Only the Forest Products Sector can deliver Net Zero for New Brunswick

Six Projects to Get There

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Jamie Stephen, PhD
Managing Director
TorchLight Bioresources
JStephen@TLBio.com

The Starting Point

New Brunswick needs an Energy Transition strategy appropriate for the province. It is not Quebec.

Economic growth must be the primary driver.

The importance of the forest products sector to New Brunswick's economy gives it a competitive advantage.

Climate change is a numbers game. Big projects are required.

BECCS is New Brunswick's largest Energy Transition opportunity by far.

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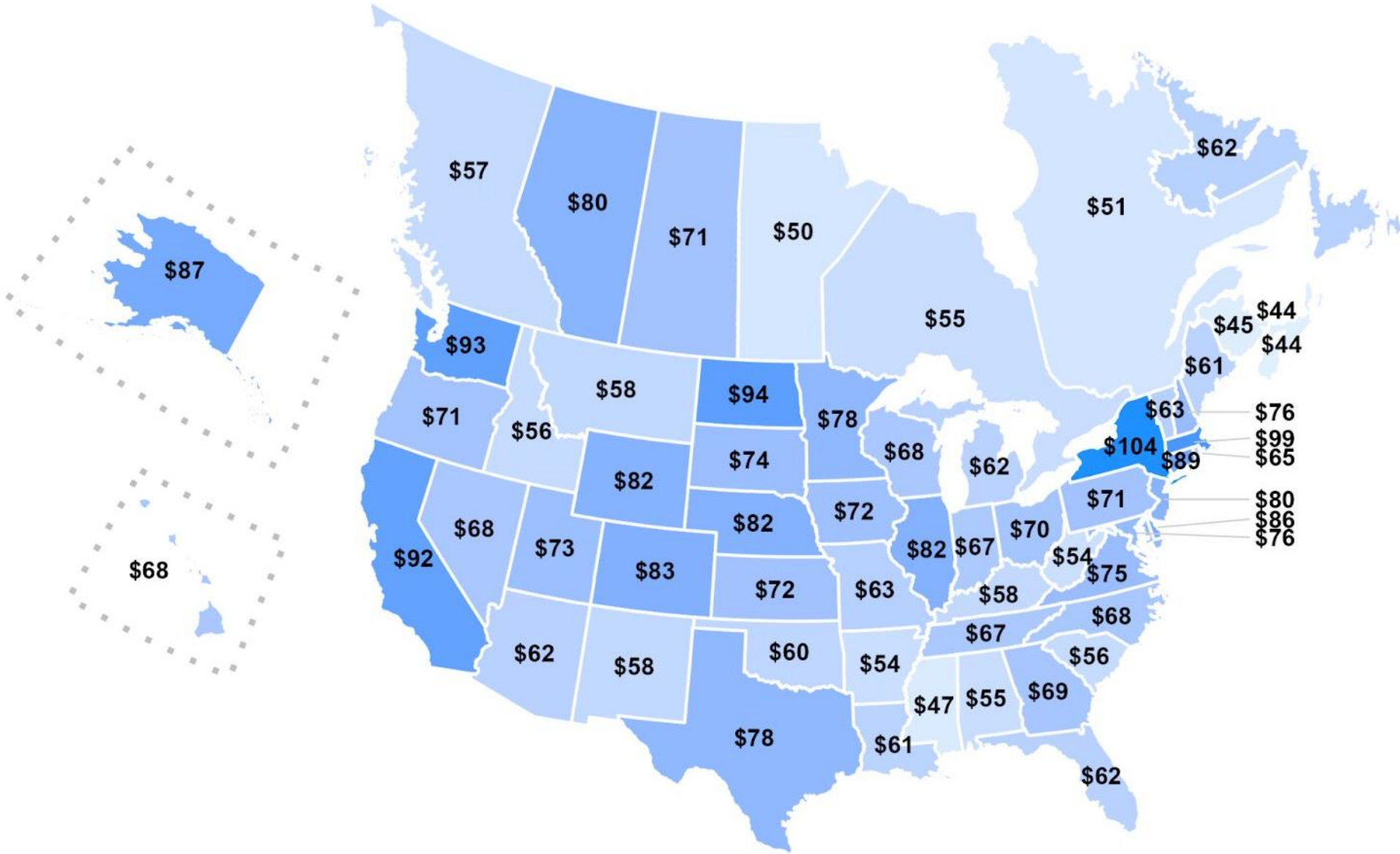
Economy

GDP per Capita in 2022 (000s USD, Purchasing Power Adjusted)

Note: Own calculations using data from Statistics Canada data table 36-10-0222, RBC June 2023 forecast, and the US BEA.
All values are in real PPP-adjusted US dollars using OECD PPPs (doi: 10.1787/1290ee5a-en). Graph by @trevortombe.



New Brunswick Trade

- By far largest export is refined petroleum products
- Second is forest products
- Lobster and shellfish distant third
- The only way for New Brunswick to ‘win’ in the energy transition is to bring forest products and oil refining together to out-compete
- BTW…other places in the world have better wind and solar resources and way cheaper natural gas

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Forests

Forestry: Managers of Carbon

- Turnover in Canada's forests 5x anthropogenic GHG emissions
- 45 B m^3 (t CO_2) in above ground biomass over 346 M ha
  - Value of >$7.5 trillion @ $170/t CO_2
  - Canada's total infrastructure valued at $0.9 trillion
- Have lost 9% of 'principal' over past 10 years (4 Gt CO_2)
  - $680 B in carbon losses ($70k for family of 4)
  - Sweden has a 5% annual return on carbon assets
- Canada has 318 billion trees
  - 2 billion trees is 0.6% of the resource

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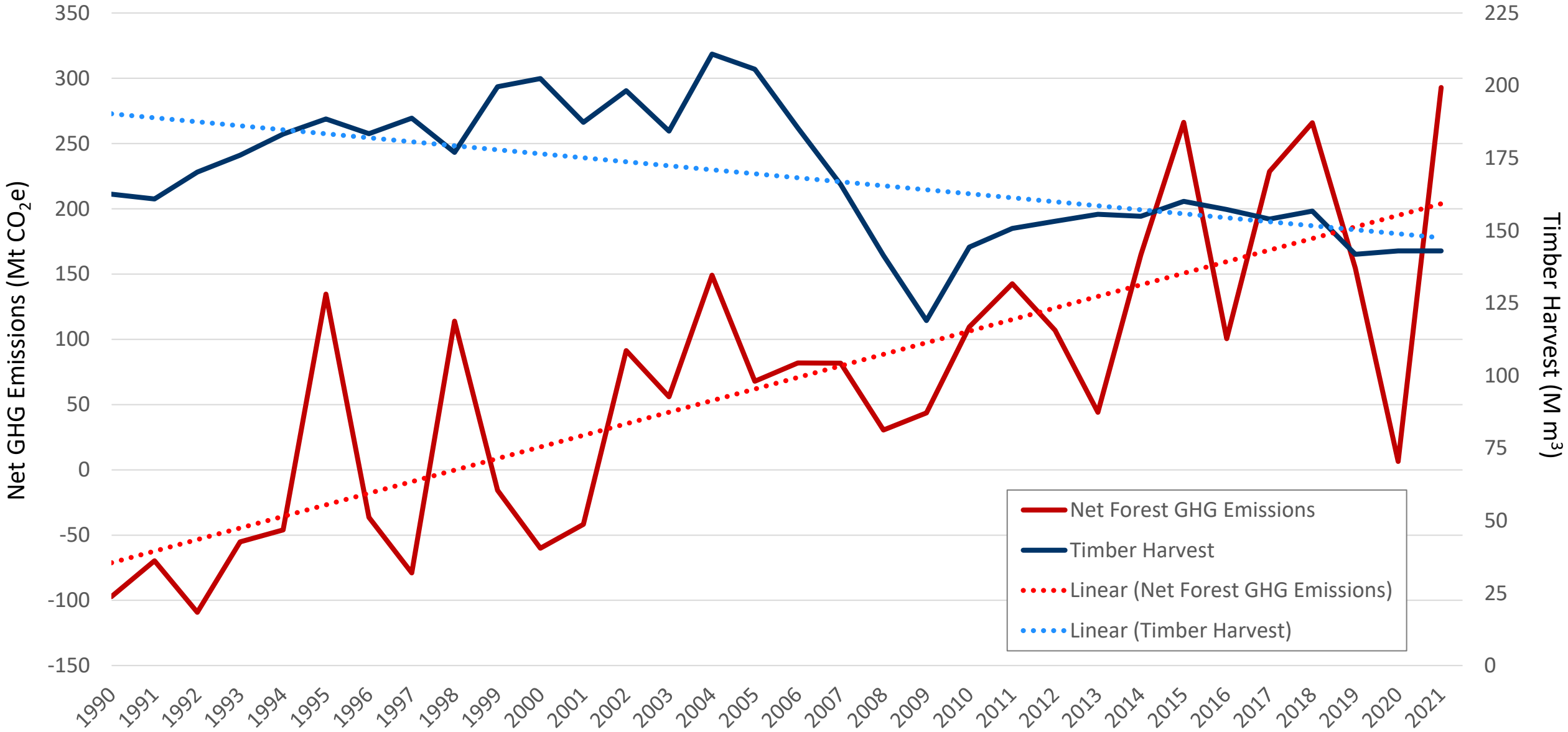
GHGs from Canada's Forests Vs. Timber Harvest



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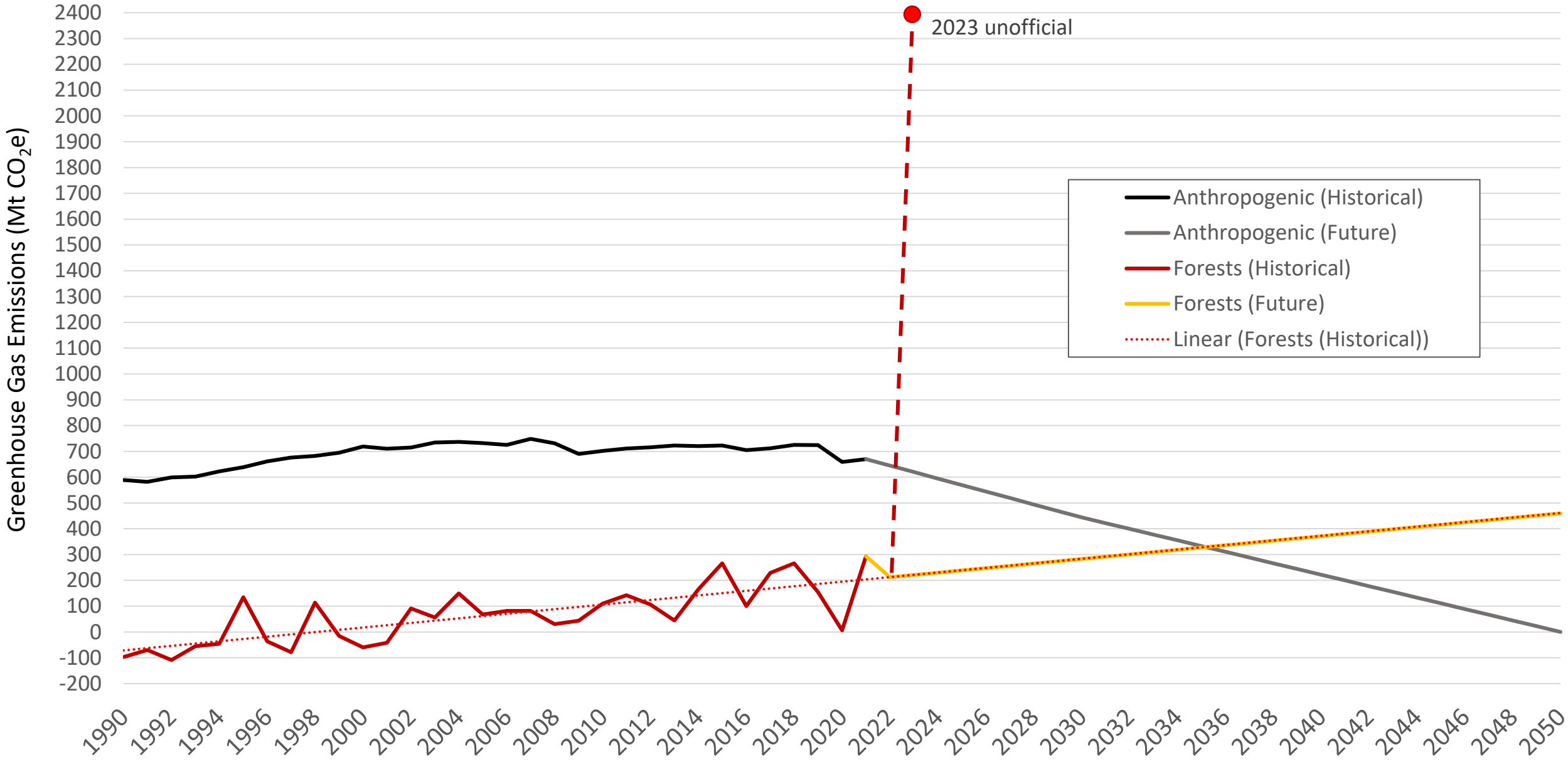
Human Vs. Forest Emissions



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85% of EU Emissions

50% of US Emission

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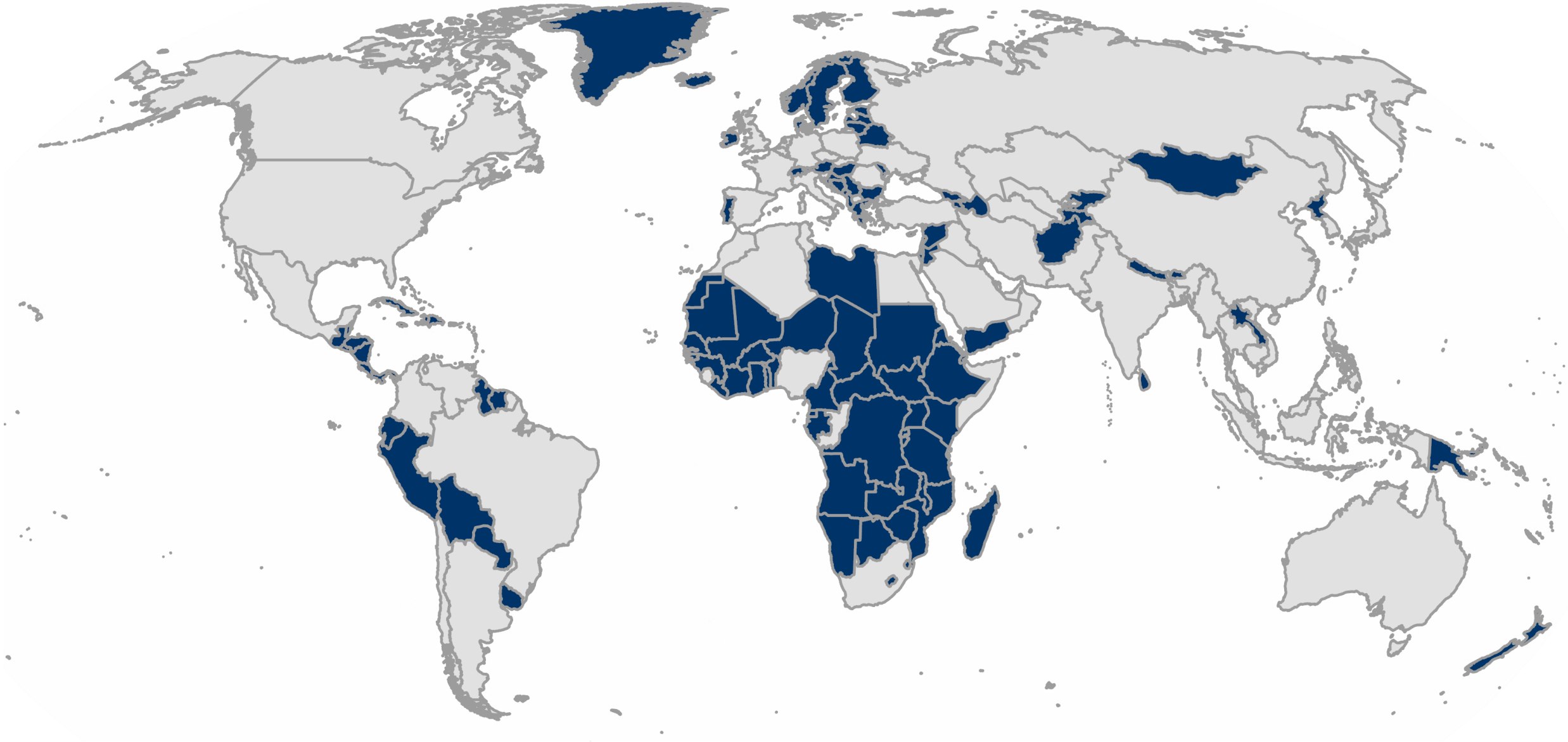
More than 138 Countries



Does it have to be this way?

