Martin Lensink
VP, CO_2 Reduction

Jaden Murphy
Process EIT

THE ENERGY TRANSITION
from an Ontario Perspective

October 19th, 2023

CEM ENGINEERING
Building A More Functional World

At CEM, we have a vision of a more functional world

CEM is a Decarbonization Project Delivery Firm

- We provide a full range of services, including:
  - Engineering/Retailed Design
  - Procurement Series
  - Project management
  - Construction coordination
  - Commissioning management
- Multi-disciplined (mechanical; electrical; civil/structural; I&C; process)
- **> 20 years** in the industry with over 50 staff
- **3 offices** across Canada (Oakville, ON; St. Catharines; ON; Calgary; AB)

CEM ENGINEERING
Building A More Functional World

Martin Lensink's CHP Experience

1982 — **LDC/Natural Gas Perspective**
Union Gas (7.5 years)

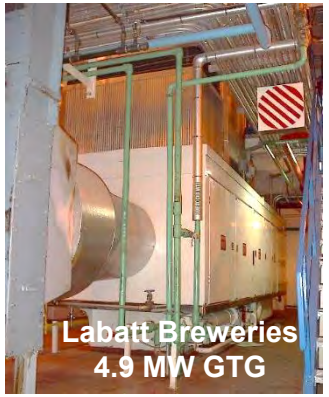
1990 — **Engineering Perspective**
SNC / W.P. London (3.5 years)

1993 — **Equipment Perspective**
US Turbine/Rolls-Royce (5 years)

1998 — **Energy Service Provider Perspective**
Toromont Energy (3 years)

2001 — **Independent Consulting Engineer**
CEM Engineering

Notable CHP Projects (Pre CEM)



Operating since 1990

H.J. Heinz, Leamington – 2 GTG's @ 3.9 MW_e ea.

CEM ENGINEERING
Building A More Functional World

CEM has designed >44 BTM* CHP Systems

*Behind The Meter

CHP System Types

15 GTG Based
- *Combustion Gas Turbine Generator*

17 ICE Based
- *Internal Combustion Engine*

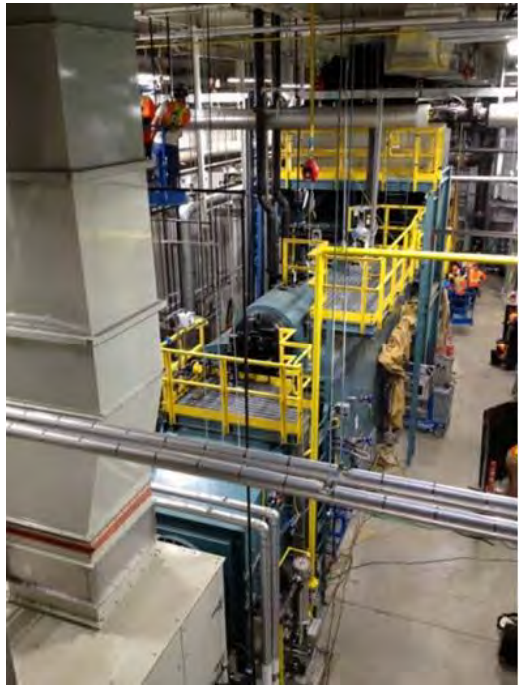
3 STG Based
- *Steam Turbine Generator (from Waste Energy Recovery)*

