COMMONWEALTH OF KENTUCKY

BEFORE THE PUBLIC SERVICE COMMISSION

In the Matter of:

INVESTIGATION OF KENTUCKY UTILITIES COMPANY'S AND LOUISVILLE GAS & ELECTRIC COMPANY'S RESPECTIVE NEED FOR AND COST OF MULTIPHASE LANDFILLS AT THE TRIMBLE COUNTY AND GHENT GENERATING STATIONS	**))))))**	**CASE NO. 2015-00194**

**RESPONSE OF
KENTUCKY UTILITIES COMPANY AND
LOUISVILLE GAS AND ELECTRIC COMPANY**

**FIRST DATA REQUEST FOR INFORMATION
TO STERLING VENTURES, LLC
DATED JULY 2, 2015**

FILED: JULY 16, 2015

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Robert M. Conroy**, being duly sworn, deposes and says that he is Director - Rates for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Robert M. Conroy

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of July 2015.

(SEAL)
Notary Public

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **Gary H. Revlett**, being duly sworn, deposes and says that he is Director – Environmental Affairs for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Gary H. Revlett

Gary H. Revlett

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of July 2015.

Judy Schooler (SEAL)

Notary Public

My Commission Expires:

JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) **SS:**
COUNTY OF JEFFERSON)

The undersigned, **Charles R. Schram**, being duly sworn, deposes and says that he is Director – Energy Planning, Analysis and Forecasting for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

Charles R. Schram
Charles R. Schram

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of July 2015.

_______________(SEAL)
Notary Public

My Commission Expires:

JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) **SS:**
COUNTY OF JEFFERSON)

The undersigned, **David S. Sinclair**, being duly sworn, deposes and says that he is Vice President, Energy Supply and Analysis for Kentucky Utilities Company and Louisville Gas and Electric Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the foregoing testimony, and that the answers contained therein are true and correct to the best of his information, knowledge and belief.

____
David S. Sinclair

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of July 2015.

______________________ (SEAL)
Notary Public

My Commission Expires:

JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **R. Scott Straight**, being duly sworn, deposes and says that he is Director of Project Engineering for LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

R. Scott Straight

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of July 2015.

(SEAL)
Notary Public

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

VERIFICATION

COMMONWEALTH OF KENTUCKY)
) SS:
COUNTY OF JEFFERSON)

The undersigned, **John N. Voyles, Jr.**, being duly sworn, deposes and says that he is the Vice President, Transmission and Generation Services for Louisville Gas and Electric Company and Kentucky Utilities Company and an employee of LG&E and KU Services Company, and that he has personal knowledge of the matters set forth in the responses for which he is identified as the witness, and the answers contained therein are true and correct to the best of his information, knowledge and belief.

John N. Voyles, Jr.

John N. Voyles, Jr.

Subscribed and sworn to before me, a Notary Public in and before said County and State, this 16th day of July 2015.

Judy Schooler (SEAL)
Notary Public

My Commission Expires:
JUDY SCHOOLER
Notary Public, State at Large, KY
My commission expires July 11, 2018
Notary ID # 512743

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 1

Witness: Charles R. Schram

Q-1. Please see *Coal Combustion Byproduct Plan for Ghent Station*, (the "Ghent Plan") Exhibit B to Sterling Ventures LLC's ("Sterling") Complaint in this case.

a. Please provide un-redacted copies of pages 3, 18, 19 and 20.

b. Please provide un-redacted copies of Appendix 2 (pages 24-28) and Appendix 3 (pages 30-35).

A-1. Please see the attached.

Coal Combustion Byproduct Plan for Ghent Station For

E.ON U.S.

Subsidiaries Kentucky Utilities and Louisville Gas and Electric

June 2009

CONFIDENTIAL INFORMATION

1. Executive Summary

Kentucky Utilities Company's ("KU") Ghent station ("Ghent") produces three primary coal combustion byproducts ("CCP"): bottom ash, fly ash and gypsum, which are currently stored in two ash treatment basins and two gypsum stacking areas. These storage areas are expected to reach full capacity in 2012, creating a need for additional CCP management solutions.

A variety of on-site and off-site options were considered to meet CCP management needs at Ghent. The most effective solutions were identified through a needs analysis and economic analysis based on engineering cost estimates.

To address the pre-2013 need for gypsum storage capacity, an opportunity to remove a quantity of gypsum to be beneficially reused as structural fill was identified. This reuse option is significantly lower cost than transporting CCP to an off-site landfill, which is the other short-term option.

For longer-term CCP storage needs, KU contracted an engineering consultant to develop potential on-site storage alternatives. Of multiple options considered, four options were selected for further economic evaluation. Based on cost estimates and qualitative factors for these alternatives, the most favorable option is a single on-site landfill to store both ash and gypsum.

The most cost effective and environmentally sound CCP management options for Ghent are:

- a proposal for beneficial reuse of 1.3 million cubic yards ("MCY") of CCP (approximately 75% of annual CCP production) by Trans Ash, Inc. in 2010-2012 (Present value of revenue requirement ("PVRR") of $7.9 million or $6.11 per cubic yard), and
- the construction of a new on-site landfill system to store both ash and gypsum production for 25 years to be in-service by 2013 (PVRR of $583 million or $12.66 per cubic yard).

In addition, KU will continue to pursue other beneficial reuse opportunities that result in lower disposal costs.

CONFIDENTIAL INFORMATION

2. Background

Kentucky Utilities Company's ("KU's") Ghent generating station ("Ghent") is located in Carroll and Gallatin Counties, Kentucky and is comprised of four coal-fired generating units for a total net station capacity of over 1,900 MW. The station produces three primary coal combustion byproducts ("CCP"): bottom ash, fly ash and gypsum. The Ghent station has four existing on-site storage facilities for CCP as follows:

- Ash Treatment Basin ("ATB") #1
- ATB #2
- North Gypsum Stack
- South Gypsum Stack

The ATBs are used to store bottom ash and fly ash which are byproducts of burning coal. ATB #1 is at maximum capacity[1] and ATB #2 is nearing maximum desired capacity. As of February 2009[2], ATB #2 can hold approximately an additional 2.5 MCY of ash. Ghent is forecast to produce approximately 0.7 MCY of ash annually, thus depleting the capacity in ATB #2 in 2012.[3]

Gypsum is produced by Ghent's flue gas desulfurization ("FGD") systems, which use limestone reagent to remove sulfur dioxide from flue gas. Until an additional repository can be developed, Ghent's gypsum is stacked on site. Based on the plant's expected generation, the existing capacity of the north and south gypsum stacks (collectively the "gypsum stack") is expected to be exhausted in 2012.[4]

Some gypsum is currently sold to a third party for beneficial reuse.[5] CertainTeed, Inc. ("CertainTeed") currently pays KU $2 per cubic yard for gypsum to be used as a raw material in the production of wallboard. This contract began in 1999 and runs through 2024. CertainTeed does not have minimum or maximum volume obligations, but their expected annual volume is approximately 222,000 cubic yards of gypsum (approximately 20% of annual gypsum production) based on recent utilization data.[6]

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[1] ATB #1 is not relevant to this analysis as it is not currently receiving any CCP, although it is available for emergency use.

[2] A bathymetric survey of ATB #2 was conducted by HDR/Quest/Rudy for GAI Consultants in February 2009.

[3] The available capacity of ATB #2 at the end of June 2009 is forecasted to be approximately 2.3 MCY.

[4] The available capacity of the gypsum stack at the end of June 2009 is forecasted to be approximately 2.6 MCY.

[5] KU identifies economically and environmentally favorable options to beneficially reuse CCP, consistent with KU's Comprehensive Strategy for Management of CCP shown in Exhibit JNV-3.

[6] Gypsum sales to CertainTeed were 263,000 tons in 2007, 375,000 tons in 2008, and 103,000 tons year-to-date through May 2009. However, their purchases decreased late in 2008 and year-to-date in 2009 as the economy slowed.

3. Process and Methodology

KU and Louisville Gas and Electric Company (collectively "the Companies") develop the most effective plan for meeting the CCP storage needs at each generating station. The process of identifying the plan consists of the three following primary tasks which are performed by several departments within the Companies.

- Needs assessment
- Development of alternatives
- Comparison of alternatives

The CCP storage needs are defined by forecasting the production of CCP over the applicable planning period as compared to the existing storage capacity. The Project Engineering department and the applicable generating station are responsible for providing an estimate of remaining capacity.

The expected life of the existing storage capacity is based on the forecast of CCP production, which is developed by Generation Planning for all stations as a function of the expected coal usage for each unit. The Companies compile information regarding the cost of generation for each unit (fuel, variable O&M, emission costs, etc.), a description of the generation capabilities of each unit (capacity, heat rate curve, commitment parameters, emission rates, availability schedules, etc.), a load forecast, the market price of electricity, and the volumetric ability (transfer capability) to access the market. All of this information is brought together in the PROSYM™[7] software, which is used to model the economic operation of the Companies' generating system. The projected coal usage data provided by this model is checked for reasonableness by comparing the results to historical data.

The Project Engineering department develops alternatives for on-site CCP storage solutions and their associated costs. Any alternatives for off-site disposal such as beneficial reuse or off-site landfill disposal are provided by the generating stations' staff and a CCP team focused on exploring alternatives for byproduct storage. The cash flows for selected options are summarized and provided to Generation Planning for evaluation.

The Generation Planning department evaluates the storage and disposal options received from Project Engineering to determine the present value of revenue requirements ("PVRR") associated with the capital expenditures and O&M expenses of each option. This analysis is performed using the Capital Expenditure Recovery module of the Strategist®[8] software model.

[7] The PROSYM™ model has formed the foundation of prior analyses involving certificates of convenience and necessity for new generating plants, environmental cost recovery for pollution control equipment, and the fuel adjustment clause.

[8] Strategist® is a proprietary, state-of-the-art resource planning computer model. The Capital Expenditure Recovery module is used to quantify the revenue requirements impact associated with capital projects.

4. Needs Assessment

The following capacities were provided by Project Engineering and the Ghent station:

- ATB #1 is at capacity and is available for emergency use only.
- As of February 2009, the remaining available capacity of ATB #2 is 2.5 million cubic yards.[9]
- The remaining available capacity of the gypsum stacks is estimated to be 2.9 MCY as of January 2009.[10]

The expected life of the remaining capacity of the ATB #2 and the Gypsum Stack were estimated by forecasting the CCP production of ash and gypsum at Ghent. The quantity of ash produced at Ghent is estimated at a coal specification of 11.5% ash by weight of the total quantity of coal used, or approximately 11.5 tons of ash per 100 tons of coal. Converting to volumetric measurement, assuming ash production consists of 80% fly ash and 20% bottom ash by weight, approximately 11.5 cubic yards of total ash is produced per 100 tons of coal.[11]

The chemical reaction by which gypsum is produced results in a net gypsum production of approximately 18% by weight of the total quantity of coal used,[12] or approximately 18 tons of gypsum per 100 tons of coal. Converting to volumetric measurement for the gypsum stack, approximately 17.8 cubic yards of gypsum is produced per 100 tons of coal.

The forecasted CCP production volume for Ghent is shown in Table 1 and depicted graphically in Figure 1 and Figure 2, based on the forecasted coal burn shown in Table 2. Table 2 also contains the historical quantities of coal burned as a comparison to the forecast. The increase in coal burn during the 2010-2013 period is due to the completion of the FGD installations at Ghent in 2009, which required prior scheduled outages on each of the Ghent units during 2007-2009. Also, with the addition of the FGDs, Ghent has lower fuel costs, resulting in higher forecasted generation.

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[9] Based on expected coal burn, Generation Planning forecasts that by the end of 2009, the remaining capacity of ATB #2 will be 1.9 MCY.

[10] Based on expected coal burn and existing beneficial reuse, Generation Planning forecasts that by the end of 2009, the remaining capacity of the gypsum stacks will be 2.2 MCY.

[11] Density assumptions for wet storage are 0.945 tons per cubic yard for bottom ash and 1.0125 tons per cubic yard for both fly ash and gypsum.

[12] Fuel specification assumptions include SO_2 content of approximately 5.9 lb/mmBTU and heat content of 22.16 mmBTU/ton.

Table 1: CCP Production Forecast (MCY)

CCP Production Forecast *(MCY – wet storage)*			
	Fly Ash	**Bottom Ash**	**Gypsum**
2009	0.54	0.14	0.88
2010	0.55	0.15	1.09
2011	0.58	0.15	1.12
2012	0.55	0.15	1.06
2013	0.55	0.15	1.09

Table 2: Ghent Coal Usage (Million Tons)

Ghent Coal Usage *(M Tons)*	
Historical	
2004	5.4
2005	5.6
2006	5.6
2007	5.3
2008	5.7
Forecast	
2009	5.6
2010	6.0
2011	6.3
2012	6.1
2013	6.1

The forecasted generation and the resulting coal usage at Ghent correspond to an average capacity factor of approximately 77%. This relatively high capacity factor is consistent with Ghent's low production cost. Since Ghent is already modeled as a baseload station, the risk of significantly underestimating CCP production is low. However, reduction in load or unexpected outages at Ghent could affect the capacity factor and lower future CCP production.

Figures 1 and 2 show the forecasted cumulative CCP production at the end of each year compared to the expected available capacity at the end of 2009. With current forecasts for ash production and without any additional on-site capacity or off-site storage or reuse, ATB #2 is expected to reach full capacity during 2012, as shown in Figure 1. Assuming no beneficial reuse beyond the expected 222,000 cubic yards per year by CertainTeed, the gypsum stack is also expected to reach maximum capacity in 2012, as shown in Figure 2.

Figure 1: ATB #2 Capacity

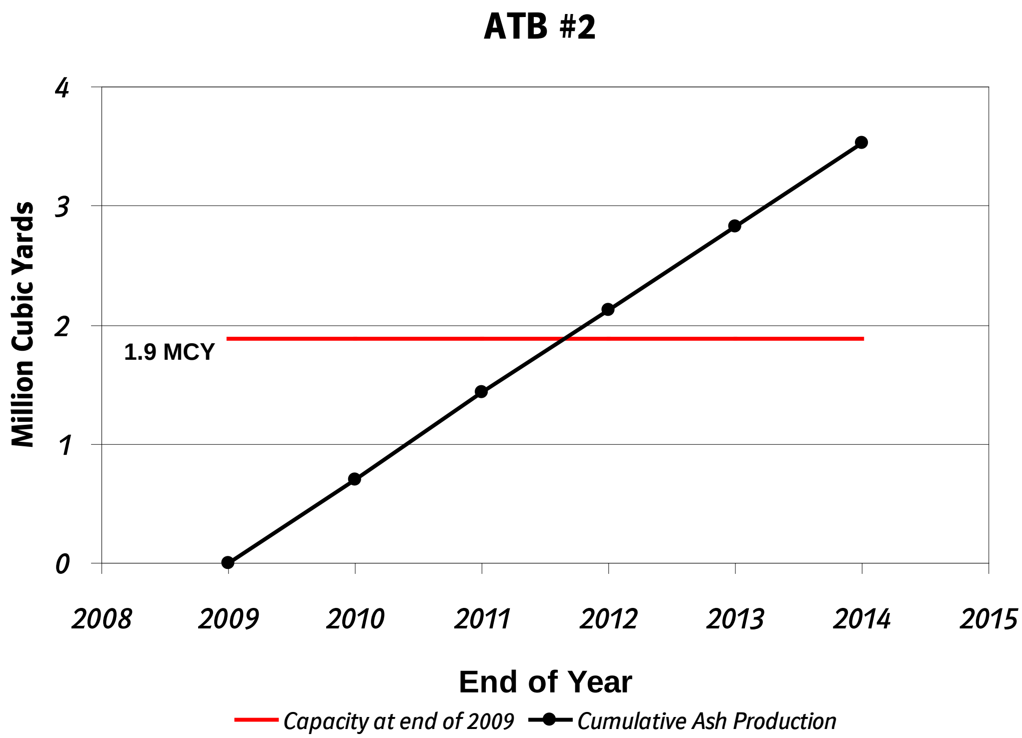
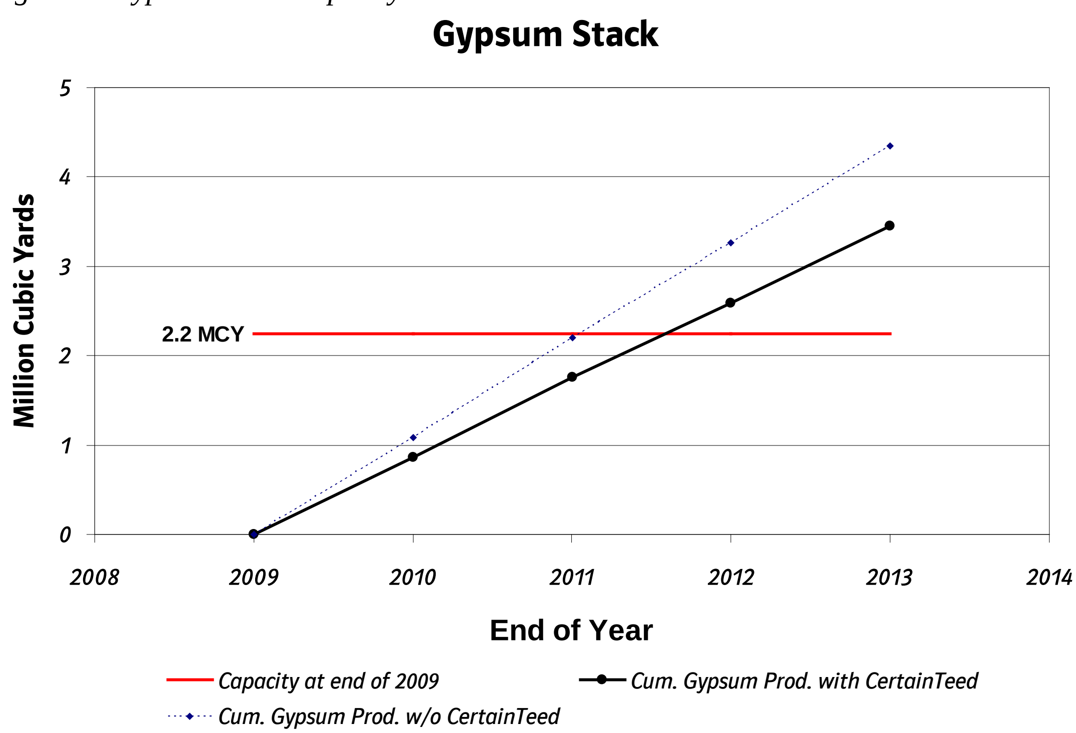


Figure 2: Gypsum Stack Capacity



In summary, the needs assessment indicates that additional CCP disposal alternatives will be needed for both ash and gypsum at Ghent by 2012. At least 0.6 MCY of CCP must be moved off-site in order to maintain operations of the existing storage facilities at Ghent through 2012.

CONFIDENTIAL INFORMATION

5. Development of Alternatives

In the case of CCP solutions for Ghent, Project Engineering and the CCP team developed two sets of options for evaluation:

1. Short-term storage options to meet 2009-2012 requirements
2. Long-term storage options to meet 2013-2037 requirements.

The short-term options were developed because long-term options cannot be in service before 2013, and on-site capacity is expected to be depleted in 2012. These options were evaluated independently, leading to a recommendation for short-term and long-term solutions.

5.1 Short-Term Disposal

As a result of ATB #2 and the gypsum stack nearing their maximum desired storage capacities, the station, in conjunction with the CCP Team, negotiated with Trans Ash, Inc. ("Trans Ash"), a company specializing in the reuse of CCP, to beneficially reuse 1.3 MCY (approximately 1.5 million tons as hauled) of CCP as structural fill. The 2009 base cost of this proposal is $6.31 per MCY[13], subject to annual adjustments to the base price and fuel cost adjustments. The base price is redetermined by increasing the previous year's price by 90 percent of the year-over-year percent change in the Consumer Price Index – All Urban Customers, U.S. City Average. The fuel adjustments are made for both off-road and on-road diesel use. Off-road fuel adjustments are calculated as the difference between the base diesel unit price of $1.75 per gallon and the average unit diesel price paid multiplied by the quantity of off-road diesel purchased each year. The on-road diesel adjustment is calculated as the product of the average quantity of fuel used and the difference between the base diesel price and the index price as published by the U.S. Department of Energy, Energy Information Administration in "The U.S. No 2 Diesel Low Sulfur (15-500 ppm) Retail Sales by All Sellers (Cents per Gallon)"

An agreement with Trans Ash would require that the full 1.3 MCY be moved in 2010-2012 to satisfy the end consumer of the beneficial reuse opportunity. Consistent with KU's CCP management strategy, this fill location has been evaluated and confirmed as appropriate for beneficial reuse. The location is not in an environmentally sensitive area.

The only near-term alternative to beneficial reuse of CCP is the use of an existing off-site commercial landfill. For 2009, the total unit cost of storage in the closest off-site landfill was estimated to be $35.97 per cubic yard[14]. In contrast to the Trans Ash proposal, an off-site landfill storage option requires that only a minimum of 0.6 MCY must be moved off-site prior to 2013 to ensure continuing operations at Ghent.

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[13] $6.31 per MCY as stored is equivalent to $5.42 per ton as hauled.

[14] $35.97 per cubic yard is equivalent to $26.80 per ton as hauled for transport and storage at Valley View landfill near Sulphur, KY, approximately 25 miles from Ghent. Cost components per ton are $1.75 for excavating and loading, $5.82 for hauling, and $19.23 for landfill tipping fee. This quoted tipping fee is slightly below the listed rates of $20-$30/ton for other regional public landfills.

CONFIDENTIAL INFORMATION

5.2 Long-Term Storage

To meet the long-term storage needs at Ghent, KU contracted GAI Consultants, Inc., Pittsburgh, PA ("GAI") to provide both an Initial Siting Study ("ISS") and a Final Conceptual Design Study of CCP storage alternatives at Ghent.[15] The ISS identified over forty potential alternatives based on combinations of a number of variables, including storage and transport methods, site locations, and relocation of transmission lines. As a result of this study, four on-site alternatives shown in Table 3 were selected for further consideration. In the process of developing the Final Conceptual Design Study, GAI refined the cost estimates for these alternatives in addition to other detailed engineering tasks. As an alternative to building on-site storage facilities, use of an existing off-site commercial landfill for storing future CCP was also considered as a long-term option.

Table 3: Alternatives for Long-Term Storage

		On-Site				
Case		**14/28**	**37**	**41**	**42/28**	**Off-Site Landfill**
Description		2 Landfills	1 Landfill	1 Pond	1 Pond 1 Landfill	
Total Capacity *(MCY)*		46.1	46.1	53.6	48.3	46.1 needed
Nominal Cost *($M)*	**Capital**	450	360	1,505	835	0
	O&M[16]	1,007	1,070	124	621	4,447

Each of the cases for on-site long-term storage was designed to hold twenty-five years of CCP production with phased construction. The total capacity required for each case differs due to the different density of CCP stored in ponds versus landfills. Table 4 shows the construction periods, the in-service years, and the capacity for each phase of the on-site cases. The site locations as shown in Figure 3 are noted as follows:

- Site M is north of ATB #2 on property owned by KU.
- Site E/F which is southeast of ATB #2 and include properties owned by KU and approximately 350 acres owned by others.
- Pond L represents vertical and lateral expansion east of ATB #2 with an impoundment.

[15] A preliminary draft of the Final Conceptual Design Study is shown in Exhibit JNV-4.
[16] The O&M figures in Table 3 include the cost for power to operate the on-site storage alternatives.

Figure 3: CCP Storage Site Alternatives

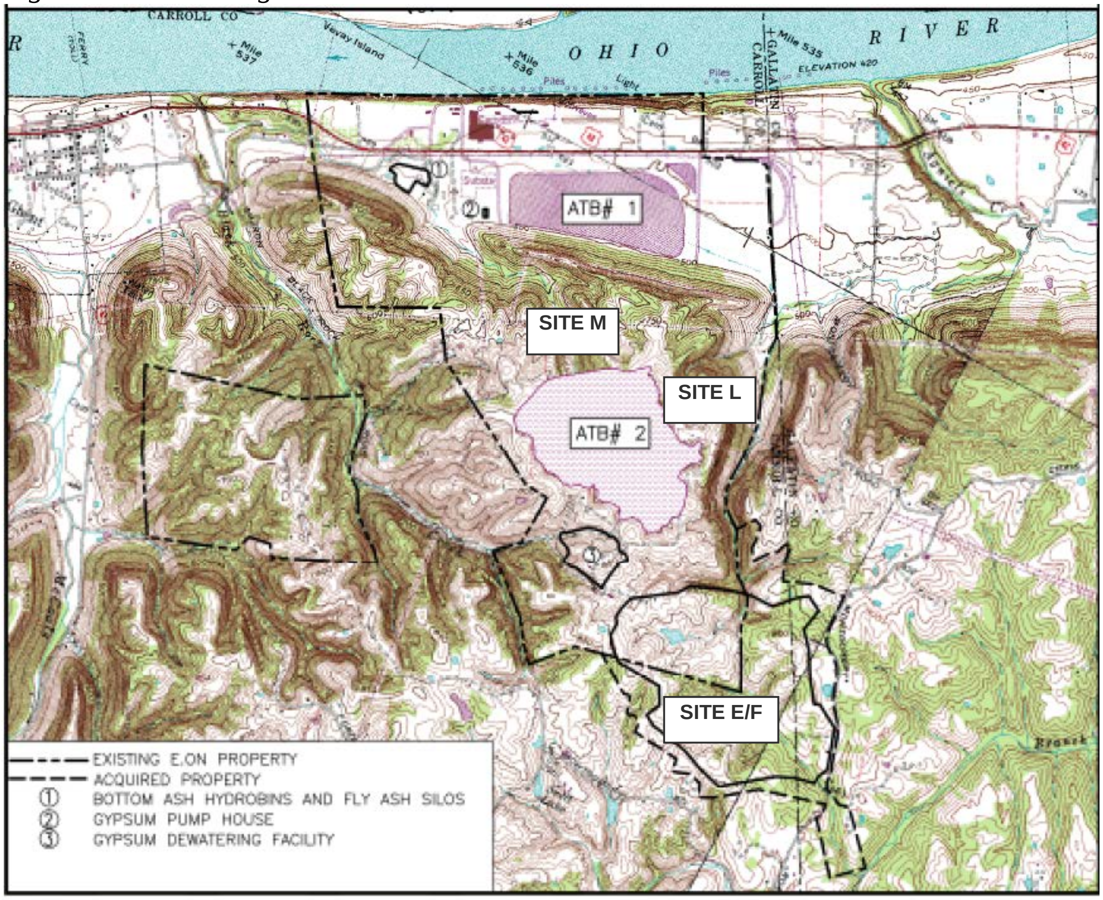


Table 4: Construction Phases for On-Site Storage Options

Case		**14/28**		**37**	**41**	**42/28**	
Site Location		M	E/F	E/F	L	L	E/F
Phase 1	**Construction**	2010-14		2010-14	2010-13	2010-14	
	In-Service	2013		2013	2013	2013	
	Capacity *(MCY)*	5.3	5.7	14.7	16.5	7.2	8.4
Phase 2	**Construction**	2016-18		2018-19	2017-19	2018-20	
	In-Service	2019		2020	2020	2021	
	Capacity *(MCY)*	8.5	8.0	12.3	15.7	8.3	7.7
Phase 3	**Construction**	--	2023-25	2024-26	2025-27	2027-29	
	In-Service	--	2026	2027	2028	2030	
	Capacity *(MCY)*	--	12.4	19.1	21.6	6.1	8.0
Phase 4	**Construction**	2027-29	--	--	--	--	
	In-Service	2030	--	--	--	--	
	Capacity *(MCY)*	6.2	--	--	--	--	--

Case 14/28. Case 14/28 consists of separate landfills for ash and gypsum with ash stored at Site M and gypsum stored at Site E/F. Construction of the landfills consists of four phases as shown in Table 4 with the first phase beginning in 2010 and the final phase ending in 2029. Figure 4 shows the phased cumulative design capacity of the landfill at Site M compared to the forecasted ash production. Figure 5 shows the phased cumulative design capacity of the landfill at Site E/F compared to the forecasted gypsum production both including and excluding the effect of the expected gypsum reuse by CertainTeed. These figures, as well as Figures 6-9, demonstrate that the designs for the timing and volume of capacity additions for each of the cases considered are reasonable compared the forecasted CCP production.

Figure 4: Long-Term Needs Assessment – Case 14/28, Landfill M

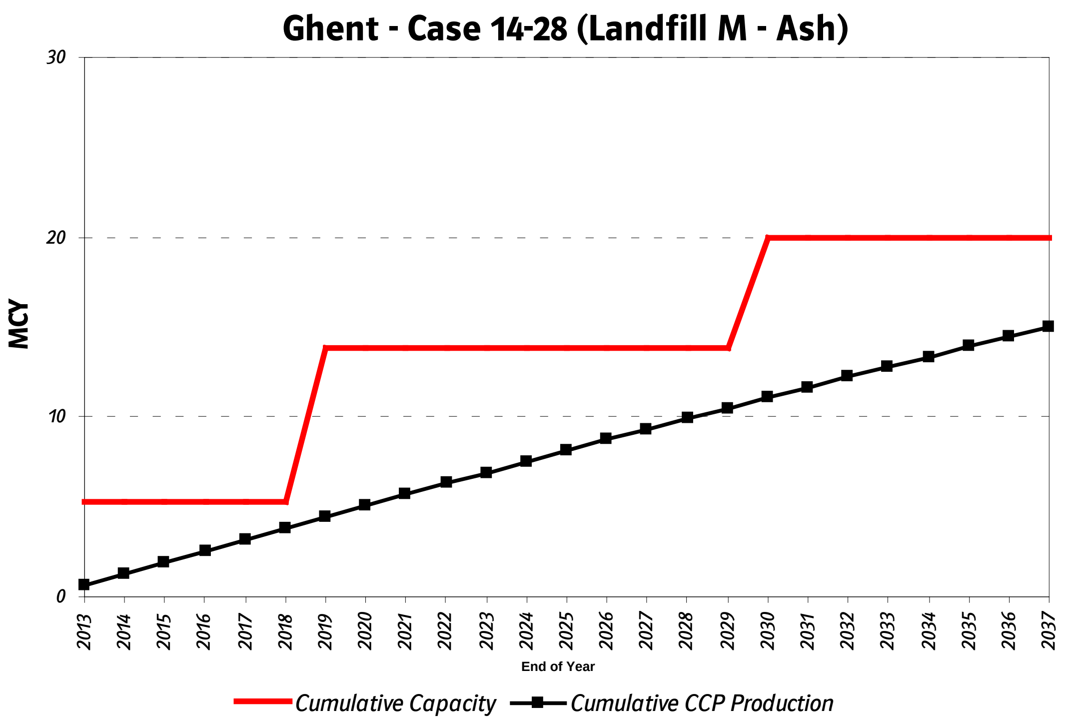
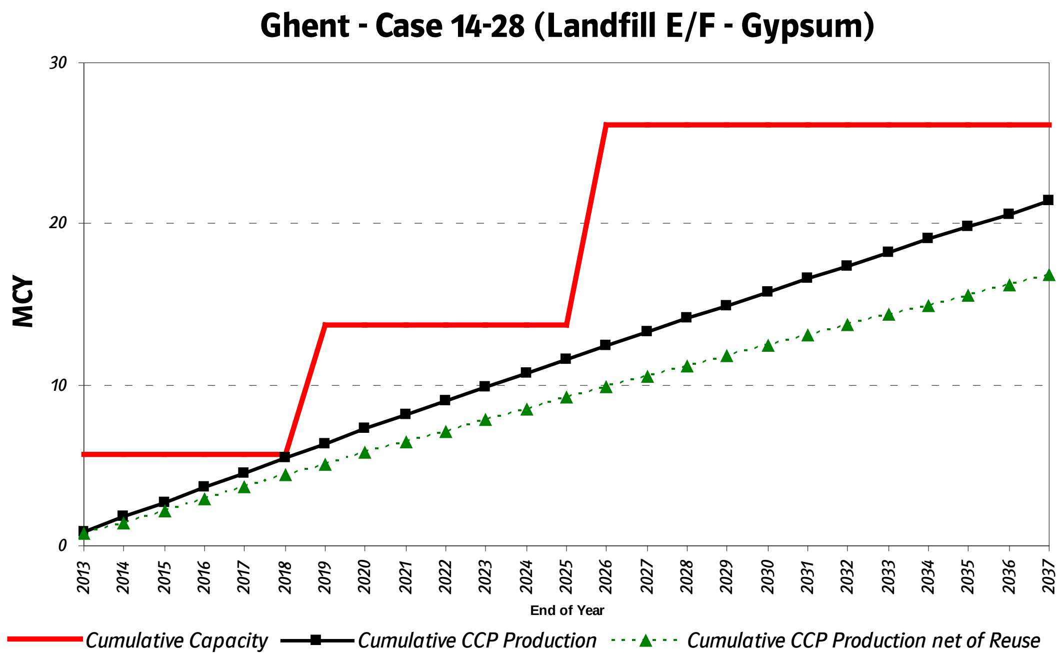
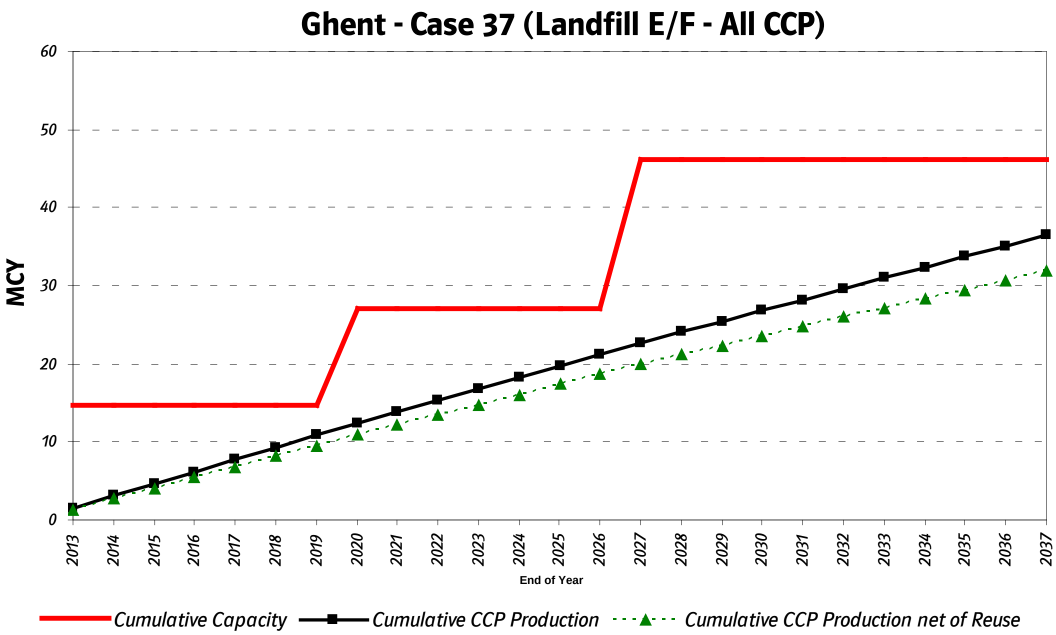


Figure 5: Long-Term Needs Assessment – Case 14/28, Landfill E/F



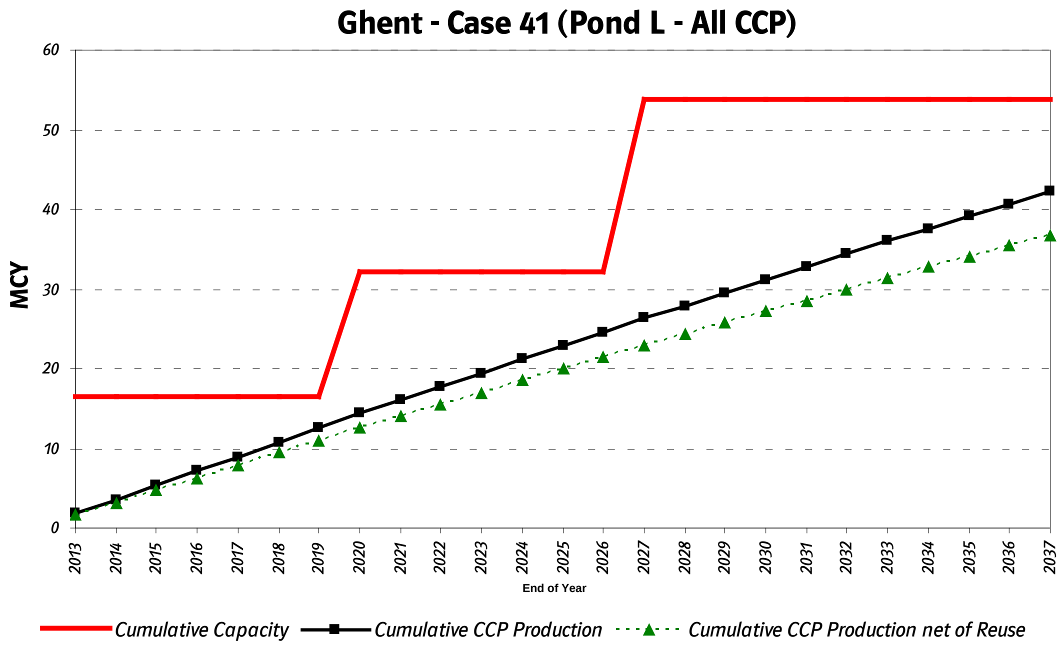
Case 37. Case 37 consists of a single landfill for both ash and gypsum at Site E/F. The construction schedule consists of three phases beginning in 2010 and ending in 2026. Figure 6 shows the phased cumulative design capacity of this landfill compared to the forecasted cumulative CCP production both including and excluding the effect of the expected gypsum reuse by CertainTeed.