Average Wildfire Rate (per Ha) Canada vs Sweden

50

Per Capita GHG (incl. Forests)

Canada = 75

Sweden = 0.7

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Harvest Rate

Sweden/Canada = 7

CA: Harvest 3.8% of growth

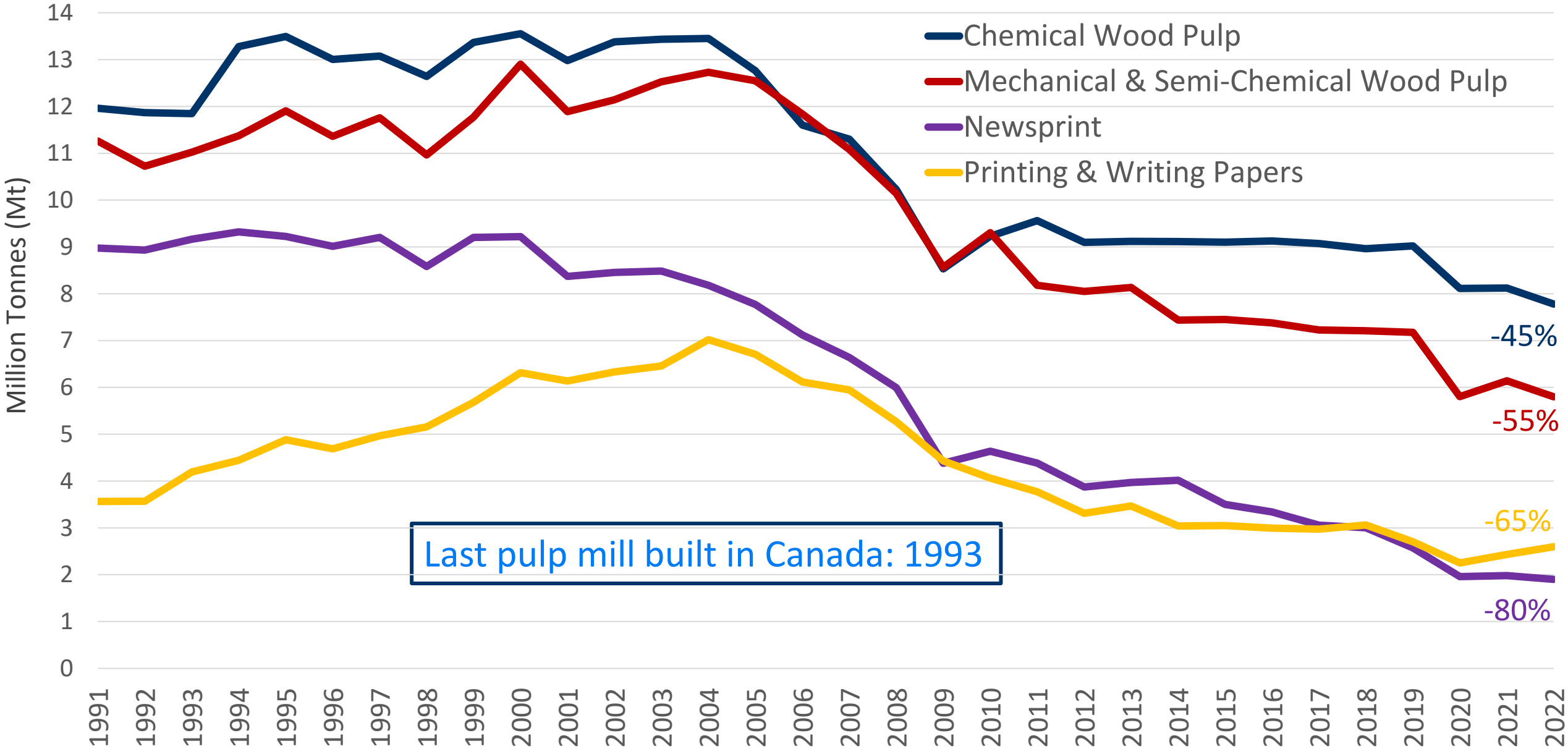
$\Delta = 1\ \text{Gt}\ CO_2/\text{yr}$

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
  - Manage to reduce wildfire risk/limit carbon release
  - Thinnings to improve forest health and productivity
- Active management requires a market for low-value wood/biomass
- Carbon is not the only value

California Bootleg Fire 2021

Canada's Pulp and Paper Production



NB & Related Closures

- Dalhousie
- Bathurst
- Miramichi (x2)
- Chandler, QC
- New Richmond, QC
- Northern Pulp, NS
- Bowater Mersey, NS

Estimated reduction in wood fibre consumption of >3 M bdt/yr

Equivalent to 5.6 Mt CO_2/yr in biogenic stack emissions

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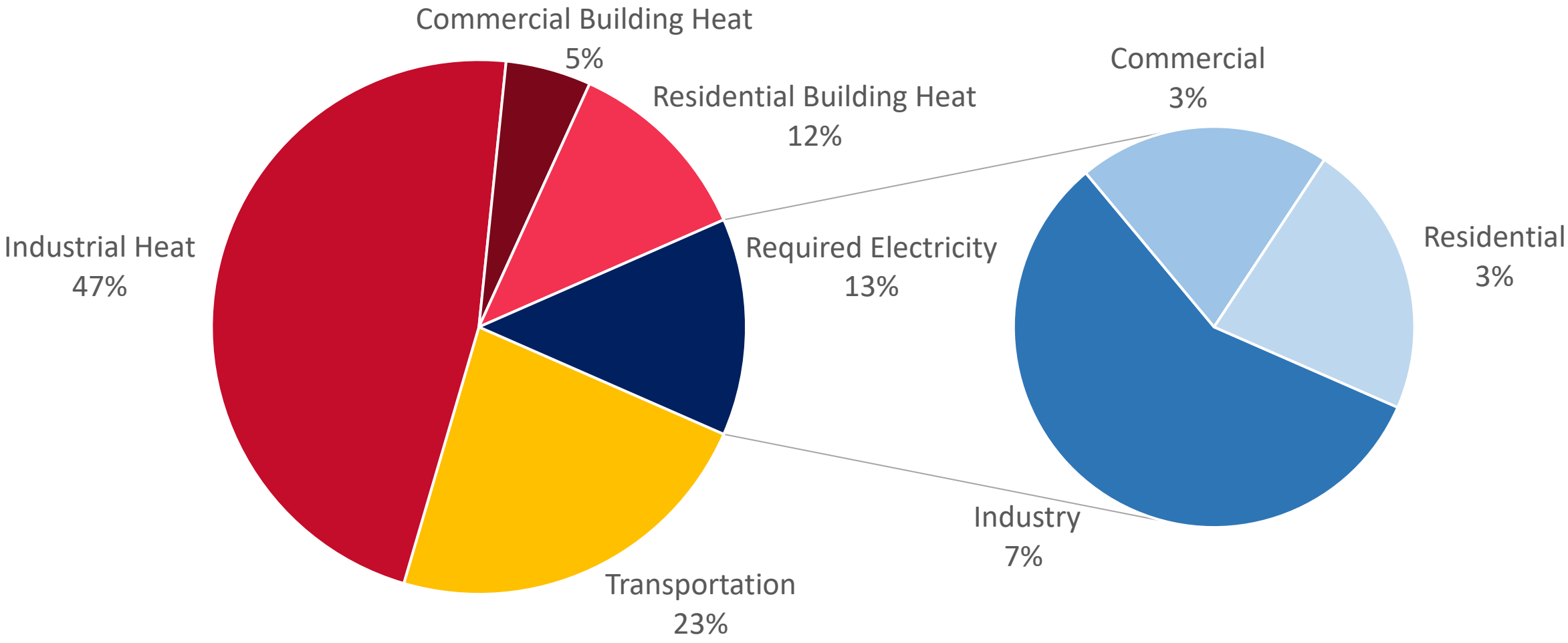
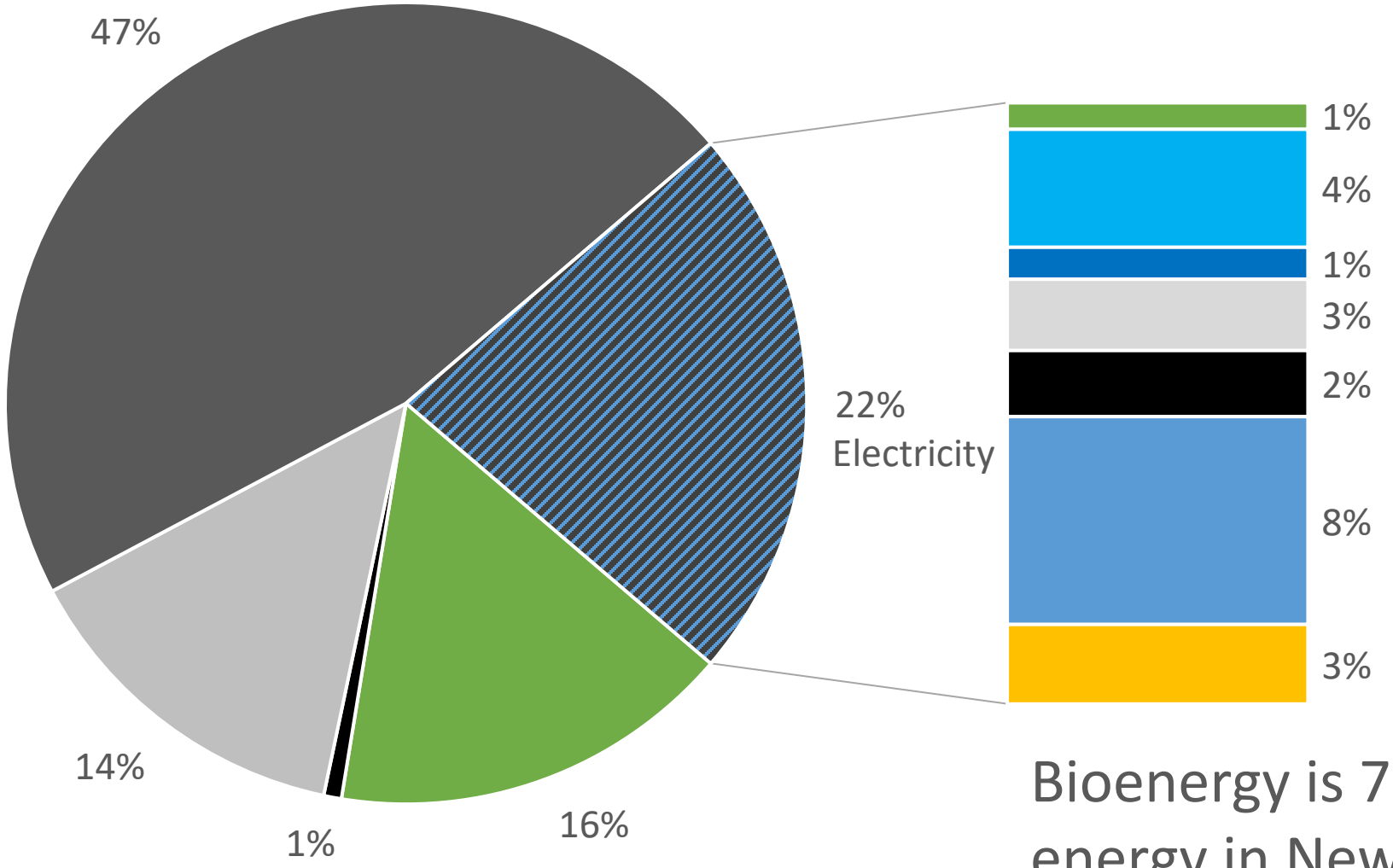
Energy and Emissions in New Brunswick

Energy Demand in New Brunswick, 2021



- **<u>Thermal energy (red shades)</u>** is almost 2/3 of New Brunswick's energy demand
- Electricity is only required for 13% and is 22% of current energy consumption

