Local (Bio)Energy

The Foundation for Economic Success and Export Growth

TORCHLIGHT

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A New World

Canada cannot achieve its economic and environmental goals without a different forest bioenergy approach.

The approach will differ by region. Depends upon two realities:

- The availability, source, and price of natural gas
- CO_2 storage geology

Wildfire risk, energy prices, and exports will drive decisions

Local energy, national & provincial policy

Realities

Trade Tariffs & Duties (*Not beautiful*)

Government Spending Priorities (Defence, Health, etc.)

Debt, Debt, and More Debt

A Climate of Climate Uncertainty

Polarized Politics

Rising Unemployment

Electricity System Capacity Pressures

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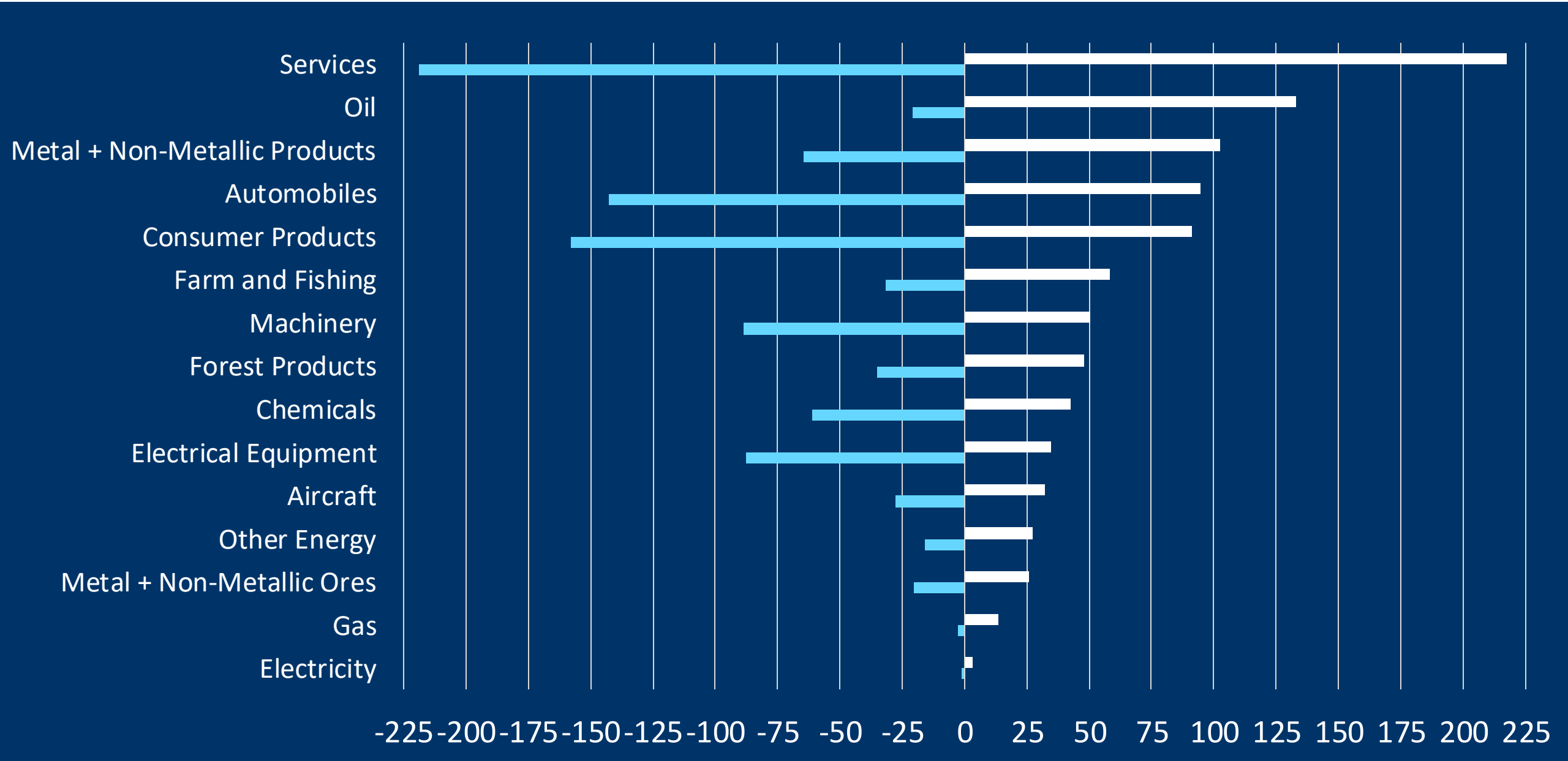
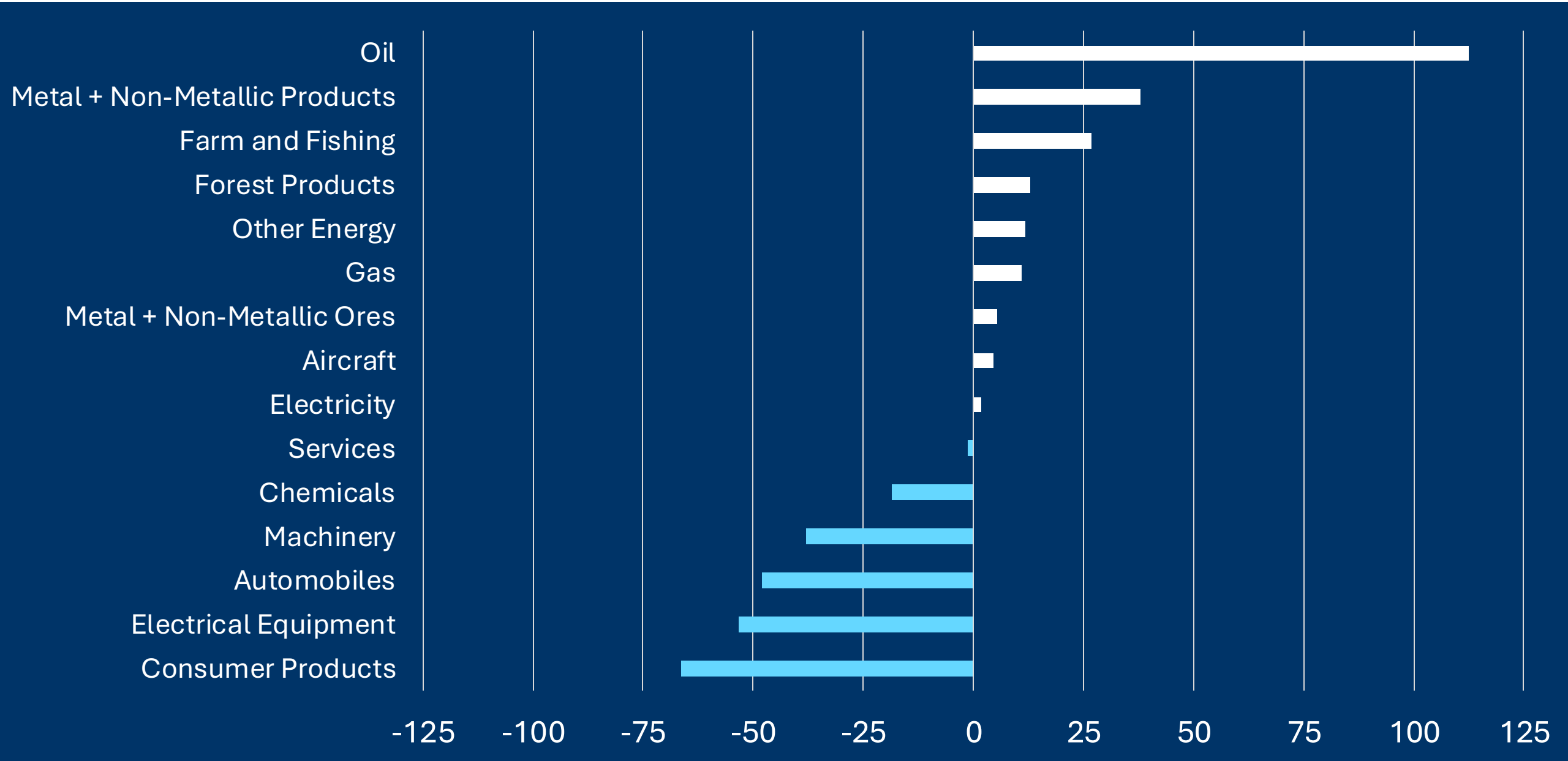
How can local forest bioenergy address national imperatives?

TorchLight Bioresources

Trade in Canada, 2004 (C$ B)



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



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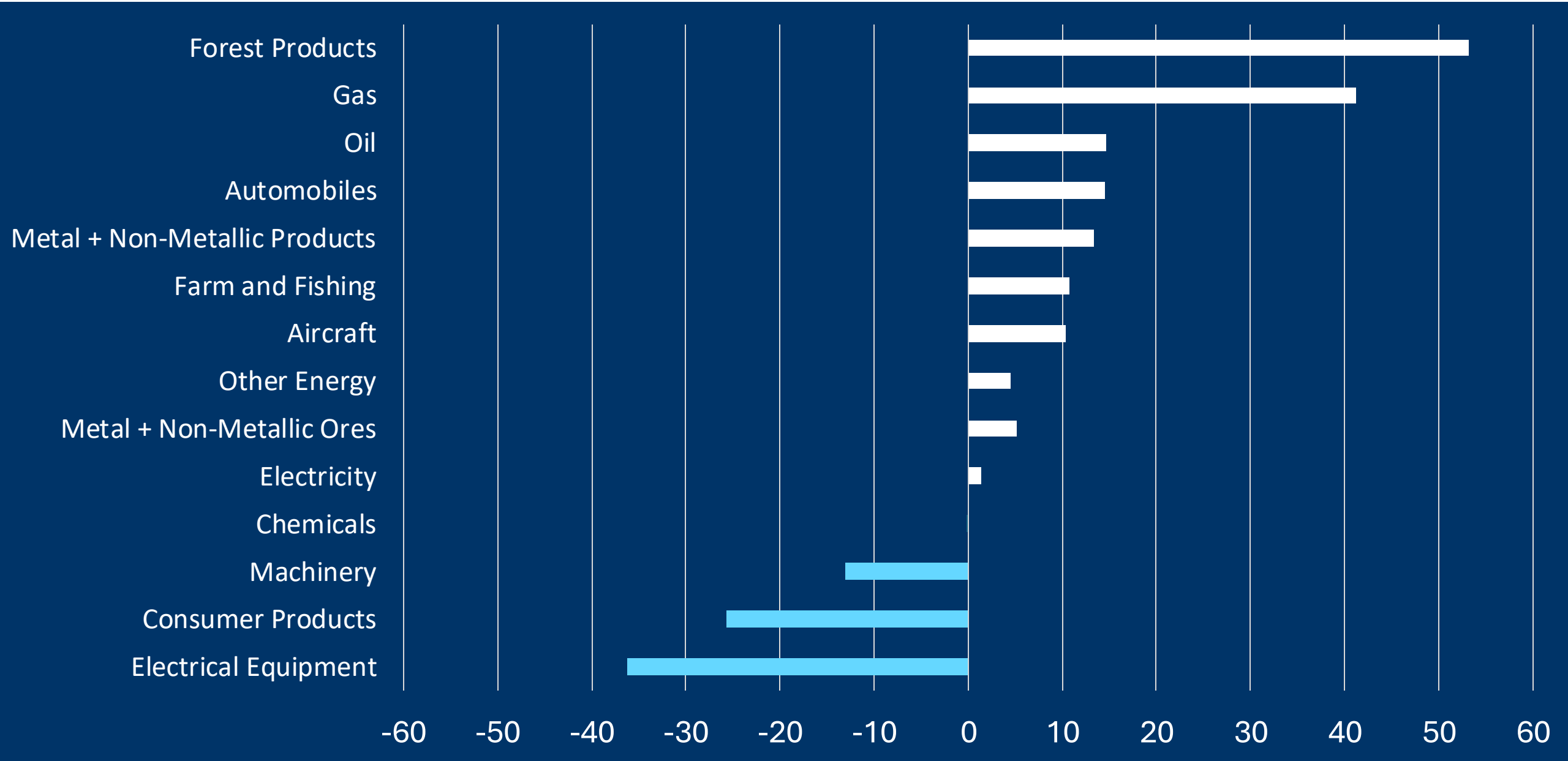
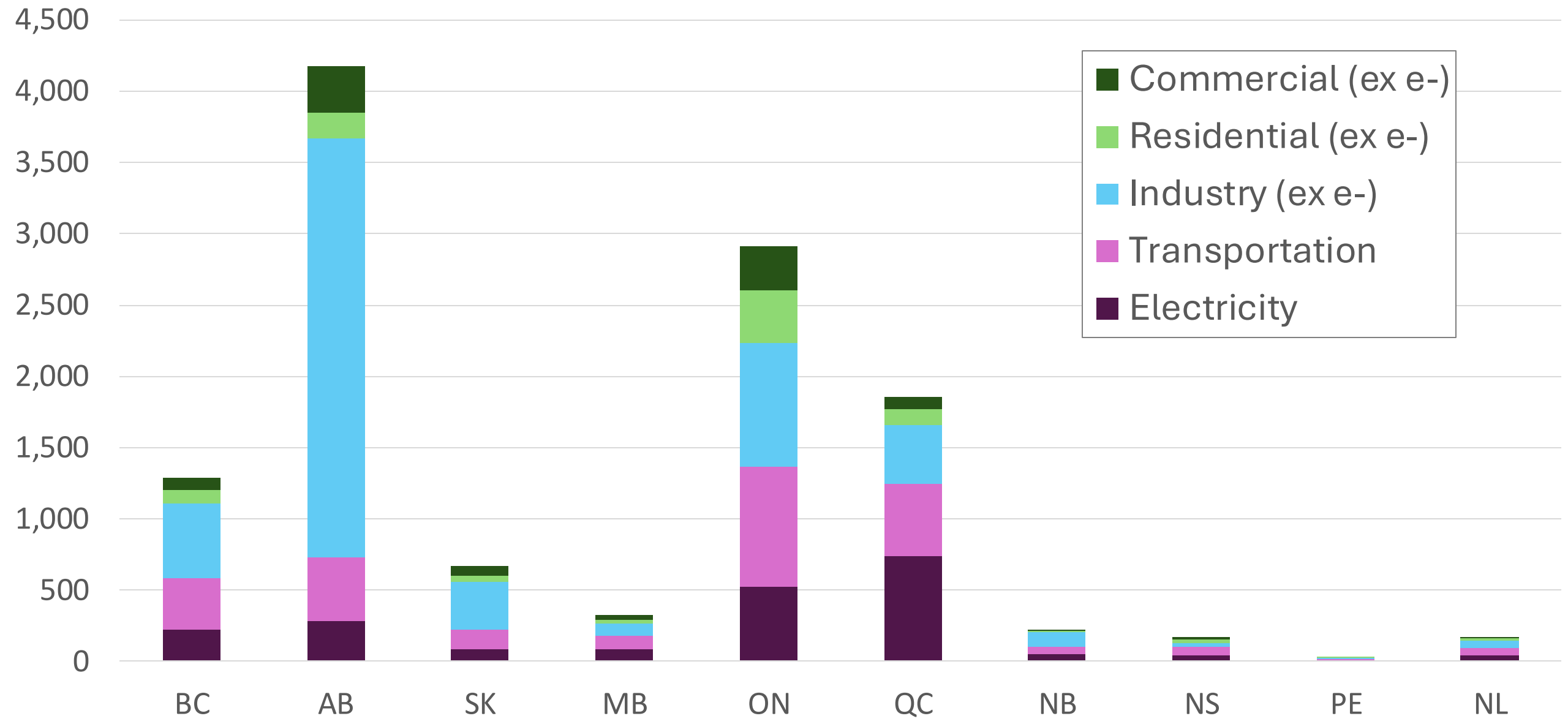


Canada Energy Consumption, 2022 (PJ)



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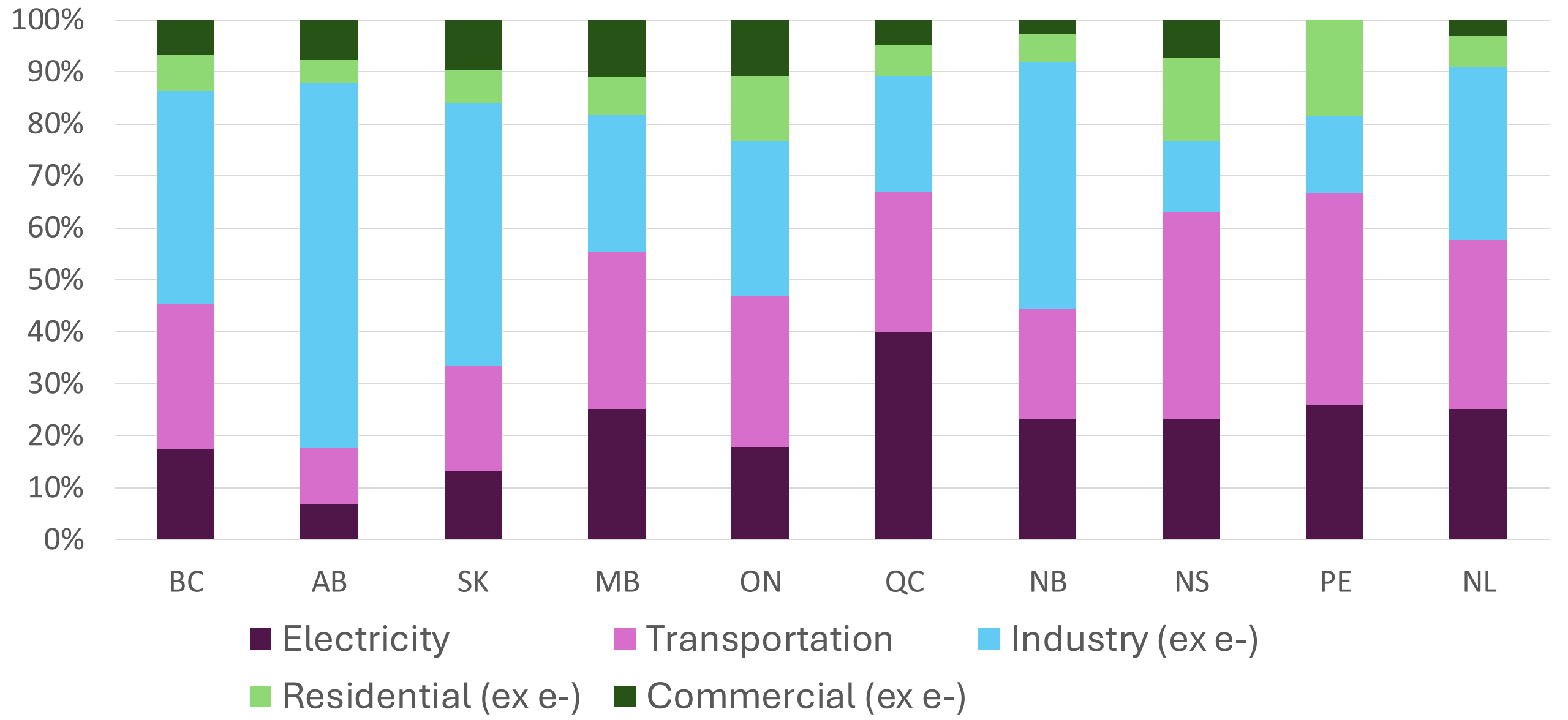
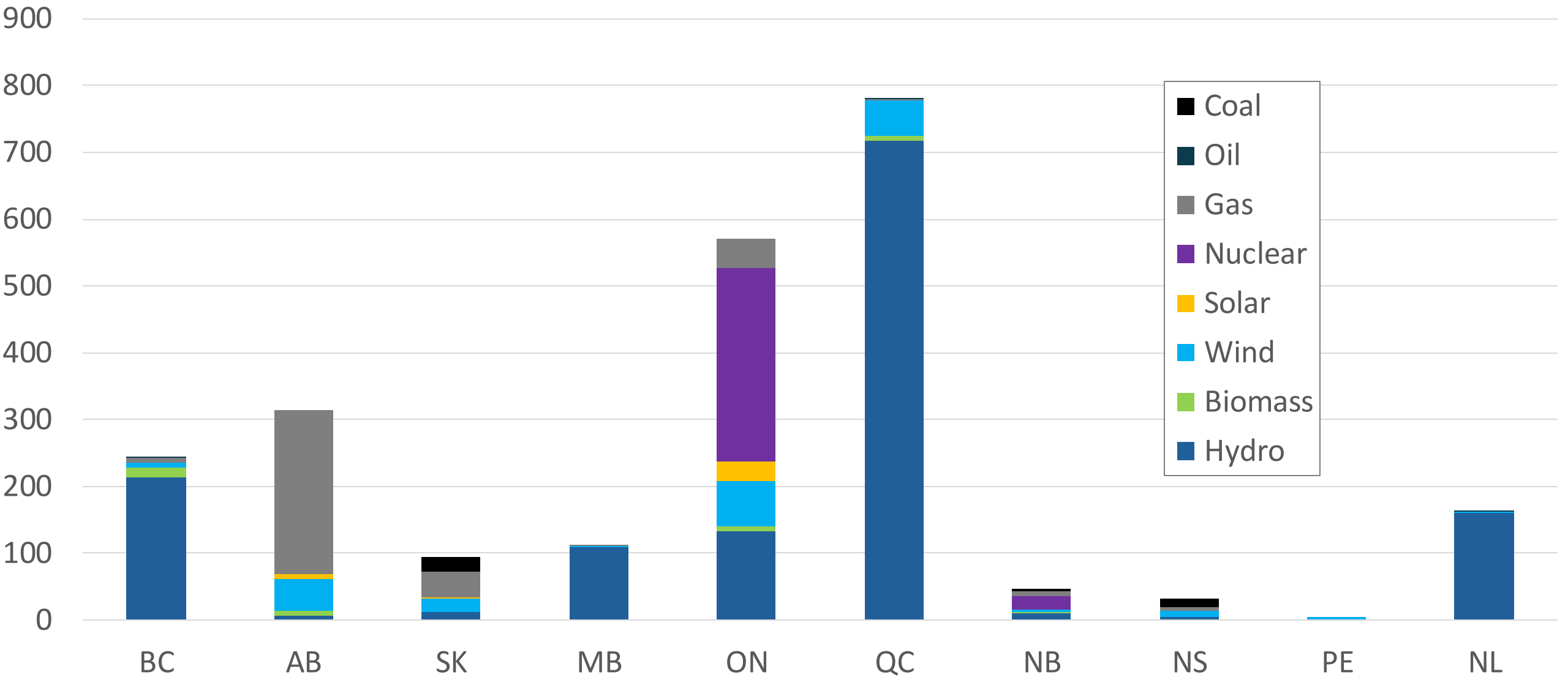