Figure 6: Long-Term Needs Assessment – Case 37, Landfill E/F



Case 41. Case 41 consists of a single pond for both ash and gypsum at Site L. The construction schedule consists of three phases beginning in 2010 and ending in 2027. Figure 7 shows the phased cumulative design capacity of this landfill compared to the forecasted cumulative CCP production both including and excluding the effect of the expected gypsum reuse by CertainTeed.

Figure 7: Long-Term Needs Assessment – Case 41, Pond L



Case 42/28. Case 42/28 consists of a pond at "Site L" for ash and a landfill at "Site E/F" for gypsum. Construction of these facilities consists of four phases as shown beginning in 2010 and the final phase ending in 2029. Figure 8 shows the phased cumulative design capacity of the pond at Site L compared to the forecasted ash production. Figure 9 shows the phased cumulative design capacity of the landfill at Site E/F compared to the forecasted gypsum production both including and excluding the effect of the expected gypsum reuse by CertainTeed.

Figure 8: Long-Term Needs Assessment – Case 42/28, Pond L

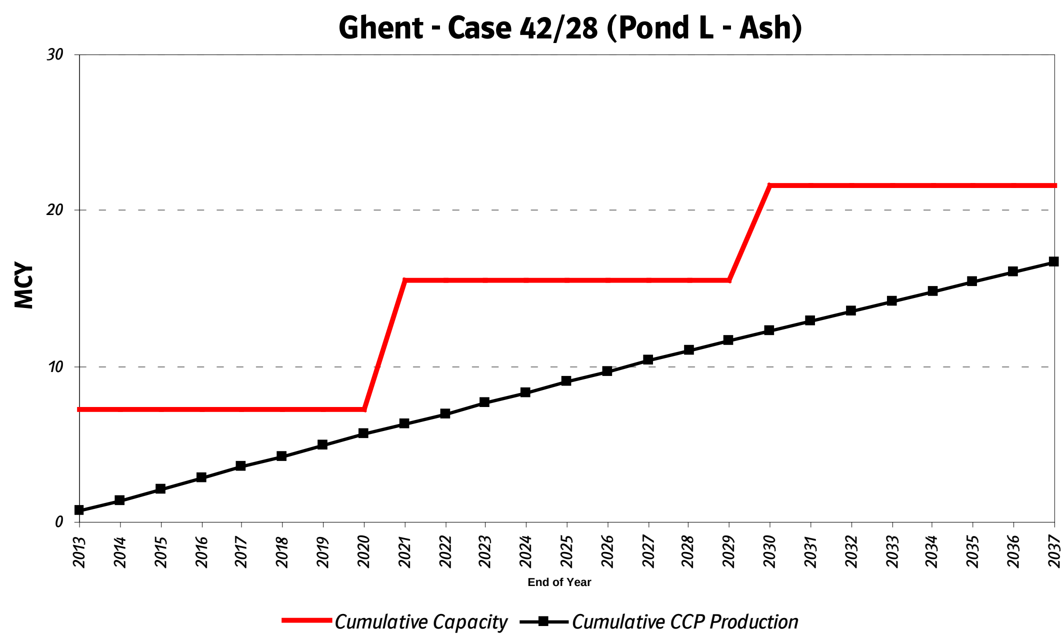
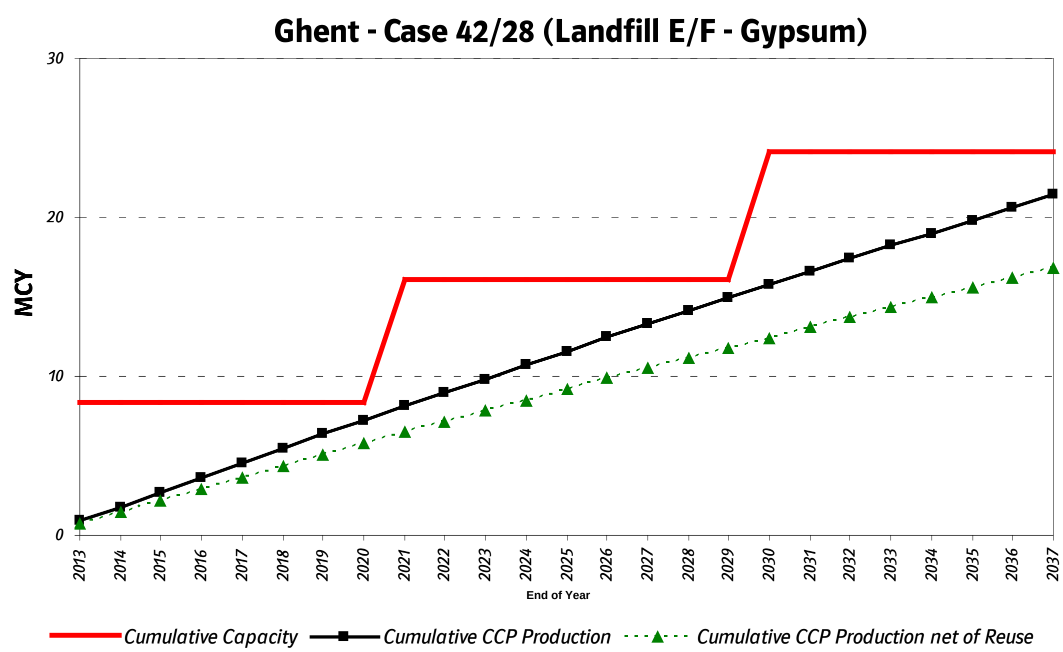


Figure 9: Long-Term Needs Assessment – Case 42/28, Landfill E/F



CONFIDENTIAL INFORMATON

6. Comparison of Alternatives

6.1 Short-Term Disposal

The short term disposal analysis compares the cost of a beneficial reuse initiative with Trans Ash to the cost of off-site landfill disposal. The Trans Ash proposal is to move 1.3 MCY in 2010 through 2012 and the plan for off-site landfill disposal is to move 0.6 MCY in 2012. Both of these options consist only of O&M costs, with no additional capital expenditure. As seen in Table 5, the Trans Ash proposal is the least-cost option to meet the short term capacity needs at Ghent. On a cost per volume basis, the Trans Ash option is almost 80% less costly than the off-site landfill option. Also, despite the higher volume requirement, the Trans Ash proposal's PVRR is $9.8 million lower than the off-site landfill alternative.

Table 5: PVRR Analysis Summary of Short-Term Alternatives

	Trans Ash Beneficial Reuse	Off-site Landfill Disposal
Total Quantity *(MCY)*	1.3	0.6
PVRR *(2009 million $)*	7.9	17.7
Delta to Least Cost Case	*Least Cost*	*9.8*
Unit Cost *(2009 PVRR $/cubic yard)*	6.11	29.49

6.2 Long-Term Storage

The long-term storage evaluation (Table 6) compares the PVRR and per-unit cost of four on-site storage alternatives selected in the engineering studies, in addition to disposal in an off-site commercial landfill. The financial assumptions related to the analysis of these cases are shown in Appendix 1, the projected cash flows are shown in Appendix 2, and the annual revenue requirements are detailed in Appendix 3.

The following is a brief comparison of the results:

Case 37. Case 37 consists of a common on-site landfill for both ash and gypsum. This is least cost on a PVRR basis by $26 million. This option is also lowest cost on a per unit volume basis at $12.66 PVRR per cubic yard. The favorable capital profile of this project results from the single landfill approach compared to Case 14/28, which includes separate landfills for ash and gypsum.

Case 14/28. Case 14/28 consists of separate landfills for ash and gypsum and involves higher up-front capital costs ($34 million higher through 2017, $6 million of which is due to transmission expenditures), an accelerated timeline for the addition of subsequent phases, and an additional construction phase compared to Case 37. This is partially offset by slightly lower annual O&M costs due to reduced distances for transporting ash. In summary, the lower costs associated with the shorter transport distances are overcome by the additional costs of the two landfills.

Cases 41 and Case 42/28. Case 41 consists of a single pond for both ash and gypsum and Case 42/28 consists of an ash pond and a gypsum landfill. The construction of an ash

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pond is significantly more capital intensive compared to a landfill, although the ongoing operation is less costly. Through 2016, both of these cases are approximately $95 million higher in total capital costs than Case 37. Construction of the second and third phases increases the capital premium to $850 million for Case 41 and $350 for Case 42/28. Inclusion of the pond closure costs in 2038 raises these figures to $1,145 million and $475 million for Cases 41 and 42/28, respectively. Although the O&M is significantly lower for these cases compared to Case 37, it is not enough to offset the effect of the higher initial capital expenditures.

Off-site landfill. The off-site landfill option consists only of O&M costs, but this option is the highest-cost alternative due to the high unit cost of off-site landfill disposal, which is approximately $26 PVRR per cubic yard.

Beneficial Reuse. KU will evaluate beneficial reuse opportunities as they arise, and will pursue proposals that are favorable to on-site disposal.

Table 6: PVRR Analysis Summary of Long-Term Alternatives
(2009 PVRR million $)

Case	**14/28**	**37**	**41**	**42/28**	**Off-Site Landfill**
PVRR					
Capital	332	284	802	538	0
O&M	277	299	35	170	1,203
Total	**609**	**583**	**837**	**708**	**1,203**
Delta to Least Cost Case	*26*	*Least Cost*	*254*	*125*	*413*
Capacity *(MCY)*	46.1	46.1	53.6	48.3	46.1
Unit Cost *(2009 PVRR $/CY)*	13.21	12.66	15.61	14.66	26.10

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7. Recommendations

The needs assessment demonstrates a need for additional CCP storage capacity at the Ghent station by 2012. Analysis of the options provided by Project Engineering demonstrates that the most favorable alternatives to meet Ghent's CCP storage needs are:

- Short-term: the proposal for beneficial reuse of 1.3 MCY of gypsum by Trans Ash in 2010 through 2012. The PVRR is $7.9 million, or $6.11 per cubic yard.
- Long-term: constructing the first phase of an on-site landfill to store both ash and gypsum, to be in-service in 2013. The PVRR is $583 million, comprised of $284 million capital and $299 million O&M.

The short-term solution utilizing beneficial reuse is almost 80% less on a per unit of volume basis than disposal at an off-site commercial landfill. The unit cost of this short-term recommendation is also lower than the unit cost of the recommended long-term on-site landfill. The long-term solution includes the construction of a single landfill and is 4% less on a PVRR basis than the dual landfill option (Case 14/28).

Further details regarding the status of this project and the expected construction schedule are shown in Appendix 4.

Appendix 1

Analysis Assumptions

- Study Period: 30-year period for operational costs impacts (2009-2038)
  50-year period for capital costs impacts (2009 through tax life of final project phase).

  The revenue requirements associated with capital costs are determined via the Capital Expenditure and Recovery module of the Strategist production and capital costing software. To completely account for capital projects costs over their lifetime, the revenue requirements associated with new capital projects were included beyond the operational study period through the end of their tax life.

- Capital and O&M costs associated with the addition of new environmental projects will be subject to recovery through the Environmental Cost Recovery ("ECR") mechanism. O&M costs for electrical power usage required to operate equipment related to CCP storage are included when comparing alternatives (noted as "Power" in Appendix 2) but are not included as recoverable costs for calculation of ECR billing factors.

- Financial data
  - Discount rate: 7.81%
  - Income tax rate: 38.9%
  - Insurance rate: 0.07%
  - Property tax rate: 0.15 %
  - Percentage of debt in capital structure: 47.01%
  - Debt interest rate/weighted cost of debt: 4.64%
  - Return on equity: 10.63%
  - Book life - average landfill phase (non-transmission): 12 years
  - Book life – transmission (line relocation): 40 years
  - Tax life: 20 years
  - Annual capital and O&M escalation rate: 6%
  - Contingency included in cost estimates: ~28%
  - E.ON US overhead included in capital costs 3.5%
  - Capital expenditures are assumed to occur at year end.

- CCP data
  - Coal ash content: 11.5%
  - Coal SO_2 content: ~5.9 lb/mmBTU
  - Coal heat content: 22.16 mmBTU/ton
  - FGD removal efficiency:
    Units 1, 3, 4 98%
    Unit 2 (currently Unit 1) 94.3%

Appendix 2

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Projected Cash Flows

Annual Cash Flows *Short-Term Options* *O&M Only ($ thousands)*		
Case	**Beneficial Reuse**	**Off-Site Landfill**
2008	-	-
2009	*50*	-
2010	*3,791*	-
2011	*3,873*	-
2012	*1,217*	*22,145*
2013+	-	-
Total	**8,931**	**22,145**

$ thousands

Case **14/28** **2 landfills**

	Annual Cash Flows										
	Capital						O&M				Total
	Phase1	*Phase2*	*Phase3*	*Phase4*	*Transmission*	**Total Capital**	*Non-Power*	*Power*	*Trans Ash*	**Total O&M**	
2008	*473*	-	-	-	-	**473**					
2009	*6,197*	-	-	-	-	**6,197**	*98*	-	-	**98**	**6,295**
2010	*52,221*	-	-	-	*7,064*	**59,285**	*137*	-	-	**137**	**59,422**
2011	*49,893*	-	-	-	-	**49,893**	*145*	-	-	**145**	**50,038**
2012	*66,710*	-	-	-	-	**66,710**	*153*	-	-	**153**	**66,863**
2013	*18,424*	-	-	-	-	**18,424**	*14,631*	*768*	-	**15,399**	**33,823**
2014	*14,990*	-	-	-	-	**14,990**	*18,471*	*785*	-	**19,255**	**34,246**
2015	*1,073*	-	-	-	-	**1,073**	*19,579*	*809*	-	**20,388**	**21,461**
2016	-	*10,487*	-	-	-	**10,487**	*20,754*	*834*	-	**21,588**	**32,075**
2017	-	*10,633*	-	-	-	**10,633**	*21,999*	*845*	-	**22,844**	**33,476**
2018	-	*16,976*	-	-	-	**16,976**	*23,343*	*858*	-	**24,201**	**41,177**
2019	-	*1,360*	-	-	-	**1,360**	*24,689*	*858*	-	**25,547**	**26,907**
2020	-	*1,550*	-	-	-	**1,550**	*26,713*	*889*	-	**27,602**	**29,151**
2021	-	*1,643*	-	-	-	**1,643**	*28,315*	*915*	-	**29,230**	**30,873**
2022	-	*1,741*	-	-	-	**1,741**	*30,014*	*930*	-	**30,944**	**32,686**
2023	-	-	*17,729*	-	-	**17,729**	*31,815*	*983*	-	**32,798**	**50,527**
2024	-	-	*18,793*	-	-	**18,793**	*33,724*	*991*	-	**34,715**	**53,508**
2025	-	-	*20,844*	-	-	**20,844**	*35,748*	*1,132*	-	**36,879**	**57,724**
2026	-	-	*2,031*	-	-	**2,031**	*37,892*	*1,171*	-	**39,063**	**41,094**
2027	-	-	-	*28,036*	-	**28,036**	*40,080*	*1,183*	-	**41,262**	**69,298**
2028	-	-	-	*28,799*	-	**28,799**	*42,485*	*1,163*	-	**43,647**	**72,447**
2029	-	-	-	*31,696*	-	**31,696**	*45,034*	*1,188*	-	**46,222**	**77,918**
2030	-	-	-	*2,714*	-	**2,714**	*47,784*	*1,212*	-	**48,996**	**51,711**
2031	-	-	-	*2,877*	-	**2,877**	*51,769*	*1,233*	-	**53,002**	**55,880**
2032	-	-	-	*4,273*	-	**4,273**	*54,875*	*1,259*	-	**56,134**	**60,408**
2033	-	-	-	*4,530*	-	**4,530**	*58,168*	*1,289*	-	**59,457**	**63,987**
2034	-	-	-	*4,802*	-	**4,802**	*61,658*	*1,315*	-	**62,972**	**67,774**
2035	-	-	-	*5,090*	-	**5,090**	*65,357*	*1,342*	-	**66,699**	**71,789**
2036	-	-	-	*5,395*	-	**5,395**	*69,279*	*1,368*	-	**70,647**	**76,042**
2037	-	-	-	*5,719*	-	**5,719**	*73,435*	*1,394*	-	**74,830**	**80,548**
2038	-	-	-	*5,641*	-	**5,641**	*310*	*1,422*	-	**1,732**	**7,373**
Total	**209,981**	**44,390**	**59,398**	**129,571**	**7,064**	**450,404**	**978,453**	**28,135**	-	**1,006,588**	**1,456,520**

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$ thousands

Case **37** **1 landfill**

	Annual Cash Flows										
	Capital						O&M				Total
	Phase1	Phase2	Phase3	Phase4	Transmission	Total Capital	Non-Power	Power	Trans Ash	Total O&M	
2008	473	-	-	-	-	473					
2009	3,849	-	-	-	-	3,849	85	-	-	85	3,934
2010	42,157	-	-	-	-	42,157	121	-	-	121	42,279
2011	59,007	-	-	-	-	59,007	129	-	-	129	59,136
2012	71,247	-	-	-	844	72,092	136	-	-	136	72,228
2013	13,557	-	-	-	-	13,557	19,003	876	-	19,879	33,436
2014	10,808	-	-	-	-	10,808	20,144	895	-	21,039	31,847
2015	637	-	-	-	-	637	21,352	923	-	22,275	22,912
2016	675	-	-	-	-	675	22,633	952	-	23,585	24,260
2017	716	-	-	-	-	716	23,991	964	-	24,955	25,671
2018	-	9,224	-	-	-	9,224	25,431	979	-	26,409	35,634
2019	-	9,847	-	-	-	9,847	26,957	978	-	27,935	37,781
2020	-	4,705	-	-	-	4,705	28,601	1,014	-	29,615	34,320
2021	-	998	-	-	-	998	30,979	1,044	-	32,023	33,020
2022	-	1,074	-	-	-	1,074	32,838	1,061	-	33,899	34,973
2023	-	1,138	-	-	-	1,138	34,808	1,121	-	35,929	37,067
2024	-	-	26,357	-	-	26,357	36,897	1,130	-	38,027	64,384
2025	-	-	27,938	-	-	27,938	39,110	1,291	-	40,401	68,339
2026	-	-	29,615	-	-	29,615	41,457	1,335	-	42,792	72,407
2027	-	-	1,437	-	-	1,437	43,944	1,349	-	45,293	46,731
2028	-	-	7,563	-	-	7,563	44,668	1,326	-	45,995	53,558
2029	-	-	2,732	-	-	2,732	47,348	1,355	-	48,703	51,436
2030	-	-	2,896	-	-	2,896	50,189	1,382	-	51,572	54,468
2031	-	-	3,070	-	-	3,070	53,201	1,407	-	54,607	57,677
2032	-	-	3,254	-	-	3,254	56,393	1,436	-	57,829	61,083
2033	-	-	3,449	-	-	3,449	59,776	1,470	-	61,247	64,696
2034	-	-	3,656	-	-	3,656	63,363	1,500	-	64,862	68,518
2035	-	-	3,875	-	-	3,875	67,165	1,530	-	68,695	72,570
2036	-	-	4,108	-	-	4,108	71,194	1,560	-	72,755	76,863
2037	-	-	4,354	-	-	4,354	75,466	1,590	-	77,056	81,411
2038	-	-	4,339	-	-	4,339	155	1,622	-	1,777	6,116
Total	**203,126**	**26,986**	**128,644**	**-**	**844**	**359,600**	**1,037,535**	**32,090**	**-**	**1,069,625**	**1,428,752**

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$ thousands

Case **41** **1 pond**

	Annual Cash Flows										
	Capital						O&M				Total
	Phase1	*Phase2*	*Phase3*	*Phase4*	*Transmission*	**Total Capital**	*Non-Power*	*Power*	*Trans Ash*	**Total O&M**	
2008	*473*	-	-	-	-	**473**					
2009	*3,778*	-	-	-	-	**3,778**	*80*	-	-	**80**	**3,857**
2010	*91,009*	-	-	-	*4,543*	**95,552**	*98*	-	-	**98**	**95,650**
2011	*91,723*	-	-	-	-	**91,723**	*104*	-	-	**104**	**91,828**
2012	*91,925*	-	-	-	-	**91,925**	*110*	-	-	**110**	**92,036**
2013	*14,142*	-	-	-	-	**14,142**	*1,828*	*612*	-	**2,441**	**16,583**
2014	-	-	-	-	-	-	*1,938*	*625*	-	**2,564**	**2,564**
2015	-	-	-	-	-	-	*2,054*	*645*	-	**2,699**	**2,699**
2016	-	-	-	-	-	-	*2,178*	*665*	-	**2,843**	**2,843**
2017	-	*98,018*	-	-	-	**98,018**	*2,308*	*674*	-	**2,982**	**101,000**
2018	-	*88,438*	-	-	-	**88,438**	*2,447*	*684*	-	**3,131**	**91,569**
2019	-	*93,744*	-	-	-	**93,744**	*2,594*	*684*	-	**3,277**	**97,021**
2020	-	-	-	-	-	-	*2,749*	*709*	-	**3,458**	**3,458**
2021	-	-	-	-	-	-	*2,914*	*729*	-	**3,643**	**3,643**
2022	-	-	-	-	-	-	*3,089*	*741*	-	**3,830**	**3,830**
2023	-	-	-	-	-	-	*3,274*	*783*	-	**4,057**	**4,057**
2024	-	-	-	-	-	-	*3,471*	*790*	-	**4,261**	**4,261**
2025	-	-	*199,900*	-	-	**199,900**	*3,679*	*902*	-	**4,581**	**204,481**
2026	-	-	*209,623*	-	-	**209,623**	*3,900*	*933*	-	**4,833**	**214,456**
2027	-	-	*222,200*	-	-	**222,200**	*4,134*	*943*	-	**5,076**	**227,276**
2028	-	-	-	-	-	-	*4,422*	*927*	-	**5,349**	**5,349**
2029	-	-	-	-	-	-	*4,687*	*947*	-	**5,634**	**5,634**
2030	-	-	-	-	-	-	*4,968*	*966*	-	**5,934**	**5,934**
2031	-	-	-	-	-	-	*5,266*	*983*	-	**6,250**	**6,250**
2032	-	-	-	-	-	-	*5,582*	*1,004*	-	**6,586**	**6,586**
2033	-	-	-	-	-	-	*5,917*	*1,028*	-	**6,945**	**6,945**
2034	-	-	-	-	-	-	*6,272*	*1,048*	-	**7,320**	**7,320**
2035	-	-	-	-	-	-	*6,649*	*1,070*	-	**7,718**	**7,718**
2036	-	-	-	-	-	-	*7,048*	*1,090*	-	**8,138**	**8,138**
2037	-	-	-	-	-	-	*7,471*	*1,111*	-	**8,582**	**8,582**
2038	-	-	*295,445*	-	-	**295,445**	*144*	*1,133*	-	**1,277**	**296,722**
Total	**293,051**	**280,200**	**927,167**	**-**	**4,543**	**1,504,961**	**101,376**	**22,426**	**-**	**123,802**	**1,628,291**

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$ thousands

Case **42/28** **1 pond/1 landfill**

	Annual Cash Flows										
	Capital						O&M				Total
	Phase1	Phase2	Phase3	Phase4	Transmission	Total Capital	Non-Power	Power	Trans Ash	Total O&M	
2008	473	-	-	-	-	473					
2009	5,972	-	-	-	-	5,972	93	-	-	93	6,065
2010	82,400	-	-	-	3,482	85,882	126	-	-	126	86,008
2011	86,581	-	-	-	-	86,581	134	-	-	134	86,715
2012	90,000	-	-	-	-	90,000	142	-	-	142	90,142
2013	19,878	-	-	-	-	19,878	11,237	735	-	11,972	31,850
2014	8,006	-	-	-	-	8,006	11,911	751	-	12,662	20,668
2015	891	-	-	-	-	891	12,626	774	-	13,400	14,290
2016	944	-	-	-	-	944	13,384	798	-	14,182	15,126
2017	1,001	-	-	-	-	1,001	14,187	808	-	14,995	15,996
2018	-	59,679	-	-	-	59,679	9,811	821	-	10,632	70,311
2019	-	59,404	-	-	-	59,404	10,400	820	-	11,220	70,625
2020	-	67,820	-	-	-	67,820	11,024	850	-	11,874	79,694
2021	-	1,264	-	-	-	1,264	18,285	875	-	19,160	20,424
2022	-	1,207	-	-	-	1,207	19,382	890	-	20,272	21,478
2023	-	1,279	-	-	-	1,279	20,545	940	-	21,485	22,764
2024	-	1,356	-	-	-	1,356	21,778	948	-	22,726	24,081
2025	-	1,437	-	-	-	1,437	23,084	1,083	-	24,167	25,604
2026	-	1,523	-	-	-	1,523	24,469	1,120	-	25,589	27,113
2027	-	-	54,245	-	-	54,245	20,488	1,131	-	21,619	75,864
2028	-	-	57,500	-	-	57,500	21,717	1,112	-	22,829	80,329
2029	-	-	80,538	-	-	80,538	23,020	1,136	-	24,156	104,695
2030	-	-	1,923	-	-	1,923	30,892	1,159	-	32,051	33,974
2031	-	-	2,231	-	-	2,231	32,746	1,180	-	33,925	36,156
2032	-	-	2,365	-	-	2,365	34,710	1,205	-	35,915	38,280
2033	-	-	2,507	-	-	2,507	36,793	1,233	-	38,026	40,533
2034	-	-	2,657	-	-	2,657	39,001	1,258	-	40,258	42,915
2035	-	-	2,816	-	-	2,816	41,341	1,283	-	42,624	45,441
2036	-	-	2,985	-	-	2,985	43,821	1,308	-	45,129	48,115
2037	-	-	3,165	-	-	3,165	46,450	1,334	-	47,784	50,949
2038	-	-	127,447	-	-	127,447	287	1,360	-	1,647	129,094
Total	**296,145**	**194,969**	**340,380**	**-**	**3,482**	**834,975**	**593,884**	**26,911**	**-**	**620,796**	**1,455,298**

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$ thousands

Case	**Off-Site Landfill (O&M Only)**		
	Capital	**O&M**	
Cost Escalation		**6%**	**2%**
2008	-	-	-
2009	-	-	-
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	*74,982*	*64,289*
2014	-	*79,481*	*65,575*
2015	-	*84,250*	*66,886*
2016	-	*89,305*	*68,224*
2017	-	*94,664*	*69,588*
2018	-	*100,343*	*70,980*
2019	-	*106,364*	*72,400*
2020	-	*112,746*	*73,848*
2021	-	*119,511*	*75,325*
2022	-	*126,681*	*76,831*
2023	-	*134,282*	*78,368*
2024	-	*142,339*	*79,935*
2025	-	*168,495*	*91,054*
2026	-	*178,605*	*92,875*
2027	-	*189,321*	*94,732*
2028	-	*200,681*	*96,627*
2029	-	*212,722*	*98,559*
2030	-	*225,485*	*100,531*
2031	-	*239,014*	*102,541*
2032	-	*253,355*	*104,592*
2033	-	*268,556*	*106,684*
2034	-	*284,670*	*108,817*
2035	-	*301,750*	*110,994*
2036	-	*319,855*	*113,214*
2037	-	*339,046*	*115,478*
2038	-	-	-
Total	-	**4,446,504**	**2,198,947**

Appendix 3

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Revenue Requirements Detail

$ thousands

Case **Short-Term Beneficial Reuse (O&M Only)**

	Capital	O&M
2008	-	-
2009	-	*50*
2010	-	*3,791*
2011	-	*3,873*
2012	-	*1,217*
2013+	-	-
2009 PVRR	**-**	**7,869**

$ thousands

Case **Short-Term Off-Site Landfill (O&M Only)**

	Capital	O&M
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	*22,145*
2013+	-	-
2009 PVRR	**-**	**17,673**

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$ thousands

Case **14/28** **2 landfills**

	Annual Revenue Requirements										
	Capital						O&M				Total
	Phase1	Phase2	Phase3	Phase4	Transmission	Total Capital	Non-Power	Power	Trans Ash	Total O&M	
2009	650	-	-	-	-	650	98	-	-	98	748
2010	6,129	-	-	-	741	6,870	137	-	-	137	7,006
2011	11,363	-	-	-	741	12,104	145	-	-	145	12,249
2012	18,362	-	-	-	741	19,103	153	-	-	153	19,256
2013	36,370	-	-	-	1,001	37,371	14,631	768	-	15,399	52,770
2014	37,980	-	-	-	956	38,936	18,471	785	-	19,255	58,191
2015	37,682	-	-	-	914	38,597	19,579	809	-	20,388	58,985
2016	35,897	1,100	-	-	876	37,873	20,754	834	-	21,588	59,461
2017	34,047	2,216	-	-	839	37,102	21,999	845	-	22,844	59,946
2018	32,239	3,997	-	-	805	37,041	23,343	858	-	24,201	61,242
2019	30,470	7,638	-	-	772	38,880	24,689	858	-	25,547	64,427
2020	28,736	7,566	-	-	739	37,040	26,713	889	-	27,602	64,642
2021	27,013	7,517	-	-	705	35,235	28,315	915	-	29,230	64,465
2022	25,293	7,481	-	-	672	33,446	30,014	930	-	30,944	64,390
2023	23,573	7,264	1,860	-	639	33,337	31,815	983	-	32,798	66,134
2024	21,546	6,880	3,832	-	606	32,863	33,724	991	-	34,715	67,578
2025	6,292	6,504	6,018	-	573	19,387	35,748	1,132	-	36,879	56,266
2026	4,207	6,135	11,500	-	540	22,382	37,892	1,171	-	39,063	61,446
2027	2,525	5,769	11,144	2,941	506	22,887	40,080	1,183	-	41,262	64,149
2028	2,012	5,404	10,597	5,963	483	24,458	42,485	1,163	-	43,647	68,106
2029	1,588	5,039	10,063	9,288	469	26,446	45,034	1,188	-	46,222	72,668
2030	1,164	4,608	9,541	17,704	454	33,471	47,784	1,212	-	48,996	82,468
2031	740	1,302	9,031	17,418	440	28,931	51,769	1,233	-	53,002	81,934
2032	316	1,066	8,532	17,289	426	27,629	54,875	1,259	-	56,134	83,763
2033	70	823	8,042	17,309	412	26,656	58,168	1,289	-	59,457	86,113
2034	18	582	7,555	17,361	397	25,914	61,658	1,315	-	62,972	88,886
2035	1	347	7,067	17,445	383	25,243	65,357	1,342	-	66,699	91,942
2036	-	258	6,580	17,560	369	24,766	69,279	1,368	-	70,647	95,413
2037	-	168	5,991	17,709	355	24,222	73,435	1,394	-	74,830	99,052
2038	-	78	1,075	17,835	340	19,328	310	1,422	-	1,732	21,060
2039	-	27	785	17,314	326	18,452	-	-	-	-	18,452
2040	-	15	665	16,228	312	17,220	-	-	-	-	17,220
2041	-	7	545	14,993	298	15,842	-	-	-	-	15,842
2042	-	2	425	7,084	283	7,794	-	-	-	-	7,794
2043	-	-	305	6,347	269	6,921	-	-	-	-	6,921
2044	-	-	184	5,615	255	6,054	-	-	-	-	6,054
2045	-	-	64	4,795	241	5,100	-	-	-	-	5,100
2046	-	-	2	3,982	226	4,210	-	-	-	-	4,210
2047	-	-	-	3,176	212	3,388	-	-	-	-	3,388
2048	-	-	-	2,376	198	2,574	-	-	-	-	2,574
2049	-	-	-	1,584	184	1,768	-	-	-	-	1,768
2050	-	-	-	890	169	1,060	-	-	-	-	1,060
2051	-	-	-	340	155	495	-	-	-	-	495
2052	-	-	-	265	99	365	-	-	-	-	365
2053	-	-	-	198	-	198	-	-	-	-	198
2054	-	-	-	139	-	139	-	-	-	-	139
2055	-	-	-	90	-	90	-	-	-	-	90
2056	-	-	-	51	-	51	-	-	-	-	51
2057	-	-	-	23	-	23	-	-	-	-	23
2058	-	-	-	6	-	6	-	-	-	-	6
2009 PVRR	**231,609**	**30,725**	**25,223**	**36,008**	**8,400**	**331,965**	**268,350**	**8,528**	**-**	**276,878**	**608,844**