Energy Consumption in NB, 2021



Bioenergy is 75% of renewable energy in New Brunswick

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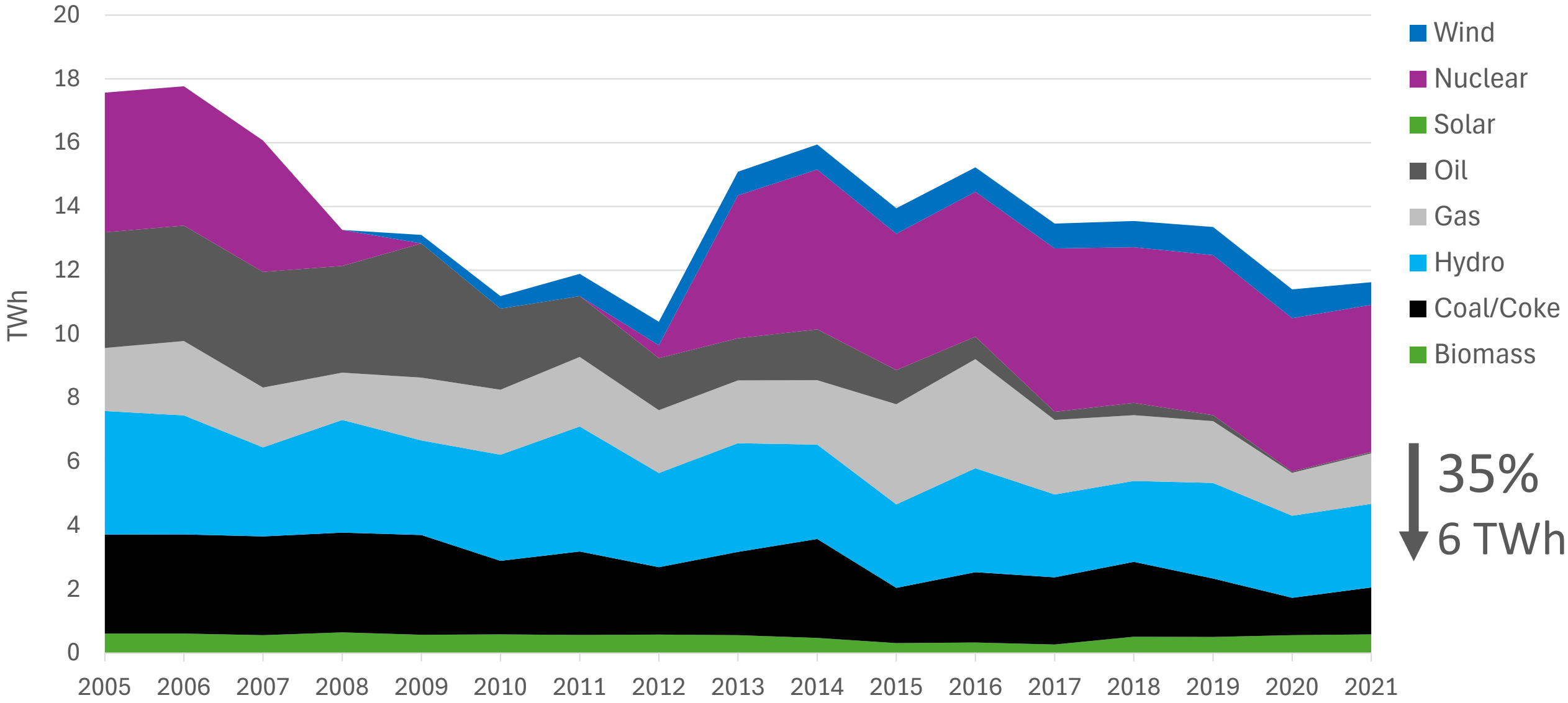
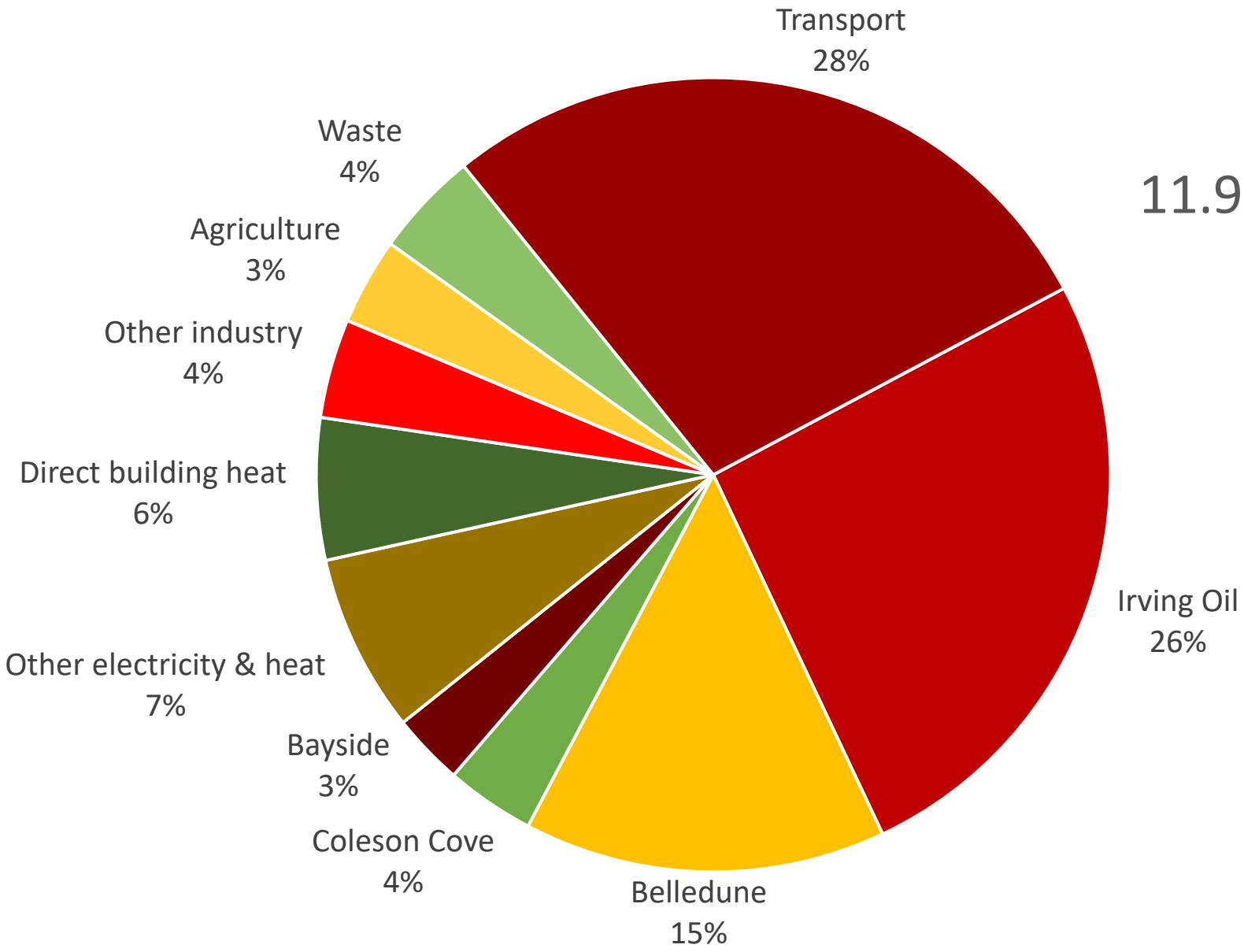
Electricity Generation in NB



New Brunswick GHG Emissions, 2021



11.9 Mt CO_2e

Climate Action = Big Projects

What Happened?

- Electricity generation has dropped by 35% (6 TWh)
- NB has gone from net electricity exporter (+3 TWh) to net importer (-2 TWh)
- Total demand has dropped by 1 TWh, with 2 TWh demand drop by industrial
  - Commercial/institutional and residential rose
- The forest products sector has been the majority of reductions
- Fuel switching from still gas and oil to natural gas
- 'Energy Transition' largely increased imports (QC electricity, US gas) and deindustrialization

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BECCS

Bioenergy with Carbon Capture & Storage

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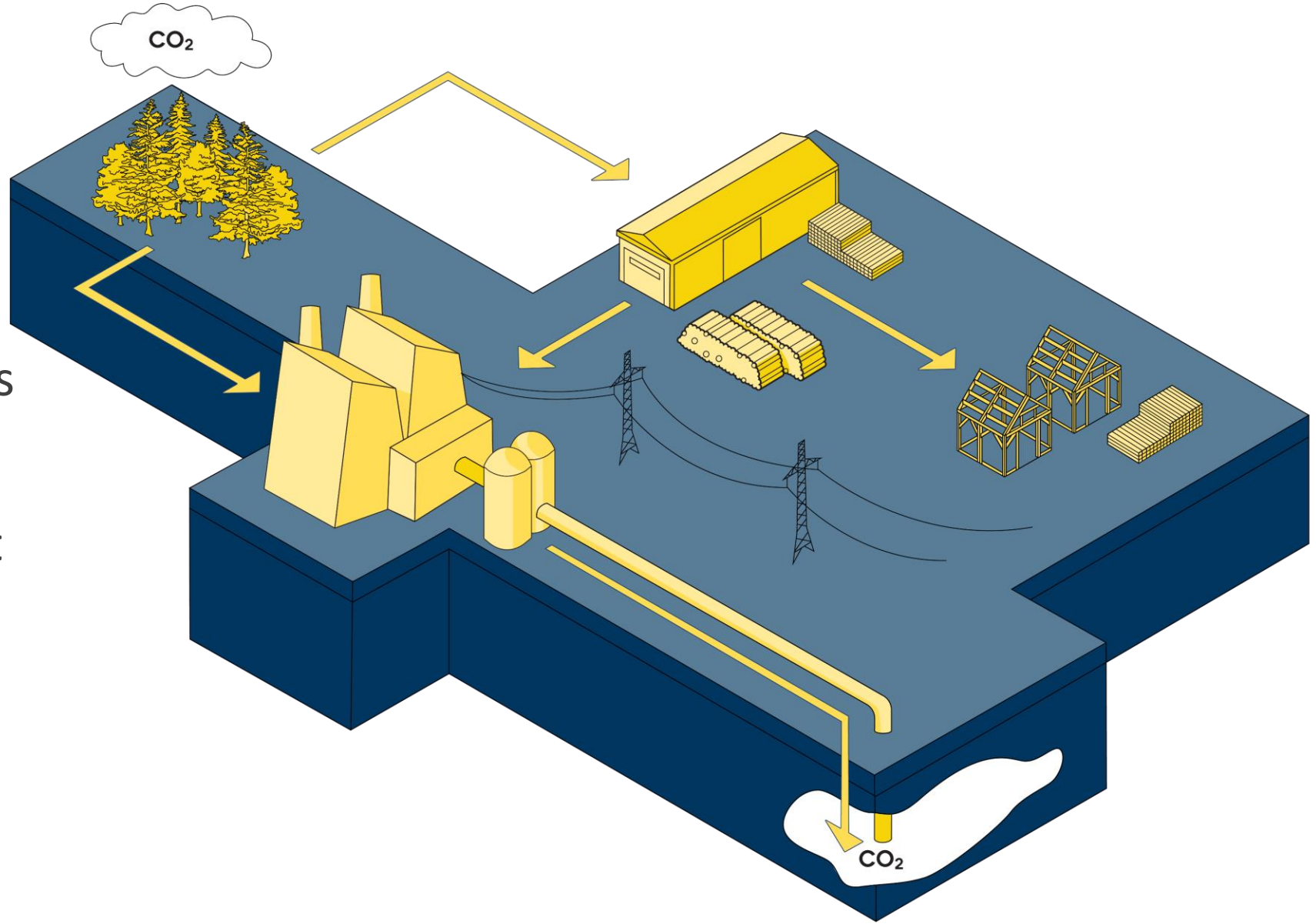
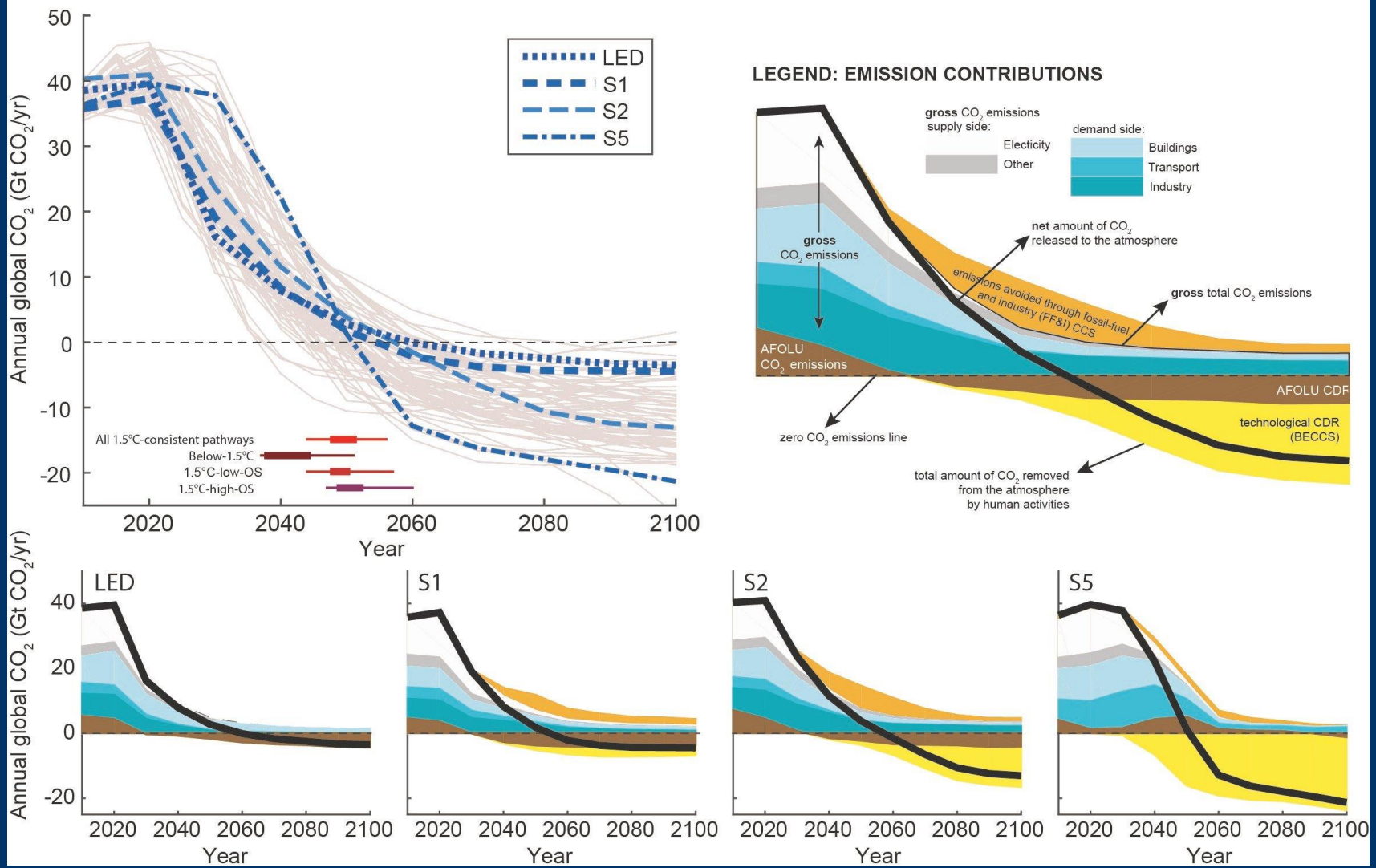
Bioenergy Carbon Capture & Storage

