Carbon Removal Utilities

BECCS and the Future of Forests in Canada

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Goal

Reduce wildfires and use decarbonization for economic growth, especially in rural regions

Strategy

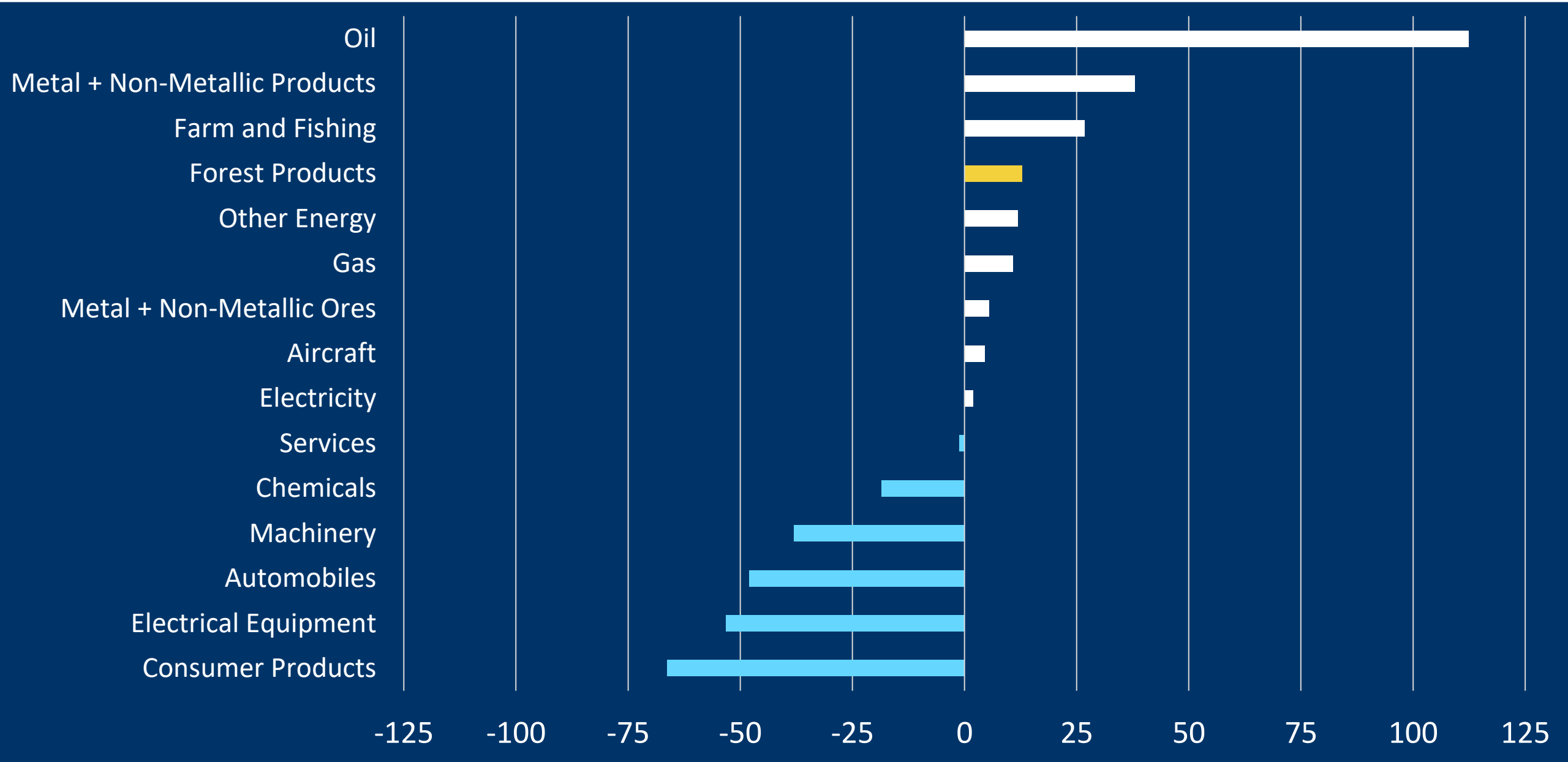
Develop BioEnergy with CCS (BECCS) Carbon Utilities

An Underinvested Public Asset

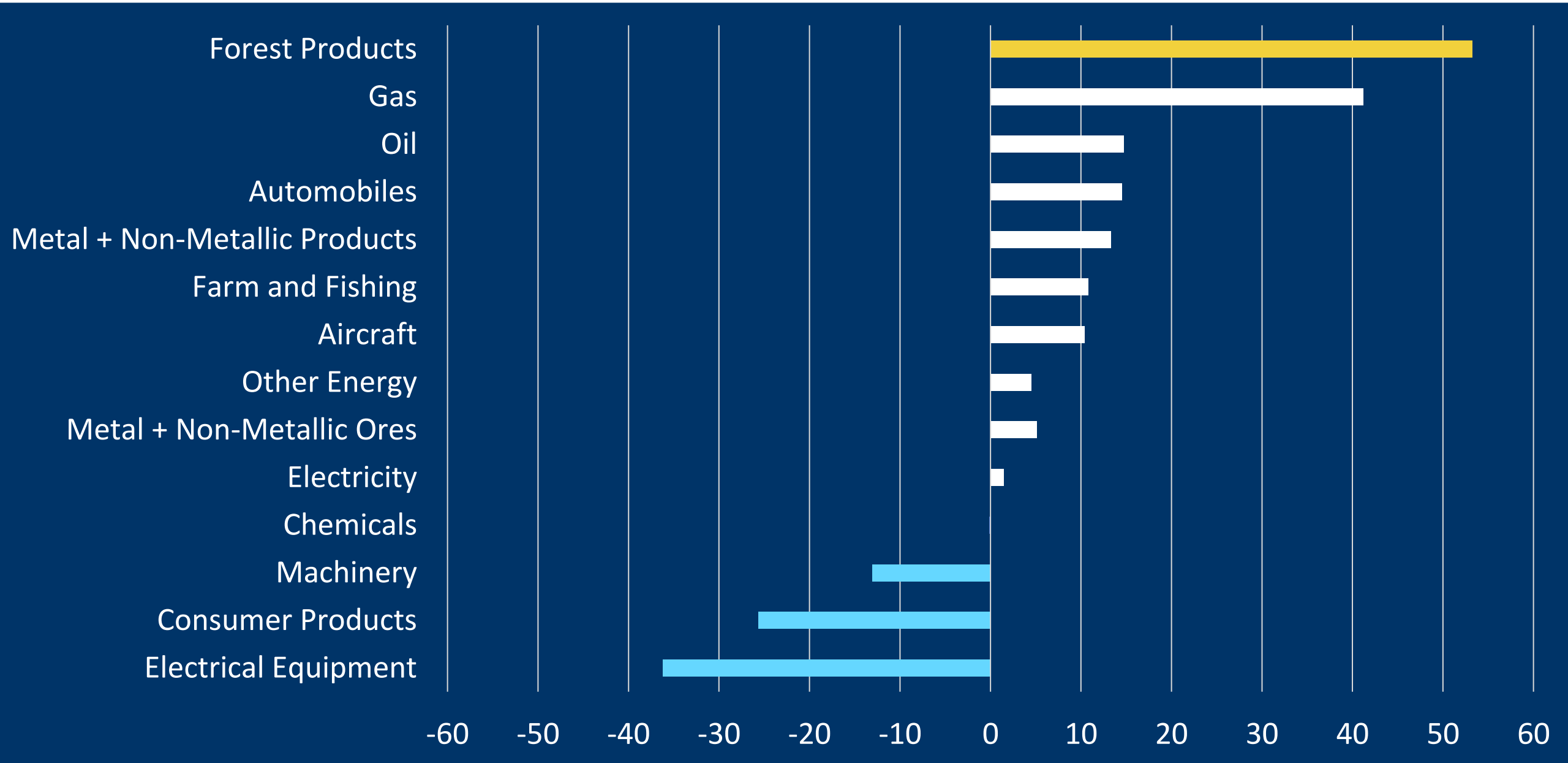
- 94% of Canada's forests are publicly-owned
- If valued at \$170/t CO_2, asset value of \$7.5 T: Canada's most valuable asset
- Annual timber harvest has decreased by 50% since 2004
- Significant asset losses occurring
  - \$400 B in asset losses in 2023 alone (wildfires)
- Other Boreal forest countries are increasing their forest carbon asset
  - Requires active management and a market for low-grade wood
  - Sweden harvests 7x the volume per forested hectare as Canada
- BECCS is the means of maximizing carbon return on assets
- Canada's largest climate liability becomes its greatest climate asset
  - Managing Canada's forests like Sweden would generate 1,000 Mt CDR/y

What is going on in the Forest Products Sector?