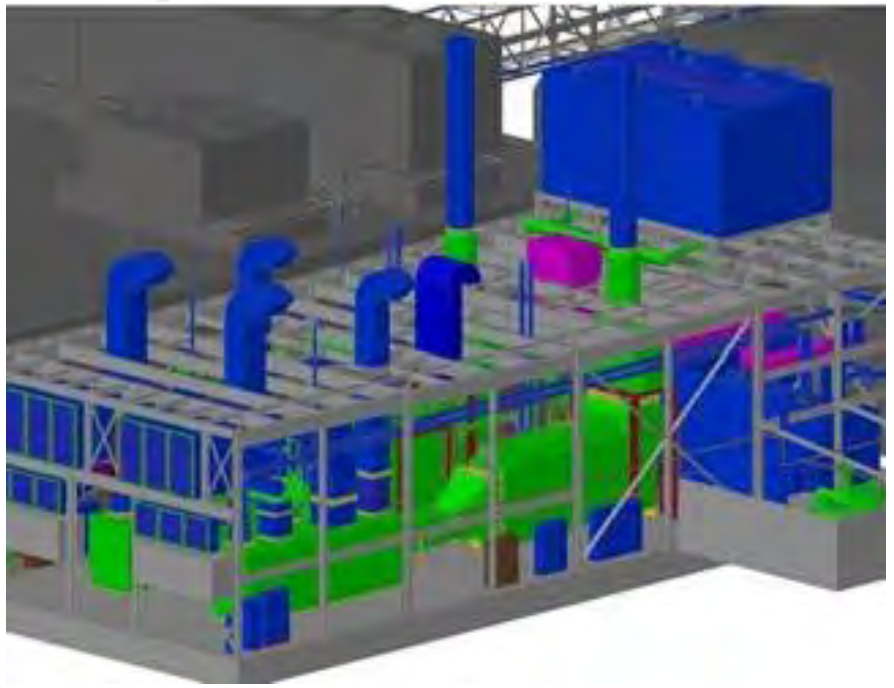
9 Boiler Projects
- *Serving Existing Steam Turbine Generators*

Boiler Case Study

- **1.13 bcf** of natural gas burned per year
- **~60,000 tonnes/year** of CO_2 emitted
- **250,000 pph** boiler makes **400 psig/600°F steam**
- Steam is supplied to **2 x 5 MW_e STGs**

Toyota Case Study

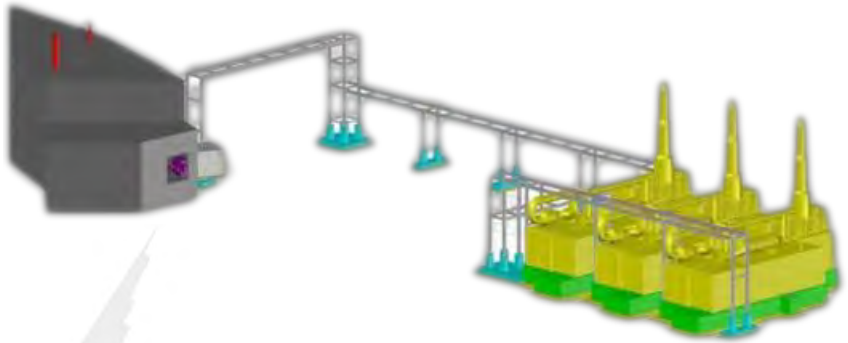




- Two (2) Combustion Gas Turbine Generators rated @ 4.5 MW_e each
- Air emissions limited to 15 ppm NO_X

Polycon Case Study

– Three (3) fully containerized Internal Combustion Engine CHPs rated ~ 2.67 MW_e each, producing steam from exhaust gas circuit and hot water from jacket water circuit



HHSC Case Study

- The project will involve detailed engineering, procurement, construction, installation, testing, and commissioning of the new generator sets, as well as the rental emergency boiler and the small steam and hot water boiler.

- Each of the 13 Generator Sets has a capacity slightly less than 2 MW_e.

- This project enables a CO_2 reduction of **~30,000 tonnes of CO_2** per year.

Basis of Our Perspective

- We serve primarily industrial customers.
- We serve selected MUSH customers and energy performance contractors.
- What has worked since 1986:
  - Class 34 and Class 43 (Accelerated Capital Cost Allowance);
  - 40% CAPEX grants for electricity conservation projects;
  - Limited success with Federal Funds (e.g., Strategic Innovation Fund).