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



BECCS is Required to Meet Climate Goals

IPCC Mitigation Pathways Compatible with 1.5 C



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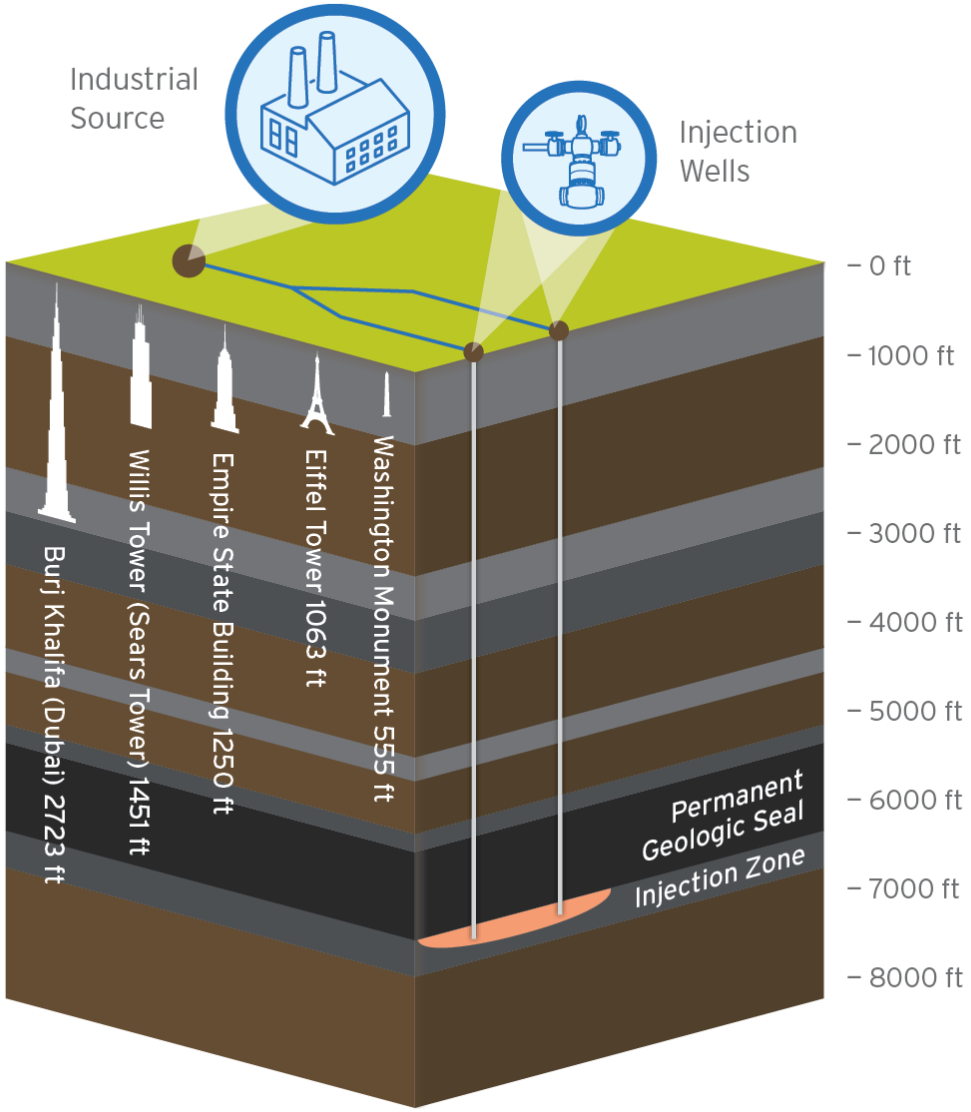
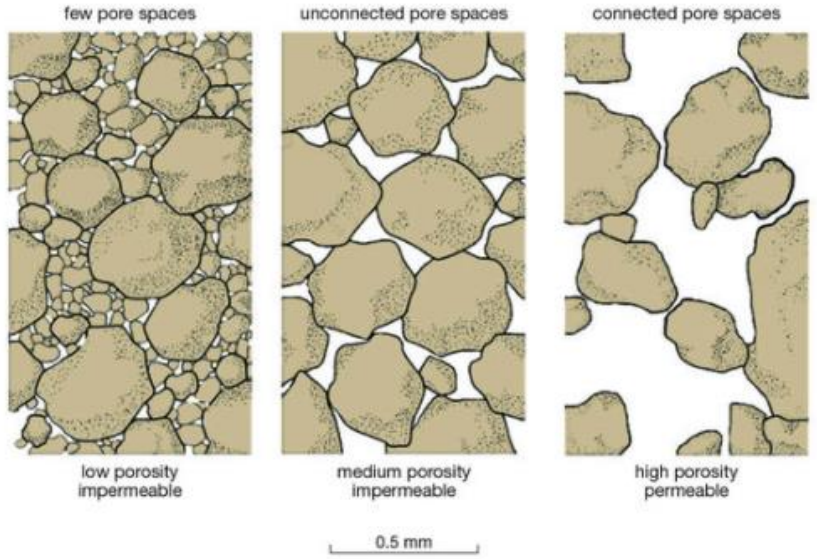
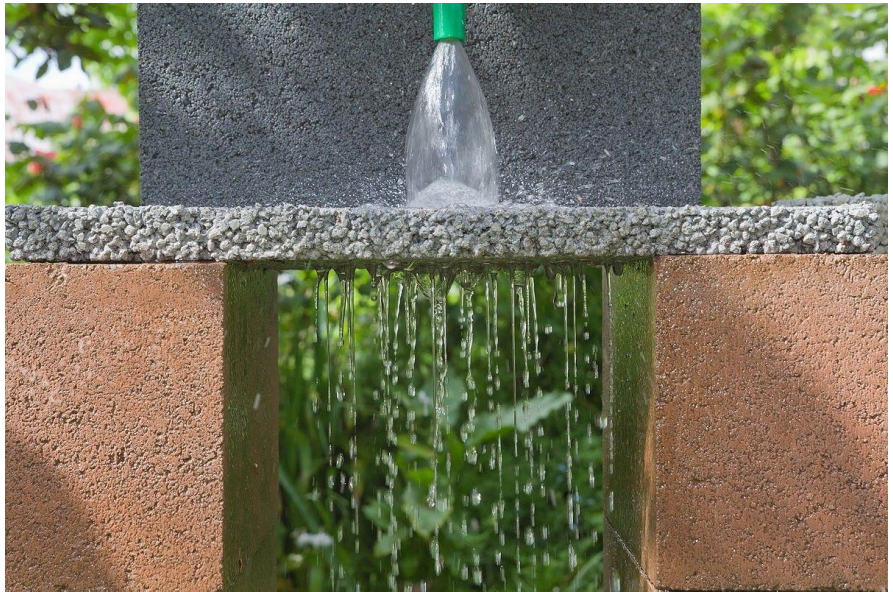
CO_2 Storage



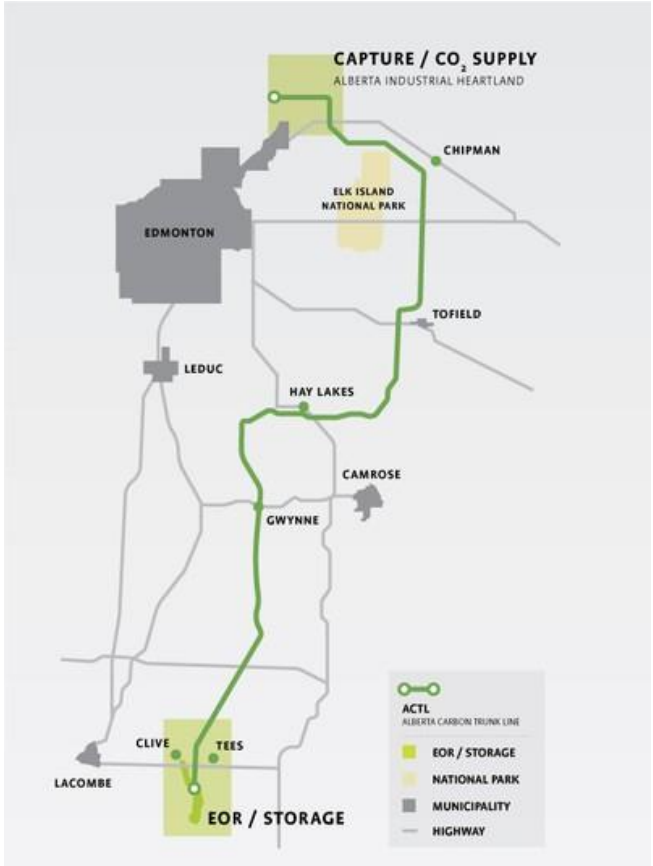




Existing North America CCS Projects

- Canada: Boundary Dam (SK), QUEST (AB), ACTL (AB)
- Boundary Dam and QUEST ~ 1 Mt CO_2/year captured
- QUEST located at Scotford upgrader operated by Shell
  - CapEx of $1 B; permanent storage
- ACTL has capacity of 14.6 Mt CO_2/yr
  - 1.6 Mt CO_2/year currently captured
  - Open access
  - Liquefied CO_2 piped 240 km to Clive, AB
  - Wolf Midstream (CPPIB) is pipeline owner
- Great Plains Synfuels in North Dakota produces natural gas from coal
- 3 Mt CO_2/yr; 40 Mt CO_2 captured to date; used for EOR in Canada
- Largest in the world are Century Plant (Texas; 8.4 Mt CO_2/yr) and Shute Creek (Wyoming; 7 Mt CO_2/yr)

Alberta Carbon Trunk Line



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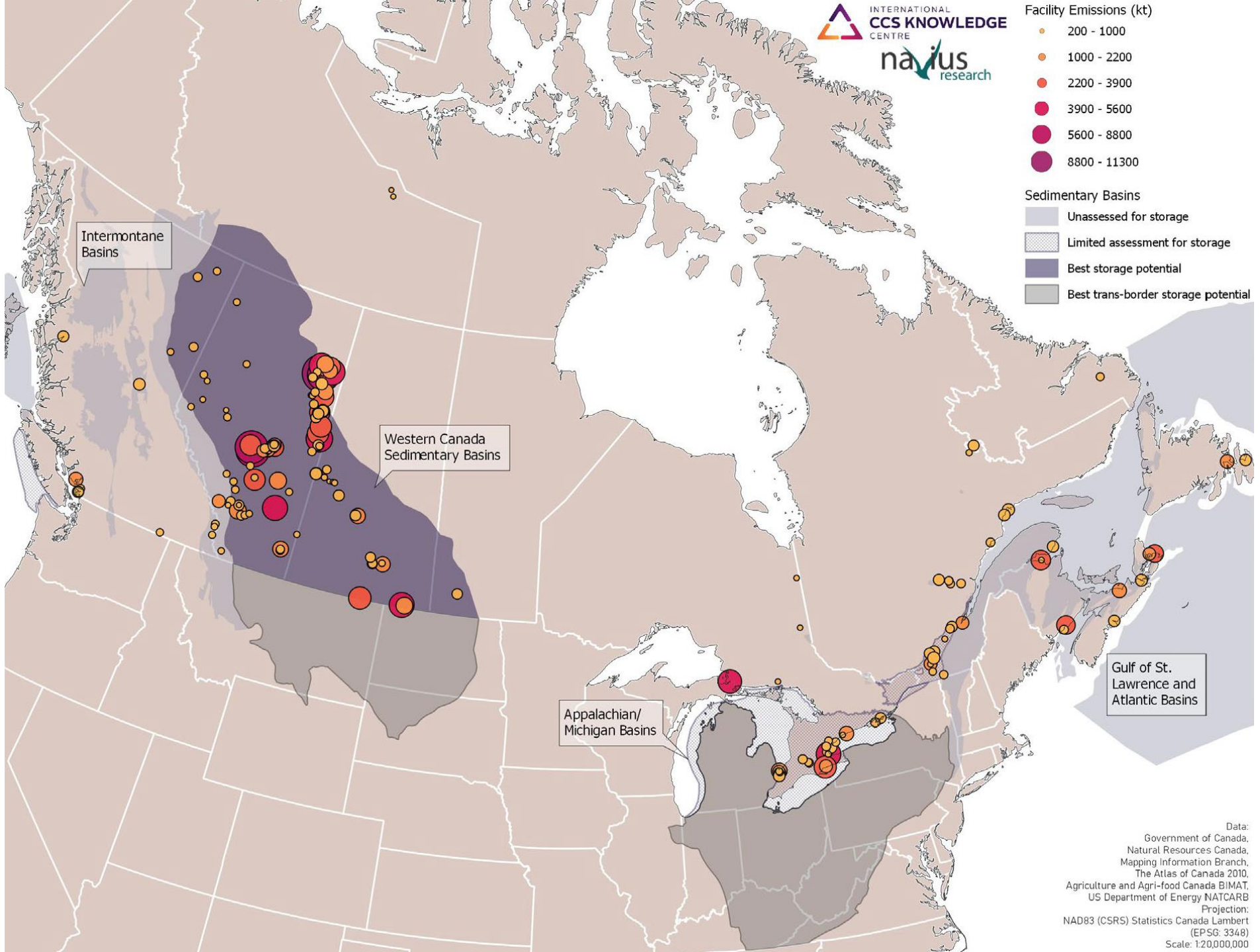
CCS Projects – Existing & Under Development


INTERNATIONAL CCS KNOWLEDGE CENTRE
navius research
Facility Emissions (kt)
200 - 1000
1000 - 2200
2200 - 3900
3900 - 5600
5600 - 8800
8800 - 11300
Sedimentary Basins
Unassessed for storage
Limited assessment for storage
Best storage potential
Best trans-border storage potential
Intermontane Basins
Western Canada Sedimentary Basins
Appalachian/ Michigan Basins
Gulf of St. Lawrence and Atlantic Basins
Data:
Government of Canada,
Natural Resources Canada,
Mapping Information Branch,
The Atlas of Canada 2010,
Agriculture and Agri-food Canada BIMAT,
US Department of Energy NATCARB
Projection:
NAD83 (CSRS) Statistics Canada Lambert
(EPSG: 3348)
Scale: 1:20,000,000

BECCS in Other Countries

Klemetsrud WtE Plant, Norway

- Part of Longship/Northern Lights
- Capture being added to waste-to-energy plant heating Oslo
- Shell Cansolv
- Under construction
- 400 kt CO_2/yr, North Sea storage
- Pilot plant and FEED showed technical viability

Mikawa Biomass Power, Japan

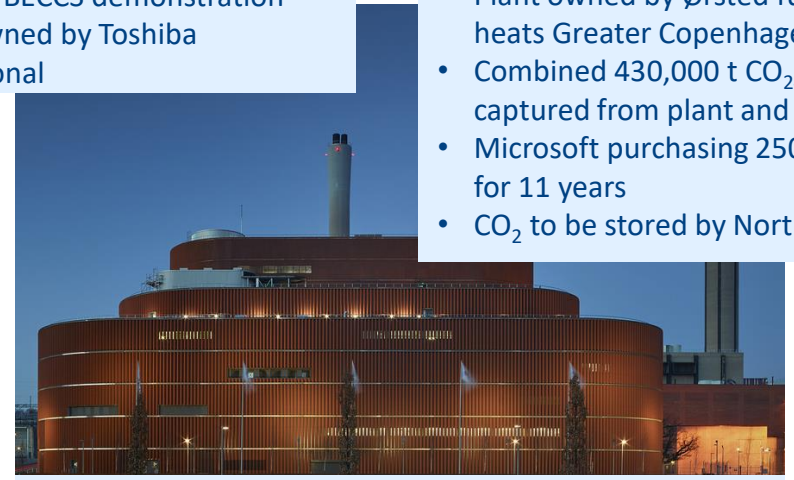
- 50 MW_e BECCS demonstration plant owned by Toshiba
- Operational

