NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

# Bio-Carbon for Canadian Iron and Steel Production

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# CanmetENERGY-Ottawa

CanmetENERGY-Ottawa leads the development of energy S&T solutions for the environmental and economic benefit of Canadians

# Metallurgical Fuels Lab

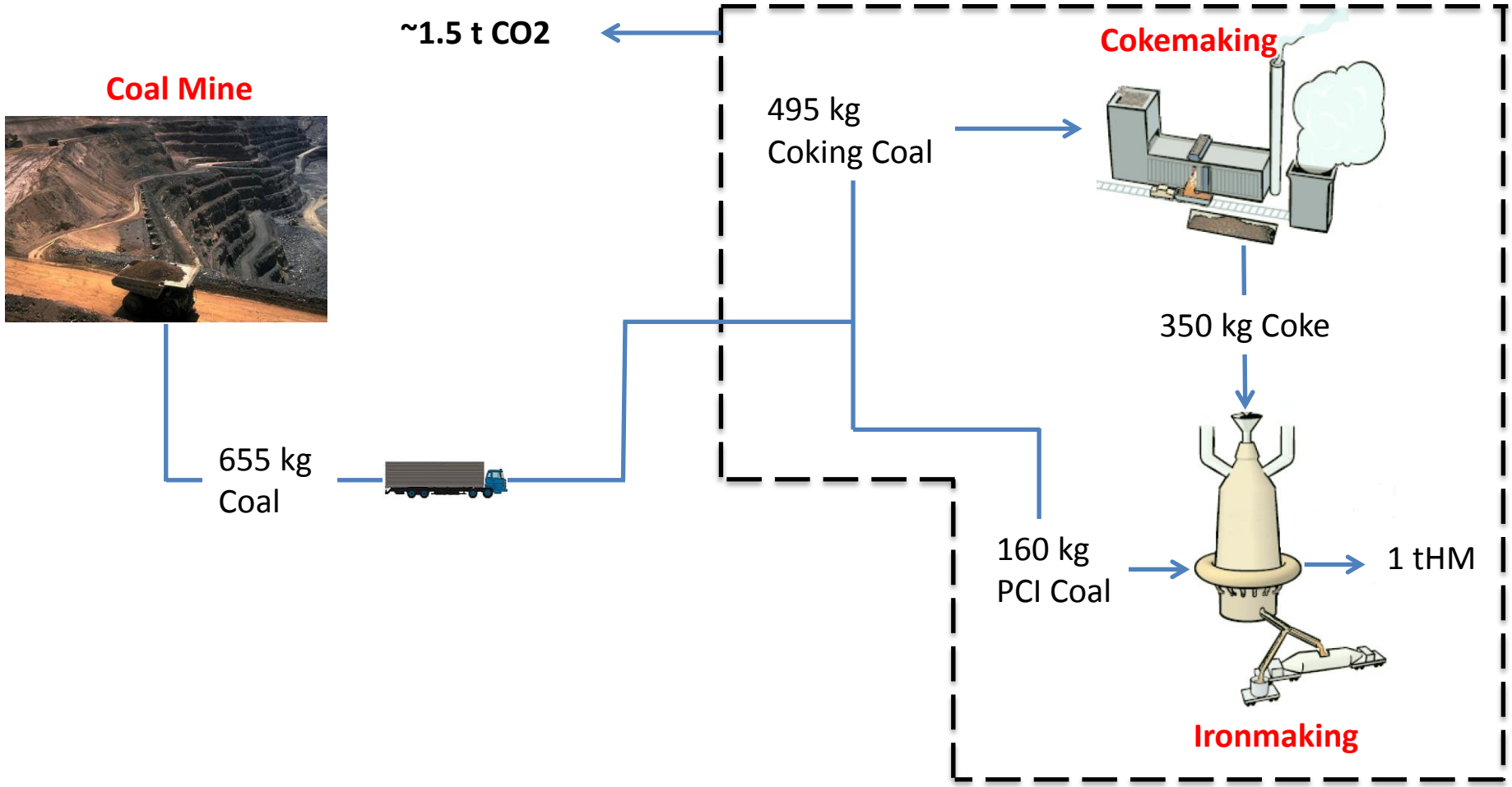
- Pierre Martin, Group Manager
- 4 Research Scientists
- 1 Research Engineer
- 10 Technologists
- Over 40 years experience in coal carbonization and blast furnace ironmaking research
- Member of Canadian Carbonization Research Association (CCRA)

# Canadian Carbonization Research Association

- Consortium of steel producers, coal producers and cokemakers
- Collaborative research to address industrial needs
- Met coal carbonization, Blast furnace ironmaking

# GHG Mitigation by Fuel Switching

- Substitution of fossil carbon by renewable bio-carbon
  - Incorporation of bio-carbon in existing iron and steel making facilities to avoid capital investment
- Medium term goal (2030)
  - 10% substitution metallurgical coal in cokemaking by renewable bio-carbon.
  - 100% replacement of injection coal in blast furnace ironmaking by renewable bio-carbon
  - 100% replacement of injection carbon (for slag foaming ) and charge carbon (for supplementary energy) in EAF steelmaking by renewable bio-carbon




# Present

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~1 t CO2

Coal Mine

445 kg Coal

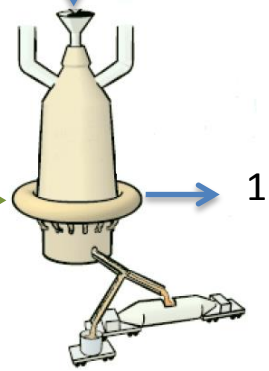
445 kg Coking Coal

Cokemaking

50 kg Biochar

350 kg Coke

160 kg Biochar



1 tHM

Ironmaking

700 kg Biomass

210 kg Biochar

Biomass Collection

Pyrolysis (yield 30%)