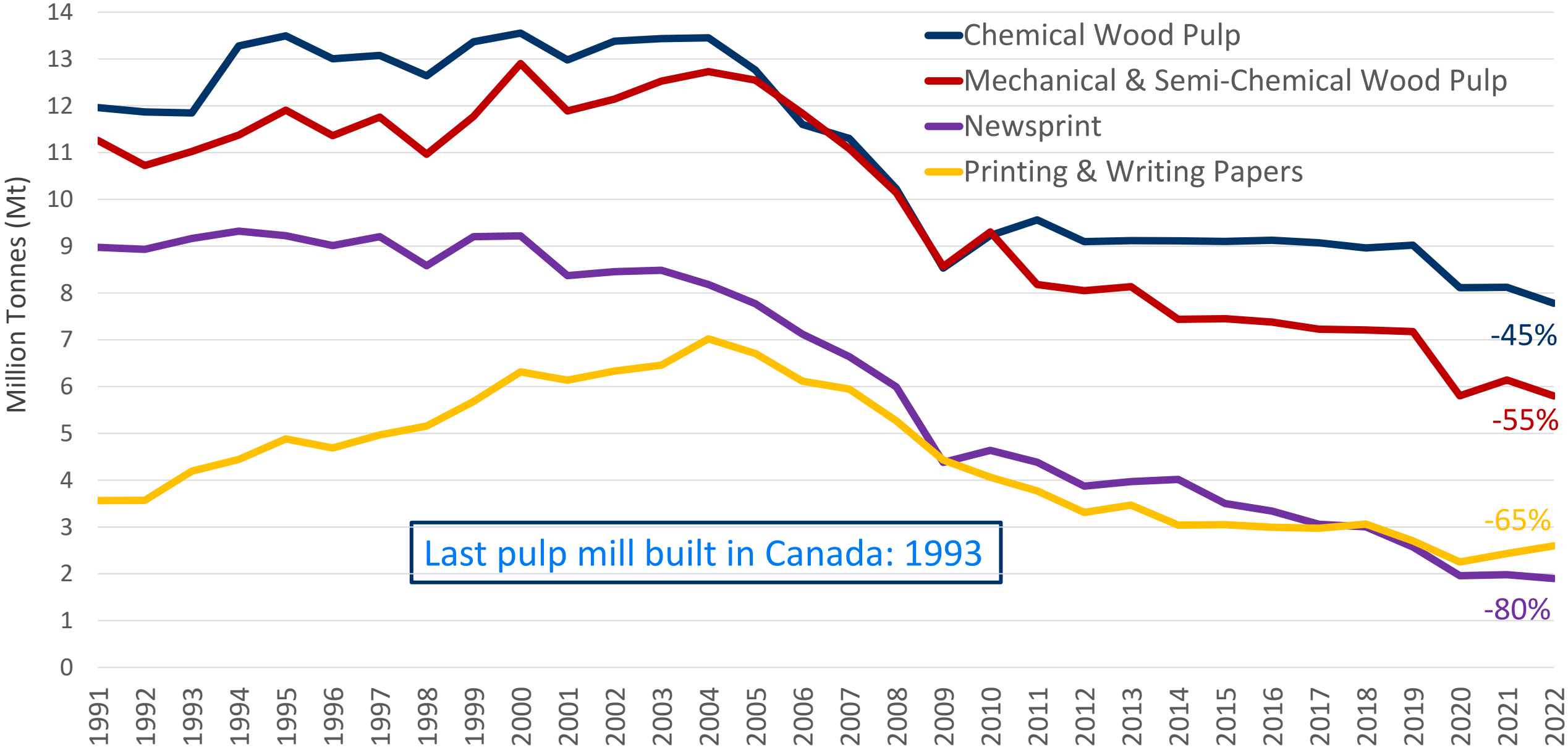
Balance of Trade in Canada, 2024 (C$ B)



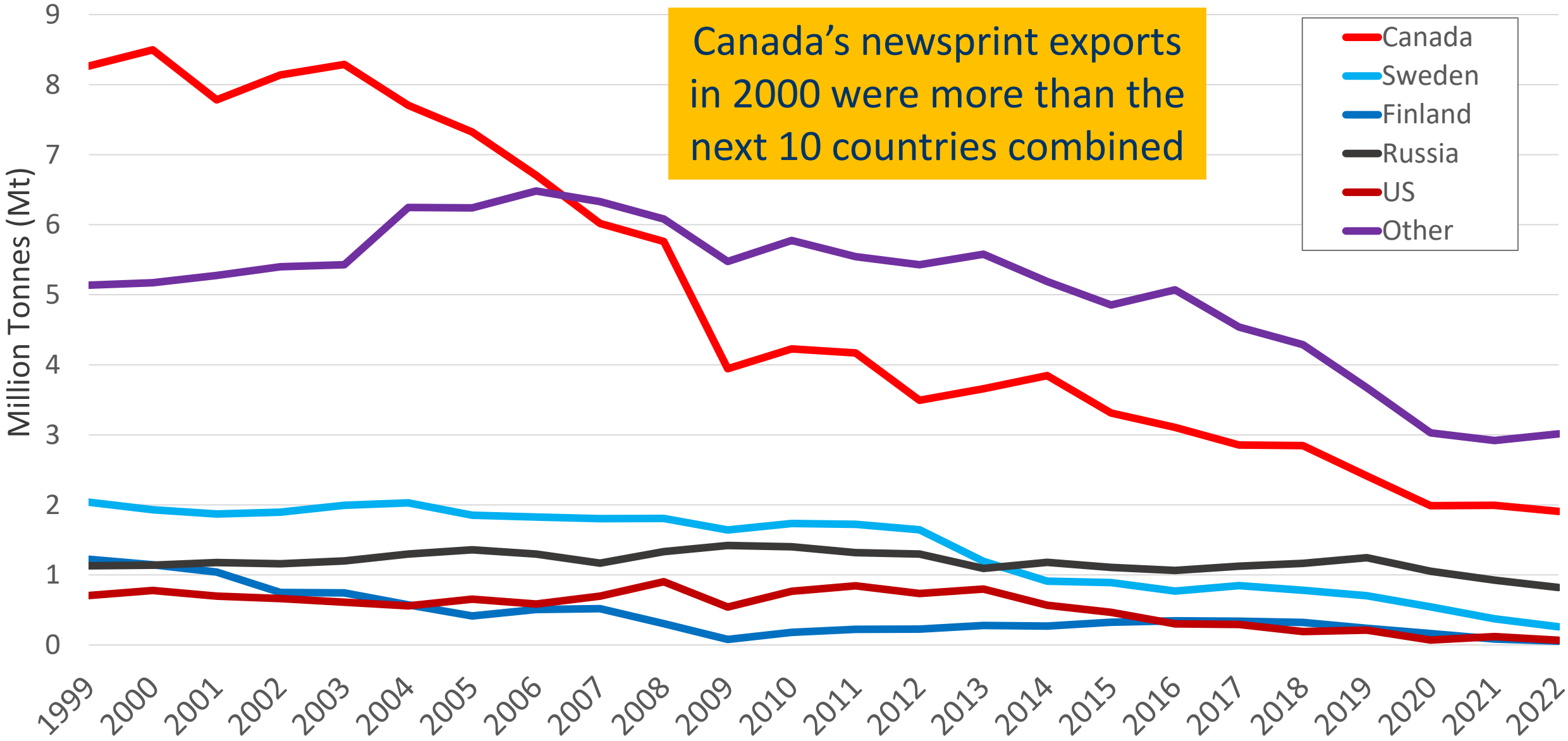
Balance of Trade in Canada, 2004 (C$2024 B)