Avedøre Biomass Plant, Denmark

- Plant owned by Ørsted fueled by straw heats Greater Copenhagen
- Combined 430,000 t CO_2/yr to be captured from plant and Kalundborg CHP
- Microsoft purchasing 250,000 t CDR/yr for 11 years
- CO_2 to be stored by Northern Lights

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



KVV8 Biomass CHP, Stockholm

- Wood chip-fuelled plant heating Stockholm via district energy system owned by Stockholm Exergi
- Plan to add capture (hot potassium capture by Capsol); pilot plant operated for multiple years
- >$250 M in EU grant funding
- 800 kt CO_2/yr, North Sea storage via Northern Lights
- FEED study complete, 2026 commissioning planned

PT Tanjungenim Lestari Pulp & Paper, ID

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

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

Pulp Mill BECCS in US

- Alabama River Cellulose (Georgia-Pacific)
  - USD 24 M from US DOE for FEED study
  - Lead on capture and storage is Blue Sky Infrastructure (Blackstone)

- Vicksburg Containerboard (International Paper)
  - USD 88 M from US DOE for Demonstration Plant
  - Partners are RTI, Schlumberger, and Amazon

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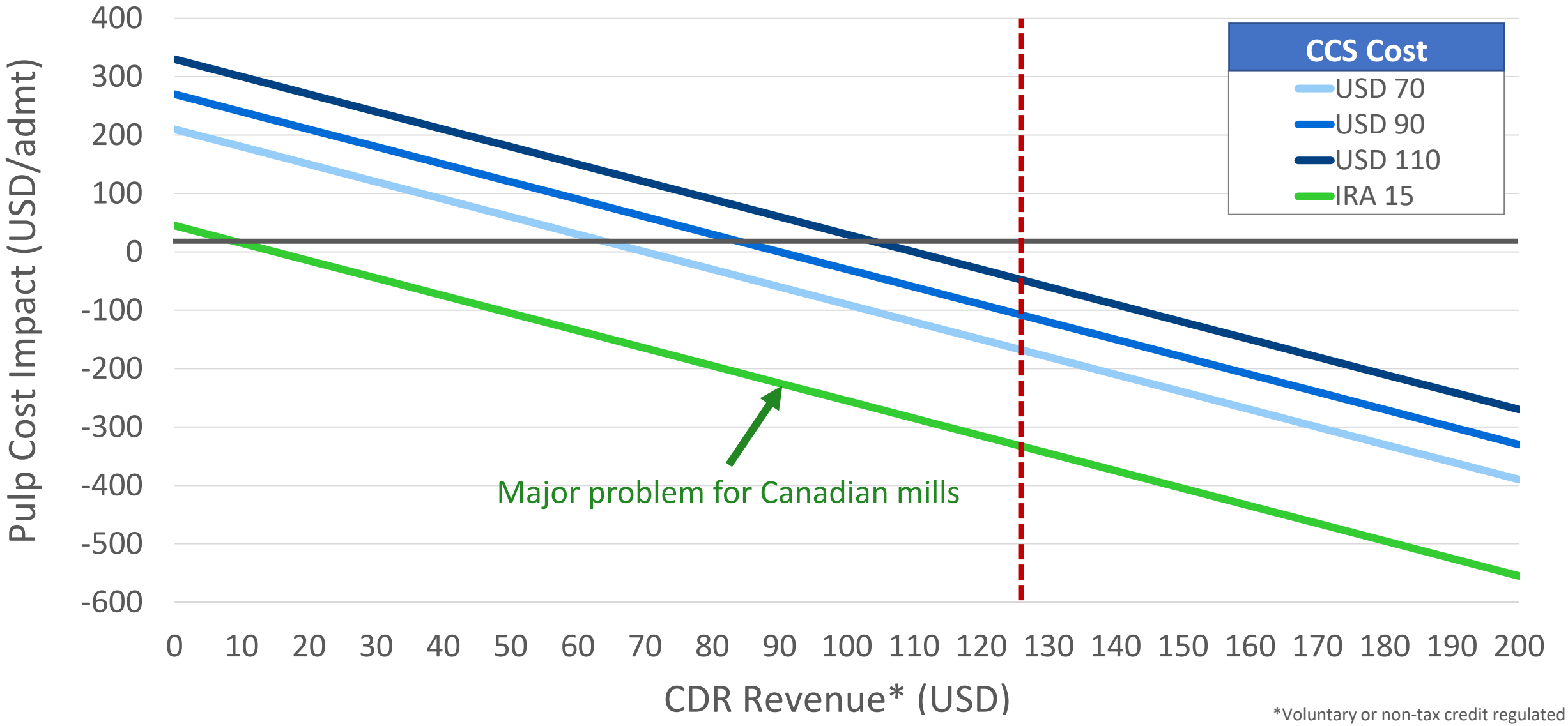
Payment for flue gas will become a competitiveness issue!

$15/t CO_2 x 3 t CO_2/admt = $45/admt

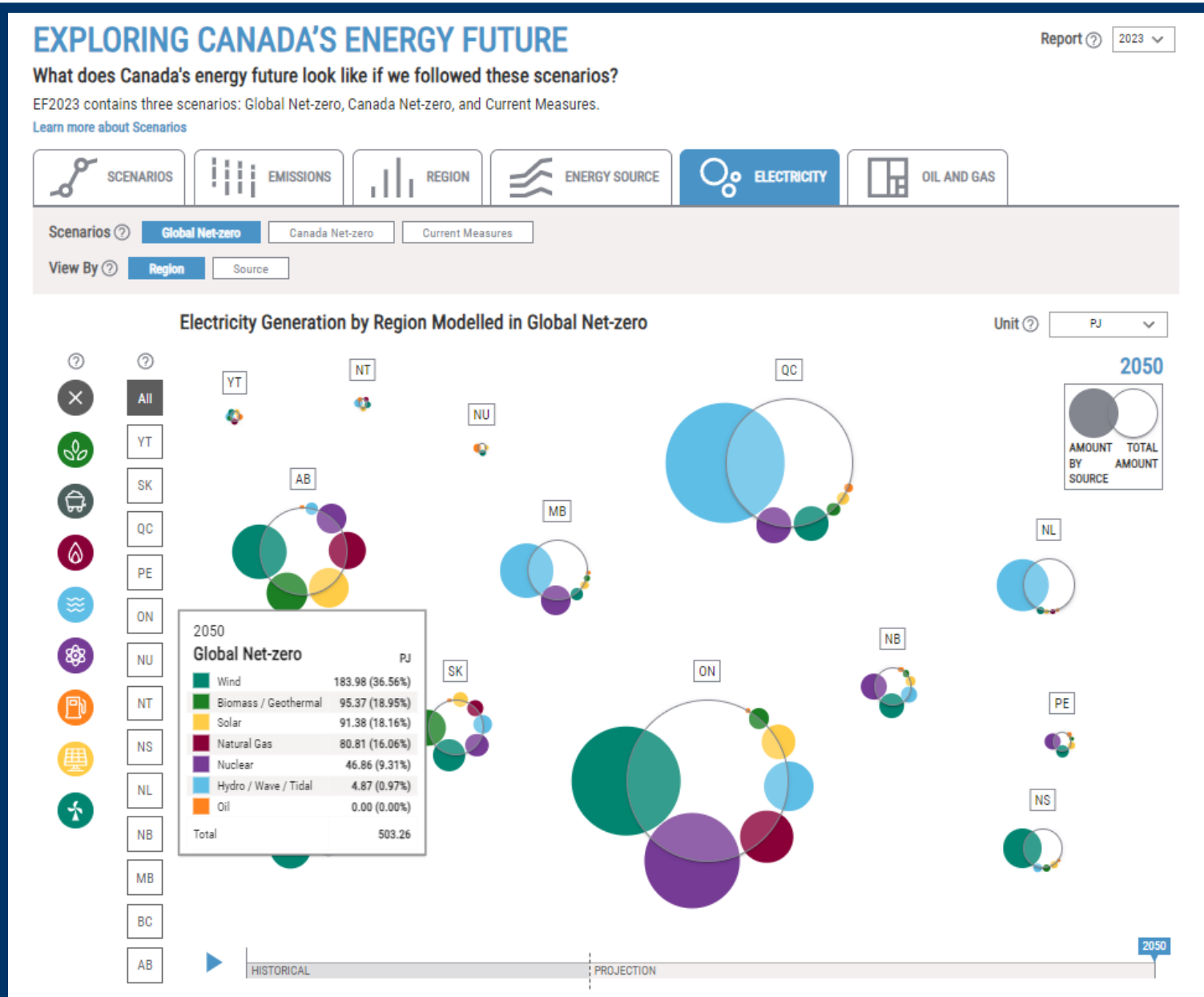
Economics of BECCS at Kraft Mills



*Voluntary or non-tax credit regulated

Canada Energy Regulator

- No Net Zero Grid or energy system without BECCS
- In 2050 Global Net Zero, CER modelled biopower as #1 electricity supply in SK and #2 in AB
- Modelled limit is biomass supply, not cost
- Negative cost electricity

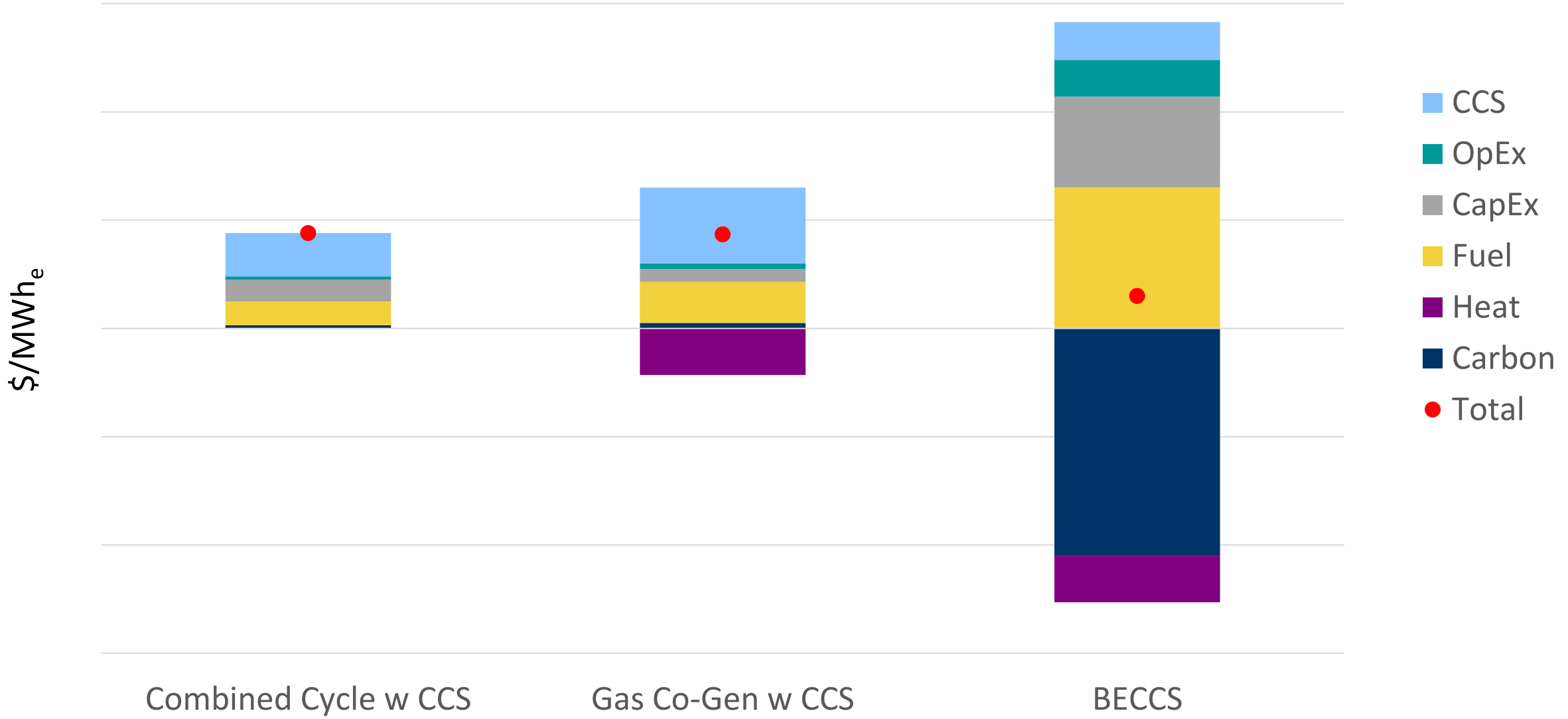


Canada Energy Regulator

"As the carbon price increases, biomass CCS units become a negative cost generation option, where its average cost of production in 2050 is -$85/MWh. Therefore, biomass CCS partially displaces all other generation technologies in Alberta and Saskatchewan."