“Canada’s” Electricity Generation, 2024 (PJ)



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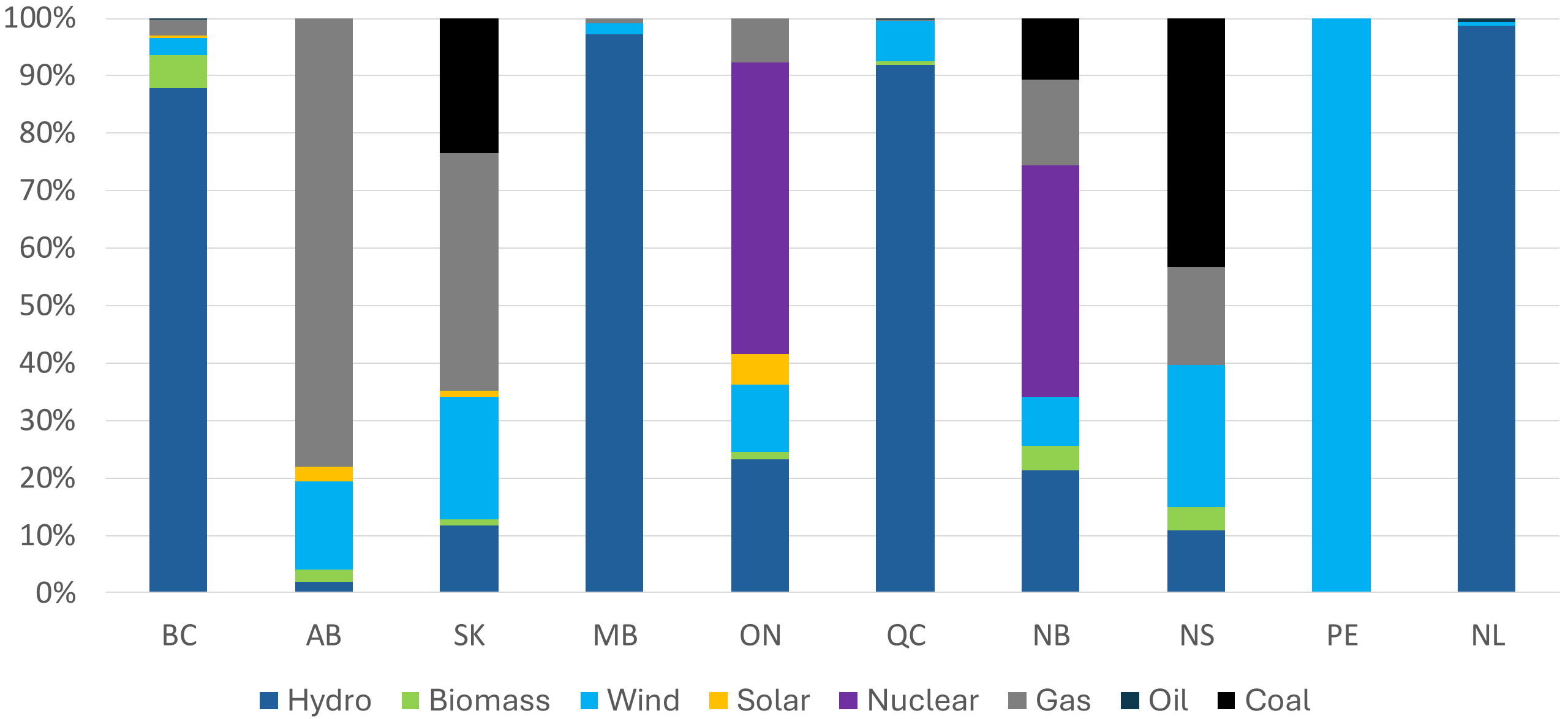
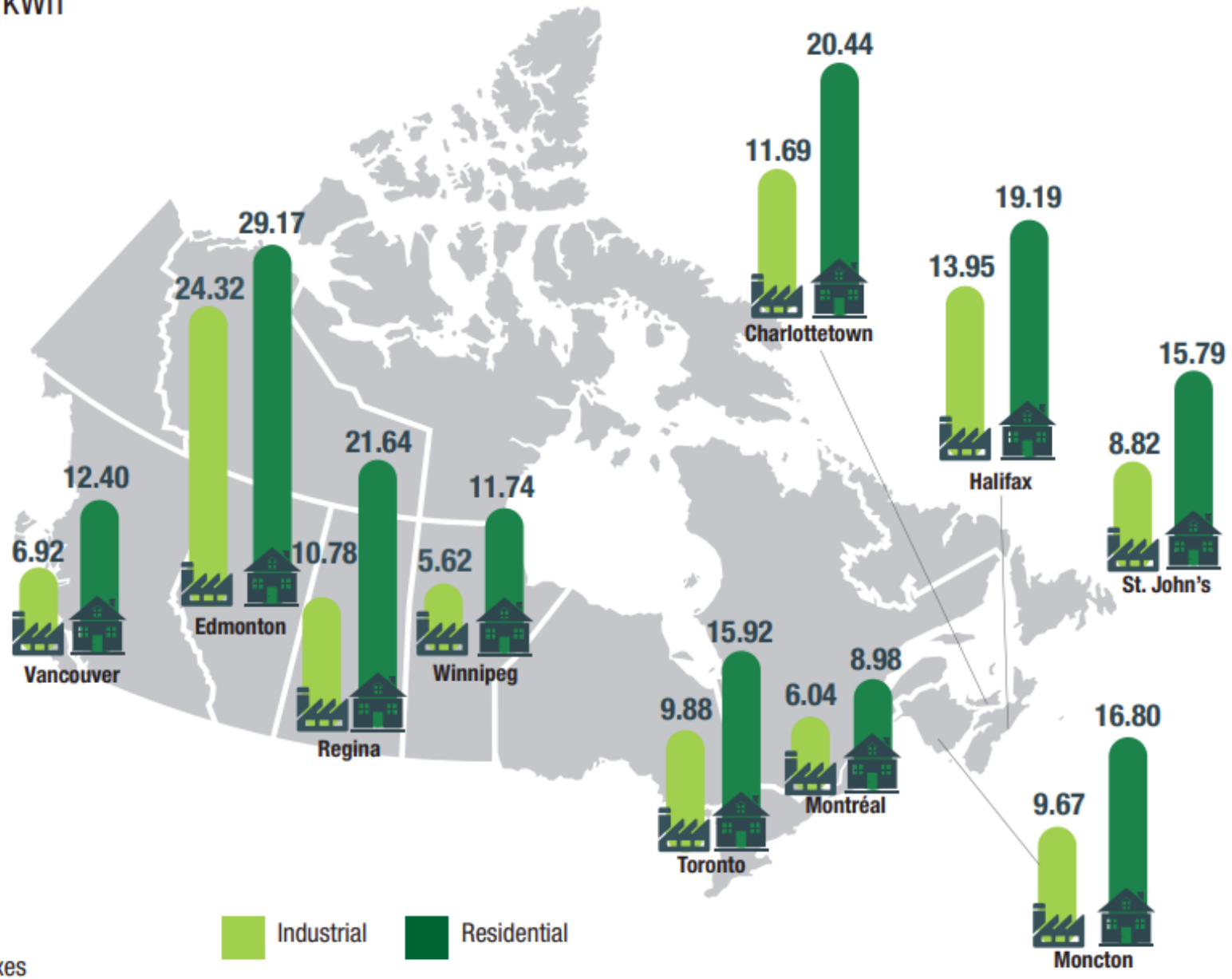


ELECTRICITY PRICES

AVERAGE LARGE INDUSTRIAL AND RESIDENTIAL ELECTRICITY PRICES* (AS OF APRIL 2023)

in cents/kWh



*including taxes

Industrial Steam/Baseboard
$150/MWh = ~$35/GJ for gas
$600/t pellets

Heat Pump (COP 2.2, incl DHW)
$200/MWh = $23/GJ for gas
$360/t pellets

$70/MWh = $8/GJ for gas

Natural Resources Canada
Energy Factbook, 2024-2025

Key Points

- There is no consistency between the provinces for energy mix
- Electricity consumption ranges from 7-40% of energy mix
- Heat represents ~2/3 of national energy consumption
- Industrial heat is the largest energy demand in provinces with higher GDP/pp
- Quebec hydro + Churchill Falls completely distorts the national energy conversation
- Biomass will not be a large electricity *energy* contributor nationally
- Residential heating for pellets a tough sell in areas with low-cost gas or electricity
- The need for affordable, low carbon steam is where biomass shines

Biomass Implications: Buildings Sector

- Elimination of the Carbon Tax
  - District heating not competitive with natural gas outside Atlantic Canada
  - (Municipal) mandated connection is only viable DH pathway QC to BC
  - Fuel switching existing DH systems near term opportunity
- Some provinces continue to subsidize electrification of building heat
  - Greater government control of energy system (Crown Corps of BC, MB, QC, NB)
  - A form of Local Energy prioritization
  - Negatively impacts grid, increases prices (industrial), capacity problems
  - Political sensitivity to electricity prices – DON'T MESS WITH BUILDING HEAT!
  - Really about climate?

Biomass Implications: Industrial Sector

- Trade + Policy Uncertainty = Limited Investment
  - US market? Who knows…
  - Industrial carbon pricing: Canada v. AB/SK
  - Only very few exceptions for access to low-cost natural gas
    - Maritimes, but depend on US markets
- Industry will not fuel switch without immediate drivers
  - Macro energy security unlikely to drive decisions
  - Cannot base decisions on macroeconomics
  - Provincial policies are not making the link

Biomass Implications: Transportation

- Policy Uncertainty: Carbon Tax + Subsidies + EV Mandate + Clean Fuel Regulations
  - Limited economic incentive for large scale shift to EVs
  - Most EV subsidies dropped/scaled back
  - EV Mandate paused and uncertain
  - Clean Fuel Regulations intact but under pressure
  - Chinese tariffs? Major grid impacts if low-cost models enter market
- No incentive for shift away from diesel
  - Hydrogen largely a bust
  - Long haul electric trucking in Canada a long way off
  - Urban air quality and fuel cost largest drivers

In Summary…

- Remote regions/Atlantic Canada still best bioheat building sector options
- Institutional energy security/GHG: Fuel switch @ existing DHS (DND & Unis)
- Municipal mandated connection to replace gas
- Transportation: gasoline & diesel not going to disappear
- Fiscal pressures will limit EV subsidies
- Adding buildings and EVs to grid will create capacity challenges in some provinces
    - Chinese EV tariffs are big uncertainty
- Industrial heat has not electrified and unlikely to do so
- Trade uncertainty overrides any decarbonization goals for most companies

What Wood Fuels Provide

1. Capacity (Dispatchable Power + Thermal Energy)
2. Biogenic CO_2 for BECCS
   - Domestic removals for consumer decarbonization
   - Exports that subsidize local energy consumption
3. Local Economic Activity & Energy Expenditures
4. Energy Security
5. Wildfire Mitigation

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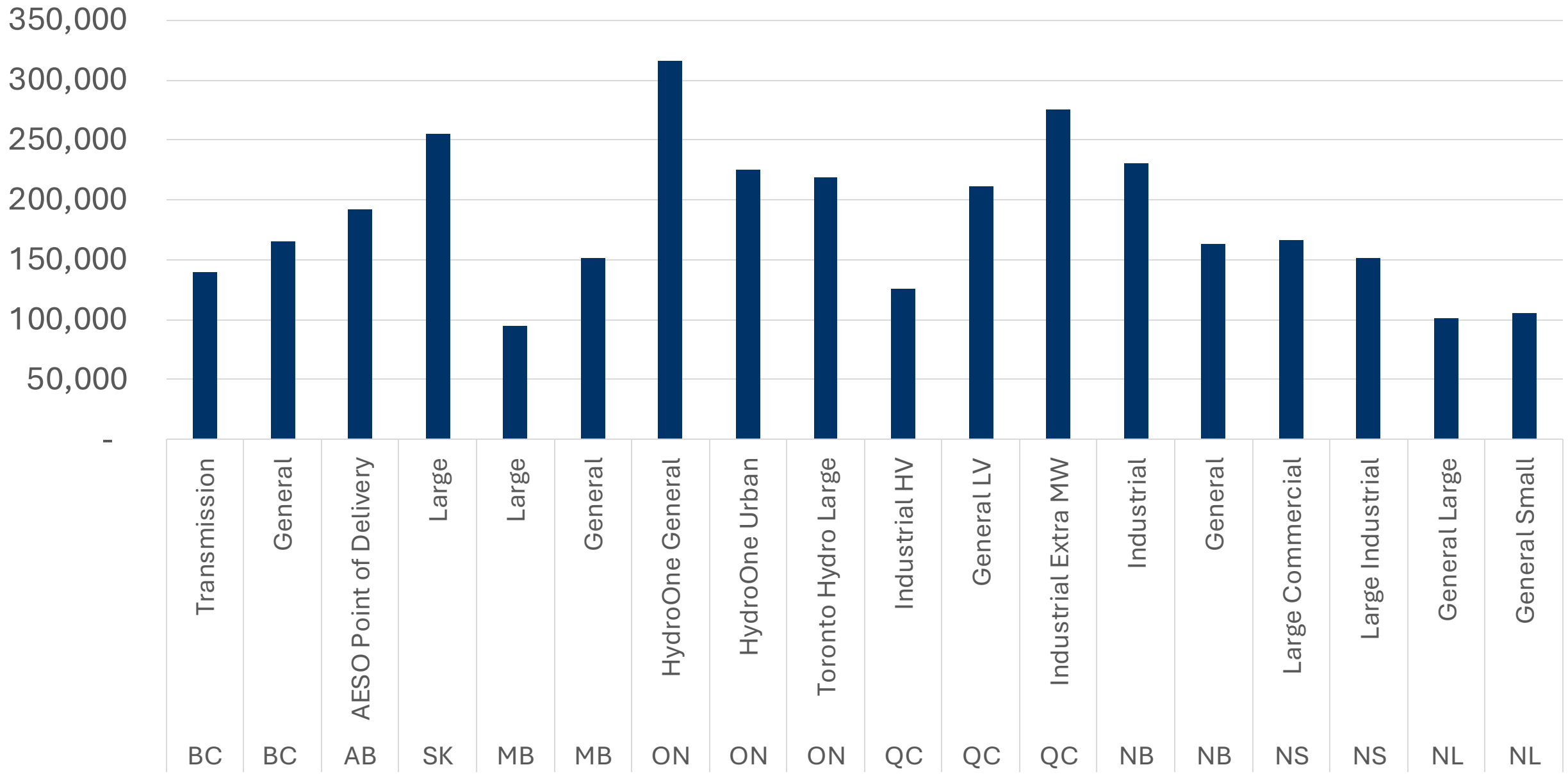
Capacity

Energy vs. Capacity

- Electricity must always be supplied
- It costs money for capacity to be available: Capacity Charges
- Generally charged on peak demand in a month
  - Not 24/7? Capacity charges far exceed energy costs
- Residential/small consumers NOT charged for capacity
  - Heat pumps
  - EVs
- Intermittent renewables: broken the link between energy generation costs and prices
- Why are rates increasing as we add more low cost-of-generation renewables?
- A large part of industrial pellet market is based on capacity

National Capacity Charges ($/MW-y)



The Value of Capacity

Manufacturer #1

- 90% uptime factory in Ontario
- Average load while operating 2.0 MWe
- Peak load over a month 4.0 MWe
    - $1.28 M/y in capacity charges
    - $81/MWh for capacity

Manufacturer #2

- 27% uptime factory in Ontario (10 hrs/day; 5 days/wk; 48 wks/y)
- Average and peak load as above, same capacity charges
    - $270/MWh for capacity

Consumers & Capacity

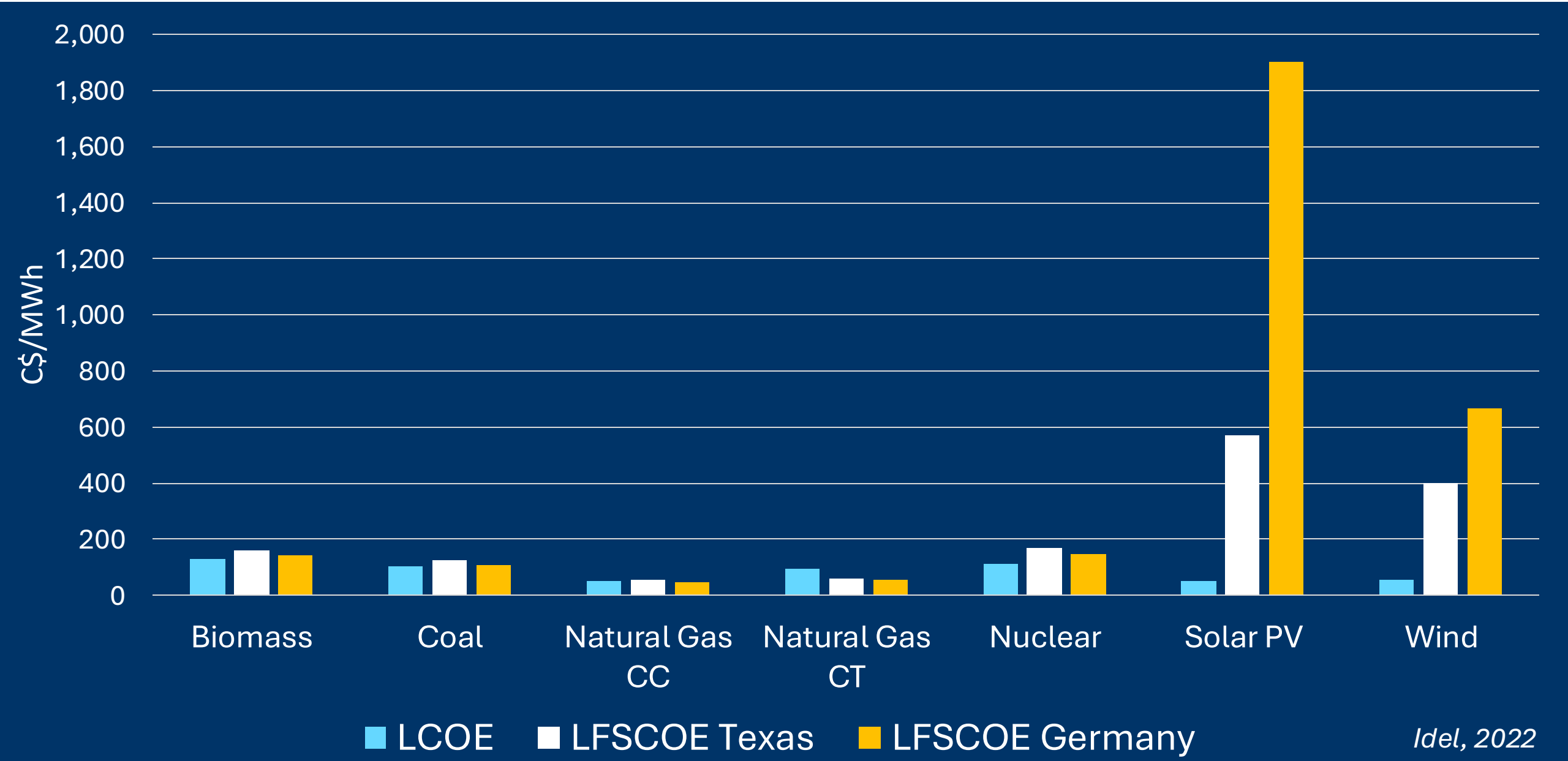
EVs

- Level 2 (Home) Charger: 7-20 kW
  - IF charged capacity in ON: 15 kW = $4,750/y

Heat Pumps

- ASHP for 2,500 ft^2 home in Toronto: Output of 18 kW
  - Assume coldest day COP of 1.4: 13 kW
  - IF charged capacity in ON: $340/mth
- BUT…heat pumps distort Capacity Charges, since the generating capacity can't only exist for 1-2 months

Supply: LCOE v. LFSCOE, C$/MWh



Idel, 2022

Supply: Cost of Generating Capacity

Annualized Fixed Cost = Annualized CapEx + Fixed O&M + Other Fixed

$$\$/\text{MW-y} = \frac{\text{Annualized Fixed Cost}}{\text{Dependable Capacity}}$$

	Biomass	Simple Cycle Gas	Onshore Wind	Offshore Wind
CapEx ($/kW$_e$)	5,500	1,700	2,100	6,000
Lifetime	50	30	25	30
Dependable %	90	95	10	25
$/MW-y	590,000	160,000	2,250,000	2,400,000

Capacity Charges in Ontario: $220,000-320,000/MW-y

Dependable Fraction = Effective Load Carrying Capability (ELCC)

Supply: Cost of Generating Capacity

But…this is just electricity

Biomass CHP = $195,000 MW-y v. Gas Simple Cycle = $160,000 MW-y

Variable costs dominated by Fuel

- Natural gas in Ontario: $5/GJ ($80/t pellets power-only; $200/t CHP)
- Natural gas in Nova Scotia: $15/GJ ($240/t power-only; $600/t CHP)

Gas supply in NS ~$8-10/GJ for much of year but up to $40/GJ during peak

But what about macroeconomics, GHGs, and wildfires?