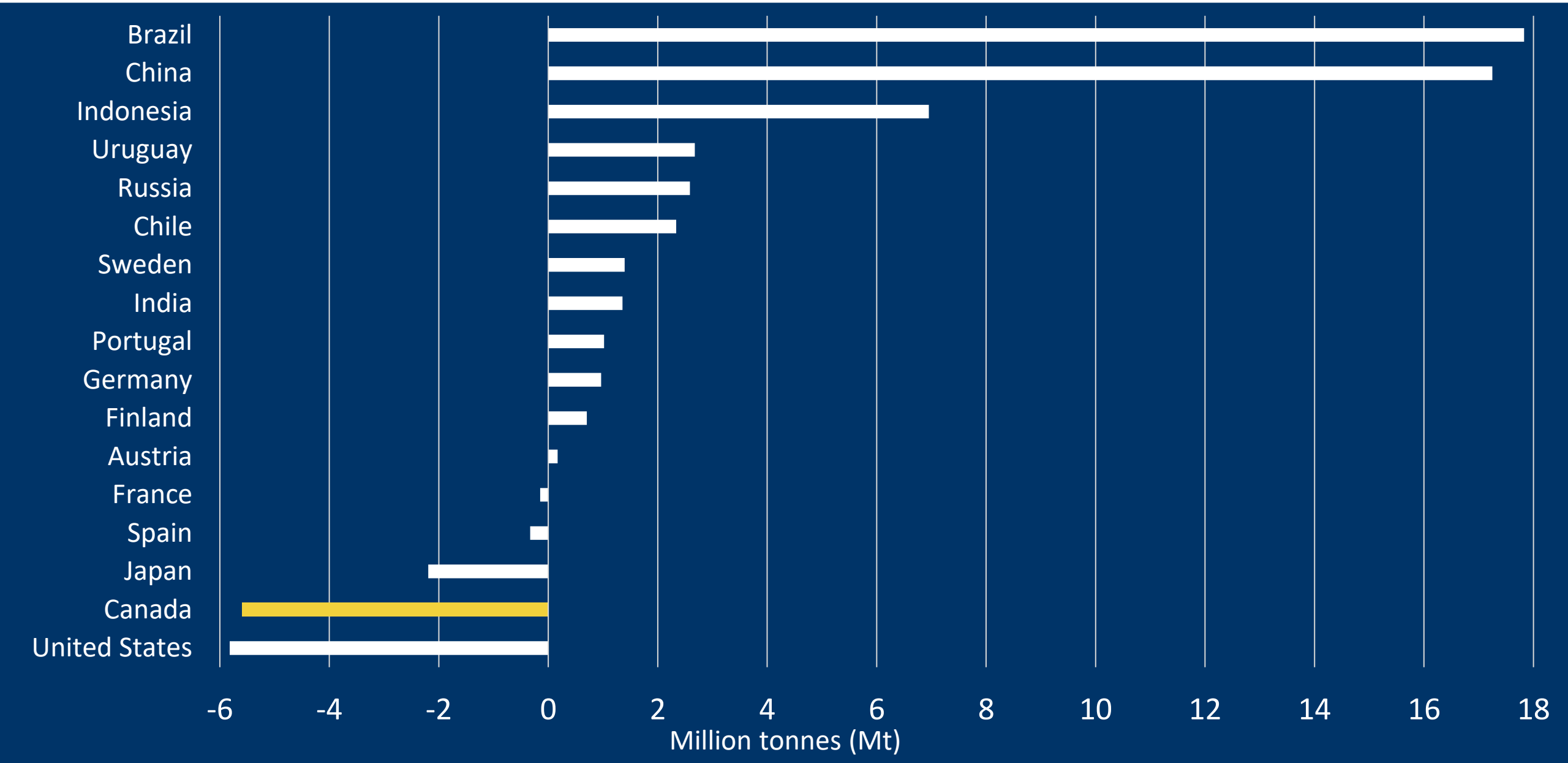
Canada's Pulp and Paper Production



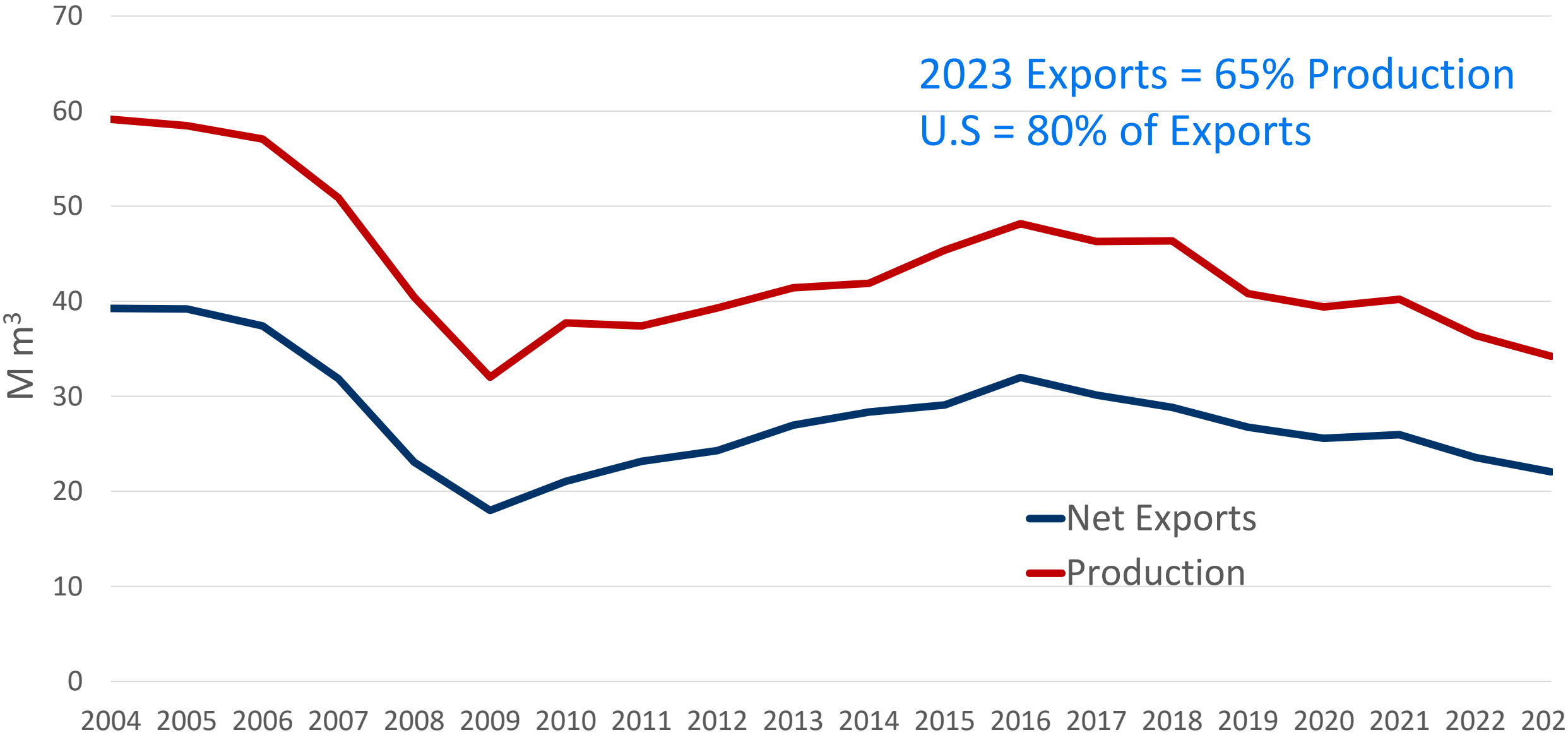
Newsprint Exports (100% of Global)



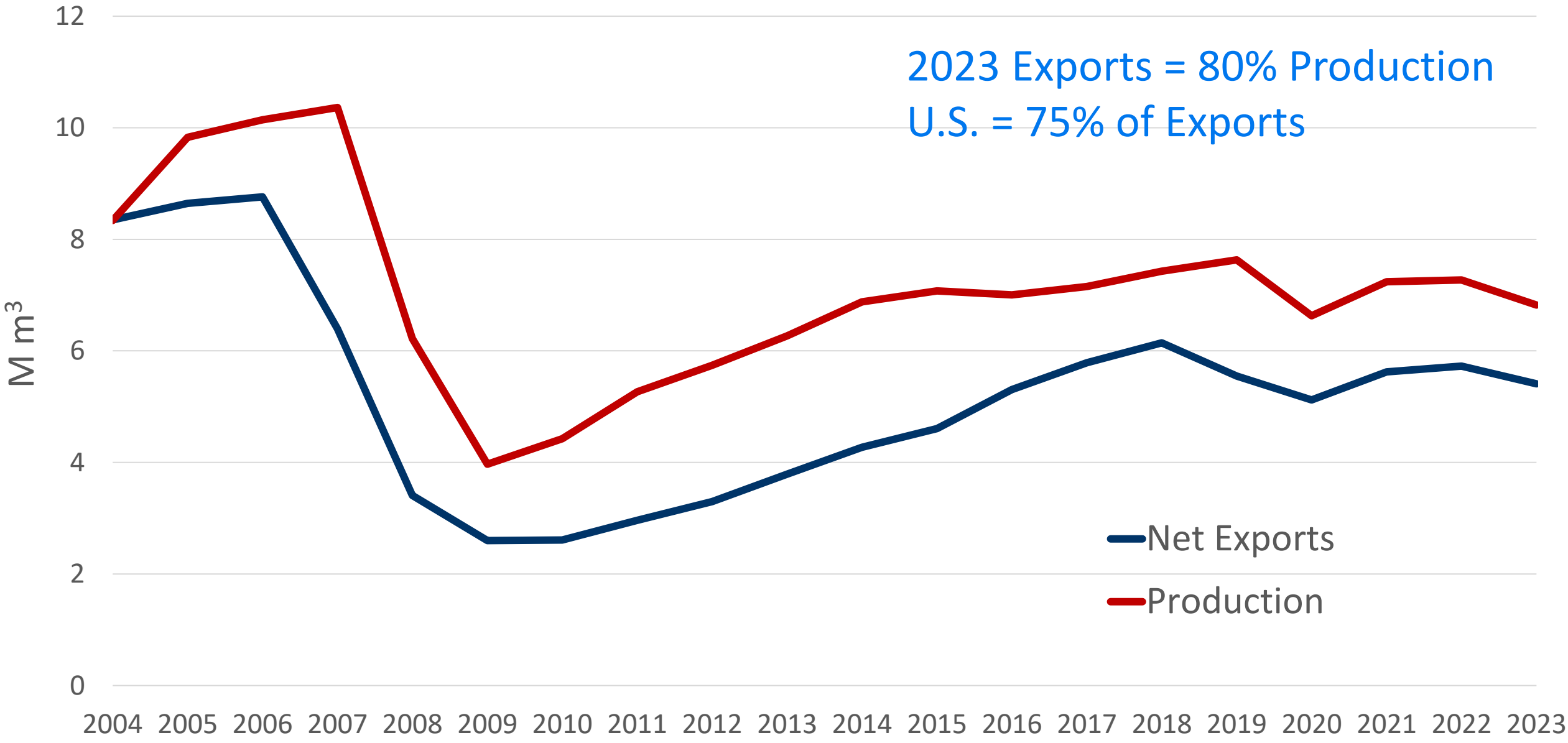
Chemical Pulp Production Change, 1999-2022



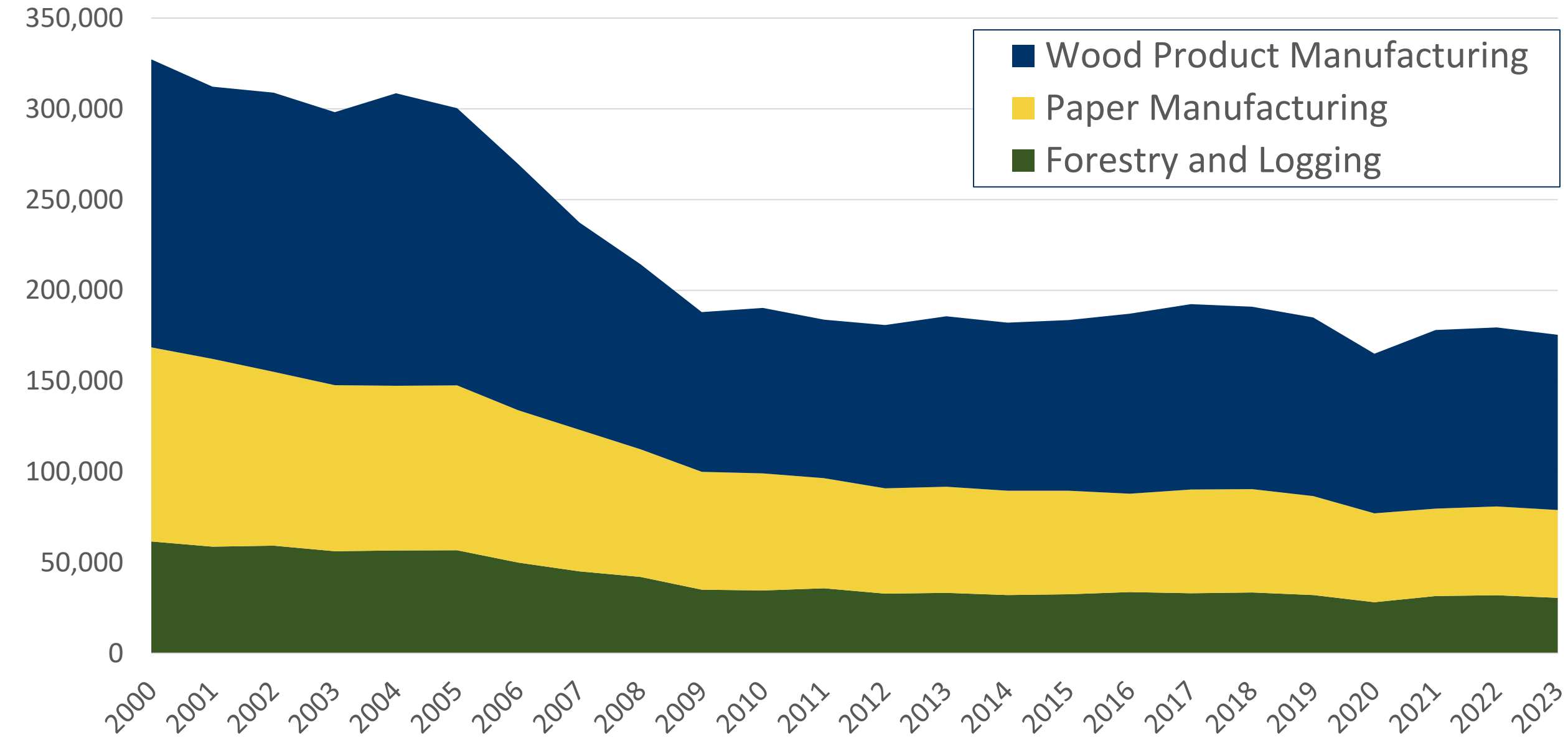
Softwood Lumber Production & Exports (M m^3)