ADM Windsor

- The project consists of two cogeneration systems each equipped with one combustion turbine generator (GTG) and one heat recovery steam generator (HRSG).
- Each GTG is derated to 4.6 MW_e, to produce electricity (total of 9.2 MW_e) and steam for use on site.
- The 4.6 MW_e rated GTGs are based on units capable of delivering 5.4 MW_e (nominal) of electricity for continuous duty.

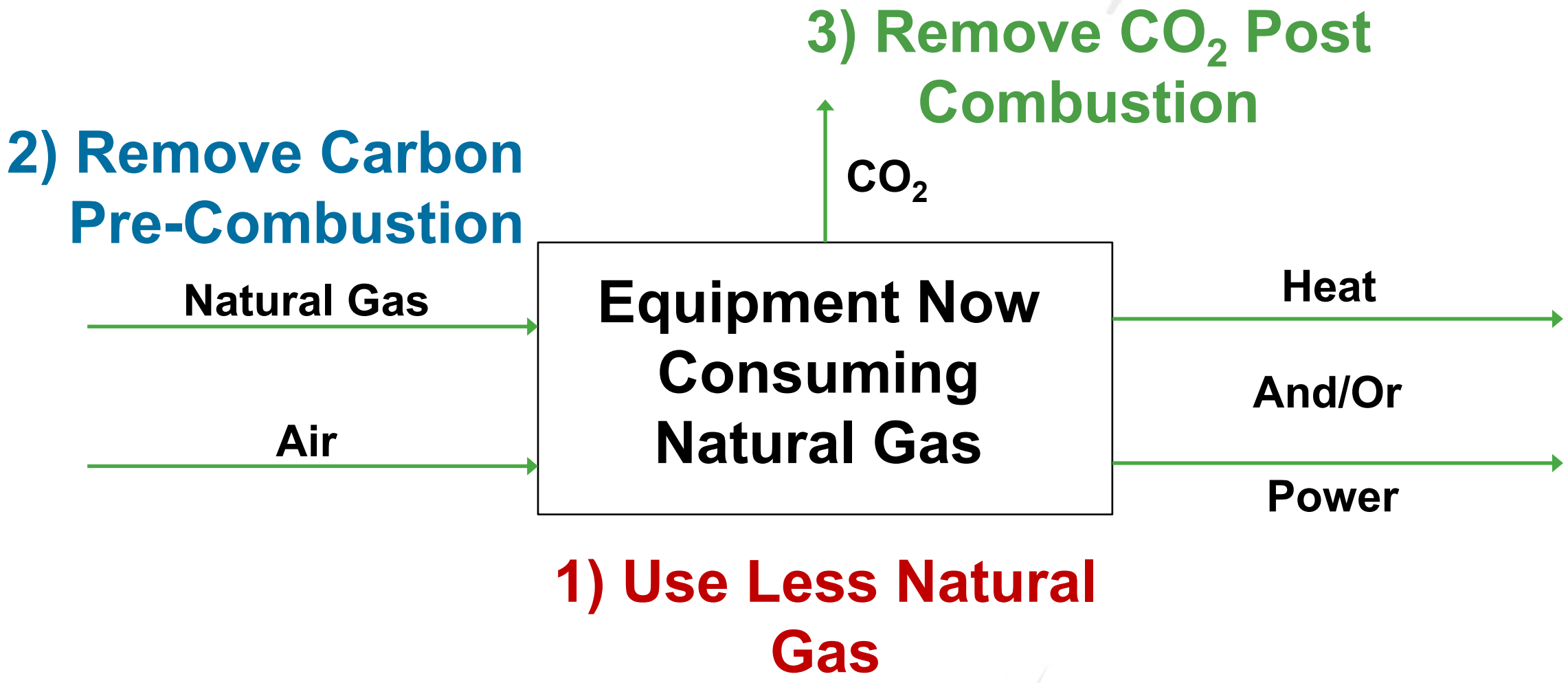
What is being done right?

1. $170/tonne is sending a signal to decarbonize *quickly.*

2. Some companies are taking the threat of Carbon Pricing very seriously:
   - Typically, subsidiaries of European or
   - Pacific Rim parent companies.