* Only AB & SK modelled as having CO_2 storage capacity

Multiple Products = Economic Viability



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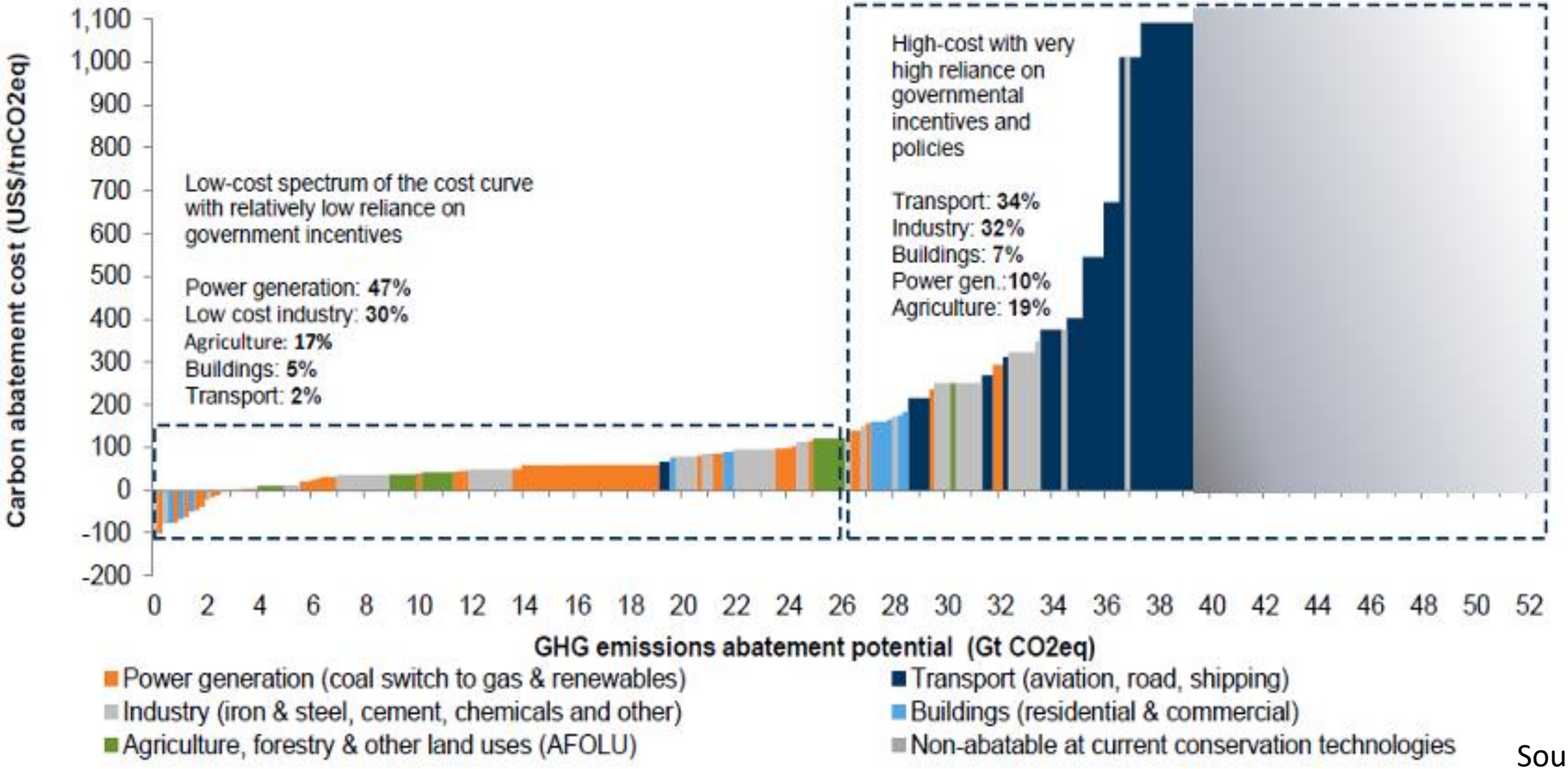
GHG Cost Abatement Curve



Source: GS

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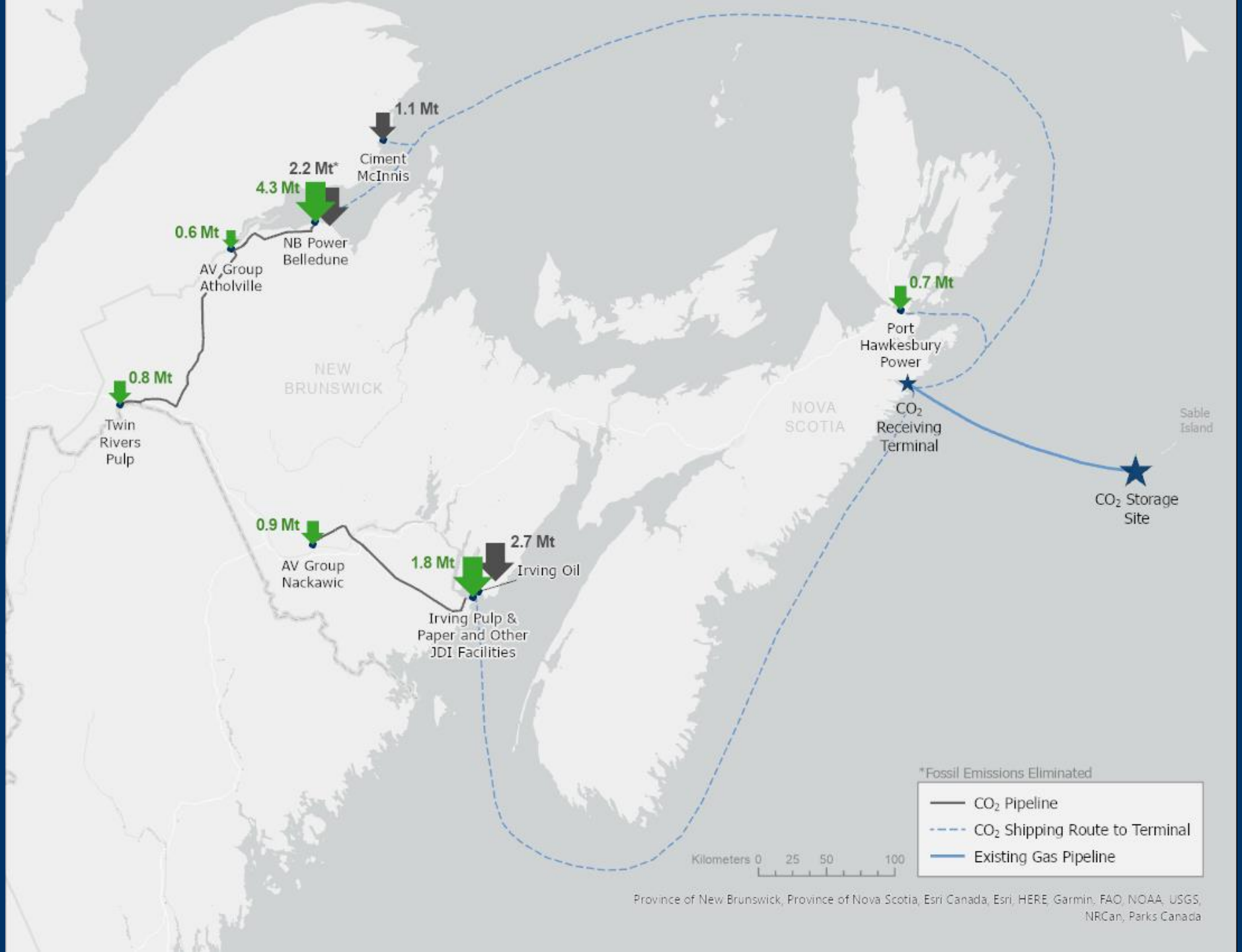
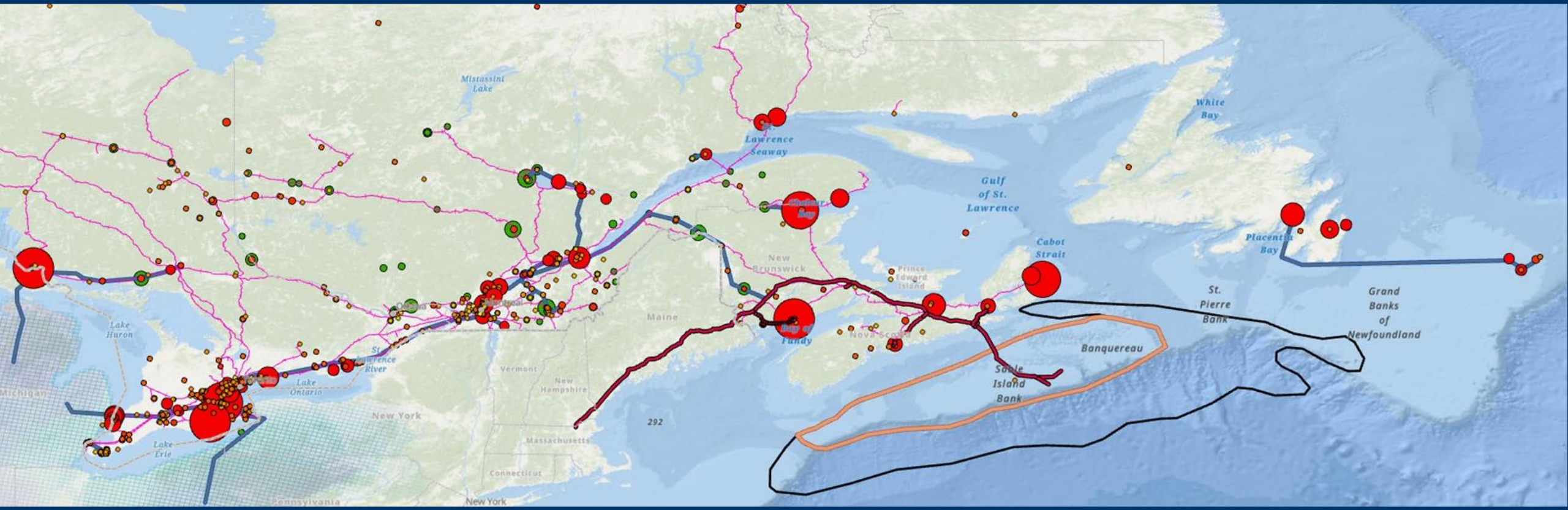
Maritime Carbon

What would BECCS look like in the Maritimes?


1.1 Mt
Ciment McInnis
2.2 Mt*
4.3 Mt
NB Power Belledune
0.6 Mt
AV Group Atholville
0.8 Mt
Twin Rivers Pulp
NEW BRUNSWICK
0.9 Mt
AV Group Nackawic
2.7 Mt
1.8 Mt
Irving Oil
Irving Pulp & Paper and Other JDI Facilities
0.7 Mt
Port Hawkesbury Power
NOVA SCOTIA
CO_2 Receiving Terminal
Sable Island
CO_2 Storage Site
*Fossil Emissions Eliminated
CO_2 Pipeline
CO_2 Shipping Route to Terminal
Existing Gas Pipeline
Kilometers 0 25 50 100
Province of New Brunswick, Province of Nova Scotia, Esri Canada, Esri, HERE, Garmin, FAO, NOAA, USGS, NRCan, Parks Canada

NRCan CO_2 Transport Modelling



Studies for NS DNRR show 100-200 Gt CO_2 of storage potential:

150-300 years of Canada's total emissions at current levels
8,400-16,800 years of New Brunswick's total emissions at current levels

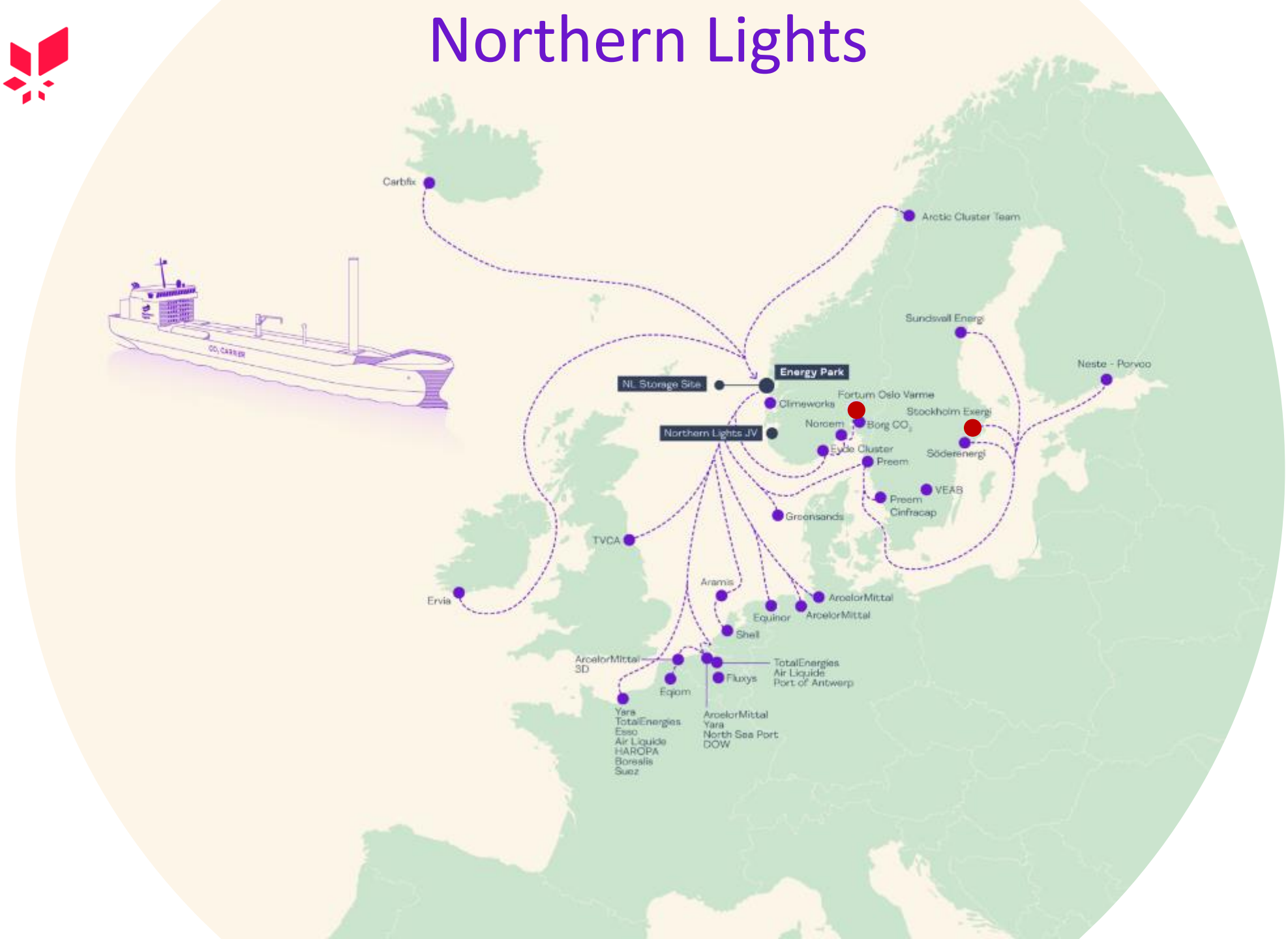
Northern Lights

equinor

Shell

TotalEnergies

C$2.5 B JV



NORTHERN LIGHTS SCOPE

CO_2 capture

Capture from industrial plants.
Liquefaction and temporary storage.