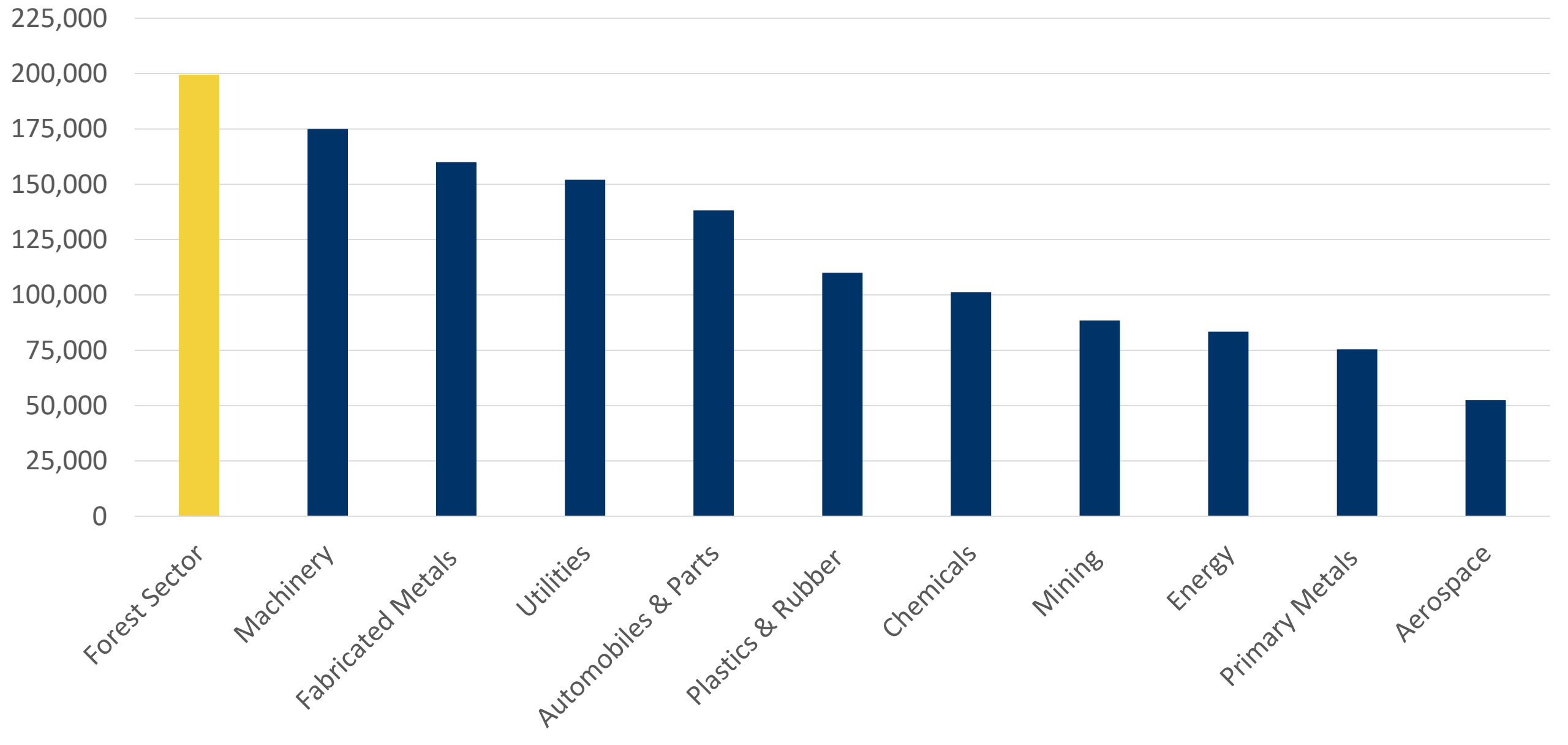
OSB Production & Exports (M m^3)



Forest Sector Direct Employment



Selected Employment, 2023



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Industries decline. That is ok.

But forestry is different.

Consider the counterfactual.

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Public GHG Emissions

Public Air Pollution

More emissions than everything else… combined!

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Wildfires are by far the largest negative economic impact of climate change in Canada

$10-35 B/y

Human and Economic Cost

- Zhang et al., 2025, Nature:

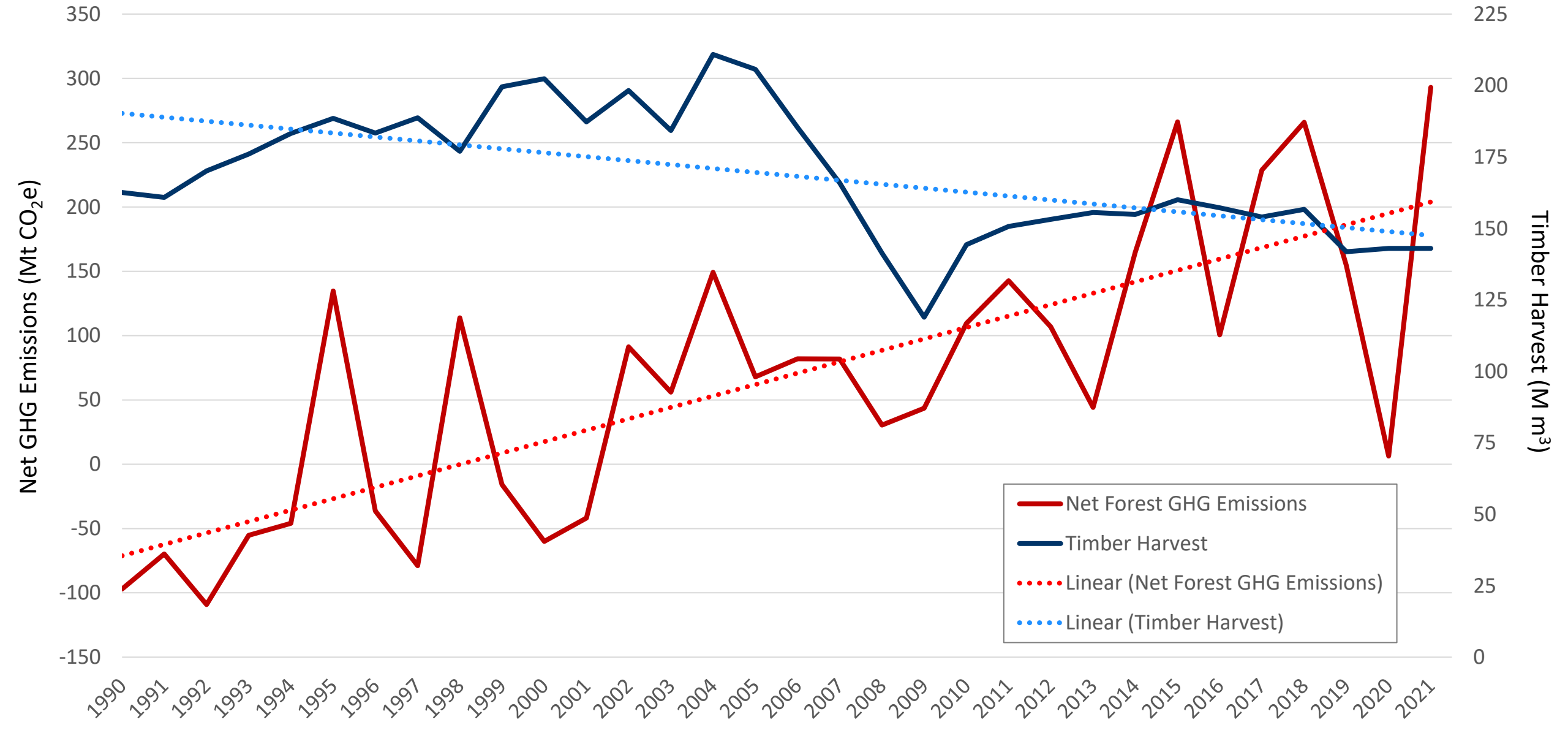
"Worldwide, we estimate that 82,100 people died prematurely attributable to chronic smoke exposure from the 2023 Canadian wildfires…Of these deaths, 41,900 occurred in North America, including 33,000 in the USA and 8,300 in Canada...In Europe, we estimate 22,400 attributable chronic deaths in Europe related to the intercontinental transport of smoke from the Canadian fires."

- Qiu et al., 2025, Nature:

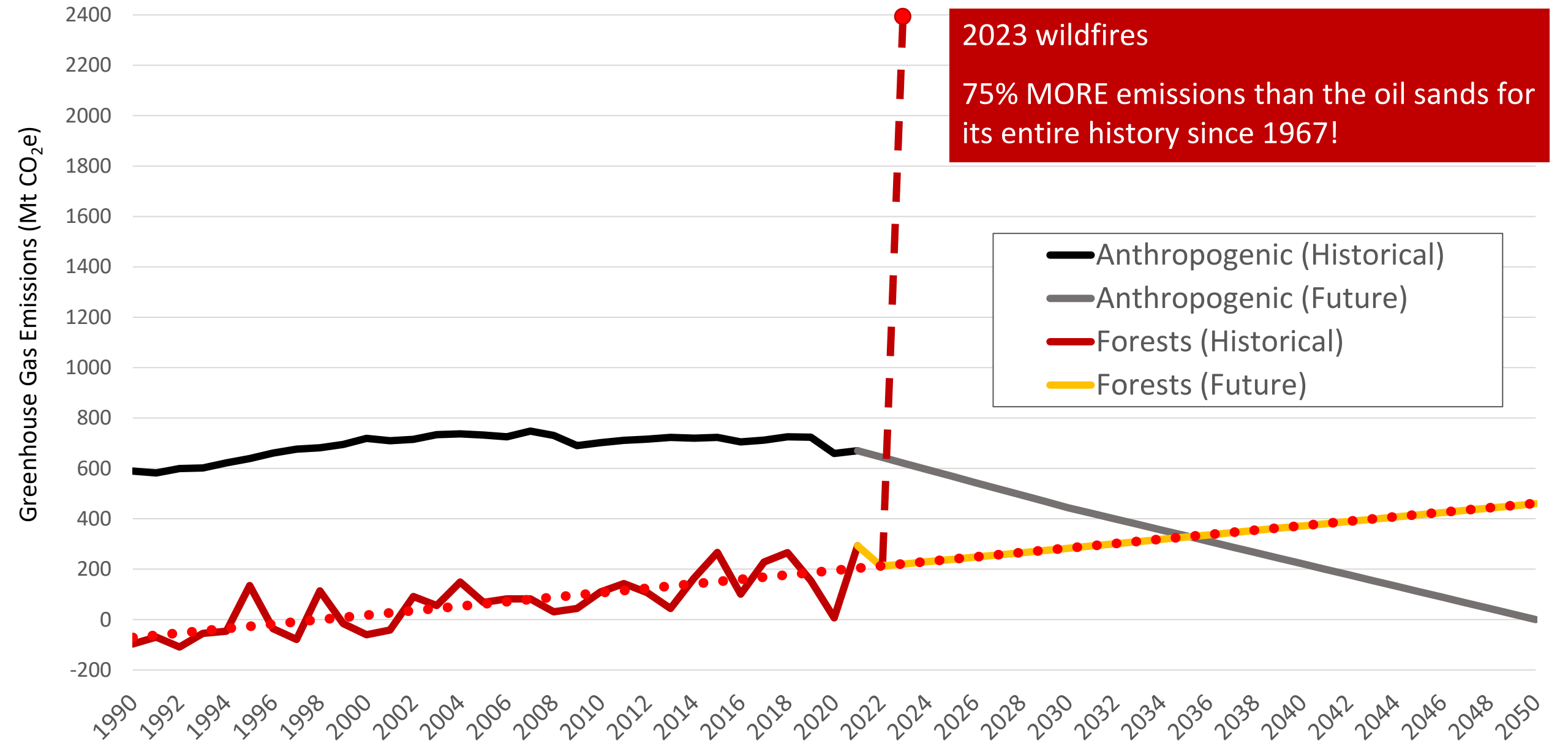
"…increase in annual excess deaths due to climate-driven wildfire smoke would result in annual damages of $608 billion in 2050 (2019 dollars)…our estimates suggest that damages from climate-induced smoke-related mortality could substantially exceed damages from all other estimated causes by mid-century in the US combined."

- Consistent with Health Canada's cost findings (pre-2020, up to $20 B/y)

GHGs from Canada's Forests Vs. Timber Harvest



Human Vs. Forest Emissions



Does it have to be this way?

Wildfire Rate (per Ha)

Canada vs Sweden

50x

2023: 500x

Harvest Rate

Sweden/Canada = 7

CA: Harvest <3.9% of growth

SE: Harvest <28% of growth

But Sweden is increasing forest carbon while Canada is losing it rapidly

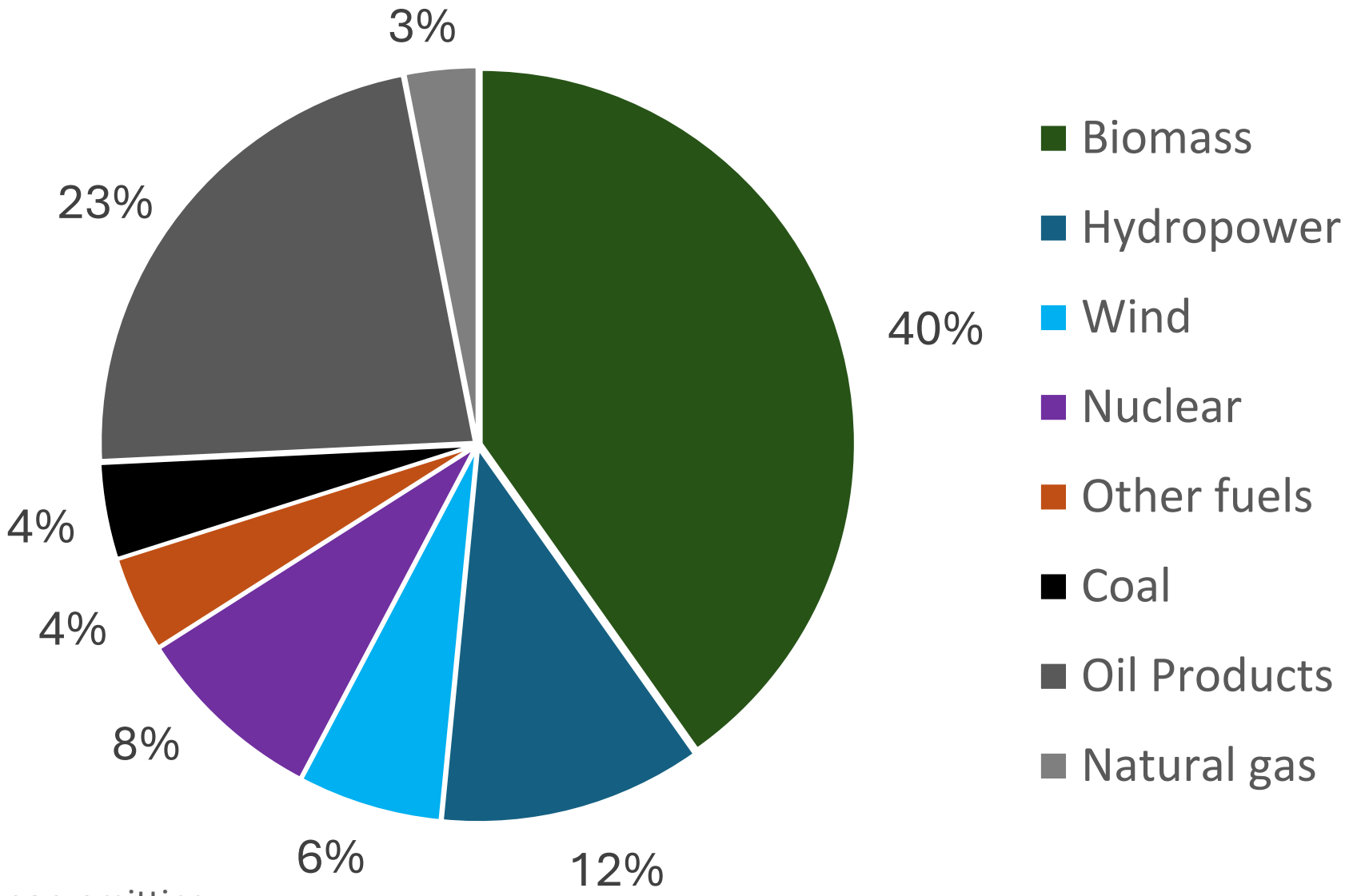
Climate-Smart Forestry

- Minimize carbon in the atmosphere
  - Maximize carbon stored in forest
  - Maximize carbon stored in long-lived solid wood products
  - Permanently store all other carbon subsurface
- Requires ACTIVE management in Boreal Forest
  - FireSmarting to reduce wildfire risk/limit carbon release
  - Thinnings to improve forest health and productivity
  - Indigenous approaches to management
- <u>Active management requires a market for low-value, high-cost wood</u>
- Carbon is NOT the only value to manage for

California Bootleg Fire 2021

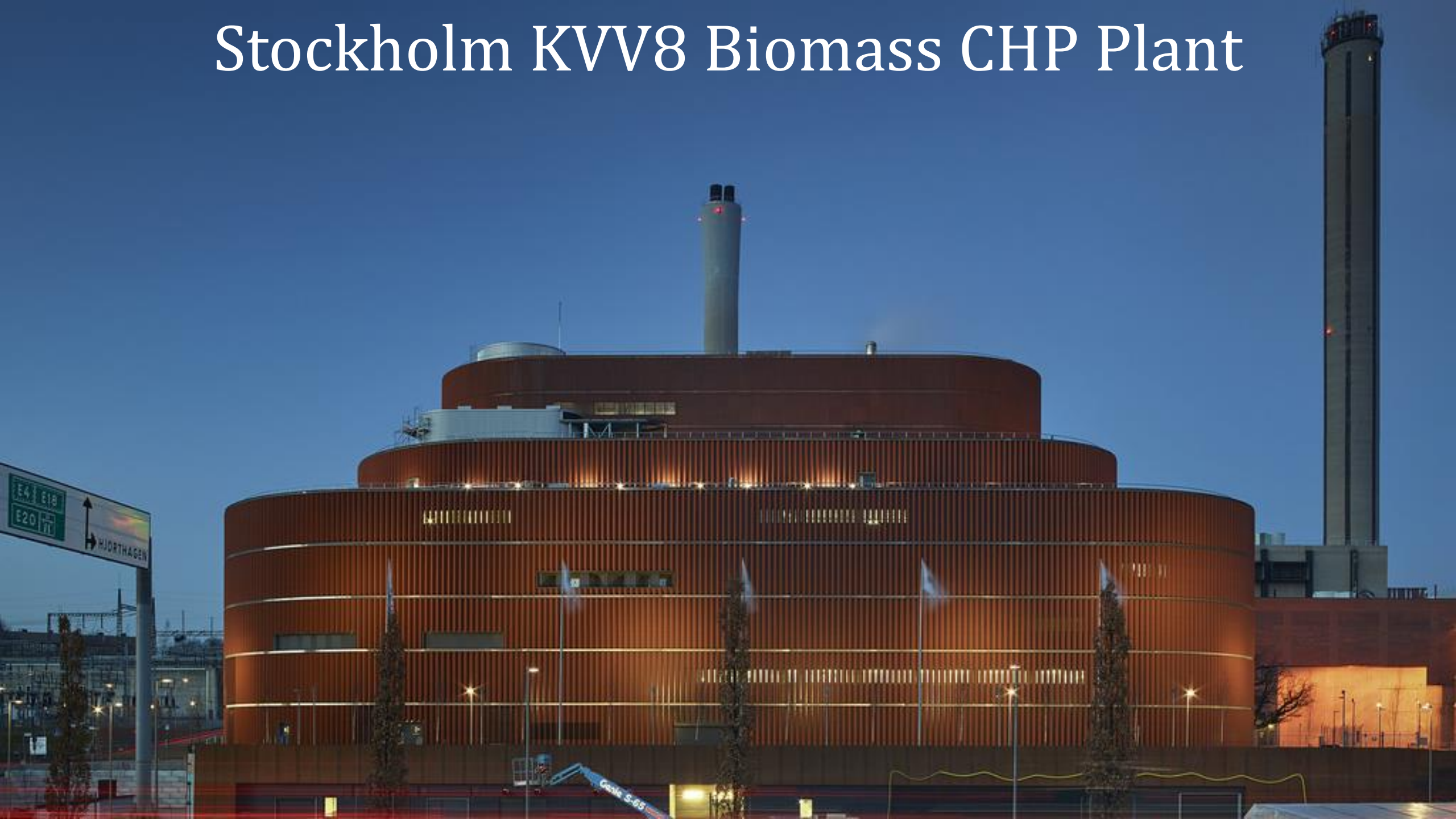
Bioenergy is generally the ONLY market for low-value wood, including thinnings, fuel treatments, and mill residues