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BECCS

BioEnergy with CCS

Atmospheric Carbon Removal

+

Bioenergy (Heat and Power)

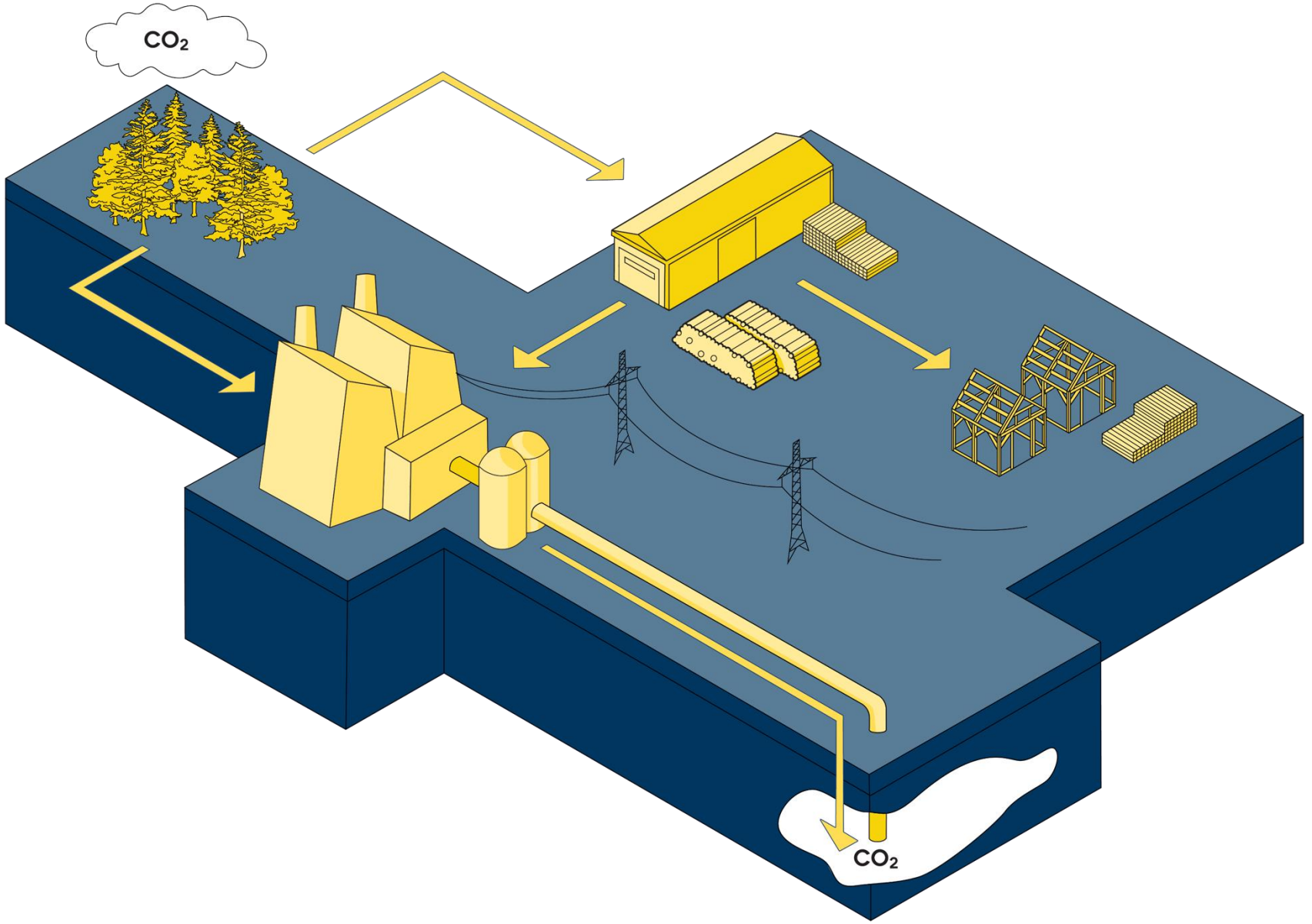
+

Carbon Capture & Storage

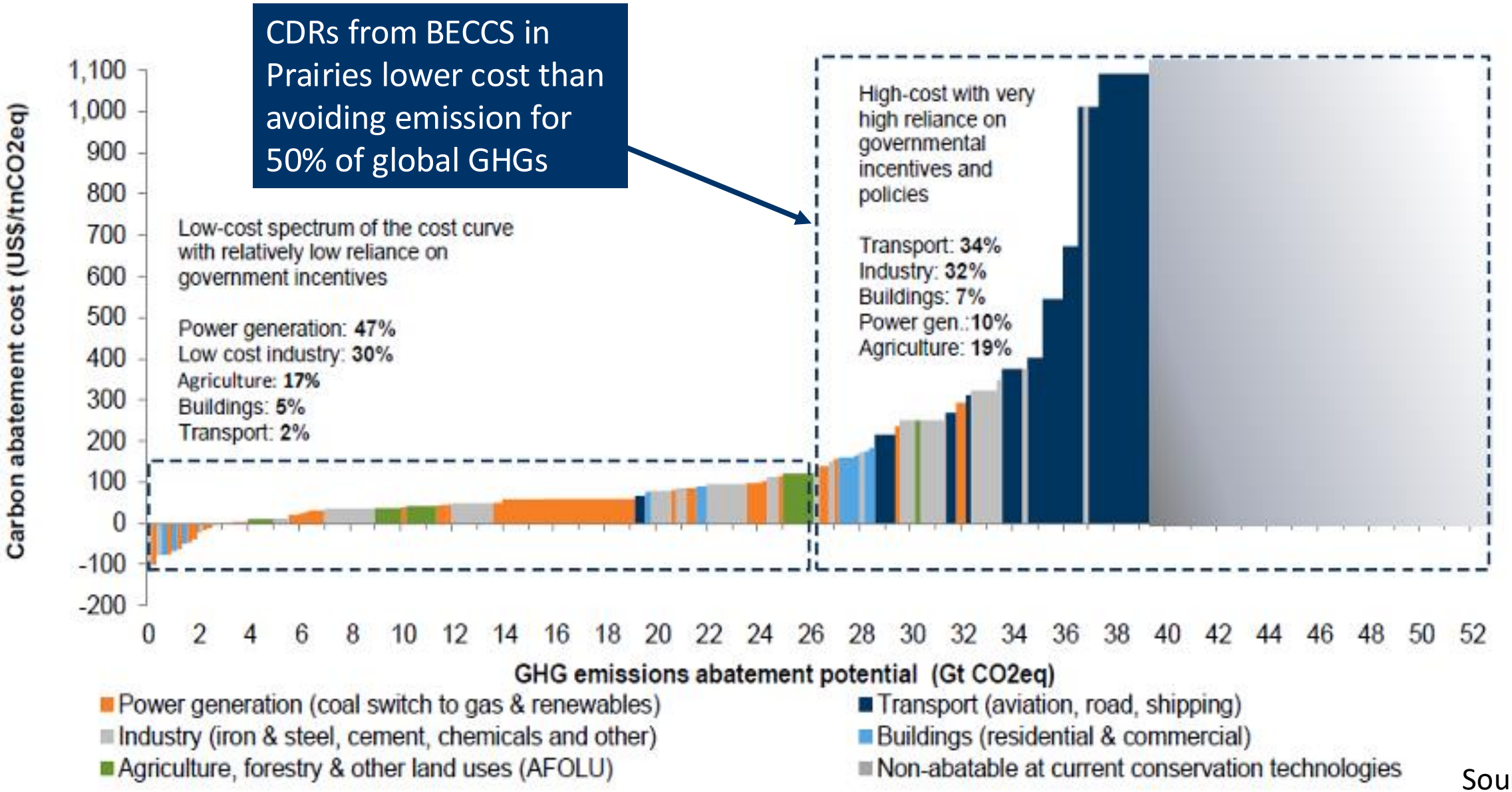
= BECCS

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
- Three sources of revenue



GHG Cost Abatement Curve



Source: GS

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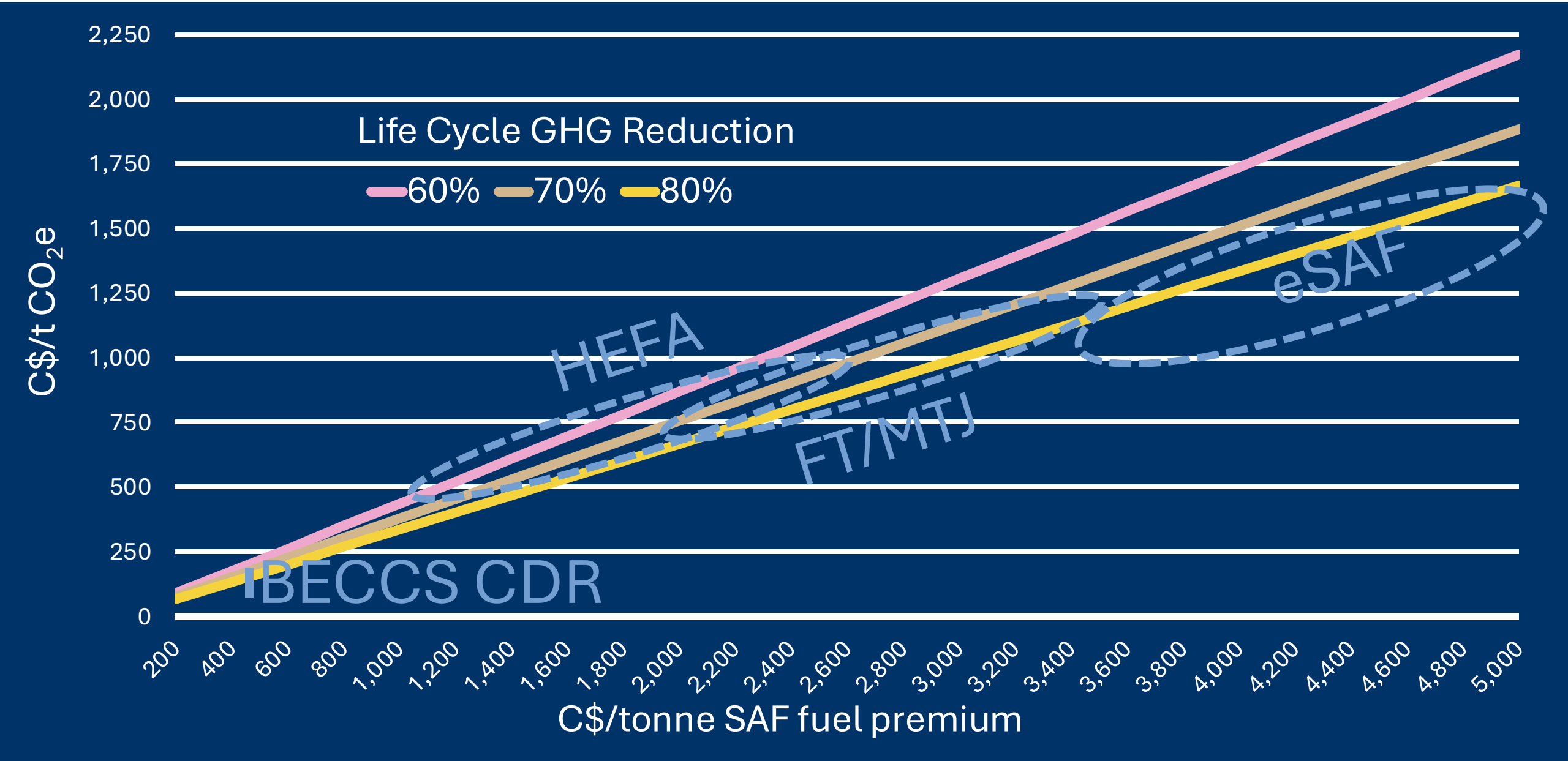
1 tonne of wood

BECCS provides **6x** the GHG reduction of conversion to SAF, renewable diesel, or ethanol

Decarbonizing Aviation



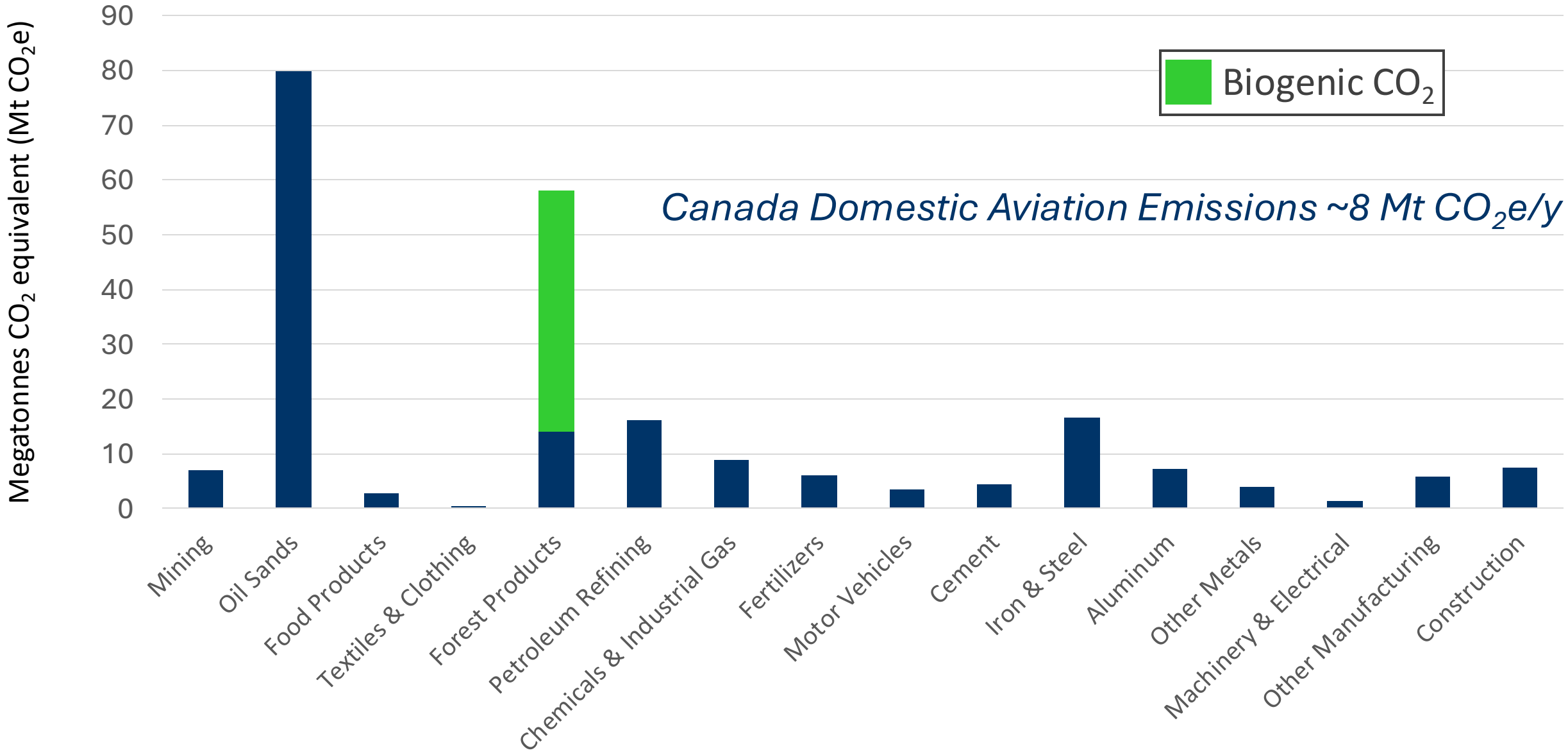
Real Life

Halifax-Vancouver Economy Roundtrip: 0.627 t CO_2e

Assume C$900 for base ticket

1. C$170/t CO_2e for BECCS: Add $107/fight **(12% increase)**
2. HEFA @ C$3,000/t, 70% reduction: Add $473/flight **(53% increase)**
3. FT @ C$4,000/t, 80% reduction: Add $836/flight **(93% increase)**
4. eSAF @ C$5,000/t, 90% reduction: Add $917/flight **(102% increase)**

Industrial CO_2 Emissions, 2022



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

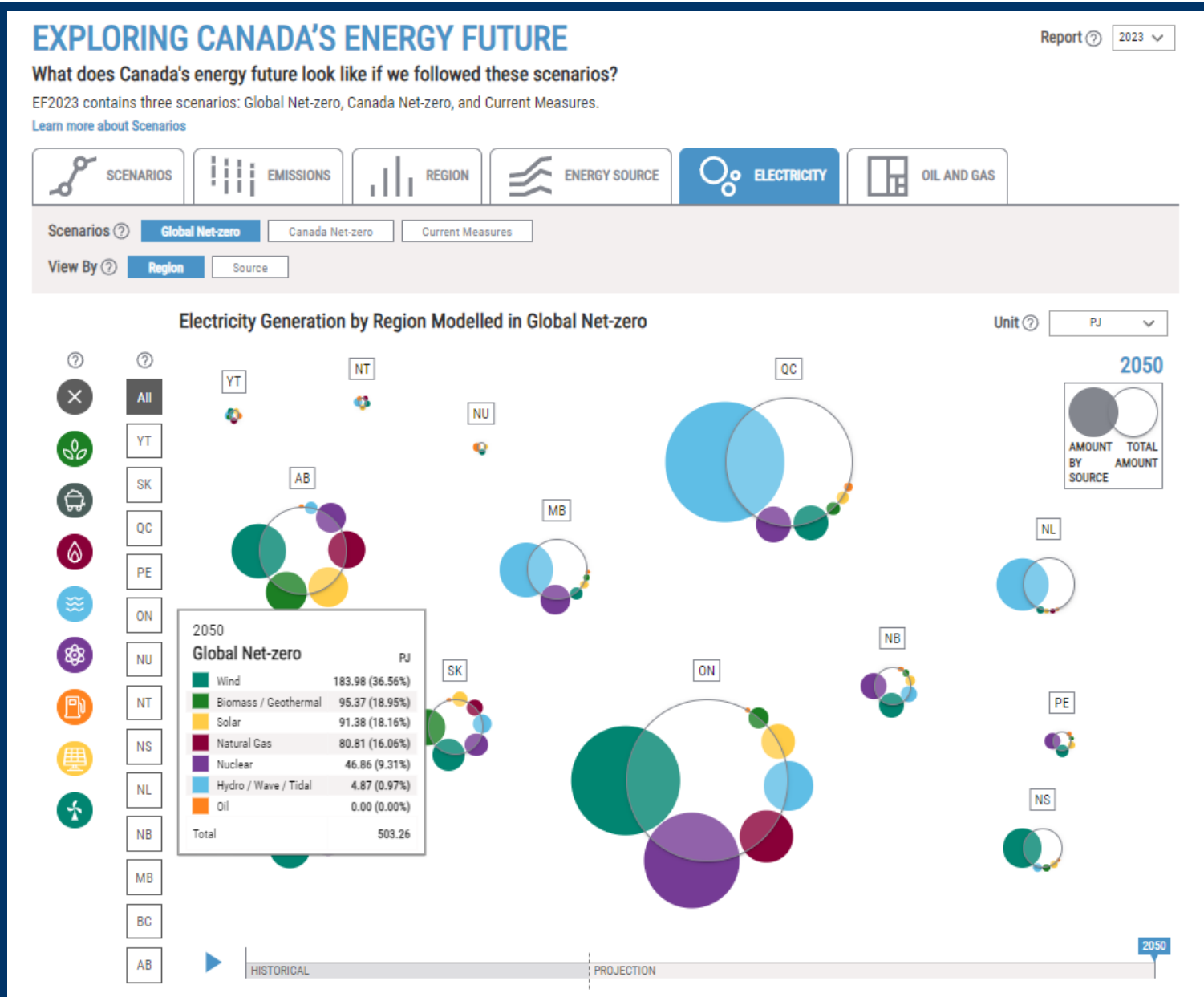
- Wood chip-fuelled plant heating Stockholm via district energy system owned by Stockholm Exergi
- Plan to add capture; pilot plant operated for multiple years; Microsoft buying 333 kt CDR/yr for 10 yr
- >$250 M in EU grant funding
- Swedish Gov't purchasing $2.6 B in CDRs
- 800 kt CO_2/yr, North Sea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

