Emission Reduction: Industrial Facility Power Strategies

Strategies and technologies to lower plant emissions

THE EMISSION EVOLUTION

Low Hanging Areas Of Emission Reduction In The Energy Sector

Low-Cost Emissions Reduction, Typically Methane

- Casing Gas
- Tanks
- Pneumatics conversion from instrument gas to instrument air
- Pressure envelope leaks
- Process Venting

The Next Tier of Reductions

- Combustion Emissions

COMBUSTION EMISSIONS REDUCTION OPTIONS

Driving The Trend To Lower Emissions

Balzac Power Station

Provincial vs Federal Regulations

Alberta's power sector heavily relies on fossil fuels, even with the move away from coal to natural gas. There are still a significant greenhouse gas emissions.

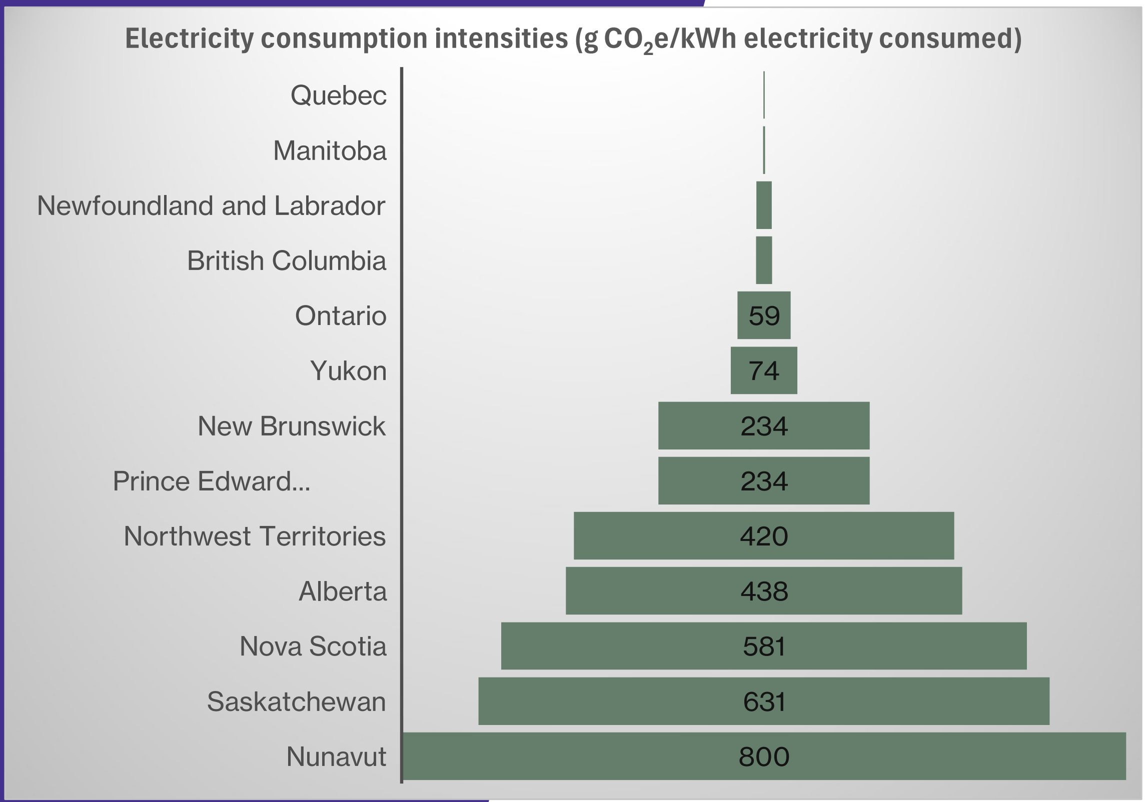
Urgency for Clean Energy Transition

Environmental and regulatory pressures are driving transition toward cleaner energy to meet climate targets and remain competitive.

