Coal Ash 2.0: A Strategic Resource

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INTRODUCTION

Since 2009, SonoAsh has focused on a new technology development pathway to enable coal ash beneficiation of both impounded and production coal ash: a sustainable, essential strategic resource with unique near- to long-term opportunities. The central consideration in the first step of coal processing is generating power is the first step to maximizing value, not the only step. In an increasingly energy and Carbon conscious world, Carbon offset accounting cannot be ignored. This includes securing the essential social benefits to drive government to less proscriptive methods and engage more collaboratively.

This paper focuses on the sole patented wet ash beneficiation available for global commercial application, the SonoAsh wet process technology.

Technology innovations to the power and metals industries, and by extension, the coal ash industry, represent a call for far greater ambition in policy. The opportunity for the coal power industry is to pursue the audacious objective of 100% ash utility. The opportunity to maximize market revenues for low Carbon materials and essential metals, explore water recover/reuse/recycle beyond governmental guidelines, simultaneously mitigating real & perceived corporate risk. These are the elements that will create the framework for Coal Ash 2.0.

The SonoAsh message to the stakeholders:

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<th>Private Sector</th>
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<tr>
<td>1. American Concrete Institute (ACI)</td>
<td>1. (State) Departments of Transportation (DOTs)</td>
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<td>2. Portland Cement Association (PCA)</td>
<td>2. American Association of State Highway &amp; Transportation Officer (AASHTO)</td>
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Coal Ash 2.0 creates win/win/win situations where vital products and commodities are produced, with reduced energy & Carbon intensity and parallel reduction of the universally undocumented corporate asset risk of the coal power industry.

HISTORY

The SonoAsh process was derived from work focused on the development of a technology approach for Mercury emission abatement to the power industry. This comprehensive development program led to the validation of the highly effective wet shear approach to create high and low Carbon fractions from coal combustion residuals (CCRs).

The low Carbon fraction can be modified to meet market requirements for both Loss on Ignition (LOI) and Mercury removal, creating a ready-mix cement (RMC) suitable for ordinary portland cement (OPC) displacement material from formerly unsaleable ash sources.

The subsequent high Carbon fraction encapsulates rare earth and nuisance metals in a matrix that notably passes US EPA Method 1311 leachate test criteria, reducing short term storage requirements by up to 75% (see Figure 7).

This multi-year effort coincided with evolutions in the US and global energy industry, with the significant increase in renewable energy sources, the rise of hydraulic fracturing shale deposits yielding phenomenal quantities of natural gas and oil. These technology innovations are the economic drivers which have contributed to the decline in coal use in the US (Figure 1).

Figure 1: Energy Breakdown (Source: Visualcapitalist.com)
Internationally, the steep decline in the nuclear industry from the 2011 Fukushima disaster has ensured coal use is significant in countries such as Germany, where hard coal and lignite still occupy 40% of the energy mix (Figure 2).

![Figure 2: Germany Energy Mix](image)

**TECHNOLOGY PATHWAY**

The changing global energy mix is such that the industry must respond with an effort to create broad opportunities and good jobs in a sustainable coal industry, underwriting enhanced energy security and innovation for modern distributed energy systems.

The ultimate objective in Figure 3 is to validate a pathway to **100%** pond ash recovery, with significant returns on investment, while creating improved opportunities for global climate change obligations.

![Figure 3: Balanced Interests for All Stakeholders](image)
DISCUSSION

Historically, coal for power generation has been viewed as a single-use fuel source. As a result, the industry structure built around coal power over the last century is a one-dimensional, low-cost fuel for electricity view, and where all by-products are wasted or sold as low-value fillers.

The narrative for coal ash as a strategic resource exists. That narrative includes proprietary technology and environmental liability considerations to change the view of coal as a single-use resource for generating electricity and heat. Instead, this model offers insight to move the coal industry from single-use to a multi-use sustainable resource, where the social license to use coal could be renewed and revenues currently unrealized create benefits not currently in place.

