Coal Fine Briquetting Using Municipal Solid Waste (MSW) and Other Binders

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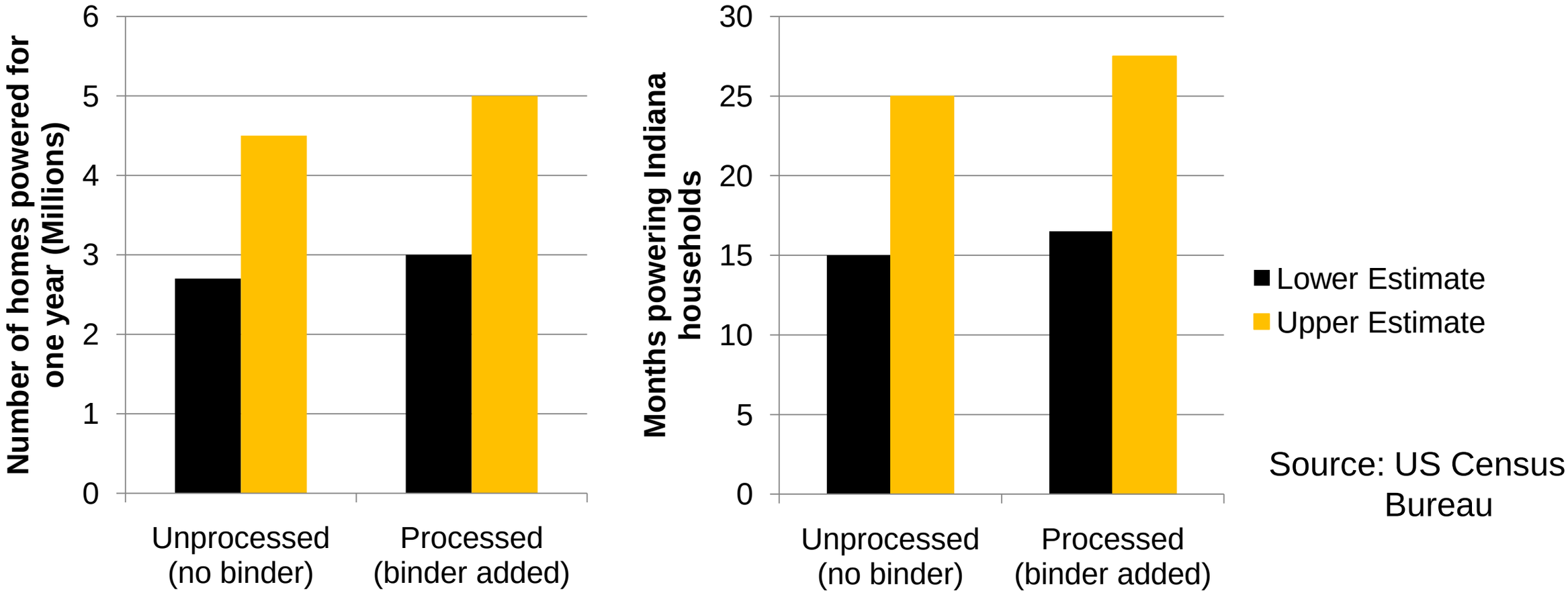
Background

- Coal fines have historically been regarded as a waste product
  - Coal fines may be much more usable for pulverized-coal boilers, but many large stoker boilers still operate in the United States
  - Using fines has been cost-prohibitive in the past
    - Large amounts of coal fines exist in Indiana and Illinois

- “A study by CQ Inc., funded by the Electric Power Research Institute, indicates that over two billion tons of bituminous waste coal fines are available for recovery east of the Mississippi River.” [1]

Background

- Approximately 12-20 million tons (Mton) of coal fines are currently available for briquetting in Indiana alone.



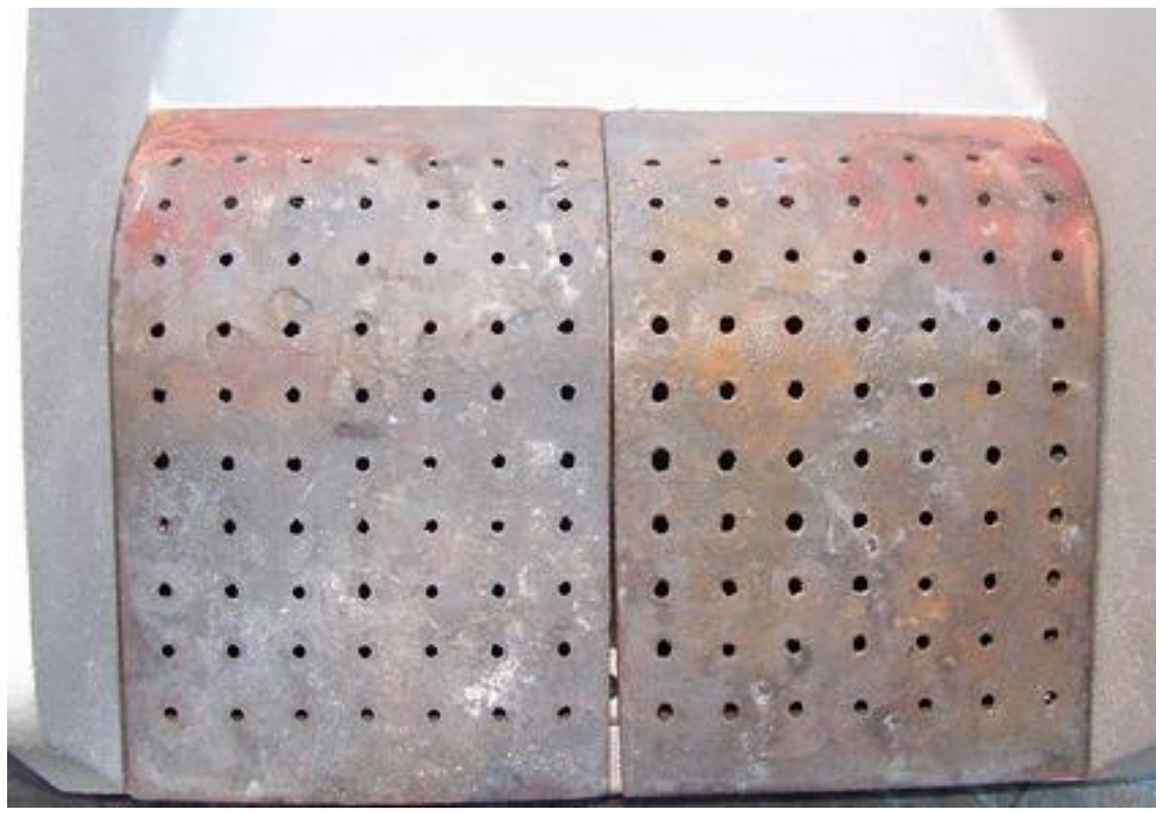
- Heat and cool Purdue campus, as well as co-generate electricity, for 80 to 133 years [2]

