Energy Using Industries

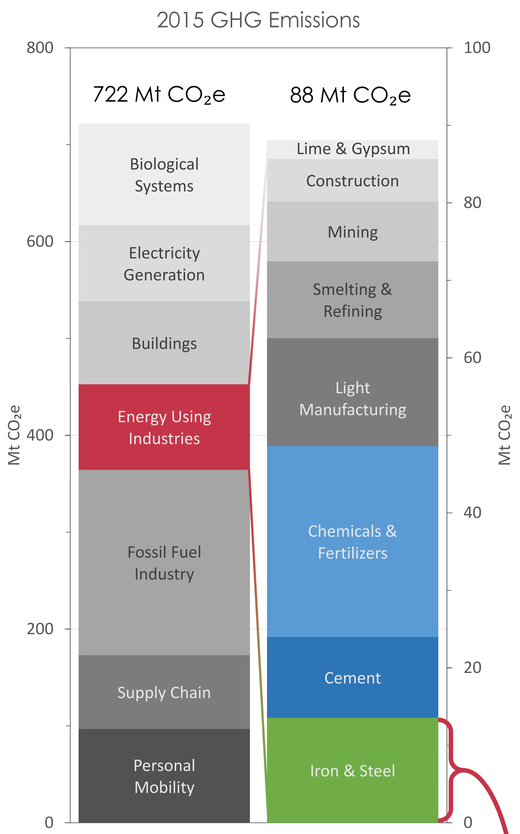
The CESAR Pathways Project: Modelling Canada's Low Carbon Future

Kyle McElheran, BSc, EIT
Energy Systems Analyst, CESAR

Song Sit, PhD, PEng
Senior Associate, CESAR

Introduction

Energy using industries represent 12% (88 Mt CO_2e) [1] of Canada's GHG emissions (see figure below). CESAR is meeting with experts in industry to develop specially tailored strategies for reducing GHG emissions. Of the many sectors within this group, three examples of these strategies are given in the table at right. A more detailed examination of iron and steel is shown to demonstrate the approach CESAR uses in its exploratory modeling.



Key Elements of Emission Mitigation

Industry	Combined Heat & Power	Fuel and Feedstock Switching	New Processes	Market Dynamics	CCS
Fertilizer	Bottoming cycle CHP with ORC captures waste heat to generate electricity reducing GHG intensity of electricity.	Switching from natural gas to renewable natural gas where resources are available greatly reduces energy and process emission intensity.	Generating hydrogen from electrolysis of water with low carbon electricity will be less GHG intensive than reforming natural gas.	The future of emissions from fertilizer production is strongly tied to demand from Canadian agriculture.	Geological CCS is only viable in western provinces with economic access to the Western Canadian Sedimentary Basin. All industries and provinces are encouraged to invest in carbon utilization research and development.
Cement	Topping cycle CHP generates heat for clinker preheating and electricity generation, reducing both process and electricity GHG intensity.	Switching from coal to natural gas or other low carbon fuels (e.g. tires) reduces energy use intensity.	Processes such as Aether and Solidia provide cement with lower GHGs and uncompromised reliability.	A future relying on hydro power will increase short term demand for cement.	
Iron & Steel	Both bottoming cycle CHP with ORC captures waste heat while off-gasses are combusted to generate electricity [2].	Switching from coking coal to natural gas and further to renewable natural gas where resources are available greatly reduces GHG intensity.	Molten oxide electrolysis is in R&D. It uses no fossil fuels and emits no CO_2 [3]. GHGs are only associated with electrical generation.	Electrifying transportation will see fewer new oil projects, impacting overall steel demand.	

Iron & Steel

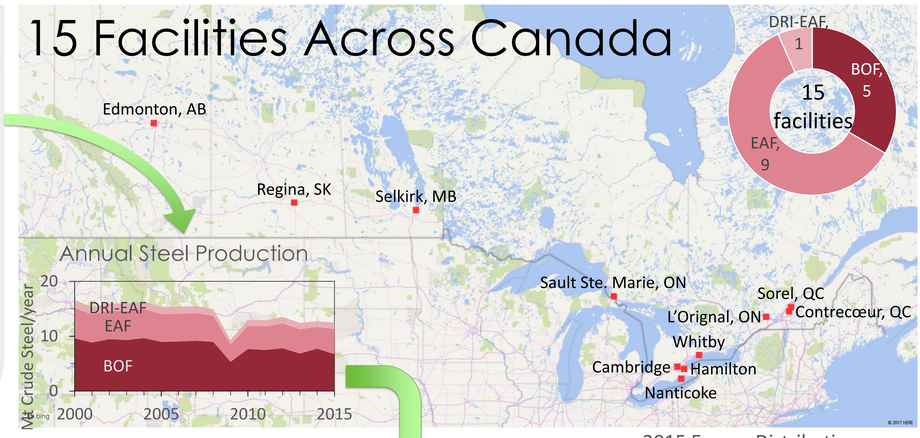
In 2015, iron and steel emitted 13.5 Mt CO_2e, 15% of all energy using industries, averaging 15.8 Mt CO_2e per year over the last ten years [1]. Melting iron in basic oxygen (BOF) and electric arc furnaces (EAF) above 1,700°C requires vast amounts of energy. To achieve an 80% GHG emission reduction by 2050, as per Canada's commitments, industry will require a combination of the options listed in the table above and more.