CONFIDENTIAL INFORMATION

$ thousands

Case **37** **1 landfill**

	Annual Revenue Requirements										
	Capital						O&M				Total
	Phase1	*Phase2*	*Phase3*	*Phase4*	*Transmission*	**Total Capital**	*Non-Power*	*Power*	*Trans Ash*	**Total O&M**	
2009	*404*	-	-	-	-	**404**	*85*	-	-	**85**	**489**
2010	*4,827*	-	-	-	-	**4,827**	*121*	-	-	**121**	**4,948**
2011	*11,017*	-	-	-	-	**11,017**	*129*	-	-	**129**	**11,146**
2012	*18,492*	-	-	-	*89*	**18,580**	*136*	-	-	**136**	**18,717**
2013	*36,103*	-	-	-	*120*	**36,223**	*19,003*	*876*	-	**19,879**	**56,102**
2014	*36,815*	-	-	-	*114*	**36,929**	*20,144*	*895*	-	**21,039**	**57,968**
2015	*36,123*	-	-	-	*109*	**36,232**	*21,352*	*923*	-	**22,275**	**58,507**
2016	*34,441*	-	-	-	*105*	**34,546**	*22,633*	*952*	-	**23,585**	**58,131**
2017	*32,804*	-	-	-	*100*	**32,905**	*23,991*	*964*	-	**24,955**	**57,860**
2018	*31,130*	*968*	-	-	*96*	**32,193**	*25,431*	*979*	-	**26,409**	**58,603**
2019	*29,419*	*2,001*	-	-	*92*	**31,512**	*26,957*	*978*	-	**27,935**	**59,447**
2020	*27,743*	*4,246*	-	-	*88*	**32,077**	*28,601*	*1,014*	-	**29,615**	**61,692**
2021	*26,076*	*4,602*	-	-	*84*	**30,763**	*30,979*	*1,044*	-	**32,023**	**62,785**
2022	*24,412*	*4,587*	-	-	*80*	**29,079**	*32,838*	*1,061*	-	**33,899**	**62,977**
2023	*22,748*	*4,581*	-	-	*76*	**27,405**	*34,808*	*1,121*	-	**35,929**	**63,334**
2024	*20,774*	*4,456*	*2,765*	-	*72*	**28,068**	*36,897*	*1,130*	-	**38,027**	**66,095**
2025	*5,490*	*4,222*	*5,696*	-	*68*	**15,476**	*39,110*	*1,291*	-	**40,401**	**55,877**
2026	*3,852*	*3,992*	*8,803*	-	*65*	**16,711**	*41,457*	*1,335*	-	**42,792**	**59,504**
2027	*2,527*	*3,767*	*16,661*	-	*61*	**23,016**	*43,944*	*1,349*	-	**45,293**	**68,309**
2028	*2,054*	*3,545*	*16,793*	-	*58*	**22,449**	*44,668*	*1,326*	-	**45,995**	**68,444**
2029	*1,582*	*3,322*	*16,987*	-	*56*	**21,948**	*47,348*	*1,355*	-	**48,703**	**70,652**
2030	*1,113*	*3,101*	*16,704*	-	*54*	**20,971**	*50,189*	*1,382*	-	**51,572**	**72,543**
2031	*703*	*2,846*	*16,447*	-	*53*	**20,048**	*53,201*	*1,407*	-	**54,607**	**74,655**
2032	*293*	*1,145*	*16,217*	-	*51*	**17,705**	*56,393*	*1,436*	-	**57,829**	**75,534**
2033	*61*	*676*	*16,014*	-	*49*	**16,800**	*59,776*	*1,470*	-	**61,247**	**78,047**
2034	*21*	*523*	*15,837*	-	*47*	**16,429**	*63,363*	*1,500*	-	**64,862**	**81,292**
2035	*6*	*370*	*15,677*	-	*46*	**16,099**	*67,165*	*1,530*	-	**68,695**	**84,794**
2036	*3*	*220*	*15,531*	-	*44*	**15,798**	*71,194*	*1,560*	-	**72,755**	**88,553**
2037	*1*	*166*	*15,399*	-	*42*	**15,608**	*75,466*	*1,590*	-	**77,056**	**92,664**
2038	-	*111*	*15,106*	-	*41*	**15,258**	*155*	*1,622*	-	**1,777**	**17,035**
2039	-	*57*	*7,992*	-	*39*	**8,088**	-	-	-	-	**8,088**
2040	-	*21*	*7,314*	-	*37*	**7,373**	-	-	-	-	**7,373**
2041	-	*10*	*6,185*	-	*36*	**6,231**	-	-	-	-	**6,231**
2042	-	*5*	*5,480*	-	*34*	**5,518**	-	-	-	-	**5,518**
2043	-	*1*	*4,782*	-	*32*	**4,815**	-	-	-	-	**4,815**
2044	-	-	*4,090*	-	*30*	**4,121**	-	-	-	-	**4,121**
2045	-	-	*3,405*	-	*29*	**3,434**	-	-	-	-	**3,434**
2046	-	-	*2,725*	-	*27*	**2,752**	-	-	-	-	**2,752**
2047	-	-	*2,135*	-	*25*	**2,160**	-	-	-	-	**2,160**
2048	-	-	*1,636*	-	*24*	**1,660**	-	-	-	-	**1,660**
2049	-	-	*1,153*	-	*22*	**1,175**	-	-	-	-	**1,175**
2050	-	-	*686*	-	*20*	**706**	-	-	-	-	**706**
2051	-	-	*260*	-	*19*	**279**	-	-	-	-	**279**
2052	-	-	*203*	-	*12*	**215**	-	-	-	-	**215**
2053	-	-	*151*	-	-	**151**	-	-	-	-	**151**
2054	-	-	*107*	-	-	**107**	-	-	-	-	**107**
2055	-	-	*69*	-	-	**69**	-	-	-	-	**69**
2056	-	-	*39*	-	-	**39**	-	-	-	-	**39**
2057	-	-	*18*	-	-	**18**	-	-	-	-	**18**
2058	-	-	*4*	-	-	**4**	-	-	-	-	**4**
2009 PVRR	**223,335**	**16,565**	**43,468**	**-**	**846**	**284,215**	**289,520**	**9,727**	**-**	**299,247**	**583,462**

CONFIDENTIAL INFORMATION

$ thousands

Case **41** **1 pond**

	Annual Revenue Requirements										
	Capital						O&M				Total
	Phase1	*Phase2*	*Phase3*	*Phase4*	*Transmission*	**Total Capital**	*Non-Power*	*Power*	*Trans Ash*	**Total O&M**	
2009	*396*	-	-	-	-	**396**	*80*	-	-	**80**	**476**
2010	*9,944*	-	-	-	*477*	**10,421**	*98*	-	-	**98**	**10,519**
2011	*19,567*	-	-	-	*644*	**20,211**	*104*	-	-	**104**	**20,315**
2012	*29,211*	-	-	-	*615*	**29,826**	*110*	-	-	**110**	**29,937**
2013	*56,269*	-	-	-	*588*	**56,857**	*1,828*	*612*	-	**2,441**	**59,297**
2014	*54,934*	-	-	-	*563*	**55,497**	*1,938*	*625*	-	**2,564**	**58,061**
2015	*52,236*	-	-	-	*540*	**52,775**	*2,054*	*645*	-	**2,699**	**55,474**
2016	*49,604*	-	-	-	*518*	**50,121**	*2,178*	*665*	-	**2,843**	**52,964**
2017	*47,033*	*10,283*	-	-	*496*	**57,813**	*2,308*	*674*	-	**2,982**	**60,795**
2018	*44,520*	*19,562*	-	-	*475*	**64,557**	*2,447*	*684*	-	**3,131**	**67,687**
2019	*42,060*	*29,396*	-	-	*454*	**71,910**	*2,594*	*684*	-	**3,277**	**75,187**
2020	*39,648*	*55,132*	-	-	*432*	**95,213**	*2,749*	*709*	-	**3,458**	**98,670**
2021	*37,247*	*52,482*	-	-	*411*	**90,140**	*2,914*	*729*	-	**3,643**	**93,783**
2022	*34,845*	*49,901*	-	-	*390*	**85,136**	*3,089*	*741*	-	**3,830**	**88,966**
2023	*32,444*	*47,383*	-	-	*368*	**80,196**	*3,274*	*783*	-	**4,057**	**84,253**
2024	*29,553*	*44,925*	-	-	*347*	**74,824**	*3,471*	*790*	-	**4,261**	**79,085**
2025	*5,647*	*42,520*	*20,972*	-	*326*	**69,465**	*3,679*	*902*	-	**4,581**	**74,046**
2026	*3,876*	*40,167*	*42,964*	-	*310*	**87,317**	*3,900*	*933*	-	**4,833**	**92,150**
2027	*3,284*	*37,859*	*66,275*	-	*301*	**107,720**	*4,134*	*943*	-	**5,076**	**112,797**
2028	*2,692*	*35,560*	*124,297*	-	*292*	**162,842**	*4,422*	*927*	-	**5,349**	**168,190**
2029	*2,100*	*33,260*	*118,323*	-	*283*	**153,966**	*4,687*	*947*	-	**5,634**	**159,601**
2030	*1,509*	*30,960*	*112,503*	-	*274*	**145,246**	*4,968*	*966*	-	**5,934**	**151,181**
2031	*917*	*28,168*	*106,828*	-	*265*	**136,176**	*5,266*	*983*	-	**6,250**	**142,426**
2032	*325*	*4,252*	*101,284*	-	*255*	**106,116**	*5,582*	*1,004*	-	**6,586**	**112,703**
2033	*14*	*3,685*	*95,864*	-	*246*	**99,810**	*5,917*	*1,028*	-	**6,945**	**106,755**
2034	-	*3,118*	*90,557*	-	*237*	**93,912**	*6,272*	*1,048*	-	**7,320**	**101,233**
2035	-	*2,551*	*85,355*	-	*228*	**88,134**	*6,649*	*1,070*	-	**7,718**	**95,853**
2036	-	*1,984*	*80,171*	-	*219*	**82,374**	*7,048*	*1,090*	-	**8,138**	**90,512**
2037	-	*1,417*	*74,986*	-	*210*	**76,613**	*7,471*	*1,111*	-	**8,582**	**85,195**
2038	-	*850*	*100,797*	-	*201*	**101,848**	*144*	*1,133*	-	**1,277**	**103,125**
2039	-	*283*	*121,636*	-	*191*	**122,111**	-	-	-	-	**122,111**
2040	-	-	*64,924*	-	*182*	**65,106**	-	-	-	-	**65,106**
2041	-	-	*60,924*	-	*173*	**61,097**	-	-	-	-	**61,097**
2042	-	-	*56,991*	-	*164*	**57,155**	-	-	-	-	**57,155**
2043	-	-	*53,121*	-	*155*	**53,275**	-	-	-	-	**53,275**
2044	-	-	*49,307*	-	*146*	**49,453**	-	-	-	-	**49,453**
2045	-	-	*45,547*	-	*136*	**45,684**	-	-	-	-	**45,684**
2046	-	-	*41,836*	-	*127*	**41,964**	-	-	-	-	**41,964**
2047	-	-	*38,133*	-	*118*	**38,252**	-	-	-	-	**38,252**
2048	-	-	*35,070*	-	*109*	**35,179**	-	-	-	-	**35,179**
2049	-	-	*32,645*	-	*100*	**32,745**	-	-	-	-	**32,745**
2050	-	-	*29,700*	-	*64*	**29,764**	-	-	-	-	**29,764**
2051	-	-	*4,483*	-	-	**4,483**	-	-	-	-	**4,483**
2052	-	-	*3,885*	-	-	**3,885**	-	-	-	-	**3,885**
2053	-	-	*3,288*	-	-	**3,288**	-	-	-	-	**3,288**
2054	-	-	*2,690*	-	-	**2,690**	-	-	-	-	**2,690**
2055	-	-	*2,092*	-	-	**2,092**	-	-	-	-	**2,092**
2056	-	-	*1,494*	-	-	**1,494**	-	-	-	-	**1,494**
2057	-	-	*897*	-	-	**897**	-	-	-	-	**897**
2058	-	-	*299*	-	-	**299**	-	-	-	-	**299**
2009 PVRR	**331,653**	**188,844**	**276,078**	**-**	**5,288**	**801,864**	**28,274**	**6,797**	**-**	**35,071**	**836,935**

CONFIDENTIAL INFORMATION

$ thousands

Case **42/28** **1 pond/1 landfill**

	Annual Revenue Requirements										
	Capital						O&M				Total
	Phase1	*Phase2*	*Phase3*	*Phase4*	*Transmission*	**Total Capital**	*Non-Power*	*Power*	*Trans Ash*	**Total O&M**	
2009	627	-	-	-	-	**627**	93	-	-	**93**	**719**
2010	9,271	-	-	-	365	**9,637**	126	-	-	**126**	**9,763**
2011	18,355	-	-	-	493	**18,848**	134	-	-	**134**	**18,982**
2012	27,797	-	-	-	471	**28,268**	142	-	-	**142**	**28,410**
2013	54,217	-	-	-	451	**54,668**	11,237	735	-	**11,972**	**66,640**
2014	54,377	-	-	-	432	**54,809**	11,911	751	-	**12,662**	**67,471**
2015	52,577	-	-	-	414	**52,991**	12,626	774	-	**13,400**	**66,391**
2016	50,119	-	-	-	397	**50,516**	13,384	798	-	**14,182**	**64,697**
2017	47,725	-	-	-	380	**48,105**	14,187	808	-	**14,995**	**63,100**
2018	45,280	6,261	-	-	364	**51,905**	9,811	821	-	**10,632**	**62,537**
2019	42,787	12,493	-	-	348	**55,628**	10,400	820	-	**11,220**	**66,848**
2020	40,344	19,608	-	-	331	**60,284**	11,024	850	-	**11,874**	**72,158**
2021	37,914	36,908	-	-	315	**75,136**	18,285	875	-	**19,160**	**94,297**
2022	35,486	35,383	-	-	299	**71,167**	19,382	890	-	**20,272**	**91,439**
2023	33,059	33,894	-	-	282	**67,235**	20,545	940	-	**21,485**	**88,720**
2024	30,166	32,451	-	-	266	**62,883**	21,778	948	-	**22,726**	**85,608**
2025	7,264	31,052	-	-	250	**38,566**	23,084	1,083	-	**24,167**	**62,733**
2026	4,928	29,694	-	-	238	**34,860**	24,469	1,120	-	**25,589**	**60,449**
2027	3,644	28,204	5,691	-	231	**37,770**	20,488	1,131	-	**21,619**	**59,389**
2028	2,958	26,593	11,723	-	224	**41,498**	21,717	1,112	-	**22,829**	**64,328**
2029	2,273	24,989	20,173	-	217	**47,652**	23,020	1,136	-	**24,156**	**71,808**
2030	1,591	23,386	38,035	-	210	**63,223**	30,892	1,159	-	**32,051**	**95,274**
2031	993	21,784	36,628	-	203	**59,608**	32,746	1,180	-	**33,925**	**93,533**
2032	395	19,854	35,291	-	196	**55,736**	34,710	1,205	-	**35,915**	**91,651**
2033	65	3,833	34,005	-	189	**38,091**	36,793	1,233	-	**38,026**	**76,117**
2034	23	3,289	32,766	-	182	**36,260**	39,001	1,258	-	**40,258**	**76,518**
2035	9	2,757	31,574	-	175	**34,514**	41,341	1,283	-	**42,624**	**77,138**
2036	4	2,227	30,425	-	168	**32,823**	43,821	1,308	-	**45,129**	**77,953**
2037	1	1,699	29,318	-	161	**31,178**	46,450	1,334	-	**47,784**	**78,962**
2038	-	1,172	41,246	-	154	**42,572**	287	1,360	-	**1,647**	**44,220**
2039	-	651	51,192	-	147	**51,990**	-	-	-	**-**	**51,990**
2040	-	256	48,231	-	140	**48,627**	-	-	-	**-**	**48,627**
2041	-	51	44,965	-	133	**45,149**	-	-	-	**-**	**45,149**
2042	-	36	27,232	-	126	**27,393**	-	-	-	**-**	**27,393**
2043	-	23	25,401	-	119	**25,543**	-	-	-	**-**	**25,543**
2044	-	13	23,584	-	112	**23,709**	-	-	-	**-**	**23,709**
2045	-	6	21,793	-	105	**21,904**	-	-	-	**-**	**21,904**
2046	-	2	20,027	-	98	**20,127**	-	-	-	**-**	**20,127**
2047	-	-	18,269	-	91	**18,359**	-	-	-	**-**	**18,359**
2048	-	-	16,514	-	83	**16,598**	-	-	-	**-**	**16,598**
2049	-	-	14,763	-	76	**14,840**	-	-	-	**-**	**14,840**
2050	-	-	12,993	-	49	**13,042**	-	-	-	**-**	**13,042**
2051	-	-	2,075	-	-	**2,075**	-	-	-	**-**	**2,075**
2052	-	-	1,782	-	-	**1,782**	-	-	-	**-**	**1,782**
2053	-	-	1,493	-	-	**1,493**	-	-	-	**-**	**1,493**
2054	-	-	1,209	-	-	**1,209**	-	-	-	**-**	**1,209**
2055	-	-	930	-	-	**930**	-	-	-	**-**	**930**
2056	-	-	657	-	-	**657**	-	-	-	**-**	**657**
2057	-	-	390	-	-	**390**	-	-	-	**-**	**390**
2058	-	-	129	-	-	**129**	-	-	-	**-**	**129**
2009 PVRR	**331,076**	**119,826**	**83,460**	**-**	**4,053**	**538,415**	**161,730**	**8,157**	**-**	**169,886**	**708,301**

CONFIDENTIAL INFORMATION

Case **Off-Site Landfill (O&M Only)**

$ thousands

using 6% cost escalation

	Capital	O&M
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	74,982
2014	-	79,481
2015	-	84,250
2016	-	89,305
2017	-	94,664
2018	-	100,343
2019	-	106,364
2020	-	112,746
2021	-	119,511
2022	-	126,681
2023	-	134,282
2024	-	142,339
2025	-	168,495
2026	-	178,605
2027	-	189,321
2028	-	200,681
2029	-	212,722
2030	-	225,485
2031	-	239,014
2032	-	253,355
2033	-	268,556
2034	-	284,670
2035	-	301,750
2036	-	319,855
2037	-	339,046
2038	-	-
2009 PVRR	**-**	**1,203,164**

using 2% cost escalation

	Capital	O&M
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	64,289
2014	-	65,575
2015	-	66,886
2016	-	68,224
2017	-	69,588
2018	-	70,980
2019	-	72,400
2020	-	73,848
2021	-	75,325
2022	-	76,831
2023	-	78,368
2024	-	79,935
2025	-	91,054
2026	-	92,875
2027	-	94,732
2028	-	96,627
2029	-	98,559
2030	-	100,531
2031	-	102,541
2032	-	104,592
2033	-	106,684
2034	-	108,817
2035	-	110,994
2036	-	113,214
2037	-	115,478
2038	-	-
2009 PVRR	**-**	**689,210**

Appendix 4

<u>Project Status *(As of April 2009*</u>*)*

<u>Detailed Design</u>
The detailed design phase for Case 37 is currently in progress. Meetings are being conducted with the E.ON U.S. property appraiser and the individual owners of properties within the boundaries of Site F. After obtaining approval from these property owners, geotechnical, archaeological, ecological, and historical structures studies have begun. This will allow for the completion of the detailed engineering design and the start of the development of the permits for this location. The permits are expected to be submitted by the end of 2009.

<u>Construction Schedule</u>
The preliminary design for the landfill is to develop it in three distinct phases. This detail as well as the closure plan for each phase will be further developed in the detailed design phase. The current schedule is shown in Table A4-1.

Table A4-1: Preliminary Construction Schedule

Task	Schedule
Property acquisition	3rd Quarter 2009
Begin first phase landfill development	2nd Quarter 2010
Finish first phase landfill development	4th Quarter 2014
Begin second phase landfill development	2nd Quarter 2018
Finish second phase landfill development	4th Quarter 2019
Begin third phase landfill development	2nd Quarter 2024
Finish third phase landfill development	4th Quarter 2026

The risks associated with the project include the following:

- Inability to reach a settlement on purchase price for one or more of the properties required for the site, resulting in lengthy eminent domain litigation
- Discovery of unknown geotechnical issues
- Litigation and intervention of the 401/404 permits for Sites E/F could delay the construction of this section of the work
- Failure of major components during start-up
- Unseasonable weather, such as exceptionally heavy rainfall, late spring, early on-set of winter, etc.
- Engineering design failure of a component of design
- Contractor delays due to shortage of materials or manpower issues
- Change in regulations

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 2

Witness: David S. Sinclair/Robert M. Conroy

Q-2. Please see Exhibits D and F attached to Sterling's Complaint in this case.

a. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the information as set forth in Exhibits D for the years 2009 through the year used to calculate the PVRR for Case 37, the chosen Ghent landfill alternative, as contemplated in the original Application for the CPCN for the Ghent Landfill, KU Case No. 2009-00197 (the "2009 KU Application").

b. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the information as set forth in Exhibits D for the years 2009 through the year necessary to calculate the PVRR of the Ghent Landfill and the CCRT facility, based upon actual costs to date, and the most recent projections of the Landfill's future costs. To the extent any line items have been added since the original 2009 KU Application and need to be added to the format of Exhibit D in order to make it complete, please include those line items (i.e., capital and operating cost of the CCRT facility).

c. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the information as set forth in Exhibits F for all phases of the Ghent Landfill as originally contemplated in the 2009 KU Application.

d. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the information as set forth in Exhibits F for all phases of the Ghent Landfill based upon the actual cost to date of the Ghent Landfill, and the most recent projections of the Landfill's future costs. To the extent any capital cost or operating and maintenance cost categories have been added since the original 2009 KU Application, please include those cost categories (i.e., capital and operating cost of the CCRT facility).

e. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the Company's PVRR Analysis of the Ghent Landfill as originally contemplated in the 2009 KU Application.

f. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the Company's PVRR Analysis of the Ghent Landfill, including the CCRT facility, based upon the actual cost to date of the Ghent Landfill, and the most recent projections of the Landfill's future costs.

g. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the information as set forth in Exhibits D for the years 2009 through the year necessary to calculate the PVRR of the Trimble County Landfill, including the CCRT facility, based upon actual costs to date, and the most recent projections of the Landfill's future costs. To the extent any line items have been added since the original 2009 KU Application and need to be added to the format of Exhibit D in order to make it complete, please include those line items (i.e., capital and operating cost of the CCRT facility).

h. Please provide a working electronic excel spreadsheet, with all cell formulas and linkages intact, with the information as set forth in Exhibits F for all phases of the Trimble County Landfill based upon the actual cost to date of the Landfill, including the CCRT facility, and the most recent projections of the Landfill's future costs. To the extent any capital cost or operating and maintenance cost categories have been added since the original version of Exhibit F in the 2009 KU Application, please include those cost categories (i.e., capital and operating cost of the CCRT facility).

i. With respect to any of the requests in subparagraphs a. through h. above, please provide copies of all calculations, work papers, spreadsheets (a working electronic excel spreadsheet, with all cell formulas and linkages intact) and any other supporting documents, including but not limited to the calculation of depreciation, useful life of landfill component asset cost and deferred tax calculations.

A-2. a. The information contained in the referenced Exhibit D is from Exhibit RMC-5 and shows the details of the impact on the calculation of the environmental surcharge and a residential customer for 2009 through 2018 of the 2009 ECR Plan projects. It did not include information beyond 2018 and as such the requested calculations are not available. Attached in Excel format is the spreadsheet used in the development of Exhibit RMC-5 and that contains the Revenue Requirements Summary for KU ECR Project 30 – Ghent Landfill Phase I as shown on SV Exhibit D.

b. See the response to part a. KU has not prepared the reference Exhibit RMC-5 with actual data. Actual costs for the referenced KU ECR Project 30 are included in KU's monthly Environmental Surcharge filings with the Commission. Copies of KU's monthly filings for December 2009 (first expenses month after Commission approval of the 2009 ECR Plan) through the most recent expense month filing (May 2015) are attached.

c. The information contained in the referenced Exhibit F was originally provided in Case No. 2009-00197 in response to KIUC's first set of data requests as an attachment to Question 1-4. See the attached being provided in Excel format.

d. See the response to part c. The referenced attachment to KIUC Question 1-4 has not been updated with actual costs. Actuals costs are included in the monthly Environmental Surcharge filings. See also the response to parts b.

e. See the attachment being provided in Excel format contained on the provided thumb drive.

f. The Companies have not performed this analysis.

g. The Companies assume the reference to Exhibit D in the request should be Exhibit E which contains the revenue requirement summary for the Trimble County Landfill. The information contained in the referenced Exhibit E is from Exhibit RMC-5 which shows the details of the impact on the calculation of the environmental surcharge and a residential customer for 2009 through 2018 of the 2009 ECR Plan projects. It did not include information beyond 2018 and as such the requested calculations are not available. See the response to part a for the requested Excel file. The attachment to part a is the spreadsheet used in the development of Exhibit RMC-5 and contains the Revenue Requirements Summary for KU ECR Project 32 and LG&E ECR Project 24 – Trimble County Landfill Phase I as shown on SV Exhibit E.

h. See the response to part g. The Companies have not prepared the referenced Exhibit RMC-5 with actual data. Actuals costs for the referenced KU ECR Project 32 and LG&E ECR Project 24 are included in the KU and LG&E monthly Environmental Surcharge filings with the Commission. See the attached for copies of LG&E's monthly filings for December 2009 (first expenses month after Commission approval of the 2009 ECR Plan) through the most recent expense month filing (May 2015). See the response to part b for the KU monthly Environmental Surcharge filings.

i. See the above responses.

Attachment in Excel

The attachment(s) provided in separate file(s) in Excel format.

Attachment in Separate File

The attachment is being provided in a separate file.

Attachment in Excel

The attachment(s) provided in separate file(s) in Excel format.

Due to the size of the attachment, it is being filed on CD or separate jump drive. Please see the Petition for Deviation.

Attachment in Separate File

The attachment is being provided in a separate file.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 3

Witness: Caryl M. Pfeiffer

Q-3. Please provide for the Ghent Generating Station and Trimble County Generating Station, CCR production by type (gypsum, fly ash, etc.) in tons and cubic yards for the period 2010 though the most recent period of 2015.

A-3. See the following chart.

CCR Production by Type

	2010 Tons	2010 Compacted Cubic Yards	2011 Tons	2011 Compacted Cubic Yards	2012 Tons	2012 Compacted Cubic Yards
Trimble						
Fly ash produced	146,995	127,822	252,605	219,657	230,769	200,669
Bottom ash produced	36,316	27,450	63,151	47,733	57,613	43,547
Gypsum produced	288,639	237,563	518,441	426,701	515,549	424,320
Ghent						
Fly ash produced	483,480	420,417	472,137	410,554	469,034	407,856
Bottom ash produced	120,315	90,941	118,034	89,217	117,258	88,630
Gypsum produced	910,354	749,262	934,427	769,076	922,862	759,557

	2013 Tons	2013 Compacted Cubic Yards	2014 Tons	2014 Compacted Cubic Yards	Jan-May 2015 Tons	Jan-May 2015 Compacted Cubic Yards
Trimble						
Fly ash produced	236,658	205,790	218,011	189,575	100,992	87,819
Bottom ash produced	59,164	44,720	54,455	41,160	25,233	19,073
Gypsum produced	522,814	430,299	509,476	419,321	247,759	203,917
Ghent						
Fly ash produced	506,354	440,308	461,994	401,734	174,697	151,910
Bottom ash produced	126,588	95,683	115,499	87,301	43,674	33,011
Gypsum produced	1,063,395	875,222	815,949	671,563	309,213	254,496

Calculations were based on the following density

Compacted Density (Tons/Yd3)	
Bottom Ash	1.323
Fly Ash	1.15
Gypsum	1.215

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 4

Witness: Caryl M. Pfeiffer

Q-4. Please provide for the Ghent Generating Station and Trimble County Generating Station, CCR beneficial use by type and use (wallboard, cement, fill, etc.), in tons and cubic yards, for the period 2010 though the most recent month of 2015 available.

A-4. See the following chart.

CCR Beneficial Use by Type and Use

Plant	CCR	Use	2010 Tons	2010 Compacted Cubic Yards	2011 Tons	2011 Compacted Cubic Yards	2012 Tons	2012 Compacted Cubic Yards
Trimble	Bottom Ash	Shingle granules & blasting grit	3,442	2,602	100	76	2,507	1,895
Trimble	Bottom Ash	Ash pond construction	48,000	36,281	2,825	2,135		
Trimble	Bottom Ash	Anti-skid material						
Trimble	Fly Ash	Concrete	6,520	5,670	11,908	10,355	29,156	25,353
Trimble	Fly Ash	Cement kiln feed					43,980	38,243
Trimble	Gypsum	Wallboard	141,026	116,071	142,695	117,444	109,793	90,365
Trimble	Gypsum	Agriculture						
Ghent	Gypsum	Wallboard	218,541	179,869	287,876	236,935	324,802	267,327
Ghent	Fly Ash	Concrete						

Plant	CCR	Use	2013 Tons	2013 Compacted Cubic Yards	2014 Tons	2014 Compacted Cubic Yards	Jan-May 2015 Tons	Jan-May 2015 Compacted Cubic Yards
Trimble	Bottom Ash	Shingle granules & blasting grit	3,500	2,646	2,188	1,654		
Trimble	Bottom Ash	Ash pond construction						
Trimble	Bottom Ash	Anti-skid material	100	76	6,000	4,535		
Trimble	Fly Ash	Concrete	21,539	18,730	14,129	12,286	4,339	3,773
Trimble	Fly Ash	Cement kiln feed	130,762	113,706	123,017	106,971	41,444	36,039
Trimble	Gypsum	Wallboard	89,691	73,820	114,593	94,315	57,036	46,943
Trimble	Gypsum	Agriculture	15,210	12,519	5,047	4,154		
Ghent	Gypsum	Wallboard	308,448	253,867	285,306	234,820	118,773	97,756
Ghent	Fly Ash	Concrete					5,139	4,469

Calculations were based on the following density

Compacted Density (Tons/Yd3)	
Bottom Ash	1.323
Fly Ash	1.15
Gypsum	1.215

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 5

Witness: Caryl M. Pfeiffer

Q-5. Please provide for the Ghent Generating Station and the Trimble Generating Station the amount of CCR transported by truck and by barge from each facility by CCR type in tons, cubic yards and number of truck loads and barges for the period 2010 though the most recent month of 2015 available.

A-5. See attached.

CCR Beneficial Use by Type, Use, and Transportation Mode

Plant	CCR	Use	2010 Tons	2010 Compacted Cubic Yards	2010 Truck Loads*	2010 Barge Loads**	2011 Tons	2011 Compacted Cubic Yards	2011 Truck Loads*	2011 Barge Loads**	2012 Tons	2012 Compacted Cubic Yards	2012 Truck Loads*	2012 Barge Loads**
Trimble	Bottom Ash	Shingle granules & blasting grit	3,442	2,602	191		100	76	6		2,507	1,895	139	
Trimble	Bottom Ash	Ash pond construction	48,000	36,281	2,667		2,825	2,135	157					
Trimble	Bottom Ash	Anti-skid material												
Trimble	Fly Ash	Concrete	6,520	5,670	261		11,908	10,335	476		29,156	25,353	1,166	
Trimble	Fly Ash	Cement kiln feed									43,980	38,243		28
Trimble	Gypsum	Wallboard	141,026	116,071	7,835		142,695	117,444	7,928		109,793	90,365	6,100	
Trimble	Gypsum	Agriculture												
Ghent	Gypsum	Wallboard	218,541	179,869	12,141		287,876	236,935	15,993		324,802	267,327	18,045	

Plant	CCR	Use	2013 Tons	2013 Compacted Cubic Yards	2013 Truck Loads*	2013 Barge Loads**	2014 Tons	2014 Compacted Cubic Yards	2014 Truck Loads*	2014 Barge Loads**	Jan-May2015 Tons	Jan-May2015 Compacted Cubic Yards	Jan-May2015 Truck Loads*	Jan-May2015 Barge Loads**
Trimble	Bottom Ash	Shingle granules & blasting grit	3,500	2,646	194		2,188	1,654	122					
Trimble	Bottom Ash	Ash pond construction												
Trimble	Bottom Ash	Anti-skid material	100	76	6		6,000	4,535	333					
Trimble	Fly Ash	Concrete	21,539	18,730	862		14,129	12,286	565		4,339	3,773	174	
Trimble	Fly Ash	Cement kiln feed	130,762	113,706		84	123,017	106,971		79	41,444	36,039		25
Trimble	Gypsum	Wallboard	89,691	73,820	4,983		114,593	94,315	6,366		57,036	46,943	1,706	
Trimble	Gypsum	Agriculture	15,210	12,519		10	5,047	4,154		3				
Ghent	Gypsum	Wallboard	308,448	253,867	17,136		285,306	234,820	15,850		118,773	97,756	6,599	
Ghent	Fly Ash	Concrete									5,139	4,469	206	

*Truck loads estimated at 18 tons per tri-axle and 25 tons per tractor-trailor

**Barge loads estimated at 1,550 tons per barge

Calculations were based on the following density

Compacted Density (Tons/Yd3)	
Bottom Ash	1.323
Fly Ash	1.15
Gypsum	1.215

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 6

Witness: David S. Sinclair

Q-6. Exhibit G attached to Sterling's Complaint is a PVRR calculation of the gypsum specific Ghent Landfill capital cost and operating and maintenance costs.

a. Please specifically identify any errors in Exhibit G and fully explain the error. By way of example, if the depreciation assumptions are incorrect, please provide an explanation of the error in book or tax depreciable life assumptions, and supply the correct assumptions for book and tax depreciation, with all supporting documentation.

b. What was the PVRR of the gypsum specific costs KU identified in Exhibit F of Sterling's Complaint as originally contemplated in the 2009 KU Application for the Ghent Landfill? Please provide copies of all calculations, work papers, spreadsheets and any other supporting documents, including but not limited to the calculation of depreciation, useful life of landfill component asset cost and deferred tax used in the PVRR calculation.

c. What is the PVRR of the gypsum specific costs of the Ghent Landfill and CCRT facility based upon the actual cost to date of the Landfill, including the CCRT facility, and the most recent projections of the Landfill's future costs? Please provide copies of all calculations, work papers, spreadsheets and any other supporting documents, including but not limited to the calculation of depreciation, useful life of landfill component asset cost and deferred tax used in the PVRR calculation.

A-6. a. Identifying and explaining any errors in Sterling Ventures' Revenue Requirement Summary for the Ghent Landfill Gypsum Disposal Cost would require original work that has not been performed. The Summary Sterling Ventures has prepared contains numerous inputs, assumptions, and calculations based on origins and support unknown to the Companies until adequate discovery responses are received. Assuming that happens, the Companies will be in a better position to disclose their positions with respect to the claims regarding the Ghent Landfill Gypsum Disposal Cost in accordance with the procedural schedule in this case.

b. The PVRR of gypsum specific costs was not computed.

c. The Companies have not performed this analysis.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 7

Witness: John N. Voyles/R. Scott Straight

Q-7. Is the Company or any of its affiliates currently beneficially using any CCR in any of their operations? If so, please describe that use, and explain if and how that use will continue after the effective date of the new CCR regulations

A-7. Currently, Cane Run Station is the only operation beneficially using CCRs on site within the Companies’ fleet. Cane Run is using CCR, in lieu of other clay and soil materials, to cap the ash pond under a permit by rule from the Kentucky Division of Waste Management. The use of CCR for the closure process at Cane Run will terminate by the effective date of the CCR regulation.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 8

Witness: Gary H. Revlett

Q-8. Do the new CCR regulations require Ghent or Trimble County's CCR to be treated prior to beneficial use? Please provide an explanation of your response and citations to economic studies, literature, papers or other information or documentation supporting your response.

A-8. Under the provisions of the federal CCR rule, treatment of CCR may not be required prior to beneficial use as long as all criteria are met. However, depending on the particular beneficial use in question, treatment or processing of CCR may be necessary to achieve required project specifications (e.g., moisture, density) or for cost effective offsite transport. See the response SV 1-9 for more information.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 9

Witness: John N. Voyles/R. Scott Straight

Q-9. If all CCR production from Trimble can be beneficially used off-site, please explain why the CCRT facility would be required? Please provide citations to economic studies, literature, papers or other information or documentation supporting your response.

A-9. The CCRT facility is required to condition the CCR prior to transport to any disposal or storage site, whether it is on-site or off-site, once the on-site impoundments (BAP and GSP) are no longer in use. It is neither feasible, practical, nor economical to move all CCR materials for beneficial reuse or disposal off-site without this conditioning due to the following reasons:

1. The majority of CCR material produced at Trimble County today is transported to on-site storage ponds or to SynMat's gypsum dewatering facility by sluicing (using large quantities of water) through pump and piping systems. It is not practical or economical to move wet materials that are primarily water by either truck or barge. For this reason, and to comply with the requirements of the CCR regulations, dewatering and conditioning the materials in the CCRT facility is necessary to facilitate movement of the materials to any site.
2. The existing equipment and systems at Trimble County for managing CCR materials are not of sufficient capacity or design to fully condition the CCRs into a useable or transportable state for beneficial use or disposal.

Specific information on how each type of CCR is managed and moved currently is described below:

1. <u>Fly Ash</u>
   a. Wet Fly Ash: Unit 1 primarily uses and Unit 2 also uses water to pull fly ash from the units and transport through a sluiced media comprised primarily of water to the bottom ash pond (BAP). This method of ash conveyance has been typical in the coal-fired generation industry that used wet impoundments for ash storage. This transport by water results in the fly ash media being primarily water by volume and thus not a viable option to transport anywhere other than a wet impoundment. The CCRT facilities includes the conversion of the units' wet fly ash transport equipment to dry to allow fly ash to be conveyed pneumatically to

large storage silos (required for surge capacity and operational flexibility) prior to final disposition.

b. Dry Fly Ash: The existing fly ash barge loading equipment is for a portion of Unit 1 and Unit 2 dry fly ash volumes and does not have the capacity to handle all of the fly ash produced by both units. Dry fly ash is similar to face powder and is dusty. This system is used to convey the dry fly ash to two intermediate storage silos. The dry fly ash can either be loaded into fully enclosed "tanker-type trucks" or covered top barges (barges with lids to keep water out) for shipping to off-site beneficial use opportunities. To account for the sizing of the existing dry fly ash system, the CCRT facility includes dry fly ash conveying equipment to transport all of the fly ash volumes produced by Unit 1 and Unit 2 to two new intermediate storage silos as mentioned in 1a above. From these two new intermediate storage silos, the dry fly ash can either be conditioned (i.e. moisture added) by pug mills prior to loading the pipe conveyor (normal) or articulated dump trucks (pipe conveyor maintenance outage) for transport to the landfill, or can by-pass the pug mills and be loaded dry directly into fully enclosed "tanker-type trucks" for beneficial use.

