COAL FINES: RESOURCE OF THE FUTURE

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INTRODUCTION

A study[1] 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. In addition, about 50 million tons are being produced annually from existing bituminous coal cleaning plants that do not have markets for additional fine coal and/or the technology to recover it. Waste coal fines are typically deposited in ponds or impoundments as a slurry that is subsequently decanted or evaporated to stabilize the deposits before they are covered during surface reclamation. Note that many ponds and impoundments are not covered or reclaimed because they were disposed before current reclamation regulations were in effect.

Source	Estimated Quantity (Million tons)
Abandoned Sites	1500
Active Sites	800
Total In-place	2300
Annual Production	50

Waste coal fines are primarily characterized by:

- Recoverability
- Handleability

Coarse, free-flowing fines that can be recovered by end loaders and other conventional earth-moving equipment are more than likely useful as fuel in fluidized bed boilers or specially-designed pulverized coal boilers. Pennsylvania Power & Light has been using waste coal fines (anthracite silt) since the 1940s and the company's two power plants in Shamokin Dam and Holtwood, PA, continue to use such fines without further processing.

Other potential uses of waste coal fines depend on more detailed quality characteristics:

- Size distribution
- Sulfur content
- Ash content
- Moisture content
- Volatile matter
- Grindability
- Other combustion characteristics

[1] Premium Fuels from Coal Refuse, CQ Inc., for Electric Power Research Institute, TR103709, February, 1994.

If waste coal fines do not meet the primary characteristics for utilization without processing, they need to be formulated into a fuel product that does meet these primary characteristics. In addition, if waste coal

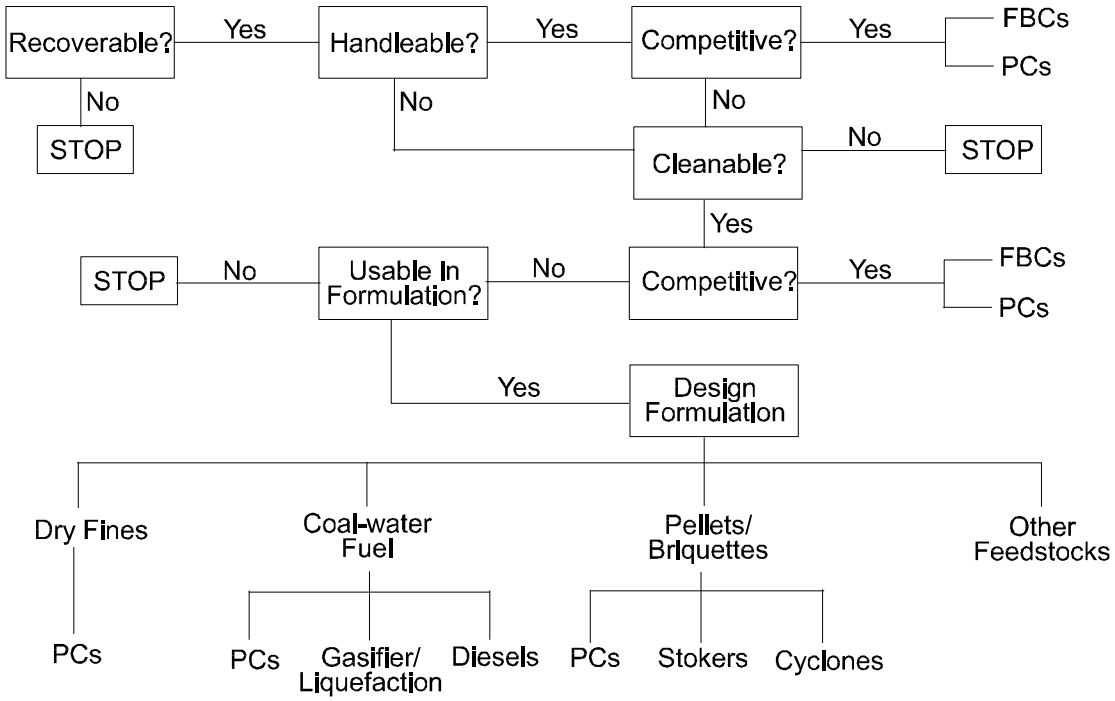
fines do not meet the secondary characteristics based on quality, the waste coal fines must be cleaned before formulation into a fuel product.

