

Recovery of Rare Earth Elements from Coal Byproducts using Battelle's Acid Digestion Process

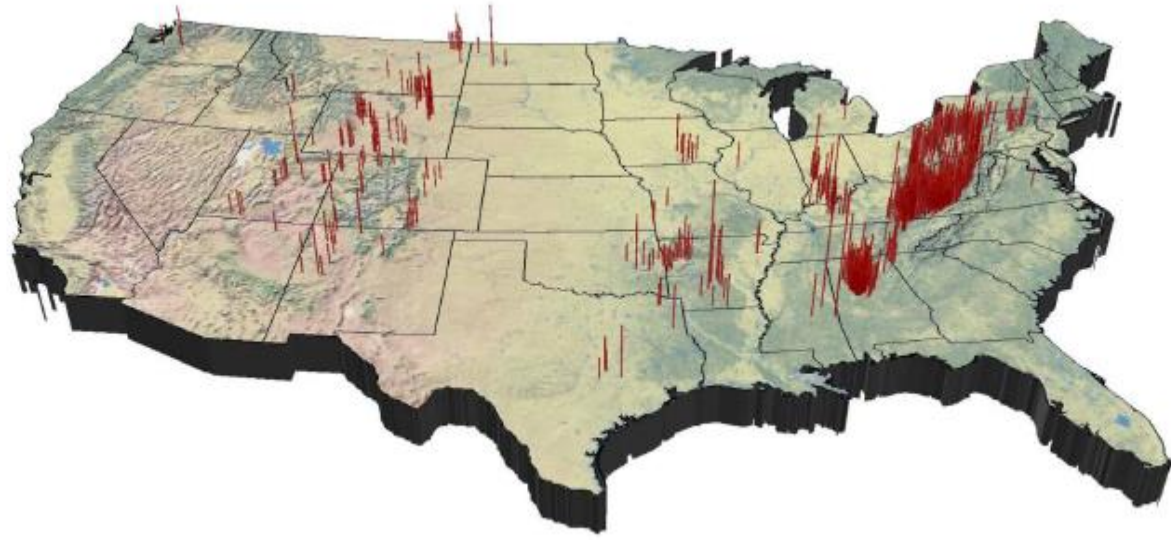
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Rare Earth Elements (REE) Background

| | Elements | Uses |
|-------------------|--------------------------------|--|
| Light Rare Earths | Sc, La, Ce, Pr, Nd, Sm, Eu, Gd | Batteries, Alloys, Motors, Electronics, Guidance Systems, Communication Systems, Catalysts |
| Heavy Rare Earths | Tb, Dy, Ho, Er, Tm, Yb, Lu, Y | |

| Country | 2014 Production, tons | 2015 Production, tons |
|-------------------|-----------------------|-----------------------|
| United States | 5,400 | 4,100 |
| Australia | 8,000 | 10,000 |
| China | 105,000 | 105,000 |
| Rest of the World | 4,600 | 4,900 |
| Total | 123,000 | 124,000 |

Data from USGS Mineral Commodity Summaries 2016



Locations where Coal REE Concentration exceeds 700 ppm

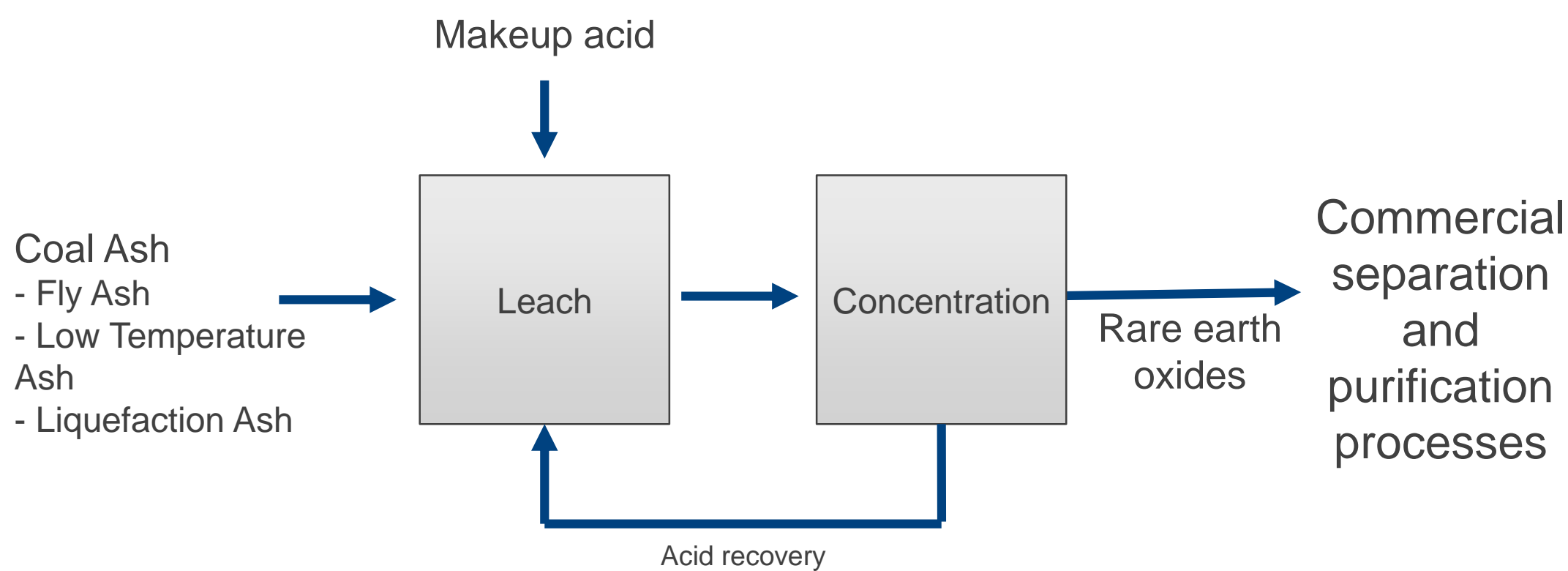
J.M. Ekmann, *Rare Earth Elements in Coal Deposits – a Prospectivity Analysis*. 26 Nov 2012.