Innovative Emission Reduction Technologies

Technologies like waste heat recovery and carbon capture offer pathways to reduce emissions and support sustainable energy production.

WHERE YOU OPERATE MATTERS



Emissions Per Horsepower on Natural Gas

VHP® Series Five L7044GSI S5 – 420g CO2e/bhp-hr

Most Efficient Thermal Power Rate

400 to 490 g CO2e/kWh

Running Compression on Power Grid in Alberta

Incorporating transmission loss (10%), 414 g CO2e/bhp-hr.

Running Compression on Power in BC

Incorporating transmission loss (10%), 17 g CO2e/bhp-hr.

Technology and Benefits of Waste Heat Recovery

Waste Heat Recovery

ORC Expansion Tank (Wellons)

Waste Heat Recovery Technology

Captures excess thermal energy from, particularly from turbines, exhaust to convert into usable energy improving efficiency.

Environmental and Economic Benefits

Reduces fuel consumption and greenhouse gas emissions while lowering operational costs and enhancing sustainability.

- Extracting usable energy from a ‘waste’ stream

- Pair with Organic Rankine Cycle (ORC) to further improve the over all thermal efficiency

Regulatory Alignment

While this supports Alberta’s provincial Tier program, currently credits are frozen at $95/tonne which presents head winds

Carbon Capture Strategies and Potential in Alberta

Carbon Capture Process

CCS captures carbon dioxide emissions from industrial sources before atmospheric release, reducing environmental impact.

Geological Storage Potential

Alberta's geological formations provide ideal sites for safe, long-term underground CO2 storage.

Innovations and Partnerships

Technological innovations and public-private partnerships accelerate CCS adoption and cost reduction.

Integration with Clean Energy

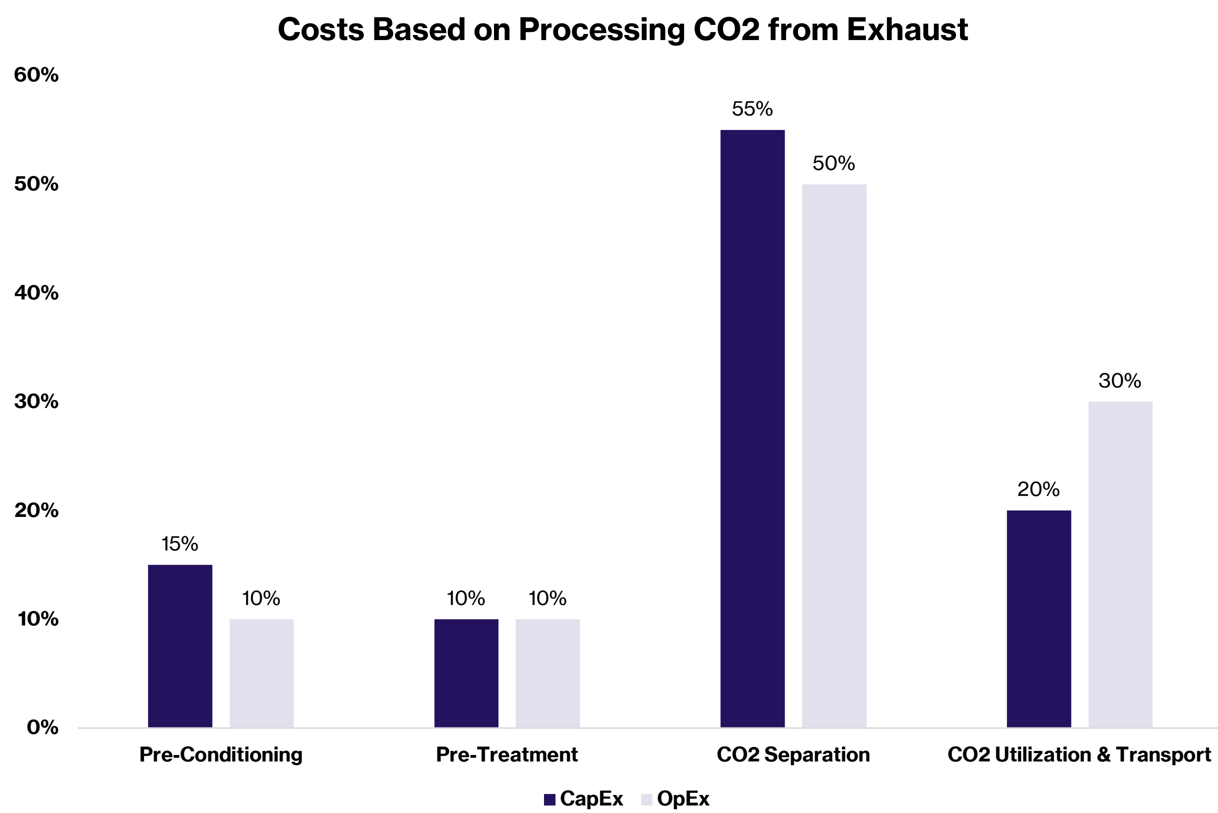
Combining CCS with waste heat recovery and renewables significantly lowers emissions from power generation.