3. Energy Efficiency projects are becoming more popular (again):
   - Focus is on reducing Scope 1 Emissions (i.e., natural gas use).
   - Energy Management Information Systems.
   - Conventional and Novel Heat Recovery.
   - Behind-The-Meter Combined Heat & Power running when grid scale natural gas plants operate.

Ways To Reduce CO_2 Emissions



What is being done right?

4. Some companies are taking ownership of emissions and deploying on-site technology to directly reduce CO_2.

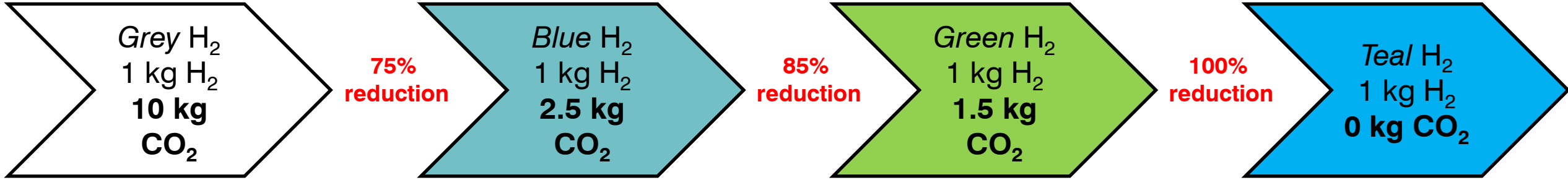
5. Renewable Natural Gas is being made available to existing natural gas users to achieve net CO_2 reductions now.

6. A lot of interest in “Green” Hydrogen is seeing a lot of interest and $ investment.
   – Compared to other types of hydrogen generation.

7. Sequestration and mineralization of captured CO_2 is now allowed under the Ontario Emission Performance Standard (EPS).

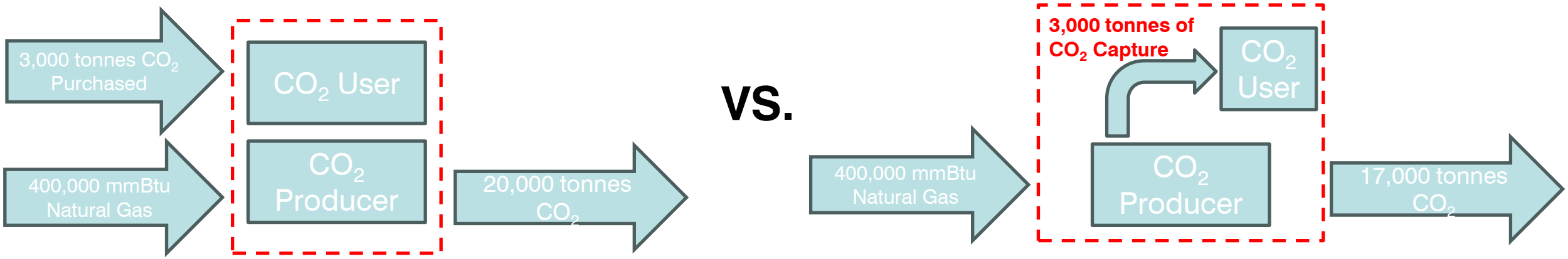
What Opportunities are Being Missed?

1. Focus is on Hydrogen as a fuel replacing Natural Gas; more clear emissions reduction when replacing “Black/Grey” Hydrogen used for industrial processes with “Blue/Green” Hydrogen.



What Opportunities are Being Missed?

2. Alternative uses of captured CO_2. Example, replacing food-grade CO_2 specifically produced for brewing or greenhouses via burning natural gas with CO_2 captured from a high efficiency cogeneration system.
   - Although the environmental outcome for the Province of Ontario would be net positive, this is still not a permissible method for receiving some exemption/relief from the Carbon Price.



3. There are a lot of approaches to reduce CO_2 emissions, but a lot of the focus is only on a "core four": **Electrification**, **Hydrogen**, **RNG**, & **Carbon Capture**.