Coal power is a safe, abundant, and low-cost fuel source that is essential for a stable and yet increasingly variable, renewable fuel world. But more can and needs to be done to ensure coal remains a valuable fuel source in a diverse energy supply matrix. That is why the downstream by-products of combusted coal are so important.

There is little value created by merely dewatering and storing ash in long term impoundments or as an ingredient in filler applications. SonoAsh is currently engaged with coal powered utilities to unlock the potential economic and environmental value of beneficiating coal ash. Since securing its patents in the North America and Europe, SonoAsh has worked diligently to explore and demonstrate commercial, high value coal ash beneficiation opportunities are achievable beyond the current cost centric models of disposal, storage and risk mitigation.

Perhaps more impactful to the bottom line, and the focus of the second SonoAsh patent, is the prospect of separation and encapsulation of commodity, strategic and rare earth metals.

ABOVE-GROUND MINING AND RARE EARTH ELEMENT (REE) RECOVERY

It is well-documented that coal ash presents a unique ore body, characterized by the number of metals present and their corresponding concentrations when compared to conventional mining. Typical assays demonstrate many of the seventeen rare earth elements (REEs) are present in various US sources such as Appalachian, Illinois and Powder River Basin coal seams.

SonoAsh international and US patent families validate wet, low-frequency sonic fracturing and separation of the Carbon from the coal ash, creating a stable, non-leaching metal encapsulation “ore” for subsequent traditional mine process techniques.
Figure 4: Sonic Reactor Application

REEs are not particularly rare. Finding them in concentrations where they can be economically mined and processed presents a considerable challenge. The SonoAsh process resolves this challenge by increasing metal concentrations to levels associated with conventional mining economics and complexity while simultaneously producing a tunable OPC displacement material.

Additionally, some rare earth elements are more valuable than others. The U.S. Department of Energy listed five particular elements of critical importance to clean energy and subject to supply risk in the next 10 years. Two more are listed as near-critical (Fig. 5).

![REE Risk of Supply](source: US DOE)

The five critical elements for these goods and services (Yttrium, Neodymium, Dysprosium, Europium, and Terbium) and the two near-critical elements (Lithium and Tellurium), are present in coal ash.
Figure 6 summarizes the opportunity to be realized with the selective recovery of these metals. Recovery of a processed ash source makes it possible for Carbon and energy offsets when compared to the energy and cost intensity associated with virgin recovery of these metals. Given that the global market is increasingly dominated by China (>95%), this represents a matter of national and international interest to find compatible, environmentally and financially stable mechanisms for nations to preserve their security and opportunities for development given the ubiquitous presence in computing, batteries, catalysts, materials and motors.

The process assumes a standard impoundment where the ash can be extracted wet in a 30% slurry before processing. The US Environmental Protection Agency (EPA) established in its Effluent Limitation Guidelines (ELGs) the imperative for pollutants commonly in fly ash such as Mercury, Arsenic, Selenium or hexavalent Chromium not be discharged.

An impediment to wet process innovation is over utility concerns over the addition of water to slurry ash from impoundments as mandated by these ELGs. SonoAsh efforts include the recovery/reuse of available onsite water and effluent streams for ash removal and processing to reduce these ELG requirements, wherever possible.

OPTIMIZING THE VALUE OF COAL

Stepping back, it is clear that the electric power utility industry structure is evolving, as is the role of coal energy. At the recent Copenhagen and Paris climate change conferences, nations from around the world looked to adopt new climate change strategies. Traditional coal power applications are under broad retreat as jurisdictions move towards natural gas, along with alternative and renewable fuels such as wind, solar, geothermal, biomass and nuclear.
SonoAsh objectives for its ash beneficiation and mining development programs are to ensure coal, properly processed after burning, provides multiple benefits, unconstrained by legacy perspectives that view it only as a single-use fuel source.

The potential for multi-use coal business model recognizing value throughout the coal life cycle holds significant upside for multiple stakeholders. By adopting a process that includes both an innovative approach to the historic reality of the cementitious properties in coal ash and above-ground mining coal ash for commodity metals, strategic metals and REEs will generate new revenue opportunities. These opportunities become available to a utility with SonoAsh facilities. In addition to a sustainable business model, variable Carbon accounting and sequestration benefits become available in participating geographies (for example, Carbon taxes to $50/metric tonne introduced in Canada through 2023).