Transport

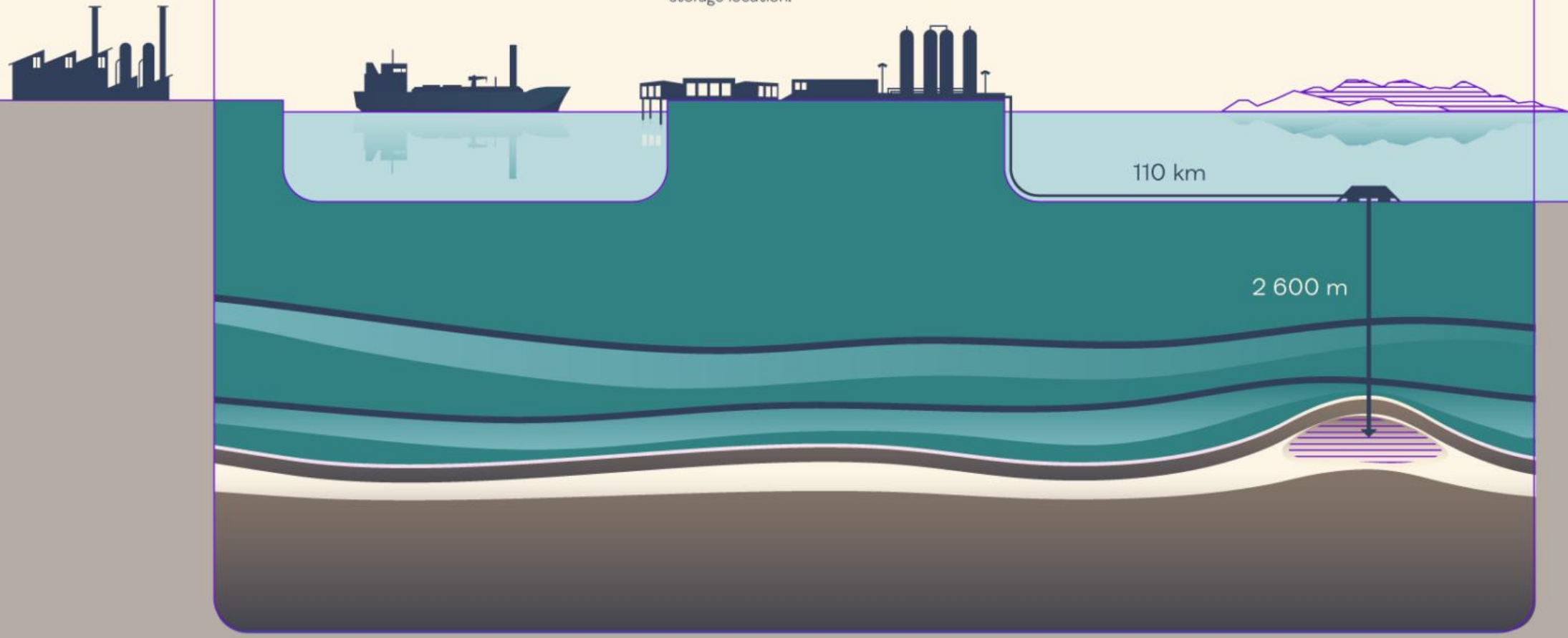
Liquid CO_2
transported by ship.

Receiving terminal

Intermediate onshore storage.
Pipeline transport to offshore
storage location.

Permanent storage

CO_2 is injected into a saline aquifer.

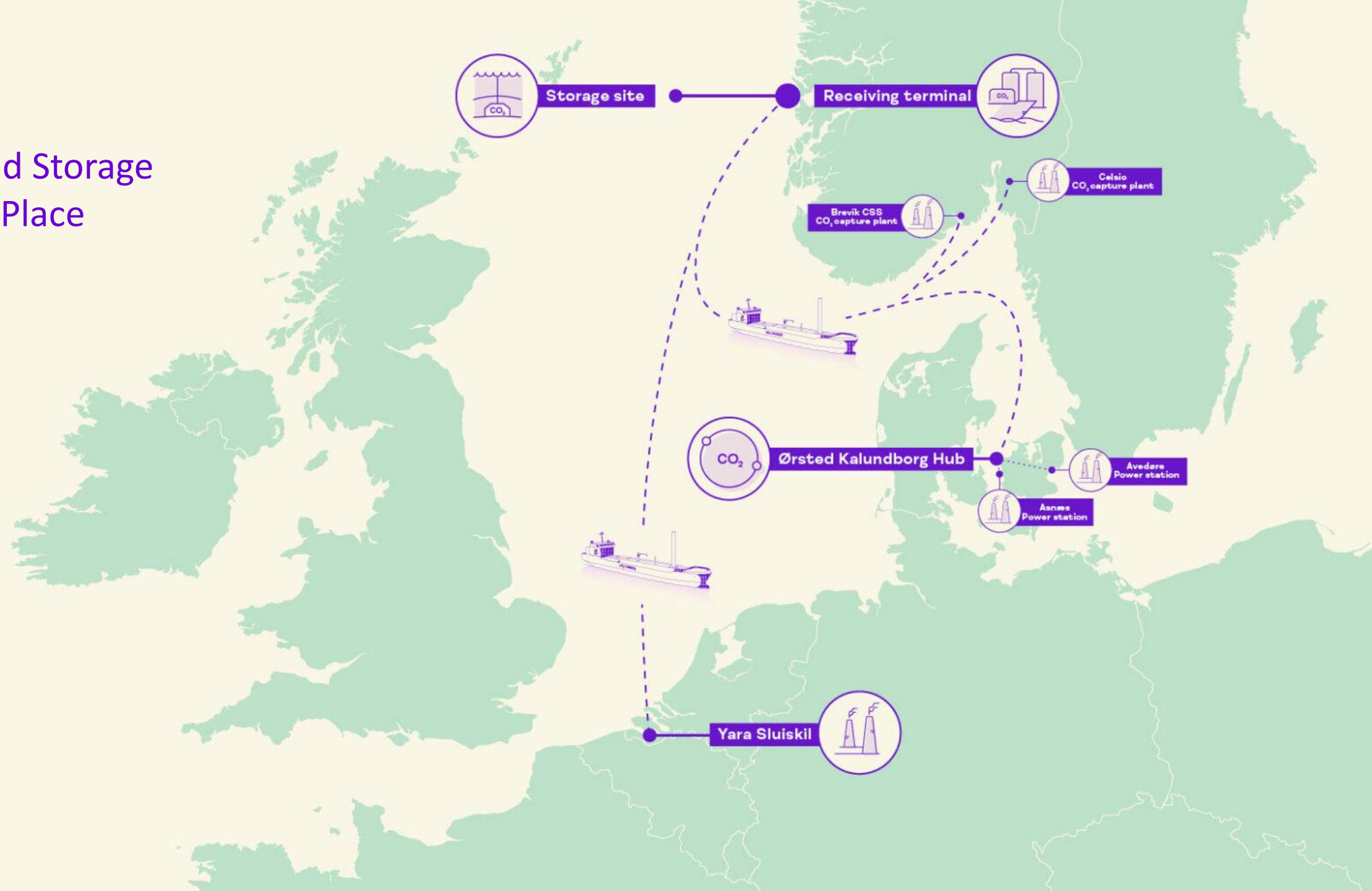



LCO_2 CARRIER

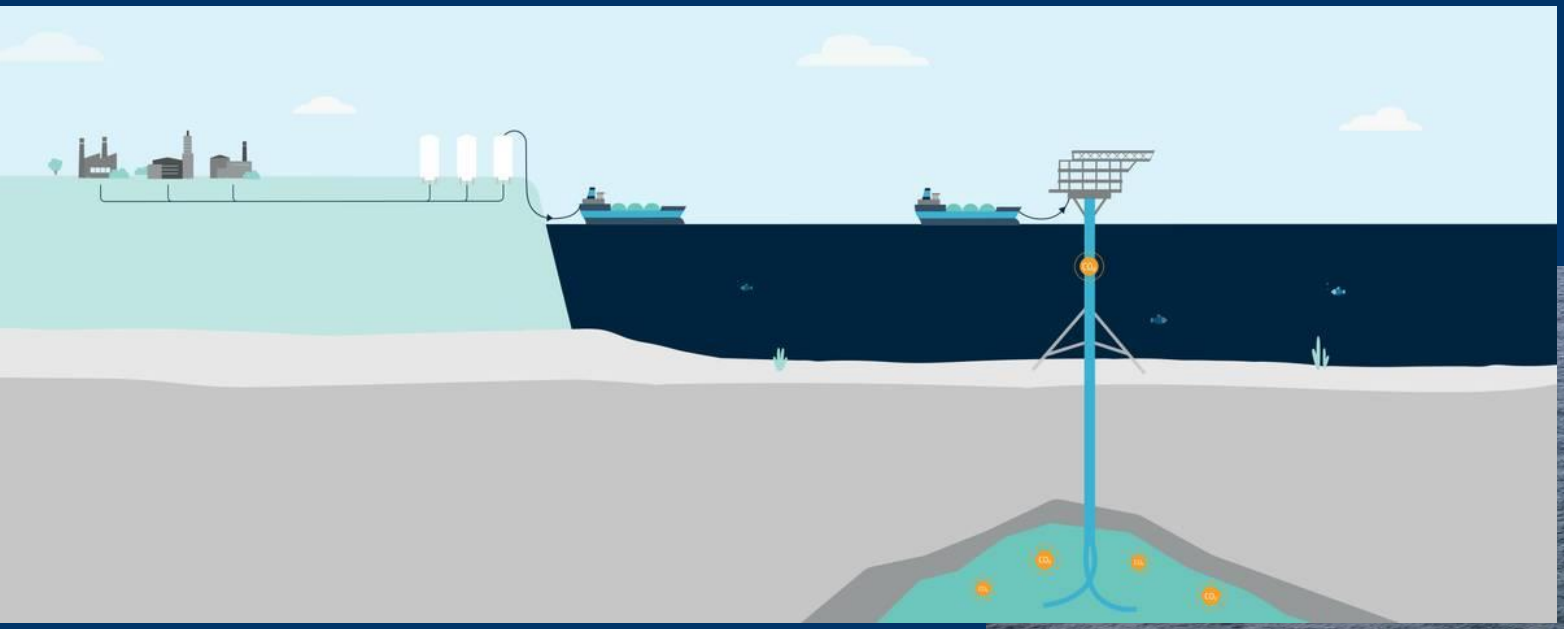
Four L-CO_2 carriers under construction

Northern Lights

Transport and Storage Contracts in Place



Greensand, Denmark



- Wintershall Dea (BASF) and INEOS
- First intercountry CO_2 transport & storage
- Planned 8 Mt CO_2/yr

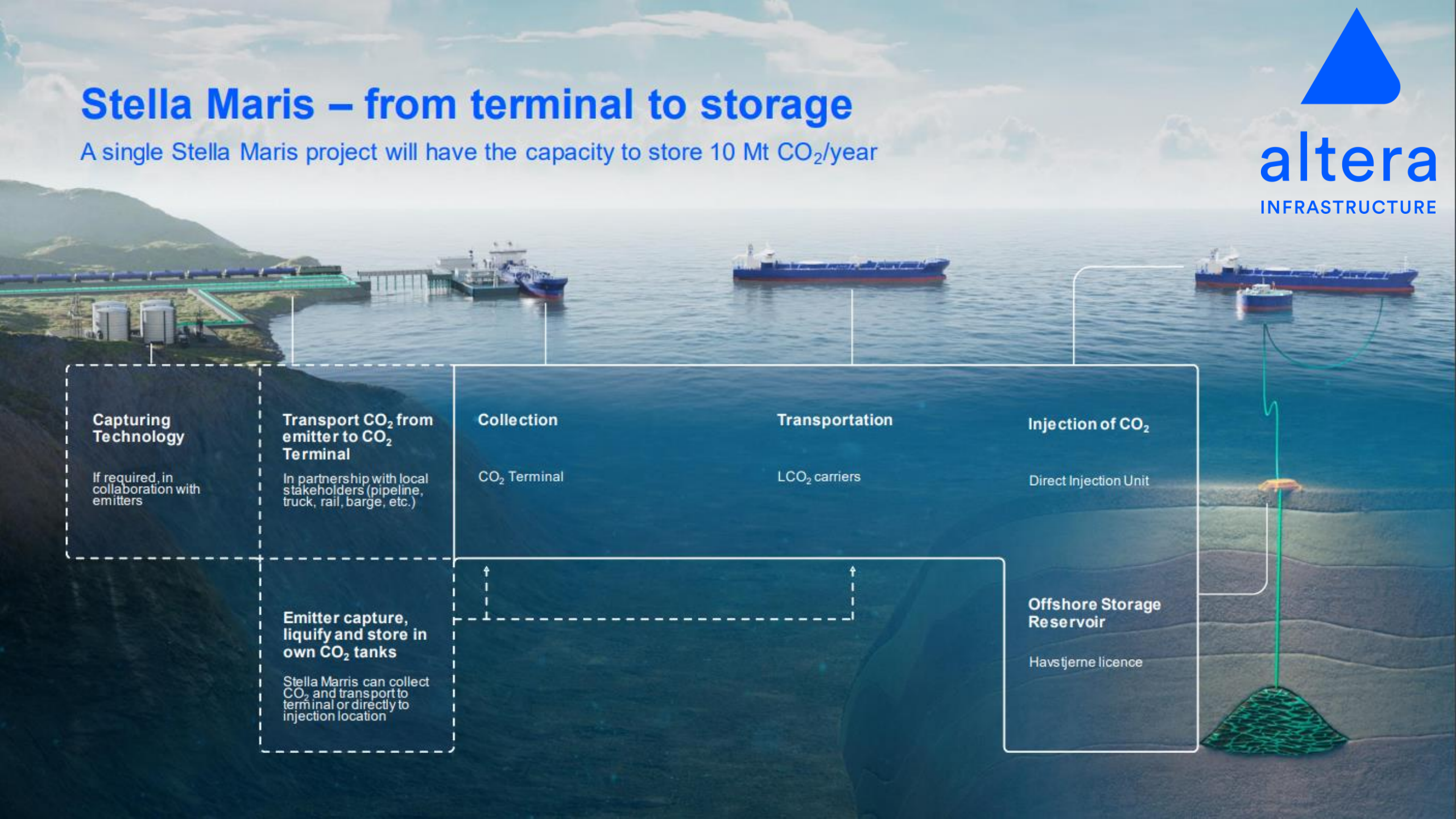
- Offshore CO_2 receiving with no pipeline
- Altera Infrastructure (Brookfield) developing similar project: Stella Maris