Energy Management in Plant

1. Utilization of Off Gases Now Flared
2. Low-Grade Waste Heat Recovery – Condensing Economizer
3. High-Grade Waste Heat Recovery – Reduce Fossil Fuel Use Elsewhere in Production
4. High-Grade Waste Heat Recovery – Make Power via Organic Rankine Cycle
5. High-Grade Waste Heat Recovery – Make Power via Supercritical CO_2
6. Electric Boilers with Thermal Energy Storage
7. **Industrial High Temperature Heat Pump**
8. Advanced Thermal Dryers (industrial energy efficiency)
9. Thermal Energy Storage (e.g., Ice Storage)
10. **Solar Thermal**
11. Green Microgrid
12. **Geo-Exchange with Heat Pump**
13. Geo-Storage with Heat Pump
14. Alternative Energy Storage Technologies

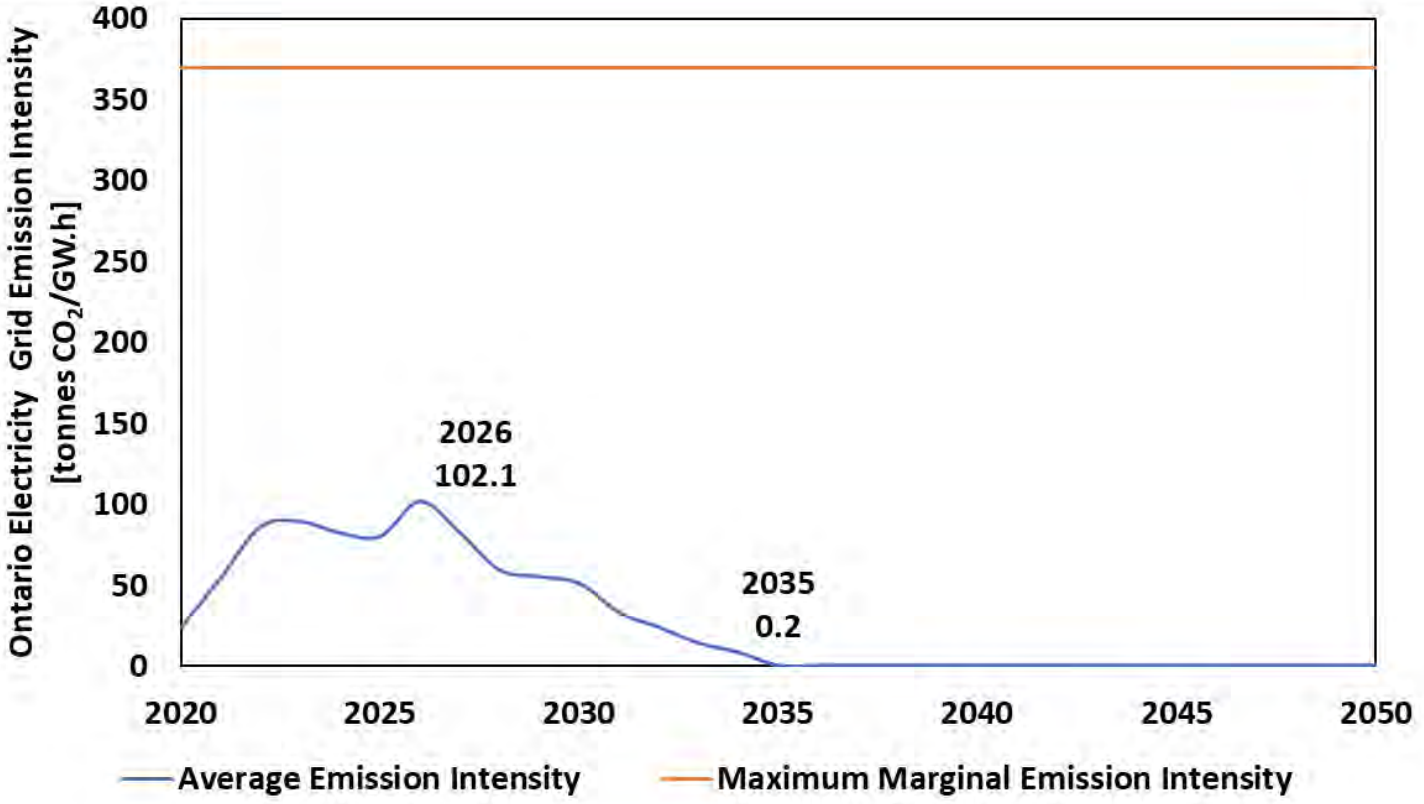
Equipment Fuel Switching

15. Production of Biogas via Slow ADs
16. Production of Biogas via Fast ADs
17. **Generation of Heat via Combustion of Biomass**
18. Generation of Syngas via Gasifier
19. **Teal Hydrogen production (via electrical reforming of Natural Gas)**
20. Teal Hydrogen production (via thermal reforming of Natural Gas)
21. **Blue Hydrogen via SMR and CCUS**
22. Renewable (Liquid) Fuel in Diesel Engines
23. **Green Hydrogen Production**
24. **Renewable Natural Gas (RNG) via Upgrading of Biogas**