2. <u>Bottom Ash</u>
   a. Unit 1's bottom ash is currently collected in water-impounded bottom ash hoppers directly beneath Unit 1 boiler and sluiced (pumped) to the BAP with large volumes of water. Since Unit 1 bottom ash is currently collected wet and sluiced to the BAP, the CCRT facility includes equipment similar to the Unit 2 submerged chain conveyor to collect and dewater Unit 1 bottom ash for beneficial use or transport to the landfill.
   b. Unit 2's bottom ash is currently collected in a submerged chain conveyor located directly beneath the Unit 2 boiler. Flights are dragged across the bottom of the submerged scraper conveyor to collect the bottom ash, and an inclined ramp is used to dewater the material prior to dumping into a three-walled concrete bunker. Water continues to decant off the bottom ash while it is temporarily stored in the bunker. Unit 2 bottom ash is then loaded into open dump trucks by a front end loaded and placed in the BAP or loaded into covered dump trucks for beneficial use.

3. <u>Gypsum</u>

   Unit 1 and Unit 2 each produce a gypsum slurry byproduct (approximately 80 to 85 percent moisture-water) which is collected as part of the blowdown stream from the wet flue gas desulfurization (WFGD) systems. Unit 1 and Unit 2 gypsum slurry is either pumped to the BAP, the GSP, or to an existing on-site dewatering facility via contract with Synthetic Materials (SynMat). The SynMat dewatering facility dewaters the gypsum slurry to approximately 10 to 15 percent moisture in preparation for beneficial use. The SynMat dewatering facility is not sized to dewater all of the gypsum slurry produced from Unit 1 and Unit 2. As a result, the CCRT facility includes gypsum dewatering equipment with adequate capacity for Unit 1 and Unit 2 gypsum production required to dewater gypsum slurry for beneficial use or transport to the landfill.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 10

Witness: Gary H. Revlett

Q-10. Please list all on-site disposal facilities at either Ghent or Trimble County that would qualify as an "Existing CCR Landfill" under the new CCR regulations. If any of those facilities would qualify as an Existing CCR Landfill as a result of the CCR regulations providing that Existing CCR Landfills must only comply with the location restrictions, but must be closed because the facility does not meet other environmental or operational requirements as set forth in the new CCR regulations (i.e., surface water protection §257.3-3, run-on, run-off controls §257.81), then please identify the reason that the facility could not be used.

A-10. Ghent Station has one facility that constitutes an existing CCR landfill under the CCR Rule. The existing Ghent Station landfill meets all the new federal CCR requirements and will continue to be utilized.

Trimble County Station does not have any facilities that constitute an existing CCR landfill.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 11

Witness: Gary H. Revlett

Q-11. Please identify all existing on-site CCR disposal facilities at Ghent and Trimble County that would be defined as a CCR Surface Impoundment under the new CCR regulations, and state whether those facilities have liners meeting the new CCR location and liner design requirements. If those facilities meet the liner and location restriction, but must be closed for other reasons, please explain those reasons.

A-11. Ghent Station has five facilities that constitute existing CCR surface impoundments under the CCR Rule:

1. Ash Treatment Basin #1
2. Ash Treatment Basin #2
3. Gypsum Stack
4. Secondary Settling Pond
5. Scrubber Reclaim Pond

None of the existing surface impoundments at Ghent will meet the CCR Rule liner requirements. The Companies have not yet determined compliance with the location restrictions for any of the impoundments. Until the requisite data is collected for each of the impoundments within the CCR rule timeframes, none of these impoundments are currently required to be closed.

Trimble County Station has two existing CCR surface impoundments.

1. Bottom Ash Pond
2. Gypsum Storage Pond

The Trimble County Gypsum Pond has a liner system that will meet the CCR rule requirements. The Companies does not believe the Bottom Ash Pond meets the liner requirements. The Companies have not determined at this time compliance with the location restrictions for either of the impoundments. Until the requisite data is collected for each of the impoundments within the CCR rule timeframes, neither of these impoundments is currently required to be closed.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 12

Witness: John N. Voyles/R. Scott Straight/Gary H. Revlett

Q-12. With respect to the Ghent gypsum stacking facility:

a. Is gypsum still to be placed in Ghent's gypsum stacking facility following the completion of the Ghent CCRT facility?

b. Will the Ghent gypsum stacking facility qualify as an "Existing Landfill" under the new CCR regulations? If so, will the Ghent gypsum stacking facility still be used as a landfill after the effective date of the new CCR regulations? Please provide citations to economic studies, literature, papers or other information or documentation supporting your response.

c. Will gypsum in the Ghent stacking facility continue to be used as a source of gypsum for beneficial users, or will all gypsum for beneficial use be loaded from the Ghent CCRT? If both facilities will be used in the future, please identify the criteria or conditions that would determine where gypsum would be sourced.

d. If the gypsum stacking facility continues to be used following the effective date of the CCR rules, what will be the projected available capacity for the next 40 years based on current beneficial use rates?

e. If the gypsum stacking facility is used following the effective date of the new CCR regulations, will gypsum be processed through the Ghent CCRT facility prior to being placed in the gypsum stacking facility?

f. What is the current capacity, and the total projected capacity, of the Ghent gypsum stacking facility?

g. Has the projected annual capacity of the Ghent gypsum stacking facility changed since the original production and capacity assumptions in Exhibit B of Sterling's Complaint? If so, please explain the facts and circumstances with supporting data that are the basis of the revised capacity projections.

A-12. a. Yes, as long as there is remaining storage capacity and regulations allow. However, it should be noted that the Ghent CCRT facility and landfill were placed in service in December 2014. The new gypsum transport system portion of the CCRT facility allows Gypsum slurry to be sent to:

i) The new CCRT to be dewatered for placement in the Phase 1 area of the new landfill for placement or for other beneficial reuse opportunities.

ii) The gypsum stack in emergency situations when gypsum cannot be sent to the CCRT facility. The gypsum stack also receives the filtrate discharge from the CCRT gypsum dewatering facility and fines purged from the WFGD processes.

iii) The existing SynMat facility, located on Ghent's property, to be dewatered for their wallboard manufacturing beneficial reuse purposes per contractual requirements.

b. No. The Ghent Gypsum Stack is an existing surface impoundment under the new CCR rule, not an existing landfill. The Companies plan to continue utilizing the stacking facility after the effective date of the new CCR rule.

c. The Ghent gypsum stack facility is not the primary source of gypsum for beneficial reuse. Gypsum produced by the WFGDs is sent either to the Synmat facility or to the new CCRT facility for de-watering as the primary source of beneficial gypsum for reuse purposes. The Companies are evaluating the new CCR Rule relative to CCR impoundment closures with the possibility of cleaning and closing the gypsum stack and utilizing the material for on-site beneficial reuse to close other impoundments. With regards to both SynMat and the CCRT facilities receiving gypsum, the priority is for SynMat to receive gypsum if they can take it. If SynMat cannot take the wet gypsum, it is sent to the gypsum dewatering portion of the CCRT facility for dewatering where it is then in a state to be transported to the landfill, or loaded onto trucks for SynMat or other entities beneficial reuse.

d. See the response to part c above. The gypsum stack is classified as a CCR impoundment under the CCR Rule and ultimately our expectation will be to close it per the requirements making it unavailable for long term storage of CCR.

e. See the responses to parts c and d above.

f. The total capacity of the gypsum stack is approximately 5.1 million cubic yards. Based on the latest volumetric survey results from November 2014, the gypsum stack has a remaining capacity of approximately 2.9 million cubic yards.

g. The gypsum stack remaining storage capacity changes regularly driven by several variables including unit capacity factors, gypsum placed in the landfill, and contractual take rates for wallboard production.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 13

Witness: Robert M. Conroy

Q-13. Please provide as an excel spreadsheet in the format as presented in Exhibits D and F of Sterling's Complaint, with the projected cost, annual revenue requirements and corresponding PVRR of the Trimble County Landfill, including the CCRT facility, for all years of its projected PVRR life, with copies of all calculations, work papers, spreadsheets and any other supporting documents, including the calculation of operating and maintenance expenses, depreciation, useful life of landfill component asset cost and deferred tax calculations.

A-13. Please refer to the response to SV 1-2 parts g and h.

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Question No. 14

Witness: David S. Sinclair

Q-14. Based upon the most recent projected cost of $501.5M, please provide in an excel spreadsheet the calculation of the PVRR of the Trimble County Landfill. To the extent not included on question 4 above, please provide copies of all calculations, work papers, spreadsheets and any other supporting documents, including but not limited to the calculation of depreciation, useful life of landfill component asset cost and deferred tax calculation used in calculating the Trimble County landfill PVRR.

A-14. See the attached being provided on a thumb drive.

Due to the size of the attachment, it is being filed on CD or separate jump drive. Please see the Petition for Deviation.

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Question No. 15

Witness: John N. Voyles/R. Scott Straight

Q-15. Please provide the CCR capacity of each phase of the Ghent Landfill and the proposed Trimble County landfill.

A-15. The capacities shown below are the values reported in the Special Waste Permit Applications submitted to the Kentucky Division of Waste Management.

Ghent Landfill (million cubic yards)

Phase 1	14.3
Phase 2	14.5
Phase 3	23.0
Total	51.8

Trimble County Landfill (million cubic yards)

Phase 1	6.0
Phase 2	6.9
Phase 3	11.1
Phase 4	9.4
Total	33.4

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Question No. 16

Witness: John N. Voyles/R. Scott Straight

Q-16. The Company provided to the Department of the Army Corps of Engineers ("Corps") the capital cost for the Ravine B landfill in the December 2014 Supplement to Alternatives Analysis (the "404 Supplement"). According to the cost summary included in the 404 Supplement, the capital cost of the Ravine B alternative is $179.7 million.[1] The Company provided information to the Commission in late 2014 that the total capital cost of the Ravine B landfill would be $668.7 million.[2]

a. Please reconcile and provide a detailed description of the capital difference between the $179.7 million cost of the Ravine B landfill as set forth in the 404 Supplement, and the $668.7 million ($501.5M/75%) capital cost provided to the Commission in the Company's 2014 Rate Case, including copies of all calculations, work papers, spreadsheets and any other supporting documents used to identify the capital cost difference.

b. Please identify specifically all of the "Common Cost" referred to in footnote 2 of Table III.D-1 of the 404 Supplement that were omitted from the Table, and the amount of such costs, both in 2012 dollars (per the Table), and the costs in 2015 dollars.

c. If not included in (b) above, please identify specifically any operating and maintenance costs common to all alternatives that were omitted from the Table III.D-1 of the 404 Supplement, and the amount of such costs, both in 2012 dollars (per the Table), and the costs in 2015 dollars.

d. Were PVRR comparative analyses done for the disposal alternatives considered in the 404 Supplement, or in any of the earlier Clean Water Act 404 applications submitted by the Company to the Corps for the Trimble Landfill? If so, Please provide copies.

A-16. a. The tables for cost of the Ravine B landfill as set forth in the 404 Supplement (SAA), and the capital cost provided to the Commission in the Companies' 2014 Rate Case

[1] See Sterling Complaint, Exhibit P at 57 of 183.
[2] See Sterling Complaint, Exhibit T

(2015BP), are not equivalent estimates for comparison purposes, and thus it is not reasonable to make direct comparisons. The SAA is based on a conceptual landfill layout equivalent in level of estimate to all other landfill alternatives evaluated (see SAA-App-IIID-1-p.2), and includes only those scopes and cost in current dollars that are unique to each alternative while excluding cost common to each alternative evaluated (i.e., CCRT). The 2015BP is based on permit application design levels for the landfill in nominal dollars that take into account the actual timing of construction.

A reconciliation of these two different types of estimates is shown in the following table:

Categories ($ millions Gross)	**SAA (original)**	**SAA (2013 Dollars)**	**2015BP**	**Explanation**
Original	180	180	669	
Escalation		6		SAA - for the sake of comparison, the entire estimate was moved into 2013 dollars.
Escalation			-122.6	2015BP - estimate is a sum of nominal (as-spent) dollars which include escalation.
Contingency			-87.3	a) SAA - contingency was not included. b) 2015BP - contingency was included.
CCR Treatment (common cost)			-214	a) SAA - estimate does not include CCR Treatment costs that are common to all alternatives The SAA did include costs for a pipe conveyor which was onsite storage specific. b) 2015BP - estimate includes CCR Treatment costs.
Landfill Design			-53	a) SAA - based on a conceptual landfill layout equivalent in level of estimate to all other landfill alternatives developed (see SAA - App IIID-1 p. 2). b) 2015BP - based on permit application design level of the landfill.
Property Acquisition			-6	a) SAA - did not include property acquisition costs. b) 2015BP - included.
TOTAL CAPITAL COST 2013 Dollars		186	186	

b. Footnote 2 is accurate which states: “"Common cost" Items anticipated to be similar in cost for all case studies are not included (e.g. project management, or the conditioning and treatment of CCR prior to transit from TC Station). Minor construction and operations costs are not included due to the conceptual nature of the design. Examples of these cost items include: minor utility line relocations, minor erosion and sedimentation/storm water management controls, surface and groundwater testing, mowing.” Also see SV Complaint Page 117 of 183 Appendix III D-1 Section 1 paragraph three which provides the explanation.

c. CCRT operating and maintenance costs that were common to all alternatives were not calculated nor were they included in the Table III.D-1 of the 404 Supplement.

d. No, they were not required. PVRR comparative analyses were not done for the disposal alternatives considered in the 404 Supplement, or in any of the earlier Clean Water Act 404 applications submitted by the Company to the Corps for the Trimble Landfill.

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Case No. 2015-00194

Question No. 17

Witness: David S. Sinclair/John N. Voyles/R. Scott Straight/Counsel

Q-17. The Company's original applications with the PSC for CPCN's for the Ghent and Trimble County Landfills included an Exhibit titled: *E.ON Comprehensive Strategy for Management of Coal Combustion Byproducts*, June 2009 (the "Comprehensive Strategy"). (See page 18 of Sterling's Complaint), which contained the following statement on the analysis of beneficial use opportunities (the "Opportunity Process"):

While many factors impact decisions on how to proceed (such as safety, ability to acquire needed permit(s), etc.) present value of revenue requirements is used as the primary economic decision metric. In some instances, additional cost metrics (such as cost per cubic yard or cost per ton) may also be quantified. Documentation for the evaluation is typically produced in close proximity to completing the evaluation. Often the supporting documentation is the source from which many internal and external presentations or business cases discussing the issue are developed. As previously stated, documentation regarding the alternatives is typically developed in coordination with consultants, however, the economic evaluation and associated documentation summarizing the economic evaluation is developed within E.ON U.S. At each decision point (such as formulation of alternatives, evaluation of options, development of documentation), oversight is built into the process to serve as a check. The function of this validation step is to subject the alternatives, evaluation or documentation to extensive "what ifs" and to confirm that a better alternative or solution does not possibly exist. For example, is it possible that more favorable economics could not be achieved by selecting an alternative site or location?

With respect to that statement, please answer the following:

a. Does the first sentence of the Opportunity Process refer to a decision on how to proceed after building and completing the first phase of a landfill only, or does the process also include a decision to proceed with constructing an on-site landfill?

b. If the Opportunity Process does not apply to the initial decision to construct a landfill, please explain why.

c. If the Company did follow the Opportunity Process, please produce the documentation referred to in the statement with respect to Sterling's 2011 proposal to beneficially use gypsum from the Ghent facility in Sterling's underground mine verses building the gypsum handling portion of the Trimble Landfill.

d. To the extent not included in the above request, please provide copies of all emails, correspondence, PVRR analyses, spreadsheets, documentation, internal or external presentations, business cases and any other information prepared and reviewed or discussed with respect to Sterling's 2011 proposal.

e. If KU did not follow the Opportunity Process with respect to Sterling's 2011 proposal, please explain why.

f. In the December 2014 Supplement to Alternatives Analysis provided to the Corps, the Company made the following statement:

> No consideration is given to timing factors that are common in many types of financial analyses, such as for a rate-of-return determination. There is no adjustment for inflation on future operations costs, possible future increases in energy costs, discounting to bring future costs to present value, or return on investment if operation costs are fully funded on Day 1 but only expended over time. LG&E considers the gross costs for construction and 37 years of operations to provide the fairest comparison of relative costs among alternatives.

What does the Company mean by the term "fairest" in its statement above? Is "fairest" synonymous with "best", or is "fairest" a comparative term viewed from the prospective of a party - in this case the Company or its ratepayers?

g. With respect to the above statement, please explain why the Company uses PVRR as the "primary economic decision metric", as stated in the Opportunity Process, for comparing potential beneficial use options if the gross cost provides the "fairest comparison of relative cost among alternatives"?

h. Please provide citations to economic studies, literature, papers or other information or other documentation supporting the conclusion that the gross cost of separate alternatives is the "fairest" method of comparing alternative investment options with differing capital and operating cost components.

i. Please provide copies of all e-mails, correspondence, economic analyses, spreadsheets, documentation, internal or external presentations, business cases and any other information prepared and reviewed or discussed with respect to the

Company's decision to use gross value verses a present value or PVRR comparison in its CWA 404 Alternatives Analysis.

j. In the MACTEC March 2012 Revised 404 Alternatives Analysis (Exhibit J of Sterling's Complaint), MACTEC states at 6-3: "The Preferred Alternative fulfills the responsibility of a publically (sic) regulated utility by the Kentucky Public Service Commission to provide the least cost alternative".

  i. Did MACTEC calculate the least cost alternative of all the presented alternatives, or was that information supplied to MACTEC by the Company?

  ii. With respect to the above statement, was the conclusion based upon a cost analysis using the PVRR of the alternatives considered, or a gross cost comparison similar to that used in the December 2014 Supplement to Alternatives Analysis?

  iii. If MACTEC's statement was based upon a PVRR comparison of the alternatives, please explain why there was a change to using the gross cost comparison in the December 2014 Supplement to Alternatives Analysis.

  iv. If MACTEC's statement was based upon economic analysis criteria other than PVRR or gross cost, please identify that economic comparison method and explain why that criteria was used.

  v. Pease provide copies of all e-mails, correspondence, gross cost, present value or PVRR analyses, spreadsheets, documentation, internal or external presentations, business cases and any other information prepared and reviewed or discussed with respect to MACTEC's statement above, and a decision, if any, to change to the gross cost comparison method used in the December 2014 Supplement to Alternatives Analysis.

A-17. Please note the quote cited in the forgoing request for information is from a much larger section in the *Comprehensive Strategy* document titled "Evaluation Process" at pages 12 through 14 and represents only one of four steps in the process used by the Companies to cost effectively manage projected coal combustion byproduct volumes. The four steps include: identification of alternatives, evaluation of alternatives, documentation of the analysis and identification of necessary refinements to the Companies implementation plan or coal combustion byproduct management strategy.

The term "Opportunity Process" referenced in the request for information is not contained in the *Comprehensive Strategy* document and is an assertion by Sterling Ventures.

a. As discussed above, the phrase “Opportunity Process” is not contained in the document. The sentence referenced in this specific request for information is contained at page 14 of 22 under the subsection labeled “Evaluation, Documentation and Validation” which is a part a larger section titled “Evaluation Process” at pages 12 through 14 of the *Comprehensive Strategy* document. The first sentence is describing a component of the coal combustion byproduct Evaluation Process. PVRR analysis and project feasibility are the primary decision criteria for all certificate of public convenience and necessity (“CPCN”) decisions subject to Kentucky Public Service Commission approval.

b. See the response to response to part a above.

c. The Companies followed the Evaluation Process. See attached. The analysis assumed that Sterling Ventures could store all gypsum from the Ghent station in its underground mine. As a result, the analysis assumed that phase 2 of the proposed landfill would be deferred and phase 3 of the proposed landfill would be eliminated altogether. The associated savings in capital costs was more than offset by increased transportation costs to the Sterling Ventures mine; overall, the proposal increased revenue requirements by $93 million.

d. The information requested to be provided in Excel format is considered to be confidential and proprietary and is being filed under seal pursuant to a Petition for Confidential Protection. Counsel for the Companies is continuing to undertake a reasonable and diligent search for other such documents and will reasonably supplement this response no later than Monday, July 20, 2015.

   Certain documents responsive to this request are not being provided because they contain communications with counsel and the mental impressions of counsel, which information is protected from disclosure by the attorney-client privilege and the work product doctrine. The Company will file no later than Monday, July 20, 2015, a privilege log describing the responsive documents the Companies are not producing on the ground of attorney-client or work product privilege.

e. The Companies followed the Evaluation Process.

f. The December 2014 Supplement to Alternatives Analysis referenced in the request for information was provided to the U.S. Army Corps of Engineers for purposes of the Section 404 permit application. The cost methodology used by LG&E in its alternatives analysis was the most appropriate under the circumstances, allowing LG&E to prepare within a reasonable time a comparison of a large number of alternatives. LG&E’s approach was also consistent with applicable regulations, including the U.S. Environmental Protection Agency’s Section 404(b)(1) guidelines, 40 C.F.R. Part 230, including the “cost considered” criteria, and provided the Corps with the information it needed to determine whether alternatives were practicable for purposes of the Section 404 permit application for the Ravine B landfill. This approach was not biased against Sterling Ventures and its proposed mine fill alternative, which was determined not to be practicable based on a number of significant uncertainties and risk issues independent of cost considerations.

A PVRR analysis of the type urged by Sterling Ventures confirms what the Section 404 alternatives analysis concluded, i.e., that the Sterling Ventures alternative would be substantially more costly than the proposed Ravine B landfill even without adding in costs to address uncertainties.

The Companies' approach in the 2014 Supplement to Alternatives Analysis was the "fairest" in the sense that it provided a reasonable comparison of the relative costs of the alternatives for purposes of identifying the "least environmentally damaging practicable alternative" for purposes of the 404 permit application process.

g. The document referred to in this question (which does not contain the phrase "Opportunity Process" as alleged in the question), is more focused on Kentucky CPCN and related ratemaking law (specifically, the PVRR and feasibility of a project) than with the environmental impact focus in the 404 permit process. As stated in the response to part a above, PVRR and the feasibility of a particular project are the primary decision criteria for all CPCN decisions subject to Kentucky Public Service Commission approval. These criteria have been long established under Kentucky law. As referenced in the response to part f above, that is not necessarily the case in the 404 permit process which is more focused on the "least environmentally damaging practicable alternative" and associated impacts of a project.

h. See the response to part f above.

i. Counsel for the Companies has not yet found any non-privileged documents responsive to this request; however, counsel is continuing to undertake a reasonable and diligent search for other such documents and will reasonably supplement this response no later than Monday, July 20, 2015.

   Certain documents responsive to this request are not being provided because they contain communications with counsel and the mental impressions of counsel, which information is protected from disclosure by the attorney-client privilege and the work product doctrine. The Companies will file no later than Monday, July 20, 2015, a privilege log describing the responsive documents the Companies are not producing on the ground of attorney-client or work product privilege.

j. The term "Preferred Alternative" in the sentence referenced in the request for information is defined in the document to mean "the storage of CCR material in Ravine B" or the Trimble County Landfill. The sentence quoted in the request simply acknowledges that the proposed landfill also satisfies the least-cost and the feasibility decision criteria Kentucky Public Service Commission purposes.

i. No, in the 2012 Alternative Analysis MACTEC did not complete a quantitative cost analysis of any of the alternatives. MACTEC eliminated all other alternative sites due to factors other than cost.

ii. As stated in the response to part j subpart i above, no quantitative cost analysis was performed by MACTEC.

iii. See the response to part J subparts i and ii above.

iv. MACTEC performed no economic analysis for any alternative.

v. Counsel for the Companies has not yet found any documents responsive to this request; however, counsel is continuing to undertake a reasonable and diligent search for other such documents and will reasonably supplement this response no later than Monday, July 20, 2015.

Ghent Station:
Analysis of Off-Site Gypsum Storage Proposal

PPL companies

Generation Planning & Analysis
February 24, 2012

February 24, 2012

1 Background

In the June 2009 ECR filing, several alternatives were considered for storing coal combustion residuals (CCR) at the Ghent Station over the next 25 years. The least-cost alternative included (a) the construction of an on-site landfill to store ash and gypsum and (b) a short-term agreement with Trans Ash to move CCR offsite until new landfill capacity became available in 2013. After the ECR filing, the EPA issued new CCR rules and Trans Ash's storage facility was no longer considered to be an approved structural fill. In 2010, after updating its forecast of CCR production, the Company learned that the short-term need for off-site ash storage had been eliminated and that the short-term need for offsite gypsum storage had been reduced to 0.1 million cubic yards (MCY). Sterling Ventures (Sterling) was identified as a potential alternative for storing the gypsum but no agreement was ultimately reached. Based on the Company's most recent CCR production forecast, the short-term need for offsite gypsum storage no longer exists. In late 2011, Sterling Ventures submitted a new proposal for storing gypsum.

2 Sterling Proposal

Sterling has proposed to store all gypsum from the Ghent Station (net of sales to CertainTeed) in its offsite storage facility for $10.95/ton. Per the proposal, Sterling will excavate, load, and haul gypsum from the existing gypsum stack at the Ghent station. In doing this, Sterling claims that the Company can defer the need for subsequent landfill phases and avoid approximately $53 million in capital costs for a dry gypsum handling system, gypsum fines project, and gypsum dewatering facility. In addition, by eliminating the need to store gypsum altogether, Sterling claims that Company can realize further capital savings by reverting to a CCR storage alternative from the 2009 ECR filing that included a smaller landfill located closer to the Ghent station. Finally, in addition to its proposal for storing gypsum, Sterling has proposed to backhaul high calcium limestone to the Ghent station for $6.50/ton. See Attachment 1 for the Sterling Ventures proposal.

3 Analysis of Sterling Proposal

The Company considered the Sterling proposal as an alternative to its current plan. Due to the costs and risks associated with operating a gypsum stack, the Company plans to retire the gypsum stack when the new landfill is in service. Therefore, contrary to Sterling's claims, Sterling will not be able to take gypsum from the existing gypsum stack and the Company will not be able to avoid the capital costs for the dry gypsum handling system, gypsum fines project, and gypsum dewatering facility. In addition, selecting a different landfill alternative at the Ghent station is not a viable option because this would require new environmental permits and delay the project by two years.

Table 1 contains a summary of the assumptions used in this analysis. The Sterling proposal defers the need for Phase II of the currently proposed landfill and eliminates the need for Phase III of the landfill altogether. Because gypsum comprises 60% of all CCR, Phases I and II of the landfill with the Sterling proposal have seven more years of landfill capacity than all phases of the landfill without the Sterling proposal. With the Sterling proposal, gypsum is dewatered at the station and transported by Sterling to an offsite storage facility for $10.95/ton. With the Company's current plan, gypsum with the same moisture content is delivered to the landfill for $4.43/ton.

Table 1 – Summary of Assumptions ($2013)

	Landfill Only	**Landfill w/ Sterling Ventures Proposal**
In-Service Year/Capacity of Phase I	2013 / 14.3 MCY	2013 / 14.3 MCY
In-Service Year/Capacity of Phase II	2022 / 14.5 MCY	2028 /14.5 MCY
In-Service Year/Capacity of Phase III	2031 / 23.0 MCY	N/A
Landfill End of Service Year	2046	2053
Dewatering Cost (all CCR)	$112,200 per month	$112,200 per month
Sterling Transport and Storage Cost	N/A	$10.95/wet ton
Cost to Place CCR in Landfill	$4.43/wet ton	$4.43/wet ton

The results of this analysis are summarized in Table 2. The levelized cost per cubic yard of CCR placed (either in the landfill or transported to an offsite storage facility) is lower in the Company's current plan; the savings in the Sterling proposal associated with deferring or eliminating the need for landfill phases are more than offset by the higher variable costs of transporting gypsum to an offsite storage facility.

Table 2 – Analysis Results

	Landfill Only	**Landfill w/ Sterling Ventures Proposal**
Net Present Value Revenue Requirements (NPVRR, $Millions)		
Capital	348	297
O&M	169	313
Total	517	610
Levelized NPVRR/CY (Dollars)	$24.51	$27.63

Sterling's cost to transport and store gypsum is $10.95/wet ton. This cost must decrease to $7.50/wet ton to break even with the Company's current proposal.

Concerning the option to purchase limestone from Sterling, Ghent's current cost of limestone is higher than $6.50/ton. If the savings in limestone costs are credited to the Sterling proposal, the Sterling proposal compares more favorably to the Company's current proposal, but the Company's current proposal is still least-cost. With the limestone option, Sterling's 'break-even' cost increases from $7.50/wet ton to $8.75/wet ton.

Attachment in Separate File

The attachment is being provided in a separate file.

From: Kevin Resnik, Jr.(k.resnik@gaiconsultants.com)
To: Waterman, Bob
CC: Lipp, Joan; Watson, Joseph; Stinnett, Jennifer; Beach, Jarrett; Gebert, Morgan; Kent Cockley; Amy Bartkus; Mike Frank; Rhombus Harloff
BCC:
Subject: RE: TC CCR: Supplemental Alternative Analysis ---- Appendix III.D-1and Table III.D-1
Sent: 12/12/2014 04:19:34 PM -0500 (EST)
Attachments: Appendix III D-1 Methods for Assessment of Costs FINAL.pdf; Table Appendix III.D-1 - Unit Cost Development FINAL.pdf; Appendix III D-1 Methods for assessment of costs FINAL.docx;

Privileged and Confidential
Attorney Work Product
Attorney-Client Communication

Bob:

Attached is revised FINAL Appendix III.D-1, and Table Appendix III.D-1. I have also included a track changes copy of Appendix III.D-1 for ease of review.

Thanks,
Kevin

Kevin P. Resnik, E.I.T.
Senior Project EIT

GAI Consultants, Inc.
385 East Waterfront Drive
Homestead, PA 15120-5005

412.476.2000 ext. 1543 | C 412.523.4209 | F 412.476.2020 |

From: Waterman, Bob [mailto:Bob.Waterman@lge-ku.com]
Sent: Tuesday, December 09, 2014 12:09 PM
To: Kent Cockley; Kevin Resnik, Jr.; Amy Bartkus; Mike Frank
Cc: Lipp, Joan; Watson, Joseph; Stinnett, Jennifer; Beach, Jarrett; Gebert, Morgan
Subject: TC CCR: Supplemental Alternative Analysis ---- Appendix III.D-1and Table III.D-1
Importance: High

Privileged and Confidential
Attorney Work Product
Attorney-Client Communication

Kent, Kevin, Amy, and Mike:

Please find the Track Change version with comments from Jack, Tom, and Lee for Appendix III.D-1. They also note that the Table is cited as Appendix Table III.D-1.

After you make the revisions, please return to me.

Thanks,

Robert C. Waterman, PE
LG&E and KU Services Company
Project Engineering Department
502-627-2439
502-548-9117 (cell)

APPENDIX III.D-1 – METHODS FOR ASSESSMENT OF COSTS

SECTION 1: APPROACH TO COST ANALYSIS

- Costs for the four case study alternatives are presented in conceptual detail in Tables III.D-1 through III.D-4 in the Supplement. For selected other alternatives, cost information is provided in Appendix IV.A-2. Analyses of project costs can apply different methodologies depending on the purpose for which the cost estimates are being made. For an alternatives analysis, the primary requirement is to generate costs that allow a fair comparison among conceptual alternatives. As such the cost analysis in GAI (2014) and in this Supplement reflects the following considerations.Costs that are common to every alternative do not need to be estimated or presented. An example for the case of CCR disposal is that all material must be processed and treated to be in a dry form (<20% moisture content) before it is transported offsite. At Trimble County Generating Station, this cost alone is estimated to exceed $6 per cubic yard. The treatment cost does not vary among alternatives and therefore is not included in the cost comparisons among alternatives. The costs in the Supplement are those appropriate for comparison among disposal alternatives, and do not represent the full cost of CCR management.
- Cost factors that are simple multipliers of construction costs are not included. An example of this is any allowance for contingencies or uncertainties. The effect of such a multiplier is to widen the gap between the lower and higher cost alternatives, which has the potential to bias the analysis toward the lowest-cost option. An exception to this consideration can be when these simple multiplier costs are projected to be significant for one type of CCR disposal facility (e.g. landfill) and insignificant or absent in another (e.g. mine). In addition, in a few instances, where a cost was developed based on a bid from a third party, which included a contingency, this is included if LG&E determined it was justified. In the late stages of an alternatives analysis, these factors can be considered if and when there may be marked differences in engineering or contingency costs between two alternatives that are otherwise close in cost.
- The line items included in the cost analysis in GAI (2014) were not "all inclusive", i.e. the line items included were only those anticipated to differ significantly between landfill alternatives. Consequently, a number of line items and their associated costs were excluded, assuming they were similar among all alternatives considered, and would not affect the overall cost difference between alternatives[1]. However, in this Supplement there are two case studies (Sterling Ventures and Valley View) that do not involve construction and operation of a conventional CCR landfill, but instead will charge a tipping fee to accept CCR material from LG&E. Therefore, Tables III.D-1 through III.D-4 include line items 38 and 47, "Additional Capital Costs" and "Additional Operations and Maintenance (O&M) Costs" respectively, to account for these costs

[1] While the Valley View Municipal Solid Waste Landfill, which was an alternative considered in GAI, 2014, is not a landfill alternative that LG&E would construct and manage, the costs associated with that alternative were so far in excess of the costs for the Ravine B alternative that it was not believed to be necessary to include these additional costs for all other alternatives solely for the sake of comparison to Valley View.

that can no longer be omitted as they will now vary between alternatives. The additional line items and associated costs included on Tables III.D-1 through III.D-4 are explained further in Support Document III.D-1-17 provided on a digital disk submitted with this Supplement.

- No consideration is given to timing factors that are common in many types of financial analyses, such as for a rate-of-return determination. There is no adjustment for inflation on future operations costs, possible future increases in energy costs, discounting to bring future costs to present value, or return on investment if operation costs are fully funded on Day 1 but only expended over time. LG&E considers the gross costs for construction and 37 years of operations to provide the fairest comparison of relative costs among alternatives.
- Costs that are expected to be small for any alternative are not quantified. An example is the cost for relocation of local water, sewer and other utility lines, which are typically a fraction of one percent of total costs. These small costs are reasonably ignored given they are dominated by the costs of landfill and transportation system construction and operation. In contrast, relocation of a large transmission line is costly enough to be considered.
- While LG&E understands that unit costs can vary on a year to year basis, costs in this analysis are not adjusted based on a particular year. Costs in GAI (2014) are based on 2012 data. Accordingly, to respond to EPA's requests for additional documentation on evaluated alternatives, the Supplement uses the same 2012 cost basis and provides more detailed documentation of the underlying cost estimates. A few cost elements developed specifically for this Supplement are based upon 2013 or 2014 information. For initial comparison purposes, it is considered acceptable to have a mixture of years in the cost estimates, so long as for any one project element (such as barge transportation) the estimates are consistent among all alternatives (in that case, 2014). In the late stages of an alternatives analysis, adjustment of costs to a common year can be considered if and when the result could markedly affect the cost comparison between two alternatives that are otherwise close in cost.
- Costs are based on relatively comparable levels of conceptual engineering. The expectation is that for any alternative, more detailed design-level engineering would identify additional cost items or contingencies. To make a fair comparison, costs for all alternatives have been made based solely on conceptual-level engineering. The assessment is more detailed for alternatives in Section III and order-of-magnitude for alternatives in Section IV.