# Goal

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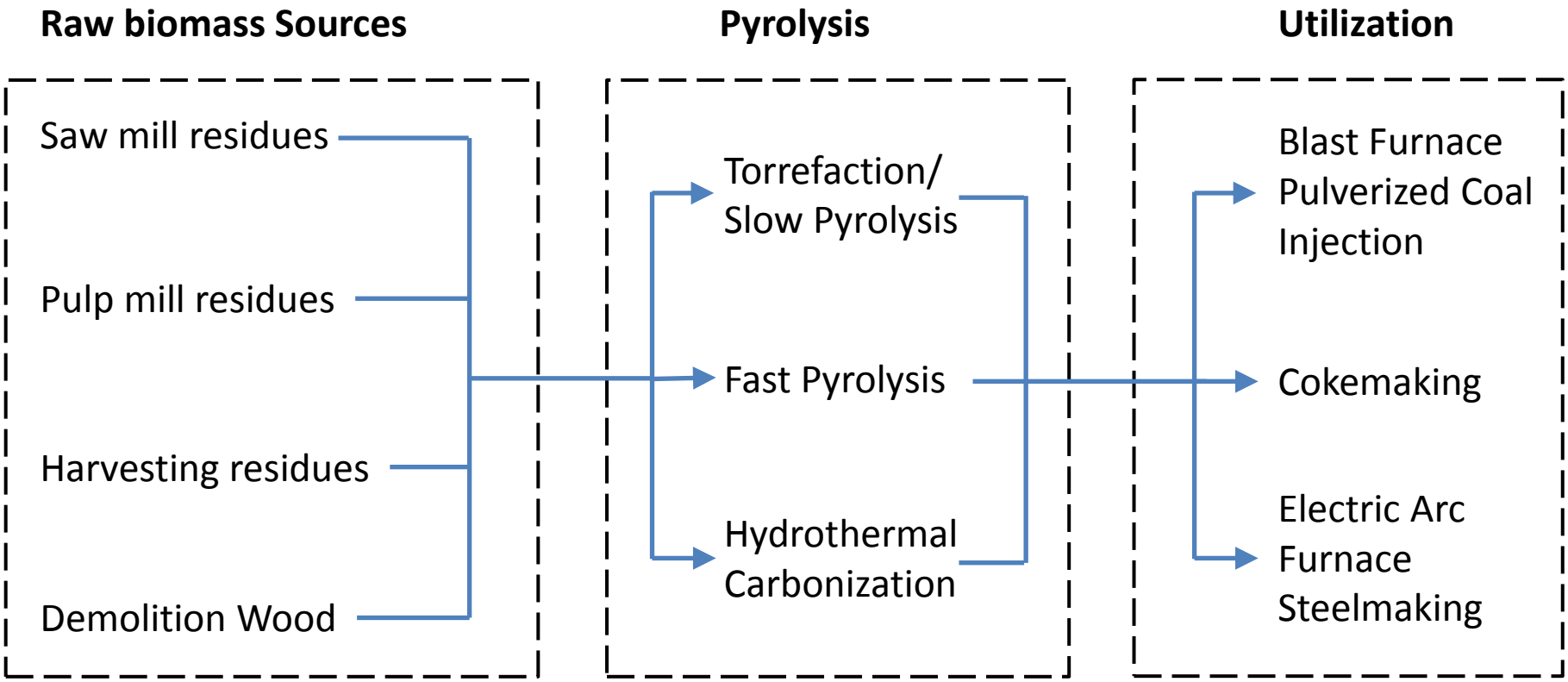
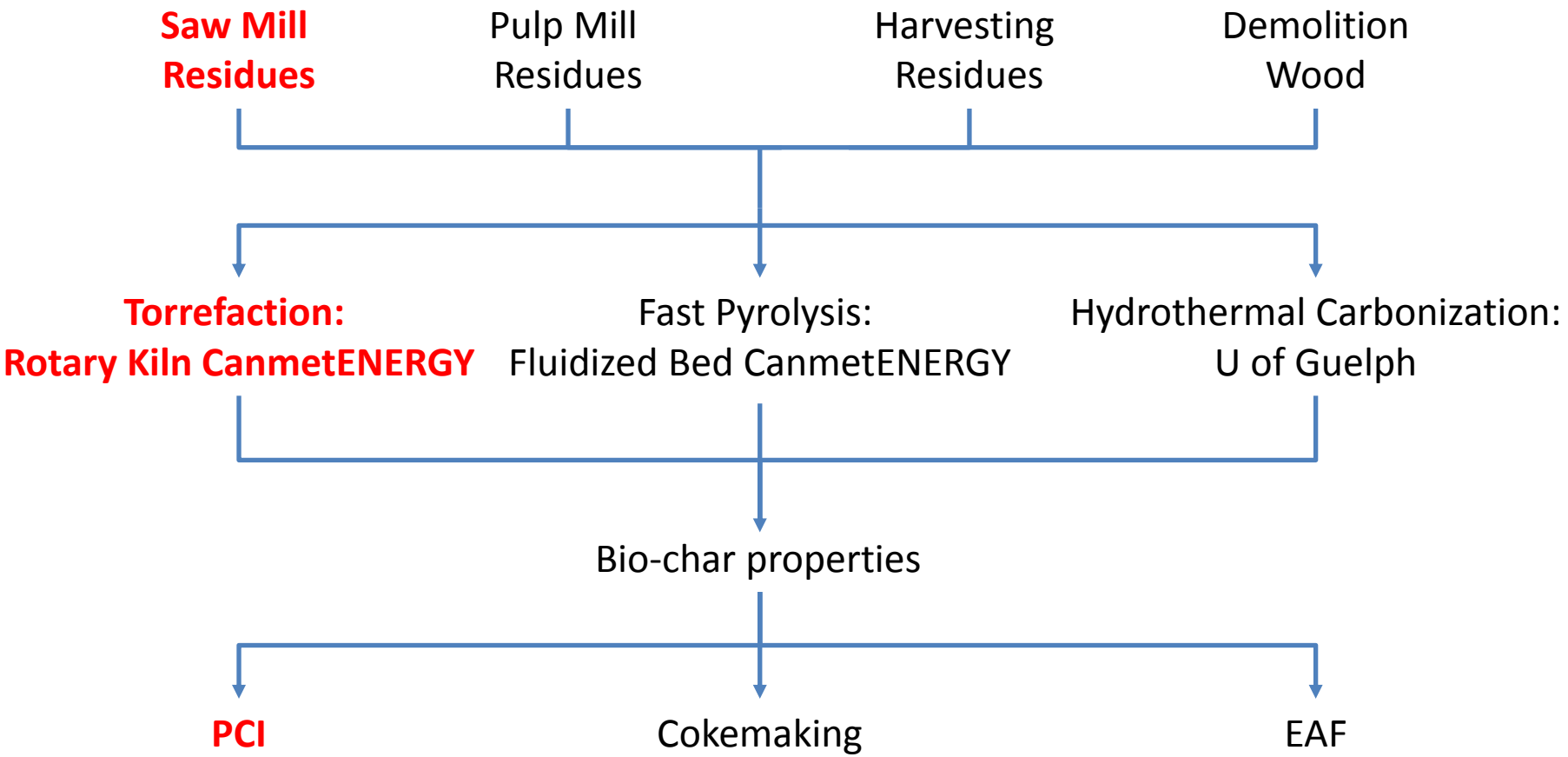
# Bio-Char Supply Chain Pathway



