MOTIVATION:
Concept – to use Indiana coal in a mine mouth environmentally friendly, high efficiency coking/coal gasification facility – to increase supply, reduce costs, & enhance electricity reliability.

At present all of the coal used in the coking process is imported from outside Indiana. The United States has a short-fall of 5.5 MTons/year of coke with high dependence on imports. Prices are high & volatile. This places an enormous strain on Indiana’s steel & foundary industries.

This concept will use Indiana coal as main feed stock, provide transportation savings, cogeneration, blending, & storage on site.
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OBJECTIVES:
Indiana is home to 22% of domestic base steel production for the United States. An international investment of $140 Million for rebuilding aging coke ovens is taking place at Wheeling-Pittsburgh Steel Corporation. Indiana coal can become an active participant in this expanding market.

Calumet’s use of Computational Fluid Dynamics (CFD) analysis maximizes the value of coke generated from Indiana coals. Comprehensive modeling will determine engineering & chemical parameter values. A proposed detailed follow-on study is to consider more detailed design including experimental data.
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Advisors & consultants (letters of commitment received) are:-
Mittal Steel
Solar Sources
Argonne National Laboratory
Coal Science Inc
Indiana Business Modernization & Technology Corp
Purdue University Calumet faculty & students
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• Accomplishments to date:
  – Consultations with industrial partners have occurred & efforts to identify further funds for expanded project have started.
  – Initial properties of Indiana coal and the properties of coke produced from it have been identified.
    • Smaller size
      – Buckwheat/Nut coke: 1 inch x ¼ inch
      – Breeze: fine
– Coke markets investigated
  • Buckwheat/Nut: upper regions of blast furnace, electric furnaces, production of ferromagnesium and ferrosilicon products, elemental phosphorous production.
  • Breeze: carbon source in steel making, palletizing, sintering, elemental phosphorous production, compression into briquettes for use in blast furnaces in combination with iron pellets.
  • CFD to enhance Indiana coal and coke uses in industry
Examples of coke quality produced via pilot oven carbonization using Indiana coal

<table>
<thead>
<tr>
<th></th>
<th>100% Indiana (Brazil Block Coal)</th>
<th>100% Indiana (Danville, No. 7 coal)</th>
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<tbody>
<tr>
<td>Coke Stability</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Coke Hardness</td>
<td>54</td>
<td>69</td>
</tr>
<tr>
<td>CSR*</td>
<td>48</td>
<td>30</td>
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<tr>
<td>Coke size, mm</td>
<td>53</td>
<td>55</td>
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<tr>
<td>Coke yield, %</td>
<td>67.9</td>
<td>67.0</td>
</tr>
<tr>
<td>Coking Time, hr</td>
<td>18.6</td>
<td>20.15</td>
</tr>
<tr>
<td>Max. Pressure, kpa**</td>
<td>2.07</td>
<td>2.96</td>
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</tbody>
</table>

(Note: CSR*=Coke strength after reaction with CO2, Max Pressure** = maximum oven wall pressure)
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Possible Future Coal Tests

Proximate Analysis:
- Moisture, Volatile matter, Fixed carbon, Ash, Sulfur, BTU/lb (heating value), Free swelling index

Ultimate Analysis:
- Carbon, Hydrogen, Nitrogen, Oxygen, Chlorine

Ash Chemistry:
- SiO₂, AL₂O₃, Fe₂O₃, CO, MgO, K₂O, P₂O₅, Na₂O

Rehological Properties:
- Gieseler Plastometry (fluid characteristics), Arnu (expansion and contraction), Sole heat oven test (SHO)

Petrographic Tests:
- Petrographic composition of coal, Rank determination by reflectance, fluorescence analysis
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• Contacts and Site Visits
  – Multiple trips to 2 steel mills
  – Coke facility and research group
    • Discussions and tours in process
  – Coking cogeneration facility
    • Discussions and tours in process
  – 2 trips to Argonne National Laboratory
  – Coal mine discussions and/or visits in process
Two main methods for coke production

- Recovery Process
  - Reducing atmosphere
  - Issues with complexity and gases
  - Issues with waste
  - Combustible gases available for turbine or boiler
  - Byproduct streams

- Non Recovery Process
  - Air introduced to burn off volatiles before they can produce pollutants
  - Heat recovery steam generation for electricity
  - Small amount of H for heating recirculated at bottom
    - Issue is: Can mass flow be modified for a CT?
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• Models considered
  – Aspen – Argonne National Laboratory
    • Detailed “recovery type” coal gasification model
    • Would require additional funding
  – Metsim
    • Will be used in this work as initial process scoping tool
    • Widely used
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• $\text{CO}_2$ sequestration
  – Preliminary conceptual investigation underway
**Task Schedule**

<table>
<thead>
<tr>
<th>ID</th>
<th>Task Name</th>
<th>Start</th>
<th>Finish</th>
<th>Duration</th>
<th>2005</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Develop Initial Plan Details and Submit to CCTR for Approval</td>
<td>3/1/2005</td>
<td>3/15/2005</td>
<td>11d</td>
<td>Jan</td>
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<td>5</td>
<td>Prepare Interim Report</td>
<td>5/2/2005</td>
<td>6/17/2005</td>
<td>35d</td>
<td>May</td>
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<td>7</td>
<td>Evaluate CFD Aspects</td>
<td>6/16/2005</td>
<td>10/18/2005</td>
<td>89d</td>
<td>Jul</td>
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<td>9</td>
<td>Prepare Final Report</td>
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<td>12/30/2005</td>
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