TRADE COMMISSIONER SERVICE

Oil & Gas Industry Training

March 7, 2024

CRIN
Clean Resource
Innovation Network

PTAC
PETROLEUM TECHNOLOGY
ALLIANCE CANADA

AGENDA

9:00 AM EST	Introduction & Land Acknowledgement	Jordan Reeves, Export Sectors and High-Intensity Services Bureau, Global Affairs Canada
9:05 AM EST	Global Outlook	Marc Godin, Director of Technology, PTAC
9:25 AM EST	Regulations & Incentives	Lindsay Campbell, Senior Advisor Carbon Strategies, Validere
9:40 AM EST	Q&A	Marc Godin and Lindsay Campbell
9:45 AM EST	Energy Transition Innovation Ecosystem in Canada Key technology participants and areas	Glen McCrimmon, CRIN, Soheil Asgarpour, past CRIN Methane Theme Lead
10:30 AM EST	Reference Tools	Glen McCrimmon, CRIN
10:40 AM EST	Break	
10:50AM EST	Canadian Energy CleanTech Directory Overview	Bruce Peachey, Senior Technology Advisor, PTAC
11:50AM EST	Closing Remarks	Global Affairs Canada
12:00PM EST	Adjournment	

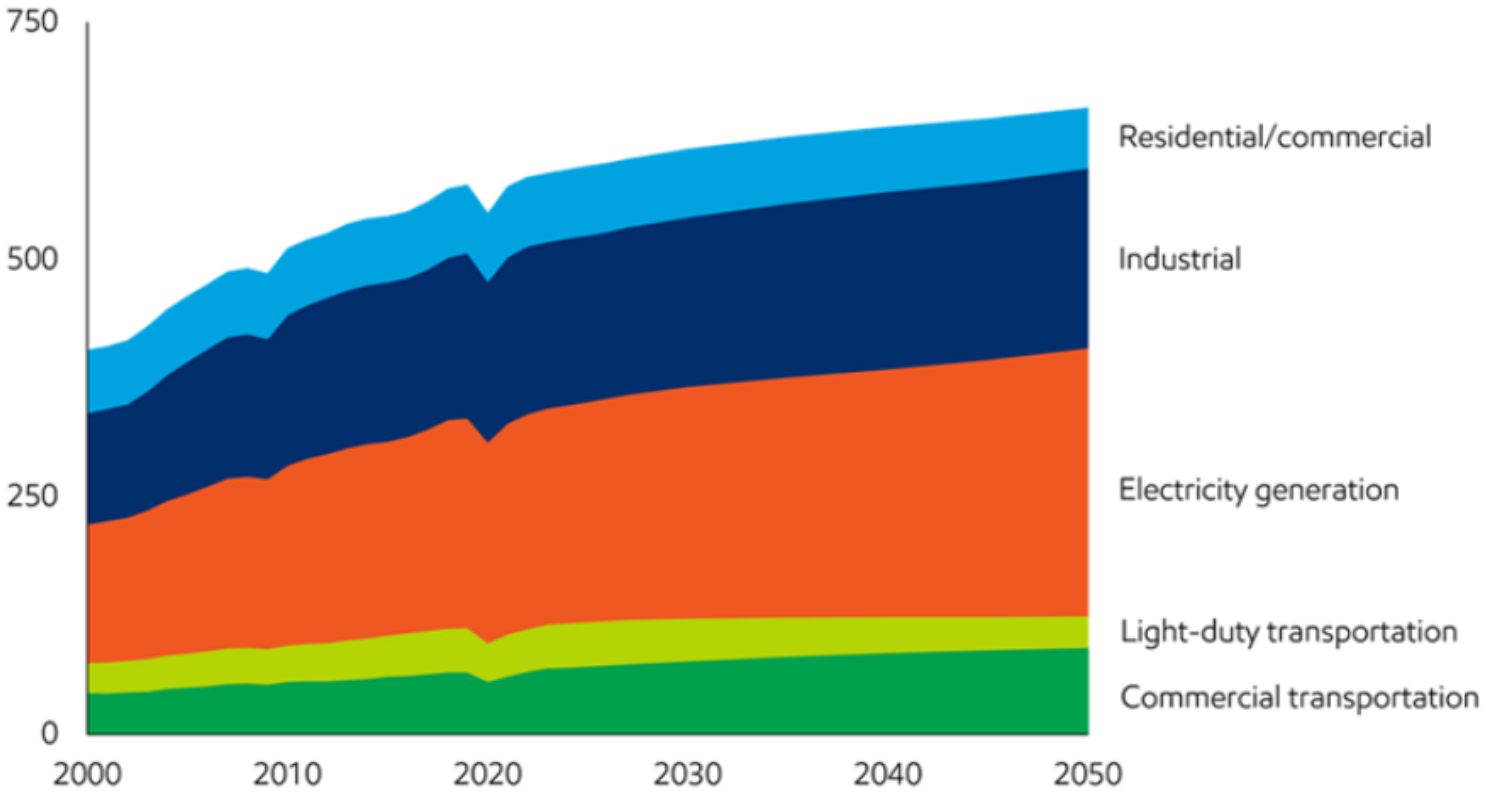
Global Outlook

Global Energy Perspectives
Transition to Net-Zero

Marc Godin, Director of Technology, Petroleum Technology Alliance Canada

Global Energy Demand by Sector

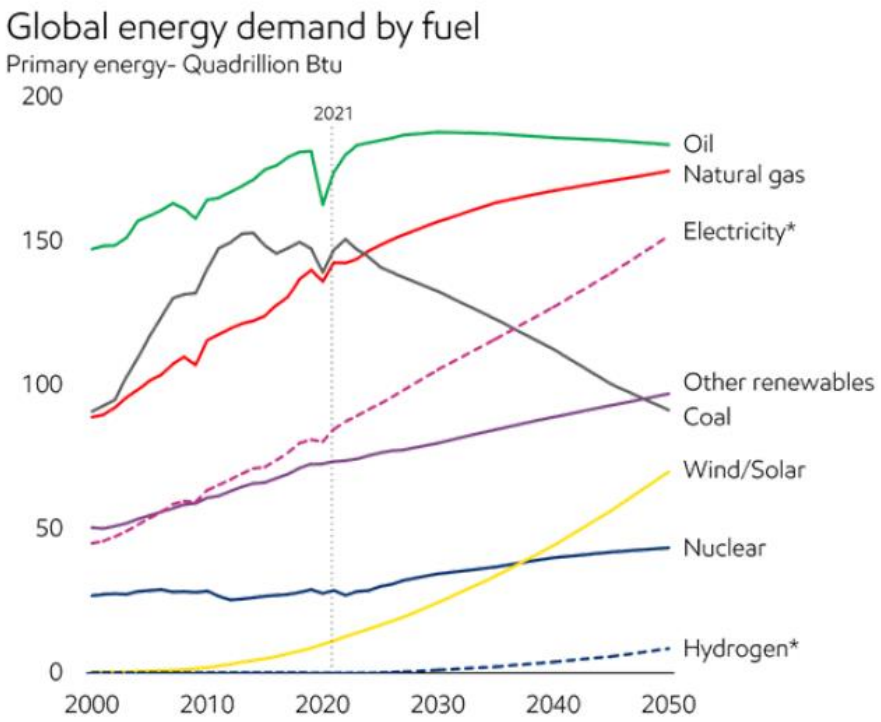
Primary energy – Quadrillion Btu

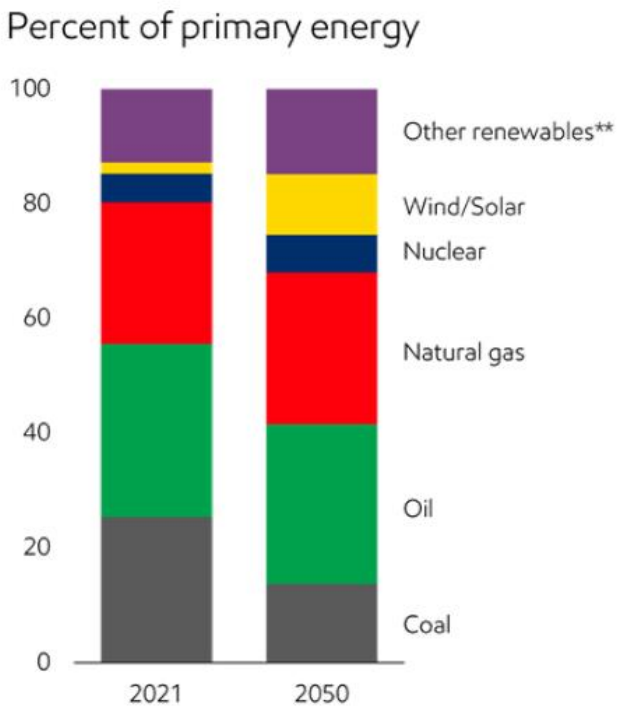


Growth 2021-2050

Source: ExxonMobil

Global Energy Demand by Fuel





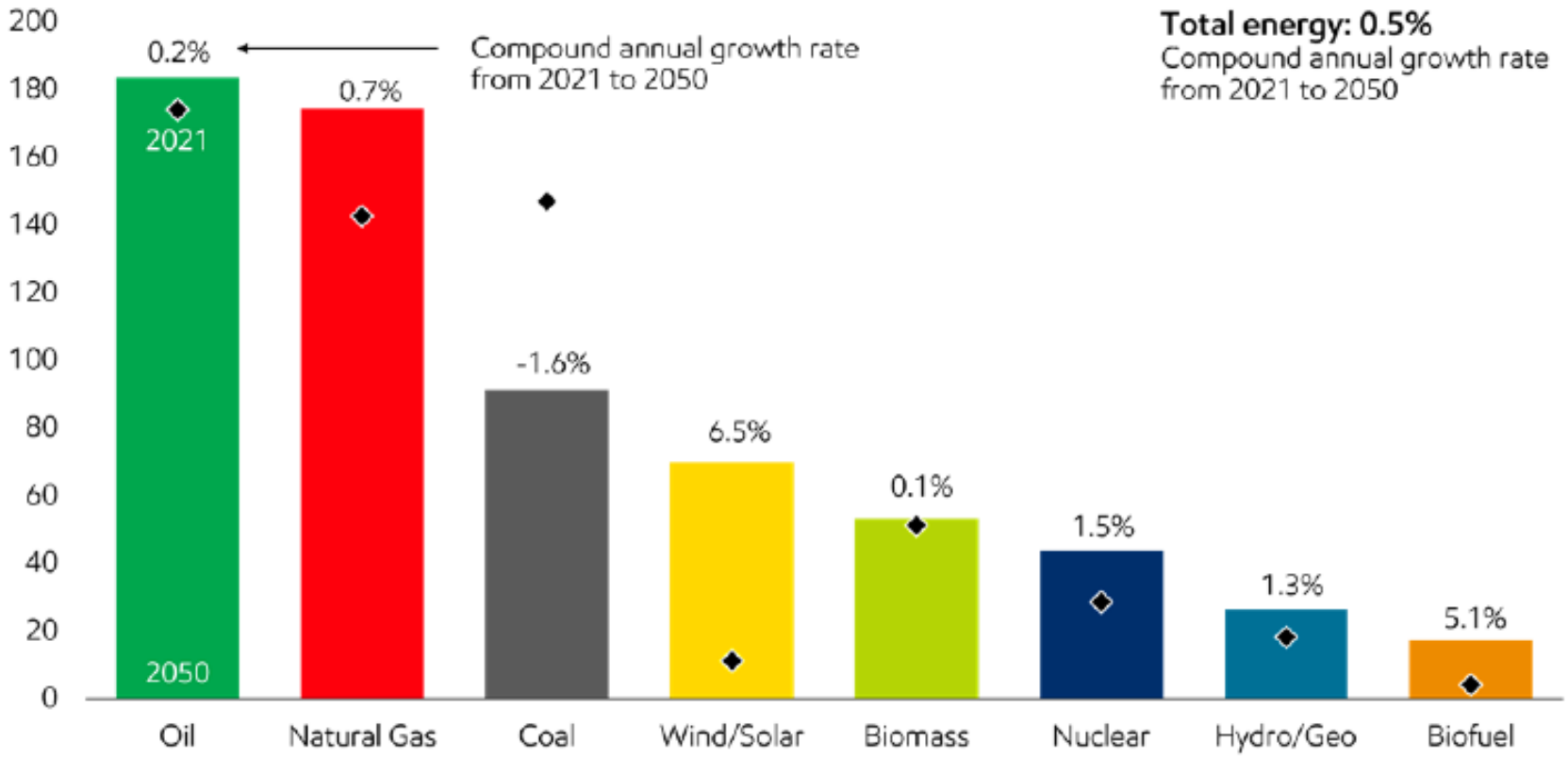
* Electricity and Hydrogen are secondary energies derived from the primary energies shown

**includes biomass, biofuels, hydropower, geothermal

Source: ExxonMobil

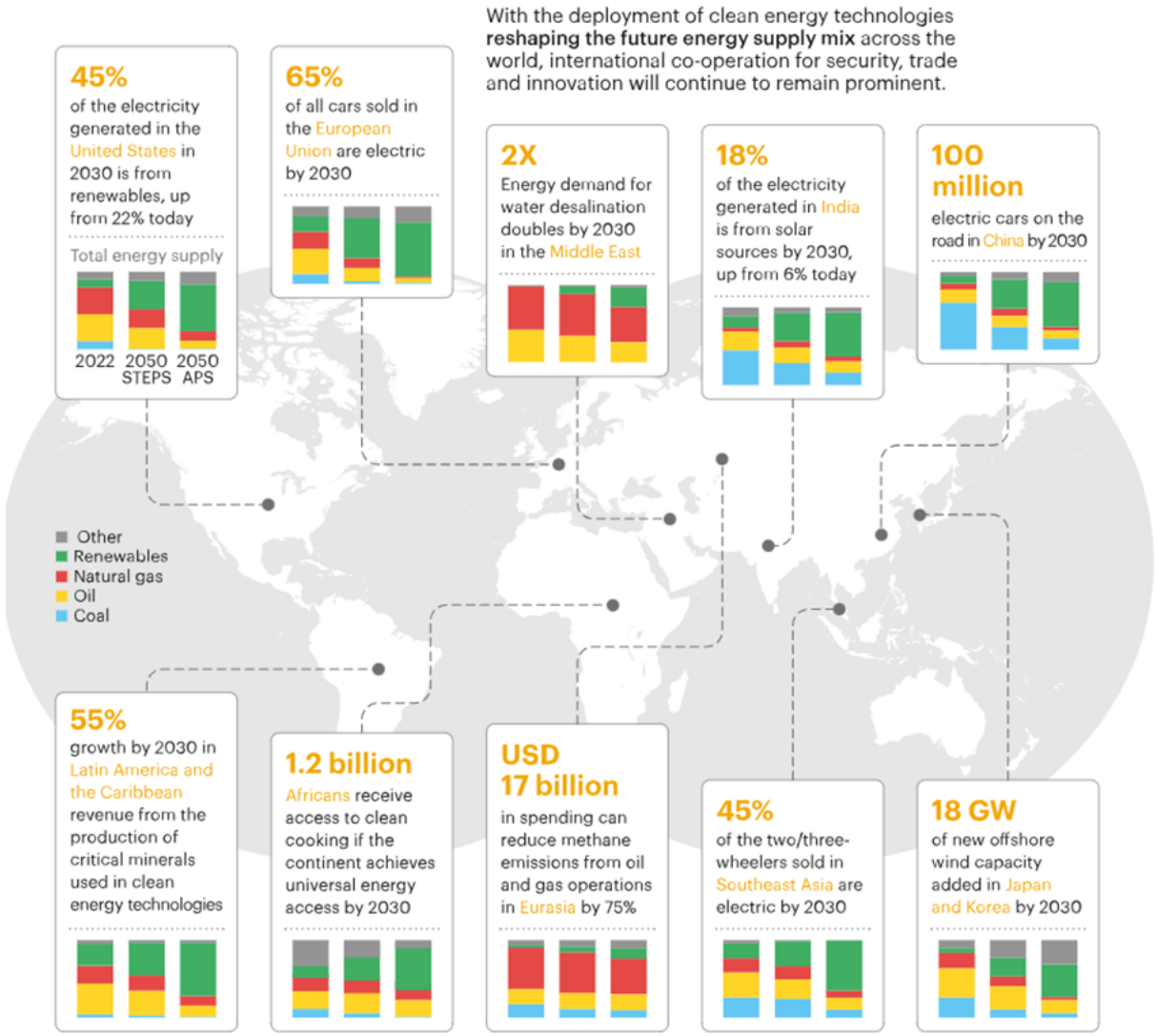
Global Energy Supply Evolves to Meet Demand Projections

2050 global demand by fuel – Quadrillion Btu



Source: ExxonMobil

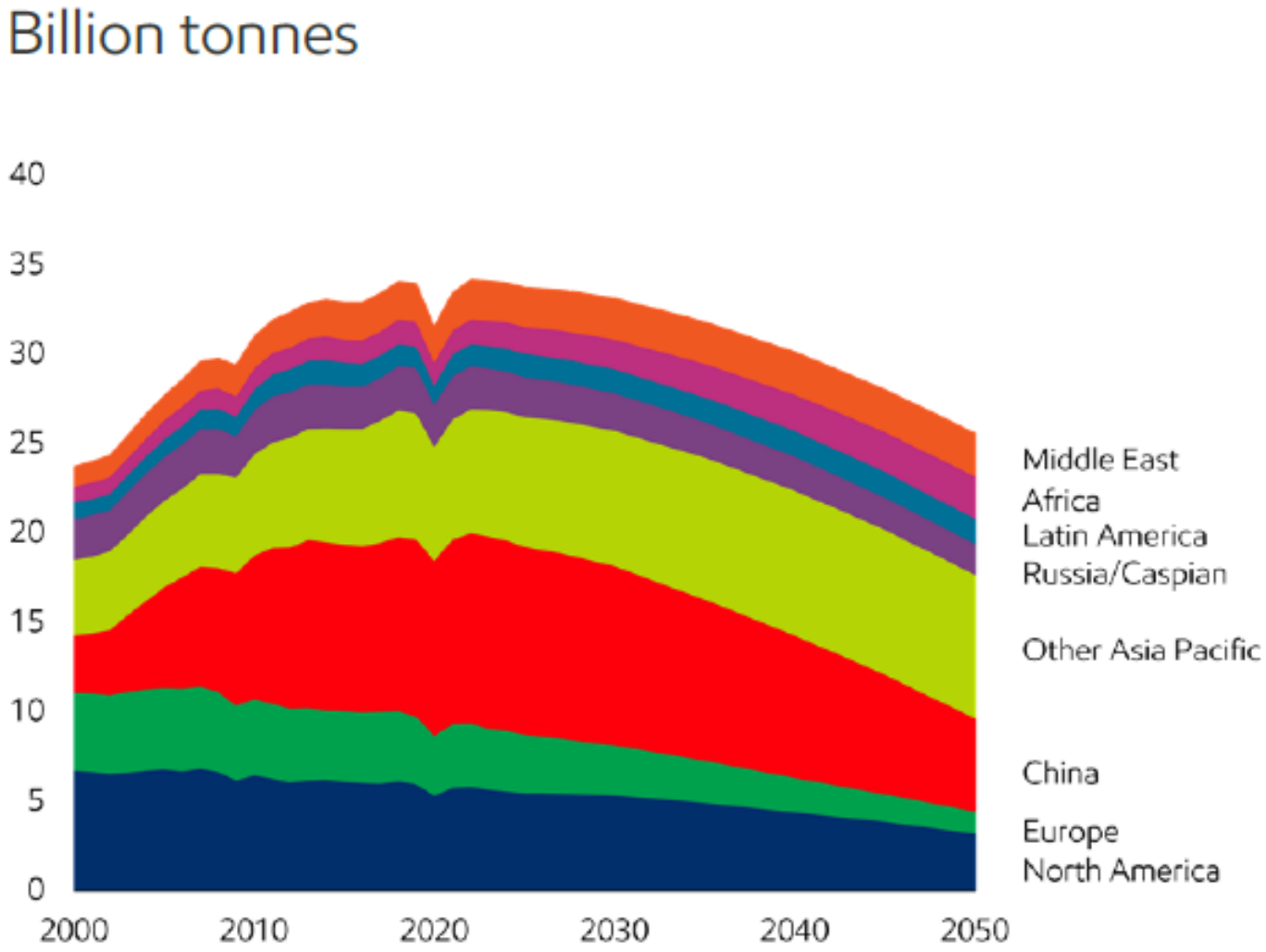
Global Deployment of Clean Energy Technologies



- Developing countries such as India and China still rely on coal.
- Developed nations no longer rely on coal as a major fuel source.

Source: IEA

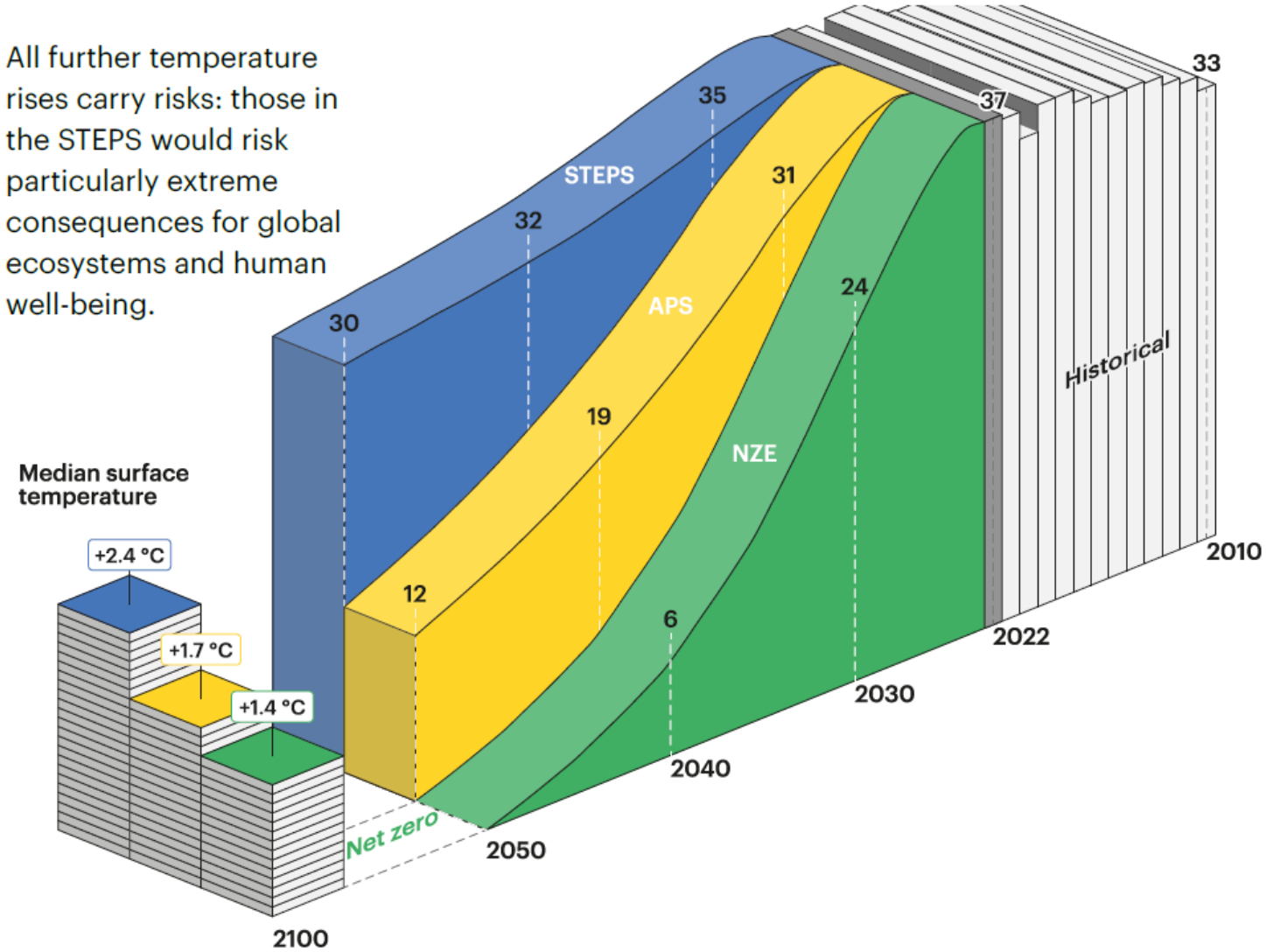
Energy-Related Co2 Emissions Peak



- To reach global climate targets, developed nations such as Canada will have to support emissions reduction and energy transition in developing countries through sharing/exporting technology and innovation

Source: ExxonMobil

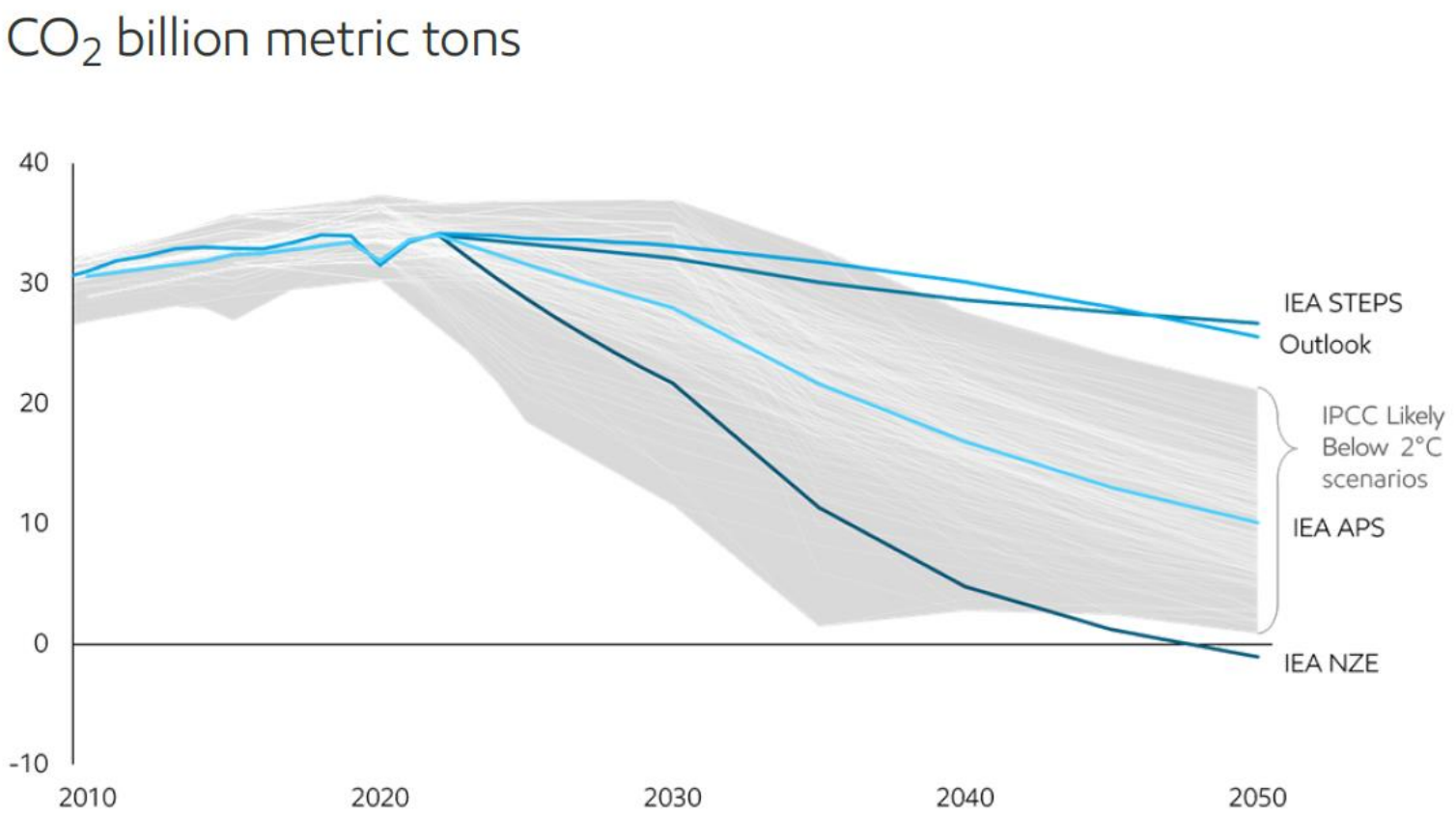
Climate Change Required Trajectories



- IEA STEPS: Stated Policies Scenario
- IEA APS: Announced Pledges Scenario
- IEA NZE: Net zero CO2 emissions by 2050, consistent with limiting the global temperature rise to 1.5 °C , in line with emissions reductions assessed in the Intergovernmental Panel on Climate Change (IPCC).