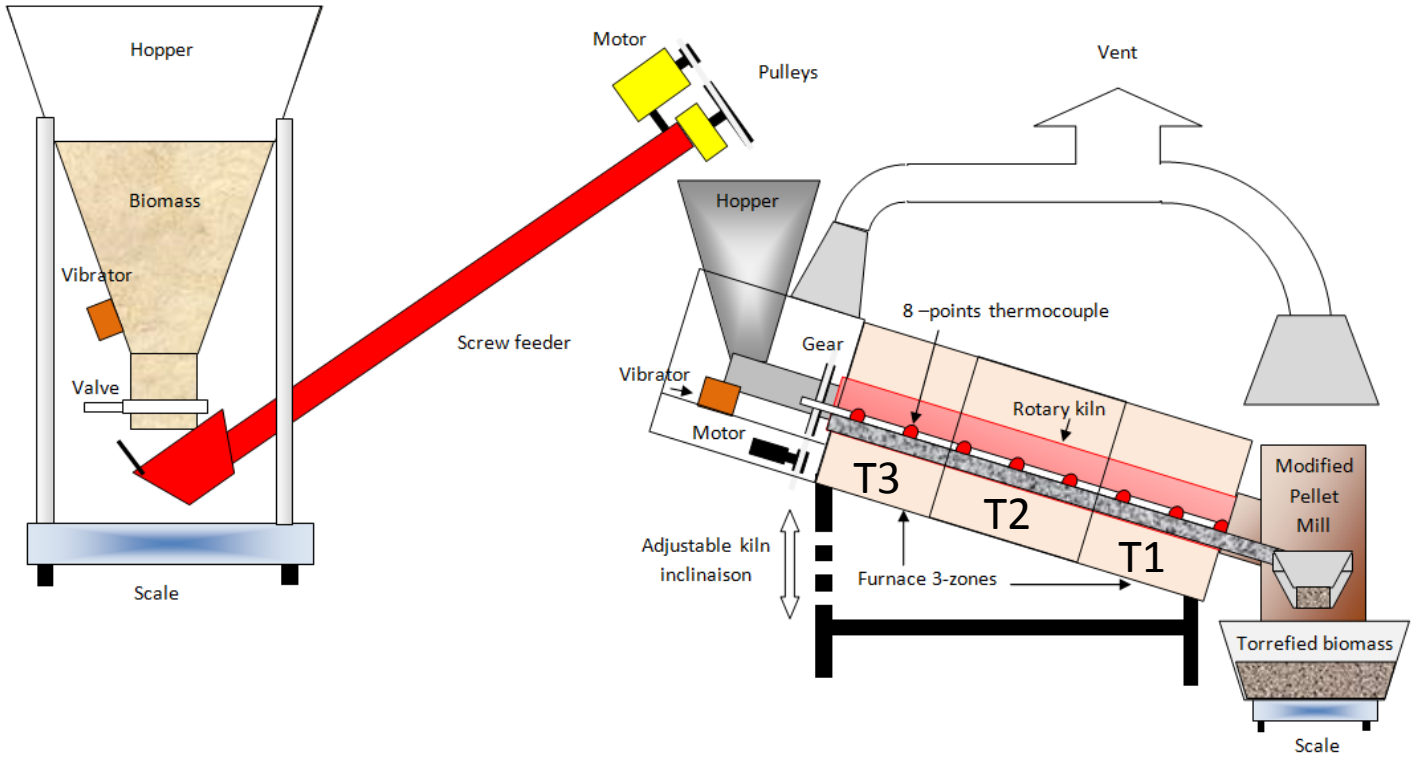
# Pyrolysis Technology Evaluation

- To understand the effect of various factors on bio-char properties to assist pathway selection
  - Effect of feedstock
  - Capability of pyrolysis technology in handling different feedstocks
  - Effect of pyrolysis technology and processing conditions
- Partners:
  - Ben Bronson (Bioenergy/CanmetENERGY): Fast Pyrolysis
  - Guy Tourigny (Bioenergy/CanmetENERGY): Torrefaction
  - Animesh Dutta (U of Guelph): Hydrothermal Carbonization