25. Renewable Natural Gas (RNG) via Hydrogen Reduction Technology
26. Renewable Natural Gas (RNG) via Pyrolysis of Wood Chips
27. e-Fuels

CO_2 Management

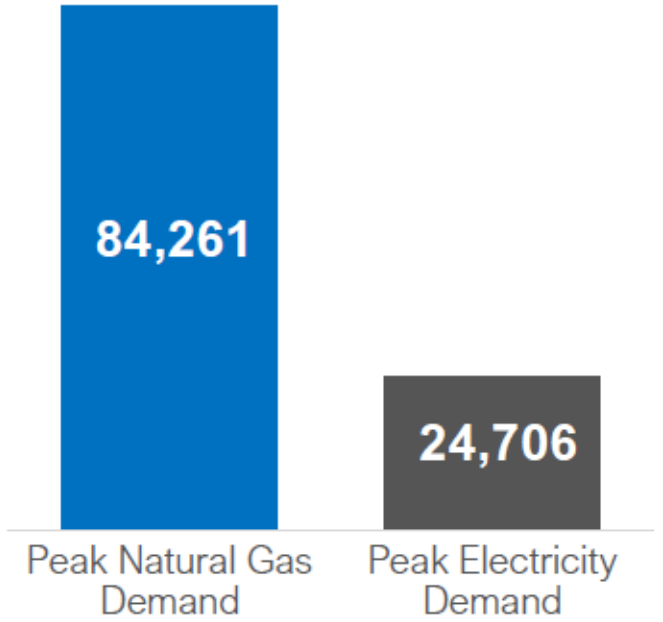
28. Post-Combustion Carbon Capture via Amine Technology
29. **Post-Combustion Carbon Capture via Membrane Technology**
30. Post-Combustion Carbon Capture via PSA
31. Post-Combustion Carbon Capture via TSA
32. **Post-Combustion Carbon Capture via Direct Mineralization**
33. **Biomass Energy with CCUS (BECCUS)**

What Opportunities are Being Missed?



Reliability

(MW)



- Natural gas infrastructure serves >3x peak electric demand at 99.999%[3] reliability

What Opportunities are Being Missed?

4. Not all industrials can easily avoid Carbon Pricing via application of technology.

5. For other industrials, uncertainty surrounding the existence of a Carbon Price in 2030 is preventing investment in decarbonization solutions.

6. We cannot really get to the 2 cents/kW.h power we need to achieve a palatable OPEX for electric boilers and H_2 generation without BTM generation.

7. Offsetting marginal emission intensity instead of average emission intensity.

8. An easier to navigate Recognized Carbon Offset program which could connect to EPS and encourage investment in projects.