Source: IEA

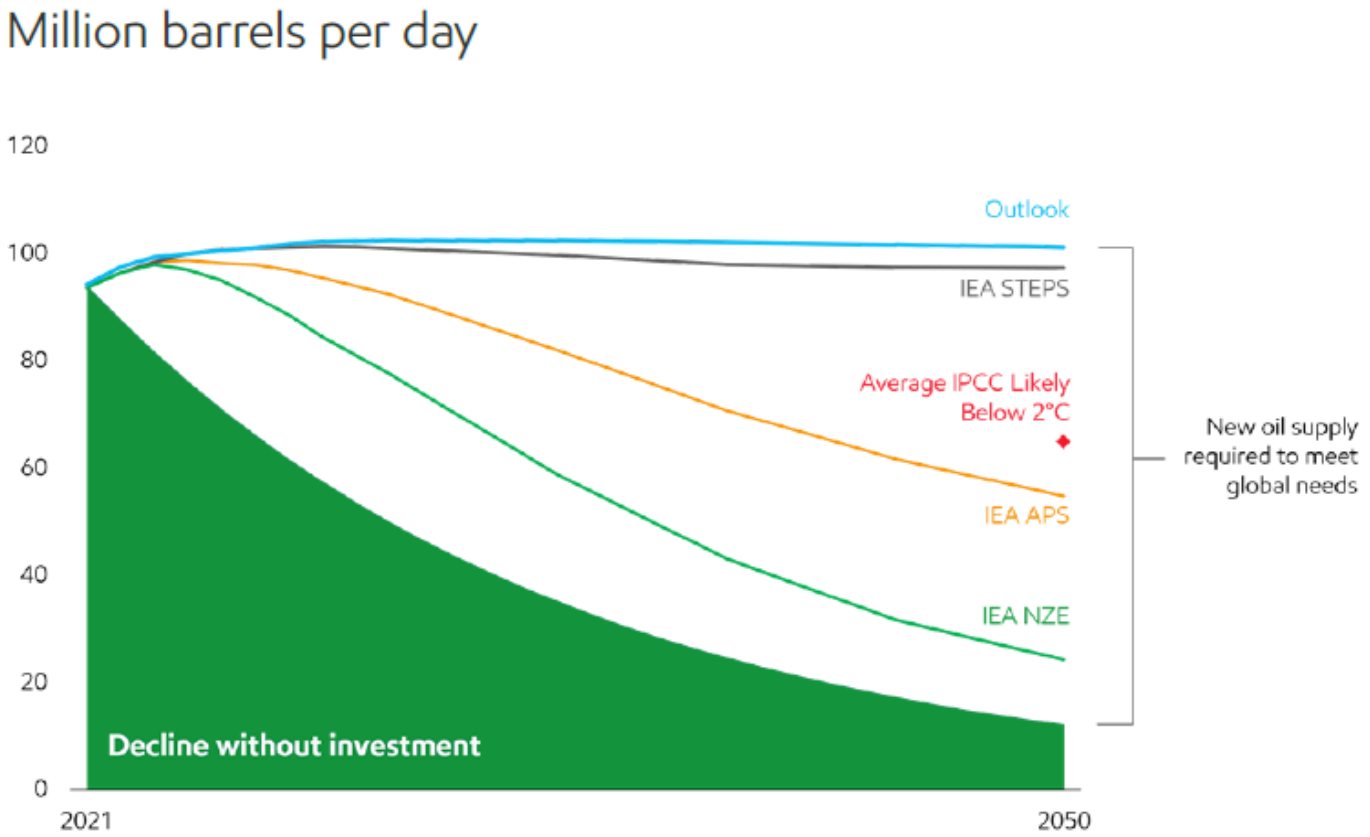
Range of Potential Outcomes



Source: ExxonMobil 2023 Global Outlook, IEA World Energy Outlook 2023, IPCC Sixth Assessment Report

Source: ExxonMobil

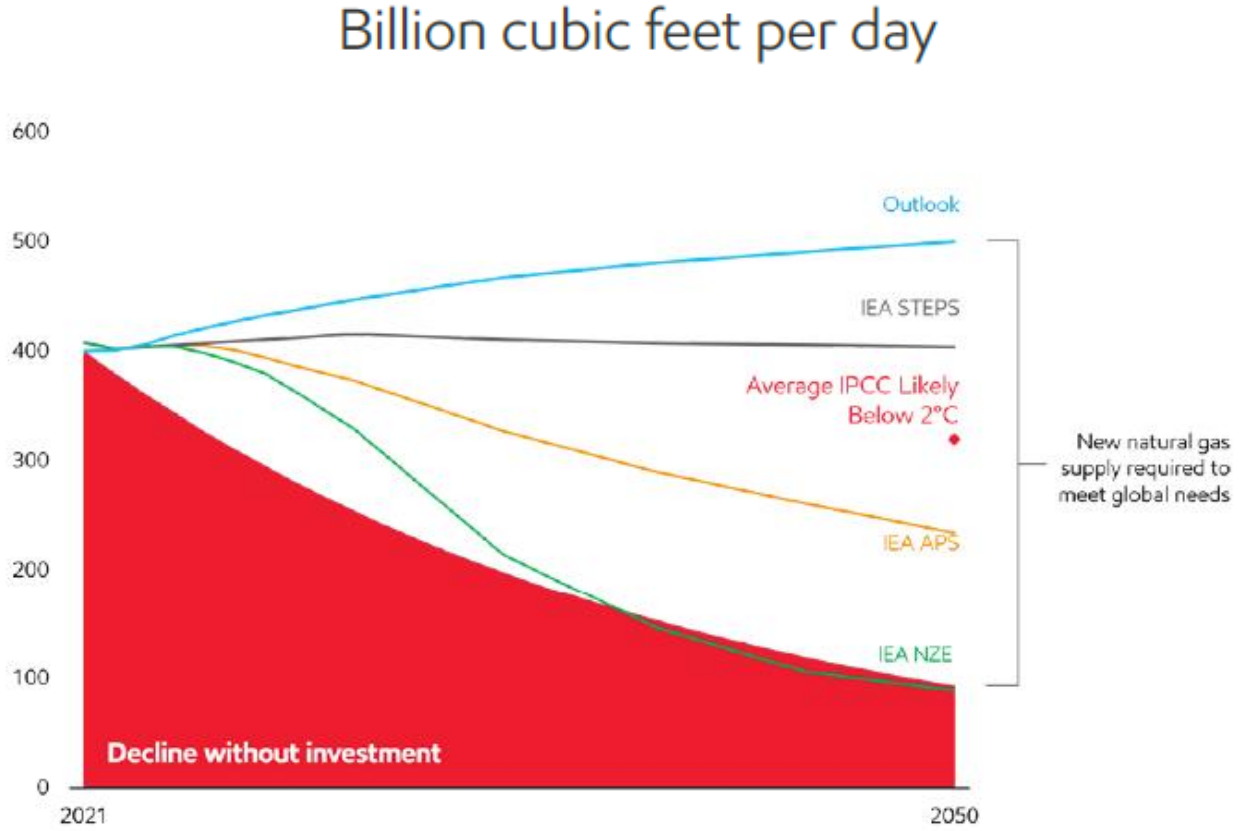
Potential Outcomes – Global Oil Supply



Source: 2023 IEA World Energy Outlook; IPCC: AR6 Scenarios Database hosted by IIASA release 1.0 average IPCC C3: "Likely Below 2°C" scenarios; ExxonMobil Analysis

- With steady global demand for oil and gas, countries with untapped oil reserves can utilize Canadian clean tech for CO2 abatement, lower production costs and enhanced oil recovery (ex. Guyana).

Global Potential Outcomes – Global Natural Gas Supply

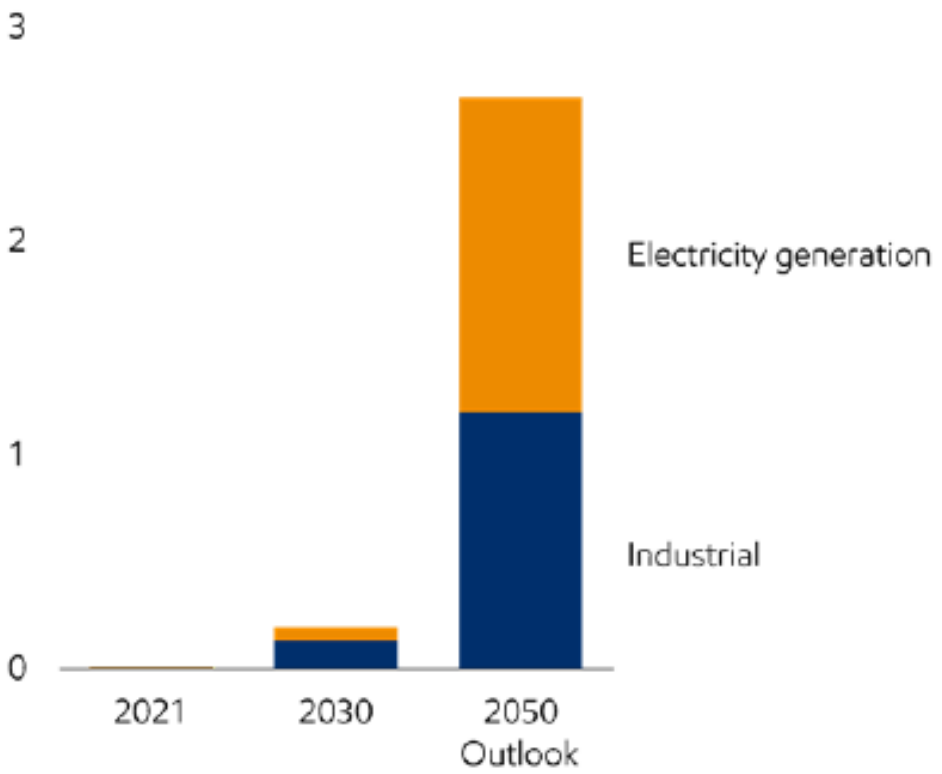


Source: 2023 IEA World Energy Outlook; IPCC: AR6 Scenarios Database hosted by IIASA release 1.0 average IPCC C3: "Likely Below 2°C" scenarios; ExxonMobil Analysis

Future Growth - CCUS

Carbon capture and storage

Billion tonnes per year

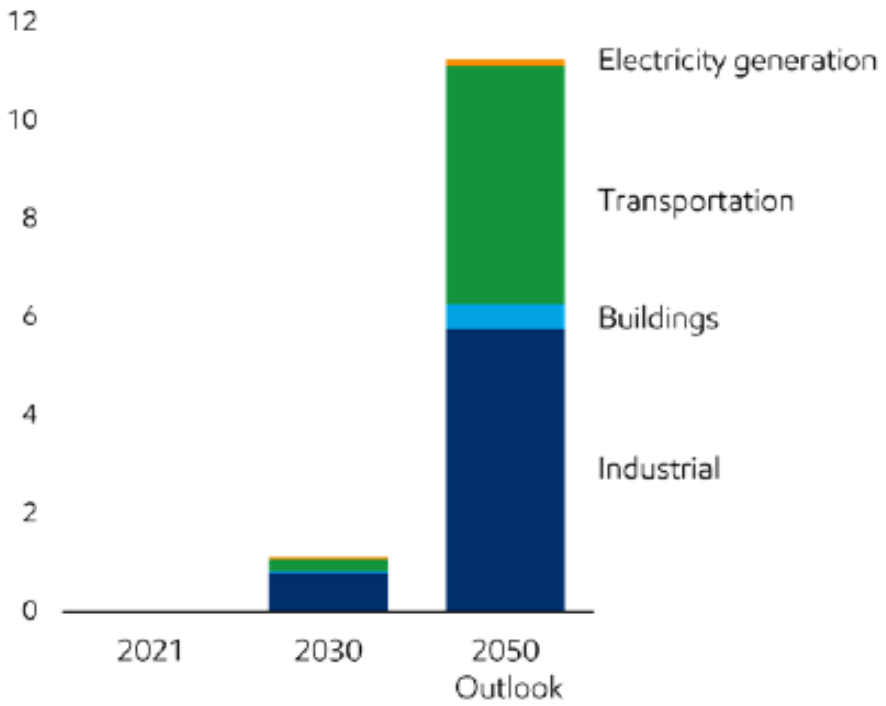


Source: ExxonMobil

Global Energy Demand by Sector

Hydrogen-based fuel use

Quadrillion Btu

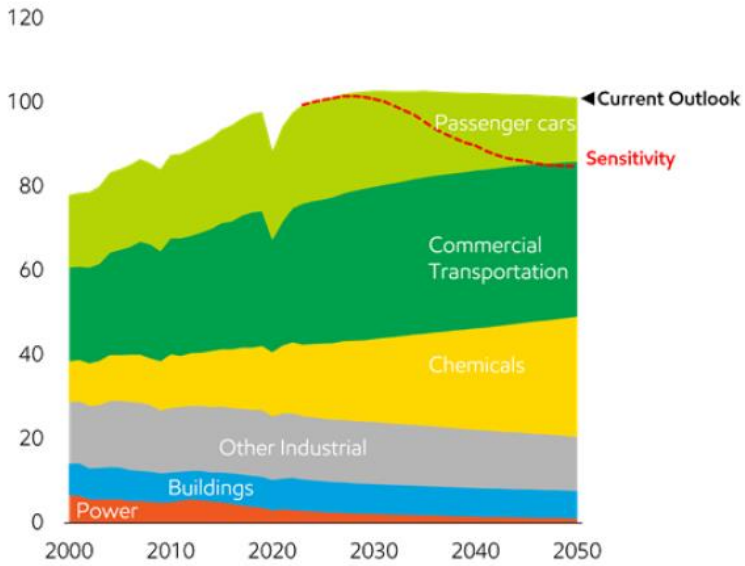


Source: ExxonMobil

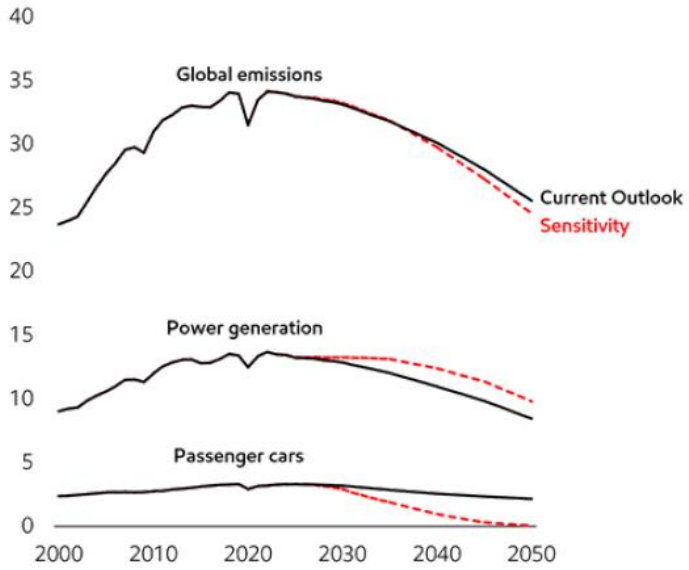
Impact of Battery Electric Vehicles

Light duty fuels demand sensitivity: 100% BEV sales in 2035

Oil ex biofuels demand back to '10 levels in sensitivity
MBDOE

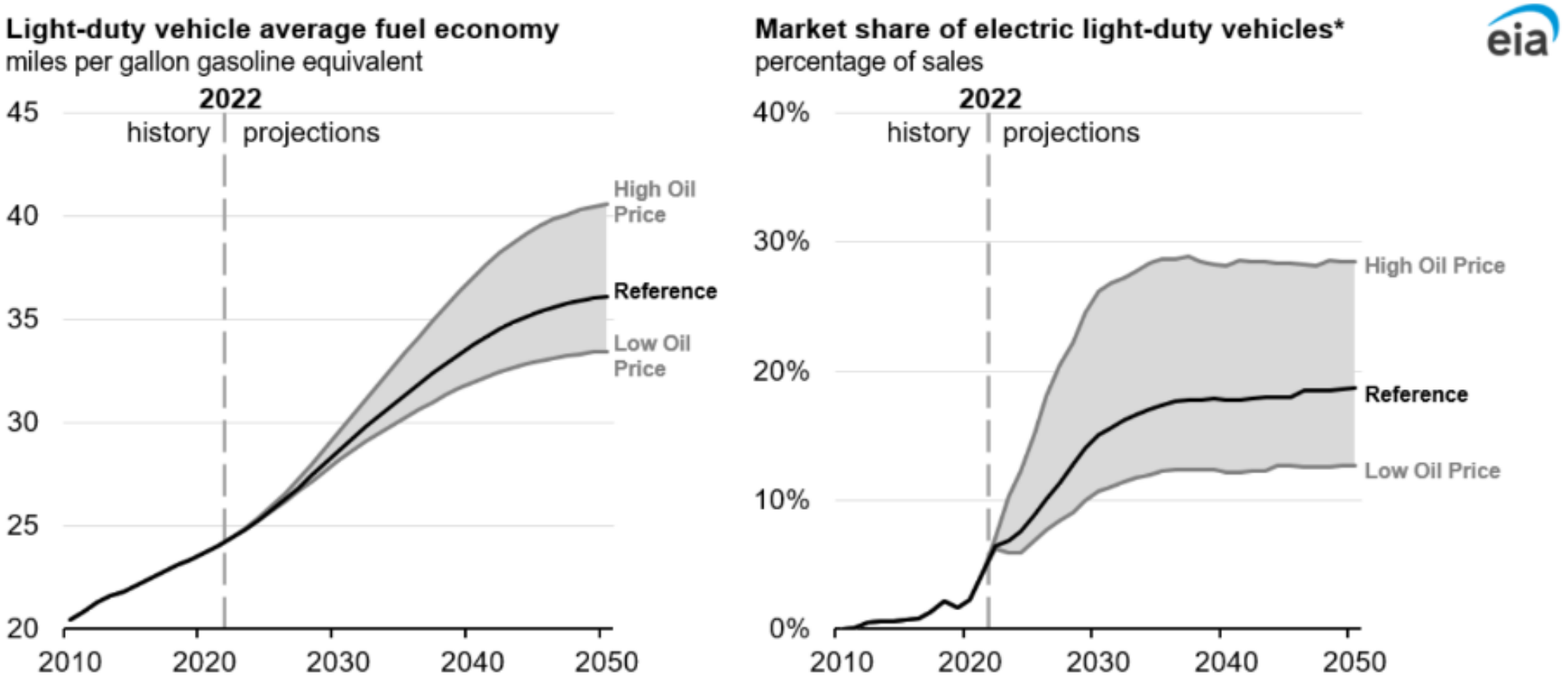


Energy-related CO2 emissions down 3.5% in sensitivity
Billion tonnes



Source: ExxonMobil

Market Share Of Electric Vehicles



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: *Includes battery electric and plug-in hybrid electric vehicles. Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases.

Source: EIA

Canadian Strengths

CRIN Clean Resource Innovation Network

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

- World class hydrocarbon deposits
- Outstanding, skilled work force
- World-class pool of professional expertise
- Outstanding transportation infrastructure
- Proven track record of applied innovation & research
- Solid regulatory system
- Stable political system
- Strong investment climate

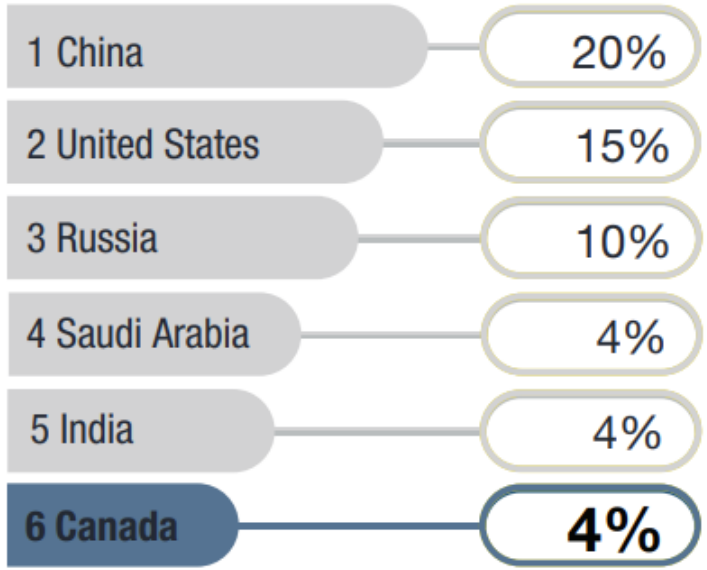
Canadian Energy Leadership

ENERGY PRODUCTION AND SUPPLY

CANADA: A GLOBAL ENERGY LEADER

The amount of primary energy produced by Canada in 2020 is **29% more** than in 2005. The world, on average, has increased energy production by **23%** in the same period.

WORLD TOTAL PRIMARY ENERGY PRODUCTION
TOP ENERGY PRODUCERS, 2020



GLOBAL ENERGY RANKINGS FOR CANADA

	Proved reserve/ capacity	Production	Exports
Crude oil	4	4	3
Uranium	3	3	5
Hydroelectricity	3	3	-
Electricity	8	6	1
Coal	16	14	7
Natural gas	17	5	6

Source: NRCan

Canadian Energy Trade

ENERGY TRADE (2021)

Energy exports

$154.3 billion representing **32%** of total Canadian goods exports

Oil and gas domestic exports totalled **$140 billion** of which **96%** were to the U.S.

exported energy products to **142** countries

The U.S. accounts for **91%** of energy exports by value ($139.8 billion).

Exports to the U.S.

	% of exports destined for U.S.	% of Canadian production exported to U.S.	% of U.S. imports coming from Canada	% of U.S. consumption supplied by Canada
Crude oil	98	77	62	25
Natural gas	100	46	99	9
Electricity	100	8	91	1
Coal*	3	1	19	0.2

*% of Canadian coal production exported is based on 2020 values.

Source: NRCan

Canadian Energy Emissions

ENERGY AND GHG EMISSIONS

Globally,

78%

of GHG emissions from human activity are from the production and consumption of energy.

This includes activities such as using gasoline for transportation, non-renewable electricity production, oil and gas production, and heating and cooling buildings.

In Canada, **about 80%** of emissions come from energy. Canadians use more energy because of our extreme temperatures, vast landscape and dispersed population.

The challenges of **transitioning** to a **lower-carbon energy system** are numerous, but they also present opportunities for **Canada to be a global leader** by **supporting innovative technologies in the energy sector**, including **promoting our growing renewables and cleantech sectors**.

Source: NRCan

Canadian GHG Performance

Since 2000, there has been a decoupling between the growth of Canada's economy and GHG emissions, largely because of technological improvements, regulations, and more efficient practices and equipment.

The year 2020 was marked by the COVID-19 pandemic, coinciding with a decrease in emissions of 66 Mt or 8.9%.