The Alternatives Analysis in GAI (2014) involved estimation of planning-level costs for several dozen CCR disposal alternatives. This Appendix documents the methods used for those estimates in more detail than was provided in GAI (2014), as well as additional cost information analyzed specifically in the case study analysis.

The development of the comparison cost estimates for the alternatives included the following steps, detailed in the following sections of this Appendix.

- Section 2 describes the identification of project elements which may be different between generic alternative designs that would account for major cost components. Construction and operation elements were identified separately based on experience with the full range of elements in a large CCR disposal facility project.
- Section 3 describes how a unit cost was prepared based on known or reliable cost sources such as a.) known standardized construction cost estimating reference books (e.g. RS Means), or b.) estimated costs quoted specifically for the alternatives analyzed in this report, or c.) estimated costs quoted from similar components of comparable past projects (i.e. past construction bid/cost experience and/or vendor/supplier quotes) for each category of project element.
- Section 4 describes how the magnitude (or unit quantity) of each element was estimated based on conceptual design drawings or other project-specific considerations.
- Section 5 describes how costs for each project element were totaled by multiplying the unit cost by the unit quantity. Costs for a few project elements were calculated on a specific site-by-site basis. An example explanation of how the unit costs and unit quantity are used to develop the cost for a particular Line Item is also included in this section.

Each step in this methodology is explained and documented here in Appendix III.D-1. If a unit cost requires additional justification or backup information, it is included in the Support Documents provided in the digital disk submitted as part of this Supplement. Appendix III.C-1 describes the conceptual design process for CCR landfills and the types of project attributes that may require a cost estimate. Tables III.D-1 through III.D-4 provide the results of the application of these methods to the four case studies.

SECTION 2: PROJECT ELEMENTS ANALYZED FOR COST

The first step in the assessment of costs was to identify the project elements that would account for major costs for a CCR disposal facility. Based on past experience with construction and operation of large CCR disposal facilities, project elements that were anticipated to cause significant differences in costs between the alternatives were identified as described below. As described above, project elements that were anticipated to be similar or the same between alternatives [for example, project management, quality assurance/quality control (QA/QC), CCR treatment and transportation system at TC Station, etc.], were not included in the cost analysis.

The following project elements were identified to be major components for a CCR disposal facility for which costs were to be developed. The project elements have been grouped between capital and operation and maintenance (O&M) costs.

Line Item #	Description	Cost ($)	Per Unit
Capital Costs			
1	Property Acquisition	$12,000	Acre
2	Clearing, Grubbing, and Site Preparation	$17,000	Acre
3	Large Utility Line Relocation	$880	Linear Foot

SUPPLEMENT TO ALTERNATIVES ANALYSIS

Line Item #	Description	Cost ($)	Per Unit
			(LF)
4	Fencing	$50	LF
5	Environmental Wetland Mitigation (cost based on adjusted mitigation units (AMU) and may be increased by 1.2 factor for temporal loss if In Lieu Fee option is utilized; rate of $72,000/acre includes the 1.2 factor)	$72,000	Acre
6	Environmental Stream Mitigation (cost based on AMU and may be increased by 1.2 factor for temporal loss if In Lieu Fee option is utilized)	$170	AMU
7	Cultural Resources (Potential Phase III data recovery)	Varies	EA
8	Indiana Bat Mitigation	$5,338	Acre
9	Road Relocation (County Road)	$350	LF
10	Road Relocation (State Road)	$400	LF
11	Pipe Conveyor Transport (similar to North Ridge Top path at Ravine B)	$2,150	LF
12	Pipe Conveyor Transport (similar to Ogden Ridge Road path at Ravine B)	$2,425	LF
13	Pipe Conveyor Transport (similar to South Ridge Top path at Ravine B)	$3,125	LF
14	Transfer Station	$250,000	EA
15	Haul Road - Off Landfill	$1,600	LF
16	Bridge - Large (36 Feet (FT) high, 440 FT long, 60 FT wide)	$4,000,000	EA
17	Bridge - Medium (200 FT long, 60 FT wide)	$1,750,000	EA
18	Perimeter Collection Channel - Fabric Form, 6-10' Bottom Width	$75.00	LF
19	Upslope Drainage Diversion Channel - Fabric Form, 1-5' Bottom Width	$50.00	LF
20	Subgrade Preparation - General Earthwork - Soil Inside Footprint (3000 foot Round Trip)	$5.65	CY
21	Subgrade Preparation - General Earthwork - Rock Blasting (3000 foot Round Trip)	$21.72	CY
22	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 1/2 Mile	$5.65	CY
23	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 1 Mile	$5.94	CY
24	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 2 Miles	$6.84	CY
25	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 4 Miles	$8.36	CY
26	Landfill Composite Liner System - 0.5 mi Round Trip Protective Cover/4 mi Round Trip Drainage Layer	$91,000	Acre
27	Landfill Composite Liner System - 1.5 mi Round Trip Protective Cover/4 mi Round Trip Drainage Layer	$93,000	Acre
28	Landfill Composite Liner System - 0.5 mi Round Trip Protective Cover/2 mi Round Trip Drainage Layer	$88,000	Acre
29	Groundwater Underdrain Drainage Pipes	$6,000	Acre
30	Leachate Collection System Drainage Pipes	$15,000	Acre
31	Large Erosion and Sedimentation/Stormwater Management (ES/SWM) Pond and Leachate Pond - Earthwork and Liner System (~35 acre-ft)	$3,000,000	EA
32	Medium ES/SWM Pond and Leachate Pond - Earthwork and Liner System (~20 acre-ft)	$2,000,000	EA
33	Final Cover System - 2 Mile Round Trip (12 Inches Clay; 12 Inches Topsoil)	$29,000	Acre
34	Final Cover System - 4 Mile Round Trip (12 Inches Clay; 12 Inches Topsoil)	$33,000	Acre

Line Item #	Description	Cost ($)	Per Unit
35	Barge Loading Facility	$8,300,000	EA
36	Barge Unloading Facility	$16,100,000	EA
37	Ancillary Costs (Critical Spares and Office/Warehouse Space)	$1,600,000	EA
38	Additional Capital Costs	Varies	LUMP
Operation and Maintenance (O&M) Costs			
39	Hauling - 1 Mile Round Trip (22 CY on landfill/private road)	$2.56	CY
40	Hauling - 2 Mile Round Trip (22 CY on landfill/private road)	$3.46	CY
41	Hauling - 3 Mile Round Trip (22 CY on landfill/private road)	$4.19	CY
42	Hauling - 30 Mile Round Trip (18 CY, 35 MPH avg)	$11.55	CY
43	Offsite CCR Disposal - Tipping Fee	Varies	TON
44	Pipe Conveyor Cost of Operation	$0.20	CY
45	Barge Loading and Unloading Operation Cost	$1,100,000	YR
46	Barge Transportation Costs	Varies	TON
47	Additional O&M Costs	Varies	LUMP

SECTION 3: UNIT COST DESCRIPTION

A variety of sources were consulted to calculate the unit costs for each project element. For standard construction costs, such as hauling, excavating, general earthwork, etc, the 2012 edition of *RS Means Heavy Construction Cost Data* was used. RS Means is widely accepted in the construction industry as one of the standards in construction cost valuation. The RS Means source provides unit costs on a nationwide level and a 'location factor' for various cities/areas throughout the United States that allows for inflation or deflation of unit costs. The 'location factors' are percentage ratios of a specific city's material and labor costs to the national average cost of the same item. The location factor from Frankfort, KY was selected for use in all cost estimating, as it is the city listed in RS Means with the closest proximity to the alternatives evaluated. The location factor used in all RS Means sourced unit costs is 0.76.

More complex project element costs (such as property acquisition, utility relocations, bridges, haul road, ponds) were typically developed from GAI or LG&E experience on previous projects and adapted or scaled to the conceptual alternatives analyzed herein. For other project elements that required outside reference (such as off-site CCR disposal/tipping fee or pipe conveyor and barge transport), unit cost information was sourced from available vendors and suppliers in the form of price quotes and budgetary cost estimates. All costs are calculated on a 2012 dollar basis except as noted in Section 4. A breakdown of the unit costs, including a listing of the elements combined to develop each unit cost, can be found in Table Appendix III.D-1– Unit Cost Development. A description of the layout and format of Table Appendix III.D-1 is as follows:

> From left to right, the column headings include the Line Item number, a checkbox that identifies whether the project element is a capital or O&M cost, a description of project element, the unit cost, the unit, the source of costing information, the RS Means # (if applicable), and any conversion calculations used to convert units. When multiple sub-items comprise a line item, the total was added up and rounded for ease of calculation.

Line Item costs that were developed from RS Means display the RS Means Item Number (correlates to the Line Item number provided in the *2012 RS Means Heavy Construction Cost Data* source books), the Line Item's original cost and unit, the adjusted cost using the location factor for Frankfort, KY, and, if necessary, the unit adjustment equation to calculate the cost in a more reasonable and easily estimated unit for the estimate (for example, converting a $ per square yard cost into $ per acre). The scans of the pages from RS Means used for the unit cost development are included as Support Document III.D-1-1.

For Line Items not developed from RS Means, and that required additional backup cost sheets, price quotes, or calculations, a short description of the source is included in the fourth column and a reference to Support Documents III.D-1-2 through III.D-1-19 is listed in the last column on the right of the table. Support Documents III.D-1-2 through III.D-1-19 include detailed backup for how these unit costs were developed.

SECTION 4: UNIT QUANTITY DEVELOPMENT

Once the Line Items were identified and unit costs for those elements were developed, the unit quantity of each Line Item was estimated for various alternatives based on conceptual design drawings and/or other project specific considerations as described herein.[2] A description of how the units for each Line Item were quantified is described below. Also included for each Line Item is a listing of the unit cost and how the unit is multiplied by the unit cost in order to quantify the estimated cost for each Line Item.

CAPITAL COSTS

Line Item 1 - Property Acquisition – A conceptual impact boundary was developed based on space required to build the CCR disposal facility, roads, pipe conveyor, borrow areas, spoil areas, laydown facilities, erosion and sedimentation/stormwater management (ES/SWM) ponds, and other ancillary facilities needed for a case study alternative. Property line information was obtained from local Property Valuation Assessment (PVA) data or existing property mapping provided by LG&E. When the impact boundary encroached at all on a property, it was assumed that the entire property would need to be purchased, with the exception of Sterling Ventures Mine, which assumes only portions of existing property encompassing the impact boundary needed to construct and operate barge unloading facility, pipe conveyor, and haul roads, would be purchased due to these parcels being large (on the order of hundreds of acres each). The total acreage of property is multiplied by the unit cost of $12,000/acre (a cost provided by LG&E based on past real estate experience[3]) to quantify the cost to acquire the property.

Line Item 2 – Clearing, Grubbing, and Site Preparation – Line Item 2 is comprised of the following two components, with unit costs given on a 'per acre' basis:

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[2] Detailed cost estimates were not needed for all alternatives for purposes of a comparative, screening level analysis. For example, a number of alternatives were determined to be not practicable based on key logistical concerns (such as lack of capacity) alone.

[3] All property was assumed to be $12,000/acre. However, property value may vary based on location. For example, Lee Bottom Flying Field may be more expensive.

-Cut and Chip Trees

-Grub Stumps and Remove

A conceptual impact boundary was developed based on space required to build the CCR disposal facility, roads, pipe conveyor, borrow areas, spoil areas, laydown facilities, ES/SWM ponds, and other ancillary facilities needed. The total forested acreage within the impact boundary, defined as any area observed to have tree cover, was calculated using United States Geological Survey (USGS) and/or aerial imagery mapping. This acreage was multiplied by the unit cost of $17,000/acre to quantify the cost to clear, grub, and prepare a site for development.

Line Item 3 – Large Utility Line Relocation – To quantify the length of utility line relocation for an alternative, aerial photography was used to identify large overhead transmission lines similar to the one that crosses the existing LG&E property in Ravine B. Where these lines crossed a facility, a route around the facility was sketched and the length of the approximate rerouted line was measured.

In order to calculate a cost for Line Item 3, the total linear footage of the utility line that crossed over the facility was multiplied by the unit cost of $880/linear foot (LF).

Minor utility line relocations are not included in this analysis.

Line Item 4– Fencing – Multiple components were included in the development of the total unit cost used in Line Item 4. These components include:

- Corner posts, line posts, corner and end post bracing, top rail, rail – middle/bottom, reinforcing wire, steel t-post, barbed wire, extension arms, eye tops – 2-3/8", chain link fencing, and gates.

With a few exceptions, fencing was placed to enclose the entire project area of an alternative, resulting in the conceptual impact boundary perimeter generally being used for the quantity. Where the topography, such as steep slopes, did not necessitate fencing or where there was already an existing fence present, such as around the TC Station, fencing was not quantified.

In order to calculate a cost for Line Item 4, the total linear footage of the impact boundary perimeter was multiplied by the unit cost of $50/LF.

Line Items 5 and 6 – Environmental Wetland and Stream Mitigation

For the Ravine B alternative, actual field-verified data and location coordinates were utilized within a GIS program to determine the total stream lengths and wetland acreages that would be impacted.

Where field-verified stream and wetland data were not available, GIS mapping techniques and publically available data sources from various government agencies were utilized to estimate the lineal feet of streams and acreage of wetlands that may be impacted. An impact boundary was first established for an alternative based on predicted land disturbances from various construction and operational activities. The locations of potential wetland areas were obtained from the National Wetland Inventory (published by the United States Fish and Wildlife Service [USFWS]). The locations of major streams were obtained from the National Hydrography Dataset (published by the United States Geological Survey [USGS]). The location of smaller streams were estimated utilizing published topographic contour data by delineating (in GIS software) streams based on the presence of ravines and high-gradient slopes. Assumptions were made concerning the stream type (ephemeral or intermittent) for these contour-based stream estimates. These assumptions were based upon knowledge of the terrain and typical stream occurrences in such areas of the Bluegrass bioregion and surrounding areas.

Under the wetland and stream compensatory mitigation Fee In-Lieu Of (FILO) program, the United States Army Corps of Engineers (USACE) directs an applicant to utilize multipliers based on the table published on the USACE's Louisville District website as presented below. To derive the amount of adjusted mitigation units (AMUs) for a specific stream reach, the multiplier is selected from the USACE's table based on the stream's flow classification (ephemeral or intermittent for this Project) and the stream's quality based on the narrative rating (good, fair, poor). The narrative rating is determined from the stream habitat score that is calculated utilizing the high-gradient stream data sheet procedure. The completion of the high-gradient stream data sheet procedure, which constitutes the rapid bioassessment protocol, is described in Kentucky Division of Water's (KDOW) Methods for Assessing Habitat in Wadeable Waters (2011).

The Kentucky Department of Fish and Wildlife Resources (KDFWR) is the state agency responsible for implementing stream and wetland restoration projects in Kentucky under the FILO program, and the agency establishes the costs per AMU for compensation purposes. The cost rate of $170 per stream AMU and $72,000 per wetland acre (based on mitigation ratio of 2.0 for all wetland acres and temporal loss factor of 1.2 as the USACE requires) was utilized to estimate mitigation fees for all alternatives for which cost estimates were developed. These AMU cost rates were in effect at the time of the initial alternatives analysis (2012) where mitigation cost estimates were initially developed for several alternatives as reported in GAI, 2014. These AMU values were applied to all cost estimates for consistency and comparison of alternatives. Note that the actual mitigation fee for an alternative will be based on the AMU cost rate in effect at the time of project implementation. For example, the KDFWR's website (accessed September 25, 2014) reports a cost per AMU of $240 for stream impacts within the Salt River Watershed area, in which all alternatives are located with the exception of Lee Bottom, Sterling Ventures, and Bethlehem Terrace. A temporal loss and cumulative impacts factor of 1.2 is also applied to the total stream and wetland AMUs for a project that utilizes the FILO program. Note that this 1.2 factor was applied to the mitigation cost estimates for all alternatives for which cost estimates were prepared (e.g., the wetland mitigation fee would therefore be $72,000 per acre). If the option of purchasing mitigation bank AMU credits is selected instead of the FILO program, then the temporal loss factor may not apply.

The cost for Line Items 5 and 6 were calculated on a site-by-site basis based on the factors discussed above.

The USACE's website includes the following mitigation calculator tools, which were accessed on September 25, 2014 (http://www.lrl.usace.army.mil/Missions/Regulatory/Mitigation/InLieuFeeProgram.aspx).

Line Item 7 – Cultural Resources (Potential Phase III data recovery) – A high level, conceptual lump sum cost was developed for each case study alternative to perform Phase I to Phase III archaeological investigations on potential archeological sites and Phase I survey and Criteria of Effect Studies for architectural/historical resources that could be affected or disturbed as a result of the project. These cost estimates are based on the number and location of previously recorded archaeological sites and architectural/historical resources and the potential to find previously unrecorded archaeological sites and architectural/historical resources. Existing data sources were consulted during this process. The data sources include aerial photographs, historic maps, and records on file at various state agencies, such as Indiana Department of Nature Resources, Historic Preservation and Archaeology (DHPA), Indiana State Historic Architectural and Archaeological Research Database (SHAARD), Kentucky Office of State Archaeology (OSA), and Kentucky Heritage Counsel (KHC). Each location had landform variables that were also considered during this process. Steep slopes, disturbed settings, and wetlands have a low potential for archaeological sites. Moderately sloping landforms with intact soils have a moderate potential for archaeological sites. Gently sloping to level areas have high potential for archaeological sites. Due to proximity to water and water-related resources, intact floodplain and terrace settings along the Ohio River have the highest potential for large prehistoric sites that have the potential to provide significant information towards our understanding of regional prehistory. Historic era domestic sites built prior to the mid-twentieth century and not impacted by later development have the highest potential to provide significant information for understanding regional history. The cost for Line Item 7 was calculated on a site-by-site basis based on the factors discussed above[4]. See Appendix III.C-1 for further description of the cultural resources process.

Line Item 8 – Indiana Bat Mitigation – The result of the Endangered Species Act Section 7(a)(2) consultation process with USFWS will likely result in requirements for compensation of lost Indiana bat habitat for any alternative involving clearing of forested areas. Until the consultation process is complete, it is unknown if USFWS will request that land be purchased through a land trust or conservation bank, deeded to a conservancy, or accepted as a deposit through the Indiana Bat Conservation Fund (IBCF). However, the USFWS Biological Opinion on Conservation Memoranda (BO) provides a methodology to estimate the cost of the mitigation. The BO suggests using a base mitigation fee equal to the average value of farm real estate as published annually by the United States Department of Agriculture (USDA) Land Values and Cash Rents report, with a multiplier based on the season of Indiana bat occupancy. The Indiana Bat mitigation fee of $5,338 per acre was applied to all cost estimates for consistency and comparison of alternatives. This mitigation fee rate was in effect at the time of the initial alternatives analysis (2012) where mitigation cost estimates were initially developed for several alternatives as reported in GAI, 2014. The mitigation rate was calculated as the average of the lowest per acre fee of $4,575 (for tree clearing between August 14th through March 31st) and the higher cost per acre fee of

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[4] Extensive cultural resources investigations have occurred to date in the Ravine B area as part of project planning/design. Therefore, cultural resources costs for alternatives located in the proximity of Ravine B represent more detailed knowledge and are estimated as being more expensive than off-site alternatives (e.g. Lee Bottom). As stated above, intact floodplain and terrace settings along the Ohio River have very high potential for archaeological sites.

$6,100 (for tree clearing between April 1st through August 15th) assuming the project area was designated as a "known maternity" area for the Indiana bat. The use of this average mitigation fee rate is based on the assumption that tree clearing would need to occur at various times throughout a given year, including during the maximum mitigation fee period, for construction purposes. Note that the actual mitigation fee for an alternative will be based on the mitigation fee per acre in effect at the time of project implementation (assuming that the USACE and USFWS requires this mitigation fee approach to compensate for habitat loss). For example, the project area is now (2014) designated as a "known non-materinity" area therefore the fee per acre could actually be less. Refer to Support Document III.D-1-4 for additional information on the basis of mitigation costs.

In order to calculate a cost for Line Item 8, the unit cost of $5,338/acre was multiplied by the total forested acreage within the impact boundary, where the acreage was estimated using USGS and/or aerial imagery mapping.

Line Items 9-10 – Road Relocation (County/State Road) – GAI developed a conceptual cost estimate to relocate a county and state road for an alternative evaluated in GAI, 2014. The total project cost for each road was divided by the total length of road being relocated to create a unit cost on a linear foot basis. These costs were rounded to $350/LF of county road and $400/LF of state road. Refer to Support Document III.D-1-6 for additional information on the basis of relocation costs. The following assumptions were made in the creation of the estimate:

-County road assumed as 18 ft out-to-out width (two 8' lanes with 1' shoulders),

-State road assumed as 24 ft out-to-out width (two 10' lanes with 2' shoulders),

-Drainage approximated as 20% of Paving and Earthwork cost,

-E&S approximated as 10% of Paving and Earthwork cost,

-Maintenance & Protection of Traffic approximated as 1.5% of Paving and Earthwork cost,

-Signing, Pavement Marking, and Delineation approximated as 1.5% of Paving and Earthwork cost,

-Mobilization approximated as 5% of Total Cost,

-30% contingency added, and

-Estimates do not include Right-of-Way Acquisition, Utility Relocation/Engineering, Post Construction Stormwater Management, Construction Phase Engineering, and Quality Assurance / Quality Control (QA/QC).

If an alternative required the relocation of county or state road(s), the approximate relocation was measured at a conceptual level. To calculate a cost for Line Items 9 and 10, the unit cost per linear foot for county ($350/LF) and state ($400/LF) roads was multiplied by the total linear footage of county and state roads being relocated.

Line Items 11-13 – Pipe Conveyor Transport – The Beumer Group provided price quotes for three pipe conveyor routes in the vicinity of Ravine B based upon existing topography and difficulty of construction. Refer to Support Document III.D-1-7 for additional information regarding these quotes. These quotes included costs for design and supply, mechanical and electrical installations, and civil and foundation work. These quotes were then developed into a unit cost on a linear foot basis, by taking total length and dividing by the total cost for each. These unit costs are $2,150/LF for a route similar to the North Ridge Top path near Ravine B (conveyor runs north along Bottom Ash Pond at TC Station, crosses to the northeast on a bridge, and runs along Wentworth Road), $2,425/LF for a route similar to the Ogden Ridge Road path near Ravine B (conveyor crosses Highway 1838 due east on a bridge, travels east up the adjacent slope and along Ogden Ridge Road), and $3,125/LF for a route similar to the South Ridge Top path near Ravine B (conveyor crosses Highway 1838 due east on a bridge and travels southeast to the ridge tops).

For each alternative, one of the three pipe conveyor routes, which most closely represented the topography of the site, was selected and the linear footage of the conceptual proposed pipe conveyor was measured. This linear foot quantity was multiplied by the route's unit cost to calculate a cost for Line Items 11-13.

Line Item 14 – Transfer Station – Additional input from the Beumer Group included direction on when a transfer station would be needed in order to turn the pipe conveyor in a new direction along its route. When the pipe conveyor contains turns of a radius less than 1000 feet or changes in direction that exceeded 90 degrees, the Beumer Group suggested the use of one transfer station in each of the quotes. They quoted the transfer station at $250,000 each. Alternatives that could not meet the design criteria of minimum pipe conveyor radius of less than 1000 feet, or that had changes in direction that exceed 90 degrees based on existing ground topography or site constraints, were assumed to require a transfer station. Alternatives that had more than one instance of not meeting the design criteria would require multiple transfer stations. The number of transfer stations was multiplied by the unit cost of $250,000 to calculate a cost for Line Item 14.

Line Item 15 – Haul Road – Off Landfill – GAI developed an estimate of probable construction costs for a haul road during a more detailed design of the Ravine B alternative. Multiple components were included in the development of the total unit cost used in Line Item 15. These components include:

-Clearing and grubbing, excavation, foreign borrow excavation, subbase-20" depth (No. 2A), subbase-8" depth (No. 2A), bituminous tack coat, bituminous concrete base course-12" depth, bituminous binder course-4" depth, bituminous wearing course-2" depth, mobilization (assume 5% of roadway total), field laboratory, inspector's field office, equipment package, 18" reinforced concrete pipe, 24" reinforced concrete pipe, geotextiles-class 2-type B, fabricform ditch lining, construction surveying, erosion and sediment pollution control, and signing and pavement marking. Estimate does not include stormwater management, right-of-way, and utility relocation costs.

In order to calculate a cost for Line Item 15, the total linear footage of the haul road required for an alternative was multiplied by the adjusted unit cost of $1,600/LF. The length of haul road was dependent upon site layout and distance from the TC Station and/or CCR transfer location (i.e. barge unloading facility or pipe conveyor discharge). Per LG&E design requirement, the haul road must also parallel the pipe conveyor route where possible to provide ease of access to the pipe conveyor for maintenance as well as for use as primary CCR transport during outages of the pipe conveyor.

Line Item 16 – Bridge – Large (36 FT high, 440 FT long, 60 FT wide) – GAI developed an estimate of probable construction costs for a 3-span prestressed concrete I-beam bridge over KY 1838 during a more detailed design of the Ravine B alternative. Multiple components were included in the development of the total unit cost used in Line Item 16. These components include:

-Structure granular backfill, masonry coating, penetrating sealer for deck, structure excavation-common, structure excavation-solid rock, steel piles-HP14X89, pile points 14", concrete-Class A, concrete-Class AA, concrete-Class C, steel reinforcement, steel reinforcement-epoxy coated, structural steel, expansion dam 4" neoprene, approach slab, prestressed concrete I-beams, 24" PVC schedule 40, 36" steel encasement, and neoprene bearing pads.

These components have base costs in various units but were quantified and totaled to calculate a total project cost of $3,604,000, rounded to $4,000,000 for the purpose of this cost analysis. The total cost did not include the following items:

-General mobilization, clearing and grubbing, construction surveying, embankment construction, utility relocation costs, permitting costs, and traffic control costs.

A large bridge unit was used in each alternative that required an approximate 400 foot span over road, stream, or other valley feature. The unit cost of $4,000,000 was multiplied by the number of large bridges necessary for an alternative to calculate a cost for Line Item 16.

Line Item 17 – Bridge – Medium (200 FT long, 60 FT wide) – A cost per square foot (SF) for various types and spans of bridges is provided in Support Document III.D-1-11. For the medium span bridges used in various alternatives, GAI selected a concrete deck with pre-stressed girder in a continuous span, which has an estimated cost of $145/SF. A bridge 200 FT long and 60 FT wide has a total area of 12,000 SF and therefore a total estimated cost of $1,740,000. This unit cost was rounded up to $1,750,000

Medium bridge units were used in alternatives that required an approximate 200 foot span over smaller road, stream, or other valley features. The unit cost of $1,750,000 was multiplied by the number of medium bridges estimated in an alternative to calculate a cost for Line Item 17.

Line Item 18 – Perimeter Collection Channel – Fabric Form, 6-10' Bottom Width – Line Item 18 estimated the linear footage of perimeter collection channels with an approximate range of 6-10' bottom width used to convey runoff from the conceptual landfill site to an ES/SWM pond. Multiple components were included in the development of the total unit cost of $75.00/LF used in Line Item 18. These components include:

-Excavation and loading, hauling-1 mile round trip, spreading, and fabric form liner.

The channels were quantified by measuring the perimeter of the conceptual landfill layout, where water would be collected and sent to the ES/SWM pond.

The unit cost of $75.00/LF was multiplied by the total linear footage, measured around the entire conceptual landfill layout, for each alternative to calculate a cost for Line Item 18.

Line Item 19 – Upslope Drainage Diversion Channel – Fabric Form, 1-5′ Bottom Width – Line Item 19 estimated the linear footage of upslope drainage diversion channels with an approximate range of 1-5′ bottom width used to divert runoff around the conceptual landfill footprint and bypassing the ES/SWM pond. The diversion channels were measured around the perimeter of the conceptual landfill layout, on the outside of the collection channels, and then to the end of the ES/SWM pond. Multiple components were included in the development of the total unit cost of $50.00/LF used in Line Item 19. These components include:

-Excavation and loading, hauling-1 mile round trip, spreading, and fabric form liner.

The unit cost of $50.00/LF was multiplied by the total linear footage for an alternative to calculate a cost for Line Item 19.

Line Item 20 – Subgrade Preparation – General Earthwork – Soil Inside Footprint (3000 foot Round Trip) – A conceptual subgrade was created for landfill alternatives using a 100-foot wide Ravine floor, minimum slopes of three percent, and maximum slopes of 3 horizontal (H) to 1 vertical (V). The cut and fill volumes required to build the conceptual subgrade were estimated using AutoCAD software to compare the elevation differences between existing ground and the subgrade surface. Line Item 20 quantified material within the landfill footprint, excluding rock, that can be taken from areas of cut and used in areas where fill is required within the conceptual landfill footprint. The unit cost associated with this Line Item was developed from the following components:

-Excavating, bulk bank, hydraulic crawler, 3 CY, for loading add 15%

-Hauling, 22 CY, off-road, 15 min wait/load/unload, 10 MPH, cycle 3000 feet

-General fill, by dozer, no compaction, and

-Compaction, sheepsfoot or wobbly wheel, 12″ lifts, 2 passes.

These components were totaled for a unit cost of $5.65/CY of material. To calculate a cost for Line Item 20, the unit cost was multiplied by the quantity of earthwork that could be used within the conceptual landfill limits of grading.

Line Item 21 – Subgrade Preparation – General Earthwork – Rock Blasting (3000 foot Round Trip) – Line Item 21 estimated the amount of rock material that would need to be excavated/blasted. The rock blasting quantity was estimated by taking the depth between existing ground and the proposed subgrade at points on a grid system. The top elevation of rock was assumed to be 15 feet below existing ground based on drilling programs performed in this region of Kentucky and online review of soils information in the area. The thickness of rock excavation (the depth of cut minus 15 feet) was multiplied by the area of each point on the grid. Finally, the total rock excavation volumes for all of the conceptual landfill footprint were summed. The unit cost associated with this Line Item was developed from the following components:

-Blasting and excavating/loading

-Hauling, 22 CY, off-road, 15 min wait/load/unload, 10 MPH, cycle 3000 feet

-General fill, by dozer, no compaction, and

-Compaction, sheepsfoot or wobbly wheel, 12” lifts, 2 passes.

These components were totaled to determine a unit cost of $21.72 per cubic yard of material. To calculate a cost for Line Item 21, the unit cost was multiplied by the quantity of rock material estimated to be excavated within the landfill limits of grading.

Line Items 22-25 – Subgrade Preparation – Borrowing or Spoiling Excess Material – Soil – ½, 1, 2, or 4 mile Round Trip – Line Items 22-25 estimated the amount of excess excavated material that could not be used as fill or additional borrow material brought into the landfill footprint in order to complete the subgrade construction. From Line Items 20 and 21, if excess material was produced or borrow material was needed to balance the estimated subgrade earthwork, the excess or deficit of material was quantified in Line Items 22-25. The material must be trucked to or from the landfill footprint and the distance from borrow sites spoil areas determines the hauling cost. The difference between Line Items 22-25 is the average round trip hauling distance assumed from the center of the landfill to the center of approximate borrow/spoil areas. The cost associated with this Line Item was developed from the following components:

- Excavating, bulk bank, hydraulic crawler, 3 CY, for loading add 15%

-Hauling, 22 CY, off-road, 15 min wait/load/unload, 10 MPH, cycle ½, 1, 2, or 4 miles (varies between Line Items)

-General fill, by dozer, no compaction, and

-Compaction, sheepsfoot or wobbly wheel, 12” lifts, 2 passes.

These components were totaled to determine a unit cost of $5.65/CY, $5.94/CY, $6.84/CY, and $8.36/CY of material, respectively. To calculate a cost for Line Items 22-25, the unit cost, using the appropriate mileage, was multiplied by the quantity of borrow/spoil material required to balance the site earthwork.

Line Items 26 through 28 – Landfill Composite Liner System ½ or 1.5 mile Round Trip Protective Cover / 2 or 4 mile Round Trip Drainage Layer – Multiple components were included in the development of the total unit costs used in Line Items 26, 27, and 28. These components include:

- 2 ft recompacted soil liner,

- geomembrane liner,

- cushion geotextile,

- 1 foot leachate collection system drainage layer, and

- 2 foot protective cover layer.

In order to calculate a cost for the Line Items 26 through 28, the area to be lined (i.e. the limits of the conceptual landfill grading of a site) was estimated and that acreage was multiplied by the composite unit cost of $91,000/acre, $93,000/acre, and $88,000/acre, respectively depending on the average haul distance from the center of landfill to the source of protective cover and drainage layer materials.

Line Item 29 – Groundwater Underdrain Drainage Pipes – Line Item 29 estimated the linear footage of underdrain interceptors and lateral pipes used to capture and convey groundwater from below the footprint of the landfill to areas downgradient of the landfill to the ES/SWM Pond. The unit cost for the Groundwater Underdrain Pipes was based on estimates for schedule 120 PVC pipe from previous experience on similar projects. The total cost per acre for these projects was used to develop a typical cost per acre to use for all landfill alternatives. The length of pipe estimated for each project was multiplied by its cost per linear foot and then divided by the area of the landfill in acres. This unit cost of $6,000 per acre was multiplied by the estimated conceptual landfill liner acreage to calculate a cost for Line Item 29.

Line Item 30 – Leachate Collection System Drainage Pipes – Line Item 30 estimated the linear footage of leachate collection system interceptors and lateral pipes used to convey water that infiltrates through the landfilled CCR material away from the landfill liner system and to the Leachate Pond. The unit cost for the Leachate Collection System Drainage Pipes was based on estimates for schedule 120 PVC pipe from previous experience on similar projects. The total cost per acre was calculated by multiplying the length of pipe estimated for each project by its cost per linear foot and then dividing that sum by the area of the conceptual landfill. This calculation was used to develop a typical cost per acre to use for all landfill alternatives. This unit cost of $15,000 per acre was multiplied by the estimated conceptual landfill liner acreage to calculate a cost for Line Item 30.

Line Items 31-32 – Large/Medium ES/SWM Pond and Leachate Pond – Earthwork and Liner System (~35/~20 acre-ft) – Multiple components were included in the development of the total unit costs used in Line Items 31 and 32. The unit cost of the medium pond was developed by scaling down the cost of the large pond with a ratio based on the ponds' volumes (20 acre-ft/35 acre-ft). Based on previous construction cost estimating experience on similar projects, these components include:

- Excavation and loading, hauling-1 mile round trip, hauling-3 mile round trip, spreading and compacting, rock blasting (emergency spillway), riser structure and dewatering pipe, 12" prepared subgrade, pond anchor trench. For containment in the leachate pond: 60-mil LLDPE geomembrane over the entire pond, cushion geotextile, 4" fabric form (FF) lining on side slopes, 8" FF lining in pond bottom. Pipe penetration seal (boot), mechanical pump system, electrical pump system, structural pump system, and leachate force main to pump leachate to a separate leachate treatment facility.

The use of the large or medium ponds depended on the layout and existing topography for an alternative. The cost for Line Items 31 and 32 was calculated by multiplying the unit cost of $3,000,000/pond and $2,000,000/pond, respectively, by the number of ponds to be used at a site.

For off-site CCR disposal alternatives that would require leachate collection and treatment (e.g. Lee Bottom) construction of a separate leachate treatment system local to the disposal facility site would likely be required. Costs for this leachate treatment system at offsite CCR disposal locations would likely be more expensive, but have not been included in this analysis.

Line Items 33-34 –Final Cover System – 2 or 4 Mile Round Trip (12 inches clay, 12 inches topsoil) – Multiple components were included in the development of the total unit costs used in Line Items 33 and 34. These components include:

- Excavating,
- 2 or 4 mile round trip (hauling distance determined by measuring from middle of landfill to borrow sites),
- spreading,
- compacting, and
- seeding of vegetative layer.

The difference between Line Items 33-34 is the estimated average hauling distance from the center of the landfill to identified potential borrow sites. In order to calculate a cost for Line Items 33 and 34, the total estimated acreage of the landfill footprint was multiplied by the composite unit cost of $29,000/acre and $33,000/acre, respectively, in order to determine the cost of placing final cover on the landfill.