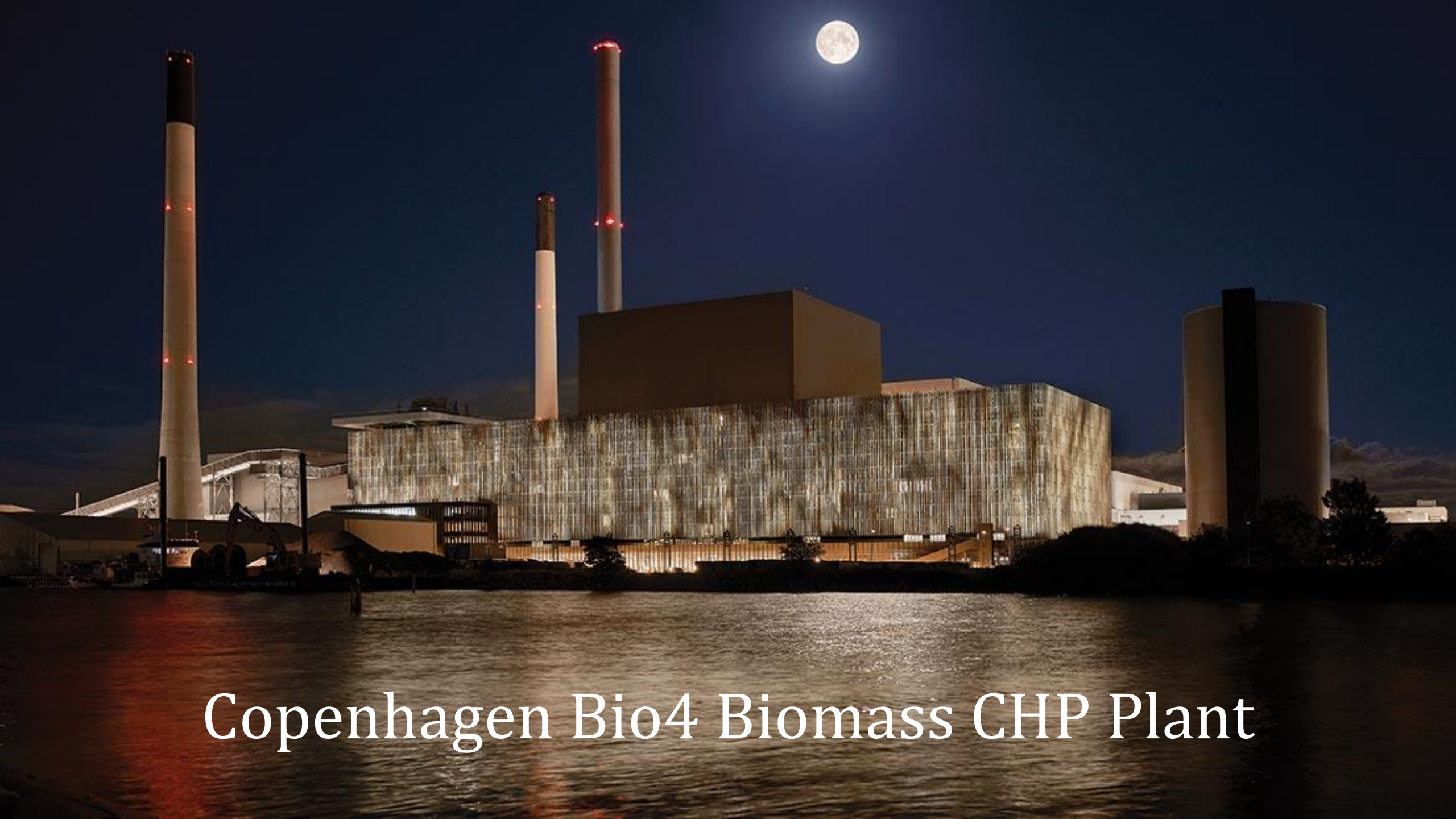
Energy Consumption in Sweden



- 58% renewable energy, 65% non-emitting

Stockholm KVV8 Biomass CHP Plant





Copenhagen Bio4 Biomass CHP Plant

Helsinki Vuosaari Biomass Heat Plant

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Modern biomass combined heat and power plants reduce air pollutant emissions by 99.995% compared to wildfires

Lower pollutants per unit energy than natural gas furnaces

Who Pays?

Active forest management generates large volumes of low-grade wood

1. Provincial Taxpayers *aka forest owners* (taxes)
2. Provincial Electricity Consumers (energy bills)
3. Domestic & International Emitters (BECCS CDRs)

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BECCS in Canada is

Mitigation

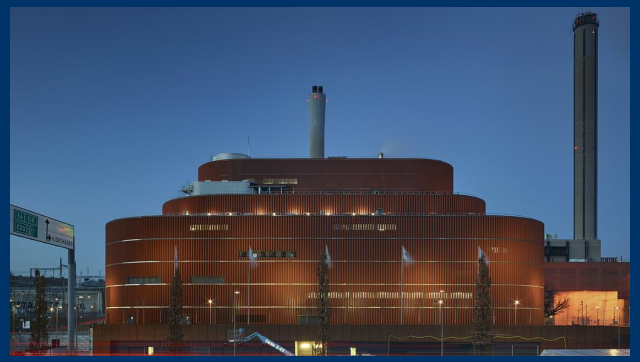
paying for

Adaptation

BioEnergy with CCS

Atmospheric Carbon Removal

+



Bioenergy (Heat and Power)

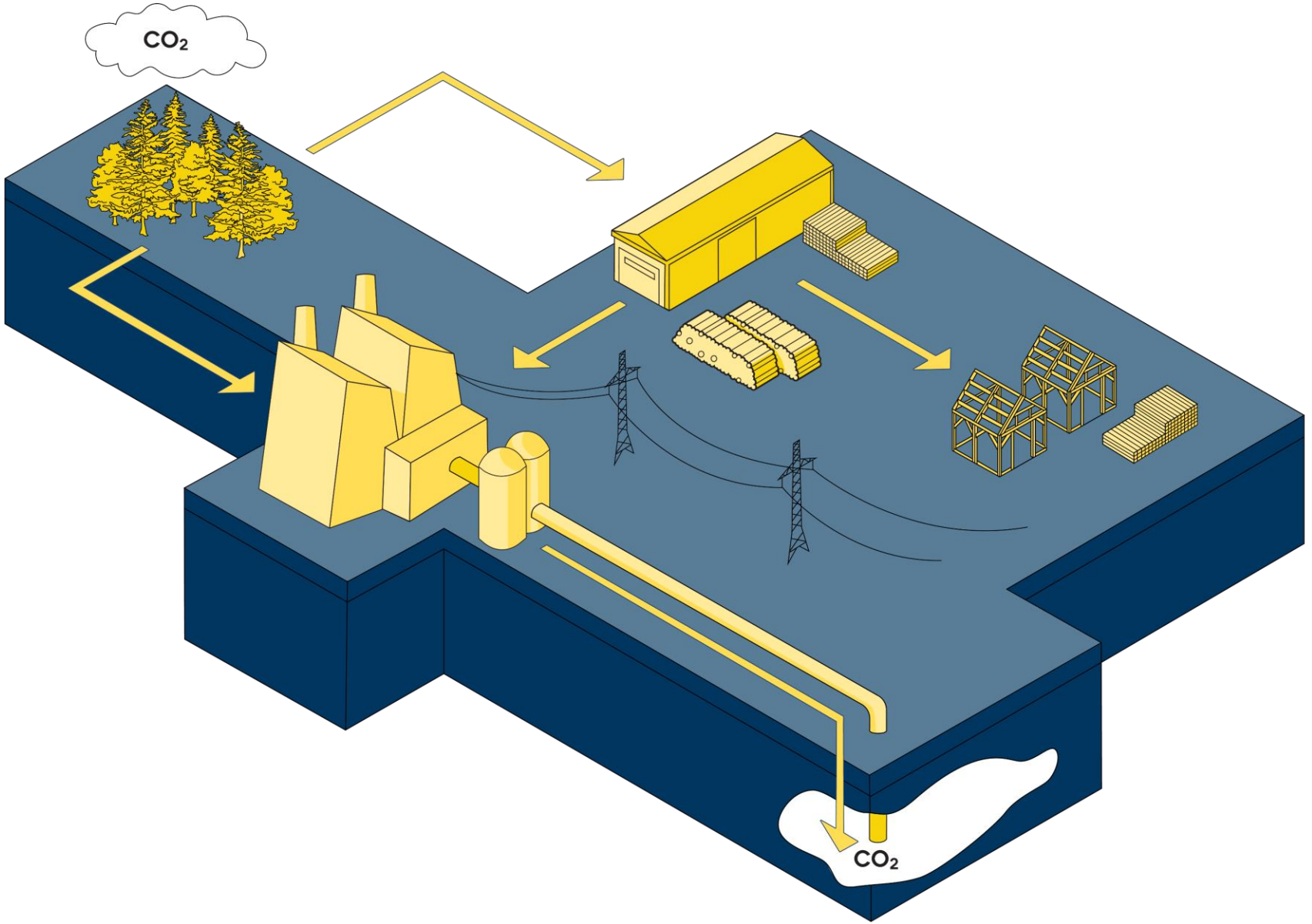
+

Carbon Capture & Storage

= BECCS

BioEnergy with Carbon Capture & Storage

- Lowest cost approach for permanent carbon dioxide removals – CDRs (negative emissions)
- Four decarbonizations at once: electricity, heat, hard-to-abate, forests
- Two or three sources of revenue