Between 2000 and 2020, Canada's GHG emissions decreased by

7.5%

while GDP increased

39%

GHG emissions decreased

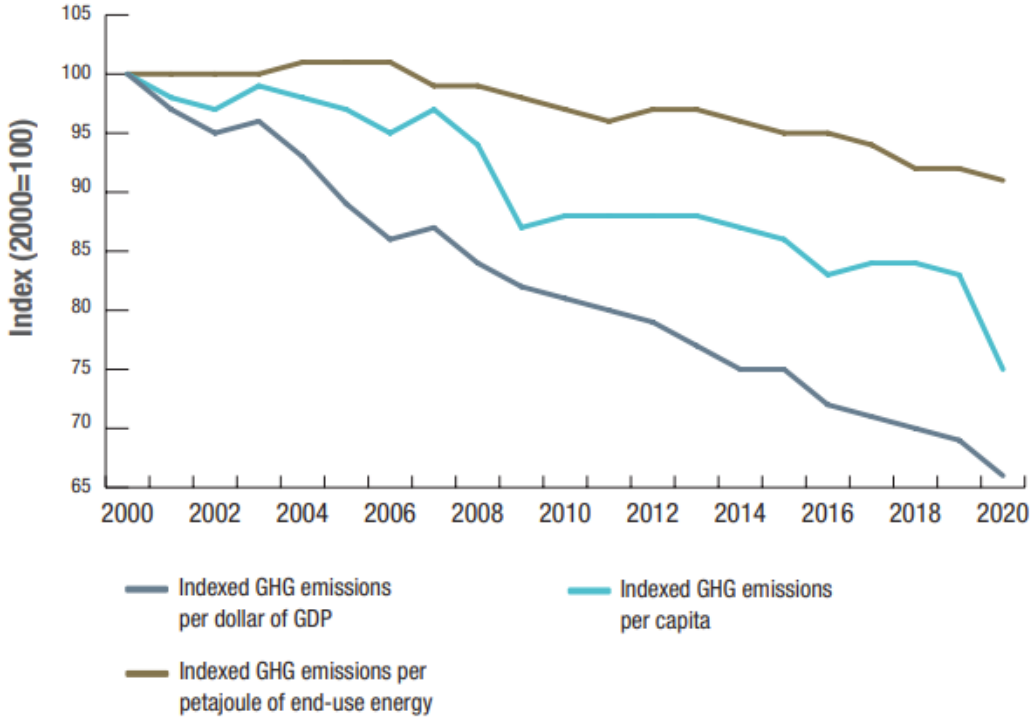
34%

per dollar of GDP and

26%

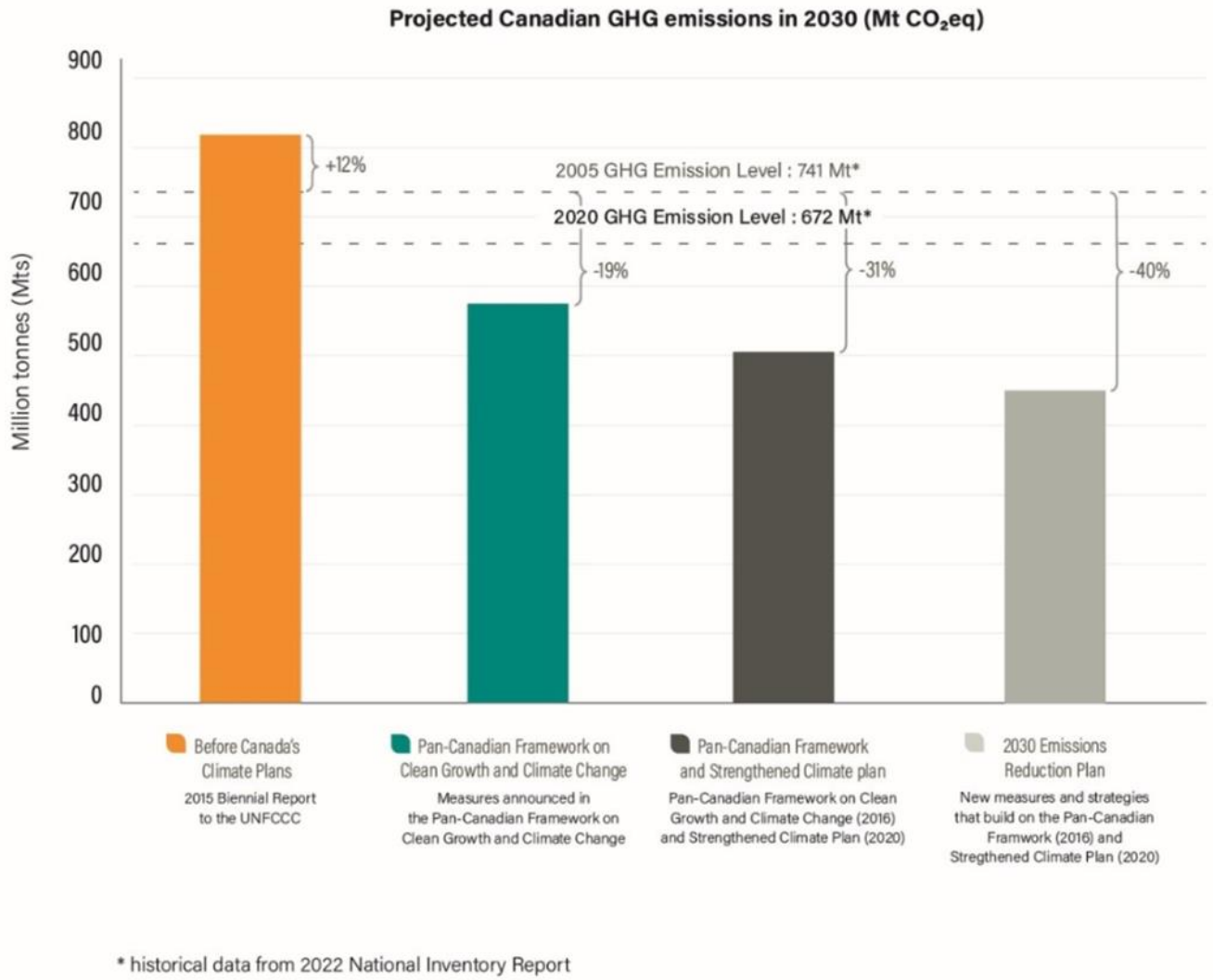
per capita.

INDEXED TREND IN GHG EMISSIONS PER PERSON, PER UNIT OF GDP AND PER UNIT OF ENERGY CONSUMED, 2000–2020



Source: NRCan

Canada Net Zero Plan



Source: Environment and Natural Resources Canada

Canada Net Zero Plan

- Net zero emissions by 2050
- 2030 Emissions Reduction Plan
- Net-Zero Advisory Body
- Net-Zero Accelerator Fund ($8 billion)
- Net-Zero Challenge

TCS Can approach PTAC

- How can TCS work with PTAC?
  - Common SME clients
  - Collaboration abroad at conferences, trade shows and trade missions
  - Country-specific webinars

- How can trade commissioners approach us with opportunities?
  - Energy transition market needs where Canadian companies, consultants, government labs and agencies have products and services.
  - First step is to consult the Guide and Company Directory:
  - Canadian Capabilities in Methane Emissions Reduction – PTAC
  - Currently focused on methane emissions, but will be expanded to other environmental and energy transition subjects in April 2024.

Thank You!

Marc Godin is a professional engineer and has an MBA. He is the Director of Technology for Petroleum Technology Alliance Canada and has +35 years of industry experience. He develops and manages projects, focusing on innovation, technology development and commercialization, R&D strategy, management, and funding.

Marc Godin, Director of Technology, Petroleum Technology Alliance Canada (PTAC)

Email: mgodin@ptac.org

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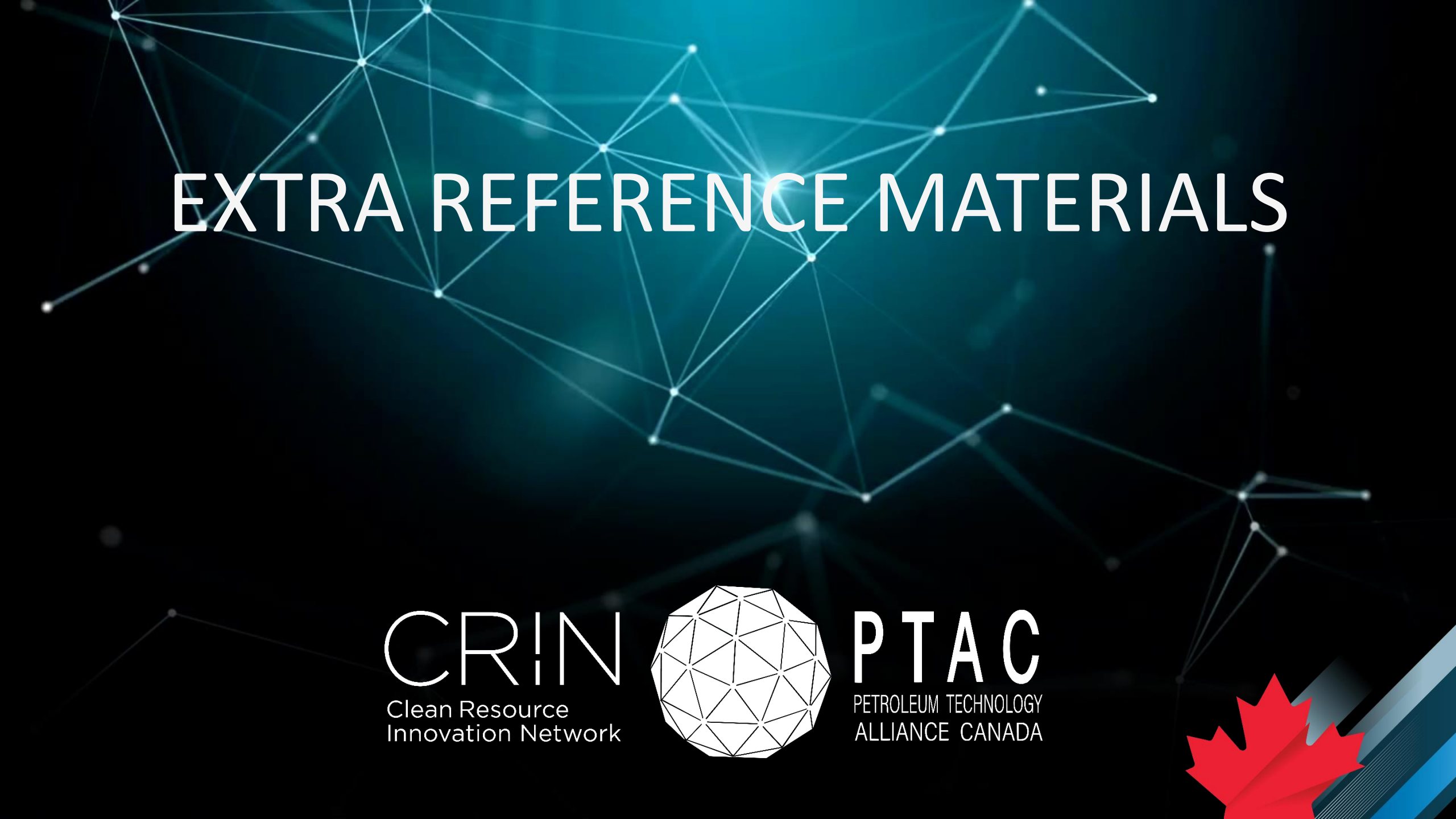
EXTRA REFERENCE MATERIALS



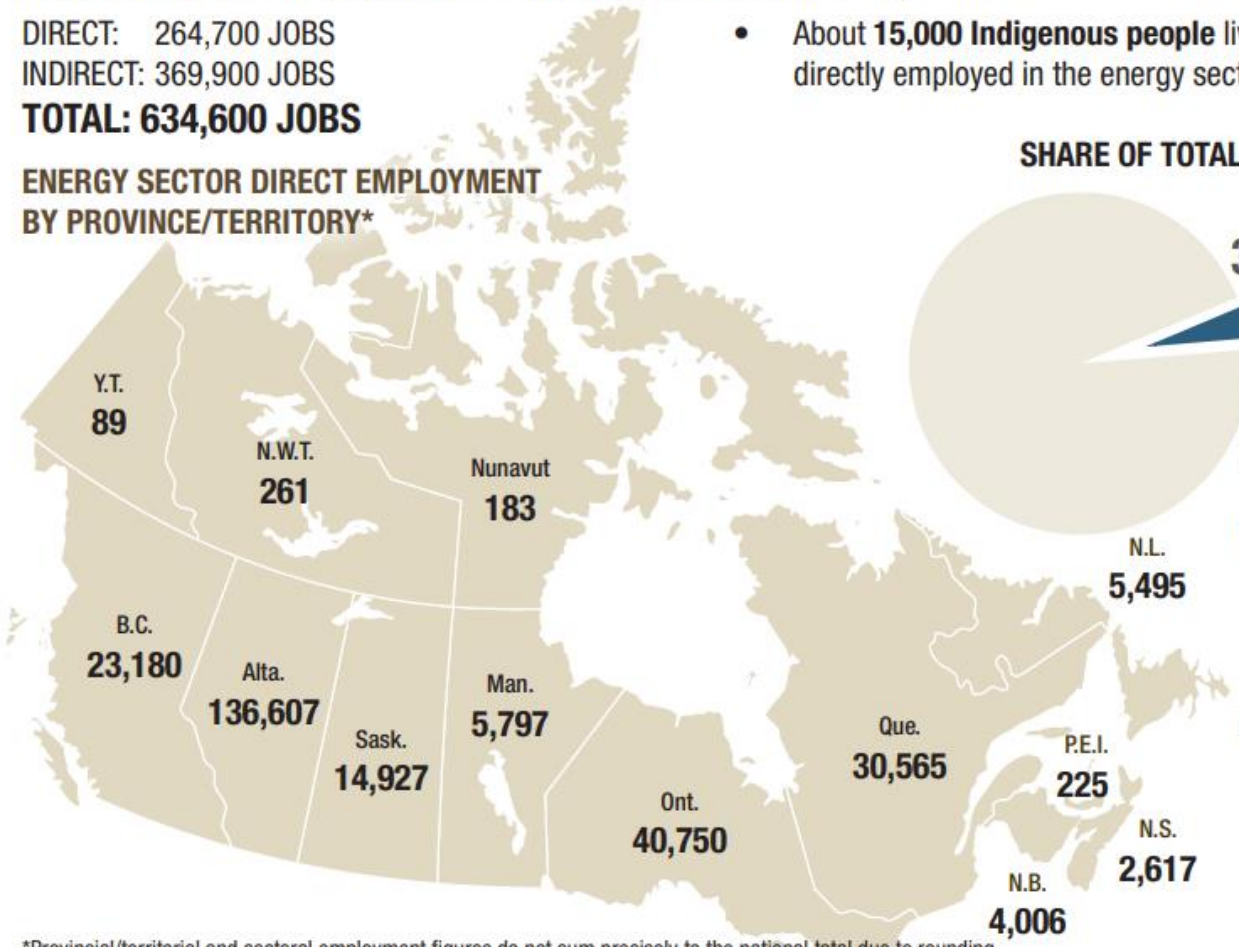
Canadian Energy Employment

EMPLOYMENT IN CANADA'S ENERGY SECTOR (2021)

DIRECT: 264,700 JOBS
INDIRECT: 369,900 JOBS
TOTAL: 634,600 JOBS

- About **15,000 Indigenous people** living off-reserve are directly employed in the energy sector.

ENERGY SECTOR DIRECT EMPLOYMENT BY PROVINCE/TERRITORY*



SHARE OF TOTAL EMPLOYMENT, 2021

TOTAL EMPLOYMENT

ENERGY DIRECT* 1.4%
- PETROLEUM 0.9%
- ELECTRICITY 0.5%
- OTHER 0.1%

ENERGY INDIRECT 2.0%

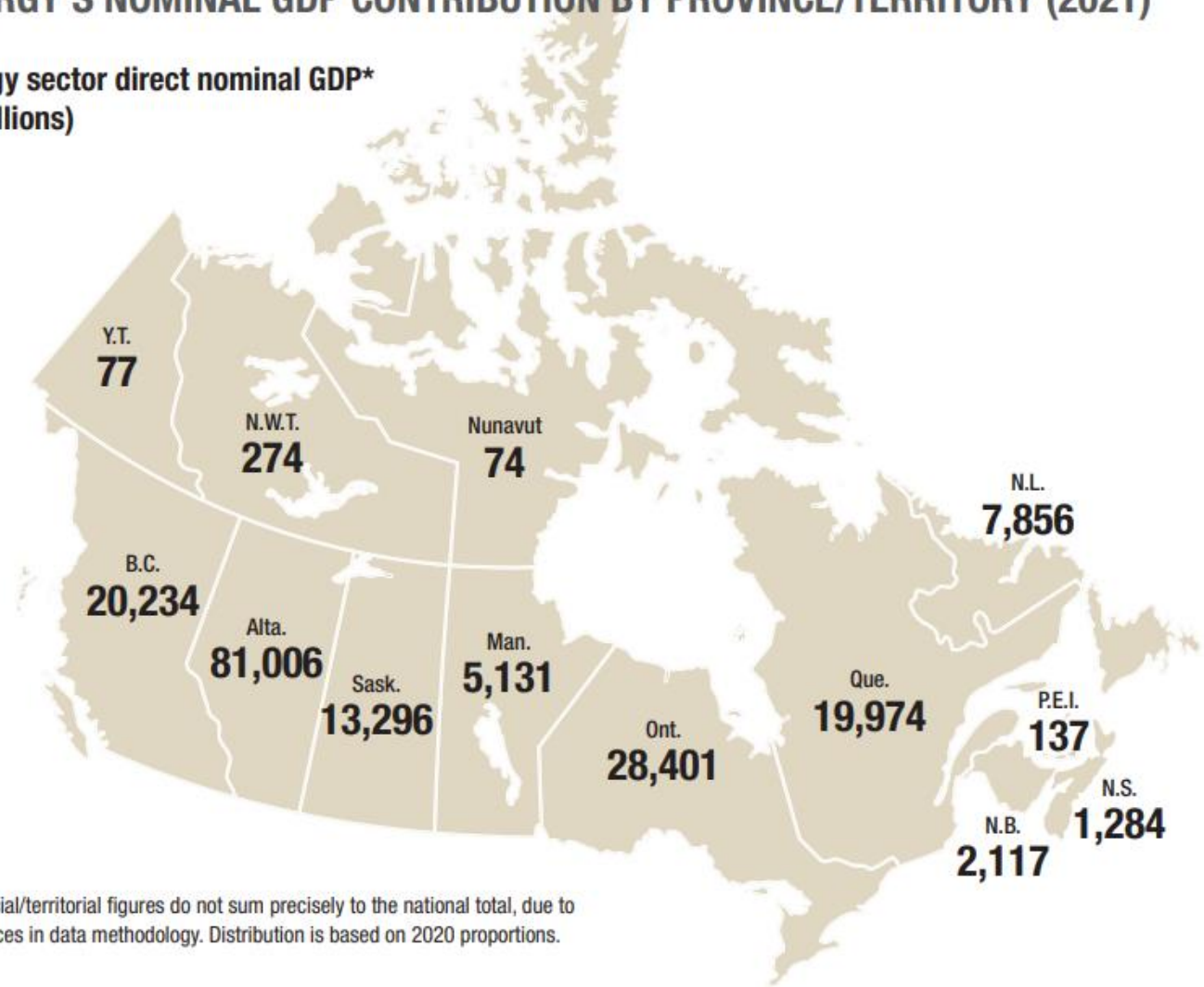
*Provincial/territorial and sectoral employment figures do not sum precisely to the national total due to rounding. The indirect contribution is not comparable to previously published estimates due to revisions and a change in estimation methodology by Statistics Canada. For more information on Statistics Canada's estimation methodology, please contact statcan.iadinfoddci-dciinfoiad.statcan@statcan.gc.ca.

Source: NRCan

Canadian Energy GDP

ENERGY'S NOMINAL GDP CONTRIBUTION BY PROVINCE/TERRITORY (2021)

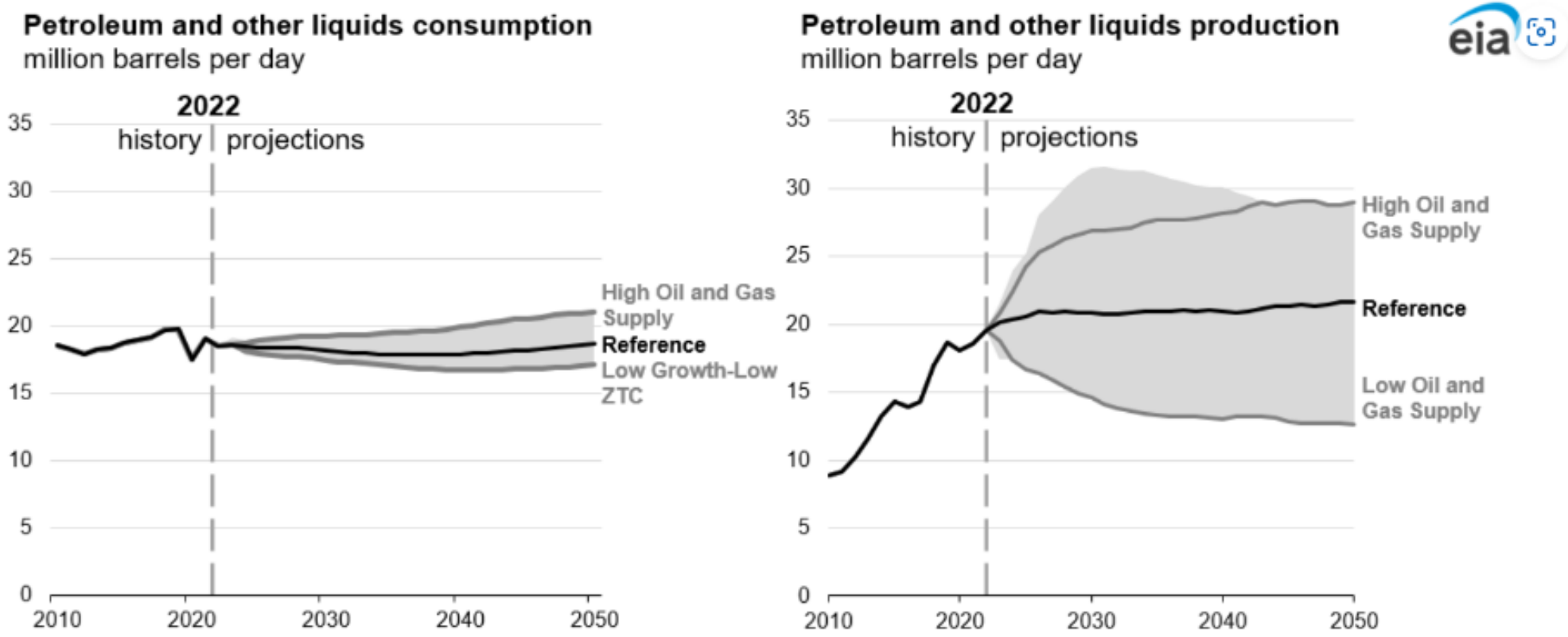
Energy sector direct nominal GDP*
($ millions)



*Provincial/territorial figures do not sum precisely to the national total, due to differences in data methodology. Distribution is based on 2020 proportions.

Source: NRCan

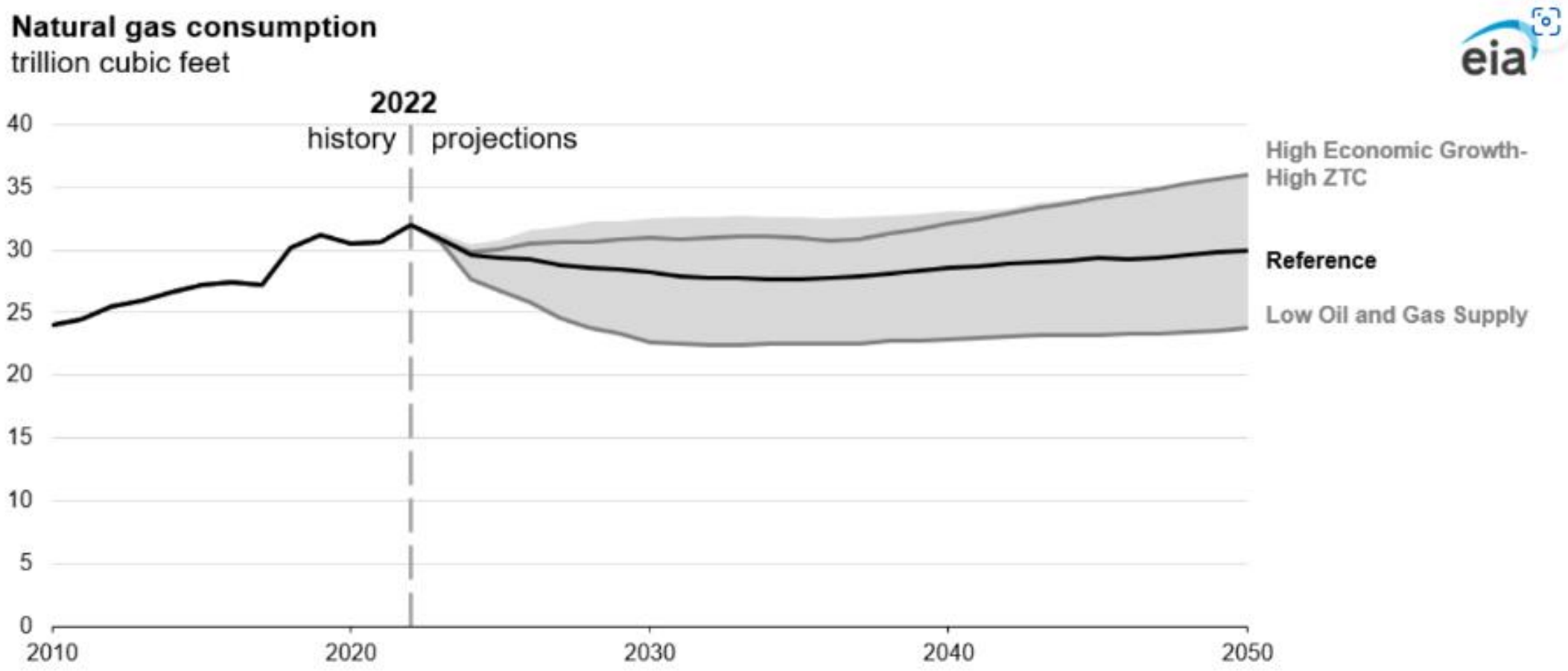
U.S. Petroleum



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Biofuels are not included in *petroleum and other liquids* production or consumption. Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases. ZTC=Zero-Carbon Technology Cost.