COST TO TRANSPORT STATE =

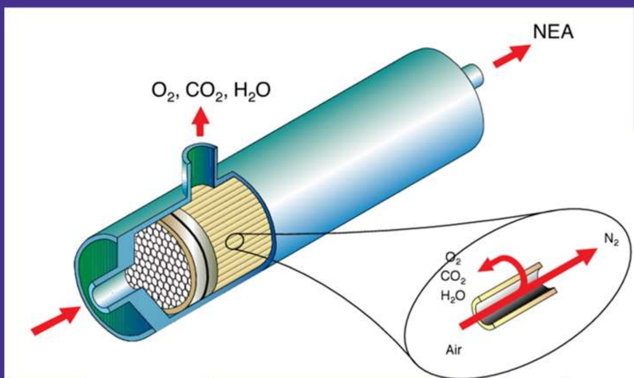
$15 / METRIC TON*

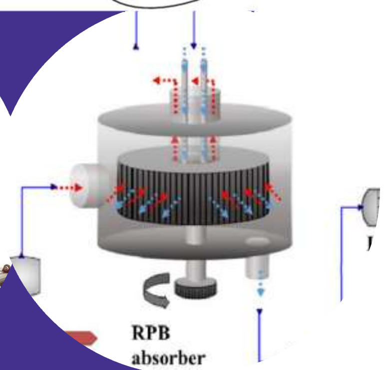
*Discharge scope, does not include well costs, assumes 10-year financing model with 12% interest

Cost CO2 Capture



Analysis of CCUS Sources





Amine Units

Simple treatment (water removal) and then compression for rather pure CO2. Roughly $15/tonne of CO2*

Other IP Based Capture Options

- Metal Organic Frameworks
- Capture as a Service
- Oxy-fuels and hydrogen to reduction NOx concentrations