Background

- Stoker boilers cannot utilize coal fines because they fall through stoker grates
  - Stoker boilers are the simplest of coal boilers currently in operation, and usually utilize a traveling grate system

Chain-grate

Perforated-plate grate



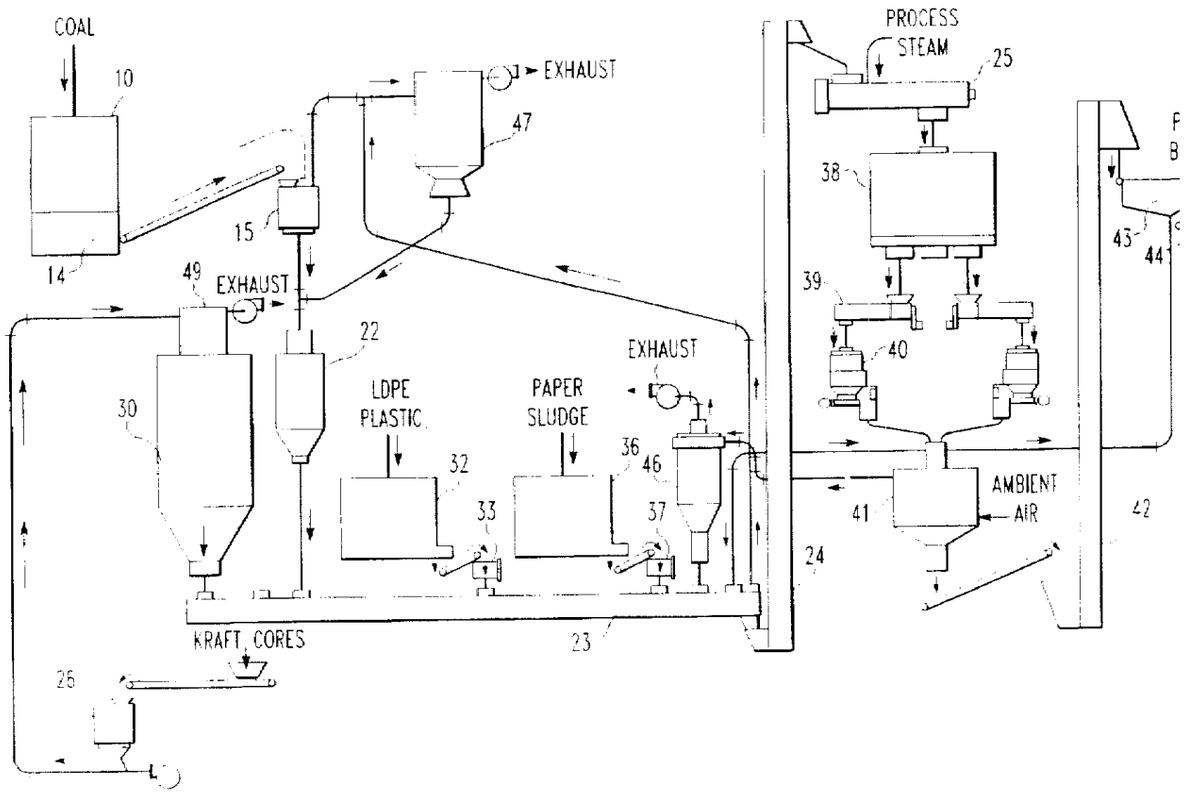
Background

- Coal briquetting has been researched for over a century
  - Studies of binding agents have been found which date to the early 1900's
    - Asphalt, coal tar pitch, starch, magnesia
  - Several patents for pelletizing coal fines currently exist
    - Most are unfeasible on a commercial scale, or are outlined in scarce detail