Stella Maris CCS
altera
INFRASTRUCTURE

Stella Maris – from terminal to storage

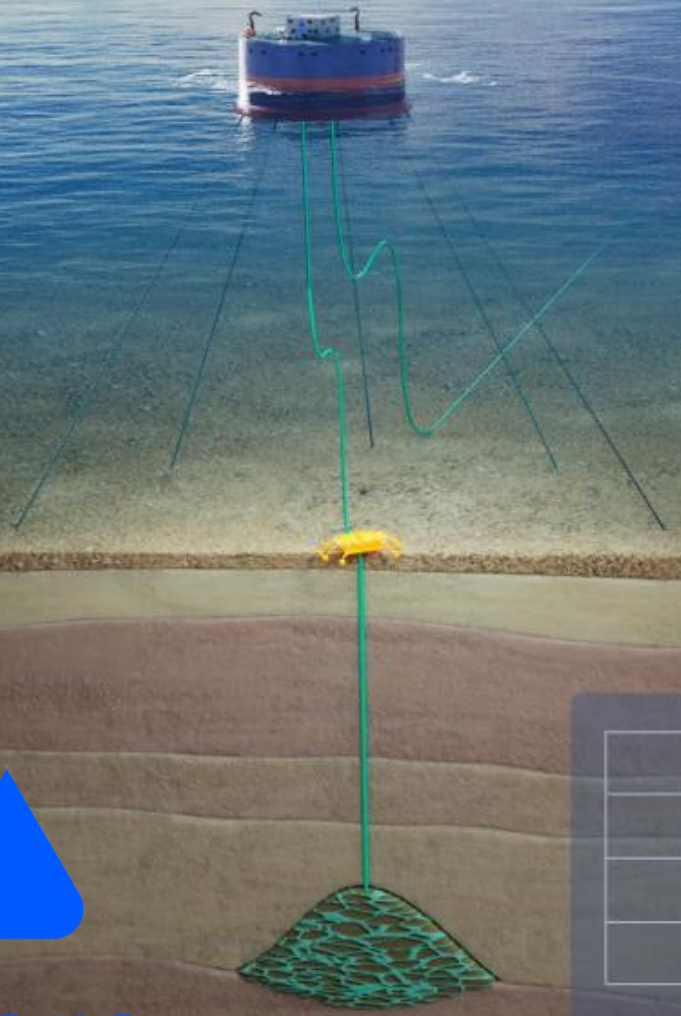
A single Stella Maris project will have the capacity to store 10 Mt CO_2/year

altera INFRASTRUCTURE



Direct Injection Unit (DIU)

Offshore Injection and Storage



Alternatives

- Injection facilities on an existing offshore installation or on new fixed offshore structure
- Direct injection from LCO_2 carrier

Principal dimensions:

Hull diameter	50m
Bilge Box diameter	62m
Main Deck diameter	50m
Hull depth	22m
Design draft	13m
Draft loaded	14m

- Allows continuous injection
- Heating and injection modules below deck
- Power from LCO_2 carrier (+ battery back-up)
- Unmanned and operations from shore
- CO_2 heated and injected into reservoir in dense phase (>5°C & 65–160 barg)

Key Innovations:

Power from LCO_2 Carrier

Normally Unmanned

Equipment for offshore loading of CO_2

Zero emission capable

Remote operation from shore

altera
INFRASTRUCTURE

Net Zero NB with Six Projects

NB 2021 GHG Emissions = 11.9 Mt CO_2e

Emitter	Volume
Irving Oil CCS	-2.7
Belledune Fuel Switch	-1.5 to -2.2
Belledune BECCS	-4.3
Irving P&P BECCS	-1.8
AV Nackawic BECCS	-0.9
AV Atholville BECCS	-0.6
Twin Rivers BECCS	-0.8
Total	-12.6 to -13.3

BECCS @ Belledune reduces NB GHG emissions by 50%

Maritime Carbon Impacts

Energy transition creates economic growth and exports

Does not force early abandonment of energy assets

Net Zero grid with unabated gas generation for peaking, ensuring reliability and affordability

CDRs can increase profitability of NB's largest exports:

1. Refined petroleum products – Lower (or zero) CI products
2. Forest products – Income from flue gas
3. Net Zero Lobster?! 🙂

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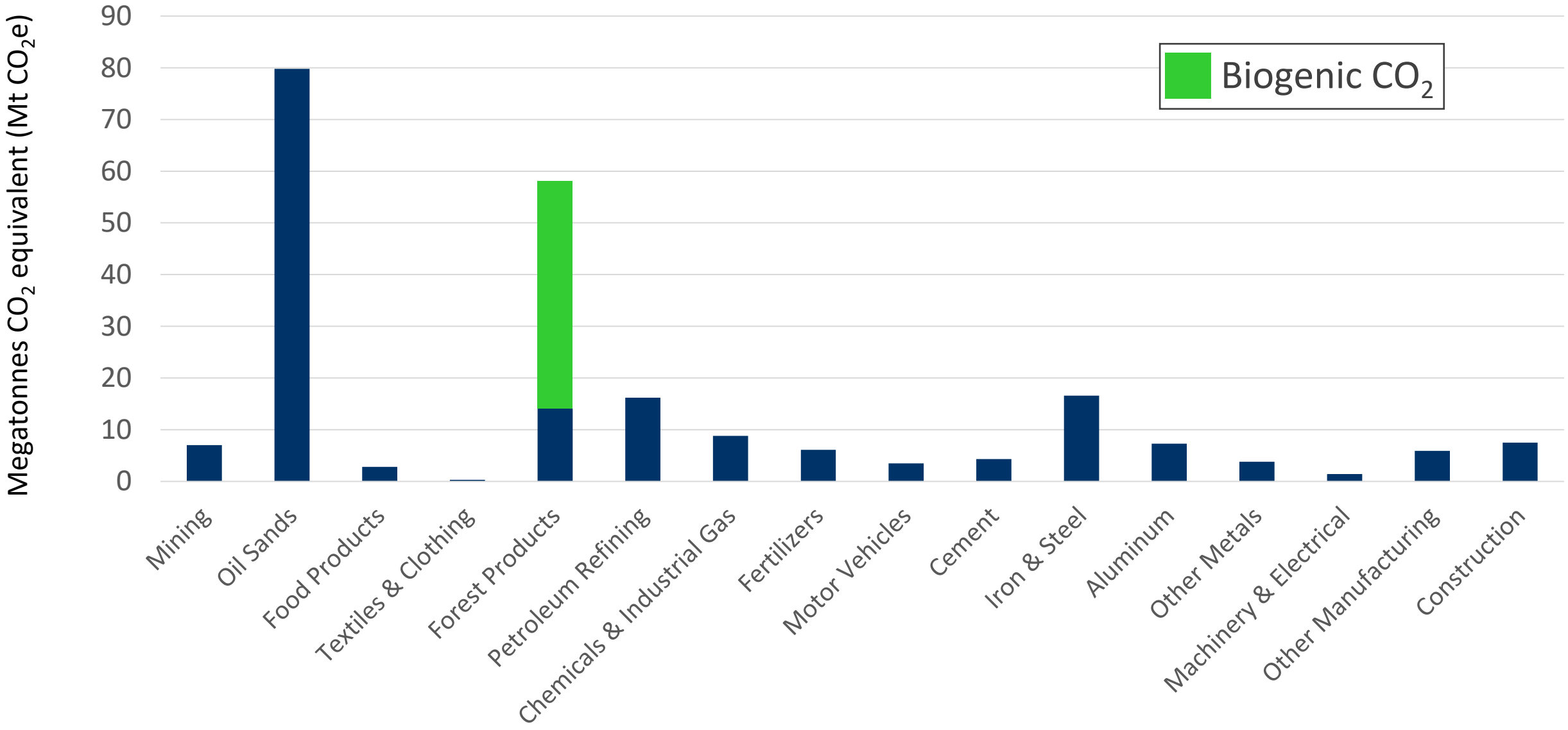
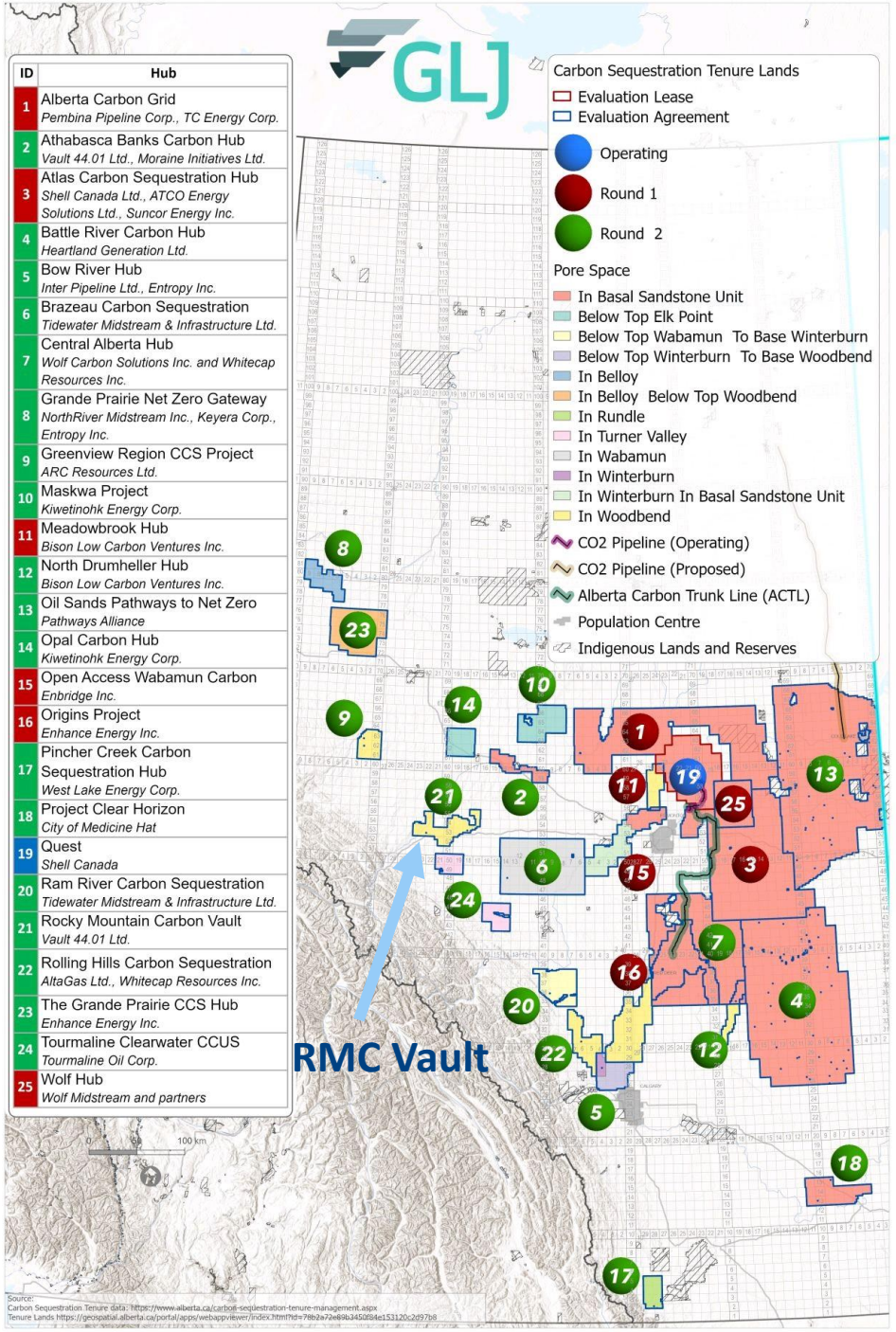
Industrial CO_2 Emissions



- 1.5 Mt CO_2/yr of carbon dioxide removals (CDRs)
- Hinton Pulp – acquired by Mondi from West Fraser
- $21 M FEED study funded by governments & partners
- CO_2 storage rights Alberta secured – RMC Vault
- Commercial capture, compression, storage technology
- $1.5 B CapEx
- CDR monetization via TIER
- www.rockymountaincarbon.com


GLJ
ID
Hub
1 Alberta Carbon Grid
Pembina Pipeline Corp., TC Energy Corp.
2 Athabasca Banks Carbon Hub
Vault 44.01 Ltd., Moraine Initiatives Ltd.
3 Atlas Carbon Sequestration Hub
Shell Canada Ltd., ATCO Energy Solutions Ltd., Suncor Energy Inc.
4 Battle River Carbon Hub
Heartland Generation Ltd.
5 Bow River Hub
Inter Pipeline Ltd., Entropy Inc.
6 Brazeau Carbon Sequestration
Tidewater Midstream & Infrastructure Ltd.
7 Central Alberta Hub
Wolf Carbon Solutions Inc. and Whitecap Resources Inc.
8 Grande Prairie Net Zero Gateway
NorthRiver Midstream Inc., Keyera Corp., Entropy Inc.
9 Greenview Region CCS Project
ARC Resources Ltd.
10 Maskwa Project
Kiwetinohk Energy Corp.
11 Meadowbrook Hub
Bison Low Carbon Ventures Inc.
12 North Drumheller Hub
Bison Low Carbon Ventures Inc.
13 Oil Sands Pathways to Net Zero
Pathways Alliance
14 Opal Carbon Hub
Kiwetinohk Energy Corp.
15 Open Access Wabamun Carbon
Enbridge Inc.
16 Origins Project
Enhance Energy Inc.
17 Pincher Creek Carbon Sequestration Hub
West Lake Energy Corp.
18 Project Clear Horizon
City of Medicine Hat
19 Quest
Shell Canada
20 Ram River Carbon Sequestration
Tidewater Midstream & Infrastructure Ltd.
21 Rocky Mountain Carbon Vault
Vault 44.01 Ltd.
22 Rolling Hills Carbon Sequestration
AltaGas Ltd., Whitecap Resources Inc.
23 The Grande Prairie CCS Hub
Enhance Energy Inc.
24 Tourmaline Clearwater CCUS
Tourmaline Oil Corp.
25 Wolf Hub
Wolf Midstream and partners
Carbon Sequestration Tenure Lands
Evaluation Lease
Evaluation Agreement
Operating
Round 1
Round 2
Pore Space
In Basal Sandstone Unit
Below Top Elk Point
Below Top Wabamun To Base Winterburn
Below Top Winterburn To Base Woodbend
In Belloy
In Belloy Below Top Woodbend
In Rundle
In Turner Valley
In Wabamun
In Winterburn
In Winterburn In Basal Sandstone Unit
In Woodbend
CO2 Pipeline (Operating)
CO2 Pipeline (Proposed)
Alberta Carbon Trunk Line (ACTL)
Population Centre
Indigenous Lands and Reserves
RMC Vault
100 km
Source:
Carbon Sequestration Tenure data: https://www.alberta.ca/carbon-sequestration-tenure-management.aspx
Tenure Lands https://geospatial.alberta.ca/portal/apps/webappviewer/index.html?id=78b2a72e89b3450f84e153120c2d97b8

Making Ideas Real

1. Industry-government consortium on advancing Maritime Carbon
2. Offshore CO_2 storage, shipping, and trade regulations – CNSOPB
   - US, Norway, Denmark, UK, Indonesia, Australia are far ahead
3. Government funding for FEED studies
   - Monetization path is too uncertain for pure private endeavour
4. Government of Canada CDR monetization policy
   - Reverse auctions, reverse carbon tax. Someone has to pay the piper.
5. Access to international compliance markets: EU, UK, Japan, Korea
6. Where will the fibre come from? Climate Smart Forestry

Take to Hospitality

New Brunswick can be Net Zero with six projects

BECCS generates CDRS for Export

Not considering negative emissions results in false conclusions

BECCS CDRs are lower cost than reducing emissions for many sources

Sale of CDRs LOWERS the Net Cost of Primary Products (Pulp, Electricity)

This is economy-transforming infrastructure and requires government and industry to collaborate, rather than just penalize and regulate

Only the Forest Products Sector can deliver Net Zero for New Brunswick

Six Projects to Get There

TorchLight Bioresources

Jamie Stephen, PhD
Managing Director
TorchLight Bioresources
JStephen@TLBio.com