Reciprocating Engines

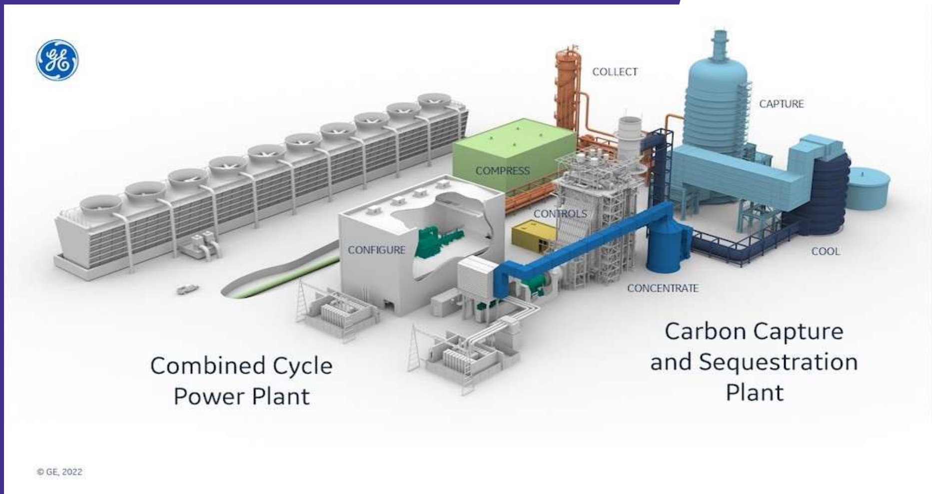
Depending on the rich or lean burn setup, there are applications of this on small scale and larger (amine). Ranges from $65 to $110/tonne of CO2*

Burners

We have seen boilers that run at 15% CO2 content in their emissions targeted in building and pulp and paper projects.

*Less costs for pipeline and injection we

Integrated Value Chain



Integrated Value Chains

- Northern Lights – European North Sea CO2 Sequestration with cement Clients (Shell/Equinor/TotalEnergies)
- Blue Spruce – Wyoming CO2/Natural Gas/ Helium development
- Google 400 MW Integrated Ethanol injection site with NGCC and CCUS
- BKV Midstream / Wolf Midstream offering midstream services for CO2
- Cenovus Enhanced Oil Recovery programs
- Occidental Permian CO2 EOR Program

Cost of Injecting CO2

Power Required

7.5 - 11 HP

Horsepower per metric ton

CapEx Cost

$140 - $170

USD per metric ton per year

Energy Consumption

165 - 200 kWh

Kilowatt-hours per metric ton

*Saturated CO2 processing, assumes roughly 1200 psig discharge at custody point, does not include well costs

Innovative Solutions Beyond Conventional Combustion

Combined Heat and Power Systems

CHP systems maximize energy use by producing electricity and thermal energy simultaneously from one fuel source. For large power generation CHP strong solution but presents regulatory hurtles for rapid approvals. In fenceline projects require prior planning or expensive retrofits.

Renewable Energy Integration

Renewable sources like wind, solar, renewable natural gas and hydro complement traditional power generation with zero emissions.

Alberta has limited hydro electric generation at only 1-3% (source; CER)