Canada Energy Regulator

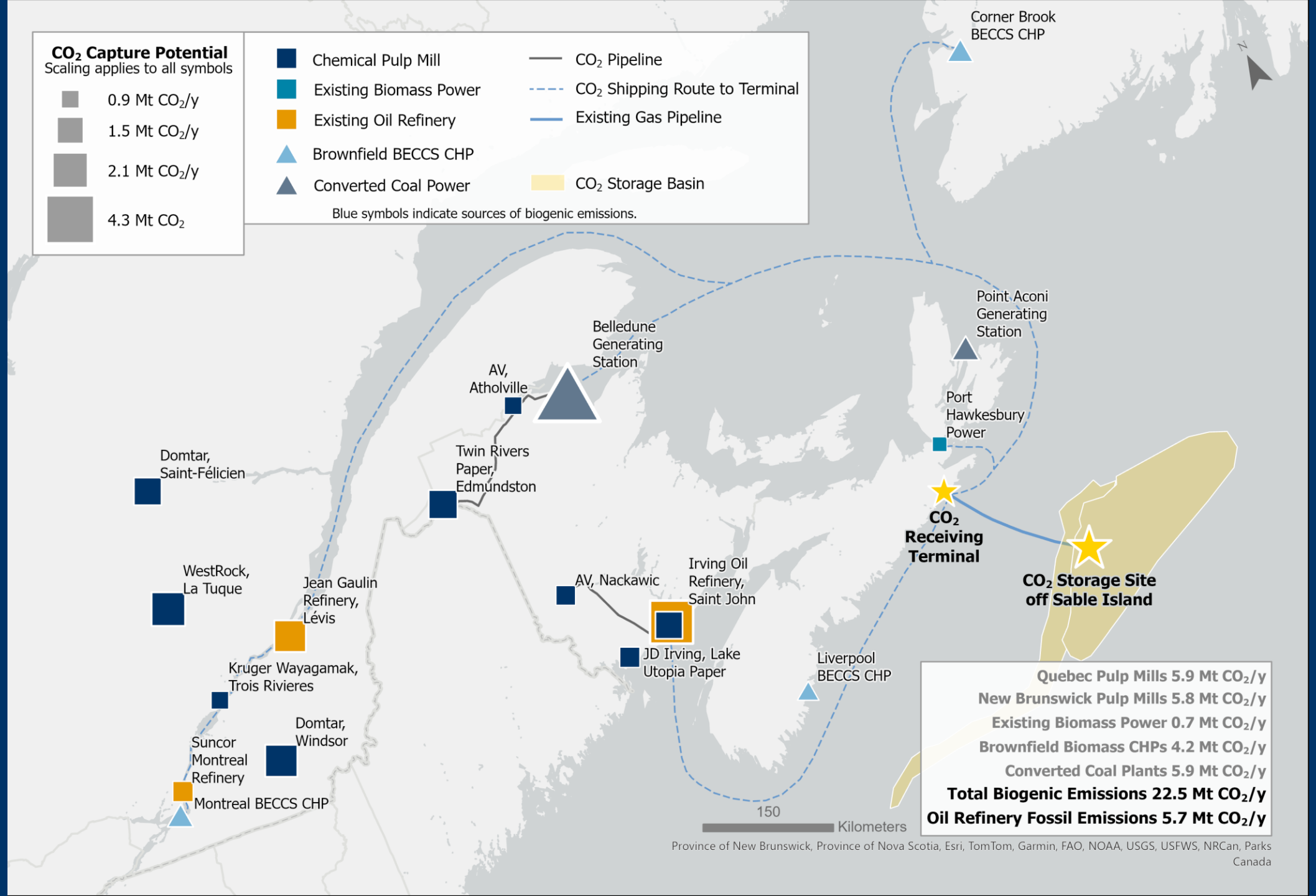
- No Net Zero Grid without BECCS
- In 2050 Global Net Zero, CER modelled biopower as #2 electricity supply in AB, #1 in SK
- 26,500 GWh (19% of supply)
- Modelled limit is biomass supply, not cost



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


CO_2 Capture Potential
Scaling applies to all symbols
0.9 Mt CO_2/y
1.5 Mt CO_2/y
2.1 Mt CO_2/y
4.3 Mt CO_2
Chemical Pulp Mill
Existing Biomass Power
Existing Oil Refinery
Brownfield BECCS CHP
Converted Coal Power
CO_2 Pipeline
CO_2 Shipping Route to Terminal
Existing Gas Pipeline
CO_2 Storage Basin
Blue symbols indicate sources of biogenic emissions.
Corner Brook BECCS CHP
Point Aconi Generating Station
Belledune Generating Station
AV, Atholville
Port Hawkesbury Power
Twin Rivers Paper, Edmundston
Domtar, Saint-Félicien
CO_2 Receiving Terminal
CO_2 Storage Site off Sable Island
WestRock, La Tuque
Jean Gaulin Refinery, Lévis
AV, Nackawic
Irving Oil Refinery, Saint John
JD Irving, Lake Utopia Paper
Liverpool BECCS CHP
Kruger Wayagamak, Trois Rivieres
Domtar, Windsor
Suncor Montreal Refinery
Montreal BECCS CHP
Quebec Pulp Mills 5.9 Mt CO_2/y
New Brunswick Pulp Mills 5.8 Mt CO_2/y
Existing Biomass Power 0.7 Mt CO_2/y
Brownfield Biomass CHPs 4.2 Mt CO_2/y
Converted Coal Plants 5.9 Mt CO_2/y
Total Biogenic Emissions 22.5 Mt CO_2/y
Oil Refinery Fossil Emissions 5.7 Mt CO_2/y
150
Kilometers
Province of New Brunswick, Province of Nova Scotia, Esri, TomTom, Garmin, FAO, NOAA, USGS, USFWS, NRCan, Parks Canada

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Macroeconomics
&
Energy Price Stability

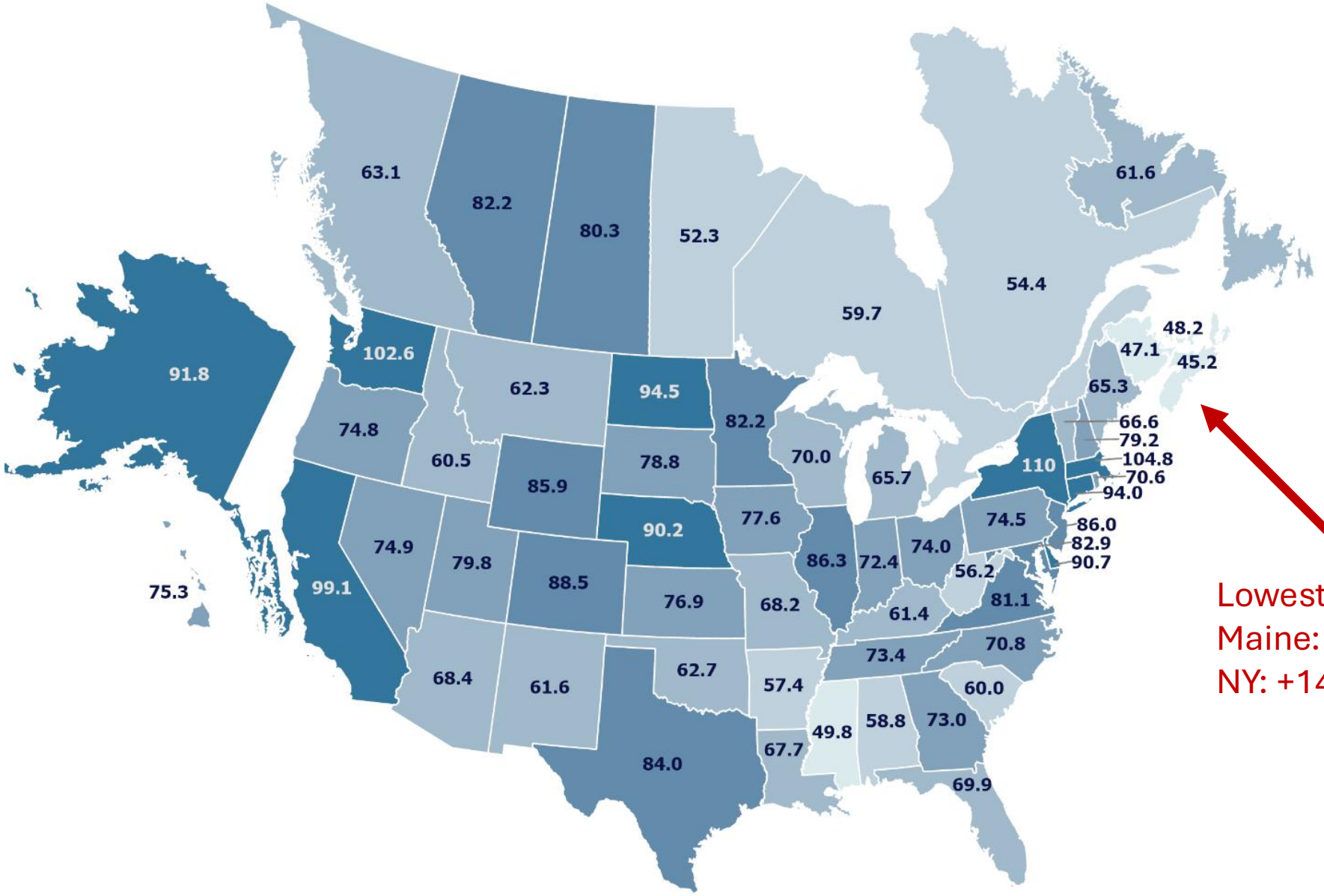
Strategy

Design an energy system for the things that matter

- Economy
- Employment
- Cash Drain
- Value-Addition and Exports
- *Who* benefits

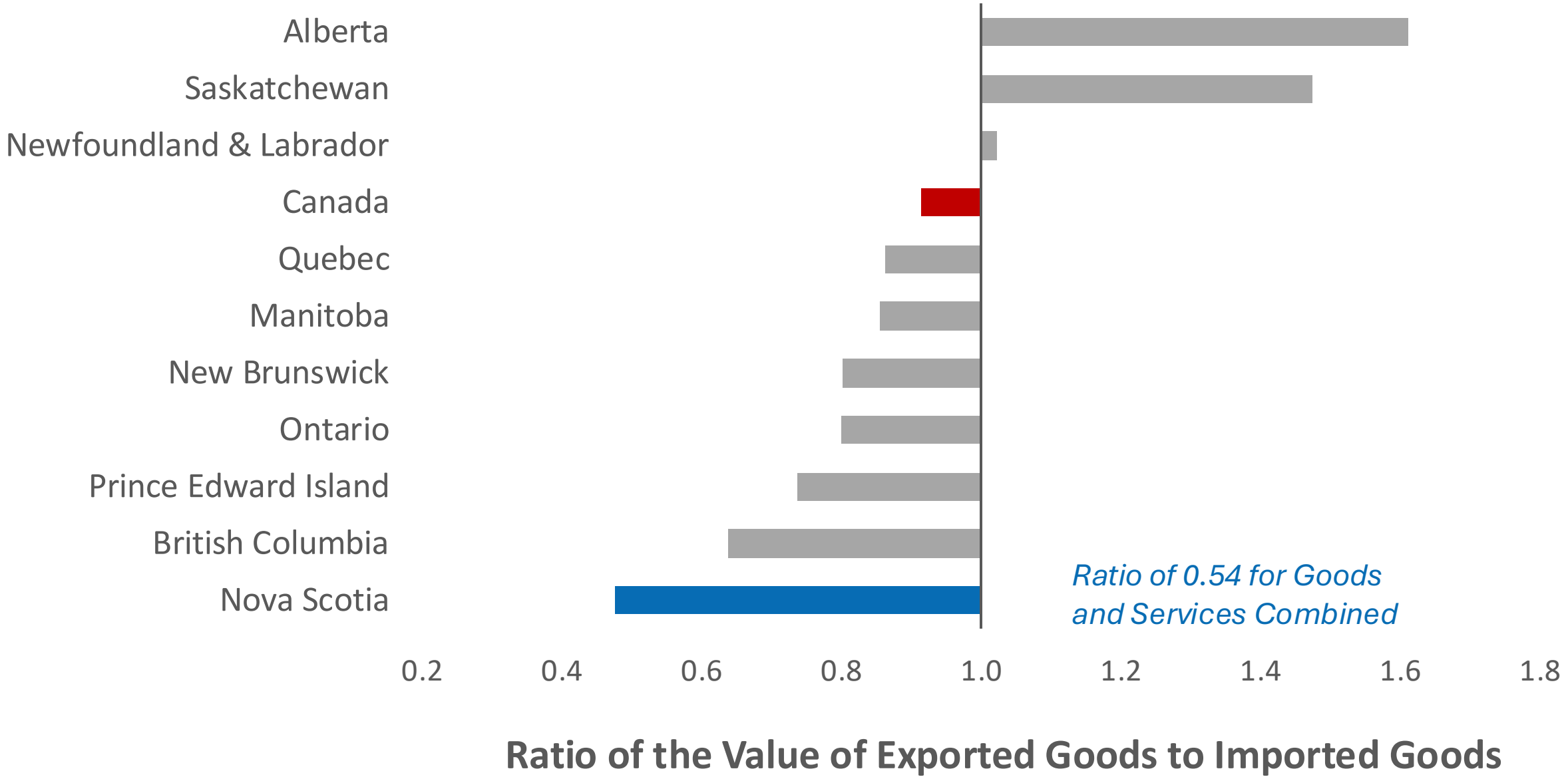
It isn't just about the cost of generation!

GDP per Capita



Lowest in Canada/U.S.
Maine: +45%
NY: +145%

Nova Scotia's Import Dependency



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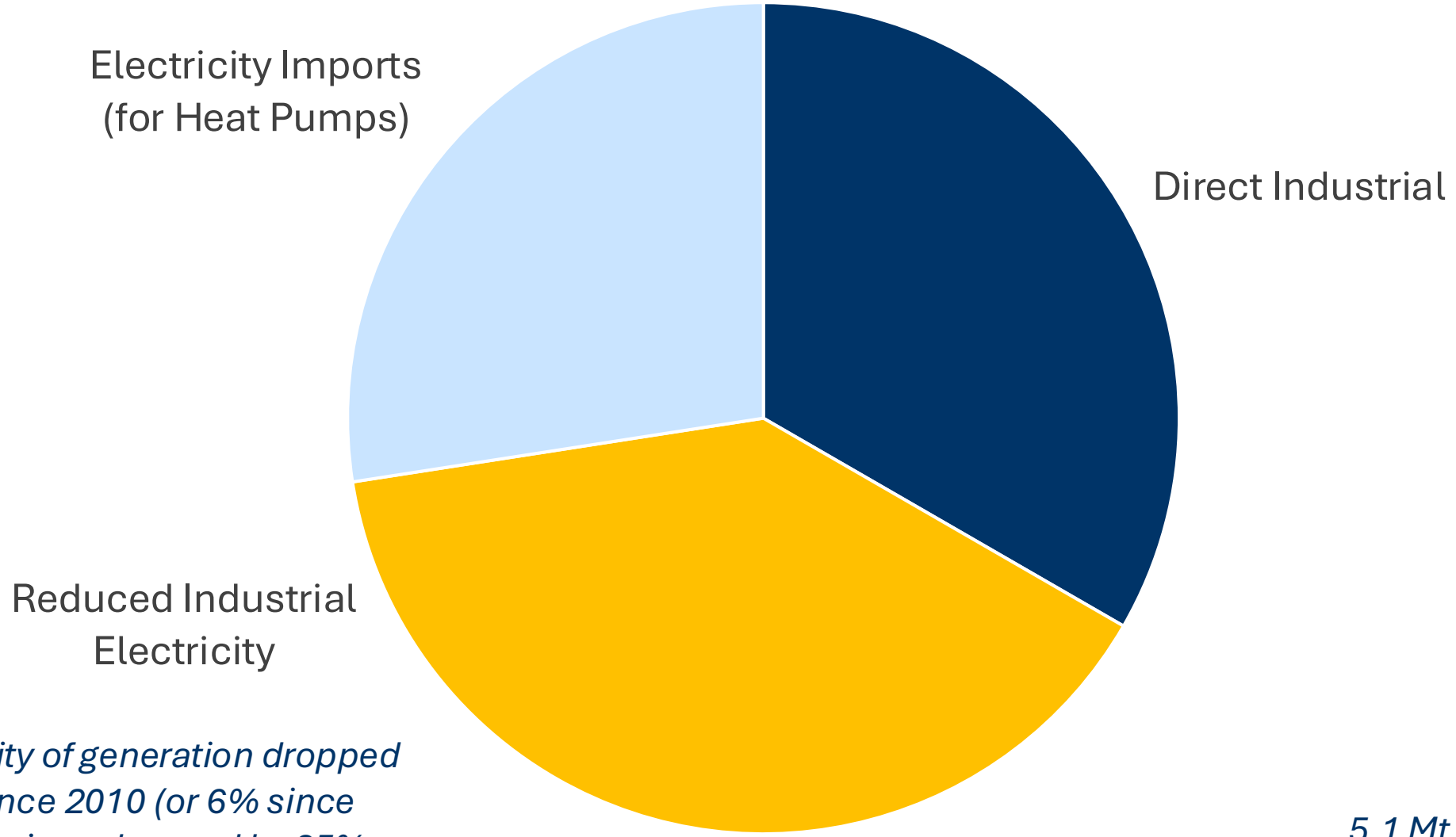
Nova Scotia has a heat & electricity cash drain of >$2 B/y

Decarbonization via Deindustrialization

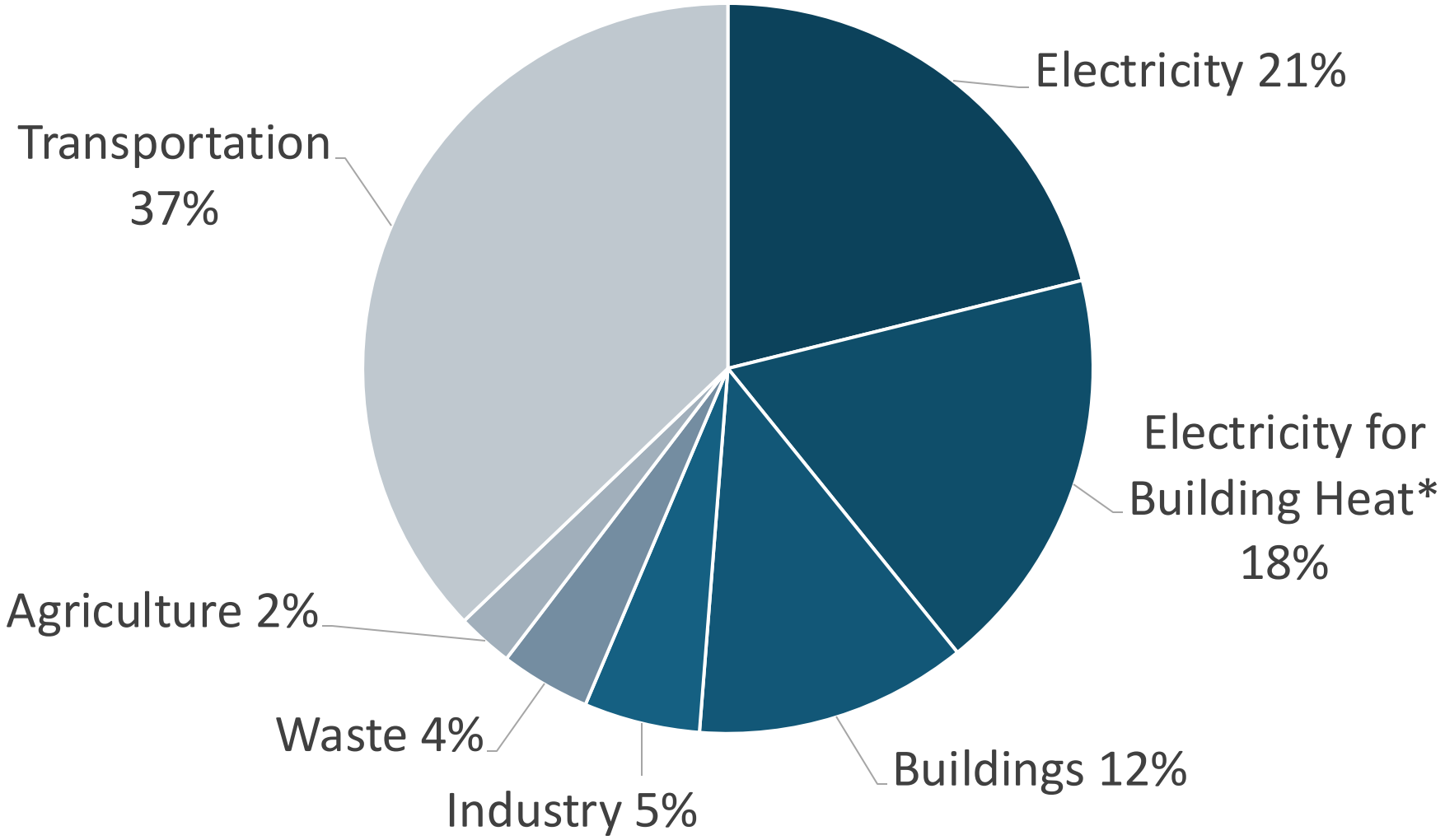
Reasons for Decarbonization in Nova Scotia, 2010-2022