Source: EIA

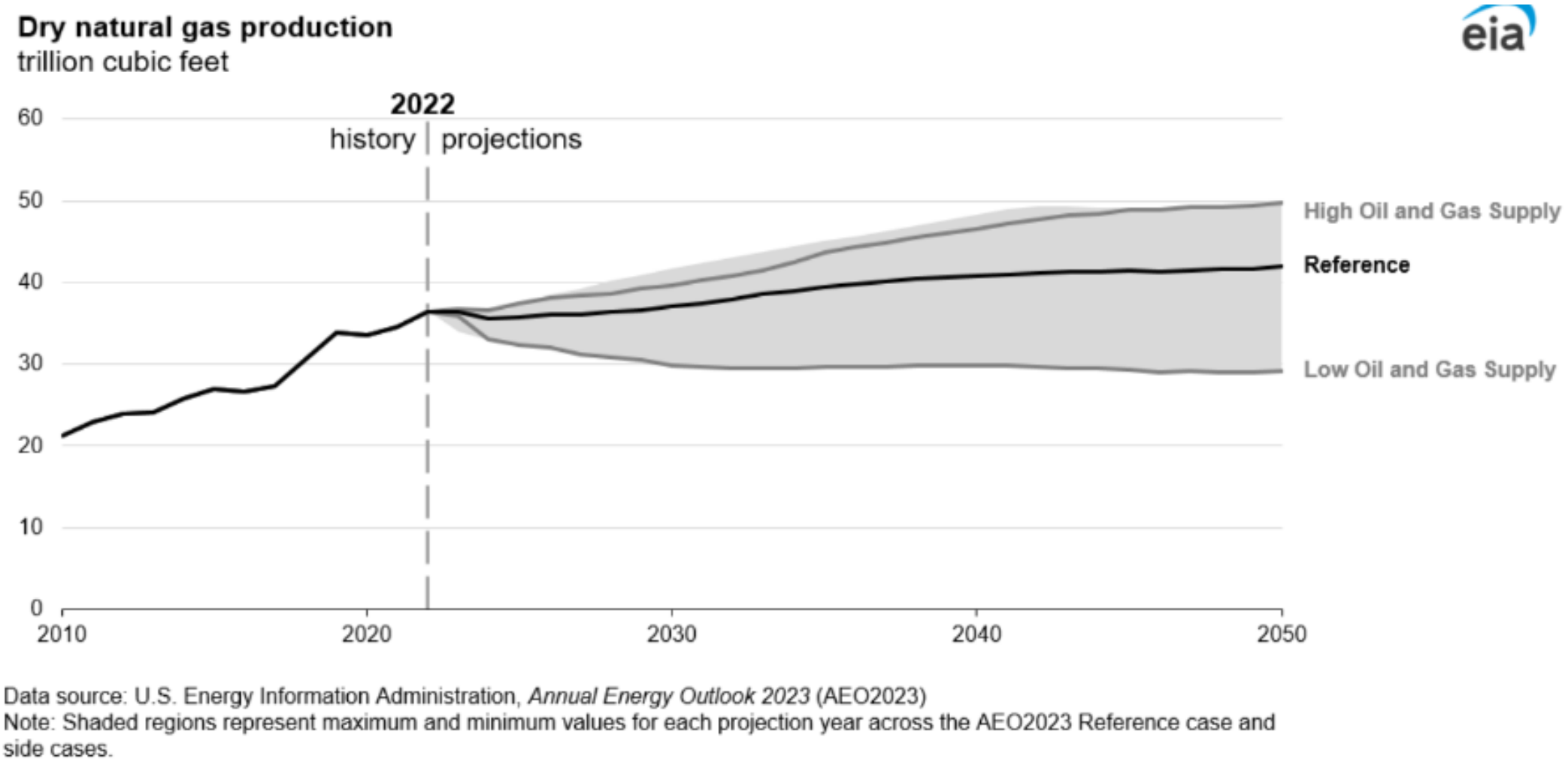
U.S. Natural Gas Consumption



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases. ZTC=Zero-Carbon Technology Cost.

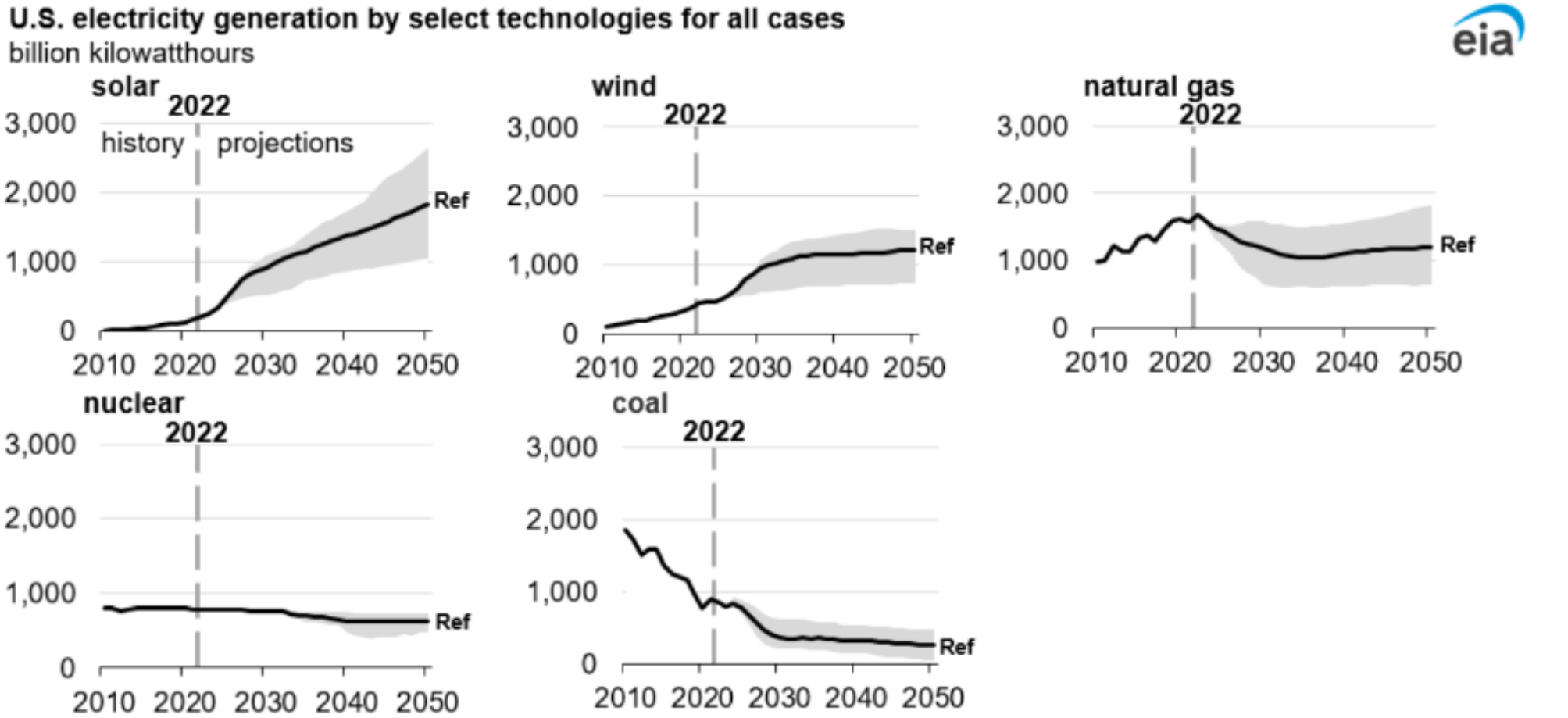
Source: EIA

U.S. Natural Gas Production



Source: EIA

U.S. Electricity Generation

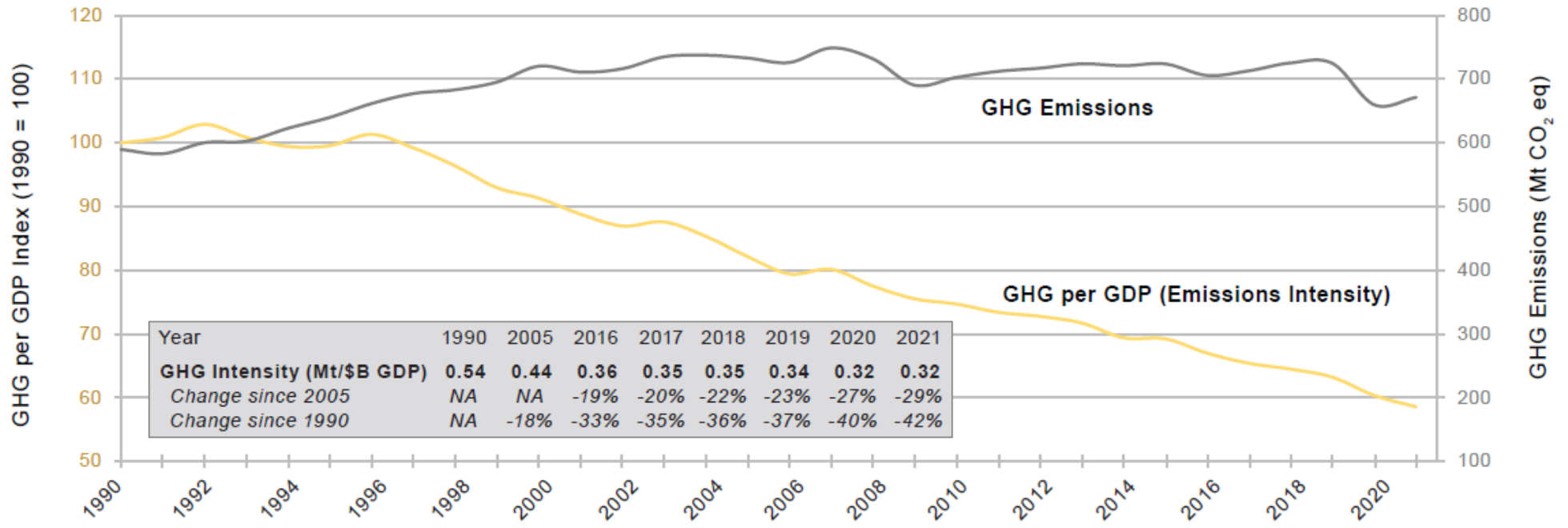


Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: Shaded regions represent maximum and minimum values for each projection year across the AEO2023 Reference case and side cases. Ref=Reference case.

Source: EIA

Canada's GHG Emissions

Figure ES–1 **Canadian GHG Emissions and Indexed Trend Emissions Intensity (excluding Land Use, Land-Use Change and Forestry)**



Year	1990	2005	2016	2017	2018	2019	2020	2021
GHG Intensity (Mt/$B GDP)	**0.54**	**0.44**	**0.36**	**0.35**	**0.35**	**0.34**	**0.32**	**0.32**
Change since 2005	*NA*	*NA*	*-19%*	*-20%*	*-22%*	*-23%*	*-27%*	*-29%*
Change since 1990	*NA*	*-18%*	*-33%*	*-35%*	*-36%*	*-37%*	*-40%*	*-42%*

Notes:
NA = Not applicable
GDP data source = StatCan (n.d.[b])

Source: Canada NIR

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❑ 9:40	Q&A	- Marc Godin, PTAC & Lindsay, Validere
❑ 9:45	Energy Transition Technology Themes	- Glen McCrimmon, CRIN & Soheil Asgarpour, PTAC
❑ 10:30	Innovation Ecosystem Reference Tools	- Glen McCrimmon, CRIN
❑ 10:40	break	
❑ 10:50	Canadian Energy CleanTech Directory	- Bruce Peachey, PTAC
❑ 11:50	Closing Remarks	- Global Affairs Canada
❑ 12:00	Adjournment	

Regulations & Incentives

Please refer to Lindsay Campbell's PDF

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Energy Transition Technology Themes

G. Glen McCrimmon MSc. P. Geo

CRIN, Director of Operations
gmccrimmon@cleanresourceinnovation.com
c. +1.587.437.7532

Glen McCrimmon is currently the Director of Operations at the Clean Resource Innovation Network (CRIN).

He is a senior energy sector leader and influencer with extensive experience in corporate innovation, subsurface technical, portfolio management, strategic planning, stakeholder relations and governance. He inspires much needed change by reminding all that "…better is always different."

Appointed Husky Energy's Chief of Innovation in 2018, Glen built on the expertise of technical leaders and out-of-the-box thinkers from across the industry, providing a coordinated approach to foster innovation. Prior to this role, he had been appointed Chief Geologist in 2016 and started with the company in 2013 as Manager of Frontier Exploration. He began his career as a geoscientist with Imperial Oil in 1996. Over his career Glen has held multi-year assignments based out of Houston, Texas, St. John's, Newfoundland and Labrador, and in Calgary.

Glen received a BSc in Geology from the University of Regina and an MSc in Earth Sciences from the University of Ottawa.

Outside of work Glen is an avid cross-country skier and runner.

Sally Dawoud, P.Eng., M.Eng., MBA

CRIN, CleanTech Advisor
sdawoud@cleanresourceinnovation.com
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Sally serves as CleanTech Advisor at CRIN enabling technology development, deployment, and adoption.

At the collision of technology, environmental stewardship, and sustainable energy, telling truths to entrepreneurs, fortune 1000 companies, and governments, is Sally. From a career straddling five continents and the full innovation to operation life-cycle, Sally blends critical thinking, practicality, and accountability, to bring our sustainable future incrementally closer, one conversation at a time. With extensive experience in oil & gas, power generation and utilities, and major infrastructure, Sally combines a unique blend of technical expertise, strategic thinking, and a passion for environmental responsibility.

She holds both BSc and MEng degrees in Geomatics Engineering from the University of Calgary, and an MBA double-majored in Strategy and Finance from the University of British Colombia.

Sally volunteers her time with various organizations including the Women In Need Society, Calgary Youth Science Fair, and Calgary Reads. She is also an avid globe trotter and reader, lover of eclectic music, and an arts enthusiast.

Clean Resource Innovation Network

CRIN Clean Resource Innovation Network

PTAC Petroleum Technology Alliance Canada

Active industry partners (incl Canada's largest oil & gas producers):

- Arc Resources
- Cenovus Energy
- ConocoPhillips Canada
- Canadian Natural Resources Limited
- Imperial Oil Limited
- Pacific Canbriam Energy
- Suncor Energy
- Tourmaline Oil

Global Affairs Canada / Affaires mondiales Canada

Trade Commissioner Service / Service des délégués commerciaux

Natural Resources Canada

CRIN IMPACT – At a Glance

CRIN Clean Resource Innovation Network | PTAC Petroleum Technology Alliance Canada

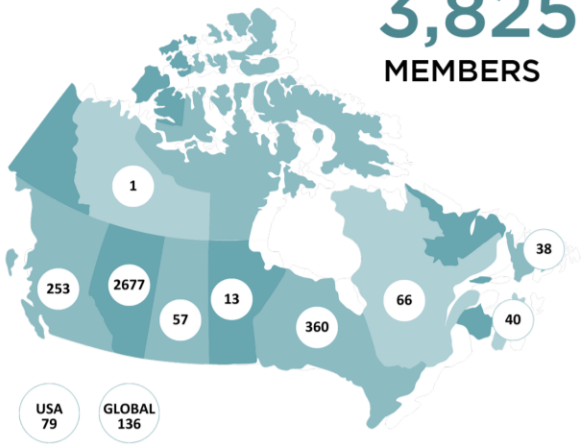
5 SECTORS

7 TECHNOLOGY THEMES

71 CRIN EVENTS

390 MEMBER EVENTS (AMPLIFIED)

3,825 MEMBERS



150+ VOLUNTEERS

3k+ VOLUNTEER HOURS

68 PROJECTS FUNDED

3.5:1 LEVERAGED FUNDING

2,800 ESTIMATED JOBS CREATED BY 2024

100 MT CO_2e GHG EMISSION REDUCTIONS ANTICIPATED BY 2033

$86M:100 MT MT CO_2e RATIO

Metrics as of March 31, 2023

Technology Themes

CRIN Clean Resource Innovation Network

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

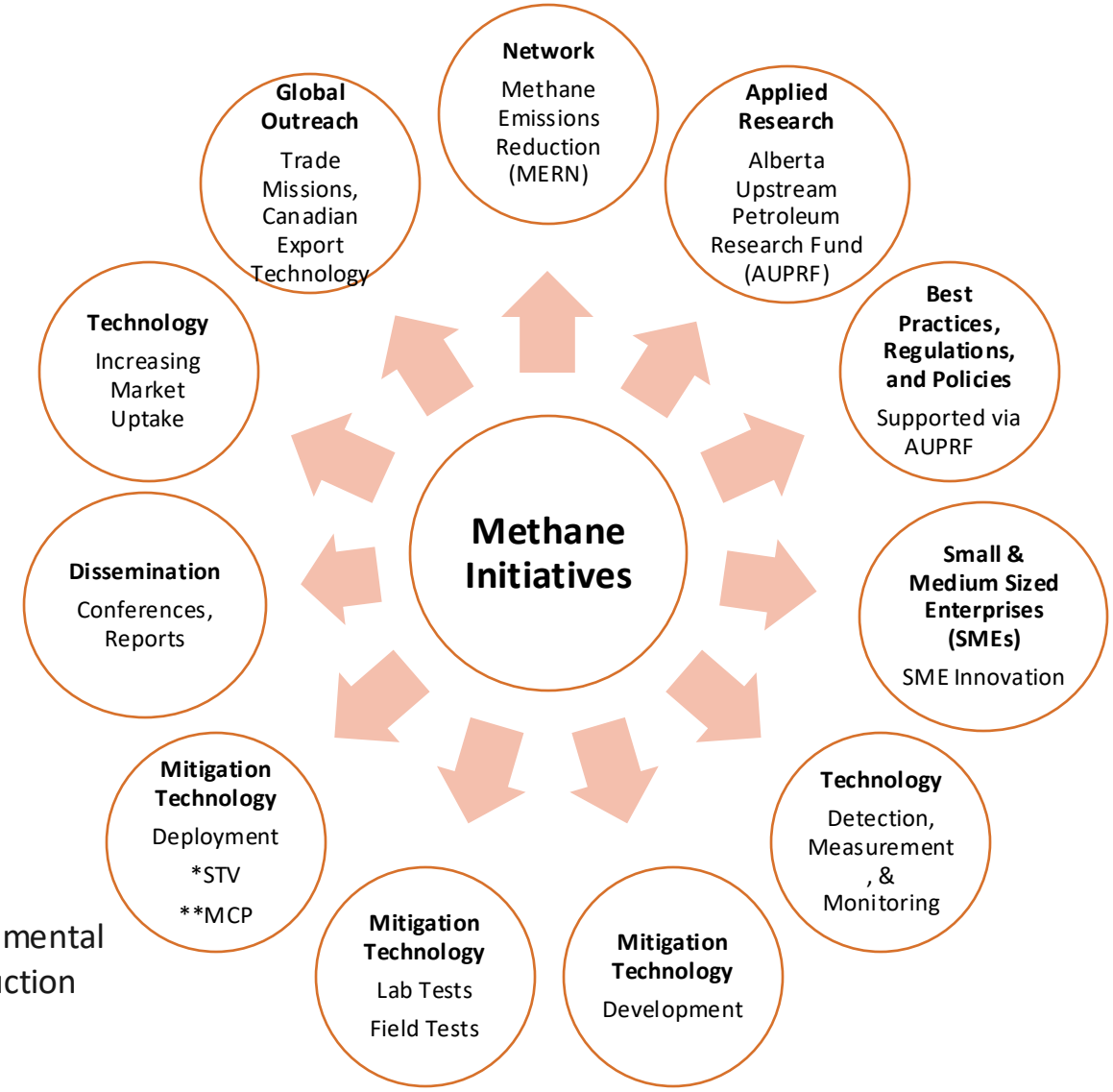
- CLEANER FUELS - REDUCING CARBON INTENSITY
- DIGITAL OIL AND GAS TECHNOLOGY
- CARBON CAPTURE AND VALUE-ADDED PRODUCTS
- METHANE MONITORING, QUANTIFICATION AND ABATEMENT
- NOVEL HYDROCARBON EXTRACTION
- NOVEL LAND AND WELLSITE RECLAMATION
- WATER TECHNOLOGY DEVELOPMENT

METHANE MONITORING, QUANTIFICATION AND ABATEMENT TECHNOLOGIES

Building Technology Capacity to Reduce Hydrocarbon Sector's Methane Emissions by 90% by 2023

Soheil Asgarpour, President and CEO, Petroleum Technology Alliance Canada and past CRIN Methane Theme Lead

CRIN & PTAC Initiatives
Methane Detection & Elimination



*Systematic Third-Party Validation of Environmental and Economic Performance of Methane Reduction Technologies (STV)

** Methane Consortium Program (MCP)

CRIN/PTAC SME Members in the Methane Space

CRIN Clean Resource Innovation Network

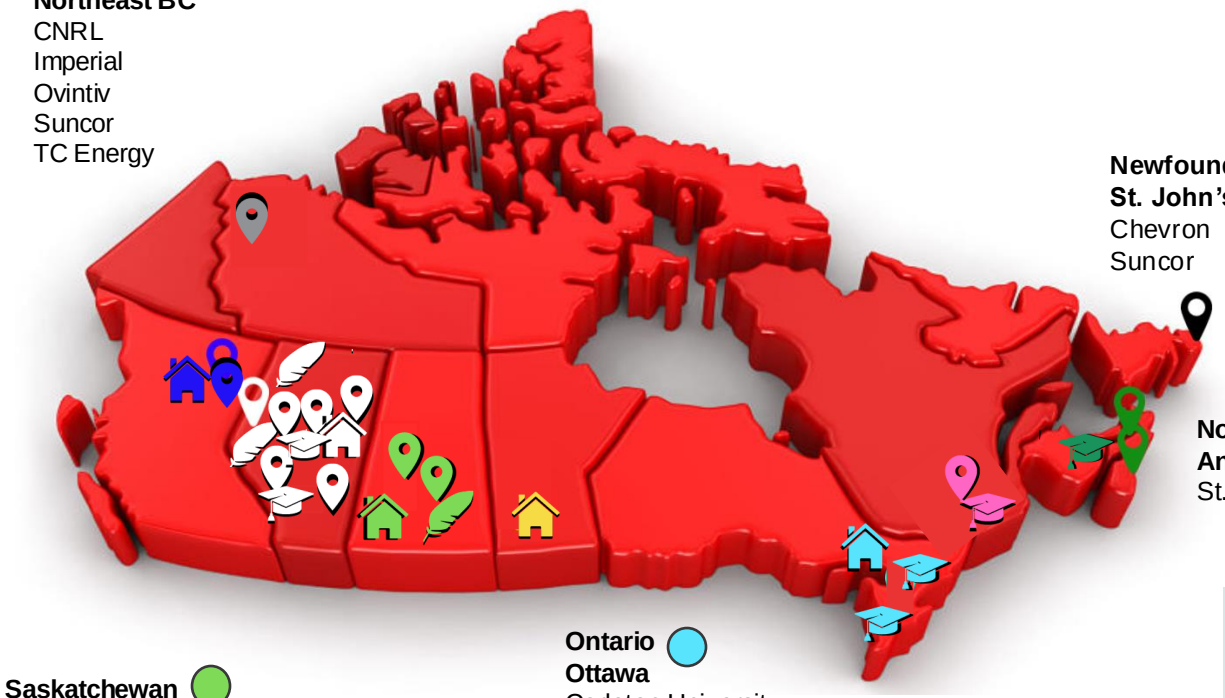
PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

CanERIC Field Facilities, Labs and Organizations

Alberta
Calgary & Rural Alberta
ATCO
Bonavista
CAPP
Cenovus
Chevron
CMC Research Institutes
CNRL
CRIN
Inter Pipeline
Orphan Well Association
Ovintiv
PTAC
SAIT
TC Energy
Teine
TEREE
Total EP Canada
University of Calgary
Whitecap
Devon
CanMET Energy
Edmonton
ATCO
University of Alberta
Fort McMurray
Suncor
Cenovus Energy
Imperial Oil
Rainier
CMC Research Institutes
Vegreville
InnoTech Alberta

British Colombia
Fort St. John
PETRONAS Canada
Northeast BC
CNRL
Imperial
Ovintiv
Suncor
TC Energy

Northwest Territories
Norman Wells
Imperial Oil



Newfoundland and Labrador
St. John's
Chevron
Suncor

Nova Scotia
Antigonish
St. Francis Xavier University

International
USA
Colorado State University
Harrisburg University
METEC
Sandford University
TC Energy
Total SA
University of Texas
State of California

Europe
Net Zero Technology Centre, Aberdeen, Scotland

Saskatchewan
Regina and Saskatoon
SRC
Rural Saskatchewan
CNRL
Inter Pipeline
TC Energy
Whitecap

Manitoba
Rural Manitoba
CNRL
TC Energy

Ontario
Ottawa
Carleton University
Rural Ontario
TC Energy
Waterloo
University of Waterloo
Windsor
University of Windsor

Quebec
Montréal
TC Energy
Université de Montréal

Legend
- Location/Facilities
- Rural Areas
- Indigenous Communities
- Academic Institutions

Technologies Developed, Field Tested, Demonstrated/Deployed (Sample)