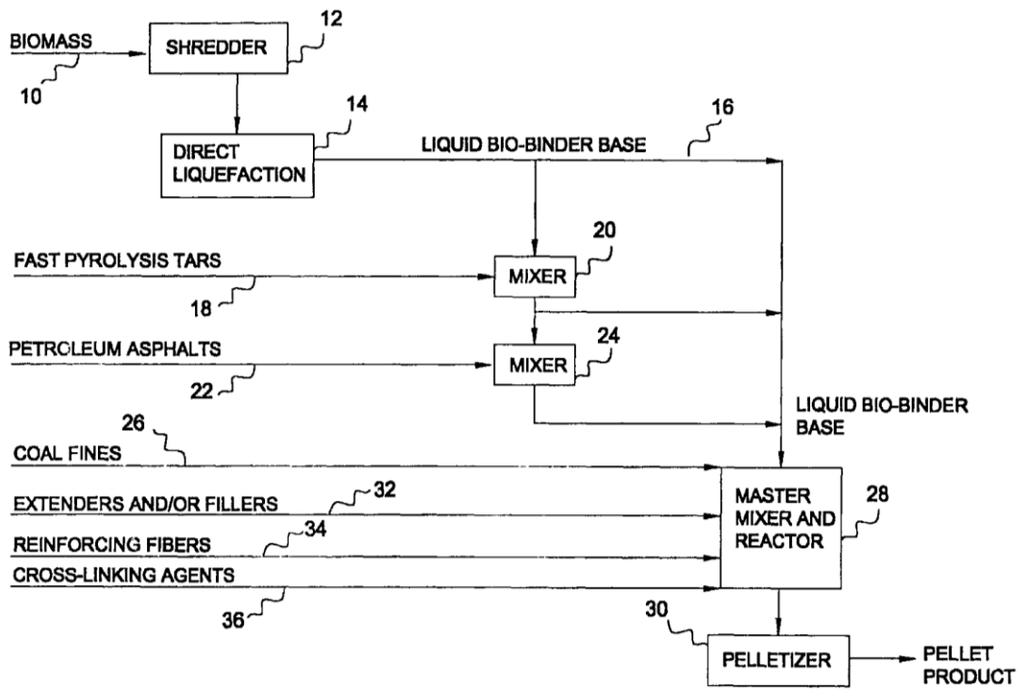
Background

- Existing patents for briquetting solid fuels

U.S. Patent 5,743,924



U.S. Patent 5,916,826



Background

- Several companies have developed methods of briquetting coal fines
- KeLa Energy – Orlando, FL
  - Produces briquettes through a patented process which utilizes recycled plastic, carpet fibers, and biomass. [3]
- Greensfields Coal Company – Beckley, WV
  - Produces briquettes through a patented process involving a proprietary binder. [4]
- No company in Indiana has developed a method of coal fine briquetting

Introduction

- **Primary objectives:**
  1. Research and evaluate the binding and combustion properties of various binders for coal fines.
  2. Develop a process to integrate binder and produce robust coal briquettes.
  3. Perform combustion testing to determine flame temperature, emissions profiles, efficiency, and chemical kinetics of the developed coal/binder product.

Introduction

- The end product should be robust, and able to be handled and stored in exactly the same manner as stoker coal (outdoor storage, transportation via conveyor and front-end loader, etc.)

Binder Considerations

- The criteria that determine a binder's suitability include:
  1. Able to be processed?
     - Ability to be pulverized to <200μm diameters
     - This will ensure homogeneity of the particle mixture
  2. Does the binder have a positive, negative, or neutral effect on the heating value?
     - A increased heating value partially offsets processing cost
  3. Water insoluble?
  4. Available for full-scale production?
  5. Cleanly combusting?
  6. Does the binder have a positive, negative, or neutral effect on ash concentration?
  7. Cost effective?

Impact of Moisture

- The moisture content of the fuel is very important - fines from a mine usually have high moisture content
  - Moisture must be removed in order to pulverize the coal to sufficiently small diameter
    - Coal fines containing too much moisture tend to agglomerate instead of pulverizing
  - Moisture must then be re-introduced to the coal fine/binder mixture before pressing
    - Moisture helps pellets cohere initially
    - Initial tests show 5% moisture to be adequate to assist binding out of die

Advantages of MSW

- Heating values of typical MSW materials
  - Note that many plastics have higher heating values than coal
  - This is why most MSW blends tend to increase overall heating values

	Heating Value, HV, MJ/kg
HDPE	30.95
LDPE	41.74
PET	15.88
PVC	14.22
PS	33.44
PP	31.98
HDPE+PVC+PS	43.69
LDPE+PP+PET	42.25
HDPE+LDPE+PET+PVC+PP+PS	45.54
Biomass Fuel [Chuah *et al.*, 2006]	14.0 - 18.4
Coal (premium) [Chuah *et al.*, 2006]	23 - 28
Natural Gas [Chuah *et al.*, 2006]	54
Gasoline [Chuah *et al.*, 2006]	45
LPG [Chuah *et al.*, 2006]	48