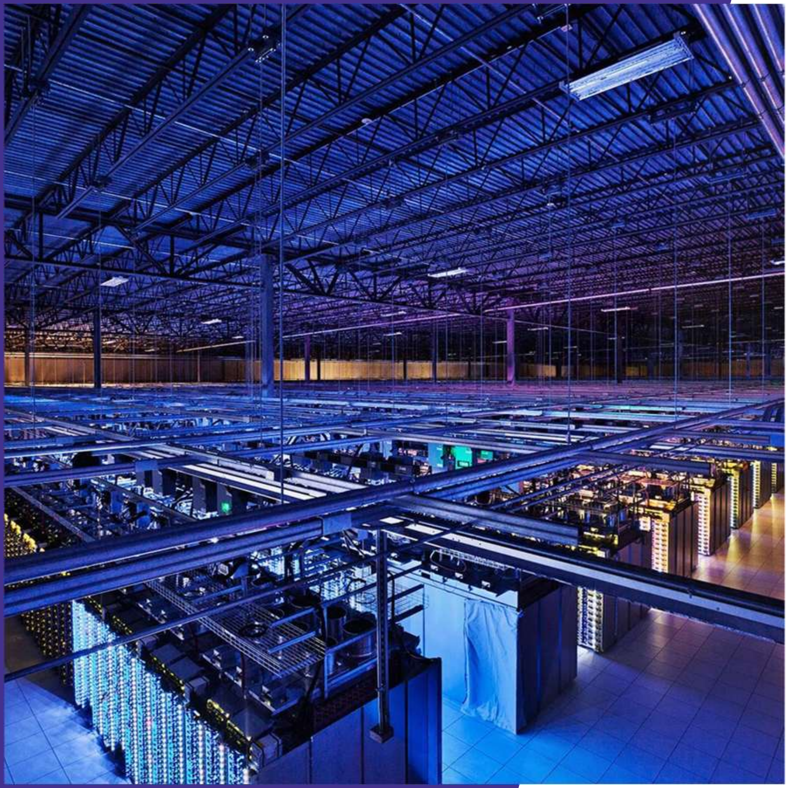
Advanced Turbine Technology

High-efficiency gas turbines reduce fuel consumption and emissions, enhancing energy generation efficiency.

Energy Storage Solutions

Battery storage balances energy supply and demand, supporting grid flexibility and reliability.

WHAT IS DRIVING DEMAND?



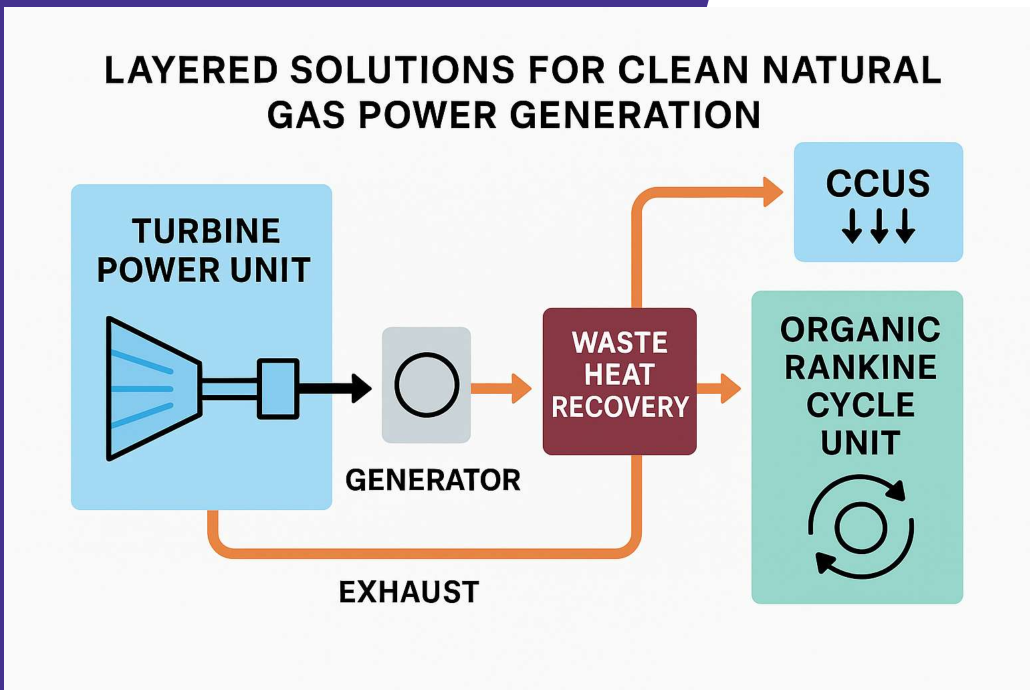
Power Demand Changes – Data Centre's

Power demand of data centre's

Year/Period	Estimated Consumption (TWh)	Notes/Context
2023	3–6	National estimate; 0.5–1% of total electricity use. Derived from regional studies including US data.
2023–2032	+4.1 (increase)	Quebec-specific projection from Hydro Québec's supply plan; reflects new data center connections.
2025	~5–9 (estimated)	Based on operational capacity of 0.75–1.4 GW (assuming ~80% load factor and 8,760 hours/year); aligns with 1% of national total. Capacity growth from 0.75 GW (2024) to 1.4 GW live (2025).
2030	~10–12 (projected)	National estimate extrapolated from capacity growth (e.g., IT load reaching 3.13 GW in 2025, CAGR ~5% to 2030) and global IEA trends (doubling of data center demand).
2035	~15+ (partial)	Ontario-specific: 8.4 TWh projected (4% of provincial demand); national total higher when including other provinces.