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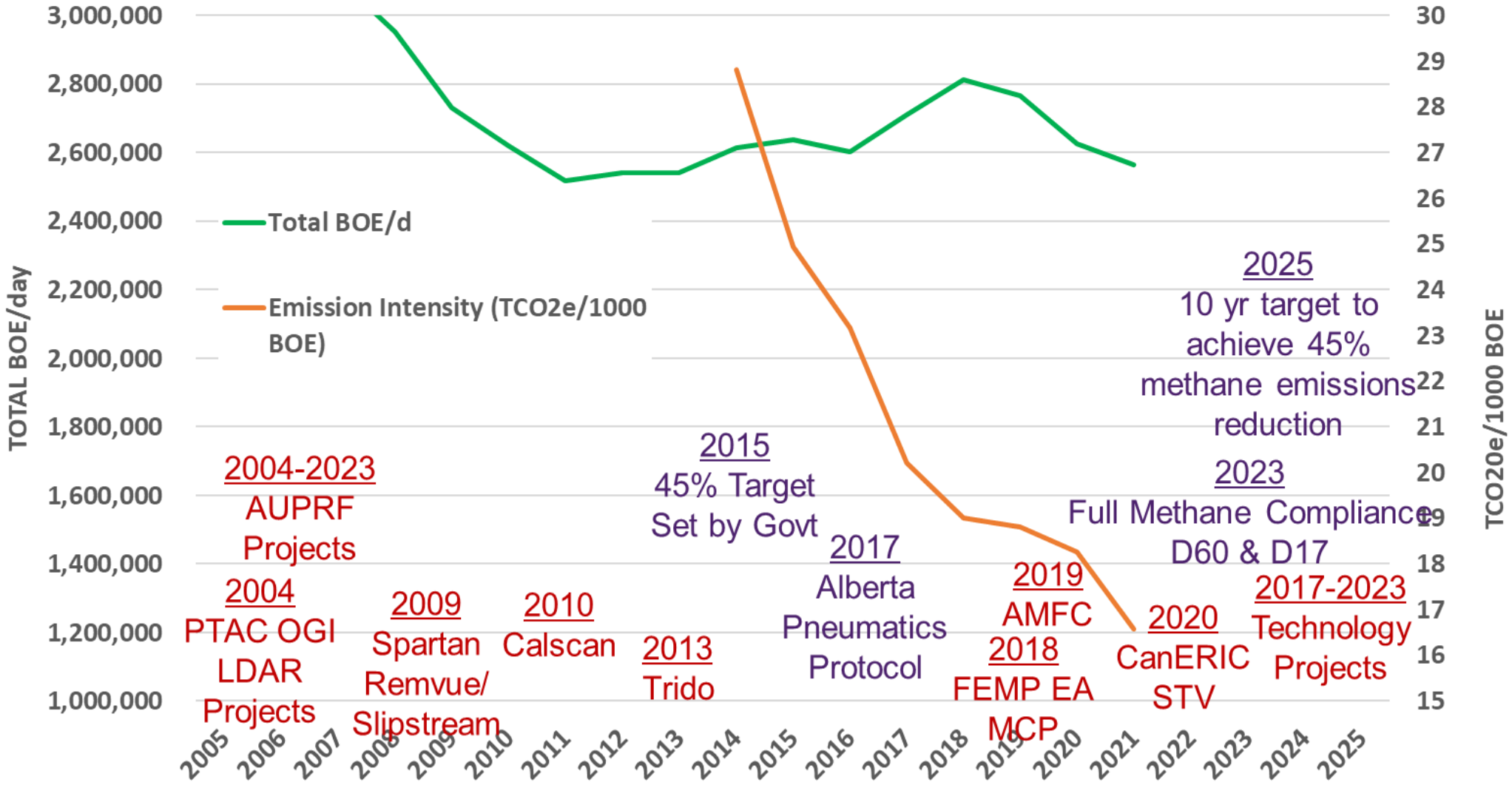
Technology Gaps	Technology Model Examples	Developed	Field Tested	Deployed/ Demonstrated
Instrument Gas to Instrument Air (single well)	LCO Instrument Air	☆	☆	☆
Instrument Gas to Instrument Air (Large site)	Trido Instrument Air	☆	☆	☆
Smart Pumps	MCI Chemical Pumps	☆	☆	☆
Dry Gas Seal (DGS)	TC Energy DGS Project	☆	☆	☆
Combustors	METAN Deployment Phase II Project	☆	☆	☆
Technology Capacity	***(*All Projects)***	**37%**	**39%**	**48%**

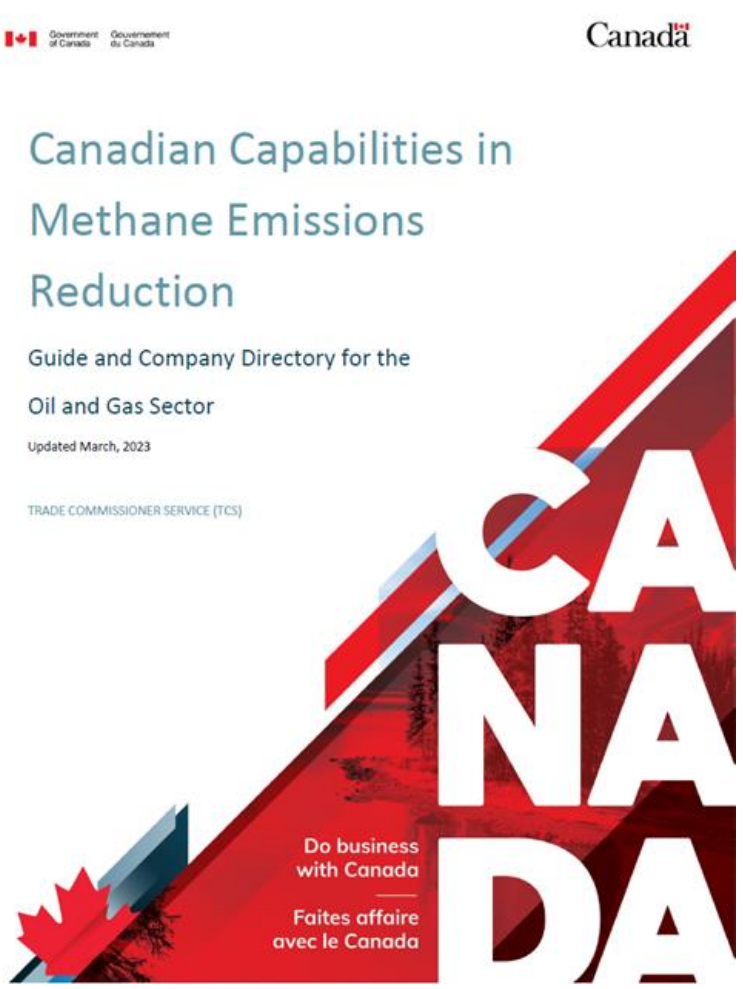
*There are over 89 projects/technologies which contribute to the 48% capacity total. A full listing of these projects can be found in the corresponding conference paper.

Emission Intensity is Decreasing with New Technology



Methane Monitoring, Quantification, & Abatement

- Featuring 60 Canadian energy cleantech companies.
- Full PDF at: https://www.ptac.org/canadian-capabilities-in-methane-emissions-reduction/
- 2024 update to include Carbon Capture and Storage, Hydrogen Enrichment, Environmental Management, Offshore, Well Reuse, Abandonment and Reclamation.



Company	Page Number	Product Categories: Combustion	Compress Methane	Instrument Air	Chemical Pumps	Electric Devices	Electricity Generation	Alternative Cement Products	Services Categories: Detection, Measurement,	Research	Reporting	Management	New Technology/Redesign
Detection, Measurement, Quantification, Monitoring													
Airdar	54								■				
Canadian UAVs*	55								■		■		■
CMC Research Institutes Inc.*	56								■	■			■
Current Surveillance Inc.*	57								■				
EnviroTrace Ltd.*	58								■				
Eosense	59								■	■	■	■	
Gas Recon Inc.	60								■	■	■	■	
GHGSat*	61								■		■	■	
GreenPath Energy Ltd*.	62								■	■	■	■	■
HETEK Solutions Inc.+	63								■		■		
IntelliView Technologies Inc.*	64								■	■	■	■	
Intricate Group Inc.	65								■	■	■		
Kuva Systems +	66								■	■	■	■	■
Montrose Environmental Group Ltd.*	67								■		■		
SolutionCorp Inc.	68								■		■		
Surface Solutions Inc +	69								■	■			
Telops*	70								■	■			
Ventbuster Instruments Inc.	71								■		■		
Vertex Resource Group Ltd.+	72								■		■		

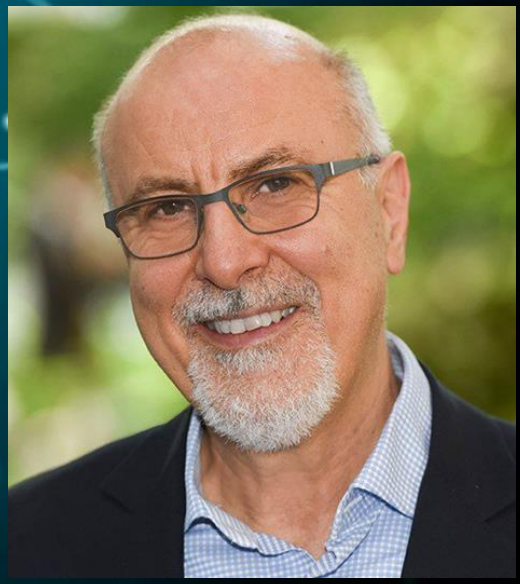
Thank You!

A Fellow of the Canadian Academy of Engineering (CAE), the Canadian Society of Senior Engineers (CSSE), and the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM), Soheil has over 40 years of technical, business, and operations experience in the hydrocarbon industry marked by providing strong leadership to several profit and not-for-profit organizations.

Soheil is serving PTAC as President & CEO, and the CAE as President, and has held executive positions with mid- and large-size oil and gas companies and Alberta Government. Soheil earned his Ph.D. in Mechanical Engineering from Rice University.

He has over 40 publications with reputable Canadian and U.S. journals in many technical and business areas. He is a distinguished author of the Journal of Canadian Petroleum Technology (JCPT). Soheil's commitment to the future of oil and gas industry has been demonstrated through the numerous awards he has received.

He has served PRI as Vice Chair, CIM as President, PSC as Chairman, and the CCA, CIPI and CRIN as a Director.

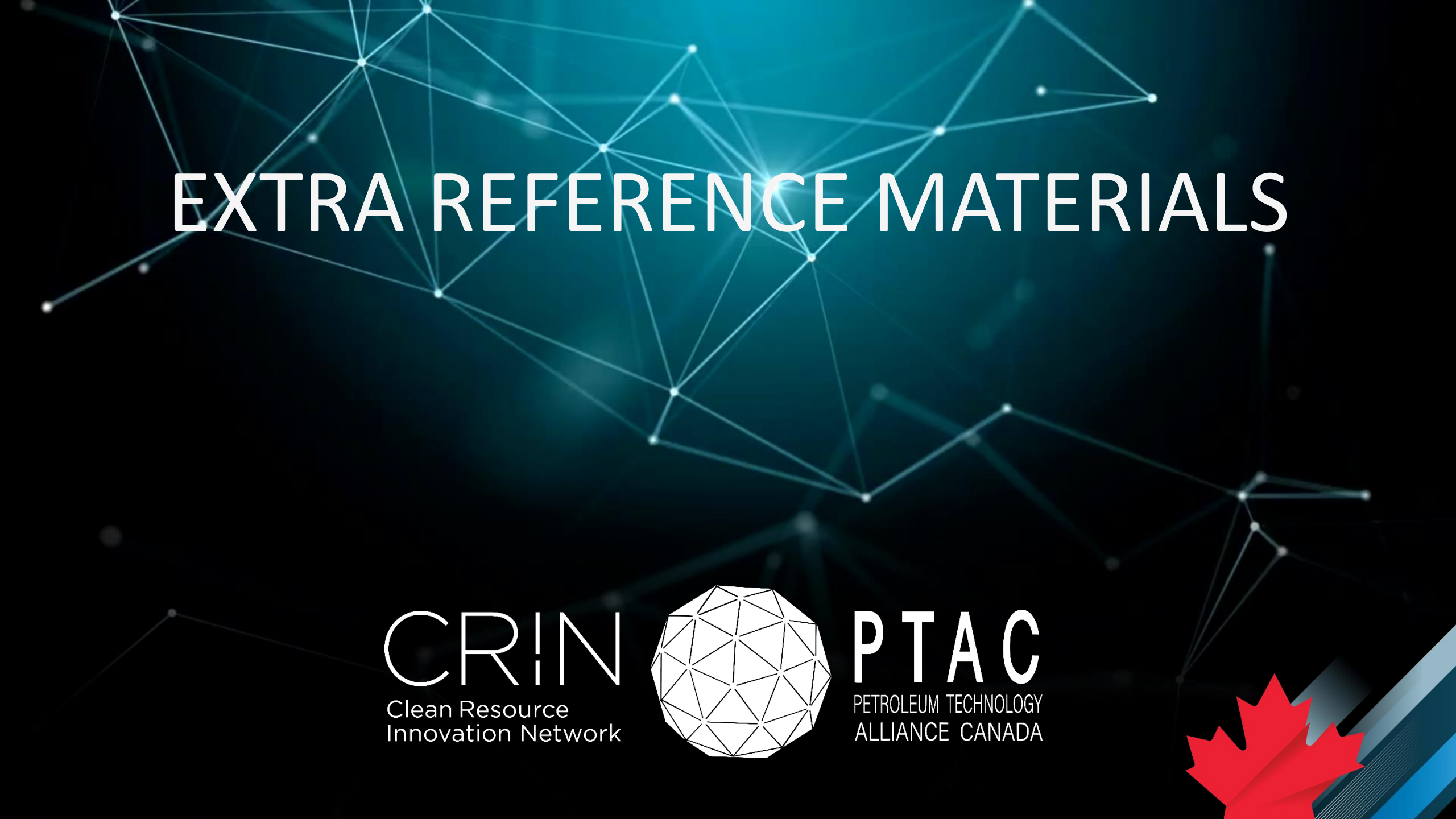


Soheil Asgarpour, President and CEO, Petroleum Technology Alliance Canada (PTAC) and past CRIN Methane Theme Lead

CRIN
Clean Resource Innovation Network

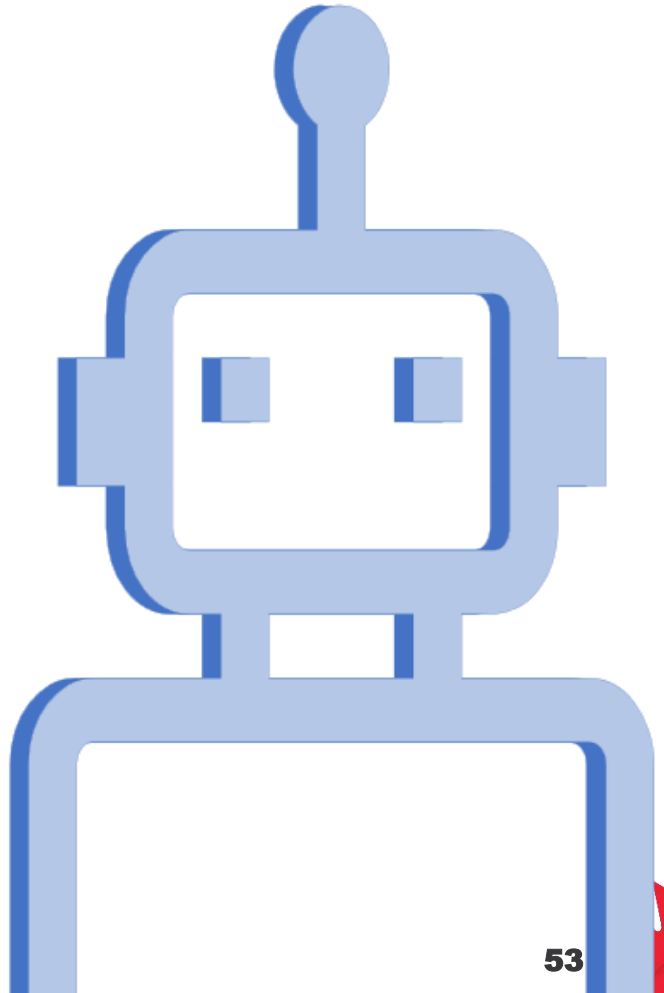
PTAC
PETROLEUM TECHNOLOGY ALLIANCE CANADA

EXTRA REFERENCE MATERIALS



Methane Detection Technologies

- SeekOps (Drone)
- Heath Consultants Inc. (Drone)
- Aerometrix (Drone)
- Altus Technologies (Truck)
- Heath Consultants Inc. (Truck)
- University of Calgary (Truck)
- Bridger Photonics (Aerial)
- Sander Geophysics Ltd. (Aerial)
- FLIR (Handheld)
- Tecvalco (Handheld)
- Luxmux (Ground-based)
- NitroTech (Controlled release)



Fugitive Emissions Management Program Effectiveness Assessment (FEMP EA)

A world class methane detection, quantification and verification applied research project.

- Study area = 2,500 km^2
- 200 facilities (a total of 30 operators)
- 100% voluntary participation from operators
- 200 sites selected for leak detection and repair surveys using optical gas imaging, Hi-Flow sampler, and Quantitative Optical Gas Imaging (QOGI)

Field Challenges

Alberta Methane Field Challenge

- Sought to understand the real-world performance of alternative methane leak detection technologies in comparison to conventional camera-based surveys.
- 2,500 km^2 in the Rocky Mountain House, Alberta region.

Methane Consortia Program Project Suite (2020/2021)

Project Lead	Project	Total Mitigated CO2e (tCO2e)	Number of Installs	Total GHG Reductions (tCO2e)	Potential for installation
Calscan	Site Electrification	1,216	10	18,240	5,000
Cenovus	Facility of the Future including electric instruments & pumps, instrument air, and remote on-site power generation.	8,658	1	8,658	
Ember	Compressor Engines	2,080	1	20,800	500
Spartan	Instrument Air Compressor	635	12	5,078	5,000
Spartan LCO	Smart Pumps	2,738.6	26	21,902	10,000
BlueSource	Pumps Optimization	674	37	6,738	5,000
NAL Resources	Grid Powered Site Conversions	817	14	8,169	10,000
Total		**16,819**	**101**	**89,586**	

EMVue Slipstream

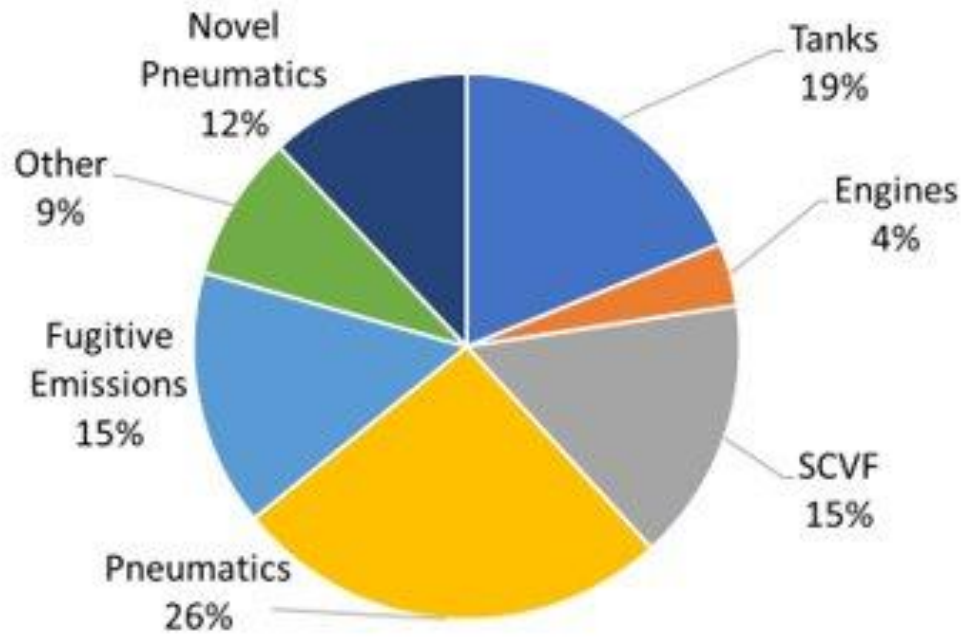
Current Benefits

- 170,000/year cars off road
- $20 Million/year value creation

One example of many PTAC technologies successfully delivering results!

Current Initiatives to Address Knowledge Gaps

Breakdown of Alberta's Methane Emissions (2018)



Knowledge Gaps:

- Tanks
- Engine Methane Slip
- Surface Casing Vent Flow (SCVF)/Leaky Wells
- Catalytic Heaters (in others)
- Flaring Alternatives (in others)
- Novel Pneumatics

Observations

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- Technologies developed and field tested through CRIN and PTAC programs played a critical role in reducing methane emissions intensity and achieving the 45% reduction target.

- Significant knowledge gaps remains to achieve the 75% reduction target, as well as Net Zero.

- Canadian Emissions Reduction Innovation Consortium (CanERIC) 2.0 program was developed to reach 75% reduction by 2030.

- The methane emissions innovation ecosystem built with the broad CRIN/PTAC network of governments, producers, academia and technology providers has delivered tangible results, continues to grow and is ready to tackle the 75% challenge.

METHANE MONITORING, QUANTIFACATION, AND ABATEMENT

Technologies to detect and monitor fugitive methane emission sources, and to enable reduction of methane emissions, improving operational efficiency, and reducing the environmental impact of methane emitters across Canada and globally.

Example technologies focus on **cost effective methane emissions detection, quantification, monitoring, reporting and mitigation technologies** from upstream, midstream, downstream, and transportation of oil and gas to enable industry to meet 75% methane emissions reduction target, including

- **Methane mitigation** from oil and condensate tanks, pneumatic devices, compressor seals, dehydrators, chemical pumps, and wells surface casing vent flow
- **Cost effective** and **accurate** methods incorporating sensors combined with digital platforms to help in detection, quantification, monitoring and reporting
- Also, methods for estimating emissions from tanks, methane slip, determining rate-based emission correlations and thresholds for upstream petroleum industry leaks, quantifying methane venting, and evaluating surface casing vent flows at inactive wells

METHANE Elimination Using Nitrogen

- Technology for **Methane Elimination Using Nitrogen - uses nitrogen to power remote, pneumatic oil & gas devices,** replacing methane and the need to vent harmful gases after use.
- Installing Kathairos' solution at multiple locations enables establishing an economic and rapid distribution network for liquid N_2, a scalable solution for methane elimination across a region. Kathairos is currently demonstrating the operational performance of the solution on wellsites of all sizes, from small, single-well pads to large (20+) well production facilities.
- **Key strengths of technology**: No power required, eliminates 100% of methane venting at wellsite, 100% uptime, no operator involvement, no maintenance required, generates precise emissions data, simple and scalable across the energy industry
- Currently active in **Canada** and the **USA** and exploring the business case for **additional international markets**

LAND & WELLSITE REMEDIATION

Solutions for land management and retirement of inactive oil and gas assets that involve accelerating timelines to closure, reducing costs, and ensuring sustainability in the methods selected for environmental management.

Example technologies and best practices

- Developing fit-for-purpose technologies and novel approaches to **maximize remediation efforts and optimize costs**
- Solutions that support **liability management** and **strategic planning of closure activities**, including remote sensing tools for **environmental monitoring and certification** of wellsites
- Onsite or offsite remediation solutions, including **nature-based solutions**, and **site & well re-purposing**
- Advanced **data gathering and analytical** techniques
- **Digital technologies** that economically enable the objectives of this focus area

Reducing LAND Footprint of Subsurface Imaging

OptiSeis's EcoSeis technology **reduces the land footprint of subsurface imaging by up to 50% and GHG emissions associated with acquiring the high-resolution seismic data** all while maintaining subsurface data quality, enabling safe and efficient field operations, and reducing costs.

This software ranks biological, ecological, and geographical surface information to automatically guide the creation of custom survey designs.

Leaders in lowering the environmental footprint of acquiring subsurface data for **imaging applications (e.g. energy security, CCUS, geothermal, critical minerals extraction,** and **nuclear waste storage**).

OptiSeis engages in extensive collaboration – 5 oil companies, 21+ service and technology providers, and 5 provincial and federal government funding agencies. OptiSeis has tripled in size and expanded into international markets.

OptiSeis is expanding into **Colombia,** the **USA,** and **Australia**.

International growth **target markets** are: **South America,** the **USA, Australia, Africa (South Africa, Egypt, Libya, Nigeria),** and the **Middle East.**

WATER

Technologies for water solutions for the O&G industry with potential applicability across other sectors.

Learn how different water technologies are being used in Canada. From reducing operational costs and improving the reliability and efficiency of water recycling to technologies to reduce the footprint of oil sands facilities and fresh-water intensity.

Example technologies and best practices

- **Water treatment technologies addressing input water quality** aspects: total dissolved solids (TDS), organics, total suspended solids (TSS), turbidity, grease, oil, and silica
- **Operational efficiency solutions:** novel instrumentation, process control, online analyzers, leak prevention, asset integrity, tank inspection and cleaning technologies, feedwater production efficiency, incorporation of artificial intelligence, machine learning, augmented/virtual reality, other digital solutions
- **Alternative steam generation technologies:** steam from alternative and recycled feedwaters
- **Technologies to improve quality and increase reuse of disposal process streams:** reducing oil and grease, TSS, organics, etc., minimizing impacts to groundwater quantity and quality

Solar-Activated WATER Treatment

- SolarPass technology for **passive, high-strength water treatment** in energy, mining, and the resources sector; for treatment **of dissolved organics in process-affected water from tailings ponds**
- Passive, low-energy treatment without input chemicals or waste concentrates that **achieves effluent quality** meeting or exceeding conventional active, high-energy treatment processes, with lower cost and capital intensity
- While the oil sands region has been a strongly aligned beachhead market for H2nanO's development, other regions with intensive energy, mining, and other resources sector industries in more equatorial and arid regions with water stress are ideal for SolarPass. Target markets: **southern USA** (mining, upstream & downstream O&G); **South America** (mining, upstream O&G); and the **Middle East** (upstream and downstream O&G).

Produced WATER Treatment with Ultrafiltration

CRIN Clean Resource Innovation Network

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

- Responsible water-management minimizes freshwater use - **Swirltex is a scalable water recycling system, high Saline Produced Water Treatment with Ultrafiltration**. Approximately 300,000m^3 of produced water can be treated annually with a single Swirlex unit, which supports the operations of up to 15 well sites.
- Reduced freshwater usage and downhole disposal of saline water, ultimately improving water recycling abilities. Anticipate **reduction in greenhouse gas due to trucking reduction** and significant **reduction of freshwater usage associated with oil and gas well fracking**.
- Swirltex is **interested in exploring international opportunities** for its technology.

ARC RESOURCES LTD.

WATER – Tailings Management Through Nano Technology

- Technology to evaluate both the dosing efficacy of Carbonix's products designed to address **water treatment and remediation** requirements of industry partners and scale up production from 100 kg/day to 5 t/day
- **Transforming oil sands mining tailings into high-value products**, eliminating the need for additional mining operations, providing an alternative solution to a protracted waste-product dilemma and enabling a circular economy
- Carbonix is **an Indigenous Canadian company** specializing in **advanced materials technologies** and sustainable solutions for resource extraction and energy transition industries. The company's product portfolio includes special adsorbents and flocculants for mining and oil sands applications, synthetic graphites and carbon blacks made for electric vehicles, energy storage, and other transportation sectors. Carbonix's proprietary carbon scaffold platform is a tool that converts high carbon waste into valuable products.
- Working towards **developing a global presence**, to promote technology and solutions into new markets

CARBONIX

Using Produced WATER to Optimize Steam Generation

- **HipVap technology is an indirectly fired steam generator (IFSG) technology**, developed to reduce the complexity and cost of **steam generation by using untreated produced water** as the boiler feedwater stream.
- Produced water is circulated in the HipVap loop, where 20% steam is generated in the IFSG heat exchanger and circulated to a steam separator. The **closed loop heat source for the IFSG heat exchanger is a hot oil, fired heater package**. The technology does not require typical front-end produced water treatment units
- Commissioned and operational plant has been **successfully generating steam** for the past year with no adverse impact to the host plant.
- Benefits include **reduction in GHG emissions, reduction in land use, decreased water use, lower capital requirement**
- Interested in **exploring international market** opportunities; have interest from the **Middle East**.