# Test Program

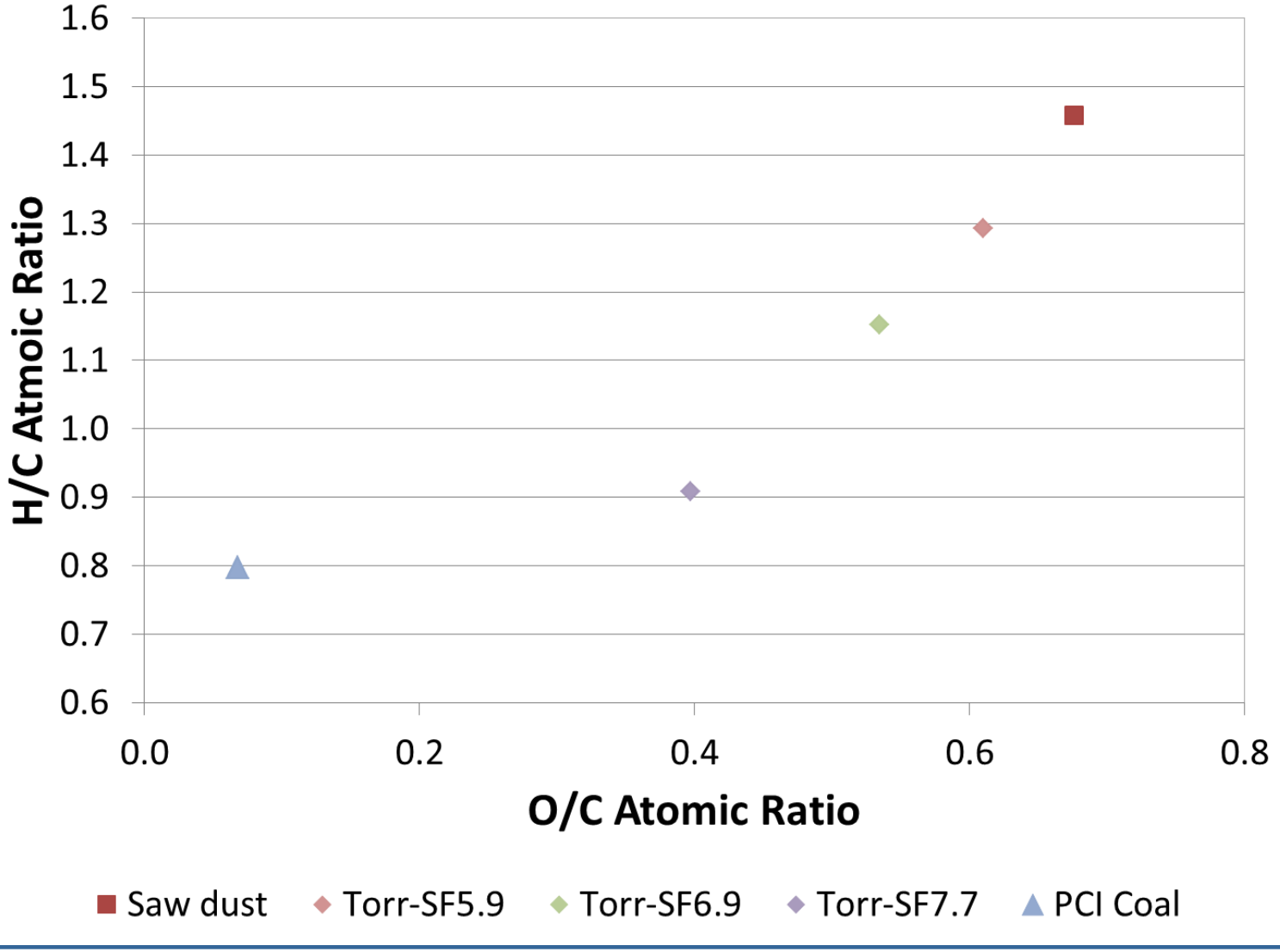


# Saw Dust Torrefaction: Rotary Kiln




| | T1 | T2 | T3 | Severity Factor |
|---|---|---|---|---|
| Torr-SF5.9 | 290 | 300 | 330 | 5.9 |
| Torr-SF6.9 | 310 | 320 | 350 | 6.9 |
| Torr-SF7.7 | 340 | 350 | 380 | 7.7 |