Line Item 35 – Barge Loading Facility – Fenner Dunlop Conveyor Belting has provided a price quote that states that a barge loading facility with the capacity to handle the full CCR production rate of 910,000 CY per year would be approximately $14,200,000. This includes facility and site construction costs of ~$8.3 million and ~$5.9 million, respectively. This loading facility would be required for any alternative that has barging as a mode of transportation and would be constructed on the Ohio River at or near the TC Station.

In order to calculate a cost for Line Item 35, the unit cost of $8,300,000 was multiplied by one for any alternative using barge transportation. These costs are calculated on a 2014 dollar basis.

Line Item 36 – Barge Unloading Facility – Fenner Dunlop Conveyor Belting has provided a price quote that states that a barge unloading facility with the capacity to handle the full CCR production rate of 910,000 CY per year would be approximately $16,100,000. This includes facility and site construction costs of ~$9.97 million and ~$6.15 million, respectively. This unloading facility would be required for any alternative that has barging as a mode of transportation. The loading facility would be constructed on the Ohio River at or near the designated alternative's disposal facility.

In order to calculate a cost for Line Item 36, the unit cost of $16,100,000 was multiplied by one for any alternative using barge transportation. These costs are calculated on a 2014 dollar basis.

Line Item 37 – Ancillary Costs (Critical Spares and Office/Warehouse Space) – Fenner Dunlop Conveyor Belting has provided a price quote that states that ancillary costs for barge transportation would be approximately $1,600,000. This unit cost includes items related to support facilities for employees consisting of office space, warehouse space, and/or maintenance supplies storage space, as well as spares for critical components in case of the need for replacement.

In order to calculate a cost for Line Item 37, the unit cost of $1,600,000 was multiplied by one for any alternative using barge transportation. These costs are calculated on a 2014 dollar basis.

Line Item 38 – Additional Capital Costs – A number of components are considered to develop the total unit cost for Line Item 38. These components include:

-LG&E Overheads and Engineering Support during design and construction;

-Intermediate Cover and Benches;

-QA/QC (Subgrade, Liner, Final Cover System); and

-Borrow Area Roads and On-Landfill Haul Roads.

These individual line item costs are Lump Sum unit costs that vary between case studies. As discussed in Appendix III.B-1, the Ravine B case study has been analyzed and designed beyond the conceptual design done for the case studies included in this Supplement to the Alternatives Analysis. Capital and operating cost estimates have been prepared for Ravine B relating to the common additional capital and operating costs for landfill alternatives and are used to estimate the same component costs at other case study alternatives on an order of magnitude basis. Engineering judgment was used to compare each of the case studies vs. Ravine B and assign an "Order of Magnitude" multiplier indicating whether the cost would be similar to, (i.e. Order of Magnitude = 1.0), or some multiple of, the estimated cost of that particular line item in Ravine B (i.e. Order of Magnitude = 0.5 or 2.0). The "Order of Magnitude" was then multiplied by the total unit cost estimated in the Ravine B detailed capital cost estimate to develop Lump Sum Unit Costs of each component above for the case studies. Support Document III.D-1-17 describes how each case study was compared to Ravine B to determine an assumed "Order of Magnitude" multiplier for each line item. Table III.D-1-17-1 is included in Support Document III.D-1-17 and lists each of the above components, their assumed "Order of Magnitude" and Lump Sum unit costs estimated for the Ravine B, Sterling Ventures, Lee Bottom, and Valley View case studies. These costs are calculated on a 2013 dollar basis.

<u>Operations and Maintenance (O&M) Costs</u>

Line Items 39-41 – Hauling – 1, 2, or 3 Mile Round Trip (22 CY on landfill/private road) – After CCR material reaches the pipe conveyor termination point or barge unloading facility, it must be hauled via truck in order to be placed in the CCR disposal facility. Line Items 39-41 quantify a cost by multiplying the unit cost of $2.56/CY, $3.46/CY, and $4.19/CY, respectively, for distance hauled by the total volume of CCR material to be stored in the disposal facility. The difference between Line Items 39-41 is the estimated hauling distance from the conveyor endpoint or unloading facility to the approximate centroid of the conceptual CCR disposal facility. Distance varies based on facility location and layout of an alternative. It is important to note that the Sterling Ventures tipping fee proposal did not address handling costs for CCR materials that come off the pipe conveyor. If trucking or other transport is needed to move the CCR into the mine, it is assumed these costs would be in addition to the tipping fee.

Line Item 42 – Hauling – 30 Mile Round Trip (18 CY, 35 MPH avg – Line Item 42 calculates the cost to haul CCR material from the TC Station to an offsite, existing CCR disposal facility at Valley View MSW Landfill. Valley View MSW Landfill is approximately 15 miles away (30 mile round trip). The distance between the TC Station and the off-site landfill is too far for pipe conveyor transportation to be feasible, and there are no barge or nearby rail alternatives. As a result, CCR material would need to be trucked at a cost of $11.55/CY for a 30 mile round trip.

Line Item 42 quantifies a cost by multiplying the total volume of CCR material to be stored in the offsite disposal facility by the unit cost of $11.55/CY.

Line Item 43 – Offsite CCR Disposal - Tipping Fee – Line Item 43 includes the tipping fee to dispose of CCR material from the TC Station to an offsite facility. One of two separate facilities, Valley View MSW Landfill or Sterling Ventures Mine, can be used depending on the alternative. A price quote from Republic Services of KY, LLC states it would cost $21.20/ton to dispose CCR material at Valley View MSW Landfill and a letter from Sterling Ventures, LLC quotes $10.15/ton to dispose of CCR material at Sterling Ventures Mine. It is important to note that tipping fees are subject to increases for new regulatory requirements and other changes in circumstances.

Line Item 43 quantifies a cost by multiplying the unit cost of either $21.20/ton or $10.15/ton, depending on the location of offsite CCR disposal.

Line Item 44 – Pipe Conveyor Cost of Operation – Beumer Group has provided a price quote that states that the pipe conveyor cost of operation would be $0.20/CY. This operational cost was based on the conceptual pipe conveyor routes included in the Line Items 11 through 13. For the purpose of this cost analysis it was assumed that all pipe conveyor routes will have similar cost of operation. The unit cost includes operation and power costs for an average length conveyor utilizing a reasonable cost per kilowatt hour. The price quoted by Beumer Group, and therefore this unit cost does not include salaries of people assigned to operate the conveyor.

In order to calculate a cost for the Line Item 44, the total volume of CCR material to be stored in the CCR disposal facility was multiplied by the unit cost of $0.20/CY to operate the pipe conveyor.

Line Item 45 – Barge Loading and Unloading Operations Cost – Fenner Dunlop Conveyor Belting has provided a price quote that includes the costs involved in managing and operating the barge loading and unloading facilities, including the estimated price to physically place the material onto the barge at the loading facility, and pick it up at the unloading facility.

To calculate the cost for Line Item 45, the unit cost of $1,300,000/year is multiplied by the number of years that barge transport of CCR material is anticipated for an alternative. These costs are calculated on a 2014 dollar basis.

Line Item 46 – Barge Transportation Costs – LG&E provided a price quote from a confidential source that includes the cost involved to physically transport the CCR material via barge. It is assumed that this unit cost includes labor, maintenance, and supplies to operate the push boat for the barges.

To calculate the cost for Line Item 46, the unit cost, which varies based on distance from TC Station to the alternative ($2.24/ton for Lee Bottom Landfill and $2.61/ton for Sterling Ventures Mine), is multiplied by the total amount of material to be disposed of at the CCR Disposal facility.

Line Item 47 – Additional O&M Costs – A number of components are considered to develop the total unit cost for Line Item 47. These components include:

-CCR Placement and Compaction, Survey of CCR Placement, and QA/QC of CCR Placement and Compaction;

-Cleanout/Maintenance of Haul Road, Sediment Basin and Leachate Pond, Leachate Pump Station O&M, Leachate System and Underdrain System, and Landfill Maintenance; and

-Dust Control.

These individual line item costs are Lump Sum unit costs that vary between case studies. As discussed in Appendix III.B-1, the Ravine B case study has been analyzed and designed beyond the conceptual design done for the case studies included in this Supplement to the Alternatives Analysis. Engineering judgment was used to compare each of the case studies vs. Ravine B and assign an "Order of Magnitude" multiplier indicating whether the cost would be similar to, (i.e. Order of Magnitude = 1.0), or some multiple of, the estimated cost of that particular line item in Ravine B (i.e. Order of Magnitude = 0.5 or 2.0). The "Order of Magnitude" was then multiplied by the total unit cost estimated in the Ravine B detailed O&M cost estimate to develop Lump Sum Unit Costs of each line item above for the case studies. Support Document III.D-1-17 describes how each case study was compared to Ravine B to determine an assumed "Order of Magnitude" multiplier for each line item. Table III.D-1-17-1 is included in Support Document III.D-1-17 and lists each of the above line items, their assumed "Order of Magnitude" and Lump Sum unit costs estimated for the Ravine B, Sterling Ventures, Lee Bottom, and Valley View case studies. These costs are calculated on a 2013 dollar basis.

SECTION 5: EXAMPLE OF LINE ITEM TOTAL COST DEVELOPMENT

After each Line Item's unit cost was developed and the magnitude (unit quantity) of each was quantified, the total cost for each Line Item for a particular alternative was determined by multiplying the unit cost by the unit quantity. For certain Line Items (i.e. Environmental Stream/Wetland Mitigation, Cemetery Relocation, Cultural Resources), costs were calculated individually on a case-by-case basis when the unit cost was expected to vary. These costs were quantified on a per alternative basis, as the degree of impact was not uniform across all sites and could not be assigned unit cost consistent across all alternatives.

An example explanation of how a particular Line Item cost is developed from the unit cost and unit quantity is provided below:

Example Line Item 2 – Clearing, Grubbing, and Site Preparation at the Sterling Ventures Mine Alternative.

Unit Cost Development:

The unit cost of $17,000 per acre consisted of two parts: "Cut and Chip Trees" and "Grub Stumps and Remove." Each of these costs were found in the *2012 RS Means Heavy Construction Cost Data* book at $14,600/acre and $7,525/acre, respectively. When multiplying the unit cost by 0.76 for the Frankfort, KY location factor (explained in Section 2.2), they become $11,111/acre for "Cut and Chip Trees" and $5,727/acre for "Grub Stumps and Remove." This totals to $16,838/acre, which was then rounded to $17,000/acre for ease of use.

Unit Quantity Development:

The quantity for Clearing, Grubbing, and Site Preparation was developed by measuring the number of forested acres assumed to be disturbed due to construction of the project. For the Sterling Ventures Mine Alternative, the only land disturbance assumed is due to construction of the pipe conveyor, haul road, and barge unloading facility. A conceptual impact boundary was developed based on a 1000 foot wide transportation corridor along the conceptual route for the pipe conveyor and haul road. The corridor is based on a conservative approximation of the limits of earthwork cut/fills required to construct a haul road and pipe conveyor system. The total forested acreage, defined as any area observed to have tree cover, within the impact boundary was calculated using USGS mapping. This was determined to be 290 acres.

290 acres multiplied by the unit cost of $17,000/acre comes to $4,930,000, which is the total cost for Line Item 2-Clearing, Grubbing, and Site Preparation in the Sterling Ventures Mine Alternative.

APPENDIX III.D-1 – METHODS FOR ASSESSMENT OF COSTS

SECTION 1: APPROACH TO COST ANALYSIS

- Costs for the four case study alternatives are presented in conceptual detail in Tables III.D-1 through III.D-4 in the Supplement. For selected other alternatives, cost information is provided in Appendix IV.A-2. Analyses of project costs can apply different methodologies depending on the purpose for which the cost estimates are being made. For an alternatives analysis, the primary requirement is to generate costs that allow a fair comparison among conceptual alternatives. As such the cost analysis in GAI (2014) and in this Supplement reflects the following considerations.Costs that are common to every alternative do not need to be estimated or presented. An example for the case of CCR disposal is that all material must be processed and treated to be in a dry form (<20% moisture content) before it is transported offsite. At Trimble County Generating Station, this cost alone is estimated to exceed $6 per cubic yard. The treatment cost does not vary among alternatives and therefore is not included in the cost comparisons among alternatives. The costs in the Supplement are those appropriate for comparison among disposal alternatives, and do not represent the full cost of CCR management.
- Cost factors that are simple multipliers of construction costs are not included. An example of this is any allowance for contingencies or uncertainties. The effect of such a multiplier is to widen the gap between the lower and higher cost alternatives, which has the potential to bias the analysis toward the lowest-cost option. An exception to this consideration can be when these simple multiplier costs are projected to be significant for one type of CCR disposal facility (e.g. landfill) and insignificant or absent in another (e.g. mine). In addition, in a few instances, where a cost was developed based on a bid from a third party, which included a contingency, this is included if LG&E determined it was justified. In the late stages of an alternatives analysis, these factors can be considered if and when there may be marked differences in engineering or contingency costs between two alternatives that are otherwise close in cost.
- The line items included in the cost analysis in GAI (2014) were not "all inclusive", i.e. the line items included were only those anticipated to differ significantly between landfill alternatives. Consequently, a number of line items and their associated costs were excluded, assuming they were similar among all alternatives considered, and would not affect the overall cost difference between alternatives[1]. However, in this Supplement there are two case studies (Sterling Ventures and Valley View) that do not involve construction and operation of a conventional CCR landfill, but instead will charge a tipping fee to accept CCR material from LG&E. Therefore, Tables III.D-1 through III.D-4 include line items 38 and 47, "Additional Capital Costs" and "Additional Operations and Maintenance (O&M) Costs" respectively, to account for these costs

[1] While the Valley View Municipal Solid Waste Landfill, which was an alternative considered in GAI, 2014, is not a landfill alternative that LG&E would construct and manage, the costs associated with that alternative were so far in excess of the costs for the Ravine B alternative that it was not believed to be necessary to include these additional costs for all other alternatives solely for the sake of comparison to Valley View.

that can no longer be omitted as they will now vary between alternatives. The additional line items and associated costs included on Tables III.D-1 through III.D-4 are explained further in Support Document III.D-1-17 provided on a digital disk submitted with this Supplement.

- No consideration is given to timing factors that are common in many types of financial analyses, such as for a rate-of-return determination. There is no adjustment for inflation on future operations costs, possible future increases in energy costs, discounting to bring future costs to present value, or return on investment if operation costs are fully funded on Day 1 but only expended over time. LG&E considers the gross costs for construction and 37 years of operations to provide the fairest comparison of relative costs among alternatives.
- Costs that are expected to be small for any alternative are not quantified. An example is the cost for relocation of local water, sewer and other utility lines, which are typically a fraction of one percent of total costs. These small costs are reasonably ignored given they are dominated by the costs of landfill and transportation system construction and operation. In contrast, relocation of a large transmission line is costly enough to be considered.
- While LG&E understands that unit costs can vary on a year to year basis, costs in this analysis are not adjusted based on a particular year. Costs in GAI (2014) are based on 2012 data. Accordingly, to respond to EPA's requests for additional documentation on evaluated alternatives, the Supplement uses the same 2012 cost basis and provides more detailed documentation of the underlying cost estimates. A few cost elements developed specifically for this Supplement are based upon 2013 or 2014 information. For initial comparison purposes, it is considered acceptable to have a mixture of years in the cost estimates, so long as for any one project element (such as barge transportation) the estimates are consistent among all alternatives (in that case, 2014). In the late stages of an alternatives analysis, adjustment of costs to a common year can be considered if and when the result could markedly affect the cost comparison between two alternatives that are otherwise close in cost.
- Costs are based on relatively comparable levels of conceptual engineering. The expectation is that for any alternative, more detailed design-level engineering would identify additional cost items or contingencies. To make a fair comparison, costs for all alternatives have been made based solely on conceptual-level engineering. The assessment is more detailed for alternatives in Section III and order-of-magnitude for alternatives in Section IV.

The Alternatives Analysis in GAI (2014) involved estimation of planning-level costs for several dozen CCR disposal alternatives. This Appendix documents the methods used for those estimates in more detail than was provided in GAI (2014), as well as additional cost information analyzed specifically in the case study analysis.

The development of the comparison cost estimates for the alternatives included the following steps, detailed in the following sections of this Appendix.

- Section 2 describes the identification of project elements which may be different between generic alternative designs that would account for major cost components. Construction and operation elements were identified separately based on experience with the full range of elements in a large CCR disposal facility project.
- Section 3 describes how a unit cost was prepared based on known or reliable cost sources such as a.) known standardized construction cost estimating reference books (e.g. RS Means), or b.) estimated costs quoted specifically for the alternatives analyzed in this report, or c.) estimated costs quoted from similar components of comparable past projects (i.e. past construction bid/cost experience and/or vendor/supplier quotes) for each category of project element.
- Section 4 describes how the magnitude (or unit quantity) of each element was estimated based on conceptual design drawings or other project-specific considerations.
- Section 5 describes how costs for each project element were totaled by multiplying the unit cost by the unit quantity. Costs for a few project elements were calculated on a specific site-by-site basis. An example explanation of how the unit costs and unit quantity are used to develop the cost for a particular Line Item is also included in this section.

Each step in this methodology is explained and documented here in Appendix III.D-1. If a unit cost requires additional justification or backup information, it is included in the Support Documents provided in the digital disk submitted as part of this Supplement. Appendix III.C-1 describes the conceptual design process for CCR landfills and the types of project attributes that may require a cost estimate. Tables III.D-1 through III.D-4 provide the results of the application of these methods to the four case studies.

SECTION 2: PROJECT ELEMENTS ANALYZED FOR COST

The first step in the assessment of costs was to identify the project elements that would account for major costs for a CCR disposal facility. Based on past experience with construction and operation of large CCR disposal facilities, project elements that were anticipated to cause significant differences in costs between the alternatives were identified as described below. As described above, project elements that were anticipated to be similar or the same between alternatives [for example, project management, quality assurance/quality control (QA/QC), CCR treatment and transportation system at TC Station, etc.], were not included in the cost analysis.

The following project elements were identified to be major components for a CCR disposal facility for which costs were to be developed. The project elements have been grouped between capital and operation and maintenance (O&M) costs.

Line Item #	Description	Cost ($)	Per Unit
Capital Costs			
1	Property Acquisition	$12,000	Acre
2	Clearing, Grubbing, and Site Preparation	$17,000	Acre
3	Large Utility Line Relocation	$880	Linear Foot

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Line Item #	Description	Cost ($)	Per Unit
			(LF)
4	Fencing	$50	LF
5	Environmental Wetland Mitigation (cost based on adjusted mitigation units (AMU) and may be increased by 1.2 factor for temporal loss if In Lieu Fee option is utilized; rate of $72,000/acre includes the 1.2 factor)	$72,000	Acre
6	Environmental Stream Mitigation (cost based on AMU and may be increased by 1.2 factor for temporal loss if In Lieu Fee option is utilized)	$170	AMU
7	Cultural Resources (Potential Phase III data recovery)	Varies	EA
8	Indiana Bat Mitigation	$5,338	Acre
9	Road Relocation (County Road)	$350	LF
10	Road Relocation (State Road)	$400	LF
11	Pipe Conveyor Transport (similar to North Ridge Top path at Ravine B)	$2,150	LF
12	Pipe Conveyor Transport (similar to Ogden Ridge Road path at Ravine B)	$2,425	LF
13	Pipe Conveyor Transport (similar to South Ridge Top path at Ravine B)	$3,125	LF
14	Transfer Station	$250,000	EA
15	Haul Road - Off Landfill	$1,600	LF
16	Bridge - Large (36 Feet (FT) high, 440 FT long, 60 FT wide)	$4,000,000	EA
17	Bridge - Medium (200 FT long, 60 FT wide)	$1,750,000	EA
18	Perimeter Collection Channel - Fabric Form, 6-10' Bottom Width	$75.00	LF
19	Upslope Drainage Diversion Channel - Fabric Form, 1-5' Bottom Width	$50.00	LF
20	Subgrade Preparation - General Earthwork - Soil Inside Footprint (3000 foot Round Trip)	$5.65	CY
21	Subgrade Preparation - General Earthwork - Rock Blasting (3000 foot Round Trip)	$21.72	CY
22	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 1/2 Mile	$5.65	CY
23	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 1 Mile	$5.94	CY
24	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 2 Miles	$6.84	CY
25	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 4 Miles	$8.36	CY
26	Landfill Composite Liner System - 0.5 mi Round Trip Protective Cover/4 mi Round Trip Drainage Layer	$91,000	Acre
27	Landfill Composite Liner System - 1.5 mi Round Trip Protective Cover/4 mi Round Trip Drainage Layer	$93,000	Acre
28	Landfill Composite Liner System - 0.5 mi Round Trip Protective Cover/2 mi Round Trip Drainage Layer	$88,000	Acre
29	Groundwater Underdrain Drainage Pipes	$6,000	Acre
30	Leachate Collection System Drainage Pipes	$15,000	Acre
31	Large Erosion and Sedimentation/Stormwater Management (ES/SWM) Pond and Leachate Pond - Earthwork and Liner System (~35 acre-ft)	$3,000,000	EA
32	Medium ES/SWM Pond and Leachate Pond - Earthwork and Liner System (~20 acre-ft)	$2,000,000	EA
33	Final Cover System - 2 Mile Round Trip (12 Inches Clay; 12 Inches Topsoil)	$29,000	Acre
34	Final Cover System - 4 Mile Round Trip (12 Inches Clay; 12 Inches Topsoil)	$33,000	Acre

Line Item #	Description	Cost ($)	Per Unit
35	Barge Loading Facility	$8,300,000	EA
36	Barge Unloading Facility	$16,100,000	EA
37	Ancillary Costs (Critical Spares and Office/Warehouse Space)	$1,600,000	EA
38	Additional Capital Costs	Varies	LUMP
Operation and Maintenance (O&M) Costs			
39	Hauling - 1 Mile Round Trip (22 CY on landfill/private road)	$2.56	CY
40	Hauling - 2 Mile Round Trip (22 CY on landfill/private road)	$3.46	CY
41	Hauling - 3 Mile Round Trip (22 CY on landfill/private road)	$4.19	CY
42	Hauling - 30 Mile Round Trip (18 CY, 35 MPH avg)	$11.55	CY
43	Offsite CCR Disposal - Tipping Fee	Varies	TON
44	Pipe Conveyor Cost of Operation	$0.20	CY
45	Barge Loading and Unloading Operation Cost	$1,100,000	YR
46	Barge Transportation Costs	Varies	TON
47	Additional O&M Costs	Varies	LUMP

SECTION 3: UNIT COST DESCRIPTION

A variety of sources were consulted to calculate the unit costs for each project element. For standard construction costs, such as hauling, excavating, general earthwork, etc, the 2012 edition of *RS Means Heavy Construction Cost Data* was used. RS Means is widely accepted in the construction industry as one of the standards in construction cost valuation. The RS Means source provides unit costs on a nationwide level and a 'location factor' for various cities/areas throughout the United States that allows for inflation or deflation of unit costs. The 'location factors' are percentage ratios of a specific city's material and labor costs to the national average cost of the same item. The location factor from Frankfort, KY was selected for use in all cost estimating, as it is the city listed in RS Means with the closest proximity to the alternatives evaluated. The location factor used in all RS Means sourced unit costs is 0.76.

More complex project element costs (such as property acquisition, utility relocations, bridges, haul road, ponds) were typically developed from GAI or LG&E experience on previous projects and adapted or scaled to the conceptual alternatives analyzed herein. For other project elements that required outside reference (such as off-site CCR disposal/tipping fee or pipe conveyor and barge transport), unit cost information was sourced from available vendors and suppliers in the form of price quotes and budgetary cost estimates. All costs are calculated on a 2012 dollar basis except as noted in Section 4. A breakdown of the unit costs, including a listing of the elements combined to develop each unit cost, can be found in Table Appendix III.D-1– Unit Cost Development. A description of the layout and format of Table Appendix III.D-1 is as follows:

> From left to right, the column headings include the Line Item number, a checkbox that identifies whether the project element is a capital or O&M cost, a description of project element, the unit cost, the unit, the source of costing information, the RS Means # (if applicable), and any conversion calculations used to convert units. When multiple sub-items comprise a line item, the total was added up and rounded for ease of calculation.

Line Item costs that were developed from RS Means display the RS Means Item Number (correlates to the Line Item number provided in the *2012 RS Means Heavy Construction Cost Data* source books), the Line Item's original cost and unit, the adjusted cost using the location factor for Frankfort, KY, and, if necessary, the unit adjustment equation to calculate the cost in a more reasonable and easily estimated unit for the estimate (for example, converting a $ per square yard cost into $ per acre). The scans of the pages from RS Means used for the unit cost development are included as Support Document III.D-1-1.

For Line Items not developed from RS Means, and that required additional backup cost sheets, price quotes, or calculations, a short description of the source is included in the fourth column and a reference to Support Documents III.D-1-2 through III.D-1-19 is listed in the last column on the right of the table. Support Documents III.D-1-2 through III.D-1-19 include detailed backup for how these unit costs were developed.

SECTION 4: UNIT QUANTITY DEVELOPMENT

Once the Line Items were identified and unit costs for those elements were developed, the unit quantity of each Line Item was estimated for various alternatives based on conceptual design drawings and/or other project specific considerations as described herein.[2] A description of how the units for each Line Item were quantified is described below. Also included for each Line Item is a listing of the unit cost and how the unit is multiplied by the unit cost in order to quantify the estimated cost for each Line Item.

CAPITAL COSTS

Line Item 1 - Property Acquisition – A conceptual impact boundary was developed based on space required to build the CCR disposal facility, roads, pipe conveyor, borrow areas, spoil areas, laydown facilities, erosion and sedimentation/stormwater management (ES/SWM) ponds, and other ancillary facilities needed for a case study alternative. Property line information was obtained from local Property Valuation Assessment (PVA) data or existing property mapping provided by LG&E. When the impact boundary encroached at all on a property, it was assumed that the entire property would need to be purchased, with the exception of Sterling Ventures Mine, which assumes only portions of existing property encompassing the impact boundary needed to construct and operate barge unloading facility, pipe conveyor, and haul roads, would be purchased due to these parcels being large (on the order of hundreds of acres each). The total acreage of property is multiplied by the unit cost of $12,000/acre (a cost provided by LG&E based on past real estate experience[3]) to quantify the cost to acquire the property.

Line Item 2 – Clearing, Grubbing, and Site Preparation – Line Item 2 is comprised of the following two components, with unit costs given on a 'per acre' basis:

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[2] Detailed cost estimates were not needed for all alternatives for purposes of a comparative, screening level analysis. For example, a number of alternatives were determined to be not practicable based on key logistical concerns (such as lack of capacity) alone.

[3] All property was assumed to be $12,000/acre. However, property value may vary based on location. For example, Lee Bottom Flying Field may be more expensive.

-Cut and Chip Trees

-Grub Stumps and Remove

A conceptual impact boundary was developed based on space required to build the CCR disposal facility, roads, pipe conveyor, borrow areas, spoil areas, laydown facilities, ES/SWM ponds, and other ancillary facilities needed. The total forested acreage within the impact boundary, defined as any area observed to have tree cover, was calculated using United States Geological Survey (USGS) and/or aerial imagery mapping. This acreage was multiplied by the unit cost of $17,000/acre to quantify the cost to clear, grub, and prepare a site for development.

Line Item 3 – Large Utility Line Relocation – To quantify the length of utility line relocation for an alternative, aerial photography was used to identify large overhead transmission lines similar to the one that crosses the existing LG&E property in Ravine B. Where these lines crossed a facility, a route around the facility was sketched and the length of the approximate rerouted line was measured.

In order to calculate a cost for Line Item 3, the total linear footage of the utility line that crossed over the facility was multiplied by the unit cost of $880/linear foot (LF).

Minor utility line relocations are not included in this analysis.

Line Item 4– Fencing – Multiple components were included in the development of the total unit cost used in Line Item 4. These components include:

- Corner posts, line posts, corner and end post bracing, top rail, rail – middle/bottom, reinforcing wire, steel t-post, barbed wire, extension arms, eye tops – 2-3/8", chain link fencing, and gates.

With a few exceptions, fencing was placed to enclose the entire project area of an alternative, resulting in the conceptual impact boundary perimeter generally being used for the quantity. Where the topography, such as steep slopes, did not necessitate fencing or where there was already an existing fence present, such as around the TC Station, fencing was not quantified.

In order to calculate a cost for Line Item 4, the total linear footage of the impact boundary perimeter was multiplied by the unit cost of $50/LF.

Line Items 5 and 6 – Environmental Wetland and Stream Mitigation

For the Ravine B alternative, actual field-verified data and location coordinates were utilized within a GIS program to determine the total stream lengths and wetland acreages that would be impacted.

Where field-verified stream and wetland data were not available, GIS mapping techniques and publically available data sources from various government agencies were utilized to estimate the lineal feet of streams and acreage of wetlands that may be impacted. An impact boundary was first established for an alternative based on predicted land disturbances from various construction and operational activities. The locations of potential wetland areas were obtained from the National Wetland Inventory (published by the United States Fish and Wildlife Service [USFWS]). The locations of major streams were obtained from the National Hydrography Dataset (published by the United States Geological Survey [USGS]). The location of smaller streams were estimated utilizing published topographic contour data by delineating (in GIS software) streams based on the presence of ravines and high-gradient slopes. Assumptions were made concerning the stream type (ephemeral or intermittent) for these contour-based stream estimates. These assumptions were based upon knowledge of the terrain and typical stream occurrences in such areas of the Bluegrass bioregion and surrounding areas.

Under the wetland and stream compensatory mitigation Fee In-Lieu Of (FILO) program, the United States Army Corps of Engineers (USACE) directs an applicant to utilize multipliers based on the table published on the USACE's Louisville District website as presented below. To derive the amount of adjusted mitigation units (AMUs) for a specific stream reach, the multiplier is selected from the USACE's table based on the stream's flow classification (ephemeral or intermittent for this Project) and the stream's quality based on the narrative rating (good, fair, poor). The narrative rating is determined from the stream habitat score that is calculated utilizing the high-gradient stream data sheet procedure. The completion of the high-gradient stream data sheet procedure, which constitutes the rapid bioassessment protocol, is described in Kentucky Division of Water's (KDOW) Methods for Assessing Habitat in Wadeable Waters (2011).

The Kentucky Department of Fish and Wildlife Resources (KDFWR) is the state agency responsible for implementing stream and wetland restoration projects in Kentucky under the FILO program, and the agency establishes the costs per AMU for compensation purposes. The cost rate of $170 per stream AMU and $72,000 per wetland acre (based on mitigation ratio of 2.0 for all wetland acres and temporal loss factor of 1.2 as the USACE requires) was utilized to estimate mitigation fees for all alternatives for which cost estimates were developed. These AMU cost rates were in effect at the time of the initial alternatives analysis (2012) where mitigation cost estimates were initially developed for several alternatives as reported in GAI, 2014. These AMU values were applied to all cost estimates for consistency and comparison of alternatives. Note that the actual mitigation fee for an alternative will be based on the AMU cost rate in effect at the time of project implementation. For example, the KDFWR's website (accessed September 25, 2014) reports a cost per AMU of $240 for stream impacts within the Salt River Watershed area, in which all alternatives are located with the exception of Lee Bottom, Sterling Ventures, and Bethlehem Terrace. A temporal loss and cumulative impacts factor of 1.2 is also applied to the total stream and wetland AMUs for a project that utilizes the FILO program. Note that this 1.2 factor was applied to the mitigation cost estimates for all alternatives for which cost estimates were prepared (e.g., the wetland mitigation fee would therefore be $72,000 per acre). If the option of purchasing mitigation bank AMU credits is selected instead of the FILO program, then the temporal loss factor may not apply.

The cost for Line Items 5 and 6 were calculated on a site-by-site basis based on the factors discussed above.

The USACE's website includes the following mitigation calculator tools, which were accessed on September 25, 2014
(http://www.lrl.usace.army.mil/Missions/Regulatory/Mitigation/InLieuFeeProgram.aspx).

Line Item 7 – Cultural Resources (Potential Phase III data recovery) – A high level, conceptual lump sum cost was developed for each case study alternative to perform Phase I to Phase III archaeological investigations on potential archeological sites and Phase I survey and Criteria of Effect Studies for architectural/historical resources that could be affected or disturbed as a result of the project. These cost estimates are based on the number and location of previously recorded archaeological sites and architectural/historical resources and the potential to find previously unrecorded archaeological sites and architectural/historical resources. Existing data sources were consulted during this process. The data sources include aerial photographs, historic maps, and records on file at various state agencies, such as Indiana Department of Nature Resources, Historic Preservation and Archaeology (DHPA), Indiana State Historic Architectural and Archaeological Research Database (SHAARD), Kentucky Office of State Archaeology (OSA), and Kentucky Heritage Counsel (KHC). Each location had landform variables that were also considered during this process. Steep slopes, disturbed settings, and wetlands have a low potential for archaeological sites. Moderately sloping landforms with intact soils have a moderate potential for archaeological sites. Gently sloping to level areas have high potential for archaeological sites. Due to proximity to water and water-related resources, intact floodplain and terrace settings along the Ohio River have the highest potential for large prehistoric sites that have the potential to provide significant information towards our understanding of regional prehistory. Historic era domestic sites built prior to the mid-twentieth century and not impacted by later development have the highest potential to provide significant information for understanding regional history. The cost for Line Item 7 was calculated on a site-by-site basis based on the factors discussed above[4]. See Appendix III.C-1 for further description of the cultural resources process.

Line Item 8 – Indiana Bat Mitigation – The result of the Endangered Species Act Section 7(a)(2) consultation process with USFWS will likely result in requirements for compensation of lost Indiana bat habitat for any alternative involving clearing of forested areas. Until the consultation process is complete, it is unknown if USFWS will request that land be purchased through a land trust or conservation bank, deeded to a conservancy, or accepted as a deposit through the Indiana Bat Conservation Fund (IBCF). However, the USFWS Biological Opinion on Conservation Memoranda (BO) provides a methodology to estimate the cost of the mitigation. The BO suggests using a base mitigation fee equal to the average value of farm real estate as published annually by the United States Department of Agriculture (USDA) Land Values and Cash Rents report, with a multiplier based on the season of Indiana bat occupancy. The Indiana Bat mitigation fee of $5,338 per acre was applied to all cost estimates for consistency and comparison of alternatives. This mitigation fee rate was in effect at the time of the initial alternatives analysis (2012) where mitigation cost estimates were initially developed for several alternatives as reported in GAI, 2014. The mitigation rate was calculated as the average of the lowest per acre fee of $4,575 (for tree clearing between August 14th through March 31st) and the higher cost per acre fee of

[4] Extensive cultural resources investigations have occurred to date in the Ravine B area as part of project planning/design. Therefore, cultural resources costs for alternatives located in the proximity of Ravine B represent more detailed knowledge and are estimated as being more expensive than off-site alternatives (e.g. Lee Bottom). As stated above, intact floodplain and terrace settings along the Ohio River have very high potential for archaeological sites.

$6,100 (for tree clearing between April 1st through August 15th) assuming the project area was designated as a "known maternity" area for the Indiana bat. The use of this average mitigation fee rate is based on the assumption that tree clearing would need to occur at various times throughout a given year, including during the maximum mitigation fee period, for construction purposes. Note that the actual mitigation fee for an alternative will be based on the mitigation fee per acre in effect at the time of project implementation (assuming that the USACE and USFWS requires this mitigation fee approach to compensate for habitat loss). For example, the project area is now (2014) designated as a "known non-materinity" area therefore the fee per acre could actually be less. Refer to Support Document III.D-1-4 for additional information on the basis of mitigation costs.

In order to calculate a cost for Line Item 8, the unit cost of $5,338/acre was multiplied by the total forested acreage within the impact boundary, where the acreage was estimated using USGS and/or aerial imagery mapping.