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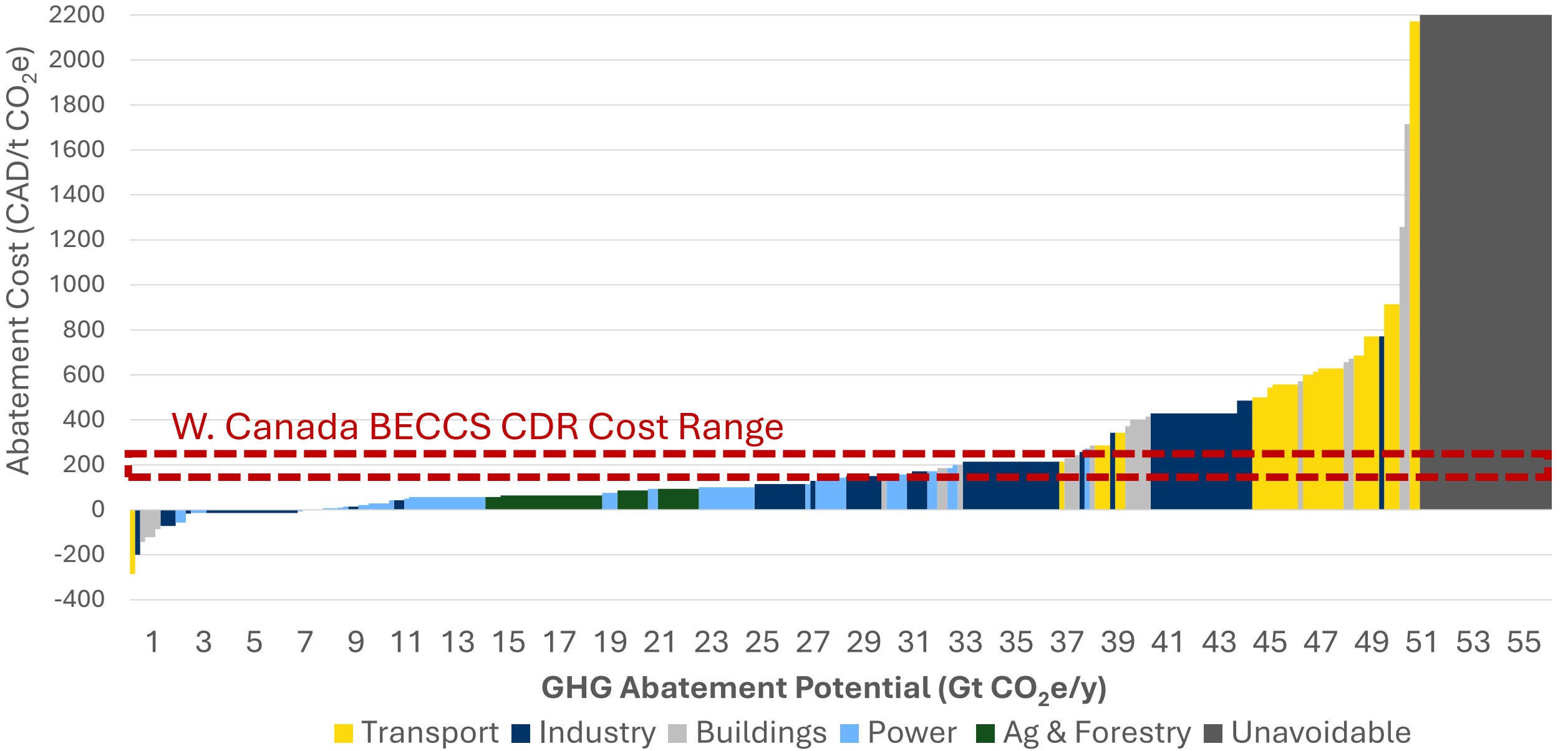
It is called NET zero for a reason

There are two sides to the carbon equation

GHG Cost Abatement Curve



Why BECCS?

1. Only option that can pay up to $\$150/m^3$ for very low grade fibre (unselective)

2. Government can buy all the product as a carbon utility

3. Exports without infrastructure

4. Most cost and carbon efficient means of decarbonization with biomass
    - *In AB, 6x the GHG reduction of conversion of wood into liquid biofuels*

5. Can leverage existing forest product facilities: CO_2 supply

BECCS in Other Countries

Avedøre Biomass Plant, Denmark

- Plant owned by Ørsted fueled by straw heats Greater Copenhagen
- 430 kt CO_2/yr to be captured from plant and Kalundborg CHP
- Microsoft buying 333 kt CDR/yr for 11 yr
- **Under construction**
- CO_2 to be stored by Northern Lights

Mikawa Biomass Power, Japan

- 50 MW_e BECCS demonstration plant owned by Toshiba
- Operational

Klemetsrud WtE Plant, Norway

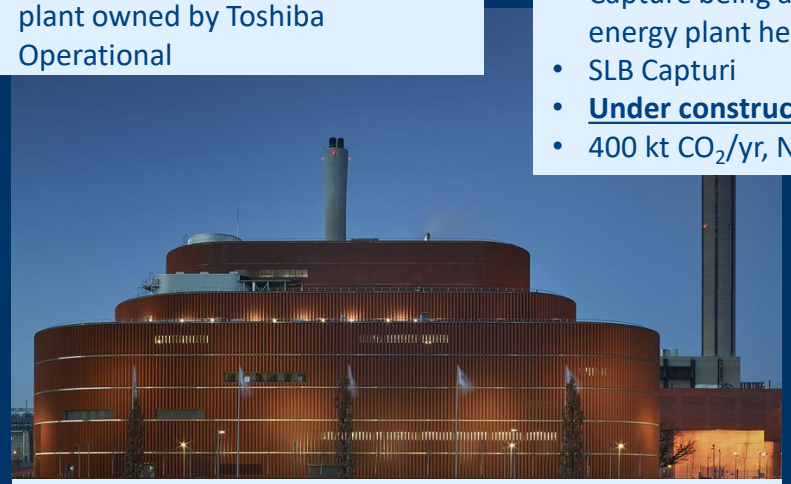
- Part of Longship/Northern Lights
- Capture being added to waste-to-energy plant heating Oslo
- SLB Capturi
- **Under construction**
- 400 kt CO_2/yr, North Sea storage

Drax Power Plant, UK

- 4,000 MW pulverized coal power plant fuel switched to wood pellets (8-9 Mt/yr)
- Formerly largest GHG emitter in Europe
- Plan to initially add capture (MHI) to 2 of 6 units
- 8 Mt CO_2/yr (2 units), North Sea storage
- >$20 M FEED underway (Worley, MHI)
- MHI operated pilot plant at site to test flue gas

PT Tanjungenim Lestari Pulp & Paper, ID

- Pertamina and Marubeni (TELPP owner) partnering to develop BECCS plant at Kraft pulp mill in Indonesia (Sumatra)

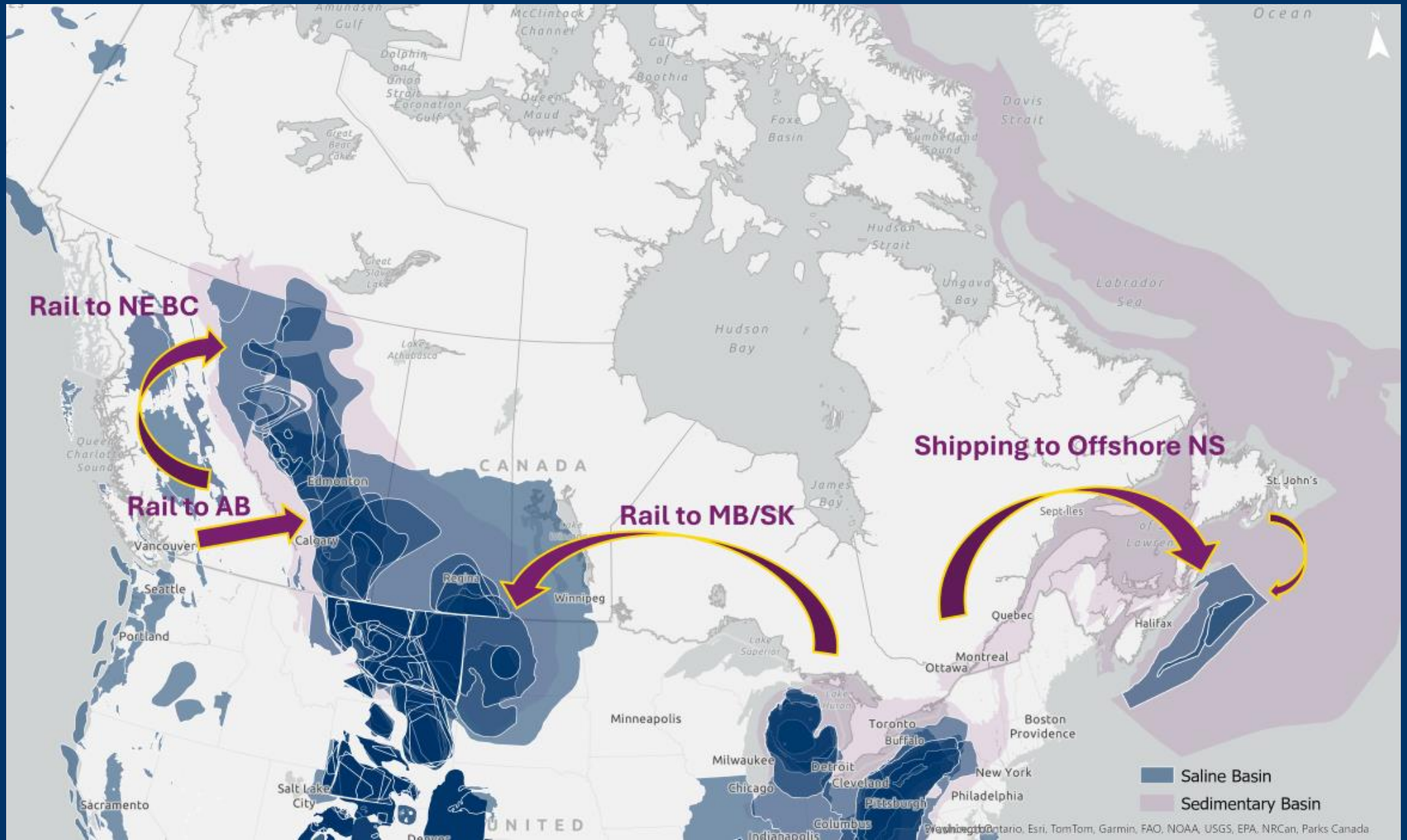


KVV8 Biomass CHP, Stockholm

- Wood chip-fuelled plant heating Stockholm via district energy system owned by Stockholm Exergi
- Plan to add capture; pilot plant operated for multiple years; Microsoft buying 333 kt CDR/yr for 10 yr
- >$250 M in EU grant funding, **under construction**
- Swedish Gov't purchasing $2.6 B in CDRs
- 800 kt CO_2/yr, North Sea storage via Northern Lights