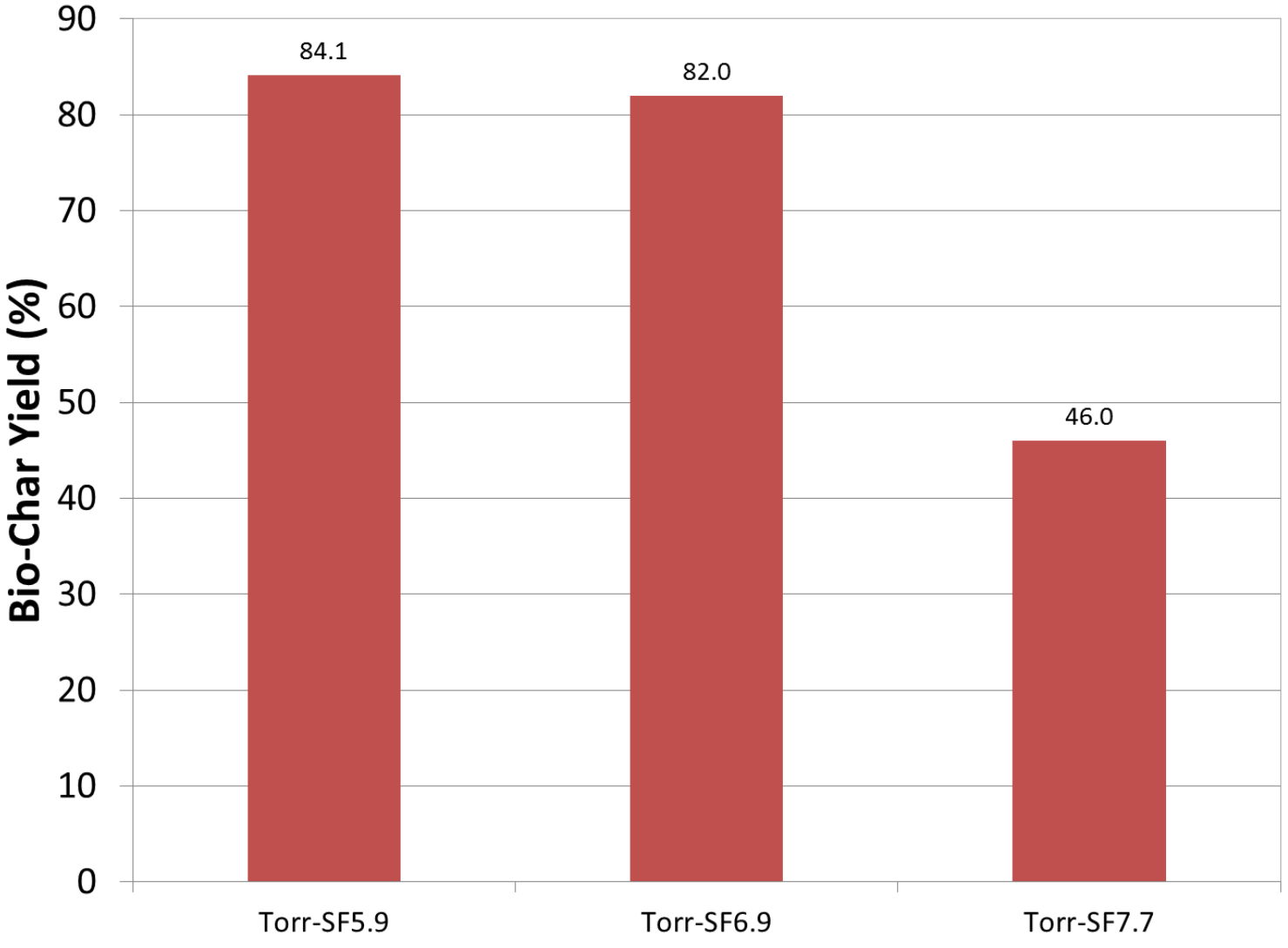
# Torrefied Saw Dust- Composition



# Torrefied Saw Dust- Composition

| | | | Injection Coal | Torrefaction SF 5.9 | SF 6.9 | SF 7.7 |
|---|---|---|---|---|---|---|
| Proximate(db) | Ash | % | 7.89 | 0.44 | 0.5 | 0.83 |
| | VM | % | 36.2 | 80.8 | 74.1 | 59.3 |
| | FC | % | 55.9 | 18.8 | 25.4 | 39.9 |
| Ultimate (db) | C | % | 77.5 | 51.7 | 54.9 | 61.6 |
| | H | % | 5.2 | 5.6 | 5.3 | 4.7 |
| | N | % | 1.7 | 0.2 | 0.2 | 0.2 |
| | S | % | 0.8 | 0.0 | 0.0 | 0.0 |
| | O | % | 7.0 | 42.1 | 39.1 | 32.7 |
| Ash Chemistry (%Ash) | SiO2 | % | 52.29 | 2.32 | 2.85 | 2.00 |
| | Al2O3 | % | 29.41 | 0.62 | 0.53 | 0.45 |
| | Fe2O3 | % | 6.55 | 11.09 | 2.57 | 4.57 |
| | TiO2 | % | 1.71 | 0.08 | 0.06 | 0.04 |
| | P2O5 | % | 0.12 | 2.94 | 3.19 | 3.19 |
| | CaO | % | 3.25 | 29.00 | 30.02 | 29.43 |
| | MgO | % | 0.95 | 6.30 | 6.68 | 6.62 |
| | Na2O | % | 0.26 | 0.58 | 0.41 | 0.38 |
| | K2O | % | 1.64 | 20.68 | 22.37 | 22.93 |

# Torrefied Saw Dust- Yield



# Blast Furnace Ironmaking

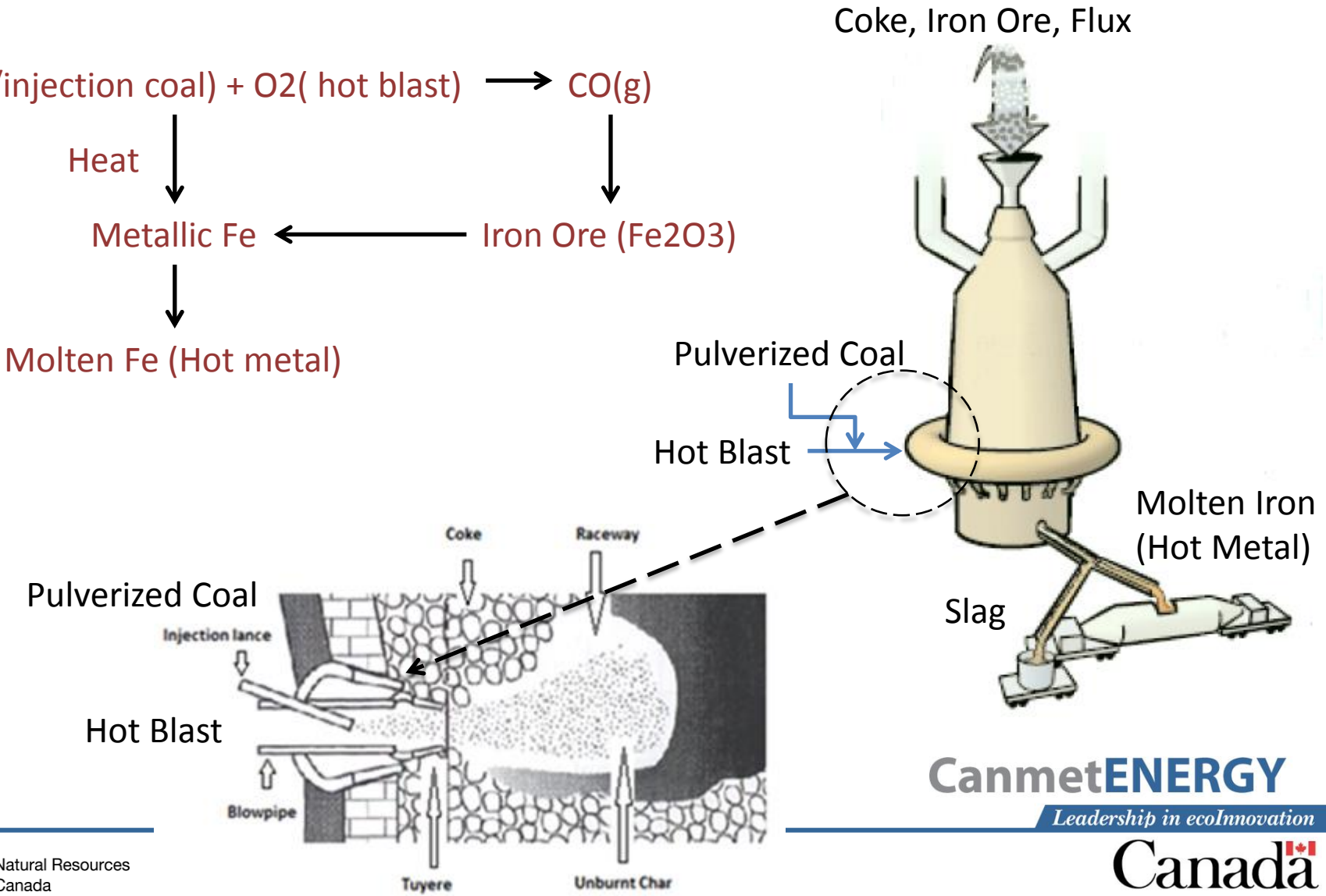
C (coke/injection coal) + O2( hot blast) → CO(g)