Carbon intensity of generation dropped by only 12% since 2010 (or 6% since 2012) but emissions dropped by 35%

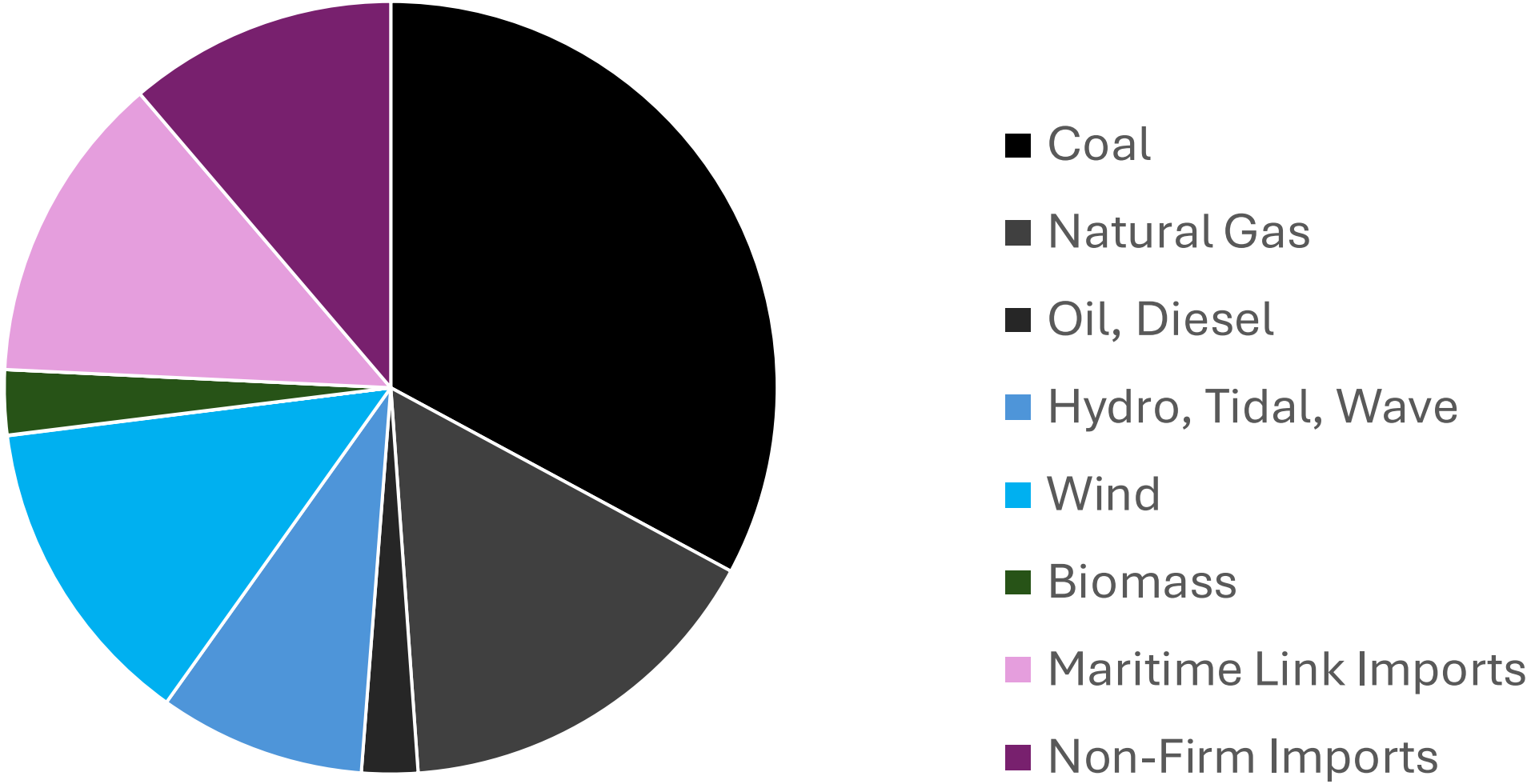
5.1 Mt CO_2e/y reduction

Nova Scotia GHG Emissions, 2022



Nova Scotia Electricity Supply, 2023

75% of Nova Scotia's electricity fuel/supply is imported



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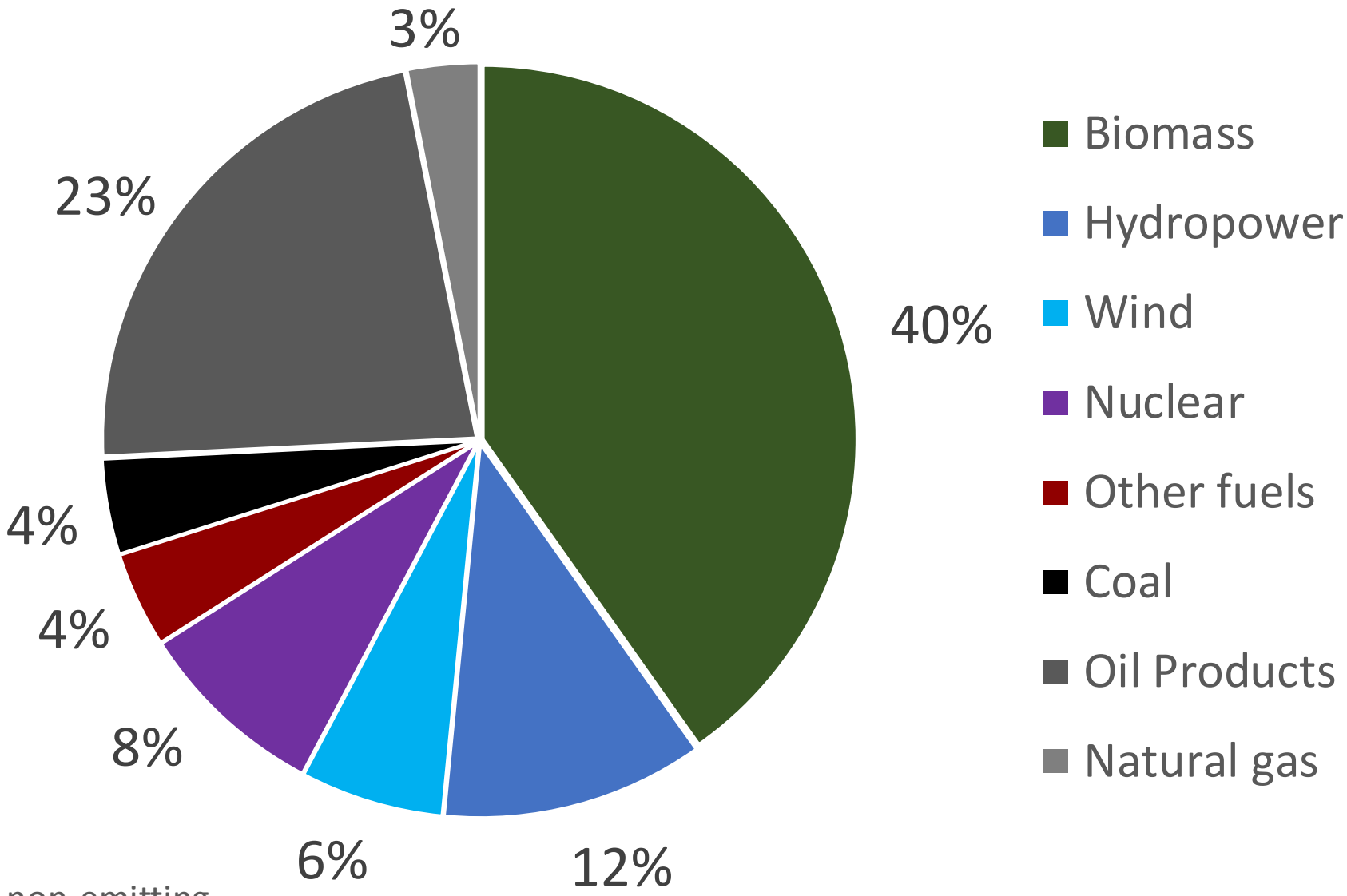
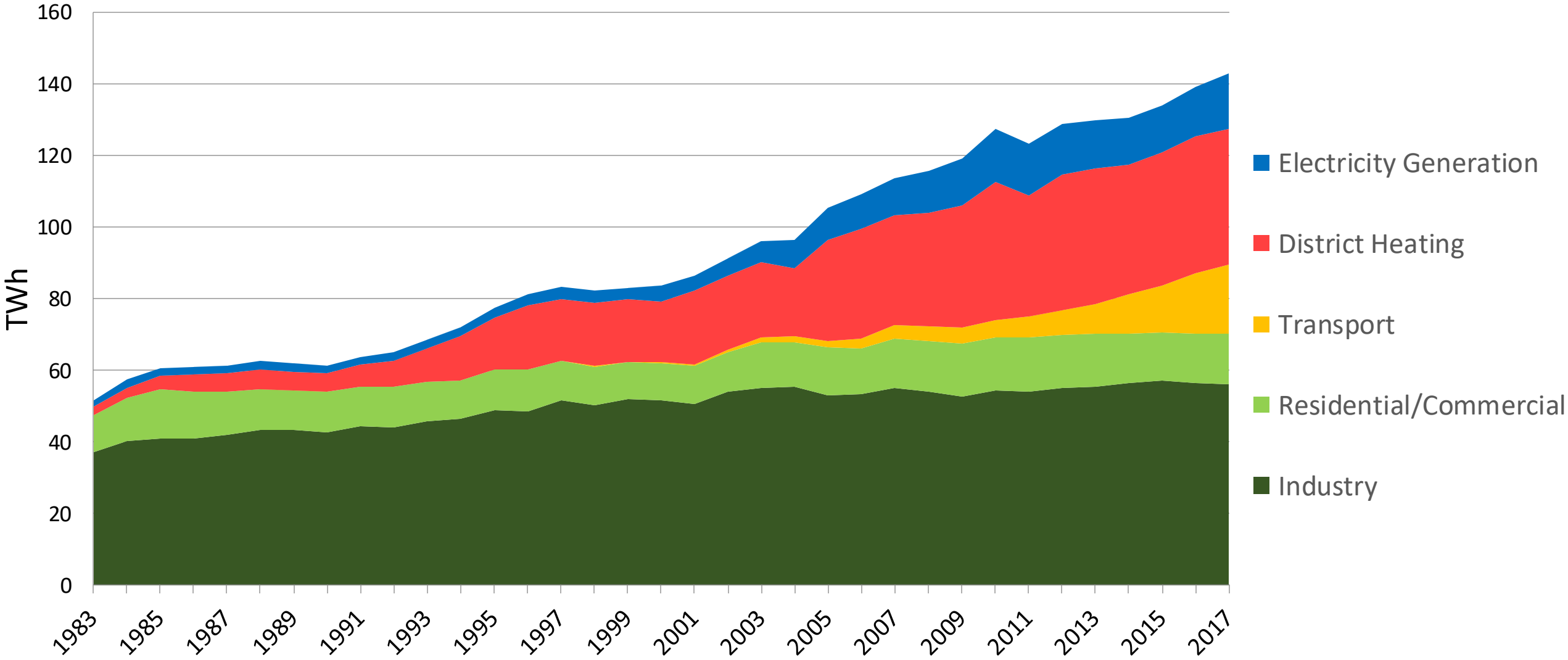
Current Nova Scotia climate and electricity strategies would see 100% building heat electrification by 2050

Energy Consumption in Sweden



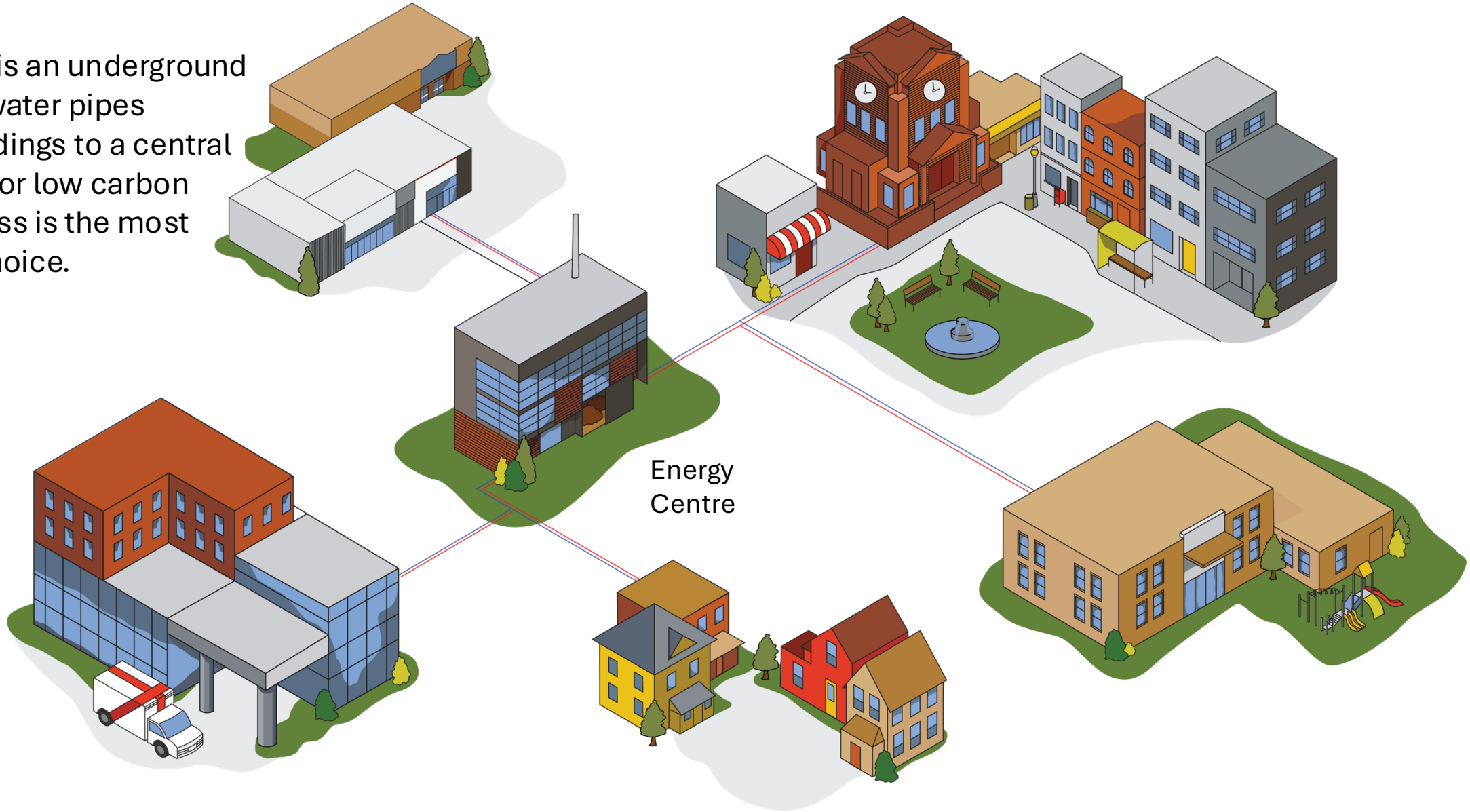
- 58% renewable energy, 65% non-emitting

Bioenergy Demand in Sweden



What is District Heating?

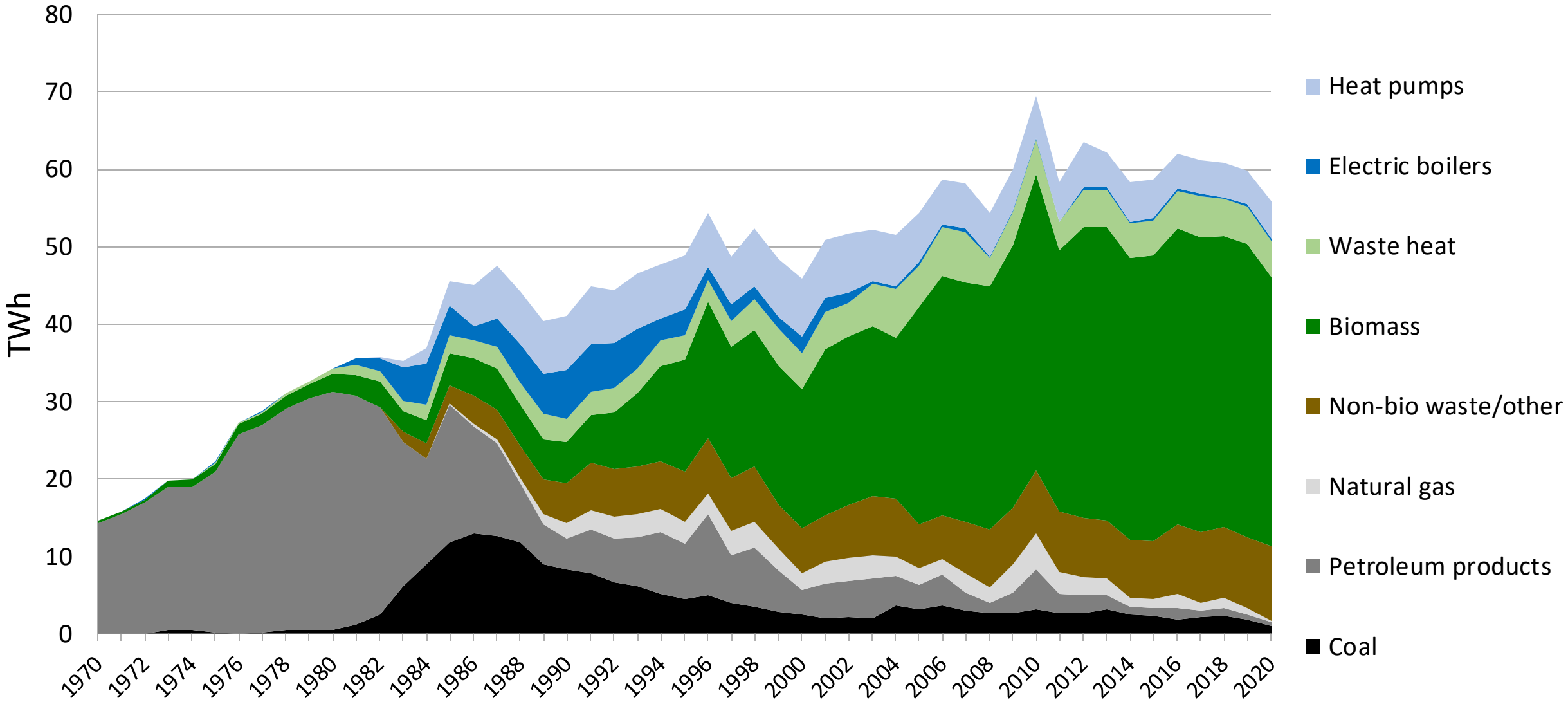
District heating is an underground network of hot water pipes connecting buildings to a central energy facility. For low carbon systems, biomass is the most common fuel choice.