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Advantages of MSW

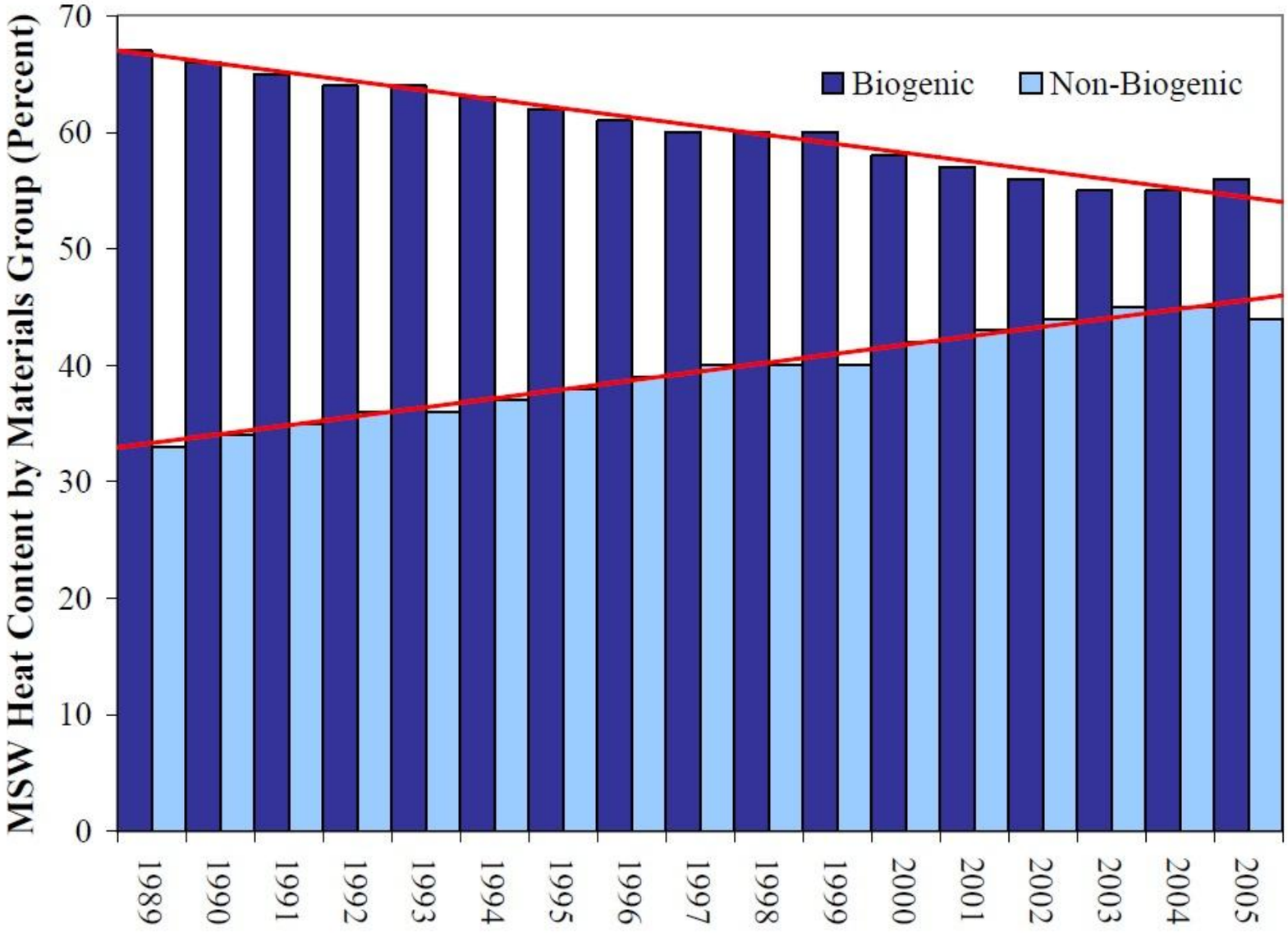
- MSW is an attractive option as a binder
  - According to the DOE 27.26 million tons of MSW plastics are landfilled annually [5]

- MSW blends being considered possess the following characteristics:
  - Increase heating value (available energy per unit mass) of the final product
  - Decrease pollutant (specifically SOx) emissions

Advantages of MSW

- EPA trends in the last 15 years show the percentage of non-biogenic (synthetic) waste is increasing in the U.S.

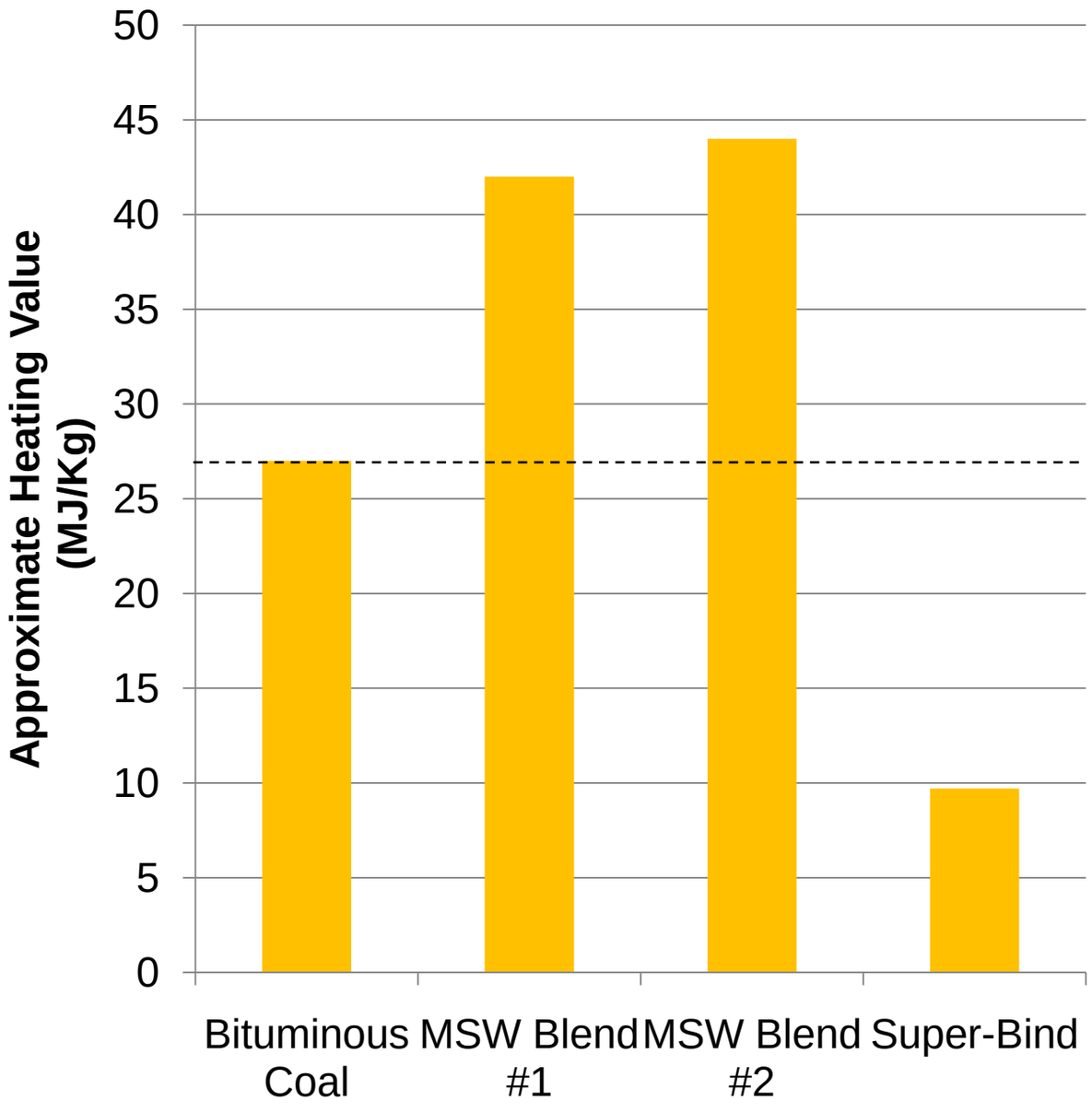
Figure 1. Trends in Municipal Solid Waste (MSW) Composition