Project Objectives

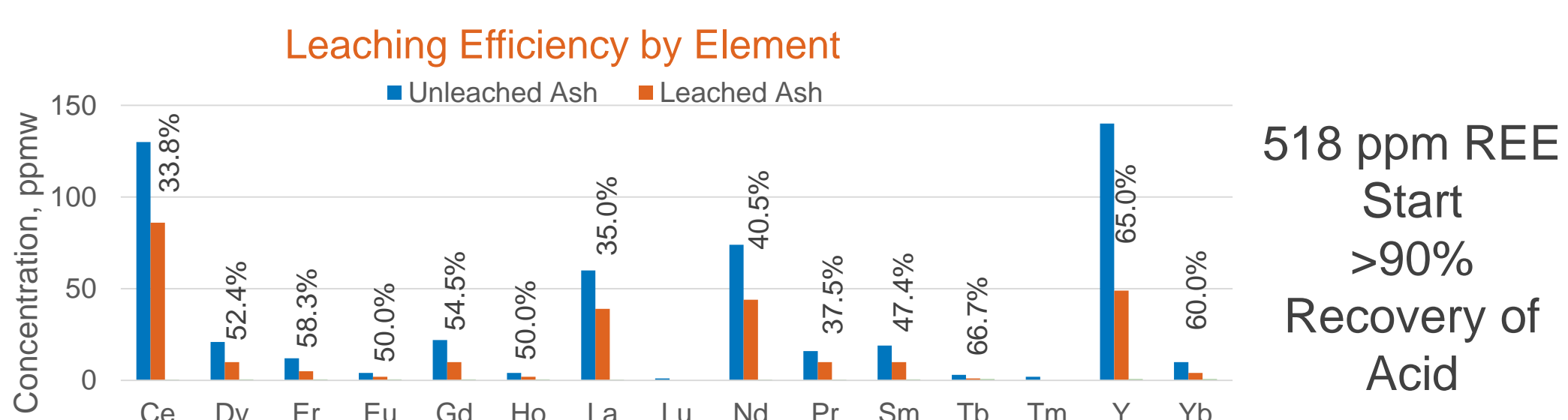
Demonstrate feasibility of Battelle's closed-loop Acid Digestion Process to extract and concentrate REEs