DIGITAL Oil & Gas Technology

Digitization technologies of the Oil and Gas sector improves efficiency, safety, profitability and environmental performance. Real time monitoring and analysis enables more informed decision making, reduced downtime, automation and lower costs.

Example technologies and best practices

- Targeted outcomes of Digitalization including
  - **Descriptive** Analytics (what happened),
  - **Diagnostic** Analytics (why did it happen),
  - **Predictive** Analytics (what will happen), and
  - **Prescriptive** Analytics (how can we make it happen)
- Improved integrity, timeliness, and accessibility of **environmental monitoring**
- **Operational efficiency and cost reduction**
- **Capital efficiency of project execution** and streamlined workflow
- Improved **reliability and cost efficiency of health and safety** and maintenance

DIGITAL Technology

CRIN Clean Resource Innovation Network

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AERIUM ANALYTICS

- RoBird is a robotic bird **reducing wildlife incidents at tailings facilities**
- Prospective partners in **Australia**
- **T**argeting leads in **South America, Africa,** and **Europe**
- Seeking collaborations with vendors of visual sensors, aviation radars, machined components, and custom foam products from different industries

VESTEC

- **Contact-based robotic Inspection** using tethered flying robots for industrial/hard-to-reach spaces where inspection is hazardous, expensive, and time consuming
- Partnership agreements with global service companies (Oceaneering and Sonomatic) and in the **US** and **Eastern Asia**
- Seeking opportunities in **Brazil** and **Guyana**

QUBE

- Artificial intelligence and continuous **monitoring technology for real-time emissions detection and reduction**
- Currently in **US**, **Australia**, **Indonesia,** the **Middle East** and **North Africa**

Novel HYDROCARBON EXTRACTION

CRIN Clean Resource Innovation Network

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

Technology solutions enabling **novel solutions to access and produce hydrocarbons** while decreasing the environmental footprint including well architectures/ completions and artificial lift in all reservoirs.

Example technologies

- **Oilsands In Situ:** Low emission extraction technologies such as solvent-dominated processes, electromagnetic heating, or subsurface heat generation
- **Heavy Oil:** Technologies that improve extraction in worm-holed reservoirs including thermal, solvent, chemical, or CO2 EOR projects for cold heavy oil production with sand (CHOPS) that emphasize gas capture vs. methane venting
- **Oilsands Mining/Extraction**: Material handling, aqueous / non-aqueous extraction though solvent or other novel processes for mined oilsands to reduce tailings, GHG emissions, and water consumption, allowing for timely reclamation after closure
- **Technologies or Downhole Treatments** that can be applied to restart/reinvigorate shut-in wells and/or minimize new disturbance by leveraging existing footprints

HYDROCARBON - Syngas Extraction with Integrated Carbon Sequestration

- **Syngas**, or synthesis gas, is a **mixture of hydrogen and carbon monoxide**, in various ratios. The gas often contains carbon dioxide and methane and can be used directly or processed further to produce “greenest blue” ammonia, methanol, and other chemicals.
- **Enhanced Hydrogen Recovery**™ (EHR™) to supply the **low cost, low carbon intensity hydrogen from stranded hydrocarbons**. EHR™ extracts hydrogen-rich syngas from ultra-deep coal and brine and reinjects associated CO_2 back into the same deep seam for permanent geological sequestration, producing clean hydrogen by turning coal ‘from a source to a sink’ of CO_2.
- Globally scalable; 'Cheaper than grey - cleaner than green' (lower cost than hydrogen from dominant steam methane reforming from natural gas and lower emissions than electrolysis of fresh water with hydropower); Onsite CO_2 sequestration from Day 1; Low freshwater demands; Small land-use footprint
- Cv̄ictus is pursuing collaborations in **India**, **China**, and around the **world**.

HYDROCARBON – Nanoparticle-based Foam for CO_2 EOR and CO_2 Storage

- Using **nanoparticle-based foam technology to improve the efficiency of CO2 Enhanced Oil Recovery (EOR) and CO2 storage**
- **Armorfoam** is a novel nanoparticle armored surfactant-based foam that is stronger, more viscous, and more stable than other foams. Its properties maximize pore space for CO2 storage and pressure maintenance for frac hit avoidance.
- Cnergreen is currently **preparing to export product to the US** and is interested in exploring collaboration opportunities across **North America**

CNERGREEN
Clean and Efficient Hydrocarbon Production

HYDROCARBON - Co-injecting Steam and Flue Gases for EOR while Reducing GHGs

- **GERI's Direct Contact Steam Generation (DCSG) co-injector combusts pressurized air and fuel** in direct contact with water, resulting in a single product stream of steam (or hot water) mixed with combustion flue gases
- Rather than venting the flue gas (CO_2 and N_2) to atmosphere, these **products of combustion are co-injected with steam into a well**, simultaneously addressing the two fundamental needs of depleted heavy oil reservoirs: heat and pressure
- **Co-Injecting steam and combustion gases** allows for enhanced oil recovery (increasing oil production) while **reducing up to 67% of GHG emissions** of conventional methods, dependent on the source of electricity and how much CO_2 is retained downhole
- Saudi Arabia & Middle East, South America, India, geographical areas non-thermal completed wells

GERI
GENERAL ENERGY RECOVERY INC.

HYDROCARBON – Electromagnetic Heating Technology for Heavy Oil & Bitumen

- **Electromagnetic Heating Technology, using radio waves, to heat and mobilize heavy oil and bitumen**
- **Eliminates the requirement for steam inherent in SAGD applications**
- Commercial-Scale Pilot is demonstrating the effectiveness of the clean heating technology in a heavy oil reservoir: pilot involves two drilled multilateral heating wells, one production well and a power converter at the surface to deliver up to 2MW of power into the heavy oil target zone
- Accelerware RF XL technology **will reduce freshwater use, have near-zero (GHG) emissions, significantly reduce surface disturbance**, will not require the addition of solvents, and will reduce costs per barrel of oil produced
- Initiated business development efforts in the Middle East, California and Latin America; interested in exploring opportunities in the **US, EU, Middle East, Latin America** and **India**

CCVAP - Carbon Capture, Hydrogen, Bitumen Beyond Combustion, Geothermal, Critical Minerals, and Value-Added Products

CRIN Clean Resource Innovation Network

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

Technologies focused on the alternative sources of energy and the conversion of hydrocarbon raw materials into innovative products of higher value from petroleum and natural gas.

Example technologies include

- **Hydrogen** generation, distribution, and use
- **Value-added non-combustion products** from bitumen (carbon fibre, asphalt binder, activated carbon)
- **Carbon capture, utilization, and storage** or conversion
- Bitumen partial upgrading
- **Critical Minerals** (lithium, vanadium, titanium, nickel) – new recovery techniques from co-produced hydrocarbons
- **Geothermal** technology for renewable energy

CCVAP - Clean HYDROGEN Production

- **Pulsed Methane Pyrolysis (PMP) technology converts natural gas into hydrogen and solid carbon**, significantly reducing CO2 emissions (up to 90%) and delivering decarbonized hydrogen at costs comparable with conventional steam methane reforming systems
- Ekona's PMP produces industrial H2 at costs comparable to incumbent steam methane reformers, while reducing GHG emissions by 90%.
- Low levelized cost of hydrogen < C$2/kg-H2 which is competitive with blue hydrogen or better
- In **pursuing international opportunities**, Ekona secured Series A investment with Baker Hughes, Mitsui, CDP Venture Capital SGR S.pA., ConocoPhillips, Na'-Nuk Investment Fund LP (McKinley Capital), Continental Innovations LLC and Trirec.
- Ekona has participated with **TCS delegations** from **Denmark, SouthEast Asia, Ecuador, and Guatemala**

CRIN

EXTRA REFERENCE MATERIALS

Technology Showcase @COP28

Later-stage Canadian technologies were showcased at the UN Climate Action Conference 2023 (COP28), in Dubai, at the CRIN Pavilion.

Technology Theme Overviews

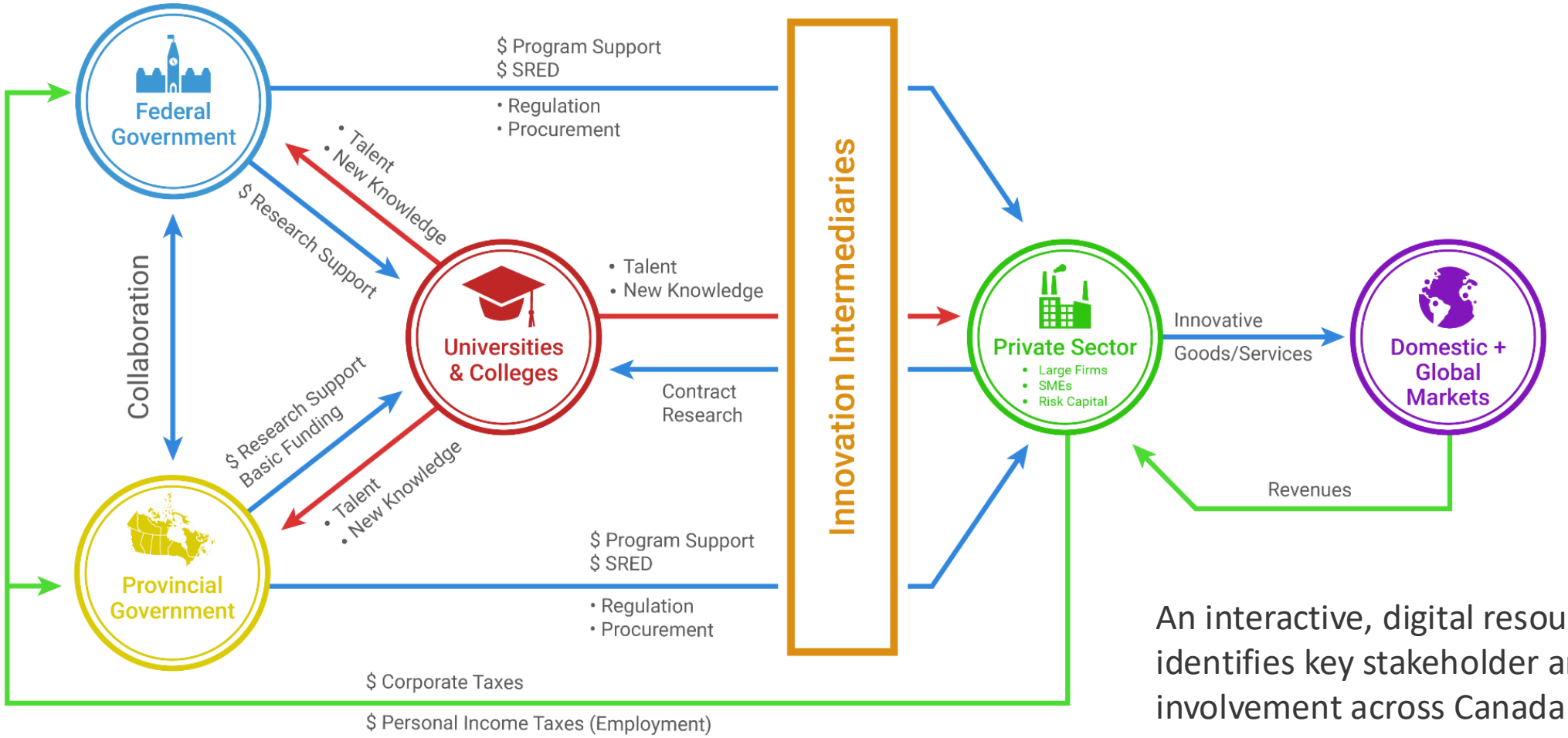
Statements from CRIN Technology Theme leads:

- Novel Hydrocarbon Extraction
- Carbon Capture & Value-Added Products
- Digital Oil & Gas

CRIN
REFERENCE TOOLS

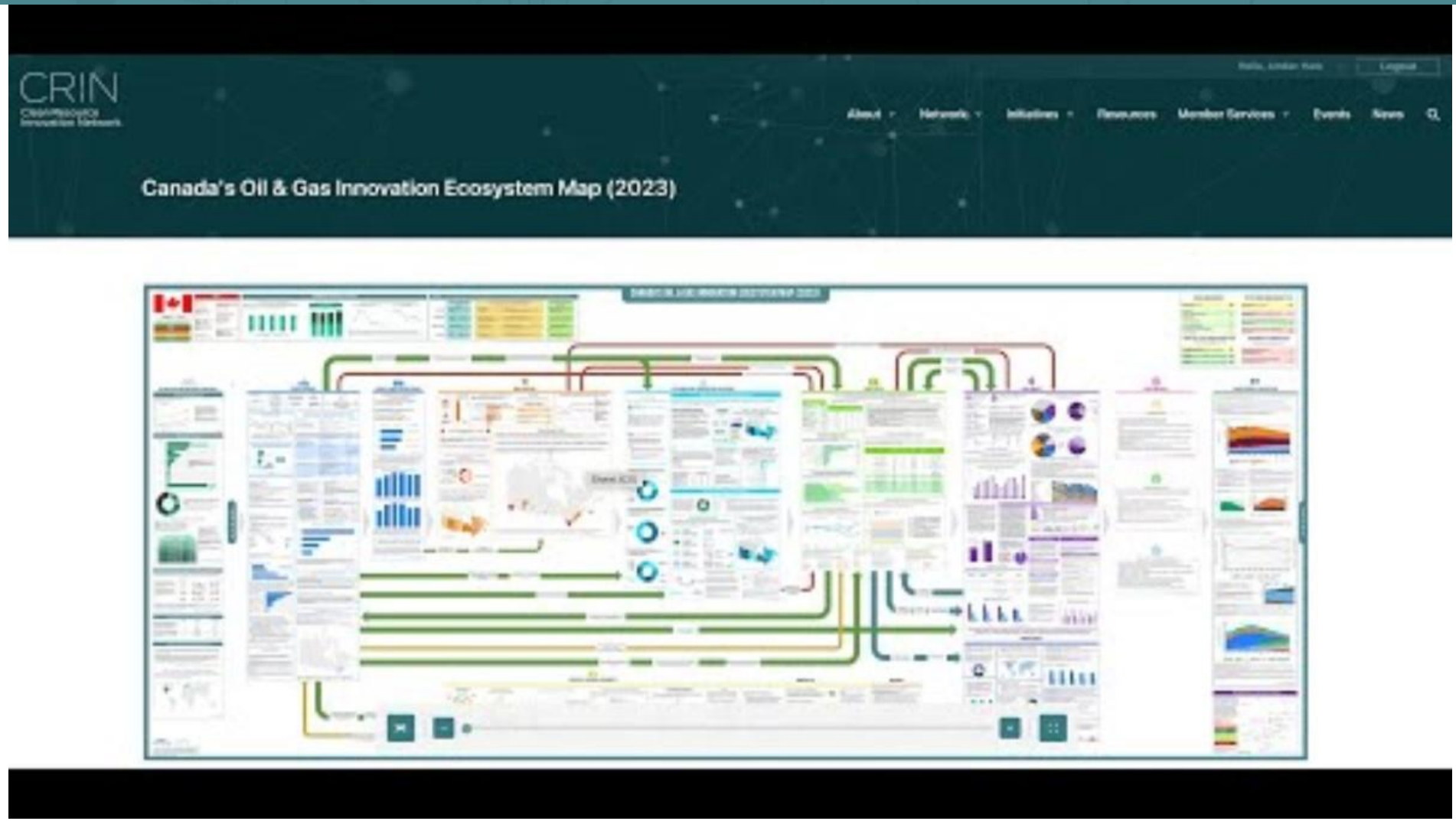
ARE YOU A MEMBER?
JOIN US!

Innovation Ecosystem Map & Dashboard

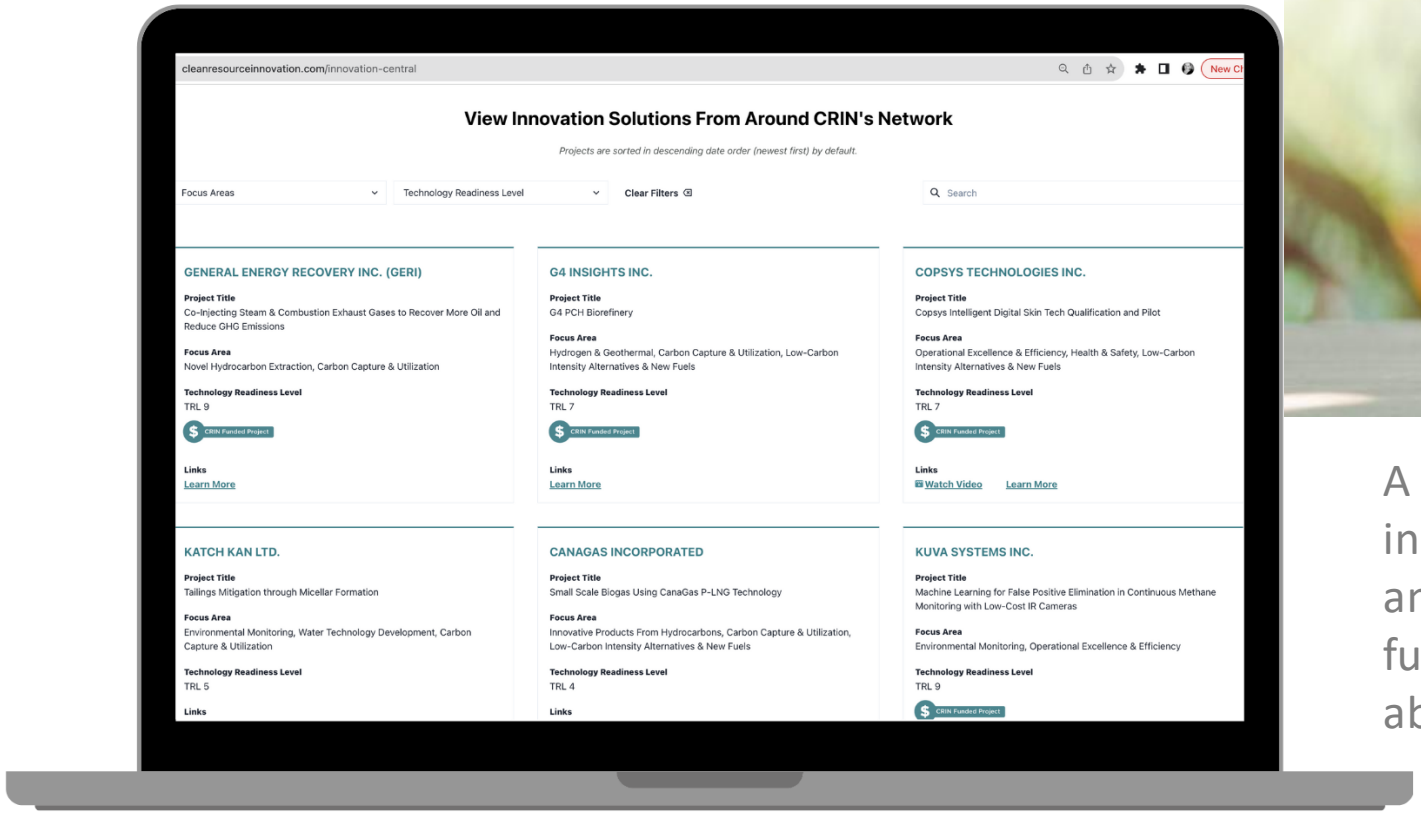


An interactive, digital resource that identifies key stakeholder and sector involvement across Canada and globally.

Innovation Ecosystem Map & Dashboard



Innovation Central



A **searchable digital platform** for innovators to showcase technology, and for technology adopters and funders to survey and learn more about new technology solutions.

PTAC Petroleum Technology Alliance Canada
CRIN Clean Resource Innovation Network
Innovation Showcase

**Note links only work in slideshow mode.*

Other CRIN Resources

Project Café series – a showcase of technology solutions and networking opportunities among like-minded professionals from various sectors to advance solution development and adoption and create new opportunities for innovation collisions.

Policy Awareness series – awareness building webinars on emerging policy directions, regulatory tools, and government support mechanisms for technology research, development, and implementation. This often includes discussions of foreign policies and their potential impact on Canadian innovation. It also includes discussions of developments in other sectors and potential benefits of cross-sector infrastructure.

Money Talks – an informational series that featured public and private funders and investors to help navigate various financial assistance programs available for researchers, innovators, entrepreneurs, and start-up technology companies in Canada.

**Note links only work in slideshow mode.*


Trade Commissioner Service
Service des délégués commerciaux
Take a break
10 9 8 7 6 5 4 3 2 1 0 minutes left

AGENDA

✓ 9:00	Introduction & Land Acknowledgement	- Jordan Reeves, Global Affairs
✓ 9:05	Global Outlook	- Marc Godin, PTAC
✓ 9:25	Regulations & Incentives	- Lindsay Campbell, Validere
✓ 9:40	Q&A	- Marc Godin, PTAC & Lindsay, Validere
✓ 9:45	Energy Transition Technology Themes	- Glen McCrimmon, CRIN & Soheil Asgarpour, PTAC
✓ 10:30	Innovation Ecosystem Reference Tools	- Glen McCrimmon, CRIN
✓ 10:40	break	
❑ 10:50	Canadian Energy CleanTech Directory	- Bruce Peachey, PTAC
❑ 11:50	Closing Remarks	- Global Affairs Canada
❑ 12:00	Adjournment	

Canadian Energy CleanTech Directory

Overview of PTAC's Canadian Capabilities in Clean Technology for the Global Upstream Oil and Gas Industry Initiative

Bruce Peachey, P. Eng.
Senior Technology Advisor, Petroleum Technology Alliance Canada

Directory Development Process

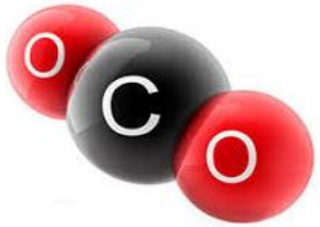
CANADIAN ENERGY EXPORT GUIDE

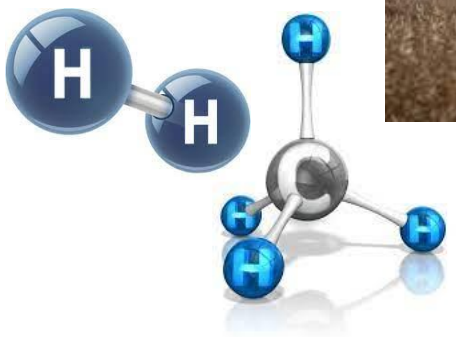
PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

Clean Technology Products and Services in Canada

- Starting Point – Entries in the Canadian Energy Export Guide under Products and Services
  - Clean Technology and Environmental Management
  - Check information and use email to invite participation in appropriate Directory
  - Environmental (190), CCS (51), Well Life (8), Offshore (7), Hydrogen Enrichment (0)
- PTAC Member List + Alberta Upstream Petroleum Research Fund (AUPRF Researchers)
  - Invite to participate
- Web Searches of Canadian Suppliers
  - Main focus is on poorly represented areas → Target to invite ~100 new companies/organizations with relevant technologies Canada-wide

Clean Tech Areas Redefined





- For under-represented topics expand definitions
  - Environmental Management → already very broad
  - CCS → Expand to include small scale injection processes
    - Improve production economics with low impact technologies
  - Offshore → Include navigation, mammals, fish, marine, GHG issues
  - "End of Well Life" → Expand to technology to reuse oil and gas wells for other purposes and unique issues with "Orphan Wells"
    - Lithium from Aquifers, Geothermal Heat/Power, Gas Storage, Waste Disposal, Monitoring
  - "Hydrogen Enrichment" → Increasing hydrogen content of streams produced or utilized upstream
    - Fuel Switching, Partial Upgrading, Gathering Systems for "Hythane" from remote sites

Content for Each Clean Technology Directory Section

- Introduction to the global impacts
- What is the Canadian Advantage?
  - Extent of experience, Magnitude of issue in Canada, Supporting Organizations
- Sources of Clean Technologies and/or Opportunities
- Case Studies from Canadian Applications
  - High level for this presentation involving integration of many products and services
  - Will evolve to company-based case studies as Directory content builds
- Canadian Capabilities – Companies, Products and Services

“Clean Technologies” Not All New e.g. Natural Gas Emissions

- Canada has regulated emissions for many decades mainly for safety and health reasons
  - Other components released with the methane can be toxic, noxious or cause odours.
- Priorities Driving Reduction:
  - Safety – Stop or shut-in if there is a hazard
  - Quality of Life – Odours shut-in until solved
  - Economics – Loss of revenues/royalties
  - Reduce GHG emissions – Newest reason to reduce

Case Studies in the Methane Directory

CRIN Clean Resource Innovation Network | PTAC Petroleum Technology Alliance Canada

Combustors

Questor

Vapour Recovery

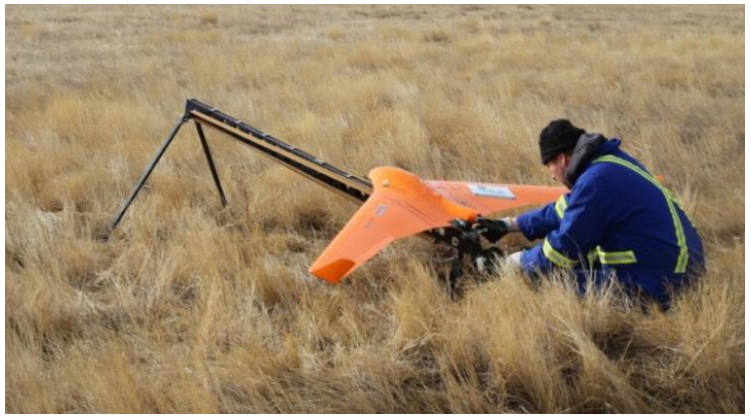
MARATHON COMPRESSOR SERVICES

Hybrid Remote Power

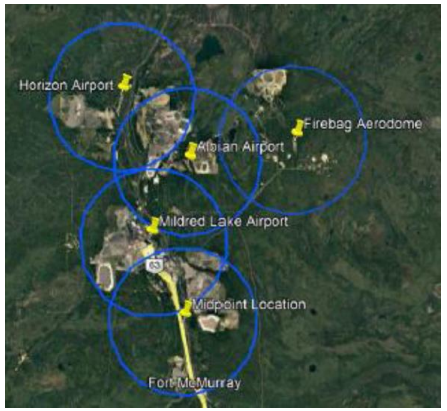
convrg

Research - Containment and Monitoring

Carbon Management Canada



Highwood Emissions Management



Monitoring

CANADIAN UAVS

Methane Emissions Example Company

Kathairos Solutions Inc.

www.kathairos.com

LOCATION
Calgary, Alberta

PRIMARY CATEGORY
Instrument Air

CONTACT INFORMATION
Oscar Donor
Sales and Marketing Manager
odonor@kathairos.com

SECONDARY CATEGORIES
Detection, Measurement, Quantification, Monitoring, Reporting,

COMPANY DESCRIPTION
The patent pending Kathairos™ solution eliminates methane emissions from pneumatic devices at remote oil and gas facilities effectively and affordably. The solution is elegant in its simplicity. Kathairos uses nitrogen to replace methane as the operating gas for pressurized devices, with no on-site electricity or operator involvement required. A specialized cryogenic tank is placed on site and tied into existing systems; liquid nitrogen stored in the tank is then vaporized at the pressures and quantities needed to drive devices. As the nitrogen depletes (about once a month), the Kathairos team refills the tanks, similar to a propane model.