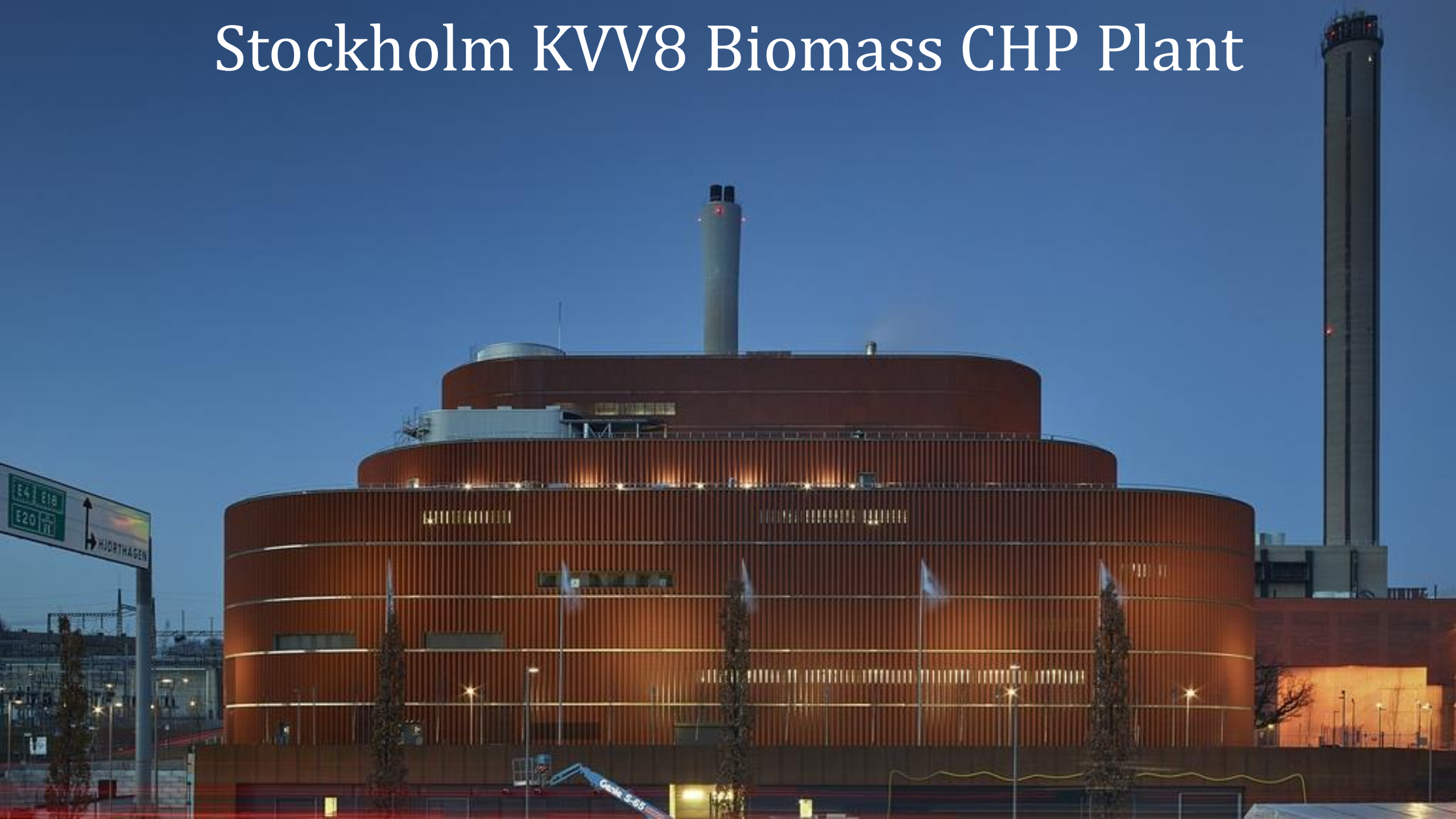
What is District Heating?

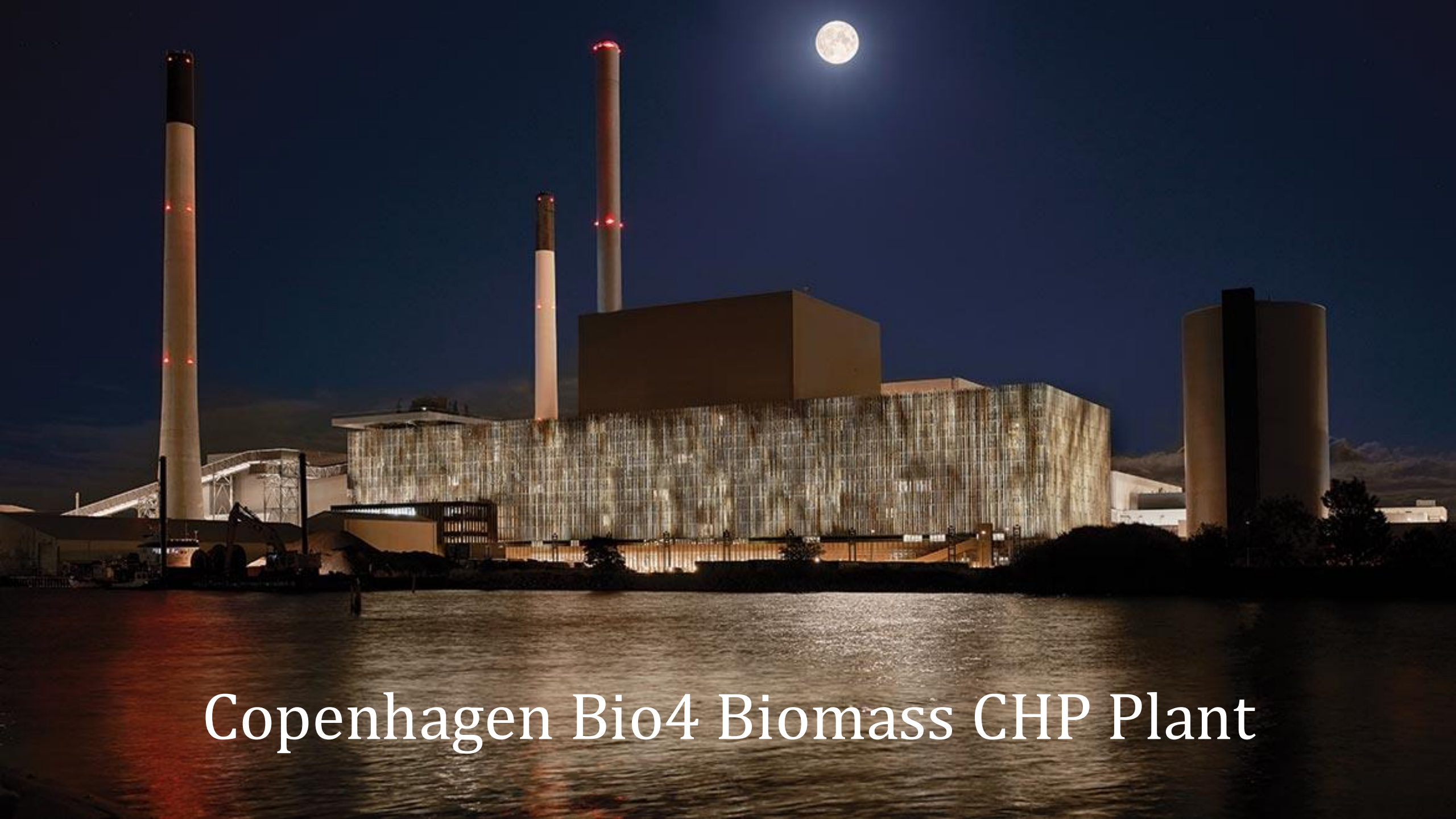
What is District Heating?

Sweden District Energy by Fuel



Stockholm KVV8 Biomass CHP Plant





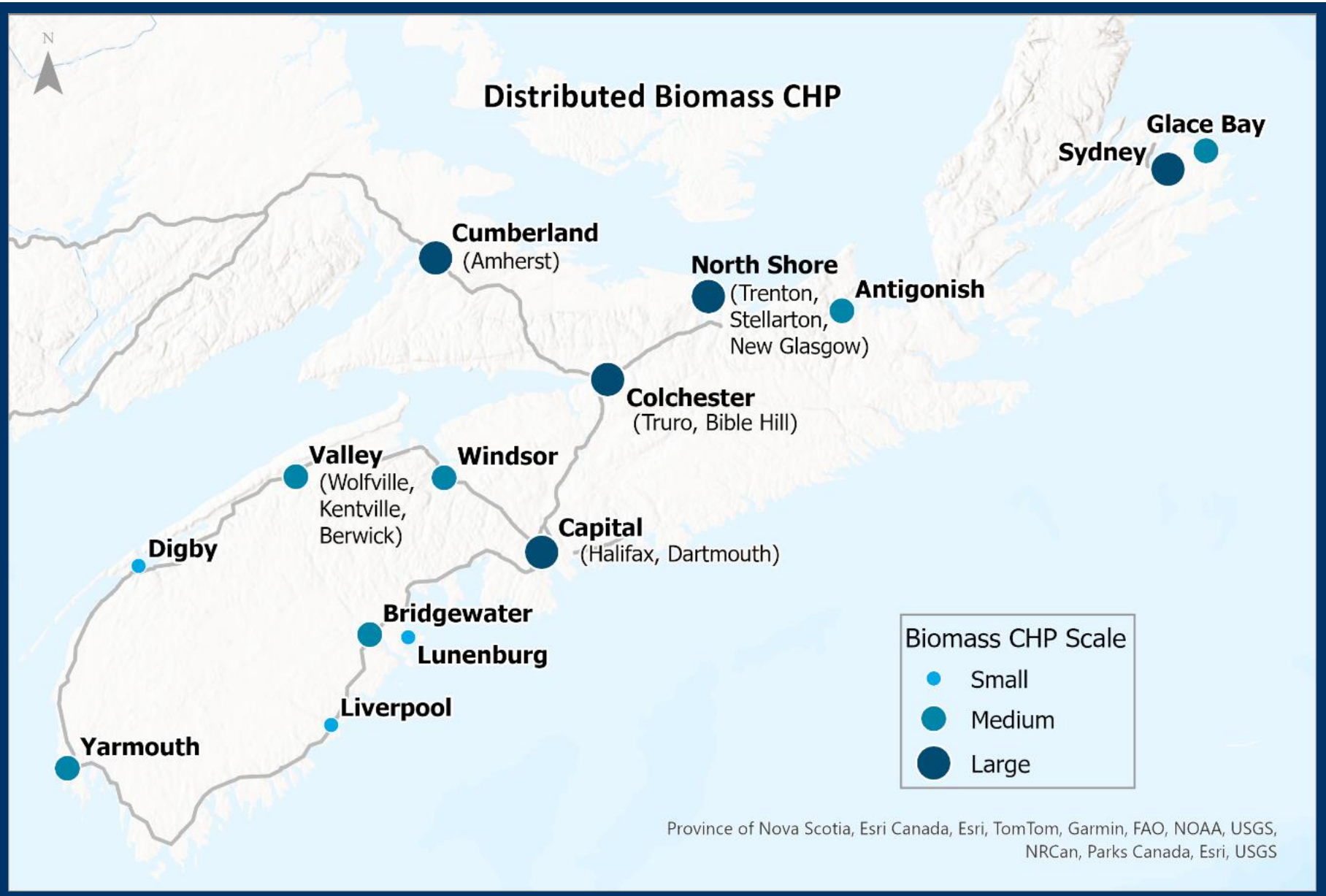
Copenhagen Bio4 Biomass CHP Plant

Recklinghausen, Germany

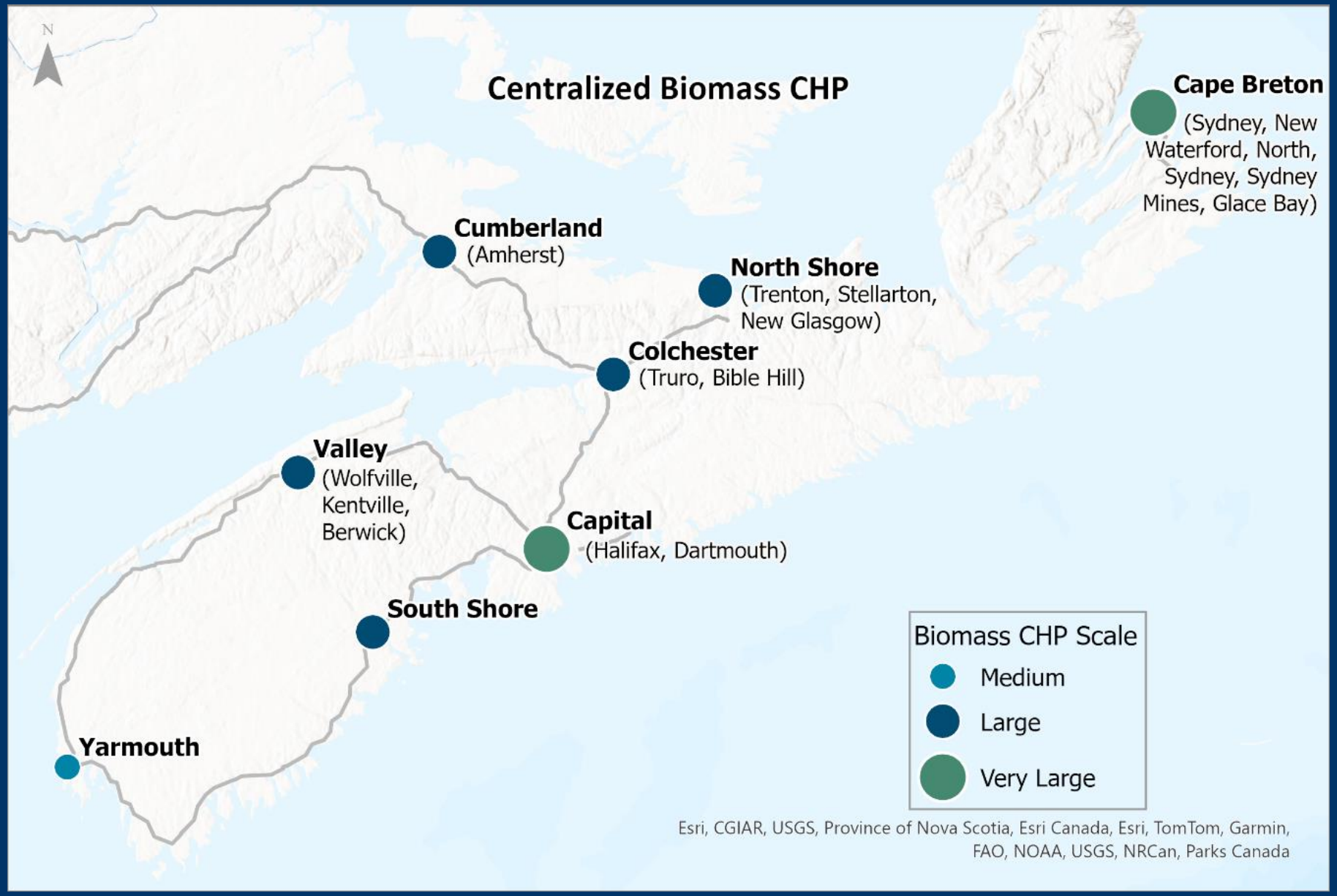
What would this look like in Nova Scotia?

torchlightbioresources.com/wp-content/uploads/2025/02/LocalEnergyNS_TorchLight_202502_Final.pdf

Distributed Approach



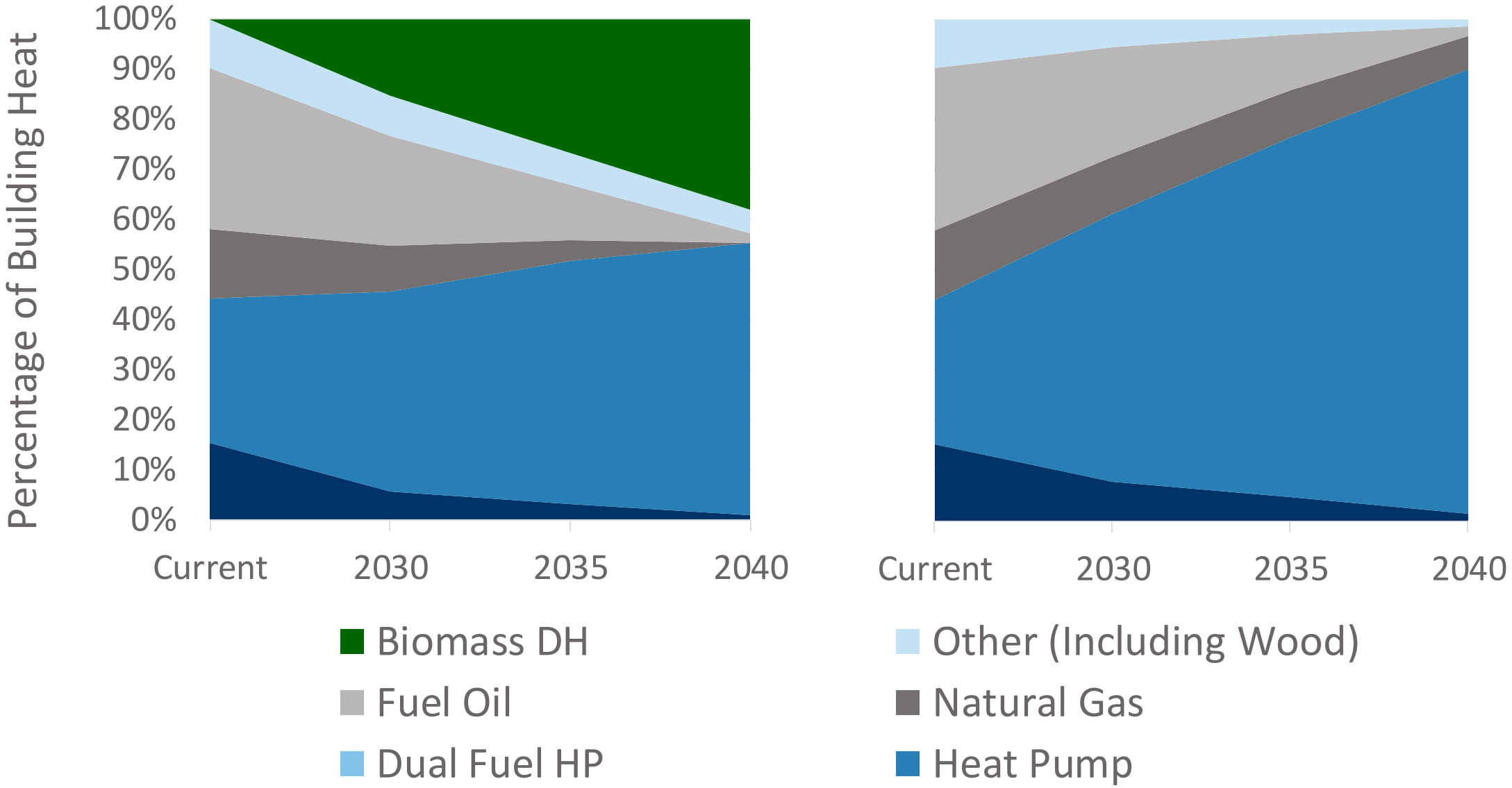
Centralized Approach



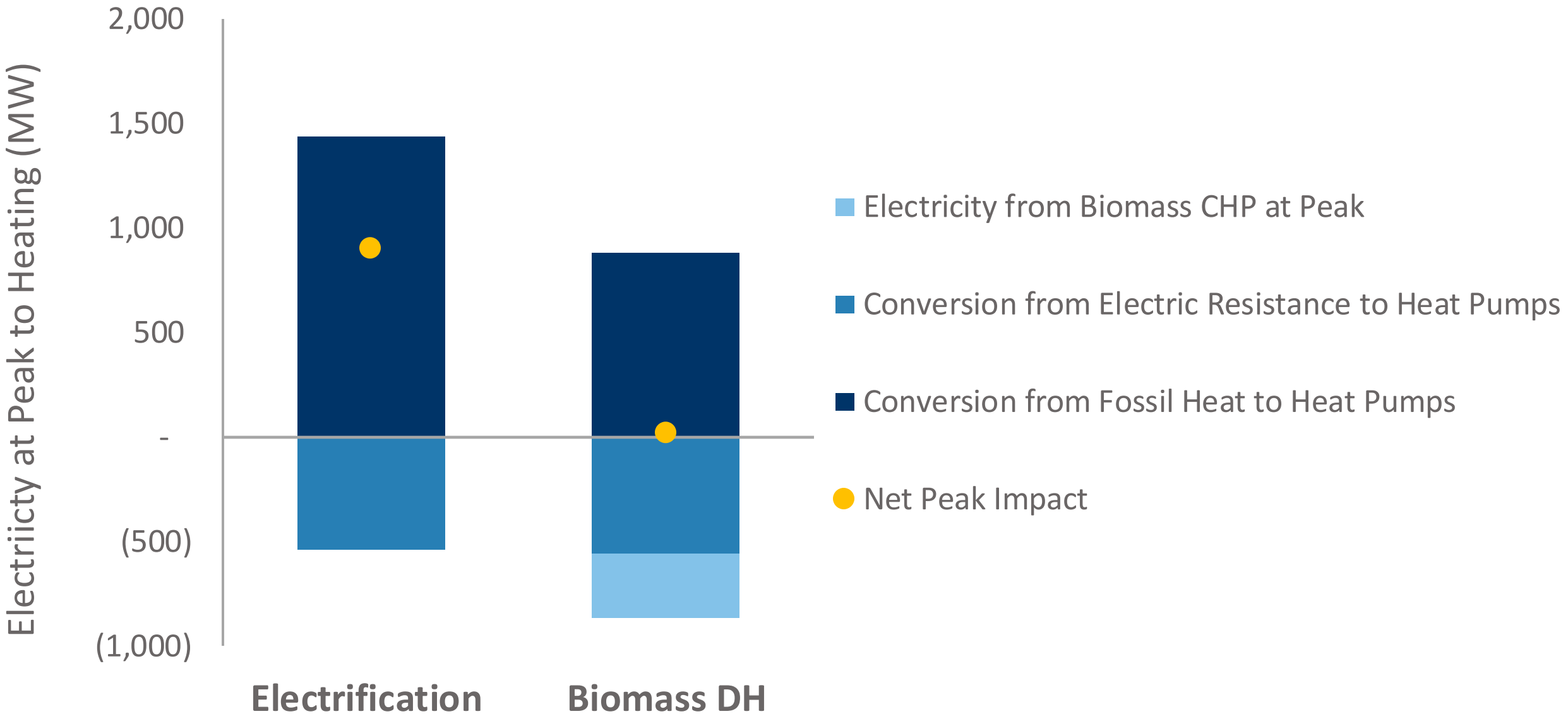
CHP Numbers

Metric	Performance
CHP Plants	7 or 14
Installed Capacity	390 MW_e/650 MW_{th}
Range	5/10 to 135 MW_e
NS Electricity Consumption	24%
NS Building Heat Consumption	40%
Annual Biomass Consumption	3.8 Mt