Heat ↓ ↓

Metallic Fe ← Iron Ore (Fe2O3)

↓

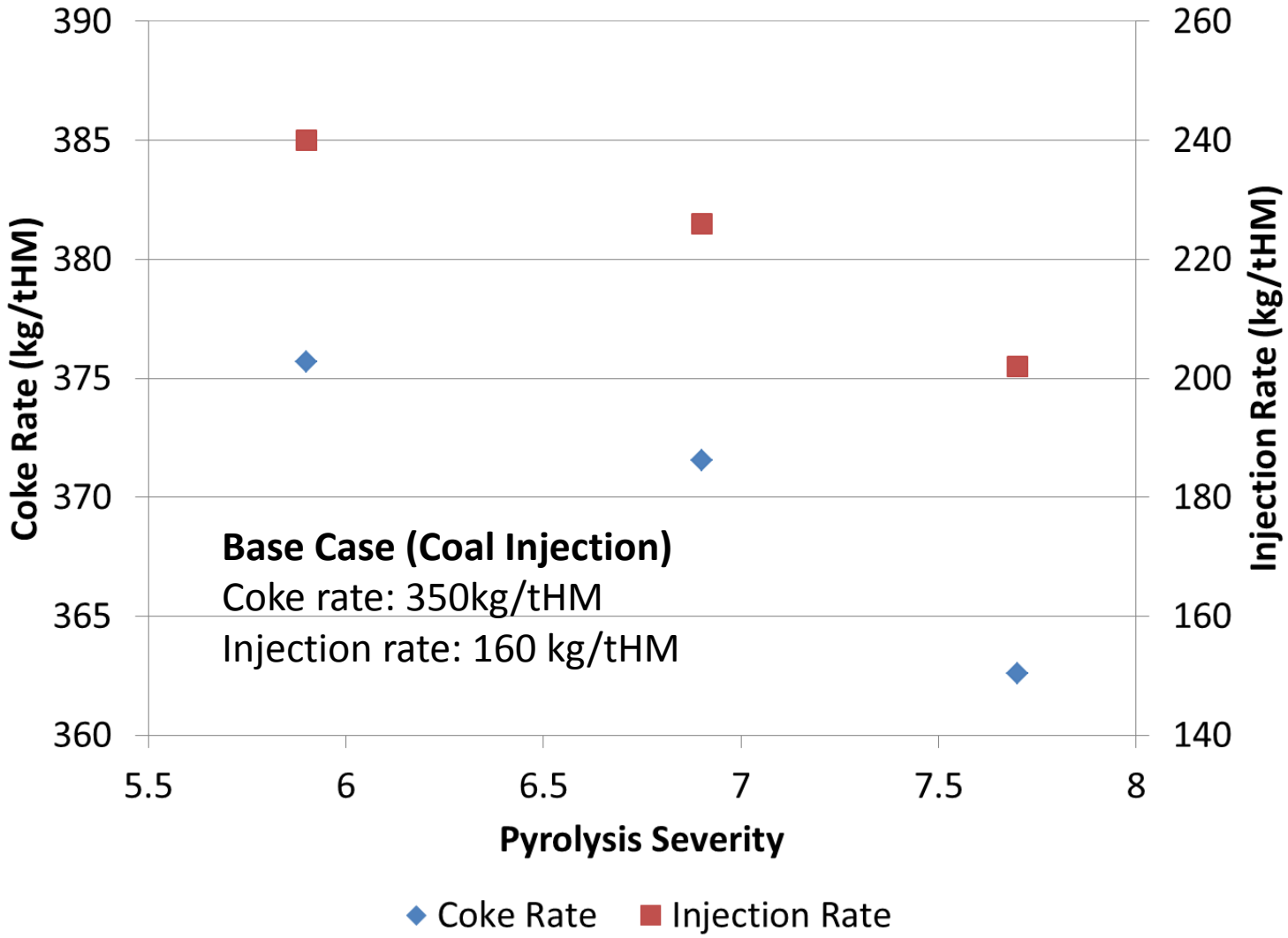
Molten Fe (Hot metal)