Mönsterås Pulp and Paper, Sweden

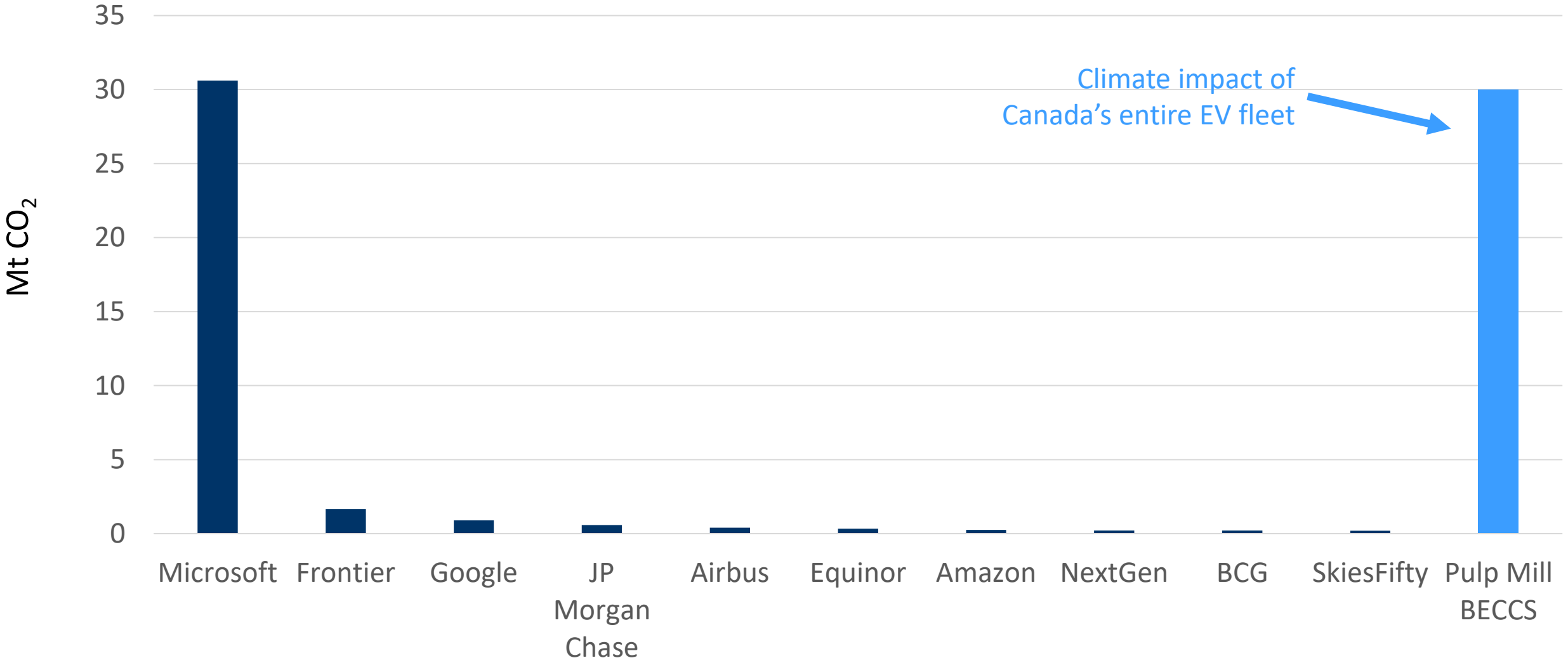
- Njord Carbon partnership on BECCS between Equinor, Södra (major forest products company), and Verdane (Nordic private equity firm)
- Södra owns three pulp mills, with Mönsterås the largest (~2 Mt CO_2/yr)
- CO_2 shipping via Northern Lights


Rail to NE BC
Rail to AB
Rail to MB/SK
Shipping to Offshore NS
CANADA
UNITED
Edmonton
Calgary
Vancouver
Seattle
Portland
Sacramento
Salt Lake City
Regina
Winnipeg
Minneapolis
Milwaukee
Chicago
Detroit
Cleveland
Toronto
Buffalo
Ottawa
Montreal
Quebec
Sept-Îles
Halifax
St. John's
Boston
Providence
New York
Philadelphia
Pittsburgh
Columbus
Indianapolis
Hudson Bay
Foxe Basin
Davis Strait
Labrador Sea
Ungava Bay
James Bay
Lake Athabasca
Great Bear Lake
Great Slave Lake
Queen Charlotte Sound
Saline Basin
Sedimentary Basin
Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NRCan, Parks Canada

Five L-CO_2 carriers launched or under construction

Voluntary CDR Market

Comparison to a single full pulp mill project required offtake



#1: BECCS CDRs as Federal Backstop

“Reduce emissions or we will remove them for you and charge you at cost.”

- No net cost to Treasury
- Structured as regulated utility
  - Fixed ROE, pass through on fuel, OpEx, debt
  - No margin on fuel critical for enhanced forest management
  - Attracts institutional and sovereign capital
- It is not about price. It is about performance
- CDR ownership transferred to industrial emitter

BECCS CDRs as Federal Backstop

GoC in the middle of the deal

Why? Too much policy risk. Crown asset. Regulated utility.

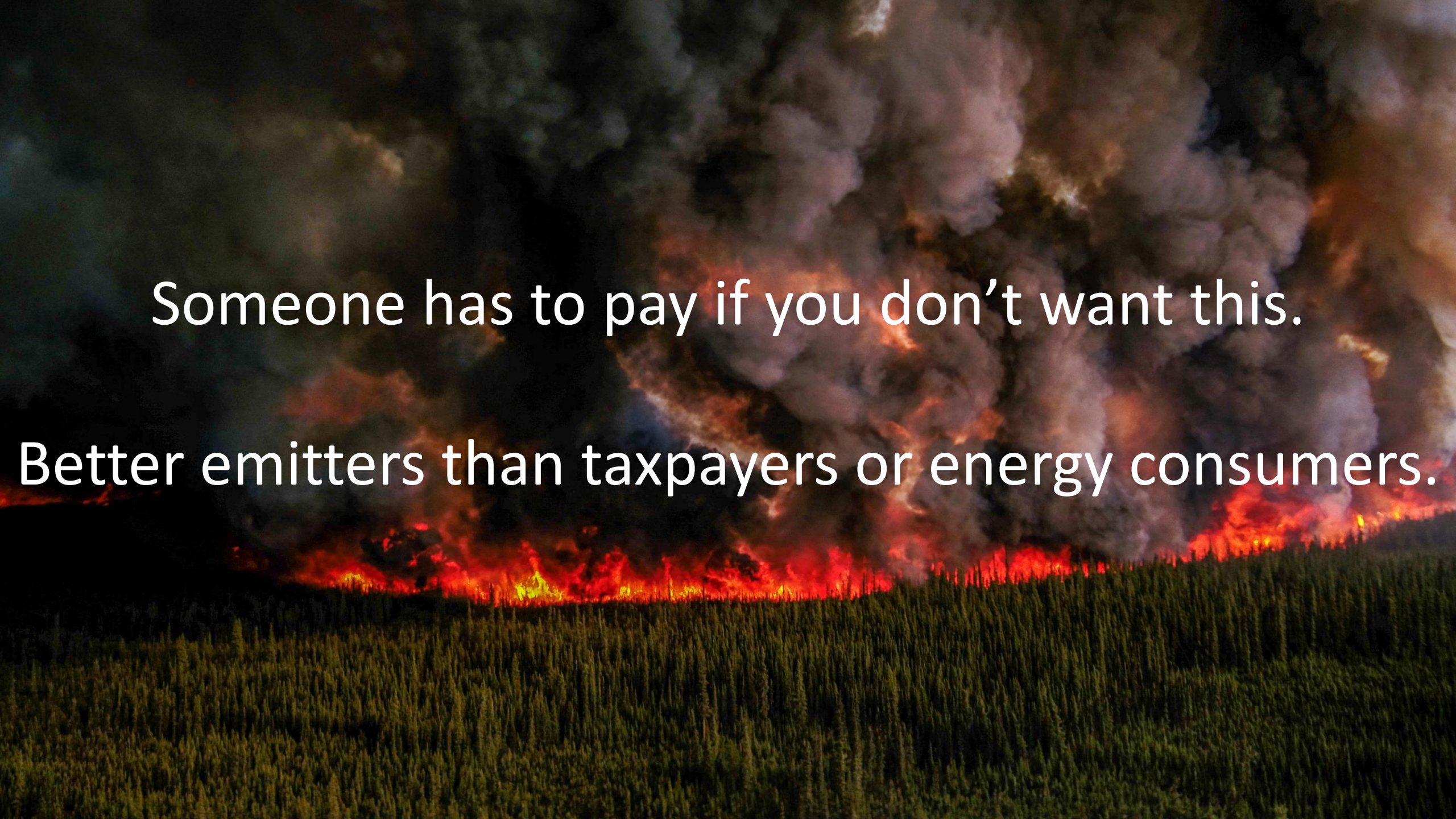
#2: Carbon Removal Charge

“Garbage disposal for Consumer Emissions”

- Only applied to emissions removed, not all
- Could be restricted to aviation, urban gasoline, etc.
- Structured as regulated carbon utility
- Public justification based on wildfire risk reduction
- Builds domestic industry gradually over time
- Would slowly shift consumer behaviour
- Implemented in combination with renewable/clean fuel policies

#3: Exports

- Canada only produces 1.3% of global GHG emissions
- Our forests are subject to 100%
- Canada has disproportionate wildfire risk – our *low lying island rising sea*
- CDRs are exportable product (corporate, ITMOs via Article 6.2/6.4)
- EU – Carbon Removals Certification Framework
- 2040 target – Up to 5% (250 Mt CO_2e/y) met with international CDRs
- Also option to bundle CDRs with energy exports (e.g., LNG)
- We buy Chinese panels and EVs, they buy our CDRs


Someone has to pay if you don’t want this.
Better emitters than taxpayers or energy consumers.

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