**DRAIN THE POND AND IMPACT THE BOTTOM LINE**

In North Carolina, Duke Energy has been mandated to find beneficial uses for the millions of tons of material in three coal ash impoundments. These impoundments hold significant value. The perspective that impoundments are unrecognized assets instead of perceived corporate and environmental liabilities is critical to the required above-ground mining paradigm shift.

During the 2015 World of Coal Ash conference in Nashville, TN, an industrial survey was presented pointing out that not only are REEs present and concentrated in these impoundments, the equivalent values of the elements range anywhere from $4,500/ton of coal ash to $46,000/ton. In practice, recovery rates would certainly be less than 100%. However, assuming the recovery rates and processing costs amount to a worst-case scenario of 10% of the total available metals revenue value, this represents a notional metal revenue value of $400 per ton makes the potential new revenue streams a viable business.

The comparative technological differences between the incumbent technologies have entrenched the idea that solely dry coal ash beneficiation technologies like Carbon burnout, thermal fluidization and electrostatic processes are viable, beyond the baseline dig and dump options, based on reduced operating costs. The SonoAsh process challenges these assumptions, offering a sequenced path for sustainable development and commercialization through high value products not currently available.

The SonoAsh patented process allows for “tunable” manufactured ash specifications from different ash sources (Figure 7) to be delivered. By removing Mercury and Ammonia to below detectable levels, the process creates a mean particle size specification tailored to market specifications while creating the opportunities for the aforementioned recovery of strategic metals.
A key feature of the SonoAsh process is to tighten the water balance with only a modest water treatment component for process blowdown. The SonoAsh process also reduces liabilities and offers significant value that far outweighs the value of the manufactured beneficiated ash.

![Figure 7: SonoAsh Process](image)

The result: Impoundments sustainably drained and liabilities will be reduced while generating new revenue streams, allowing for new project financing opportunities by monetizing the risk and realizing the application value of new metal and traditional pozzolanic material creation, all with an unprecedented low Carbon footprint (Figure 8).

![Figure 8: SonoAsh Value Drivers](image)

SUMMARY

The coal industry needs a new narrative.
Combusting coal, not just for its historic power generation value, but to concentrate and recover commodity, strategic and REE metals, is essential for a sustainable future and business model in the coal ash industry.

SonoAsh offers a patented, economically and socially viable method of unconventional mining. The significant financial basis driving current industry metrics of power generation and clean building material production is supported by vital supplemental benefits:

- Enhanced social perception and license,
- Comprehensive environmental liability reduction
- GHG credit opportunities, and
- Carbon offset and efficiency

These benefits represent attainable deliverables in the current political climate for stabilizing the coal industry’s footing and value. A new perspective on the starting point moves coal from a single-use power source of the past to a high return and technically and socially important component in the necessary diverse energy infrastructure being realized daily.

**ABOUT SONOASH**

Based in Vancouver, BC, Canada, SonoAsh is an engineering technology company leveraging its patented and industry validated processes to create a high-value ore source for aboveground mining and highly cementitious green building materials from variable quality coal ash. In addition to the technology, patents, and know-how, the SonoAsh principals are professional chemical and mechanical engineers with nearly 100 years of combined industrial, management, and strategy experience.

**ABOUT THE AUTHOR**

Claudio Arato is an award-winning, licensed professional engineer in Canada with more than 25 years’ experience and degrees from the University of British Columbia in Chemistry and Chemical Engineering. Arato is the SonoAsh Chief Technology Officer and is the inventor of the SonoAsh technology and other industrial sonochemical applications. He has served as technical lead on numerous clean technology startup ventures, has developed numerous granted patents, working in North America, Mexico and Europe.

Bruce Sifton is a licensed professional engineer in Canada with more than 25 years’ experience and degrees from the University of New Brunswick in Chemistry and a Masters in Chemical Engineering. Sifton is the President of SonoAsh, an accomplished entrepreneur in creating numerous North American ventures.
REFERENCES