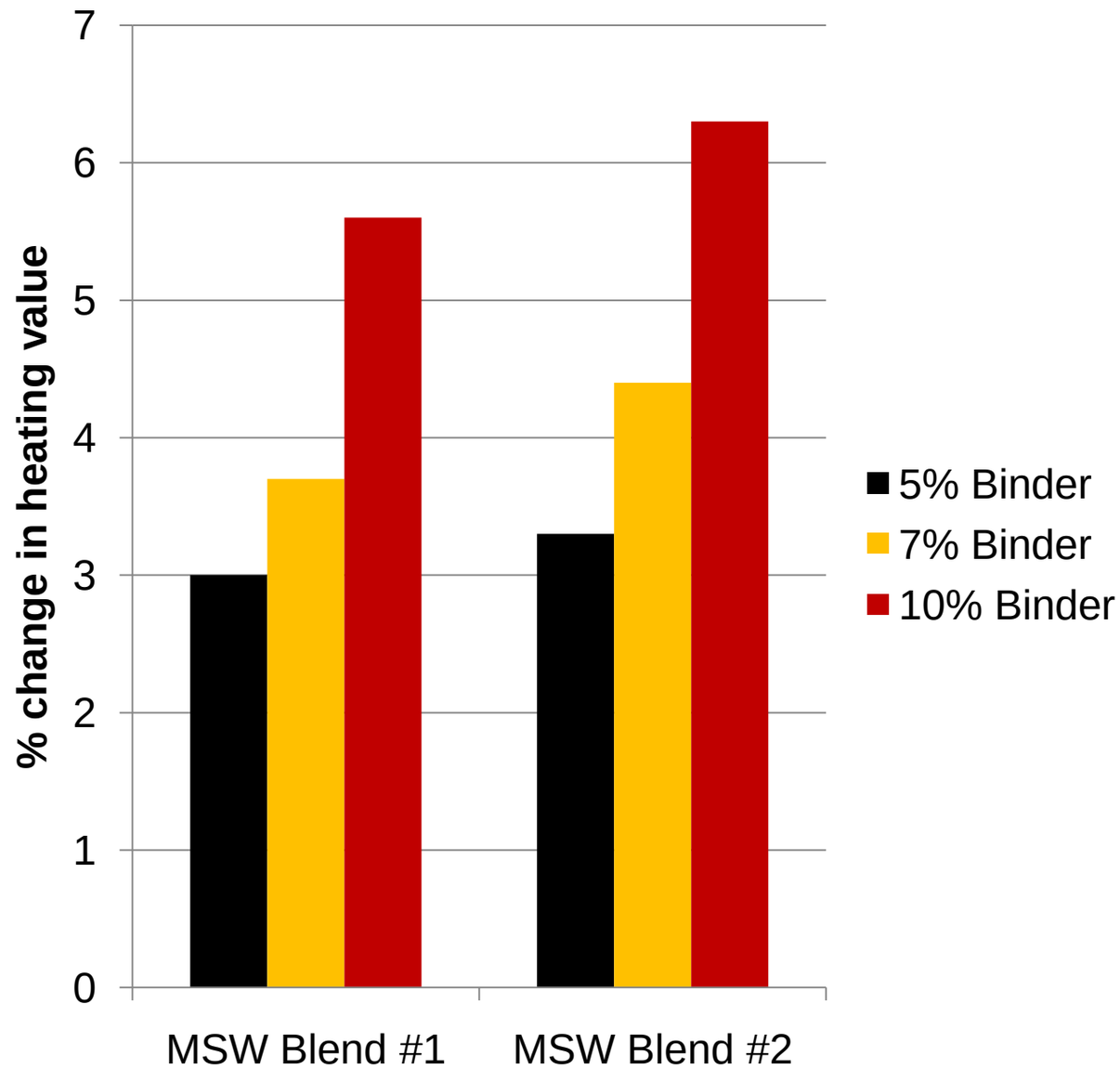


Source: Table 1 and Environmental Protection Agency, *Municipal Solid Waste in the United States: 2005 Facts and Figures*. http://www.epa.gov/msw/msw99.htm

