovery
  - > Carbon sequestration and storage?
  - > but reservoir emissions are locked in for many decades
- Trade benefits weak because HQ imports coal power at night and displaces gas during peak periods
- Common view that storage hydropower has no or insignificant GHG emissions is clearly incorrect

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14