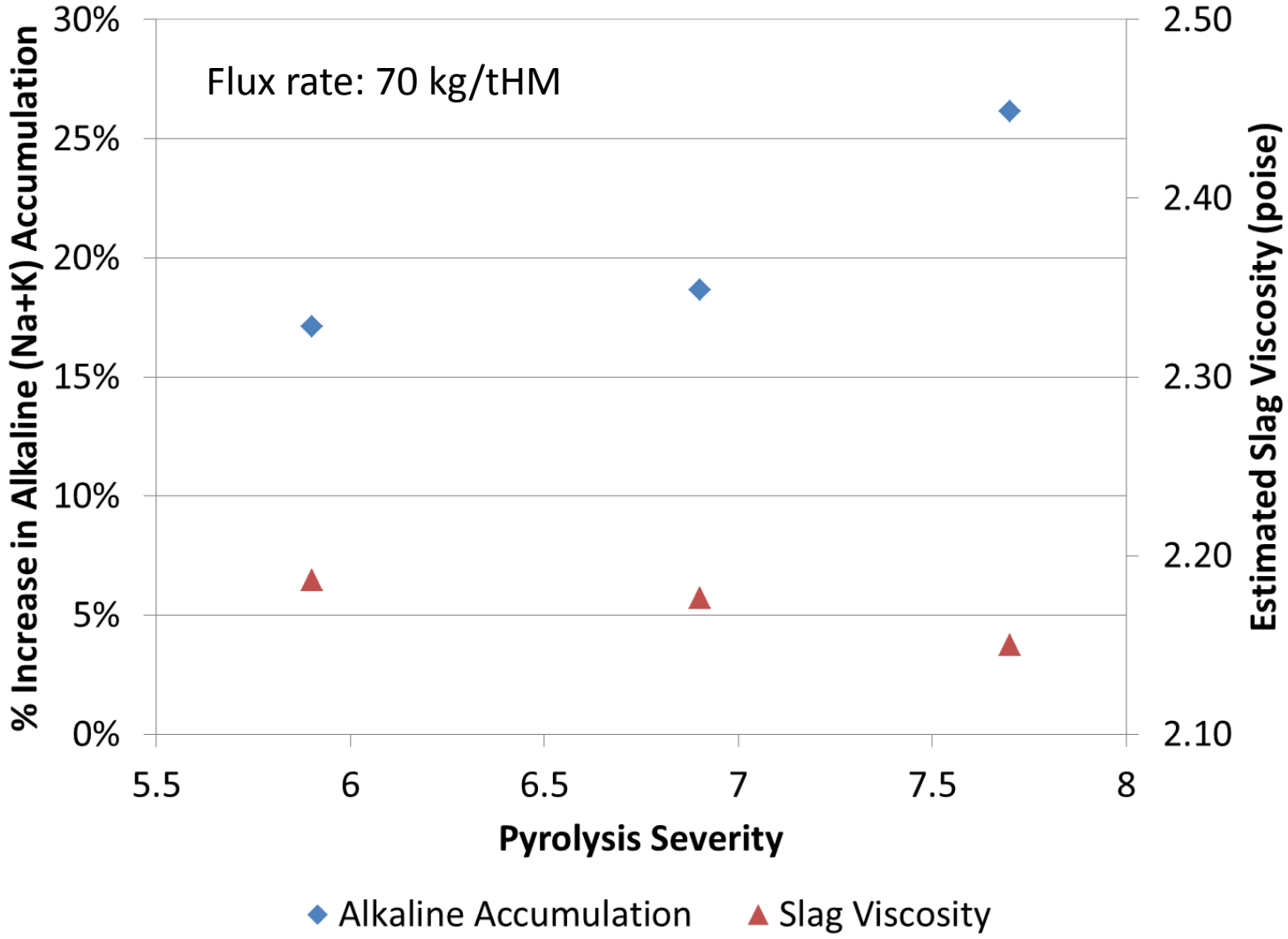
# Replacing PCI by Torrefied Saw Dust

- Heat and mass balance modeling
- Thermodynamic modeling
- Effect on blast furnace operations
  - Fuel (coke + injectant) consumption
  - Alkaline (Na+K) accumulation
- Potential GHG reduction
- Raw biomass demand