Advantages of MSW

- A coal pellet having the following mass percentages of the specified binder will contain (approximately) the following energy contents



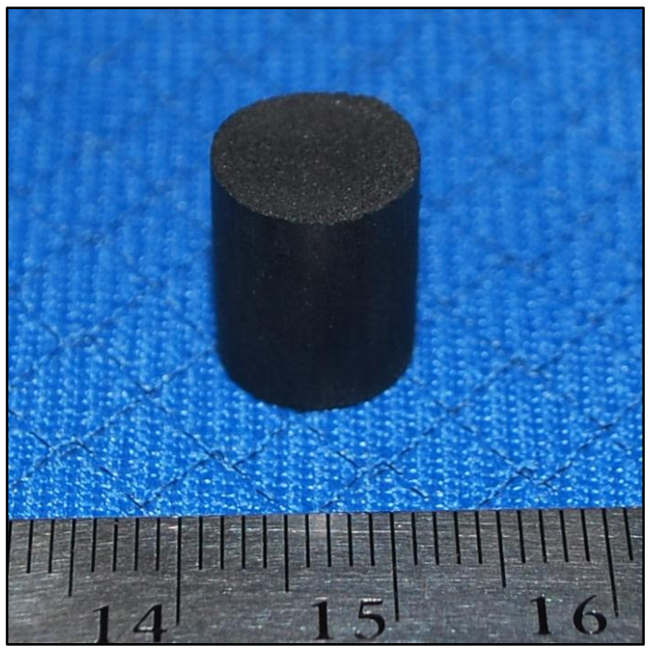


MSW vs. Other Binders

- A variety of other binders have been considered, including inorganic binders, commercially-available livestock feed binders, and other types of waste (rubber, shingles, municipal waste sludge)
  - Inorganic compounds decrease heating values and increase ash
    - Increased ash = increased cost of ash disposal
    - Some regulations prevent “synfuel” ash from being sold to concrete producers
- Commercial binders reduce the value of using coal fines for large-scale power generation use
- Other types of waste need energy-intensive processes to be used

Commercial Binders

- **Super-Bind® -** A commercially available feedstock binder which is safe for animal consumption. Super-Bind® is a “lignin sulfonate pellet binder that improves pellet quality” [6].
- Lignins are complex molecules found in the cell walls of woody plants.
- Lignin Sulfonate is a co-product of paper production**.** [7]



P = 12.9ksi,10% moisture

Pellet pressed with 2% Super-Bind®. Pellet shows exceptional coherence with no tendency to disintegrate along edges.

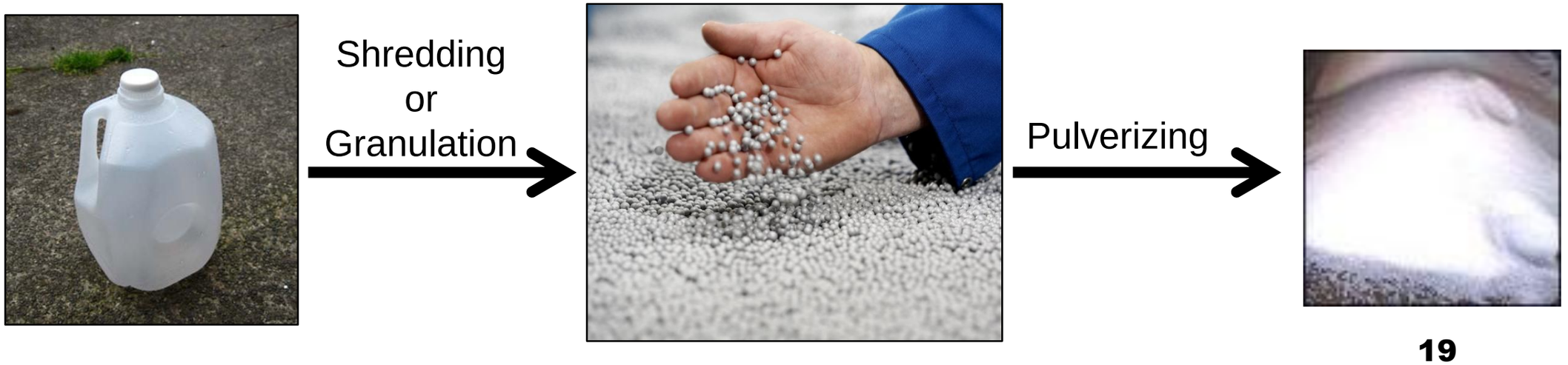
Silicates

- Two different clays are under consideration due to their extremely effective binding properties
  - **Attapulgite:** A silicate which is abundant in clays mined from the south-eastern United States. It is commonly sold as a spill adsorbent.
    - Inexpensive and abundant

  - **Montmorillonite:** A silicate found in clay. Commonly found in volcanic ash.
- Used as pharmaceuticals to treat gastrointestinal problems