Line Items 9-10 – Road Relocation (County/State Road) – GAI developed a conceptual cost estimate to relocate a county and state road for an alternative evaluated in GAI, 2014. The total project cost for each road was divided by the total length of road being relocated to create a unit cost on a linear foot basis. These costs were rounded to $350/LF of county road and $400/LF of state road. Refer to Support Document III.D-1-6 for additional information on the basis of relocation costs. The following assumptions were made in the creation of the estimate:

-County road assumed as 18 ft out-to-out width (two 8' lanes with 1' shoulders),

-State road assumed as 24 ft out-to-out width (two 10' lanes with 2' shoulders),

-Drainage approximated as 20% of Paving and Earthwork cost,

-E&S approximated as 10% of Paving and Earthwork cost,

-Maintenance & Protection of Traffic approximated as 1.5% of Paving and Earthwork cost,

-Signing, Pavement Marking, and Delineation approximated as 1.5% of Paving and Earthwork cost,

-Mobilization approximated as 5% of Total Cost,

-30% contingency added, and

-Estimates do not include Right-of-Way Acquisition, Utility Relocation/Engineering, Post Construction Stormwater Management, Construction Phase Engineering, and Quality Assurance / Quality Control (QA/QC).

If an alternative required the relocation of county or state road(s), the approximate relocation was measured at a conceptual level. To calculate a cost for Line Items 9 and 10, the unit cost per linear foot for county ($350/LF) and state ($400/LF) roads was multiplied by the total linear footage of county and state roads being relocated.

Line Items 11-13 – Pipe Conveyor Transport – The Beumer Group provided price quotes for three pipe conveyor routes in the vicinity of Ravine B based upon existing topography and difficulty of construction. Refer to Support Document III.D-1-7 for additional information regarding these quotes. These quotes included costs for design and supply, mechanical and electrical installations, and civil and foundation work. These quotes were then developed into a unit cost on a linear foot basis, by taking total length and dividing by the total cost for each. These unit costs are $2,150/LF for a route similar to the North Ridge Top path near Ravine B (conveyor runs north along Bottom Ash Pond at TC Station, crosses to the northeast on a bridge, and runs along Wentworth Road), $2,425/LF for a route similar to the Ogden Ridge Road path near Ravine B (conveyor crosses Highway 1838 due east on a bridge, travels east up the adjacent slope and along Ogden Ridge Road), and $3,125/LF for a route similar to the South Ridge Top path near Ravine B (conveyor crosses Highway 1838 due east on a bridge and travels southeast to the ridge tops).

For each alternative, one of the three pipe conveyor routes, which most closely represented the topography of the site, was selected and the linear footage of the conceptual proposed pipe conveyor was measured. This linear foot quantity was multiplied by the route's unit cost to calculate a cost for Line Items 11-13.

Line Item 14 – Transfer Station – Additional input from the Beumer Group included direction on when a transfer station would be needed in order to turn the pipe conveyor in a new direction along its route. When the pipe conveyor contains turns of a radius less than 1000 feet or changes in direction that exceeded 90 degrees, the Beumer Group suggested the use of one transfer station in each of the quotes. They quoted the transfer station at $250,000 each. Alternatives that could not meet the design criteria of minimum pipe conveyor radius of less than 1000 feet, or that had changes in direction that exceed 90 degrees based on existing ground topography or site constraints, were assumed to require a transfer station. Alternatives that had more than one instance of not meeting the design criteria would require multiple transfer stations. The number of transfer stations was multiplied by the unit cost of $250,000 to calculate a cost for Line Item 14.

Line Item 15 – Haul Road – Off Landfill – GAI developed an estimate of probable construction costs for a haul road during a more detailed design of the Ravine B alternative. Multiple components were included in the development of the total unit cost used in Line Item 15. These components include:

-Clearing and grubbing, excavation, foreign borrow excavation, subbase-20" depth (No. 2A), subbase-8" depth (No. 2A), bituminous tack coat, bituminous concrete base course-12" depth, bituminous binder course-4" depth, bituminous wearing course-2" depth, mobilization (assume 5% of roadway total), field laboratory, inspector's field office, equipment package, 18" reinforced concrete pipe, 24" reinforced concrete pipe, geotextiles-class 2-type B, fabricform ditch lining, construction surveying, erosion and sediment pollution control, and signing and pavement marking. Estimate does not include stormwater management, right-of-way, and utility relocation costs.

In order to calculate a cost for Line Item 15, the total linear footage of the haul road required for an alternative was multiplied by the adjusted unit cost of $1,600/LF. The length of haul road was dependent upon site layout and distance from the TC Station and/or CCR transfer location (i.e. barge unloading facility or pipe conveyor discharge). Per LG&E design requirement, the haul road must also parallel the pipe conveyor route where possible to provide ease of access to the pipe conveyor for maintenance as well as for use as primary CCR transport during outages of the pipe conveyor.

Line Item 16 – Bridge – Large (36 FT high, 440 FT long, 60 FT wide) – GAI developed an estimate of probable construction costs for a 3-span prestressed concrete I-beam bridge over KY 1838 during a more detailed design of the Ravine B alternative. Multiple components were included in the development of the total unit cost used in Line Item 16. These components include:

-Structure granular backfill, masonry coating, penetrating sealer for deck, structure excavation-common, structure excavation-solid rock, steel piles-HP14X89, pile points 14", concrete-Class A, concrete-Class AA, concrete-Class C, steel reinforcement, steel reinforcement-epoxy coated, structural steel, expansion dam 4" neoprene, approach slab, prestressed concrete I-beams, 24" PVC schedule 40, 36" steel encasement, and neoprene bearing pads.

These components have base costs in various units but were quantified and totaled to calculate a total project cost of $3,604,000, rounded to $4,000,000 for the purpose of this cost analysis. The total cost did not include the following items:

-General mobilization, clearing and grubbing, construction surveying, embankment construction, utility relocation costs, permitting costs, and traffic control costs.

A large bridge unit was used in each alternative that required an approximate 400 foot span over road, stream, or other valley feature. The unit cost of $4,000,000 was multiplied by the number of large bridges necessary for an alternative to calculate a cost for Line Item 16.

Line Item 17 – Bridge – Medium (200 FT long, 60 FT wide) – A cost per square foot (SF) for various types and spans of bridges is provided in Support Document III.D-1-11. For the medium span bridges used in various alternatives, GAI selected a concrete deck with pre-stressed girder in a continuous span, which has an estimated cost of $145/SF. A bridge 200 FT long and 60 FT wide has a total area of 12,000 SF and therefore a total estimated cost of $1,740,000. This unit cost was rounded up to $1,750,000

Medium bridge units were used in alternatives that required an approximate 200 foot span over smaller road, stream, or other valley features. The unit cost of $1,750,000 was multiplied by the number of medium bridges estimated in an alternative to calculate a cost for Line Item 17.

Line Item 18 – Perimeter Collection Channel – Fabric Form, 6-10' Bottom Width – Line Item 18 estimated the linear footage of perimeter collection channels with an approximate range of 6-10' bottom width used to convey runoff from the conceptual landfill site to an ES/SWM pond. Multiple components were included in the development of the total unit cost of $75.00/LF used in Line Item 18. These components include:

-Excavation and loading, hauling-1 mile round trip, spreading, and fabric form liner.

The channels were quantified by measuring the perimeter of the conceptual landfill layout, where water would be collected and sent to the ES/SWM pond.

The unit cost of $75.00/LF was multiplied by the total linear footage, measured around the entire conceptual landfill layout, for each alternative to calculate a cost for Line Item 18.

Line Item 19 – Upslope Drainage Diversion Channel – Fabric Form, 1-5' Bottom Width – Line Item 19 estimated the linear footage of upslope drainage diversion channels with an approximate range of 1-5' bottom width used to divert runoff around the conceptual landfill footprint and bypassing the ES/SWM pond. The diversion channels were measured around the perimeter of the conceptual landfill layout, on the outside of the collection channels, and then to the end of the ES/SWM pond. Multiple components were included in the development of the total unit cost of $50.00/LF used in Line Item 19. These components include:

-Excavation and loading, hauling-1 mile round trip, spreading, and fabric form liner.

The unit cost of $50.00/LF was multiplied by the total linear footage for an alternative to calculate a cost for Line Item 19.

Line Item 20 – Subgrade Preparation – General Earthwork – Soil Inside Footprint (3000 foot Round Trip) – A conceptual subgrade was created for landfill alternatives using a 100-foot wide Ravine floor, minimum slopes of three percent, and maximum slopes of 3 horizontal (H) to 1 vertical (V). The cut and fill volumes required to build the conceptual subgrade were estimated using AutoCAD software to compare the elevation differences between existing ground and the subgrade surface. Line Item 20 quantified material within the landfill footprint, excluding rock, that can be taken from areas of cut and used in areas where fill is required within the conceptual landfill footprint. The unit cost associated with this Line Item was developed from the following components:

-Excavating, bulk bank, hydraulic crawler, 3 CY, for loading add 15%

-Hauling, 22 CY, off-road, 15 min wait/load/unload, 10 MPH, cycle 3000 feet

-General fill, by dozer, no compaction, and

-Compaction, sheepsfoot or wobbly wheel, 12" lifts, 2 passes.

These components were totaled for a unit cost of $5.65/CY of material. To calculate a cost for Line Item 20, the unit cost was multiplied by the quantity of earthwork that could be used within the conceptual landfill limits of grading.

Line Item 21 – Subgrade Preparation – General Earthwork – Rock Blasting (3000 foot Round Trip) – Line Item 21 estimated the amount of rock material that would need to be excavated/blasted. The rock blasting quantity was estimated by taking the depth between existing ground and the proposed subgrade at points on a grid system. The top elevation of rock was assumed to be 15 feet below existing ground based on drilling programs performed in this region of Kentucky and online review of soils information in the area. The thickness of rock excavation (the depth of cut minus 15 feet) was multiplied by the area of each point on the grid. Finally, the total rock excavation volumes for all of the conceptual landfill footprint were summed. The unit cost associated with this Line Item was developed from the following components:

-Blasting and excavating/loading

-Hauling, 22 CY, off-road, 15 min wait/load/unload, 10 MPH, cycle 3000 feet

-General fill, by dozer, no compaction, and

-Compaction, sheepsfoot or wobbly wheel, 12" lifts, 2 passes.

These components were totaled to determine a unit cost of $21.72 per cubic yard of material. To calculate a cost for Line Item 21, the unit cost was multiplied by the quantity of rock material estimated to be excavated within the landfill limits of grading.

Line Items 22-25 – Subgrade Preparation – Borrowing or Spoiling Excess Material – Soil – ½, 1, 2, or 4 mile Round Trip – Line Items 22-25 estimated the amount of excess excavated material that could not be used as fill or additional borrow material brought into the landfill footprint in order to complete the subgrade construction. From Line Items 20 and 21, if excess material was produced or borrow material was needed to balance the estimated subgrade earthwork, the excess or deficit of material was quantified in Line Items 22-25. The material must be trucked to or from the landfill footprint and the distance from borrow sites spoil areas determines the hauling cost. The difference between Line Items 22-25 is the average round trip hauling distance assumed from the center of the landfill to the center of approximate borrow/spoil areas. The cost associated with this Line Item was developed from the following components:

- Excavating, bulk bank, hydraulic crawler, 3 CY, for loading add 15%

-Hauling, 22 CY, off-road, 15 min wait/load/unload, 10 MPH, cycle ½, 1, 2, or 4 miles (varies between Line Items)

-General fill, by dozer, no compaction, and

-Compaction, sheepsfoot or wobbly wheel, 12" lifts, 2 passes.

These components were totaled to determine a unit cost of $5.65/CY, $5.94/CY, $6.84/CY, and $8.36/CY of material, respectively. To calculate a cost for Line Items 22-25, the unit cost, using the appropriate mileage, was multiplied by the quantity of borrow/spoil material required to balance the site earthwork.

Line Items 26 through 28 – Landfill Composite Liner System ½ or 1.5 mile Round Trip Protective Cover / 2 or 4 mile Round Trip Drainage Layer – Multiple components were included in the development of the total unit costs used in Line Items 26, 27, and 28. These components include:

- 2 ft recompacted soil liner,

- geomembrane liner,

- cushion geotextile,

- 1 foot leachate collection system drainage layer, and

- 2 foot protective cover layer.

In order to calculate a cost for the Line Items 26 through 28, the area to be lined (i.e. the limits of the conceptual landfill grading of a site) was estimated and that acreage was multiplied by the composite unit cost of $91,000/acre, $93,000/acre, and $88,000/acre, respectively depending on the average haul distance from the center of landfill to the source of protective cover and drainage layer materials.

Line Item 29 – Groundwater Underdrain Drainage Pipes – Line Item 29 estimated the linear footage of underdrain interceptors and lateral pipes used to capture and convey groundwater from below the footprint of the landfill to areas downgradient of the landfill to the ES/SWM Pond. The unit cost for the Groundwater Underdrain Pipes was based on estimates for schedule 120 PVC pipe from previous experience on similar projects. The total cost per acre for these projects was used to develop a typical cost per acre to use for all landfill alternatives. The length of pipe estimated for each project was multiplied by its cost per linear foot and then divided by the area of the landfill in acres. This unit cost of $6,000 per acre was multiplied by the estimated conceptual landfill liner acreage to calculate a cost for Line Item 29.

Line Item 30 – Leachate Collection System Drainage Pipes – Line Item 30 estimated the linear footage of leachate collection system interceptors and lateral pipes used to convey water that infiltrates through the landfilled CCR material away from the landfill liner system and to the Leachate Pond. The unit cost for the Leachate Collection System Drainage Pipes was based on estimates for schedule 120 PVC pipe from previous experience on similar projects. The total cost per acre was calculated by multiplying the length of pipe estimated for each project by its cost per linear foot and then dividing that sum by the area of the conceptual landfill. This calculation was used to develop a typical cost per acre to use for all landfill alternatives. This unit cost of $15,000 per acre was multiplied by the estimated conceptual landfill liner acreage to calculate a cost for Line Item 30.

Line Items 31-32 – Large/Medium ES/SWM Pond and Leachate Pond – Earthwork and Liner System (~35/~20 acre-ft) – Multiple components were included in the development of the total unit costs used in Line Items 31 and 32. The unit cost of the medium pond was developed by scaling down the cost of the large pond with a ratio based on the ponds' volumes (20 acre-ft/35 acre-ft). Based on previous construction cost estimating experience on similar projects, these components include:

- Excavation and loading, hauling-1 mile round trip, hauling-3 mile round trip, spreading and compacting, rock blasting (emergency spillway), riser structure and dewatering pipe, 12" prepared subgrade, pond anchor trench. For containment in the leachate pond: 60-mil LLDPE geomembrane over the entire pond, cushion geotextile, 4" fabric form (FF) lining on side slopes, 8" FF lining in pond bottom. Pipe penetration seal (boot), mechanical pump system, electrical pump system, structural pump system, and leachate force main to pump leachate to a separate leachate treatment facility.

The use of the large or medium ponds depended on the layout and existing topography for an alternative. The cost for Line Items 31 and 32 was calculated by multiplying the unit cost of $3,000,000/pond and $2,000,000/pond, respectively, by the number of ponds to be used at a site.

For off-site CCR disposal alternatives that would require leachate collection and treatment (e.g. Lee Bottom) construction of a separate leachate treatment system local to the disposal facility site would likely be required. Costs for this leachate treatment system at offsite CCR disposal locations would likely be more expensive, but have not been included in this analysis.

Line Items 33-34 –Final Cover System – 2 or 4 Mile Round Trip (12 inches clay, 12 inches topsoil) – Multiple components were included in the development of the total unit costs used in Line Items 33 and 34. These components include:

- Excavating,
- 2 or 4 mile round trip (hauling distance determined by measuring from middle of landfill to borrow sites),
- spreading,
- compacting, and
- seeding of vegetative layer.

The difference between Line Items 33-34 is the estimated average hauling distance from the center of the landfill to identified potential borrow sites. In order to calculate a cost for Line Items 33 and 34, the total estimated acreage of the landfill footprint was multiplied by the composite unit cost of $29,000/acre and $33,000/acre, respectively, in order to determine the cost of placing final cover on the landfill.

Line Item 35 – Barge Loading Facility – Fenner Dunlop Conveyor Belting has provided a price quote that states that a barge loading facility with the capacity to handle the full CCR production rate of 910,000 CY per year would be approximately $14,200,000. This includes facility and site construction costs of ~$8.3 million and ~$5.9 million, respectively. This loading facility would be required for any alternative that has barging as a mode of transportation and would be constructed on the Ohio River at or near the TC Station.

In order to calculate a cost for Line Item 35, the unit cost of $8,300,000 was multiplied by one for any alternative using barge transportation. These costs are calculated on a 2014 dollar basis.

Line Item 36 – Barge Unloading Facility – Fenner Dunlop Conveyor Belting has provided a price quote that states that a barge unloading facility with the capacity to handle the full CCR production rate of 910,000 CY per year would be approximately $16,100,000. This includes facility and site construction costs of ~$9.97 million and ~$6.15 million, respectively. This unloading facility would be required for any alternative that has barging as a mode of transportation. The loading facility would be constructed on the Ohio River at or near the designated alternative's disposal facility.

In order to calculate a cost for Line Item 36, the unit cost of $16,100,000 was multiplied by one for any alternative using barge transportation. These costs are calculated on a 2014 dollar basis.

Line Item 37 – Ancillary Costs (Critical Spares and Office/Warehouse Space) – Fenner Dunlop Conveyor Belting has provided a price quote that states that ancillary costs for barge transportation would be approximately $1,600,000. This unit cost includes items related to support facilities for employees consisting of office space, warehouse space, and/or maintenance supplies storage space, as well as spares for critical components in case of the need for replacement.

In order to calculate a cost for Line Item 37, the unit cost of $1,600,000 was multiplied by one for any alternative using barge transportation. These costs are calculated on a 2014 dollar basis.

Line Item 38 – Additional Capital Costs – A number of components are considered to develop the total unit cost for Line Item 38. These components include:

-LG&E Overheads and Engineering Support during design and construction;

-Intermediate Cover and Benches;

-QA/QC (Subgrade, Liner, Final Cover System); and

-Borrow Area Roads and On-Landfill Haul Roads.

These individual line item costs are Lump Sum unit costs that vary between case studies. As discussed in Appendix III.B-1, the Ravine B case study has been analyzed and designed beyond the conceptual design done for the case studies included in this Supplement to the Alternatives Analysis. Capital and operating cost estimates have been prepared for Ravine B relating to the common additional capital and operating costs for landfill alternatives and are used to estimate the same component costs at other case study alternatives on an order of magnitude basis. Engineering judgment was used to compare each of the case studies vs. Ravine B and assign an "Order of Magnitude" multiplier indicating whether the cost would be similar to, (i.e. Order of Magnitude = 1.0), or some multiple of, the estimated cost of that particular line item in Ravine B (i.e. Order of Magnitude = 0.5 or 2.0). The "Order of Magnitude" was then multiplied by the total unit cost estimated in the Ravine B detailed capital cost estimate to develop Lump Sum Unit Costs of each component above for the case studies. Support Document III.D-1-17 describes how each case study was compared to Ravine B to determine an assumed "Order of Magnitude" multiplier for each line item. Table III.D-1-17-1 is included in Support Document III.D-1-17 and lists each of the above components, their assumed "Order of Magnitude" and Lump Sum unit costs estimated for the Ravine B, Sterling Ventures, Lee Bottom, and Valley View case studies. These costs are calculated on a 2013 dollar basis.

Operations and Maintenance (O&M) Costs

Line Items 39-41 – Hauling – 1, 2, or 3 Mile Round Trip (22 CY on landfill/private road) – After CCR material reaches the pipe conveyor termination point or barge unloading facility, it must be hauled via truck in order to be placed in the CCR disposal facility. Line Items 39-41 quantify a cost by multiplying the unit cost of $2.56/CY, $3.46/CY, and $4.19/CY, respectively, for distance hauled by the total volume of CCR material to be stored in the disposal facility. The difference between Line Items 39-41 is the estimated hauling distance from the conveyor endpoint or unloading facility to the approximate centroid of the conceptual CCR disposal facility. Distance varies based on facility location and layout of an alternative. It is important to note that the Sterling Ventures tipping fee proposal did not address handling costs for CCR materials that come off the pipe conveyor. If trucking or other transport is needed to move the CCR into the mine, it is assumed these costs would be in addition to the tipping fee.

Line Item 42 – Hauling – 30 Mile Round Trip (18 CY, 35 MPH avg – Line Item 42 calculates the cost to haul CCR material from the TC Station to an offsite, existing CCR disposal facility at Valley View MSW Landfill. Valley View MSW Landfill is approximately 15 miles away (30 mile round trip). The distance between the TC Station and the off-site landfill is too far for pipe conveyor transportation to be feasible, and there are no barge or nearby rail alternatives. As a result, CCR material would need to be trucked at a cost of $11.55/CY for a 30 mile round trip.

Line Item 42 quantifies a cost by multiplying the total volume of CCR material to be stored in the offsite disposal facility by the unit cost of $11.55/CY.

Line Item 43 – Offsite CCR Disposal - Tipping Fee – Line Item 43 includes the tipping fee to dispose of CCR material from the TC Station to an offsite facility. One of two separate facilities, Valley View MSW Landfill or Sterling Ventures Mine, can be used depending on the alternative. A price quote from Republic Services of KY, LLC states it would cost $21.20/ton to dispose CCR material at Valley View MSW Landfill and a letter from Sterling Ventures, LLC quotes $10.15/ton to dispose of CCR material at Sterling Ventures Mine. It is important to note that tipping fees are subject to increases for new regulatory requirements and other changes in circumstances.

Line Item 43 quantifies a cost by multiplying the unit cost of either $21.20/ton or $10.15/ton, depending on the location of offsite CCR disposal.

Line Item 44 – Pipe Conveyor Cost of Operation – Beumer Group has provided a price quote that states that the pipe conveyor cost of operation would be $0.20/CY. This operational cost was based on the conceptual pipe conveyor routes included in the Line Items 11 through 13. For the purpose of this cost analysis it was assumed that all pipe conveyor routes will have similar cost of operation. The unit cost includes operation and power costs for an average length conveyor utilizing a reasonable cost per kilowatt hour. The price quoted by Beumer Group, and therefore this unit cost does not include salaries of people assigned to operate the conveyor.

In order to calculate a cost for the Line Item 44, the total volume of CCR material to be stored in the CCR disposal facility was multiplied by the unit cost of $0.20/CY to operate the pipe conveyor.

Line Item 45 – Barge Loading and Unloading Operations Cost – Fenner Dunlop Conveyor Belting has provided a price quote that includes the costs involved in managing and operating the barge loading and unloading facilities, including the estimated price to physically place the material onto the barge at the loading facility, and pick it up at the unloading facility.

To calculate the cost for Line Item 45, the unit cost of $1,300,000/year is multiplied by the number of years that barge transport of CCR material is anticipated for an alternative. These costs are calculated on a 2014 dollar basis.

Line Item 46 – Barge Transportation Costs – LG&E provided a price quote from a confidential source that includes the cost involved to physically transport the CCR material via barge. It is assumed that this unit cost includes labor, maintenance, and supplies to operate the push boat for the barges.

To calculate the cost for Line Item 46, the unit cost, which varies based on distance from TC Station to the alternative ($2.24/ton for Lee Bottom Landfill and $2.61/ton for Sterling Ventures Mine), is multiplied by the total amount of material to be disposed of at the CCR Disposal facility.

Line Item 47 – Additional O&M Costs – A number of components are considered to develop the total unit cost for Line Item 47. These components include:

-CCR Placement and Compaction, Survey of CCR Placement, and QA/QC of CCR Placement and Compaction;

-Cleanout/Maintenance of Haul Road, Sediment Basin and Leachate Pond, Leachate Pump Station O&M, Leachate System and Underdrain System, and Landfill Maintenance; and

-Dust Control.

These individual line item costs are Lump Sum unit costs that vary between case studies. As discussed in Appendix III.B-1, the Ravine B case study has been analyzed and designed beyond the conceptual design done for the case studies included in this Supplement to the Alternatives Analysis. Engineering judgment was used to compare each of the case studies vs. Ravine B and assign an "Order of Magnitude" multiplier indicating whether the cost would be similar to, (i.e. Order of Magnitude = 1.0), or some multiple of, the estimated cost of that particular line item in Ravine B (i.e. Order of Magnitude = 0.5 or 2.0). The "Order of Magnitude" was then multiplied by the total unit cost estimated in the Ravine B detailed O&M cost estimate to develop Lump Sum Unit Costs of each line item above for the case studies. Support Document III.D-1-17 describes how each case study was compared to Ravine B to determine an assumed "Order of Magnitude" multiplier for each line item. Table III.D-1-17-1 is included in Support Document III.D-1-17 and lists each of the above line items, their assumed "Order of Magnitude" and Lump Sum unit costs estimated for the Ravine B, Sterling Ventures, Lee Bottom, and Valley View case studies. These costs are calculated on a 2013 dollar basis.

SECTION 5: EXAMPLE OF LINE ITEM TOTAL COST DEVELOPMENT

After each Line Item's unit cost was developed and the magnitude (unit quantity) of each was quantified, the total cost for each Line Item for a particular alternative was determined by multiplying the unit cost by the unit quantity. For certain Line Items (i.e. Environmental Stream/Wetland Mitigation, Cemetery Relocation, Cultural Resources), costs were calculated individually on a case-by-case basis when the unit cost was expected to vary. These costs were quantified on a per alternative basis, as the degree of impact was not uniform across all sites and could not be assigned unit cost consistent across all alternatives.

An example explanation of how a particular Line Item cost is developed from the unit cost and unit quantity is provided below:

Example Line Item 2 – Clearing, Grubbing, and Site Preparation at the Sterling Ventures Mine Alternative.

Unit Cost Development:

The unit cost of $17,000 per acre consisted of two parts: "Cut and Chip Trees" and "Grub Stumps and Remove." Each of these costs were found in the *2012 RS Means Heavy Construction Cost Data* book at $14,600/acre and $7,525/acre, respectively. When multiplying the unit cost by 0.76 for the Frankfort, KY location factor (explained in Section 2.2), they become $11,111/acre for "Cut and Chip Trees" and $5,727/acre for "Grub Stumps and Remove." This totals to $16,838/acre, which was then rounded to $17,000/acre for ease of use.

Unit Quantity Development:

The quantity for Clearing, Grubbing, and Site Preparation was developed by measuring the number of forested acres assumed to be disturbed due to construction of the project. For the Sterling Ventures Mine Alternative, the only land disturbance assumed is due to construction of the pipe conveyor, haul road, and barge unloading facility. A conceptual impact boundary was developed based on a 1000 foot wide transportation corridor along the conceptual route for the pipe conveyor and haul road. The corridor is based on a conservative approximation of the limits of earthwork cut/fills required to construct a haul road and pipe conveyor system. The total forested acreage, defined as any area observed to have tree cover, within the impact boundary was calculated using USGS mapping. This was determined to be 290 acres.

290 acres multiplied by the unit cost of $17,000/acre comes to $4,930,000, which is the total cost for Line Item 2-Clearing, Grubbing, and Site Preparation in the Sterling Ventures Mine Alternative.

TRIMBLE COUNTY GENERATING STATION LANDFILL PROJECT
SUPPLEMENT TO ALTERNATIVES ANALYSIS
TABLE APPENDIX III.D-1 - UNIT COST DEVELOPMENT[1,2,3]

BY:RJH 12/05/14
CHECKED:KPR 12/05/14

		Unit Cost ($)	Unit	Source	Source Support Document	RS Means Item Number	Original Cost ($)	Original Unit	Trimble, KY Adjusted Cost ($)	Adjusted Unit	Adjustment Equation
CAPITAL COSTS											
	General Project / Permitting / Infrastructure Cost Impacts										
1	Property Acquisition	$ 12,000	Acre	LG&E Supplied Estimate	N/A	N/A	-	-	-	-	N/A
2	Clearing, Grubbing, and Site Preparation	$ 17,000	Acre	See Below	See Below	See Below	-	-	16,837	Acre	Sum of Sub-Items
	Cut and Chip Trees	*$ 11,111*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.11.10.10.0300*	*14,600*	*Acre*	*11,111*	*Acre*	*N/A*
	Grub Stumps and Remove	*$ 5,727*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.11.10.10.0350*	*7,525*	*Acre*	*5,727*	*Acre*	*N/A*
3	Large Utility Line Relocation	$ 880	LF	Inflated LG&E Supplied Estimate - Scaled from 90% TC Construction Estimate	Support Document III.D-1-2	N/A	5,954,000	Lump Sum	872	LF	$5,954,000 / 6,825 LF
4	Fencing	$ 50	LF	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-3	*See Support Document III.D-1-3*	-	-	-	-	N/A
5	Environmental Wetland Mitigation (cost based on adjusted mitigation units)	Varies	Acre	Kentucky Department of Fish and Wildlife Resources Fee In-Lieu Of Program	Support Document III.D-1-4	N/A	-	-	-	-	N/A
6	Environmental Stream Mitigation (cost based on adjusted mitigation units)	Varies	LF	Kentucky Department of Fish and Wildlife Resources Fee In-Lieu Of Program	Support Document III.D-1-4	N/A	-	-	-	-	N/A
7	Cultural Resources (Potential Phase III data recovery)	Varies	EA	GAI Cost Estimate	Support Document III.D-1-5	N/A	-	-	-	-	N/A
8	Indiana Bat Mitigation[4]	$ 5,338	Acre	GAI Cost Estimate	Support Document III.D-1-4	N/A	5,338	Acre	5,338	Acre	($4,575 + $6,100) / 2
9	Road Relocation (County Road)	$ 350	LF	GAI Cost Estimate	Support Document III.D-1-6	N/A	303	LF	350	LF	Round up
10	Road Relocation (State Road)	$ 400	LF	GAI Cost Estimate	Support Document III.D-1-6	N/A	350	LF	400	LF	Round up
	CCR Transportation										
11	Pipe Conveyor Transport (similar to North Ridge Top path at Ravine B)	$ 2,150	LF	Recent Vendor/Contractor Supplied Estimate	Support Document III.D-1-7	N/A	-	-	-	-	N/A
12	Pipe Conveyor Transport (similar to Ogden Ridge Road path at Ravine B)	$ 2,425	LF	Recent Vendor/Contractor Supplied Estimate	Support Document III.D-1-7	N/A	-	-	-	-	N/A
13	Pipe Conveyor Transport (similar to South Ridge Top path at Ravine B)	$ 3,125	LF	Recent Vendor/Contractor Supplied Estimate	Support Document III.D-1-7	N/A	-	-	-	-	N/A
14	Transfer Station	$ 250,000	EA	Recent Vendor/Contractor Supplied Estimate	Support Document III.D-1-8	N/A	-	-	-	-	N/A
15	Haul Road - Off Landfill	$ 1,600	LF	Scaled from Recent Haul Road Construction Package Cost Estimate	Support Document III.D-1-9	N/A	10,487,982	Lump Sum	1,565	LF	$10,487,982 / 6,700 LF
16	Bridge - Large (36 FT high, 440 FT long, 60 FT wide)	$ 4,000,000	EA	Scaled from Recent Haul Road Construction Package Cost Estimate	Support Document III.D-1-10	N/A	3,965,000	EA	4,000,000	EA	Round up
17	Bridge - Medium (200 FT long, 60 FT wide)	$ 1,750,000	EA	Scaled from Recent Haul Road Construction Package Cost Estimate	Support Document III.D-1-11	N/A	145	SF	1740000	EA	$/SF * SF
	Landfill Preparation										
18	Perimeter Collection Channel - Fabric Form, 6-10' Bottom Width	$ 75.00	LF	Recent Construction Bid Price or Supplier Quote on Similar Project	N/A	N/A	-	-	-	-	N/A
19	Upslope Drainage Diversion Channel - Fabric Form, 1-5' Bottom Width	$ 50.00	LF	Recent Construction Bid Price or Supplier Quote on Similar Project	N/A	N/A	-	-	-	-	N/A
20	Subgrade Preparation - General Earthwork - Soil Inside Footprint (3000 ft R.T.)	$ 5.65	CY	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-12	*See Support Document III.D-1-12*	7.42	CY	5.65	CY	N/A
21	Subgrade Preparation - General Earthwork - Rock Blasting (3000 ft R.T.)	$ 21.72	CY	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-12	*See Support Document III.D-1-12*	28.54	CY	21.72	CY	N/A
22	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 1/2 Mile RT	$ 5.65	CY	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-12	*See Support Document III.D-1-12*	7.42	CY	5.65	CY	N/A
23	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 1 Mile RT	$ 5.94	CY	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-12	*See Support Document III.D-1-12*	7.81	CY	5.94	CY	N/A
24	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 2 Miles RT	$ 6.84	CY	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-12	*See Support Document III.D-1-12*	8.99	CY	6.84	CY	N/A
25	Subgrade Preparation - Borrow or Spoiling Excess Material - Soil - 4 Miles RT	$ 8.36	CY	2012 RS Means Heavy Construction Cost Data	Support Document III.D-1-12	*See Support Document III.D-1-12*	10.99	CY	8.36	CY	N/A
26	Landfill Composite Liner System - 0.5 mi Round Trip (RT) Protective Cover/4 mi RT Drainage Layer	$ 91,000	Acre	See Below	See Below	See Below	-	-	90,682	Acre	Sum of Sub-Items-rounded to $91,000
	Protective Cover - 24 Inch Layer (Trimble CCRs)	***$ 17,139***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***17,139***	*Acre*	***Sum of Sub-Items***
	Loading	*$ 4,543*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.1350*	*1.85*	*CY*	*4,543*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Hauling Protective Cover Layer - 0.5 Mile Round Trip	*$ 7,317*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5090*	*2.98*	*CY*	*7,317*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Leachate Collection Drainage Layer - 12 Inch Layer (Trimble Bottom Ash)	***$ 12,830***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***12,830***	*Acre*	***Sum of Sub-Items***
	Loading	*$ 2,271*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.1350*	*1.85*	*CY*	*2,271*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	Hauling Drainage Layer - 4.0 Mile Round Trip	*$ 7,919*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5120*	*6.45*	*CY*	*7,919*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	Spreading	*$ 2,640*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*2,640*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	10 OZ/SY Cushion Geotextile	***$ 4,985***	*Acre*	***GAI Cost Estimate from Past Project***	***Support Document III.D-1-13***	***N/A***	*1.03*	*SY*	***4,985***	*Acre*	*$/SY * 1SY/9SF * 43560SF/Acre*
	60-mil LLDPE Geomembrane	***$ 32,670***	*Acre*	***GAI Cost Estimate from Past Project***	***Support Document III.D-1-13***	***N/A***	*6.75*	*SY*	***32,670***	*Acre*	*$/SY * 1SY/9SF * 43560SF/Acre*
	Recompacted Soil Liner (RSL) - 24 Inch Layer	***$ 23,057***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***23,057***	*Acre*	***Sum of Sub-Items***
	Excavation & Loading	*$ 4,076*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.0300*	*1.66*	*CY*	*4,076*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Hauling RSL Layer - 1.0 Mile Round Trip	*$ 11,172*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5110*	*4.55*	*CY*	*11,172*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Compacting	*$ 1,891*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5720*	*0.77*	*CY*	*1,891*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Compacting	*$ 638*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5060*	*0.26*	*CY*	*638*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
27	Landfill Composite Liner System - 1.5 mi RT Protective Cover/4 mi RT Drainage Layer	$ 93,000	Acre	See Below	See Below	See Below	-	-	93,088	Acre	Sum of Sub-Items-rounded to $93,000

TRIMBLE COUNTY GENERATING STATION LANDFILL PROJECT
SUPPLEMENT TO ALTERNATIVES ANALYSIS
TABLE APPENDIX III.D-1 - UNIT COST DEVELOPMENT[1,2,3]