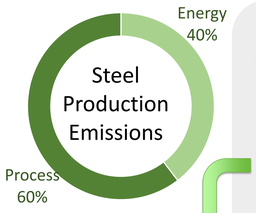
Canadian Landscape

15 steel facilities in Canada (see map) produced 12 Mt of crude steel in 2015 [5], 40% of which came from recycled scrap [6].

Furnace Properties [6]			
Type	BOF	EAF	DRI*-EAF
Recycled Input	10%-20% Scrap	Up to 100% Scrap	40% Scrap 60% DRI
Primary Fuel	Coal Coke Natural Gas	Electricity	Natural Gas Electricity
Energy Intensity (GJ/t CS)	16.3	9.1	18.7

* Direct reduced iron





Emissions

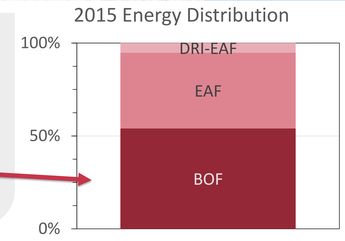
Overall emissions are determined by the carbon intensity of each fuel.

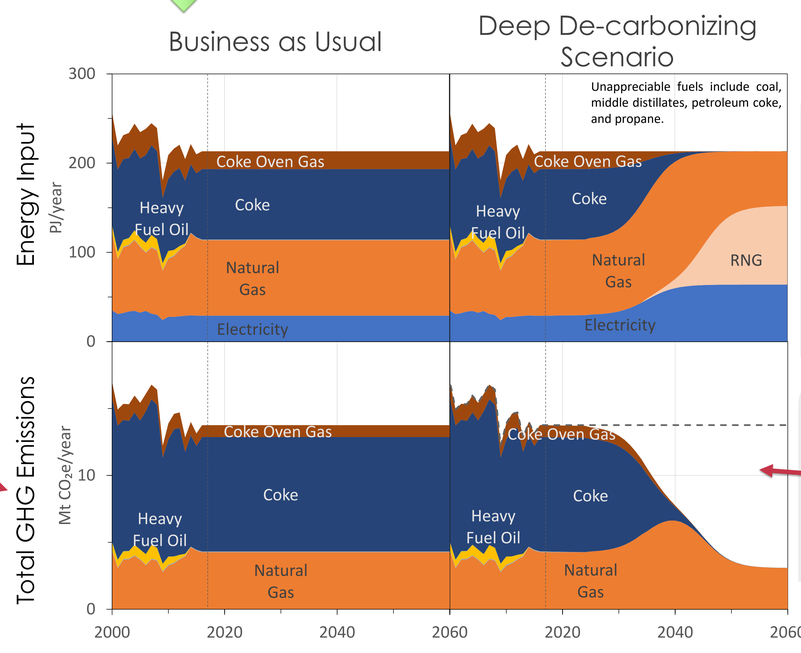
Process emissions represent more than half of total emissions, emanating from coke based methane and other sources [1].

Energy Use

In total, the basic oxygen furnace (BOF) requires the highest amount of energy.

Fuel switching, as described in the table above, would have a large impact on this breakdown.





Changes

- Coal, coke, and coke oven gas replaced with natural gas between 2025 – 2045.
- 60% of natural gas replaced with renewable natural gas (RNG) between 2035 – 2060 (see poster 6)
- Increase use of electricity to 30% by increasing recycling between 2025 – 2045.

Results

- Over 225 Mt CO_2e avoided in total by 2060

Reduction Below 2005 Levels	
2030	**2050**
16%	80%

Note: Electricity emissions are counted in CESAR's Pathways Project narrative on electricity generation.

Conclusions

As demonstrated in the iron and steel industry, a single type of transformation is clearly not sufficient to achieve the Canadian GHG reduction targets. Therefore, a diverse combination of aggressive changes will be needed in every sector of the energy using industries. As other markets, like transportation and buildings, experience their own transformations, the dynamic change in demand will profoundly affect how energy using industries operate. In adapting to these external changes, solutions for GHG reduction will be found in the way each industry uses energy and how carbon intensive the energy and process is. Many unique journeys make up the pathway to Canada's low carbon future for energy using industries.

Acknowledgments

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