Processing Challenges

- Some binders (namely plastics) are difficult to pulverize to small particle diameters due to their very high ductility
  - Liquid N_2 has been used to freeze plastics so they are easily shattered
  - This becomes the main processing challenge, as plastics are well-suited in all other categories presented



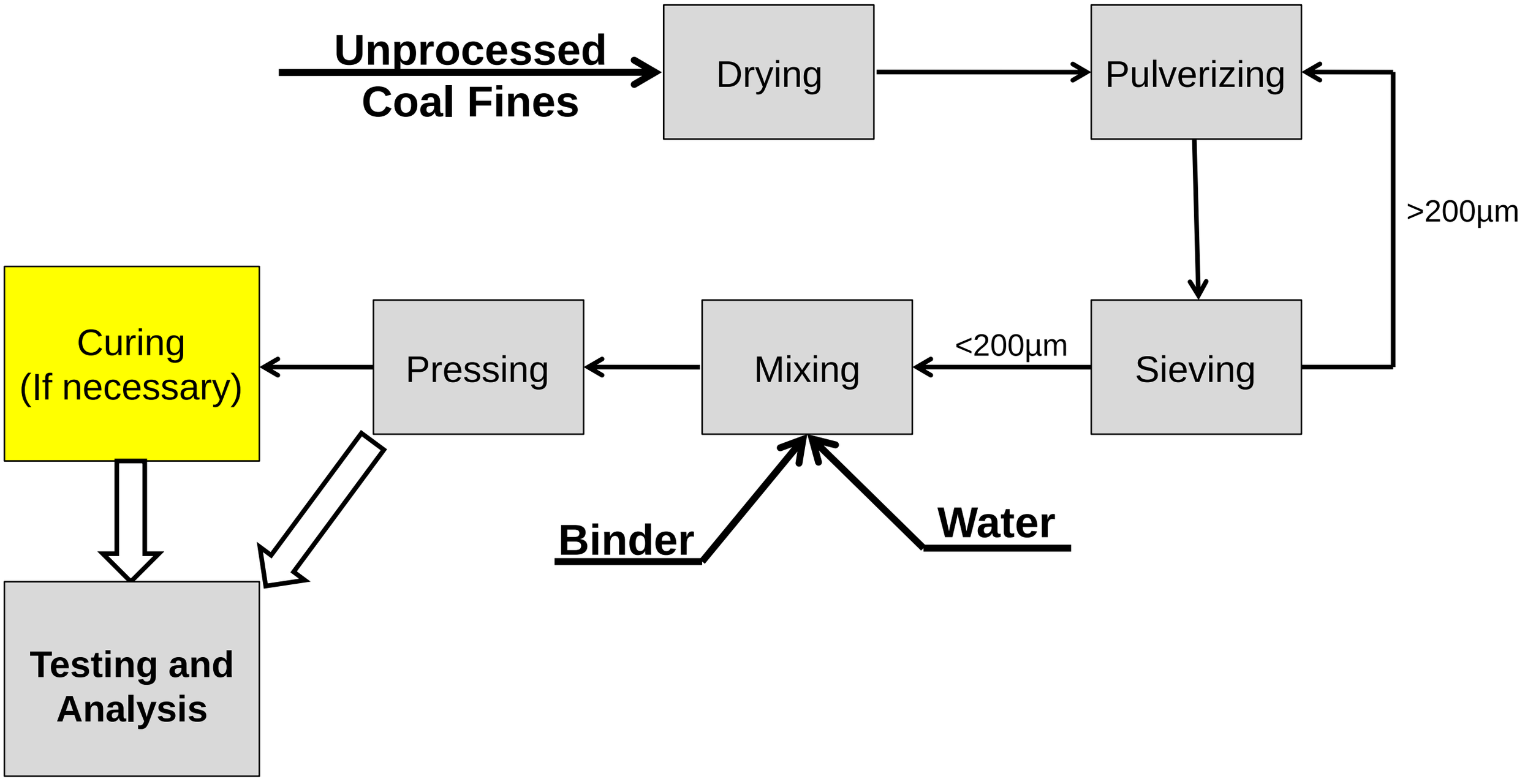
Economic Challenges

- A low processing cost must be kept in order to not damage profit margin of using the synthetic coal product
- Cost of the synthetic coal product comes from a variety of variables, including:
  1. Cost of coal fines
  2. Cost of binder
  3. Cost of equipment to pulverize coal and reduce binder to acceptable size
  4. Cost of energy to drive all machinery
- Tax credits exist for using “synfuel”

Current Status

- List of potential binders has been determined
- Initial pellets have been pressed with varying binder weight percentages
  - Minimum die pressures have been established to achieve an acceptable degree of cohesion
- Laboratory-scale briquetting to be started over summer months
- Chemical combustion testing and analysis to begin after briquetting
  - Gas chromatography, TGA/DSC, Spectroscopy