# Carbon and Energy Input



# Alkaline Accumulation



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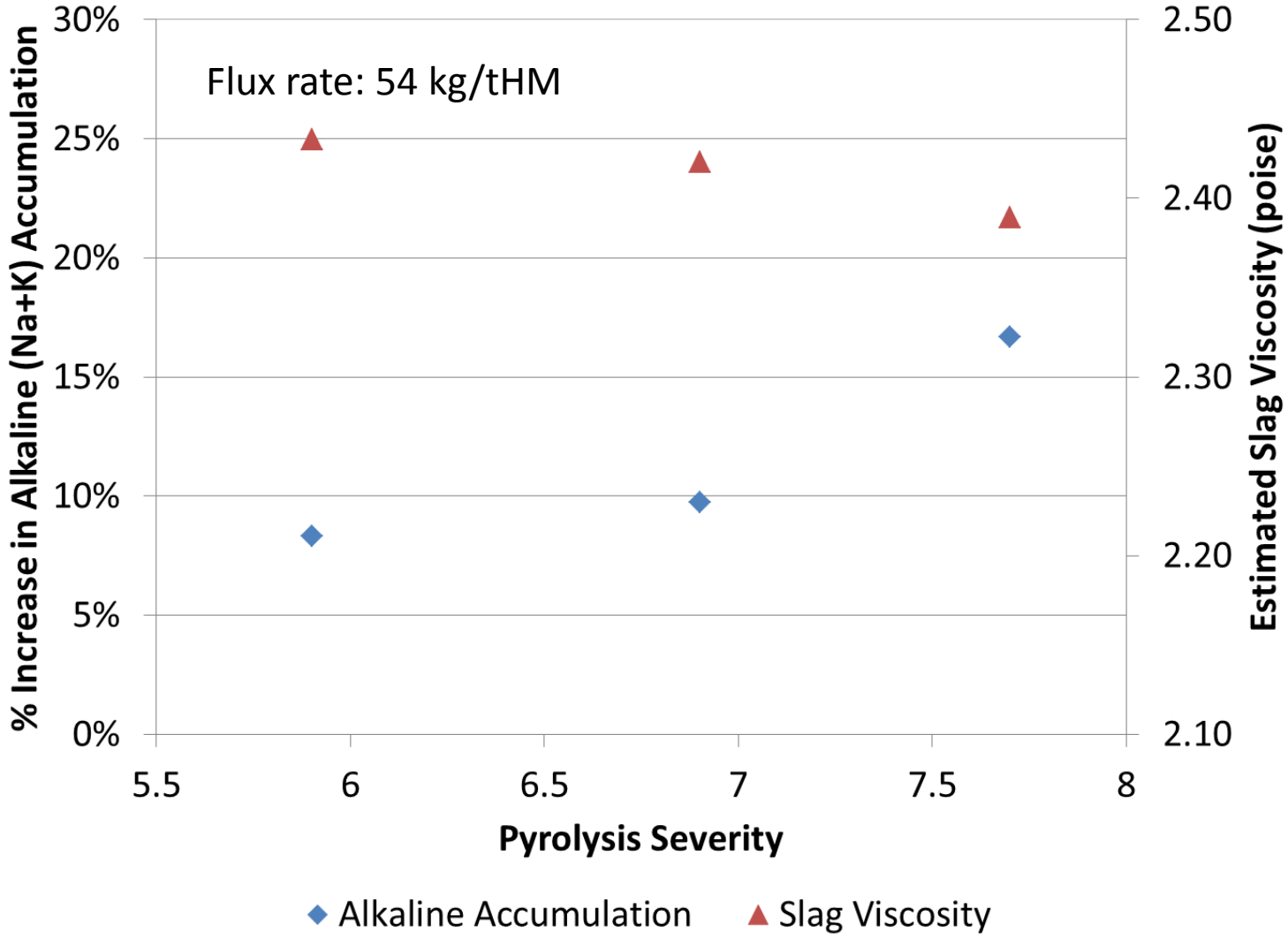
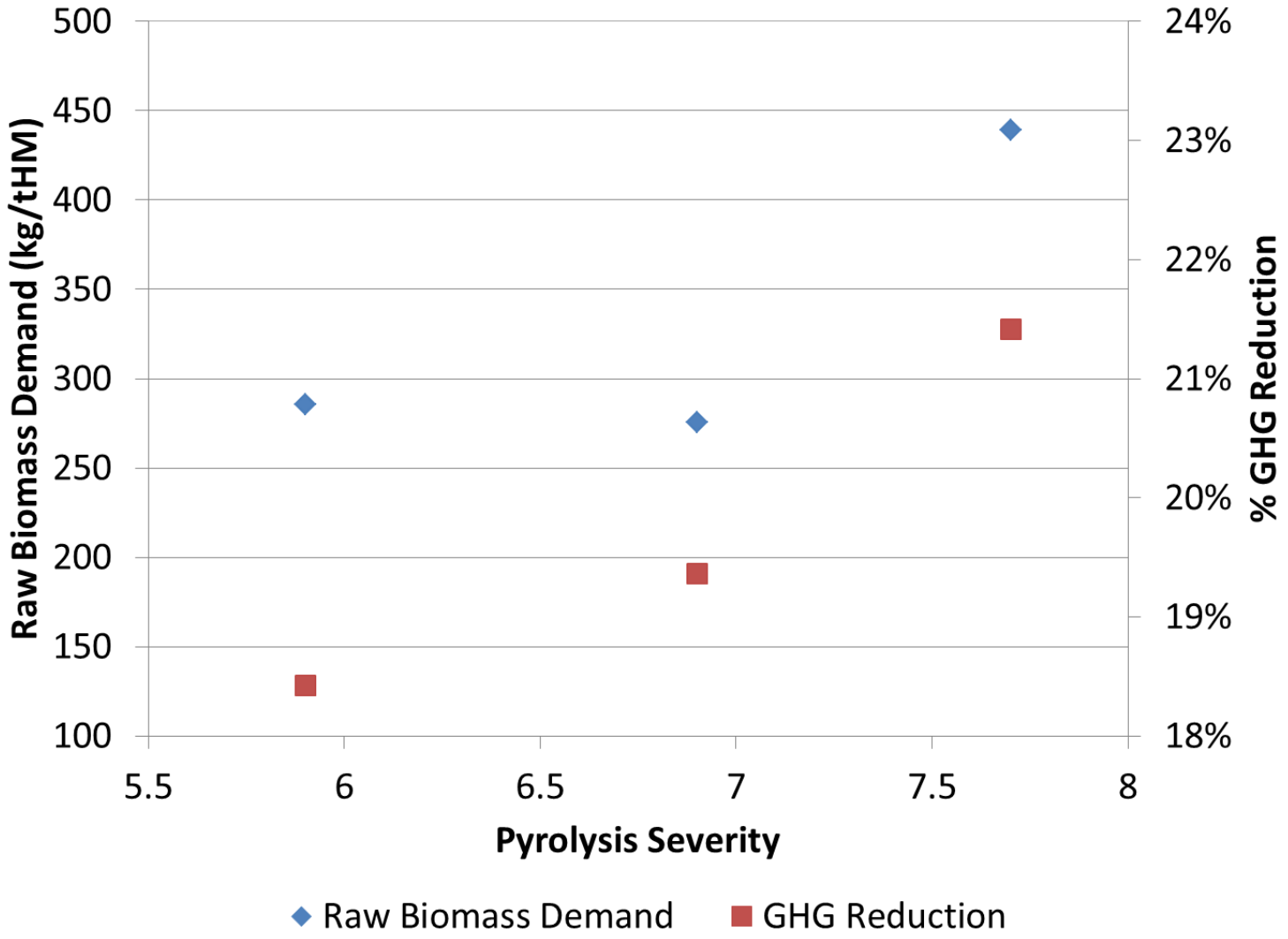


# Potential GHG Reduction



# Next Step

- Comparison of combustion kinetics of biochar produced at different pyrolysis severity in CanmetENERGY injection simulation rig

Pulverized coal injection simulation rig

# Future Work

- Repeat analysis with biochar produced by
  - different pyrolysis technologies
  - different raw biomass materials
- Supply information to steel producers, biochar producers and raw biomass suppliers to assist decision making
- Establishment of biochar supply chain to meet the technical needs of steel production

# Acknowledgements


- Natural Resources Canada Energy Innovation Program
- Canadian Carbonization Research Association
- Canadian Steel Producers Association