9. Replacement of long-term energy storage (248 BCF of natural gas storage capacity in Ontario, almost 73 TW.h of energy) in the province with lower carbon energy carriers.

What Opportunities are Being Missed?

10. Lack of ITC clarity and funding clarity is delaying investment and threatening CO_2 reduction goals/targets.

11. Uptake of Industrial Heat Pumps is limited because incentives are either not clear or slow to materialize.

12. Electric boiler uptake in the MUSH sector could be much higher:
    - But is limited by local grid capacity and
    - lack of Demand Response programs.

13. Federal Funding applications are complex and often require “perfect” applications which:
    - Achieve environmental, labour, and indigenous goals simultaneously.
    - Not every project can realize.

What Opportunities are Being Missed?

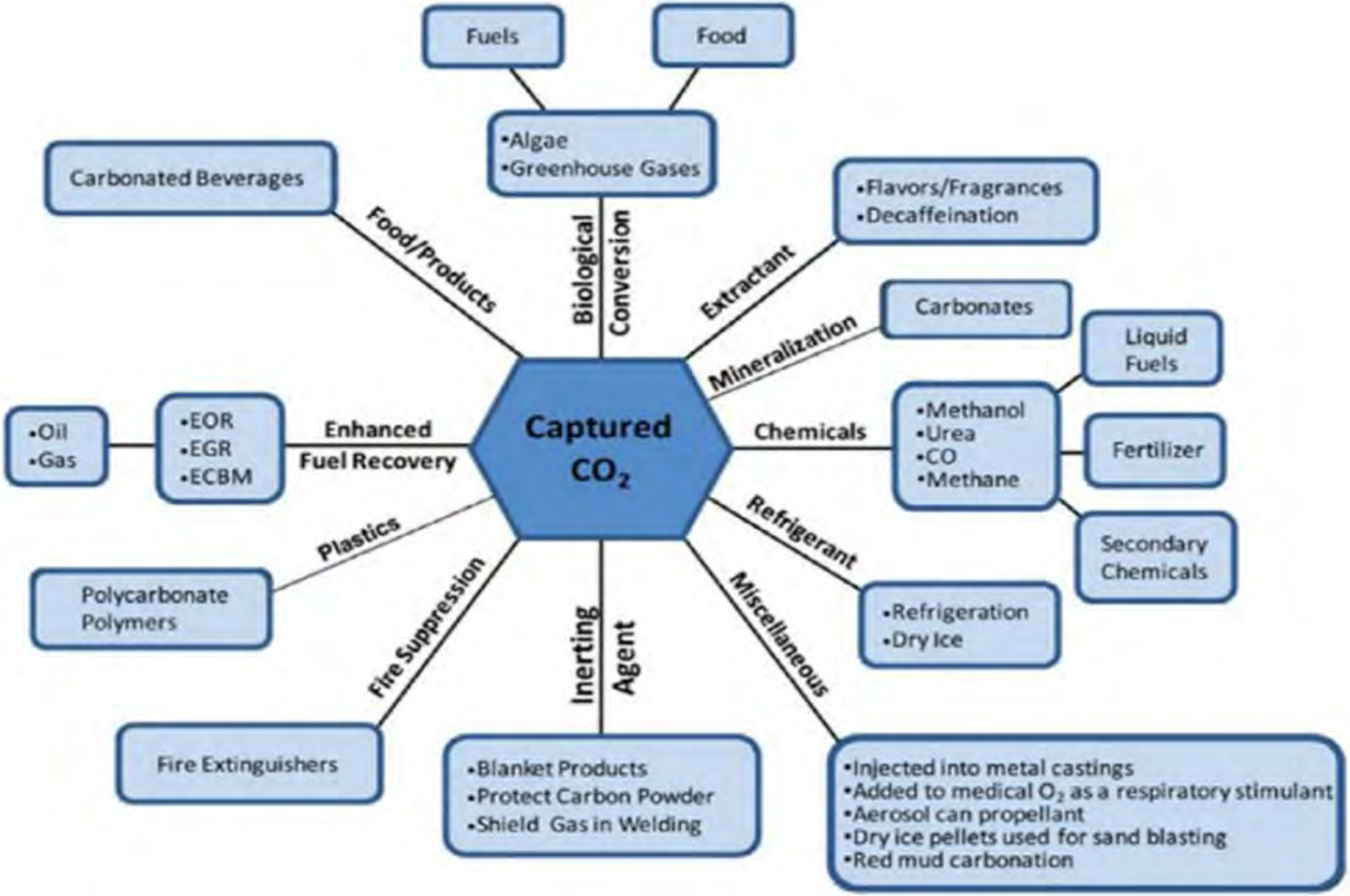
14. Incentives from LDCs are too small & not material for capital intensive decarbonization projects.
    – OEB framework will require updates to address this.