Experimental Procedures

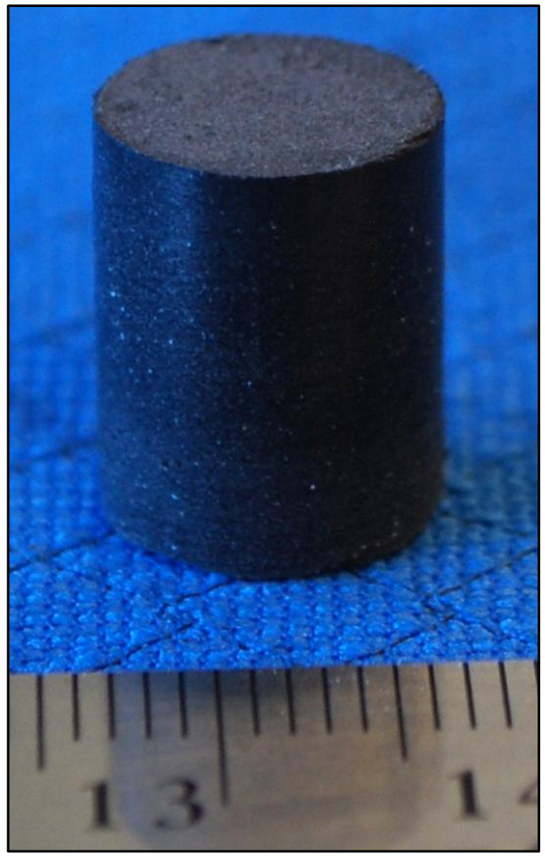


Experimental Procedures

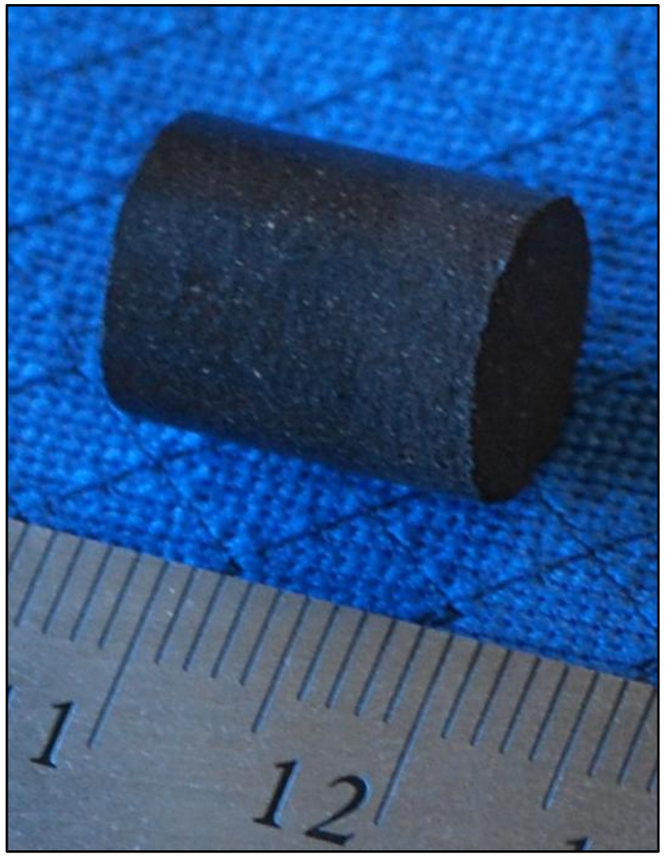
Pulverizer

Hydraulic Press

Project Progress

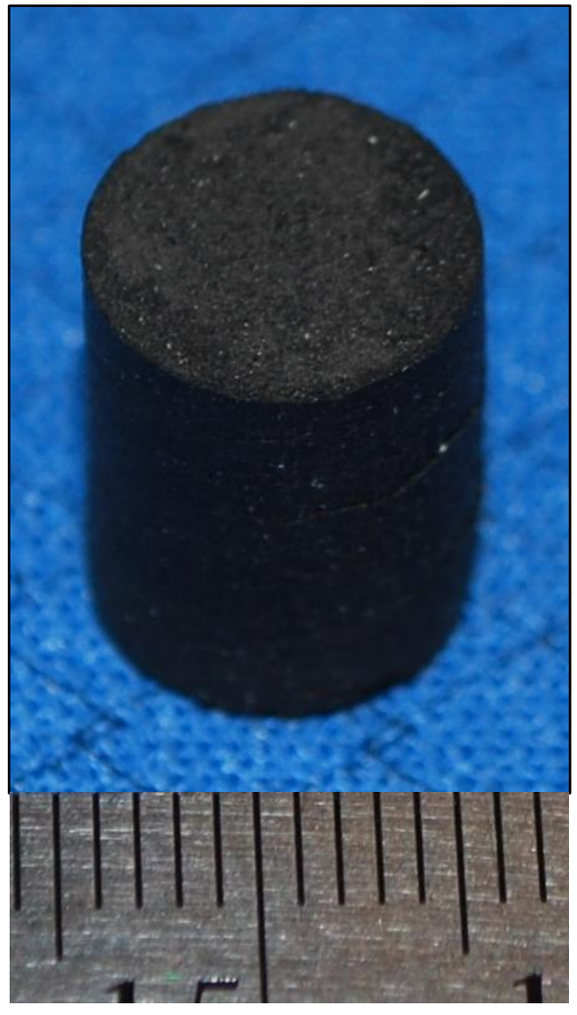


7% MSW#1
P= 12.9ksi



7% MSW#1
P= 12.9ksi

7% MSW#1
P= 9.7ksi



7% MSW#1
P= 6.5ksi

Coal pellets pressed using MSW Blend #1 at varying die pressures.

Conclusion

- Millions of tons of waste coal fines are unused
  - Recent developments in binders has made briquetting coal fines economically viable
- To utilize coal fines in stoker boilers, they must be formed into coherent pellets so as not to fall through grating
- A binding agent needs to be combined with coal fines
- Several binders have been considered, and MSW plastic appears to possess many desirable qualities in a binding agent
- Samples have been received and initial pressing has begun to determine feasibility
- Laboratory-scale briquetting will begin over summer months

Acknowledgements

William Harrington
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References

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