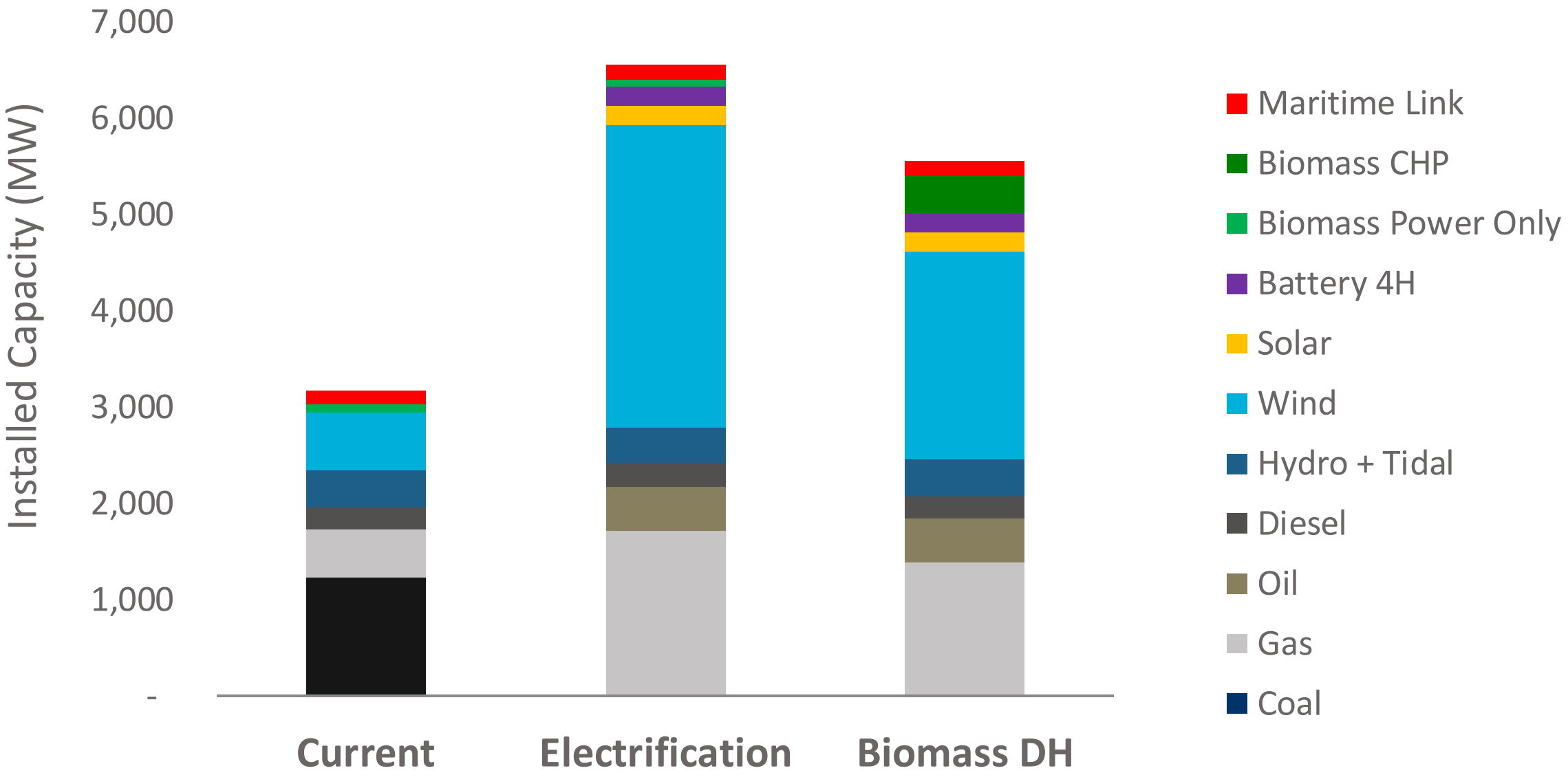
Building Heat Mix



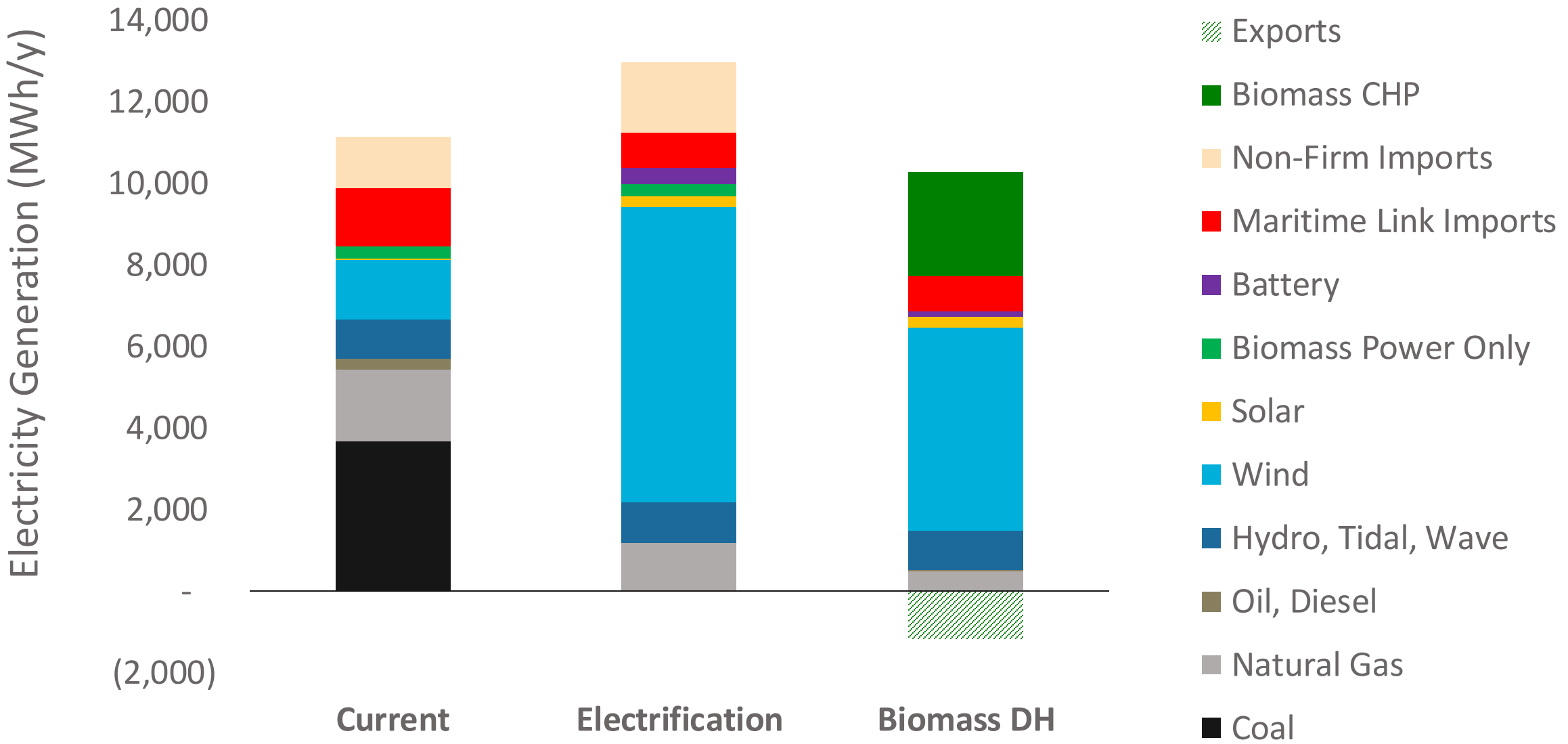
Additional Peak Electricity Load



Installed Electrical Capacity



Annual Electricity Generation

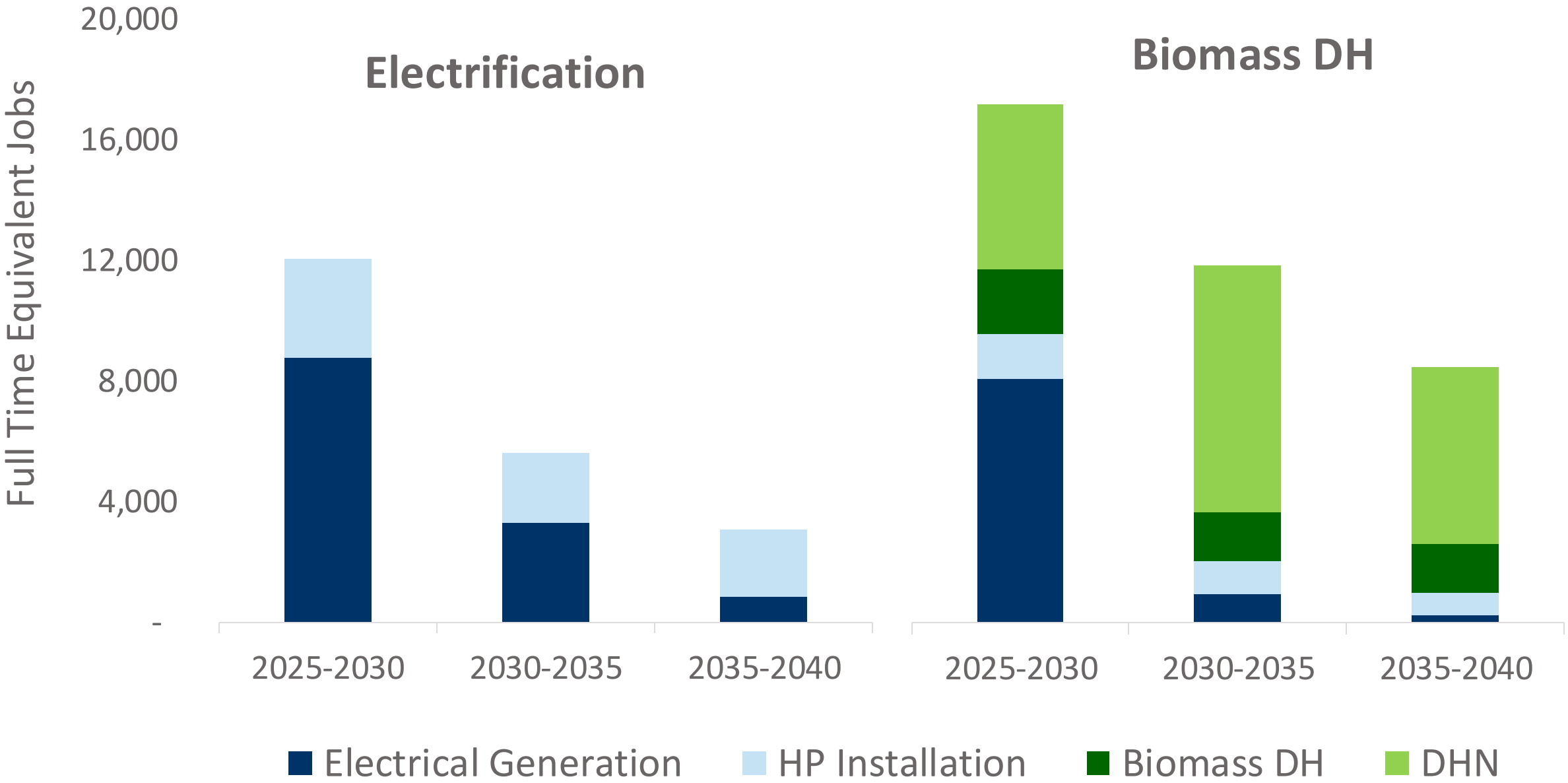


Fuel Cost Competitiveness

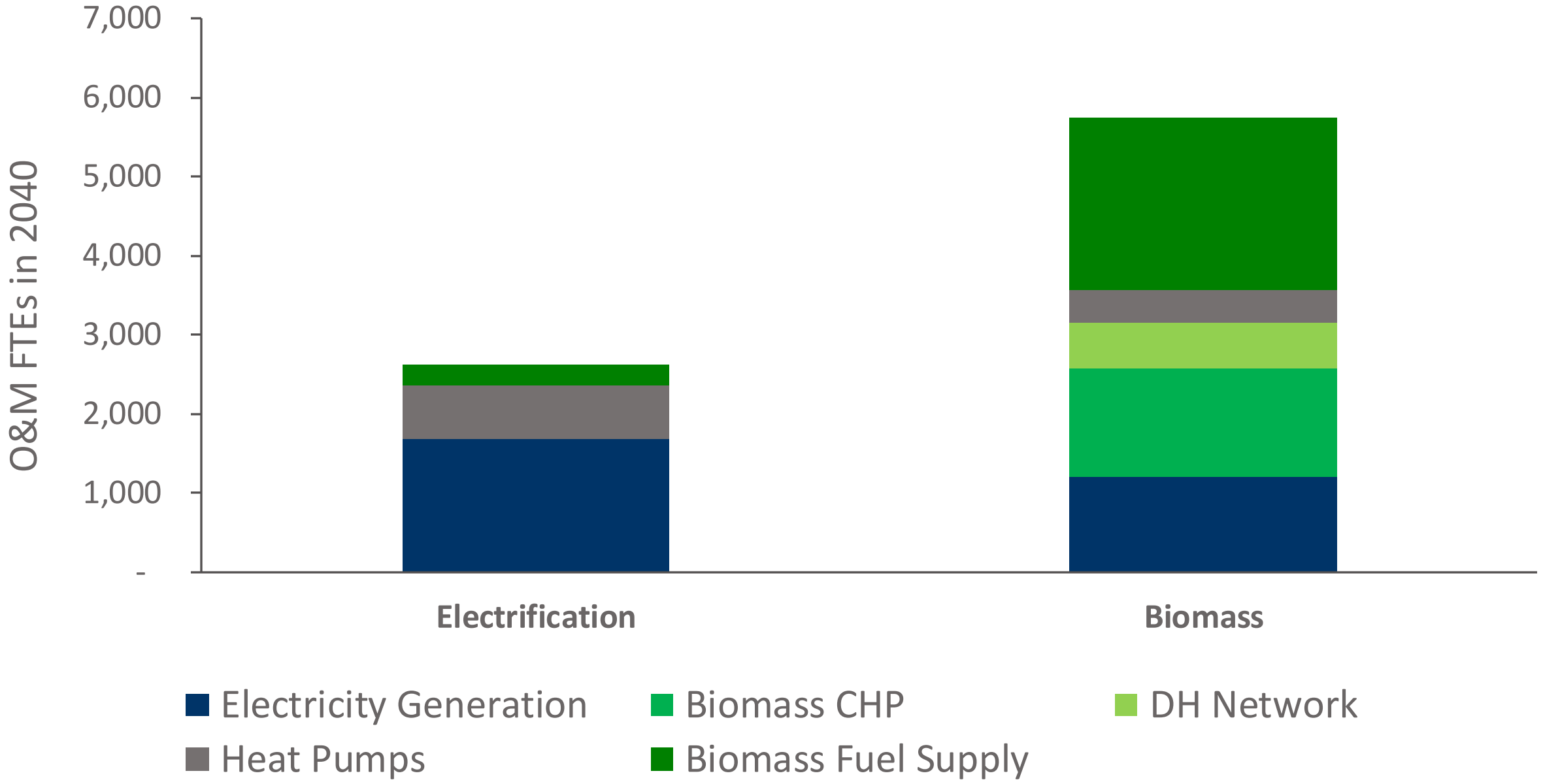
Energy Source	Price	$/GJ Heat
Heating Oil	$1.50/L	$50
Electricity^	$0.18/kWh	$50
Heat Pump*^	$0.082/kWh	$23
Natural Gas	$22/GJ	$26
Wood Biomass**	$75/tonne	$9
Wood Biomass CHP	$75/tonne	$1

*Assumes COP of 2.2 including electric DHW
**Excludes value of electricity co-generation