The system works on a lease arrangement and involves no up-front capital costs. System cost and nitrogen usage reflect actual vent rates, making it economical to convert wellsites of all sizes (annual costs start at $3000/year). In addition to its hardware and software offerings, Kathairos has an in-house emission offset management team that converts customers' emission reduction activities to valuable emission offsets. In the vast majority of cases, the value of offsets more than covers the annual cost of the Kathairos technology.

COUNTRIES EXPORTED TO
United States (Active in Marcellus, D-J, Bakken, Permian, Haynesville basins; trials underway in others)

INTERNATIONAL APPLICATIONS AND EXPERIENCE
Operations across Canada and the U.S.

TECHNICAL CAPABILITIES
Liquid nitrogen (LIN) is the backbone of the company's technology and powers the solution. Since LIN is inert, non-corrosive and waterless, it is the ideal candidate to replace natural gas used by pneumatic devices. Stored at -196c, LIN becomes gas naturally when exposed to everyday temperatures, even during winter. In addition, when stored in a tank, LIN builds pressure as it becomes gas. The Kathairos™ solution takes advantage of this naturally occurring phenomenon, resulting in a solution that has no moving parts, no maintenance, no electricity requirements and has no emissions. The only operator involvement is an on/off isolation valve, everything else is automated. On-site sensors and telemetry systems transmit all data to a cloud-based portal and Kathairos' proprietary emissions tracking software.

The solution has also been used by customers for pigging, and to act as back-up for grid-connected air systems liable to power outage.

For each company, information is being requested → information provided by the company in their own words

- Contact Information
- Technology Categories they Service (often more than one)
- Company Description
- Countries Exported to
- International Applications and Experience
- Technical Capabilities

Methane Directory available online: https://www.ptac.org/canadian-capabilities-in-methane-emissions-reduction/

Environmental Management

- A major focus globally on “cradle to grave” impacts of development
- Largest Clean Tech Sector in the Export Guide (~190)
- Very Broad Coverage for Air, Water, Land, Ecological, Remediation & Reclamation
- Technology needs vary with geography, resource being produced, stage of development, enforced regulations

Bakersfield, California, U.S.A.

Source: Dessert Sun

Caspian Sea, Azerbaijan

Source: Offshore Energy

Lake Maricaibo, Venezuela

Source: Reuters

Environmental Management Canadian Advantage

CRIN Clean Resource Innovation Network | PTAC Petroleum Technology Alliance Canada

- Global reputation as a well-regulated and environmentally conscious industry
  - Improving continuously since first production In Ontario, 1858
  - 2nd largest country in the world by area
  - 3rd largest supply of renewable fresh water
- Developments are widespread and co-exist in many different geographies – farmland, muskeg, boreal forest, mountains, arctic, offshore, in most provinces/territories
- Produce almost every type of oil and gas – sweet/sour gas, condensates, shales, light/medium/heavy oil and bitumen (mining and thermal)

Impact Reduction Opportunities

- Impacts and solutions vary with the issue and stage of development
  - Exploration Stage – Mainly land disturbance impacts
  - Development Stage – Ecological impacts of intense activity
  - Production Operations
    - Conventional Oil – Spill potential (oil/salt water), operator monitoring
    - Conventional Gas – Main impact gas plant operations
    - In-situ Oil Sands – Intense activity in muskeg and boreal forests
    - Shale Resources – Extremely large volumes of water required
  - Gathering Systems and Pipelines – Ecological impacts of linear features, protection of 100,000s km of lines

Source BOE Report

Source: BC Government

Source: CAPP

Source: CBC News

Source: Energy Job Shop

Environmental Management Case Study

- Water Treatment Specialist based in Richmond B.C.
  - Company listed in Energy Export Guide
- Oil and Gas Produced Water
  - “Solutions for minimizing offsite disposal, improving hydrocarbon recovery, reducing polymer consumption, and protecting injection well assets.”
- Shale Gas
  - “Provide end-to-end solutions that reduce volume while safely managing NORMs and volatile emissions” from return flows from shale fracturing operations
- Enhanced Oil Recovery
  - “Advanced solutions can reduce polymer consumption and deliver recycled injection water with lower hardness and suspended solids”
- Sensors
  - “ScaleSense is an automated, real-time sensor for saline waters”

Saltworks

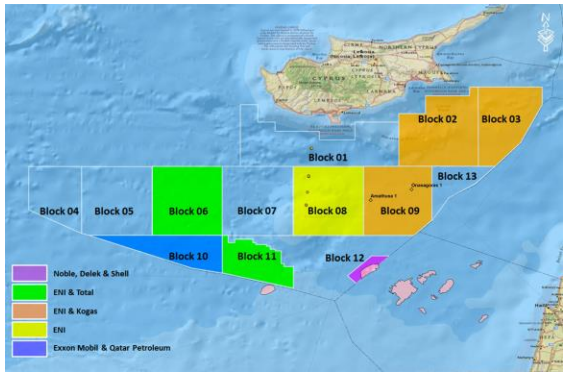
http://www.saltworkstech.com

Environmental Management Capabilities

- Random Examples from Export Guide
- Products
  - Water treatment equipment – filters, softeners, deoiling, separation
  - Air emissions mitigation systems – vapor recovery, incineration
  - Low land impact – seismic options, rig mats,
  - Noise suppression – insulation, mufflers
  - Monitoring systems – on-lease, truck mounted, air bourne, satellite
- Services
  - Environmental/ecological research – Alberta Upstream Petroleum Research Fund (AUPRF https://auprf.ptac.org/)
  - Engineering/monitoring – Design, reviews, technical expertise
  - Reporting – Systems, audits, analysis

Offshore Clean Technology

Oil Offshore Guyana & Suriname



Natural Gas Offshore Cyprus

Source: Radio Free Europe Radio Liberty

- Globally offshore developments are growing rapidly in new regions
  - Guyana, Suriname, Cyprus, Romania – little national prior experience or technical capabilities for offshore developments
  - Occurring rapidly to replace oil and gas from Russia
- Many developments in areas without marine environmental research institutions or government policies
- Increasing concerns with security of offshore installations and pipelines where offshore infrastructure is “exposed”


Nordstream Pipelines Offshore Denmark

Offshore Oil and Gas Canadian Advantage

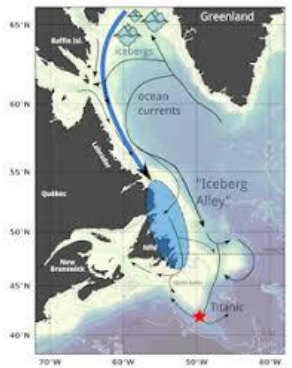
Hibernia

Hebron

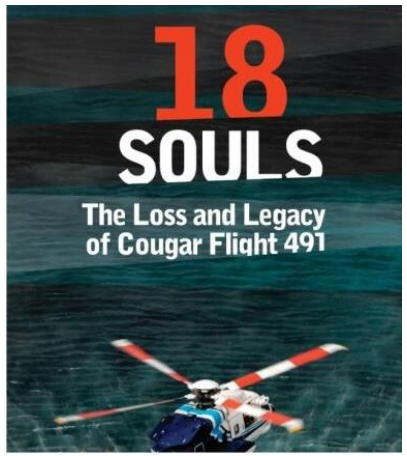
- Not generally recognized as a leader due to smaller volumes and fewer projects, however:
  - Canadian offshore areas are the most challenging in the world
    - Ice, ice bergs, winter storms, distance from shore
  - Longest maritime coastlines in the world (240,000 km)
  - Over 5 million km^2 of ocean Exclusive Economic Zone in three oceans and Great Lakes producing about 22% of Canadian Oil production
  - Four Major Projects – Hibernia, Terra Nova, White Rose, and Hebron
- Very active in Marine research – mammals, ice, fisheries, safety – Developments regulated by provincial and Federal govt's

Terra Nova

White Rose



Impact Reduction Opportunities



- Current Energy Export Guide Clean Technology Section only lists 7 Offshore Suppliers mainly focused on offshore power or utilities
- Platform/ship stability and operations are a concern as there are no flow lines to shore due to ice scour → tankers required to transport oil
- Operations close to the Grand Banks fishing grounds and marine mammal populations
- On-board and shore-based systems to support reliability critical to environmental and safety performance
- Personnel protection in the North Atlantic environment

Offshore Case Study

- Ocean Mammal Detection Systems Based on AI
  - Environmental Consulting on Offshore Activity Impacts on Whales
  - Montreal based Whale Seeker for Aerial and Satellite Detection

"Revolutionize your environmental impact assessments with Möbius and Cetus, cutting-edge AI-powered monitoring solutions. Eliminate human bias, enhance data accuracy, and streamline marine mammal monitoring for expanded project scopes and precise recommendations."

  - Avoid tanker whale incidents, monitor whale populations to assess impacts on populations and behaviors.
  - Partner in "The Whale Carbon Plus Project" showing how healthy whale populations enhance carbon capture to the oceans.

https://www.whaleseeker.com/

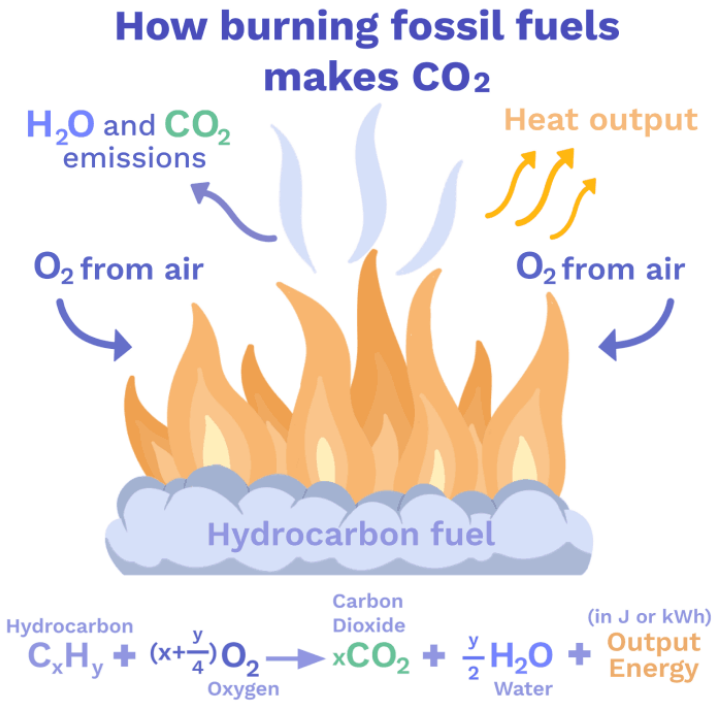
https://thewhalecarbonplusproject.com/

Offshore Oil and Gas Capabilities

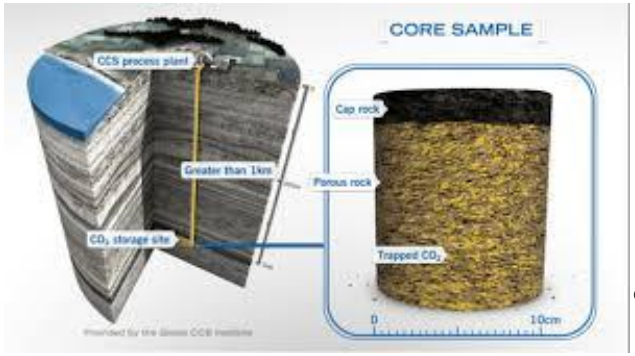
- Ocean Technology Based Networks
  - Canada's Ocean Supercluster https://oceansupercluster.ca
  - Ocean Technology Alliance Canada https://canadasoceanassets.ca/directory/wpbdp_category/oil-and-gas/
  - Supported by major Canadian offshore producers:
    - ExxonMobil, Chevron, Murphy Oil, Equinox, Cenovus, Suncor
- Random Examples from Energy Export Guide
- Products
  - Monitoring technologies to protect offshore and marine infrastructure
  - Sub-sea surveying systems and ocean floor geophysics
- Services
  - Marine systems and services
  - Training to support marine environmental monitoring and management

Carbon Capture (CCUS) Technology

- Aggressive “Net Zero” Targets with energy demand continuing to grow globally will require CCUS technologies
  - Potential demand for 1,000 to 2,700 Gt of cumulative injection by 2100 which is over 10,000 times the CO_2 injected to date for Enhanced Oil Recovery (EOR)
- U.S. has the lead in use of these technologies due to decades of CO_2 EOR, access to offshore CCS sites in the Gulf of Mexico, large coastal hydrogen plants and Policies
- Other countries have announced many projects, mainly for offshore disposal of CO_2 from offshore oil and gas platforms with international pipelines

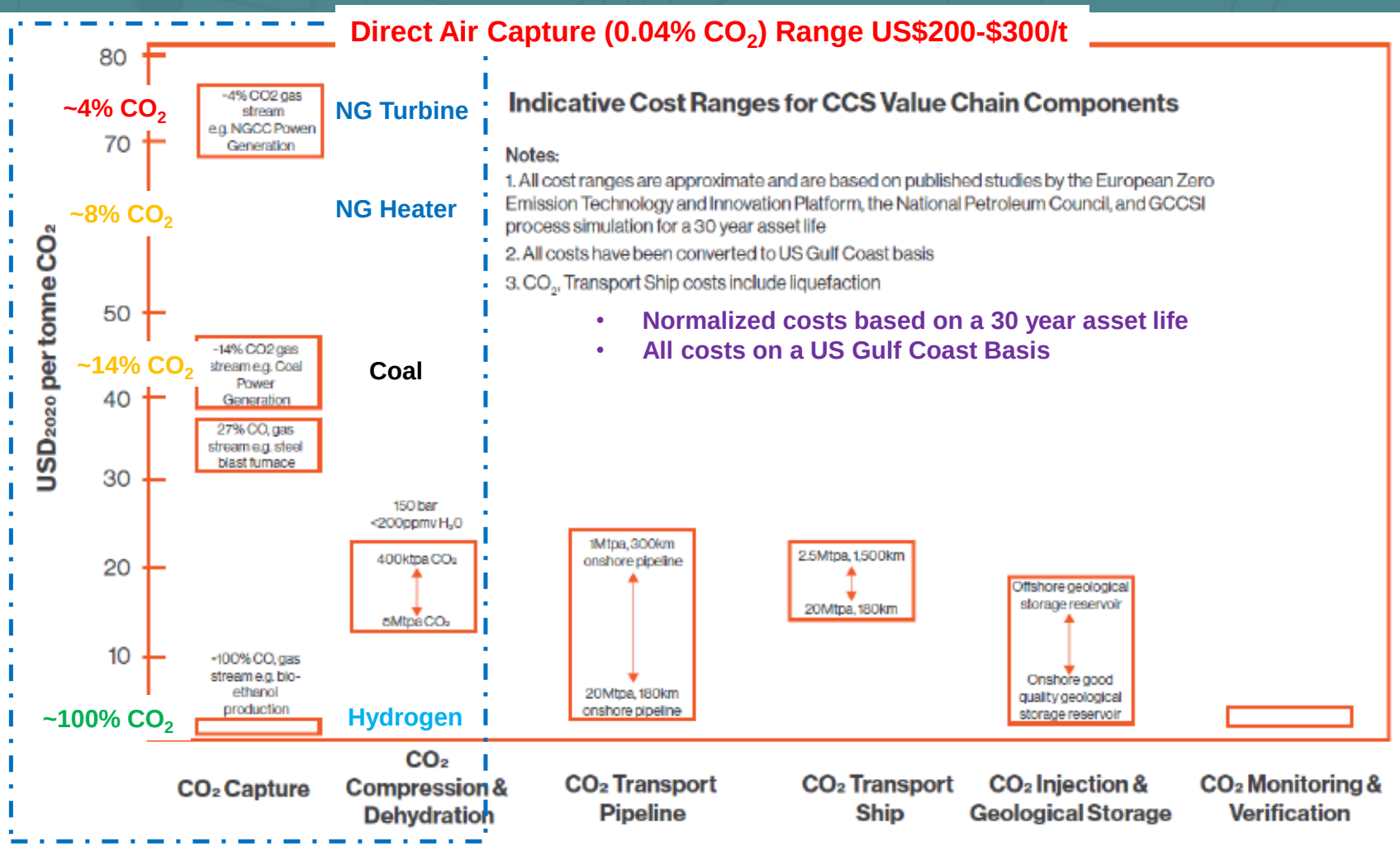


CCUS Canadian Advantage



- Extremely large potential "pore space" onshore near large CO_2 sources in oil sands and petrochemicals
  - Weyburn CO_2 EOR Project has injected more CO_2 than any other single project → Approx. 36 Mt to date. Main operator as a result has Net Negative GHG Emissions
- Large hydrogen plants in western Canada produce concentrated CO_2
  - Global scale Shell Quest (1 MT/yr) and Alberta Carbon Trunk Line (14.6 Mt/yr) projects are in operation
- Decades of experience across the industry with gas "sweetening" processes and "acid gas" injection which are required for CO_2 capture and disposal
  - Approximately 1/3rd of the gas produced in Canada was "sour" containing CO_2 and Hydrogen Sulphide

CCUS Opportunities



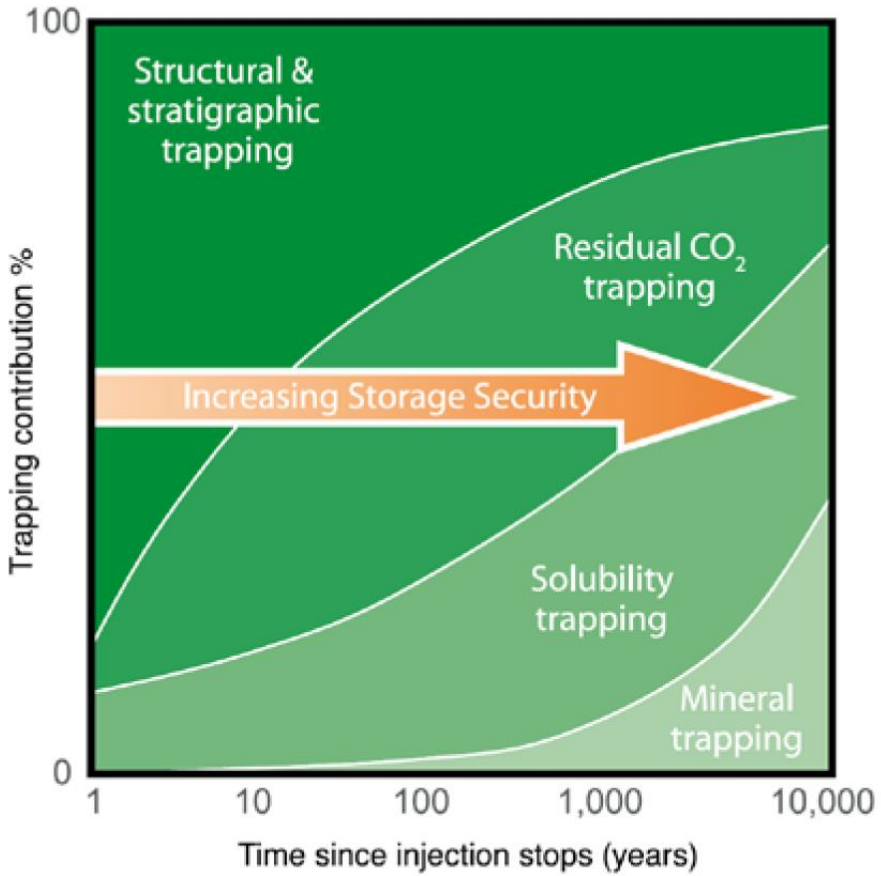
- **Reducing high costs** – Both in Energy and in Capital

CCS Project Components:

- CO_2 Capture
- Compression/Dehydration
- CO_2 Pipelines/Ships if Offshore
- CO_2 Injection Sites
- Monitoring and Verification

Circular Carbon Economy Section 6 Remove: Carbon Capture and Storage, August 2020, Figure 5, Global Capture and Storage Institute, https://www.globalccsinstitute.com/wp-content/uploads/2020/11/Remove-Carbon-Capture-and-Storage-6.pdf

CCUS Opportunities Continued



- Canadian Technology Providers addressing unknowns
  - Can provide research and testing to confirm containment, extent and response to CO_2 injection
  - Address concerns with CO_2 pipeline reliability and safety
  - Geotechnical and geochemical uncertainties
  - Assessing time required for monitoring which could be hundreds or thousands of years until CO_2 reacts
- Safety concerns of people living near injection sites
  - Blowouts have occurred from wells used for natural gas storage

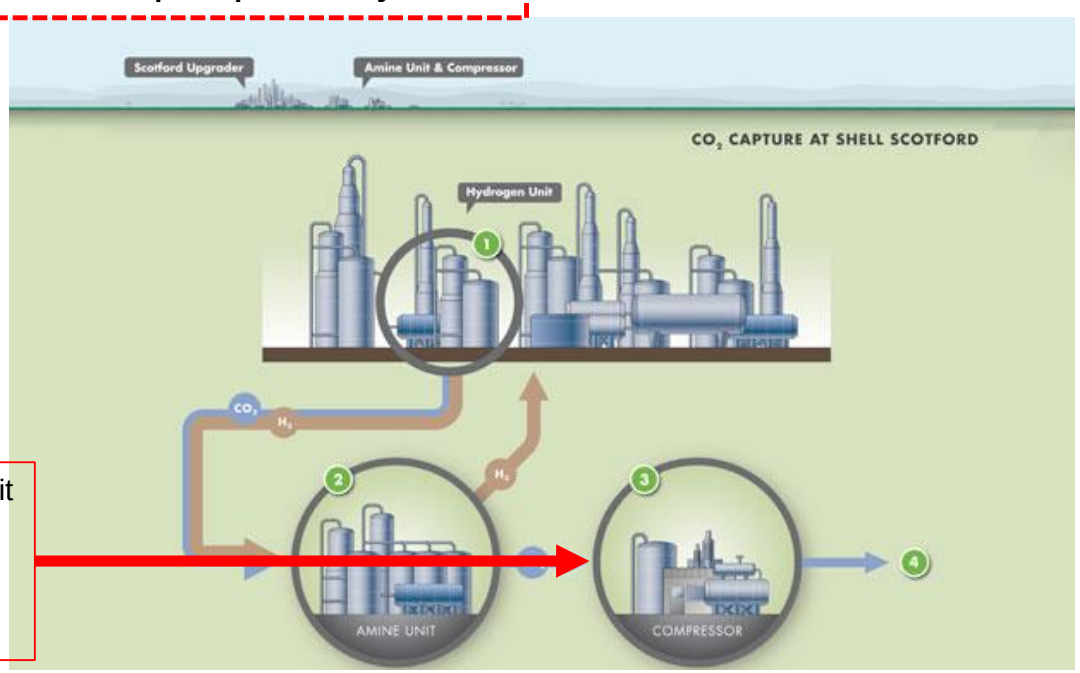
CCS Case Study

Shell Quest Process at Scotford

- Methane conversion to CO_2/H_2 in Hydrogen Unit
- Separate Relatively Pure CO_2 in Amine Unit
- Compress and dehydrate CO_2 to 14.5 Mpa
- Send CO_2 by Pipeline to Deep Aquifer Injection

- First and largest demonstration by Shell
- Almost $1B invested by Shell partners, Alberta and Canada
  - Over 7.7 Mt injected since start-up in 2015

Average CO_2 Injected ~1.13 Mt/yr
Average CO_2 Avoided ~0.89 Mt/yr
GHG Mark-up = 21%
2019 Shell Quest annual report:
https://open.alberta.ca/publications/quest-carbon-capture-and-storage-project-annual-report-2019



Stream from Amine Unit
- T = 25°C
- P = 200 kPa(a)
- $[CO_2]$ = 98.4%
- $[H_2O]$ = 1.6%

Excludes mark-ups for making and separating hydrogen

Annual Reports are publicly available

CCUS Capabilities

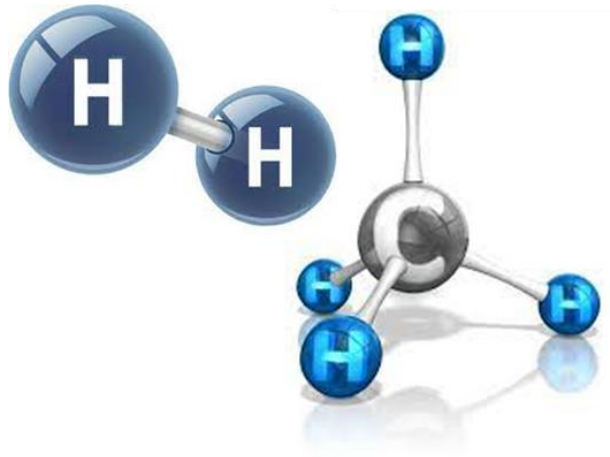
- Products
  - Existing sour gas plants and pipelines can be repurposed for CCS
  - Manufactures specialized in stainless steel vessels and piping
  - Sour gas compression equipment
  - Monitoring and emergency response equipment
- Services
  - Many capable engineering contractors have experience designing these plants
  - Sour gas handling training courses and qualified workers
  - Research – geophysical, geotechnical, geochemical, life cycle analysis, pipeline design
- Total of 51 entries in Energy Guide under CCUS
  - Excellent potential to add more
  - Many systems still untested except on smaller scales

Hydrogen Enrichment Technology

- Globally hydrogen conversion efforts mainly affect downstream users though hydrogen manufacturing and fuel replacement
- Upstream oil and gas operations generally will be the last to have access to economic hydrogen, so assumed focus is on enriching upstream products with hydrogen
- Focus is on:
  - Fuel switching to hydrogen rich fuels → Compressed natural gas
  - Partial upgrading of heavy oil bitumen to increase the hydrogen content and leave carbon in the field
  - Utilizing upstream facilities to gather hydrogen as hythane from upstream or renewable hydrogen sources

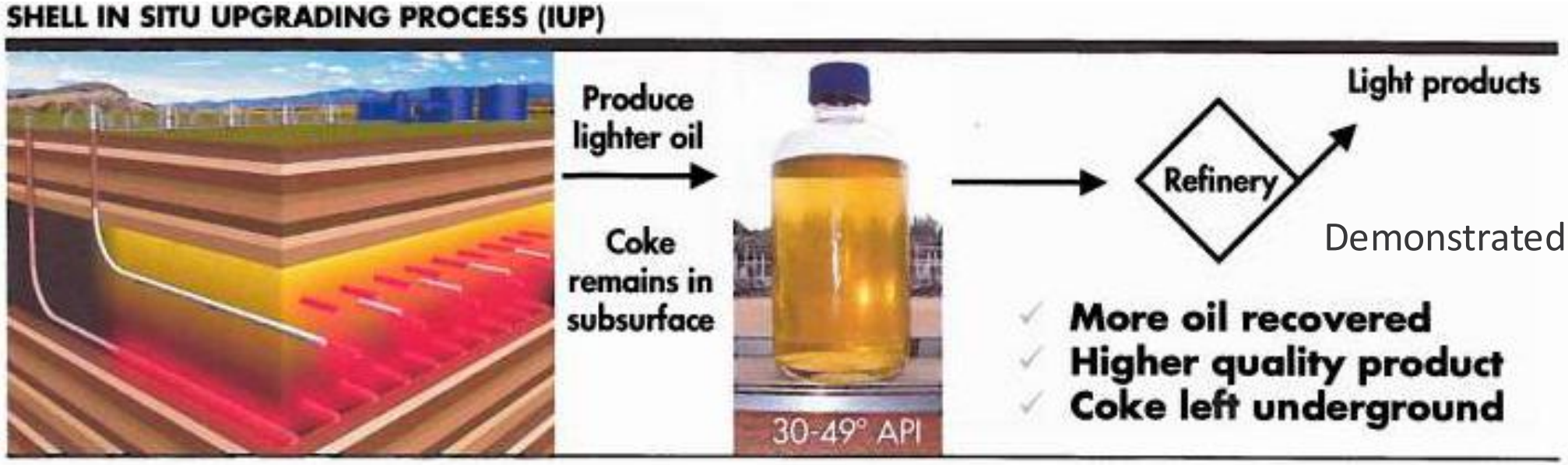
Hydrogen Enrichment
Canadian Advantage

- Easy and widespread access to pressurized natural gas, available at a low cost. Have converted fleets to natural gas when oil prices were high
- Strong incentive to upgrade heavy oil/bitumen → Increase H-C ratio
- Many renewable power sources (wind and hydro) are located near natural gas gathering and pipeline systems.