Potential Uses for Recovered Waste Coal Fines

Without Cleaning	After Cleaning	After Cleaning & Formulation
FB Boiler	FB Boilers	PC Boilers
PC Boilers[1]	PC Boilers	PC Boilers[2]
		Cyclone Boilers
		Stoker Boilers
		Diesel Engines
		Gasifiers
		Liquefaction Plants

FB - Fluidized Bed
PC - Pulverized Coal
[1] designed for waste fines
[2] co-fired as slurry

FINE COAL RECOVERY DECISION TREE



This
decision tree presents the traditional process followed by the owner of waste coal fines to select appropriate technologies and target the markets that will be the most probable users of the owner's products.

CLEANING AND DEWATERING TECHNOLOGIES

Fine coal cleaning technology development has resulted in a series of commercial processes to clean fine coal based on size, density or surface characteristics. Size-based processing equipment includes screens

and classifying cyclones. Sizing can be used to remove high-ash fractions or to separate coal into size fractions for subsequent cleaning by other methods. Density-based processes such as spirals, hydrocyclones, and heavy-media cyclones have been proven at commercial scale and are readily available throughout the world.

Advances in conventional froth flotation and the development and commercialization of column flotation have also established industry confidence in processing waste coal fines.

Other technologies such as oil agglomeration, centrifugal jigs, advanced froth flotation, liquid cyclones, and technologies that combine density and surface-based methods have been developed and are in various stages of demonstration and commercialization. Consequently, in general, there is no lack of cleaning technologies for processing waste coal fines; the issue is selecting the most cost-effective technology (or technologies) for a given source of waste coal fines.

The primary economic and technical barrier to the extensive development of waste coal fines is dewatering. When cleaning is required to change the quality characteristics of waste coal fines, the capital and operating costs for water removal after cleaning may be substantial enough to make the entire project uneconomical. Moreover, if the waste coal particles are ultrafine, conventional dewatering equipment may be unable to recover enough saleable product to justify a project investment.

Of course, thermal drying is technically feasible, but generally unaffordable and difficult to permit in many instances.

FORMULATION

The alternatives for formulating a product from waste coal fines have some common characteristics and some unique requirements.

The simplest and most logical product to formulate from waste coal fines is coal-water fuel. Using the "GPU Technology", a slurry of about 50 percent solids is produced and cofired in existing power boilers to supplement heat input, reduce NO_x, and reduce fuel costs. As the demand develops for coal-water fuels cofiring technology, a complementary market for coal-water fuels will also develop.

DOE's GranuFlow technology offers improved handleability without costly moisture reduction. For waste coal fines (clean or raw) that meet the primary utilization criteria and the quality criteria with the exception of handleability and moisture content, the GranuFlow technology can be used. It incorporates an additive into the centrifuge operation to displace surface moisture from the coal particles to enhance dewatering and produce a free-flowing, non-freezing product that can be incorporated with coarser coal for direct utilization.

	Waste Fines	Clean Fines	Coal-water Fuel	GranuFlow	Pellets/ Briquettes
1. Customer's Quality/ Requirements	Yes	Yes	Yes	Yes	Yes

2. Must Be Transportable	Yes	Yes	Yes	Yes	Yes
3. Must Be Handleable As a Solid	Yes	Yes	No	Yes	Yes
4. Must Be Competitive With Coarse Coal	Yes	Yes	No	Yes	Yes
5. Must Be Dewatered	V	Yes	No	Yes	Yes
6. Customer Investment Required	No	No	Yes	No	No
7. Transportation is a Major Cost Factor	No	No	Yes	No	Yes*