15. Biomass supply is not adequately supported.
    – To establish 10+ year supply contracts required for projects.

16. Development of Blue H_2 projects stalled due to lack of clarity w.r.t Carbon Price exemption for alternative CO_2 utilization activities.

17. Acceptable CO_2 utilization is far too limited and missing lots of low hanging fruit opportunities.

CO_2 Has Many Uses



Source: Technology Services Inc. (Sudhir Brahmbhatt) (tsinc-us.com)

How will the transition shake out?

1. Ontario will not meet 2030 goals.

2. Ontario is moving too slow.

3. “Cutting-edge” projects will take longer than expected, without assistance.

4. 2050 goals will be missed, as we wait for “perfect” solutions to become:
   - technically feasible,
   - financially feasible,
   - **implementable** (e.g., NIMBYism, Standard of Living impacts).

How will the transition shake out?

5. ECCC's and NRCan's separate (sometimes ununified) approach to decarbonization is holding back "Made in Canada" solutions to the Energy Transition (regional differences!).

6. In the next 30 years, not everything can be economically electrified.

7. Without more low carbon peaking electricity generation, Electrification will be akin to "pushing" your emissions to the grid and wiping your hands clean.

How will the transition shake out?

8. Large build out of RNG projects in the short term.

9. <u>But</u> supply of RNG could be significantly less than demand.

10. Natural gas use will be limited to high temperature applications in “hard-to-abate” sectors.

How will the transition shake out?

11. We must consider revising how decarbonization funding is administered.

12. Administration of funding by Federal administrators is:
    - limiting/slowing market innovation and
    - minimizing opportunities for Provinces to fund and build projects (which work for that specific province).

13. The U.S. will leapfrog Canada (again) w.r.t decarbonization, due to ease with which funding can be accessed via the Inflation Reduction Act.

What is NOT Working

- Federal Government as delivery agent of CO_2 reduction.
- NRCan & ECCC not on the same page.
- Federal Programs (LCEF, OBPS DIP, GIFMP);
  - Low probability of success.
  - Very time consuming.
  - Subject to political interference.
- Expanding list of acceptable uses of captured CO_2.

What MIGHT Work

- Electric LDCs deliver Scope 2 emission reduction projects.
- Natural Gas LDCs deliver Scope 1 emission reduction projects.
- Clear simple rules like SOE/PSUI (see next page).
- Audit trail via (co-funded) DES.
- If you meet the criteria, you get the grant.

Program Rules – SOE/PSUI

- Budget of $650 million.
- Reduce industrial electricity use by 300 MW.
- Nameplate capacity <= 10 MW.
- Cycle efficiency greater than 65% HHV.
- Grant for eligible project is the lesser of:
  - $230/MW.h of annual electricity savings.
  - 40% of eligible project capital costs.
  - $$$ to bring project down to one (1) year simple payback.

Example: 15 MW_e CHP

Contact Information

If you would like to explore decarbonization further:

Martin Lensink, P. Eng.

martin@cemeng.ca

905-708-4050

FOLLOW US

905-935-5815

info@CEMeng.ca

POWER & UTILITIES

BIOGAS / RNG

HYDROGEN

CARBON CAPTURE