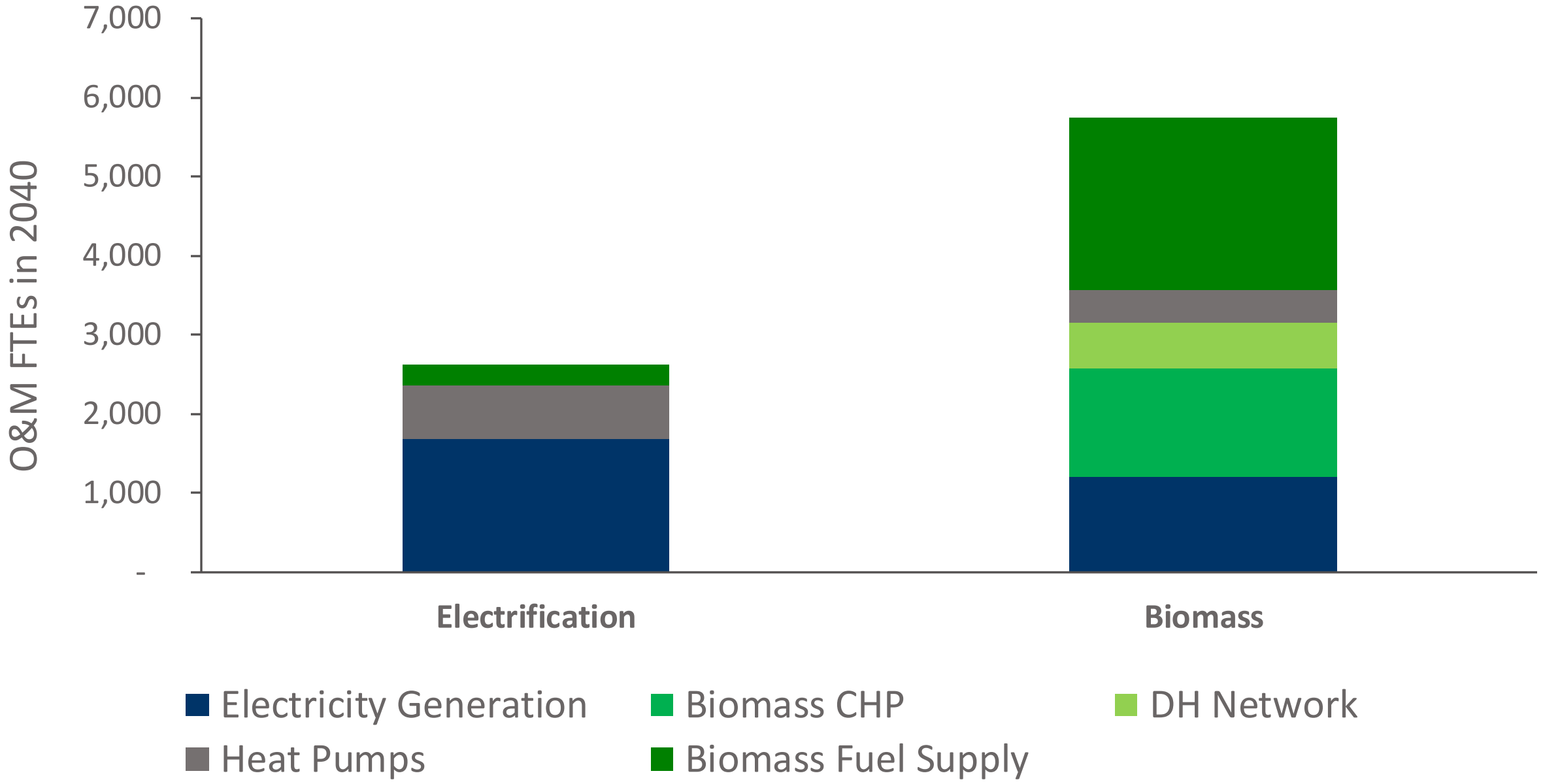
Construction Employment



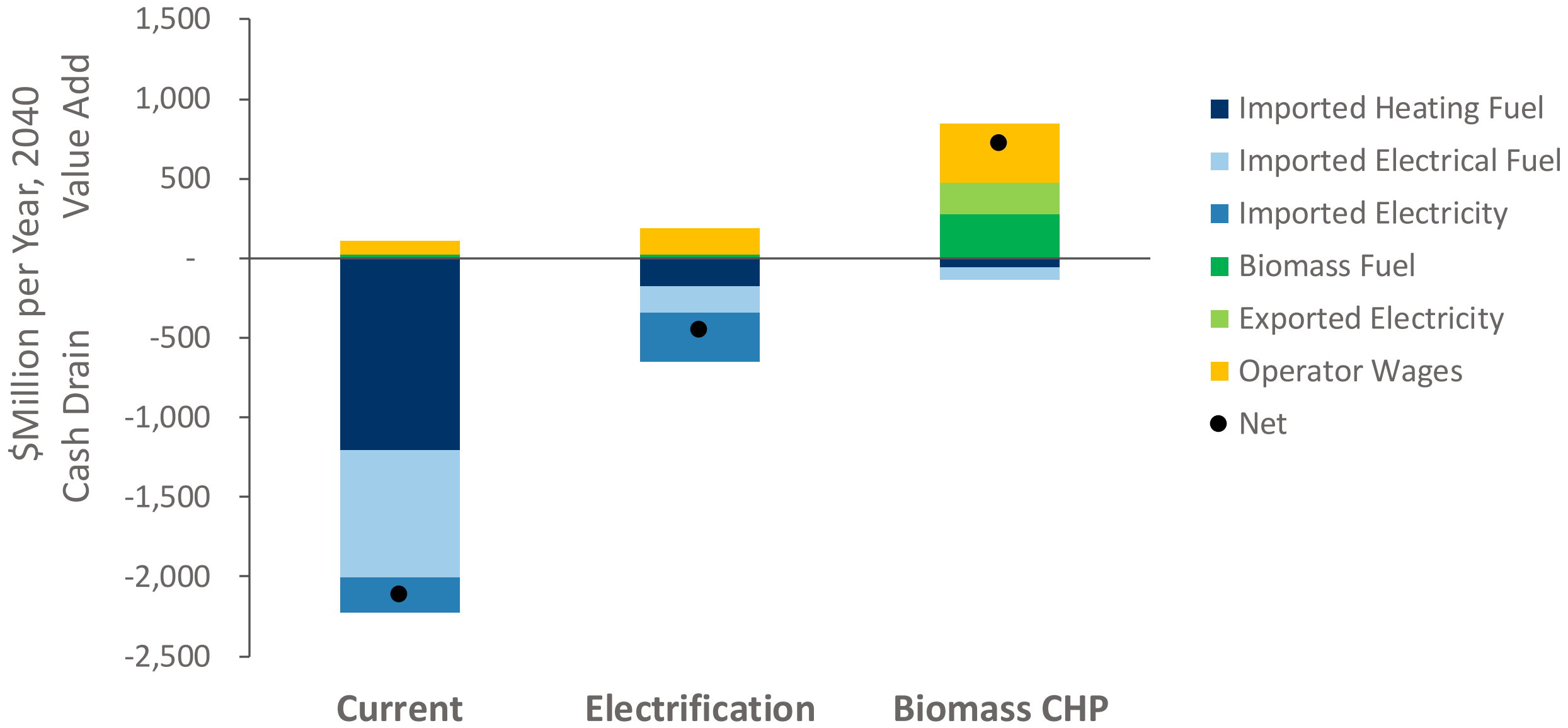
Permanent O&M Employment



Permanent O&M Employment



Macroeconomic Impact



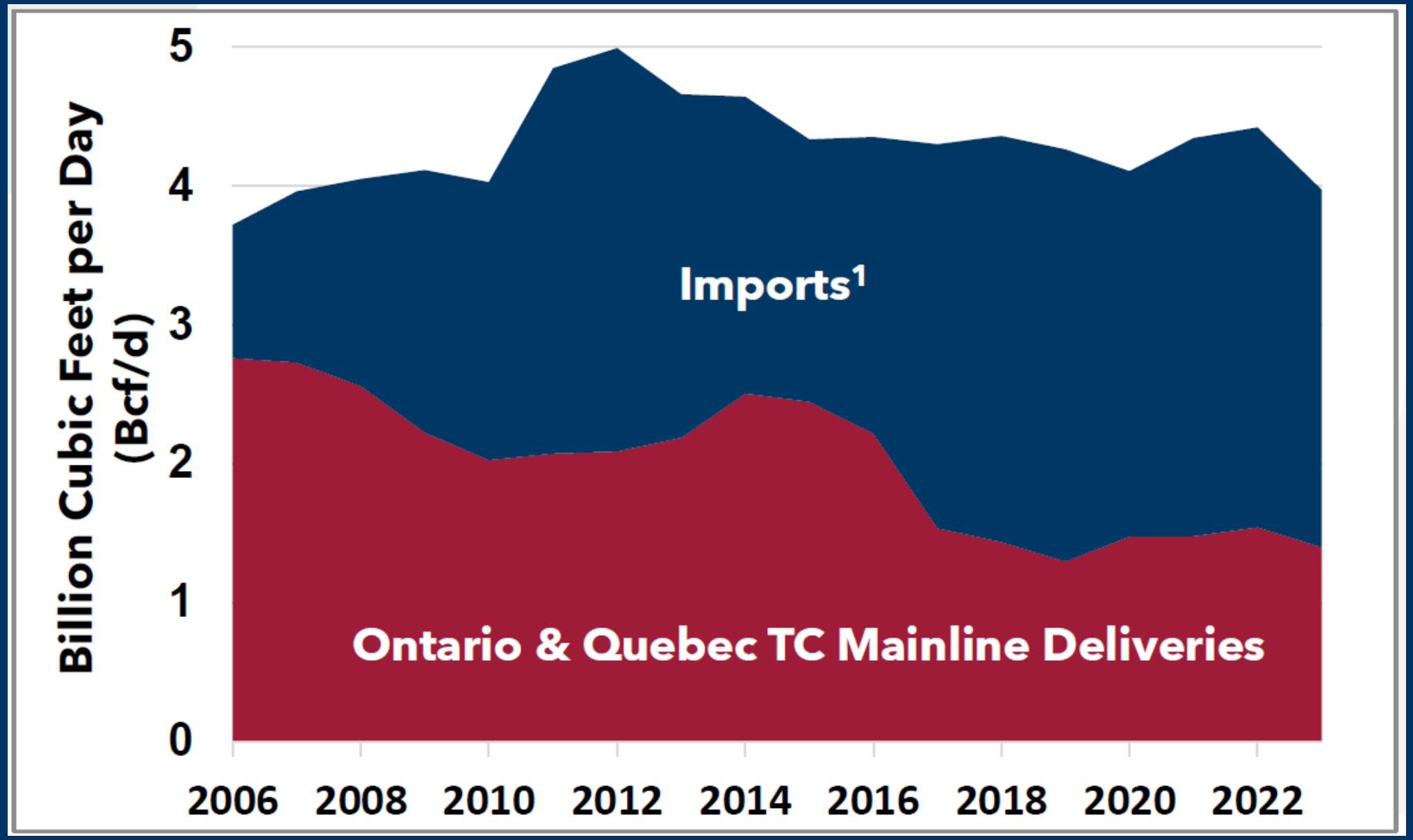
Realistic?

- CapEx of $8-9 B (~$550 M/y for 15 years)
- Annual CapEx < Annual Electrification Cash Drain
  - 2025-2030 baseline cash drain > total CapEx
- Pension fund equity capital, preferred debt
  - Multiple CA pension-fund owned DH owner/operators
- Cost of electricity generation competitive

Current Industrial Bioheat Consumers

Energy Security

ON/QC Import all their Gas. 2/3 via US



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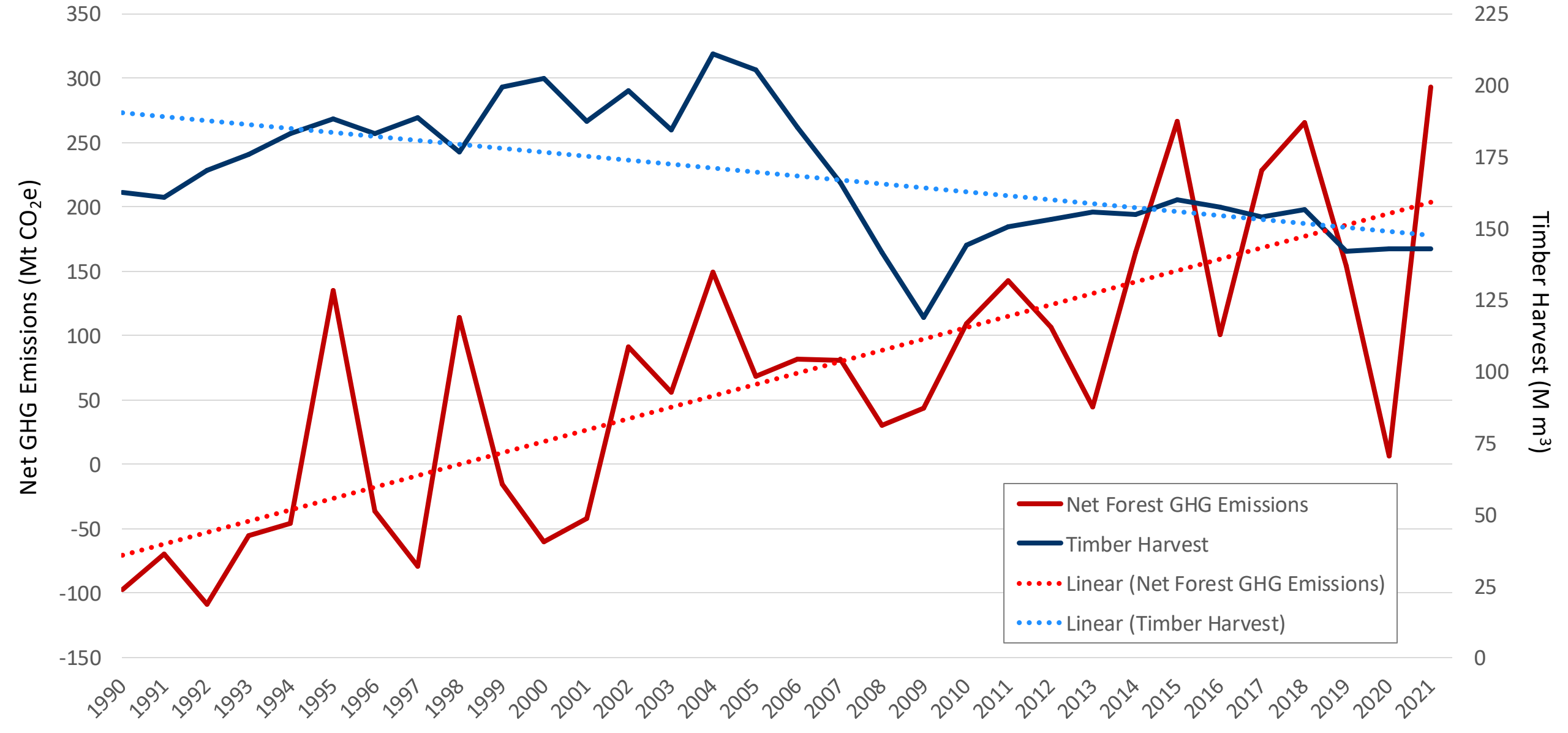
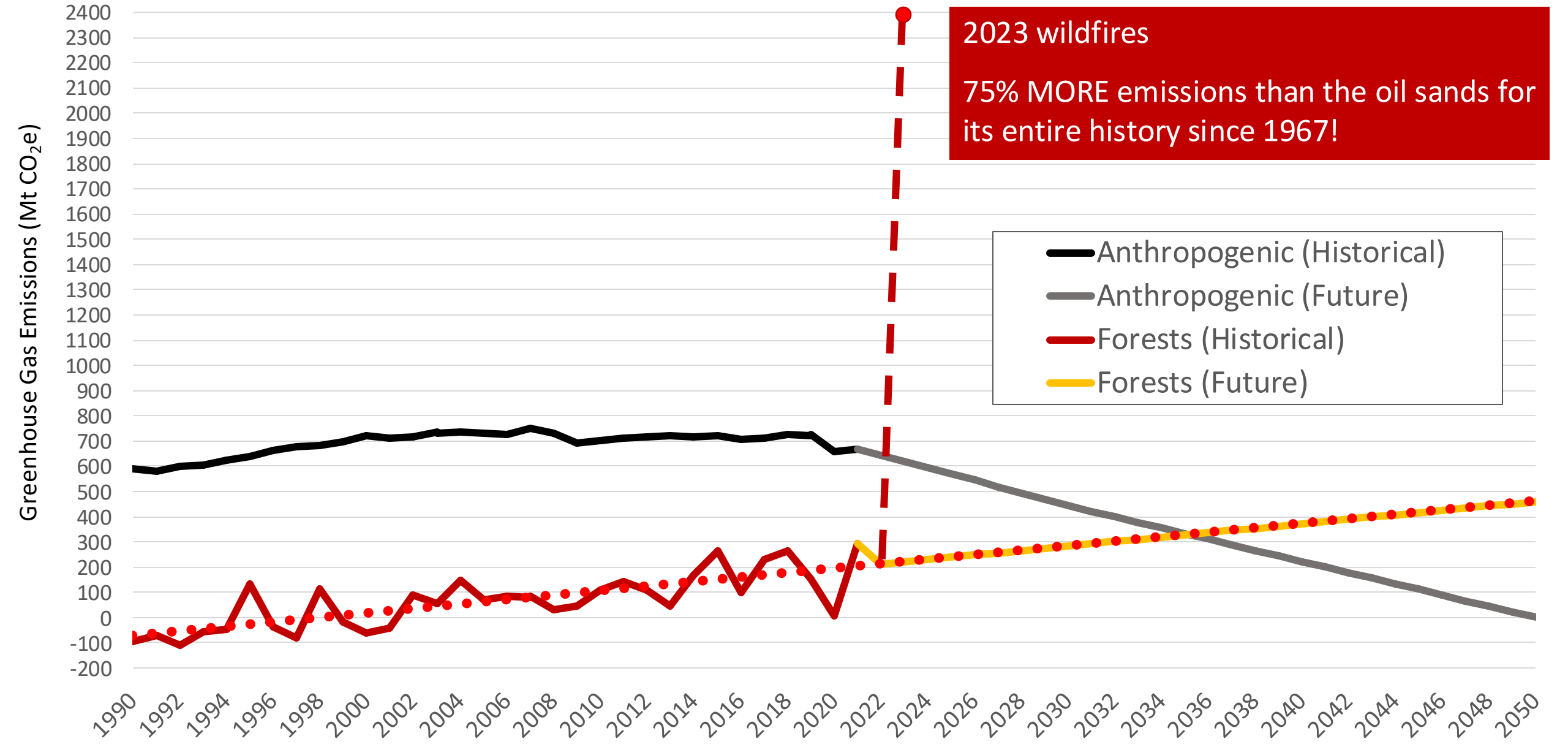
Wildfires
(and our real climate imperative)

GHGs from Canada's Forests Vs. Timber Harvest



Human Vs. Forest Emissions



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Public GHG Emissions

Public Air Pollution

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

Swedish rate in Canada & use for BECCS:

1 Gt CDR/y

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
- Active management requires a market for low-value, high-cost wood
- Carbon is NOT the only value to manage for

California Bootleg Fire 2021

Who Pays?

Active forest management generates large volumes of low-grade, high-cost wood

1. Provincial Taxpayers (taxes) – *Forest owners*

2. Provincial Energy Consumers (energy bills)

3. Provincial, National, and International Emitters (BECCS via carbon removal charge)

What is the Role for Wood Fuels?

1. Capacity (Dispatchable Power + Thermal Energy)
2. Biogenic CO_2 for BECCS
   - Domestic removals for consumer decarbonization
   - Exports that subsidize local energy consumption
3. Local Economic Activity & Energy Expenditures
4. Energy Security
5. Wildfire Mitigation

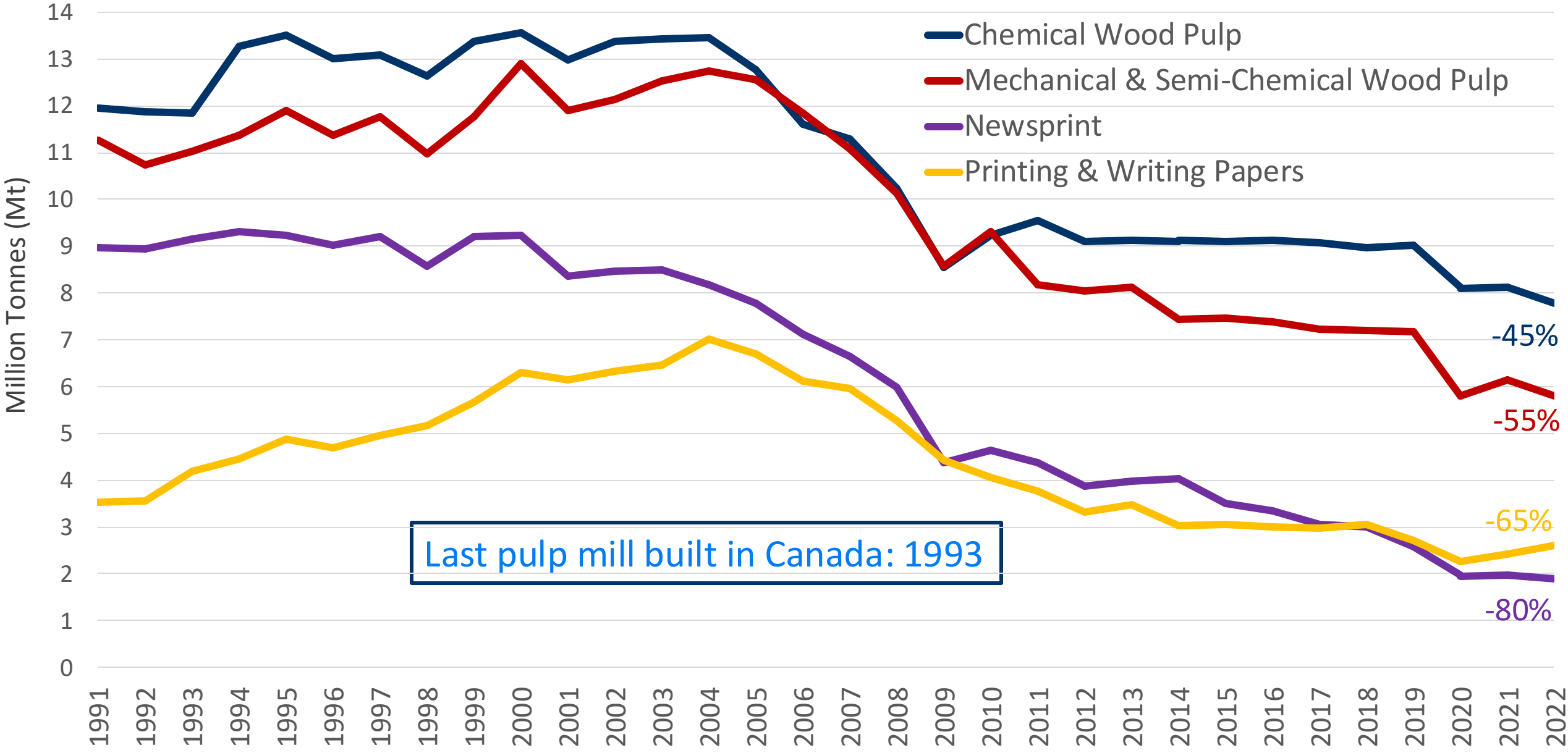
Local (Bio)Energy

The Foundation for Economic Success and Export Growth

TORCHLIGHT

Jamie Stephen, PhD
Managing Director
JStephen@TLBio.com

Canada's Pulp and Paper Production



Chemical Pulp Production Change, 1999-2022