Google has now signed a deal for 400MW natural gas power gen with carbon capture. First major to do so.

How Do We Layer In These Solutions?



For natural gas power generation:

- Goal is to increase the overall thermal efficiency by using waste heat recovery and ORC
- Offset other heat users point source emissions
- High efficiency turbines and operating at efficiency point (loaded properly)
- Carbon Capture for CCUS or EOR

Capital Deployment – The Dollars & Cents Of It

Power Generation vs Grid Connection

Cost of fuel and capital to build *vs* long term agreements and time to bring the power lines to site

The upside of Carbon Capture

Tax incentive

Possible 'deal' requirements

Layering in Technologies

ORC can offset some of the power needs for CCUS

CCUS has ~ 30% parasitic load on the system

Technologies like waste heat recovery and carbon capture offer pathways to reduce emissions and support sustainable energy production.

Generation Costs With Waste Heat Recovery


Turbine unit (Solar Turbines)

Power Generation Costs

Cost depend on region and individual client needs but have been hovering around $ 1,800 / kW to $2,500 / kW

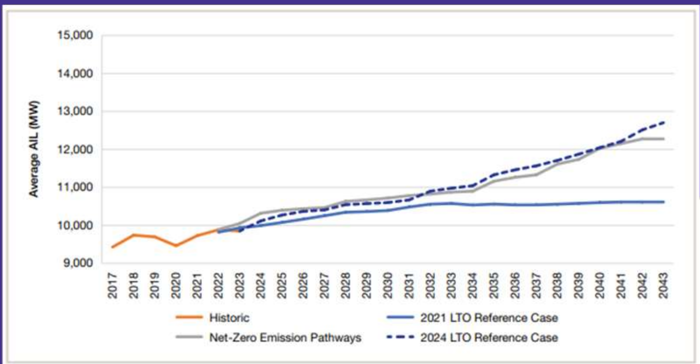
Waste Heat Recovery

Hot Oil WHRC unit install costs have been seen at $425 - $550 / kW

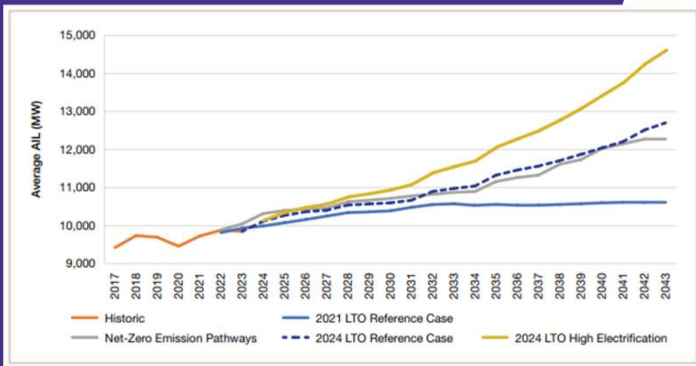
Other considerations

- Additional user groups
- Maintenance and back ups
- Reduction of other fuel gas users

Summary – Demand Vs Cost



2024 AESO Reference Case



2024 AESO High Electrification Case

Demand is set to increase in the next 20 years

Alberta's expected demand could increase by 1.2% yearly according to AESO for the reference case.

If the High Electrification case is applied and could require ~45% total increase by 2043 or nearly double the reference case

Increased demand will push cost / kWhr up

Regulations require emission reduction and therefore, to meet demand layering of these emission reduction actions are critical

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Project Development and Execution

Carbon Capture, Utilization & Storage

Power Generation

Natural Gas Processing

Industrial Gas Processing