Hydrogen Enrichment Opportunities

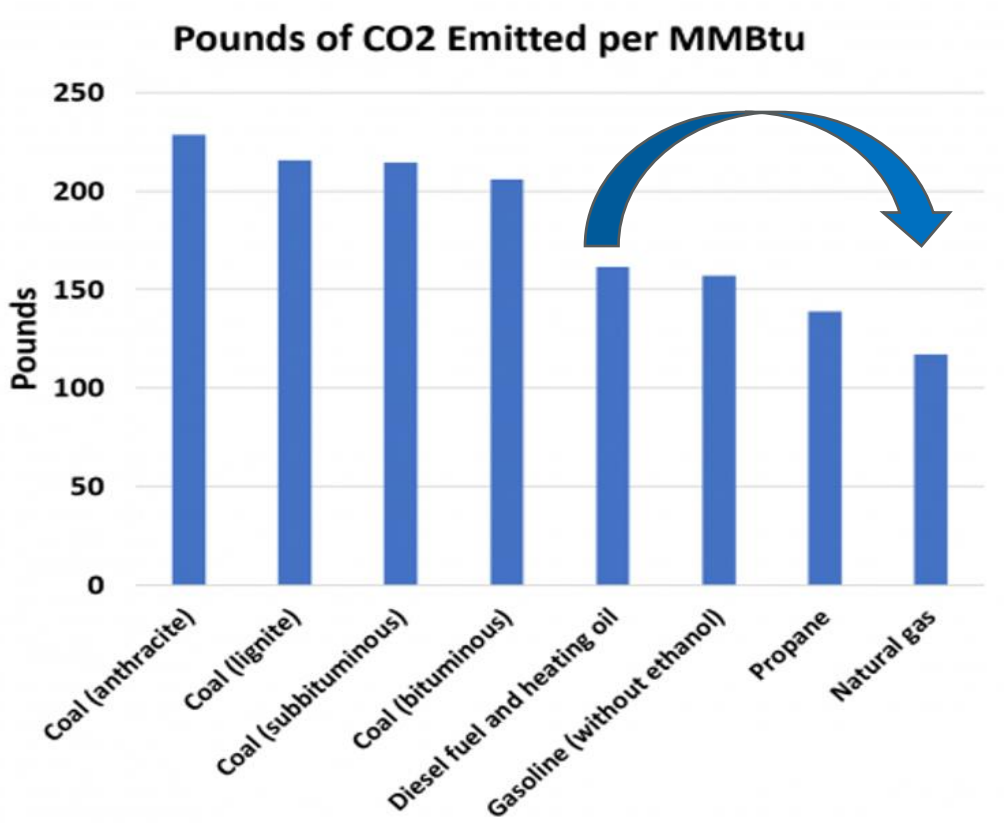
- Fuel conversion to natural gas still results in GHG emission
- Many upgrading processes have been demonstrated or piloted few have moved on to commercial scale in Canada
  - Economics are mainly an issue for smaller producers without large scale upgrader capacity
- Transfer of hydrogen from remote sites



Demonstrated in Alberta Oil Sands

Hydrogen Enrichment Study

- Conversion of Rigs to Alternative Energy
  - Canadian Association of Energy Contractors results
  - Systems demonstrated potential GHG reductions:
    - High-line power – GHG savings 98, 21 or 16% (BC, AB, SK)
    - Natural gas + Batteries – 31-40%
    - Bi-fuel + Batteries – 24%
    - Natural gas Generation – 20-25%
    - Batteries – 14-20%
    - Bi-fuel conversion – 12-15%
- Compressed Natural Gas for Truck Fleets
  - Enbridge https://www.enbridgegas.com/
  - Certarus Low Carbon Energy Solutions https://certarus.com/contact-us



Pounds of CO_2 Emitted per MMBtu for Selected Fuels. Source: EIA

https://caoec.ca/esg

Hydrogen Enrichment Capabilities

- Products
  - Natural gas compressors and generators
  - Carburator conversion packages – diesel to CNG
  - Partial Upgrading Processes
  - Remote renewable hydrogen plants
  - Hydrogen/methane separation equipment
- Services
  - Engineering contractors
  - Research Pipelines and Reliability Testing
  - Life cycle assessments
- Reviewing entries in Energy Export Guide under Hydrogen

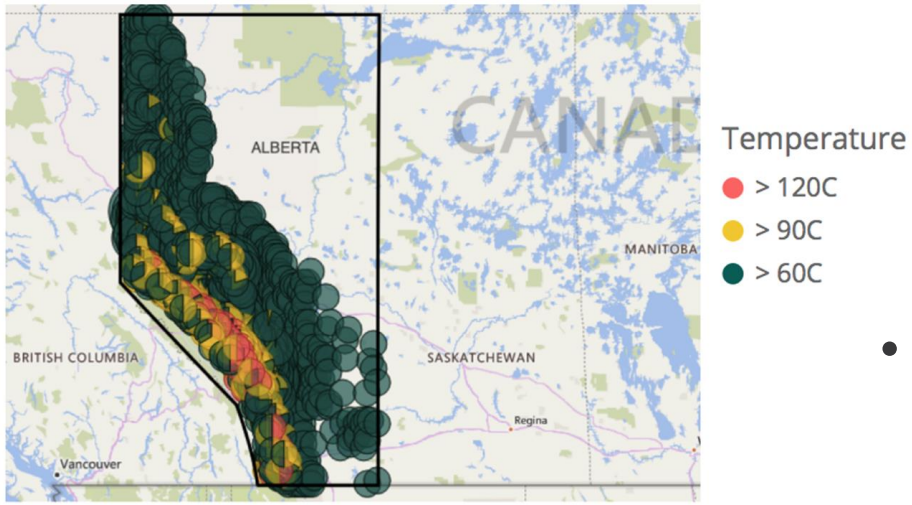
End of Producing Life Technology

- Globally millions of oil and gas wells become depleted and are replaced with new wells
  - In the U.S. roughly 5 million wells have been drilled since 1859
    - Over 3 million plugged, capped and abandoned
    - Potentially over 100,000 are “orphan wells” (no clear owner)
- The US Energy Information Administration estimates oil and gas demand will continue to increase to at least 2050
- New Wells will also be required for
  - CCS, storage of CO_2 or Hydrogen, disposal of wastes, monitoring

End of Producing Life Canadian Advantage

Orphan Well Association

Alberta Energy Regulator



Geothermal Temperatures in Wells

- Regulations, enforcement and funding working to reduce shut-in and orphan wells.
- Canadian active wells onshore
  - Alberta – Total 470,000 → 33% active → 20% certified as reclaimed
  - Saskatchewan – Total 145,000 → 20% active
  - British Columbia – Total 30,000 →30% active
  - Ontario – Total 27,000 → 5% active
  - Manitoba – Total 12,000 → 40% active
- Opportunities to reuse wells
  - Alberta legislation for ownership of pore space for CCS
  - Alberta legislation for ownership of thermal energy

End of Producing Life Opportunities

- Assess wells for other potential uses before abandonment or while still in operation
- Potential other uses for wells or benefitting from well data
  - Single well stimulation for increased production
  - Natural Gas/Hydrogen Storage – depleted gas pools
  - Geothermal Heating → Oil wells not hot enough for power
  - Minerals from aquifers → Co-processing of produced water
  - Disposal of Waste-water, Hazardous Materials,

Natural Gas Storage
Dawn, Ontario

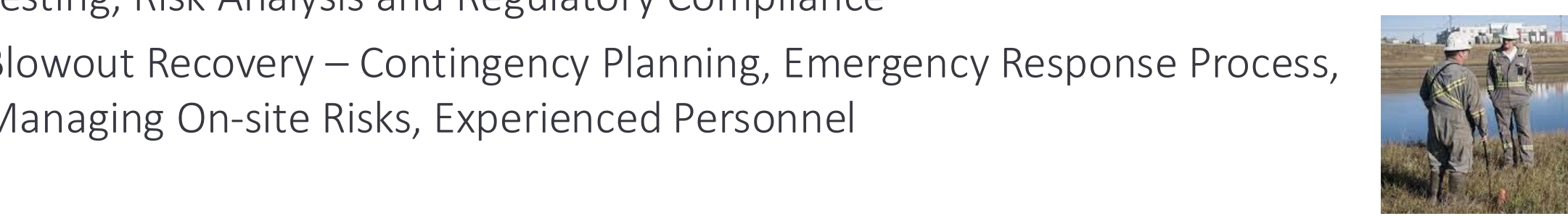
Lithium from Oil Wells

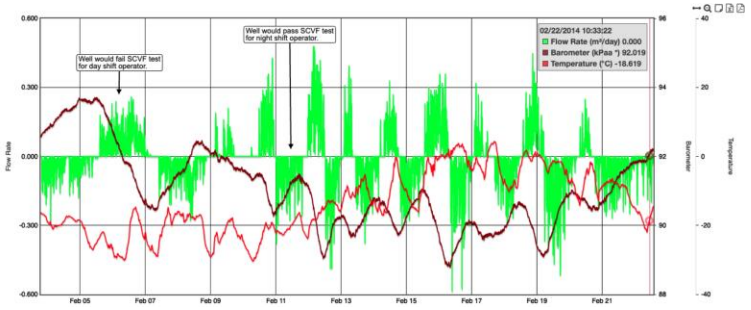
Or

Lithium from Evaporation

End of Producing Life Case Study

- Data Collection - Capstone utilizes VentMeter™ technology, the most precise real-time data collection system with the industry-leading flow and pressure resolution.
- Well Integrity Assessments – Site Assessments, Surface Casing Flow Testing, Risk Analysis and Regulatory Compliance
- Blowout Recovery – Contingency Planning, Emergency Response Process, Managing On-site Risks, Experienced Personnel





VENTMETER™
TECHNOLOGY LEADING THE FIELD
Exclusively through Capstone

End of Life Well Capacities

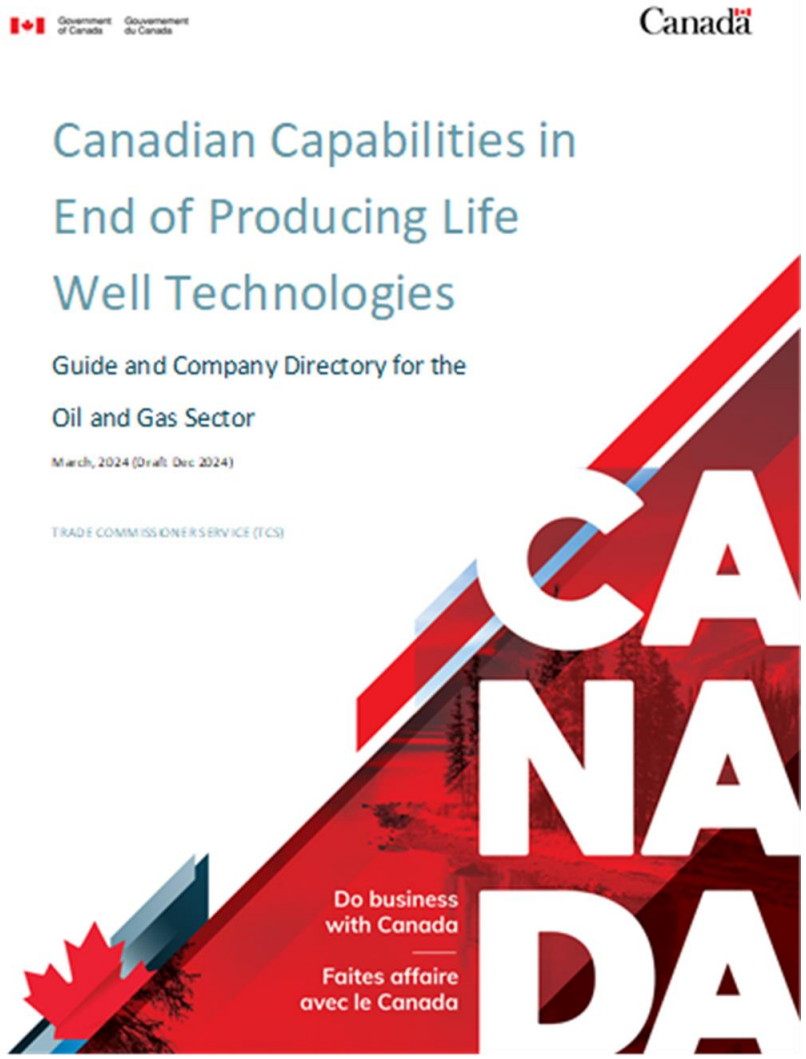
Products

- Sub surface minerals processes
- Gas Storage Facilities Compression/Dehydration
- Single Well Stimulation Equipment
- Mineral Extraction Process Equipment
- Thermal Heat Pumps/Exchangers

Services

- Well abandonment, re-entry and well integrity services
- Well Site Reclamation Services
- Engineering and Information Management

Summary Plan for Clean Technology Directories



- Project launched in December 2023
- Introductory sections of directories drafted
- Working to engage Canadian Contributors in each area:
  - Contacts from Energy Export Guide
  - PTAC Members
  - Other contacts from web searches by area
- Work to be completed by March 31, 2024
- Directories will be available on-line through PTAC
  - Intended to be regularly updated

Thank You!

Bruce Peachey FCIC, FEIC, FCSSE is a professional engineer with a BSc in Chemical Engineering (’76) from the University of Saskatchewan and has over 45 years of experience in the energy industries. His consulting company New Paradigm Engineering Ltd. (NPEL) was a founding member of PTAC in 1996. He supports PTAC as a Senior Advisor for a wide range of technical areas and works with SMEs both through PTAC and NPEL. He has taught and continues to support 4th year Petroleum and Chemical Engineering students at the University of Alberta. NPEL has completed reports for both NRCan and ECCC, on R&D needs, GHG and CCUS issues related to oil and gas operations.

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CRIN
Clean Resource Innovation Network

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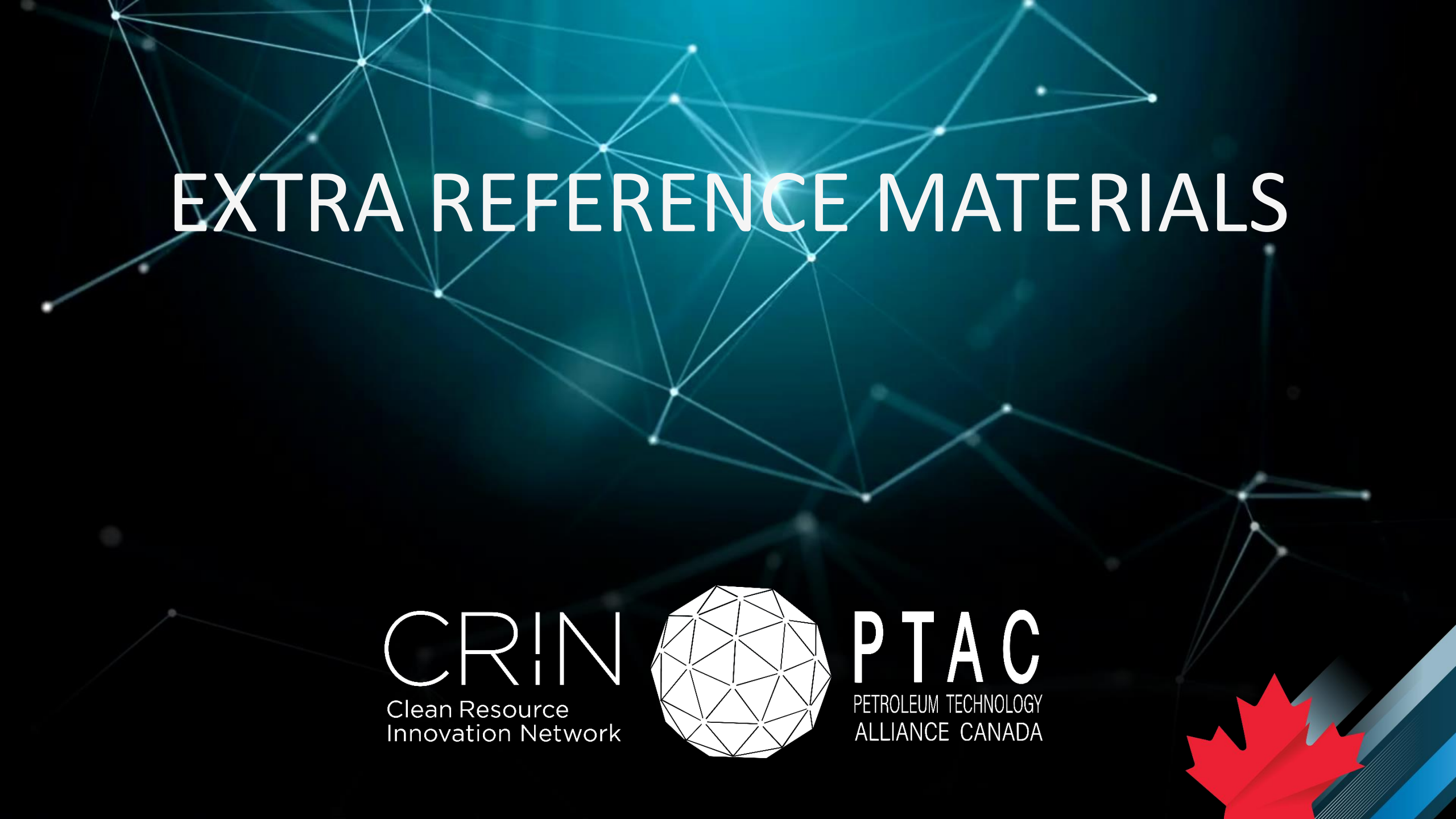
PETROLEUM TECHNOLOGY ALLIANCE CANADA

EXTRA REFERENCE MATERIALS

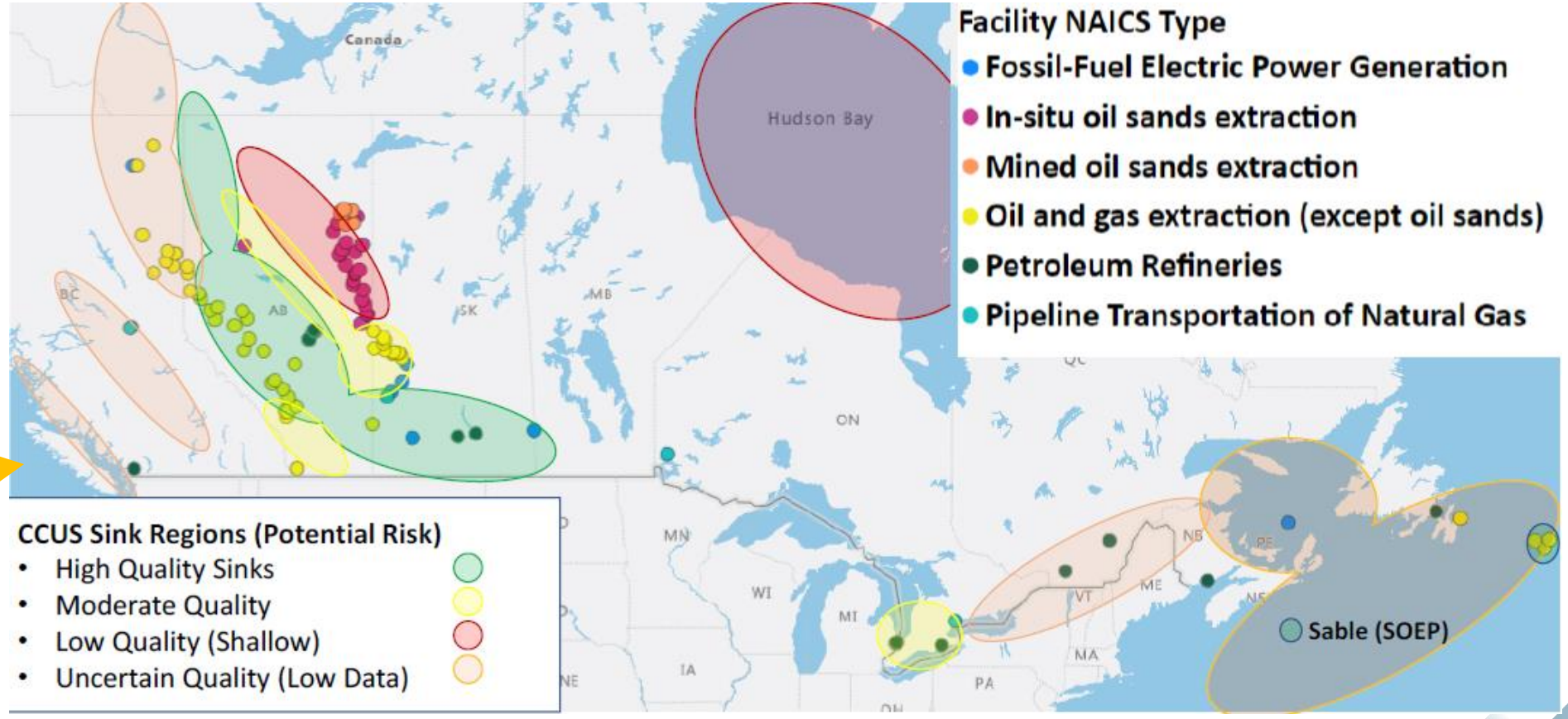


Environmental Management Case Study

- Efficient Water Use
  - Originally all water used was fresh surface water, produced water sent to deep disposal
  - 2-3 m^3 of water per m^3 of bitumen produced
  - Now most of the water used is recycled produced water, very little to disposal, remainder left in reservoirs to replace bitumen produced.
- Clean Technologies
  - Engineering and demonstrations starting in ~1981
  - More water coming from “brackish” sources of no use for people or agriculture
  - Water de-oiling technologies, water softening
  - Once proven it is now a requirement for all operations.

CCUS Opportunities

- Where can CCS happen with low risk?



Map Source: New Paradigm Study for NRCan August 2022: "Carbon Capture Potential and Risks Study"

"Solid Carbon" Proposal CCS into basalt formations in the Juan da Fuca Plate. Risks????
https://solidcarbon.ca/

AGENDA

✓ 9:00	Introduction & Land Acknowledgement	- Jordan, Global Affairs
✓ 9:05	Global Outlook	- Marc, PTAC
✓ 9:25	Regulations & Incentives	- Lindsay, Validere
✓ 9:40	Q&A	- Marc, PTAC & Lindsay, Validere
✓ 9:45	Energy Transition Technology Themes	- Glen, CRIN & Soheil, PTAC
✓ 10:30	Innovation Ecosystem Reference Tools	- Glen, CRIN
✓ 10:40	break	
✓ 10:50	Canadian Energy CleanTech Directory	- Bruce, PTAC
❑ 11:50	Closing Remarks	- Deric, Global Affairs
❑ 12:00	Adjournment	

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