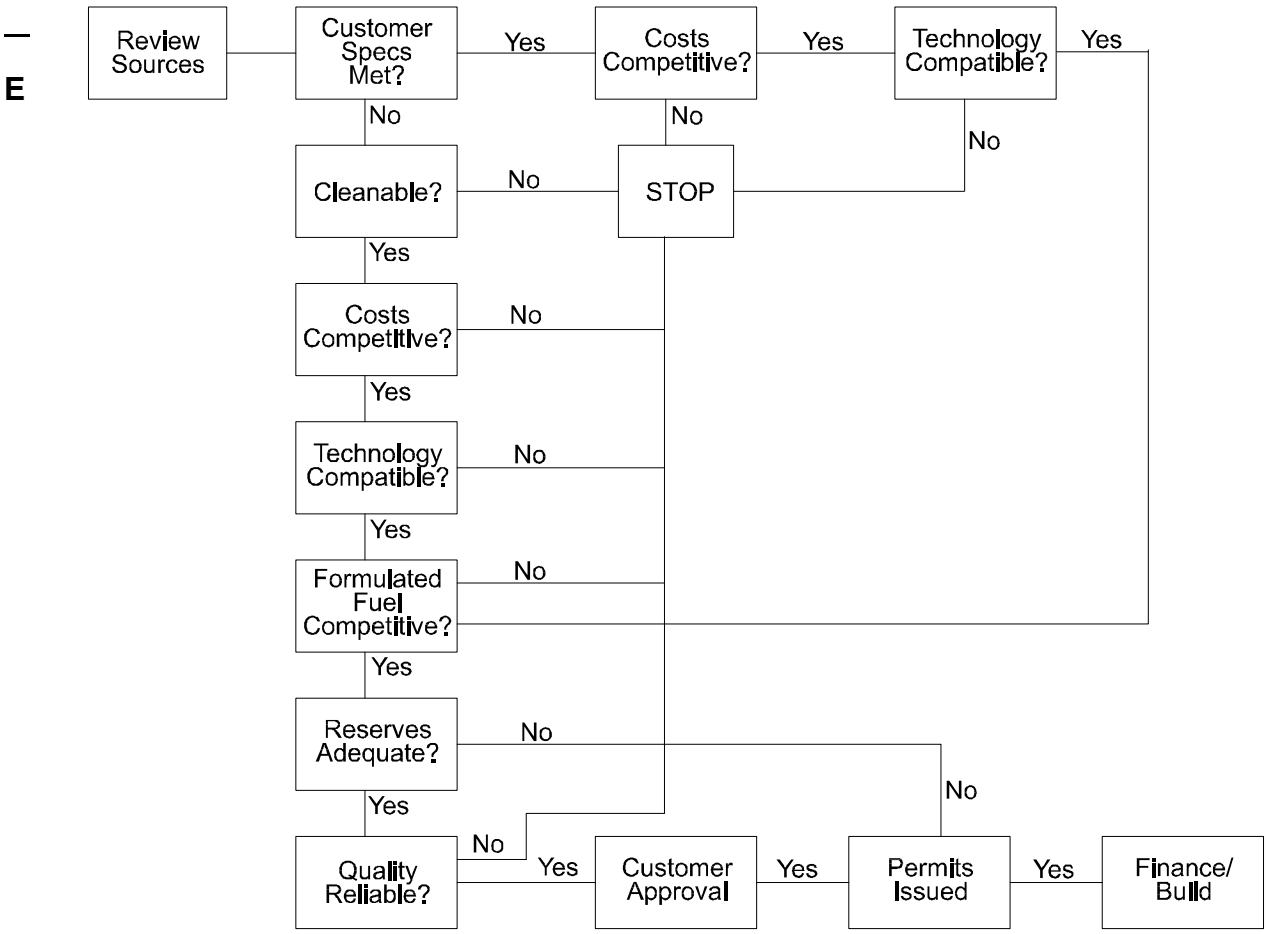
_____
* If other wastes or binders are used
V - Varies