- Target >2 wt% REE in concentrate

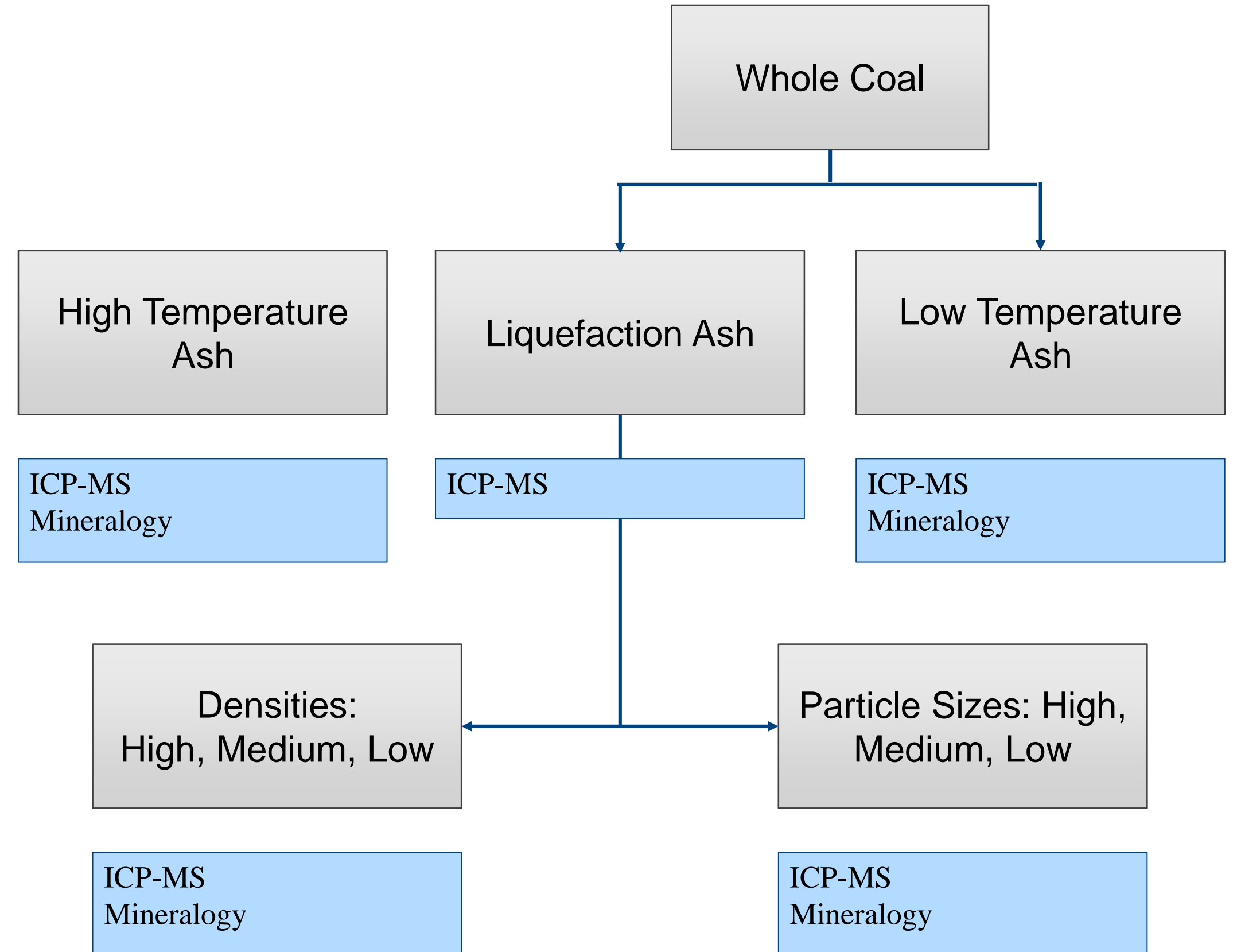
Technical Approach



Demonstrated Results

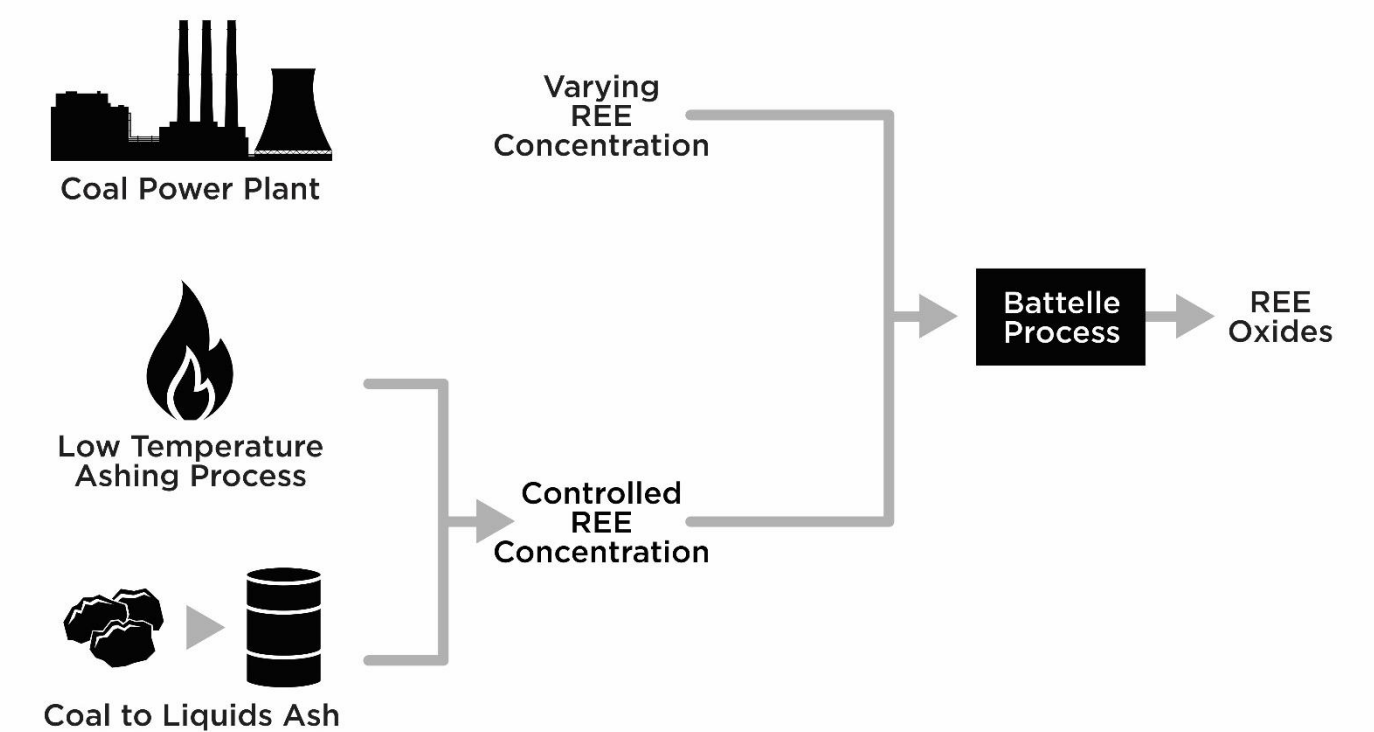


Sampling and Analysis



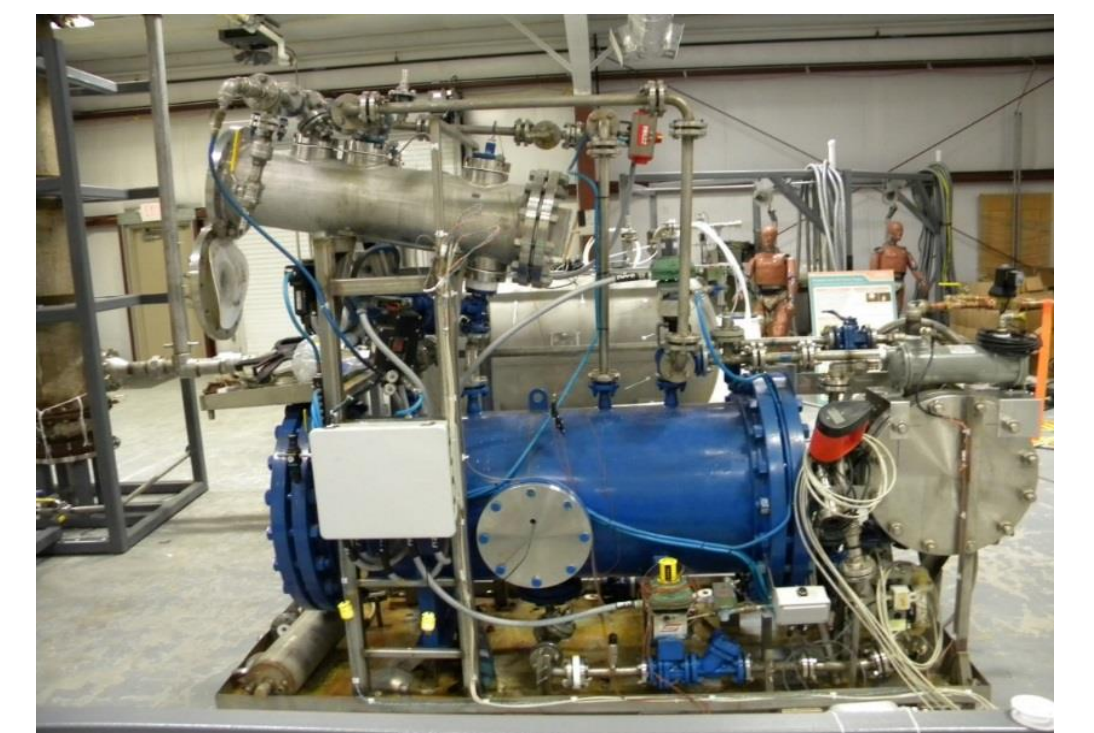
Feasibility Study

Techno-Economic Assessment to establish path to profitable operation



Process Design And Next Steps

Integrated bench scale system design for potential phase 2



Acknowledgements

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