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Net Zero Emissions Steel R&D: Supply of Alternate Reductants/Fuels

Background

In responds to the CSPA call for climate action (Canada's Steel Industry: A Sustainable Choice), CCRA has developed a research program to address the technical challenges in achieving net-zero emission steel production by 2050 (New Ear for CCRA). In the CCRA research program, activities are categorized into 5 pillars for promoting collaboration between research groups and with industrial partners. The supply of alternate reductants and alternate fuels is one of the R&D pillars.

The drive to replace fossil-based fuels and reductants targets three complementary routes: biomass and its derivatives, hydrogen (low-carbon), and renewable electricity. Each has the same general issue of developing the supply at a reasonable price. Biomass, bioproducts and bioenergy is perhaps the most challenging as the supply chains, conversion technologies, and properties needed in the bioproducts are still being developed.

Goal Statement

To establish the economically sustainable supply of alternate reductants and alternate fuels by:

- Identification of sustainable biomass feedstock supplies and biogenic reductants and fuels production, with the necessary processing to provide bioproducts suitable to the iron and steel industry;
- Establishment of regional renewable hydrogen hubs; and
- Non-emitting electricity supply and electricity grid delivery infrastructure development.

Specific Objectives

- To establish reliable quantification of the supply of biomass in Canada, with database of properties, and models for different collection/transformation/distribution scenarios
- To establish the gasification technologies suitable to feed DRI and the range of syngas composition produced from likely feedstocks
- To establish rigorous descriptions of the effect of process parameters and feedstock properties on the properties of biocarbon produced by slow pyrolysis, and relate these properties to behaviour in industrial equipment
- To establish the properties of bio-oils from fast pyrolysis and the means to use these products in the iron and steel industry
- To establish international standards for pyrogenic biocarbon, mitigating risk for adoption by industry and assisting the development of the supply-side
- To establish the characteristics of economically attractive and environmentally sustainable hydrogen production and supply hubs

Projects Overview

Biomass Supply

- **High-Impact Feedstocks**
  - Identify feedstocks with high volumes and concentrations
    - Survey and reconcile public domain estimates of residues
    - Rank according to three categories – woody, agricultural and municipal
  - Database of properties
  - Evaluation of hub-and-spoke compared to linear conversion supply models

Gasification

- **Survey of technologies and syngas compositions suitable for DRI**
  - Biosyngas combined with renewable hydrogen to optimize thermal performance
- **Identification of mid-scale gasification technologies to displace natural gas as a fuel**
  - Updraft and downdraft gasifiers produce fuel gas at 1 – 20 MWth scale
  - Applications in smaller facilities like reheat furnaces
- **Production of renewable hydrogen**
  - Biosyngas processing to maximize hydrogen production
  - Possibility of CO_2 capture for negative carbon emissions
- **Electricity generation from product gas**
  - Scenario development for electricity generation in engines and turbines using product gas (air-blown) or syngas, or residual gas from hydrogen production

Slow Pyrolysis

- **Rotary drum/screw reactor**
  - Effect of temperature, residence time of biocarbon properties
  - Effect of feedstock properties on biocarbon properties
  - Possibility of interactions for combinations of feedstocks
- **Upgrading vapour by-products**
  - Characterize yield and composition of vapour products
    - Variability with feedstock and processing conditions
  - Condense and separate liquids
    - Chemical and physical properties (fuel suitability)
    - Chemical upgrading to liquid transportation fuel
    - Uses as bioproduct – binder, additive
  - Autothermal reforming to high-quality fuel gas
    - Processing conditions
    - Reactor design
    - Use reforming to minimize variability of fuel gas

Fast Pyrolysis

- **Processing High-Impact Feedstocks**
  - Effect of temperature, residence time of bio-oil properties
  - Effect of feedstock properties on bio-oil properties
- **Uses of bio-oil**
  - Nozzle design for bio-oil burners for standard combustion applications
  - Combustion behaviour in non-standard conditions (i.e., PCI injection) and design solutions
  - Applications as binder for biocarbon applications
  - Slurry production and properties as gasification feedstock to maximize energy content

Projects Overview

Biocarbon Standards

- **Participate in ISO TC238 to adopt and develop standards for pyrogenic biocarbon**
  - Identify the existing international standards that suit pyrogenic biocarbon
  - Identify gaps in the suite of existing standards and work to develop suitable standards
  - Identify standards most applicable to iron and steel production uses
  - Direct a Canadian mirror committee to ensure the national perspectives for both producers and users are represented internationally
  - Lead, where necessary, the international efforts at development of particular standards

Hydrogen Network

- **Modeling, TEA, and LCA of Blue-H2 Production, Purification, and Transportation**
  - Determine the lowest cost and lowest environmental impact pathways for blue-H2 production, purification, and transportation
  - Scenario-based supply and demand models developed for several key H2-hubs across Canada

Project Team

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