If the intended customer does not have slurry cofiring capability and if the moisture content or quantity of fines in the GranuFlow product is a limitation, some form of pelletizing or briquetting is required. In the last few decades, the use of pelletizing and briquetting technologies has been very limited for coal due to the relative costs of these technologies compared to the incremental cost of mining additional coarse coal. However, several companies have advanced the state-of-the-art in binder manufacturing and reduced the amount of binder required to make a competent pellet or briquette. This work has been driven by investor interest in capturing synthetic fuels tax credits (IRS Section 29).

Others, including CQ Inc., have incorporated other solid or liquid wastes with waste coal fines to produce more economical pellets or briquettes without binders and some of these pellets or briquettes have been demonstrated to have lower emissions characteristics than coal. Consequently, the value added by tax credits, the inclusion of other wastes, and/or emissions reduction has made pelletizing or briquetting commercially feasible for coal fines.

When a technology developer or project developer plans to use waste coal fines as feedstock for a formulated fuel product, the traditional decision tree changes to one that is focused on finding the right source of fines.

FORMULATED FUEL FEEDSTOCK DECISION TREE



CONOMICS

The cost of energy from waste coal fines is driven by the cost of the waste coal fines, the environmental costs associated with the site, the quantity of usable material that is recovered from the waste coal fines, and the cost of cleaning and formulation, if needed. Of these, the quantity of usable fuel that can be recovered (yield) is especially important and is highly variable. In the following example, the cost of acquiring and cleaning the coal is $6/ton. At 50 percent yield, the cost to produce the clean coal is $12/ton plus $12/ton for pelletizing for a total cost of $24/ton. However, if the yield is 30 percent, the cost of producing the pelletized clean coal increases to $32/ton. Yield can only be projected accurately if the impoundment is properly sampled and a washability analyses performed on the samples.

	$/Raw Ton	$/Clean Ton
Waste Coal Fines Cost	0.50	--
Excavating, land farming or dredging	2.00	--
Cleaning Cost[2]	3.50	--
Adjustment for yield[3]	--	12.00
Pelletizing cost[4]	--	12.00
Total	6.00	24.00

[2] $2 million capital investment plus O&M cost for 250,000 tpy production
[3] Assumed to be 50%
[4] Capital investment of $3 million plus O&M costs

Note: This example includes the minimum cost case for recovering waste coal fines and using them without further processing or formulation and the full cost, including processing and pelletization. The costs for producing coal-water slurry or GranuFlow product would likely fall between these two cases.

CONCLUSIONS

Based on today's environmental climate that "encourages" reclamation of existing waste piles and impoundments and the availability of technology to use recovered fine coal or other products formulated from it, the U.S. waste coal fines resource is likely to be more vigorously developed within the next decade. The pending deregulation of the U.S. electric utility industry is incentivizing utilities to find the lowest-cost sources of usable fuel for existing power plants and to the degree that waste coal fines or products formulated from them are economical and useful in existing units, the market is waiting.

The greatest technical challenge to developing this resource is fine coal dewatering and in fact the limitations of dewatering technology or its cost is the single largest deterrent to increased use of waste coal fines today. Efforts to develop or enhance dewatering technologies can be justified.

The commercialization of pelletizing technology that incorporates industrial wastes should sufficiently prove the economics and emissions reduction potential of coal/waste fuels to justify continued research into alternative pelletized fuel feedstocks such as agricultural wastes, biomass, and construction wood waste.

Since some formulated products' costs are strongly influenced by the costs to transport either the ingredients or the product, siting the formulation plant in close proximity to the fines source or the customer is critical.

Every project that utilizes waste coal fines must be evaluated on its own merits whether the project is initiated by a fines owner or a technology developer. Verifying the quantity of waste coal fines available, the expected yield from the recovery and processing operation, and the expected quality and cost of the final product must be systematically investigated to minimize the risks inherent in any waste utilization project.