BY:RJH 12/05/14
CHECKED:KPR 12/05/14

		Unit Cost ($)	Unit	Source	Source Support Document	RS Means Item Number	Original Cost ($)	Original Unit	Trimble, KY Adjusted Cost ($)	Adjusted Unit	Adjustment Equation
CAPITAL COSTS											
	Protective Cover - 24 Inch Layer (Trimble CCRs)	***$ 19,546***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***19,546***	*Acre*	***Sum of Sub-Items***
	Loading	*$ 4,543*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.1350*	*1.85*	*CY*	*4,543*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Hauling Protective Cover Layer - 1.5 Mile Round Trip	*$ 9,724*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5090*	*3.96*	*CY*	*9,724*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Leachate Collection Drainage Layer - 12 Inch Layer (Trimble Bottom Ash)	***$ 12,830***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***12,830***	*Acre*	***Sum of Sub-Items***
	Loading	*$ 2,271*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.1350*	*1.85*	*CY*	*2,271*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	Hauling Drainage Layer - 4.0 Mile Round Trip	*$ 7,919*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5120*	*6.45*	*CY*	*7,919*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	Spreading	*$ 2,640*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*2,640*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	10 OZ/SY Cushion Geotextile	***$ 4,985***	*Acre*	***GAI Cost Estimate from Past Project***	***Support Document III.D-1-13***	***N/A***	*1.03*	*SY*	***4,985***	*Acre*	*$/SY * 1SY/9SF * 43560SF/Acre*
	60-mil LLDPE Geomembrane	***$ 32,670***	*Acre*	***GAI Cost Estimate from Past Project***	***Support Document III.D-1-13***	***N/A***	*6.75*	*SY*	***32,670***	*Acre*	*$/SY * 1SY/9SF * 43560SF/Acre*
	Recompacted Soil Liner (RSL) - 24 Inch Layer	***$ 23,057***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***23,057***	*Acre*	***Sum of Sub-Items***
	Excavation & Loading	*$ 4,076*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.0300*	*1.66*	*CY*	*4,076*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Hauling RSL Layer - 2.0 Mile Round Trip	*$ 11,172*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5110*	*4.55*	*CY*	*11,172*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Compacting	*$ 1,891*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5720*	*0.77*	*CY*	*1,891*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Compacting	*$ 638*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5060*	*0.26*	*CY*	*638*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
28	Landfill Composite Liner System - 0.5 mi RT Protective Cover/2 mi RT Drainage Layer	$ 88,000	Acre	See Below	See Below	See Below	-	-	88,349	Acre	Sum of Sub-Items-rounded to $88,000
	Protective Cover - 24 Inch Layer (Trimble CCRs)	***$ 17,139***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***17,139***	*Acre*	***Sum of Sub-Items***
	Loading	*$ 4,543*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.1350*	*1.85*	*CY*	*4,543*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Hauling Protective Cover Layer - 0.5 Mile Round Trip	*$ 7,317*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5090*	*2.98*	*CY*	*7,317*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Leachate Collection Drainage Layer - 12 Inch Layer (Trimble Bottom Ash)	***$ 10,497***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***10,497***	*Acre*	***Sum of Sub-Items***
	Loading	*$ 2,271*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.1350*	*1.85*	*CY*	*2,271*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	Hauling Drainage Layer - 2.0 Mile Round Trip	*$ 5,586*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5110*	*4.55*	*CY*	*5,586*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	Spreading	*$ 2,640*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*2,640*	*Acre*	*$/CY * 1FT/3FT * 43560CF/9SF*
	10 OZ/SY Cushion Geotextile	***$ 4,985***	*Acre*	***GAI Cost Estimate from Past Project***	***Support Document III.D-1-13***	***N/A***	*1.03*	*SY*	***4,985***	*Acre*	*$/SY * 1SY/9SF * 43560SF/Acre*
	60-mil LLDPE Geomembrane	***$ 32,670***	*Acre*	***GAI Cost Estimate from Past Project***	***Support Document III.D-1-13***	***N/A***	*6.75*	*SY*	***32,670***	*Acre*	*$/SY * 1SY/9SF * 43560SF/Acre*
	Recompacted Soil Liner (RSL) - 24 Inch Layer	***$ 23,057***	*Acre*	***See Below***	***See Below***	***See Below***	-	-	***23,057***	*Acre*	***Sum of Sub-Items***
	Excavation & Loading	*$ 4,076*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.0300*	*1.66*	*CY*	*4,076*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Hauling RSL Layer - 2.0 Mile Round Trip	*$ 11,172*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5110*	*4.55*	*CY*	*11,172*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Compacting	*$ 1,891*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5720*	*0.77*	*CY*	*1,891*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Compacting	*$ 638*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5060*	*0.26*	*CY*	*638*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
29	Groundwater Underdrain Drainage Pipes	$ 6,000	Acre	GAI Cost Estimate	Support Document III.D-1-14	N/A	-	-	-	-	N/A
30	Leachate Collection System Drainage Pipes	$ 15,000	Acre	GAI Cost Estimate	Support Document III.D-1-14	N/A	-	-	-	-	N/A
	Erosion and Sediment / Stormwater Management (ES/SWM) and Leachate Ponds[5]										
31	Large ES/SWM Pond and Leachate Pond - Earthwork and Liner System (~35 acre-ft)	$ 3,000,000	EA	GAI Cost Estimate	Support Document III.D-1-15	N/A	-	-	-	-	N/A
32	Medium ES/SWM Pond and Leachate Pond - Earthwork and Liner System (~20 acre-ft)	$ 2,000,000	EA	Scaled from GAI Cost Estimate	Support Document III.D-1-15	N/A	1,847,253	EA	2,000,000		Round up
	Landfill Cap Cover System										
33	Final Cover System - 2 Mile RT (12 Inches Clay; 12 Inches Topsoil)	$ 29,000	Acre	See Below	Support Document III.D-1-1	See Below	-	-	28,233	Acre	Sum of Sub-Items
	Seeding of Vegetative Layer	*$ 3,507*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*32.92.19.14.4600*	*80.50*	*M.S.F*	*3,507*	*Acre*	*$ / 1000 S.F * 43560*
	Excavating	*$ 6,532*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.0300*	*2.66*	*CY*	*6,532*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
	2.0 Mile RT	*$ 11,172*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5110*	*4.55*	*CY*	*11,172*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
	Compacting	*$ 1,743*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5040*	*0.71*	*CY*	*1,743*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
34	Final Cover System - 4 Mile RT (12 Inches Clay; 12 Inches Topsoil)	$ 33,000	Acre	See Below	Support Document III.D-1-1	See Below	-	-	32,899	Acre	Sum of Sub-Items
	Seeding of Vegetative Layer	*$ 3,507*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*32.92.19.14.4600*	*80.50*	*M.S.F*	*3,507*	*Acre*	*$ / 1000 S.F * 43560*
	Excavating	*$ 6,532*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.16.42.0300*	*2.66*	*CY*	*6,532*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
	4.0 Mile RT	*$ 15,838*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.20.5120*	*6.45*	*CY*	*15,838*	*Acre*	*$/CY * 2FT/3FT * 43560CF/9SF*
	Spreading	*$ 5,279*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.17.0020*	*2.15*	*CY*	*5,279*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
	Compacting	*$ 1,743*	*Acre*	*2012 RS Means Heavy Construction Cost Data*	*Support Document III.D-1-1*	*31.23.23.23.5040*	*0.71*	*CY*	*1,743*	*Acre*	*$/CY * 1CY/27CF * 2FT * 43560AC*
	Barge Transport										

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 18

Witness: John N. Voyles/R. Scott Straight/Gary H. Revlett

Q-18. With respect to the Trimble County gypsum storage pond:

a. Will gypsum still be placed in Trimble's gypsum storage pond following the completion of the Ghent CCRT facility and landfill?

b. Will the Trimble gypsum storage pond qualify as an "Existing Landfill" under the new CCR regulations? If so, will the Ghent gypsum stacking facility still be used as a landfill after the effective date of the new CCR regulations?

c. Will gypsum in the Trimble gypsum storage pond continue to be used by wallboard manufacturers after completion of the CCRT, or will all gypsum for wallboard manufacturers be loaded from the CCRT?

d. If the Gypsum stacking facility is used following the effective date of the new CCR regulations, will gypsum be processed through the Trimble gypsum storage pond prior to being placed in the gypsum stacking facility?

e. What is the current capacity, and the total projected capacity, of the Trimble gypsum storage pond?

f. Has the projected annual capacity of the Trimble gypsum storage pond changed since the production and capacity assumed in Exhibit C attached to Sterling's Complaint?

g. What is the moisture content range of gypsum removed from the Trimble gypsum storage pond for transport to wallboard manufacturing plants?

h. What is the current process used by wallboard manufacturers or other beneficial users to transport gypsum from Trimble County to the beneficial use site?

A-18. a. Yes. Gypsum from Trimble County's units will be placed in Trimble County's gypsum storage pond ("GSP") until it reaches its full capacity or regulations require it to be closed. Ghent's CCRT facility and landfill have been placed in service. The Ghent facilities have no impact on Trimble County's gypsum storage pond operation.

b. The Trimble Gypsum Pond constitutes an existing surface impoundment, rather than an existing landfill, under the CCR Rule. The Companies plan to continue utilizing the Trimble Gypsum Pond and the Ghent Gypsum Stack after the effective date of the CCR rule.

c. None of the gypsum slurry sent to the Trimble County GSP is used by wallboard manufacturers. After completion of the CCRT, gypsum slurry can be sent to any of the following:
   i) To the GSP as long as there is remaining storage capacity and the CCR regulations allow that to continue
   ii) To the existing SynMat facility to be dewatered for their use per contractual requirements
   iii) To the new CCRT to be dewatered for use by wallboard manufacturers or placement in the landfill

d. Trimble County does not have a stacking facility.

e. The total capacity of the Trimble County GSP is approximately 1.8 million cubic yards. Based on the latest volumetric survey results from December 2014, the GSP has a remaining capacity of approximately 1.3 million cubic yards.

f. The Trimble County GSP remaining capacity changes regularly driven by several variables including unit capacity factors and contractual take rates for wallboard production.

g. Gypsum is not reclaimed from the Trimble County GSP for transport to wallboard manufacturing plants.

h. Trucks and barges are used to transport gypsum from Trimble County to the beneficial use site.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 19

Witness: John N. Voyles/R. Scott Straight

Q-19. With respect to the gypsum barge loading facility at the Trimble County Station:

a. What is the current maximum capacity of the barge loading facility?

b. Please describe the specific capacity limiting factors at the gypsum barge loading facility. Please provide copies of all equipment specifications, calculations, work papers, spreadsheets and any other supporting documents, used in support of your response.

c. Who owns the barges and tugs currently used to transport gypsum from the barge loading facility?

d. Does LG&E and/or KU currently own any barges or tugs used to transport gypsum from the barge loading facility to end users? If so, how many?

A-19. The gypsum barge loading facility at Trimble County Station is owned and operated by SynMat. The Companies do not control this facility or have the right to load material through it without approval from SynMat.

a. SynMat has historically loaded gypsum barges at a rate of around 300 tons/hour.

b. The Companies have not performed such an analysis for the reasons stated above.

c. The barges and tugs used to transport gypsum from the barge loading facility are owned primarily by Ingram.

d. The Companies do not currently own any barges or tugs.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 20

Witness: John N. Voyles/R. Scott Straight/Caryl M. Pfeiffer

Q-20. What are the average hours per day, and number of days per years, that the Trimble gypsum barge loading facility, fly ash barge loading facility and limestone barge unloading facility operate? Please provide copies of all calculations, work papers, spreadsheets and any other supporting documents, used in support of your response.

A-20. The Companies do not have the specific information requested. Based on the information readily available, during the period January through June 2015, the average hours per day, and number of days per year are shown in the following chart.

Facility	Average Hours to Load/Unload Barge	Days per Year (through June 2015)
Fly Ash Loading[1]	16	27
Gypsum Loading[2]	5.5	5
Limestone Unloading[3]	3	80

1 – Hours are an estimate based on plant operating history.
2 – Hours are an estimate from SynMat.
3 – Hours are based on station unload reports (see supporting detail below).

Average Hours to Unload Barges

	Hours to unload Trimble limestone barges:						
	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	
	2.25	3.00	3.00	3.00	3.00	1.75	
	2.50	2.25	2.00	3.25	2.25	2.00	
	1.50	2.50	4.00	2.00	9.50	2.00	
	2.50	4.50	2.50	2.00	3.00	2.75	
	3.50	4.00	2.50	2.25	2.75	2.00	
	2.25	3.00	2.75	2.50	2.50	3.50	
	3.00	1.00	2.00	3.00	4.75	5.00	
	1.25	3.25	3.50	4.50	3.00	3.00	
	3.00	2.50	3.00	2.25	3.00	3.50	
	3.00	3.50	2.50	1.00		1.00	
	4.00	7.00	2.50	3.00		2.00	
	2.50	2.50	3.50			3.50	
	3.00	3.25	3.50			2.50	
	5.00		3.25			3.75	
	6.00		3.75			3.00	
			3.00			2.50	
			3.25			3.25	
			3.00			2.25	
						2.50	
						2.25	
						2.50	
Total hours	**45.25**	**42.25**	**53.50**	**28.75**	**33.75**	**56.50**	**260.00**
# Barges	**15.00**	**13.00**	**18.00**	**11.00**	**9.00**	**21.00**	**87.00**

Total hours	260
# barges	87
Ave hours per barge	**3**

Three (3) hours per barge on average January through June

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 21

Witness: Caryl M. Pfeiffer/Counsel

Q-21. With respect to the Synthetic Materials ("Synmat") contract, please answer the following. Please provide copies of all equipment specifications, calculations, work 10 papers, spreadsheets and any other supporting documents, used in support of your responses.

a. What is the contract period of the Synmat contract, and terms under which the contract can be extended by either party?

b. What is the minimum and maximum purchase tons in the Synmat contract? If the contract has a deferral period, please explain the deferral period contractual terms.

c. What are the penalties for Synmat not buying the minimum contracted purchase amount?

d. Does KU and/or LG&E have any knowledge or reason to believe that Synmat would not be able to meets its obligations under the contract?

e. Please explain in detail why it is not reasonable to assume that the contract with Synmat will continue, or that Synmat will not perform as set forth in the contract.

f. Please explain why it is not reasonable to assume that the current volume of beneficial use of Trimble County's gypsum production by Synmat or any other beneficial use party will not continue in the future.

g. If it is reasonable to assume that some beneficial use of Trimble County's gypsum production will continue in the future by Synmat and/or other beneficial users, please provide the amount of beneficial use that it is reasonable to assume will continue, and the amount the Company has planned for or expects to continue.

h. Is the contract between Synmat and Lafarge dated December 11, 2007 for delivery of Trimble County gypsum to Lafarge plants still in place?

i. Has the Company investigated or had discussions with Synmat or any other party as to whether anticipated closings of coal-fired power plants and/or the conversion of coal-fired power plants to natural gas will have an impact on future demand for gypsum and/or fly ash from Ghent or Trimble County. If so, please provide all e-mails, correspondence, PVRR analyses, spreadsheets, documentation, internal or external presentations, business cases, forecasts and any other information prepared, reviewed or discussed with respect to anticipated future demand.

A-21. a. The requested information is considered to be confidential and proprietary. See the response to PSC 1-8b(2).

b. See the response to part a above.

c. See the response to part a above.

d. The Companies do not expect SynMat to sell the minimum required tonnage in the near future due to current market conditions.

e. The Companies expect the contract with SynMat to continue in the future.

f. The quality of Trimble County Station's by-product is subject to change in the future for many reasons including the addition of new environmental control equipment and actions taken to meet regulatory requirements. This could also affect the quantity of by-product available for market.

g. The Companies expect similar volumes of gypsum to be sold in the future as has been sold in the past. However, the amount of beneficial use is always subject to change based on market conditions, by-product quality and quantity, changes in environmental compliance requirements, etc.

h. The Companies are not a party to the agreement referenced in this question.

i. General discussions have taken place on what impact plant closings could have on the marketability of by-product; however, no conclusive action has taken place. Concerning documents responsive to this request, see attached. Counsel for the Companies is continuing to undertake a reasonable and diligent search for other such documents and will reasonably supplement this response no later than Monday July 20, 2015.

From: Tom H. Adams(Thomas.Adams@acaa-usa.org)
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CC:
BCC:
Subject: ARTBA reports
Sent: 07/03/2015 02:23:33 PM -0400 (EDT)
Attachments: ARTBA final historical.compressed.pdf; ARTBA final forecast.compressed.pdf;

All,

Attached please find the ARTBA reports as delivered. The historical document is 74 pages. The forecast is 48 pages. Dawn Santoianni is working on a summary document of about 10 pages. Final review of that document is being completed. It should be available in about one week.

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PRODUCTION AND USE OF COAL COMBUSTION PRODUCTS IN THE U.S.

Market Forecast Through 2033

PREPARED BY: AMERICAN ROAD & TRANSPORTATION BUILDERS ASSOCIATION

PREPARED FOR: AMERICAN COAL ASH ASSOCIATION

JUNE 2015

ABOUT ARTBA

Established in 1902, the American Road & Transportation Builders Association's (ARTBA) membership includes over 6,000 private and public sector representatives that are involved in the planning, designing, construction and maintenance of the nation's roadways, waterways, bridges, ports, airports, rail and transit systems.

ABOUT THE AUTHOR

This research was conducted by a team led by Dr. Alison Premo Black, vice president of policy and chief economist for the American Road & Transportation Builders Association in Washington, D.C. Research support was provided by Darwyyn Deyo.

Dr. Black, who earned her PhD in Economics at The George Washington University in the Nation's Capital, also holds an M.A. in International Economics and Latin American Studies from the Johns Hopkins School of Advanced International Studies. She graduated magna cum laude from Syracuse University, where she was a member of Phi Beta Kappa and the Golden Key Honors Society, with majors in International Relations, Latin American Studies and Spanish. Since joining ARTBA in 2000, Dr. Black has led teams and authored over 75 studies examining state transportation funding and investment patterns and was responsible for the 2011 report "The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction."

ACKNOWLEDGMENTS

This study relied on historical data on coal combustion products (CCPs) compiled by the American Coal Ash Association (ACAA), considered the authoritative source for CCP production and use statistics in the U.S. ACAA conducts a voluntary annual survey of the coal-fueled electric utility industry to track quantities of CCPs produced and beneficially used. The annual CCP Production & Use Survey Report has been used by industry and government agencies including the Environmental Protection Agency and the Department of Energy.

This study relied on energy data related to electric generation, projected coal unit retirements, fuel costs, and CCP disposition from the U.S. Energy Information Administration (EIA). The EIA collects, analyzes and disseminates independent and impartial energy information for policymakers and public understanding. The EIA publishes the Annual Energy Outlook and data collected directly from generators on numerous annual survey forms.

The author wishes to thank Dr. Fred Joutz, Professor of Economics and Co-director of the Research Program on Forecasting at The George Washington University and Dr. Anthony M. Yezer, Director of the Center for Economic Research at The George Washington University for their suggestions and input on the modeling methodology and report.

Dr. Joutz has served as a consultant and technical expert to the Energy Information Administration, including work on EIA's Short-Term Energy Outlook (STEO), Annual Energy Outlook (AEO and NEMS), and International Energy Outlook (IEO). He is a Senior Fellow of the US Association of Energy Economics.

Dr. Yezer has been a Fellow of the Homer Hoyt School of Advanced Studies in Real Estate and Urban Economics since 1991. He has served as an expert witness for the Federal Trade Commission and testified before Congress on issues related to credit market regulation and subprime mortgage lending.

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EXECUTIVE SUMMARY

Coal combustion products (CCPs), which are byproducts formed during the combustion of coal to produce electricity, have long been considered valuable materials that have numerous applications, including the construction of dams, bridges and highways; building products; manufacturing; mining and agricultural uses. Products containing CCPs can be found in nearly every U.S. home, including gypsum wallboard, foundations, roofing shingles and concrete driveways.

Collectively known as "coal ash," CCPs are a class of materials that have varied chemical and physical characteristics. The use of CCPs in place of mined or manufactured materials yield economic, sustainability and performance benefits. The two most widely-used types of CCPs are fly ash in concrete and flue gas desulfurization (FGD) material in wallboard, accounting for 45 percent and 25 percent of total CCP utilization, respectively.

The production and availability of CCPs is directly tied to the amount of coal-fueled electricity generation. Although coal once accounted for over 50 percent of electricity generated in the U.S., that percentage has been falling in recent years due to coal unit retirements and competition from natural gas. This report was commissioned to evaluate the availability and utilization of CCPs amidst a changing energy landscape, and draws on data and analysis from a companion document that evaluates historical trends in CCP production and use.

This study draws on four decades of CCP production and utilization data, projections for future coal-fueled electricity generation, and analysis of economic factors to forecast future CCP production and use.

A series of ten individual econometric models were created using Box-Jenkins methods to forecast values for the production and utilization for the different categories of CCPs: fly ash, bottom ash, FGD material, boiler slag and fluidized bed combustor (FBC) ash.

The modeling process included model identification and selection, estimating parameters, forecasting and model validation. Each forecast includes upper and lower bounds based on 95 percent confidence levels, to give the reader an idea of alternative production and utilization scenarios, based on trends in the historical data.

CCP production and use data is from the American Coal Ash Association (ACAA). Additional inputs for the models include electric power and coal consumption projections from the U.S. Energy Information Administration (EIA) in the 2014 baseline case of the Annual Energy Outlook.

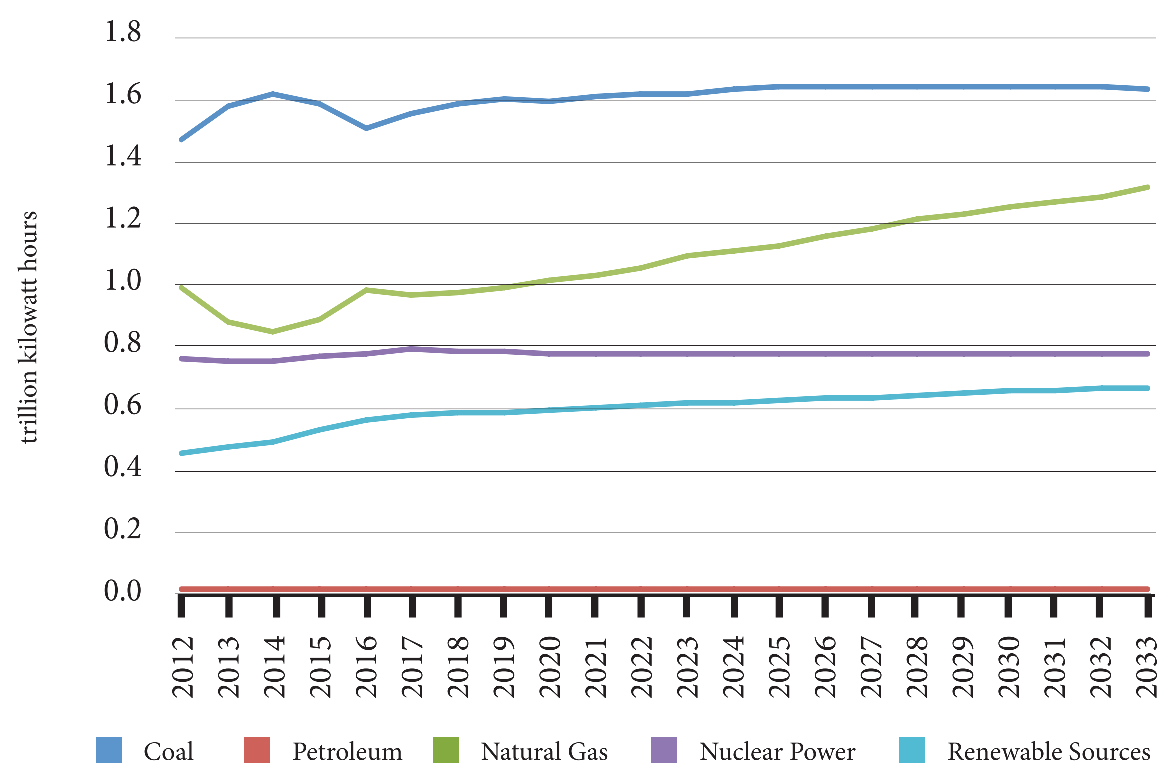
This study also considered the impact on CCP production of alternative "low growth" and "high growth" scenarios for coal-fueled electricity generation from the EIA.

CCP PRODUCTION WILL INCREASE THROUGH 2033

Despite the retirement of coal-fueled generating units and increased reliance on natural gas for power generation, electric power generation from coal is expected to remain relatively steady through 2033, as shown in Figure E-1. This is due to increasing demand for electricity derived from several economic factors including population growth. As a result, CCP production is forecast to grow from 114.7 million short tons in 2013 to 120.6 million short tons in 2033 as shown in figure E-2.

Alternative scenarios for "low growth" and "high growth" in CCP production forecast a range from 94.8 to 161.5 million short tons in 2033. These alternative scenarios represent lower and upper bounds for forecast production. The "low growth" scenario corresponds to accelerated retirements of coal-fueled electricity generating units over the next 20 years.[1] The "high growth" scenario corresponds to growth in fly ash and FGD material production consistent with historical patterns. It is important to note that even under the "low growth" scenario with accelerated coal-fueled generating unit retirements, production of fly ash and FGD material is still expected to exceed utilization.

FIGURE E-1: COAL-FUELED ELECTRIC POWER EXPECTED TO REMAIN RELATIVELY STEADY THROUGH 2033



[1]The accelerated retirements scenario is derived from the U.S. EIA Annual Energy Outlook 2014, which assumes an additional 110 gigawatts (GW) of coal-fueled generating capacity is retired compared to the reference case. The reference case includes the impacts of environmental regulations including MATS, ELG and CCR rules.

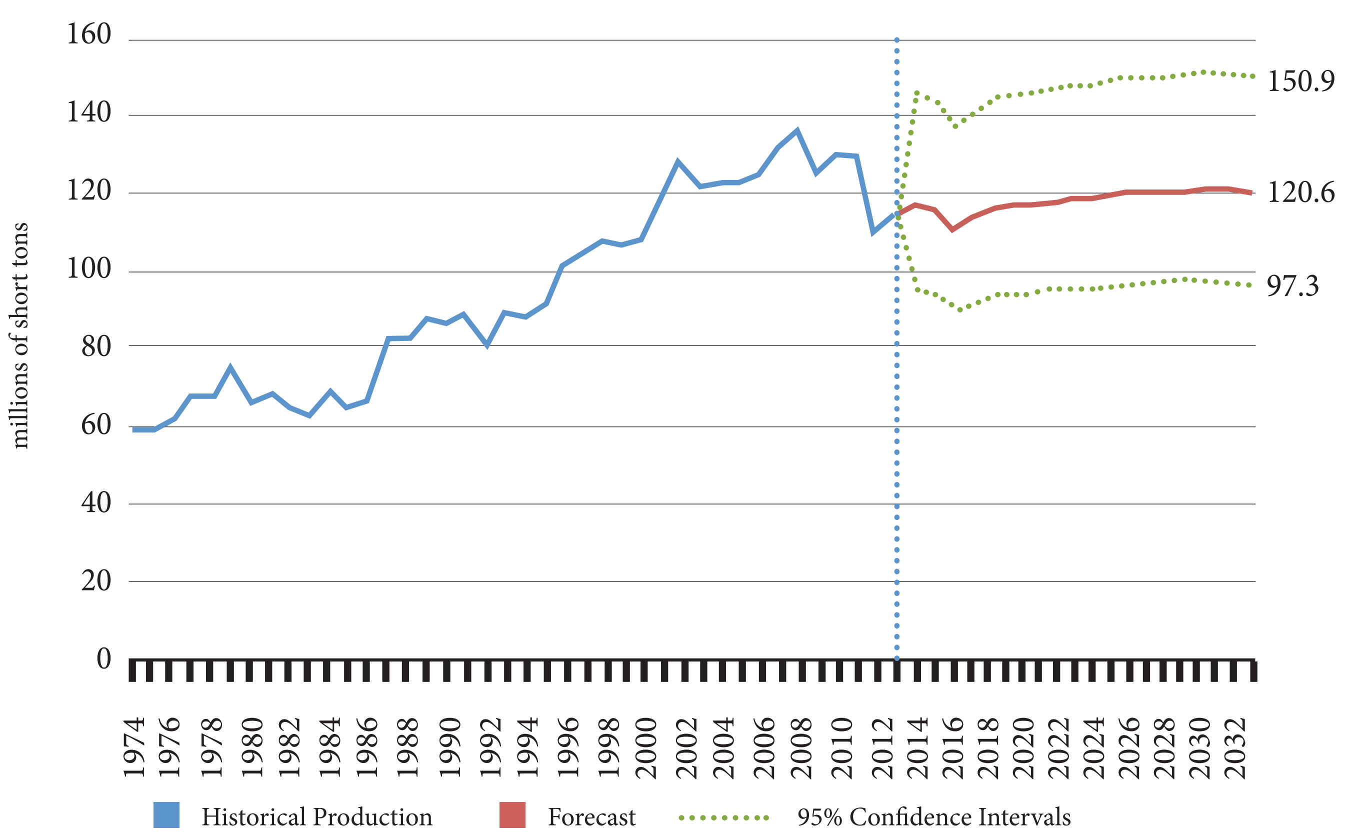
Expenditures on emissions control equipment and a shift toward dry CCP handling to comply with environmental regulations, including Mercury and Air Toxics Standards (MATS), Effluent Limitations Guidelines (ELG) and disposal standards for coal combustion residuals (CCR), will likely increase the supply of CCPs.

Fly ash, which represents the largest percentage of CCPs by tonnage, is expected to increase by about two percent over the next 20 years to 54.6 million short tons in 2033. As coal-fueled power plants shift to dry handling of CCPs to comply with regulations, the availability of useable fly ash is expected to increase.

Production of FGD material is expected to increase from 35.2 million short tons in 2013 to 38.8 million short tons in 2033. The exception to forecast growth is boiler slag, which is created in boilers that are typically over 30 years old. As these older vintage units are retired, boiler slag production is forecast to decrease by 43 percent through 2033.

In addition to ongoing production, reclamation of ash from ponds or landfills and beneficiation technologies to mitigate ash quality impacts from emissions control have the potential to provide additional future supply of CCPs.

FIGURE E-2: CCP PRODUCTION IS FORECASTED TO GROW SLIGHTLY

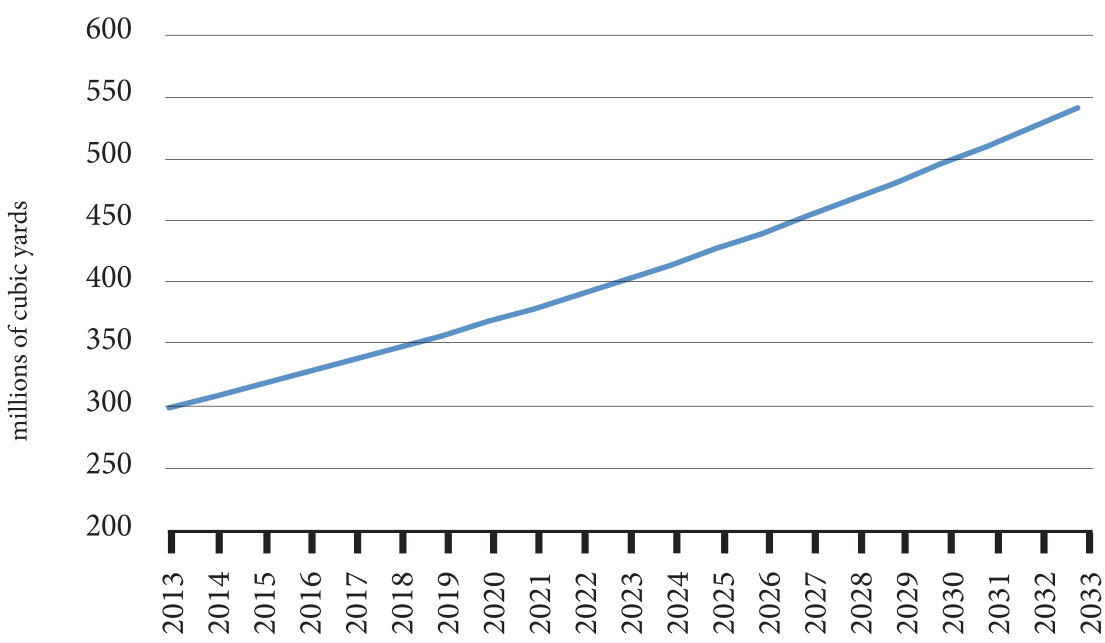


REGULATORY CERTAINTY AND CONSTRUCTION MARKET DEMAND WILL DRIVE CCP UTILIZATION

Nearly two-thirds of CCPs are used in construction-related markets. Projected growth for the U.S. economy, housing starts and rising demand in the ready-mixed concrete market (as shown in Figure E-3) are expected to be major drivers for future CCP utilization. The December 2014 promulgation of a final rule by the U.S. Environmental Protection Agency (EPA) specifically exempting beneficial use of CCPs from regulation has restored regulatory certainty to markets.[2]

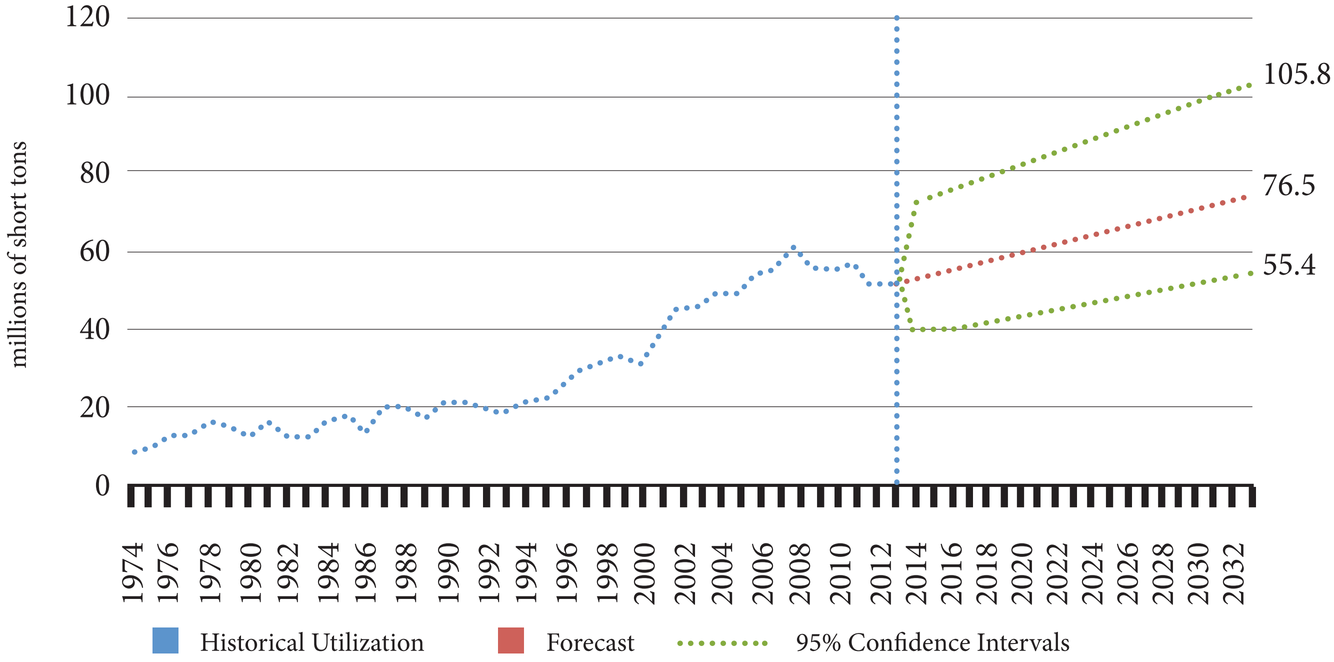
CCP utilization is projected to increase from 51.6 million short tons in 2013 to 76.5 million short tons in 2033, as shown in Figure E-4. The overall utilization rate for CCPs is projected to grow from 45 percent in 2013 to 63 percent in 2033.

FIGURE E-3: PROJECTED DEMAND FOR READY-MIXED CONCRETE WILL HELP DRIVE CCP UTILIZATION



[2]The final rule, Disposal of Coal Combustion Residuals from Electric Utilities was published in the Federal Register on April 17, 2015 and uses the terminology coal combustion residuals (CCRs) rather than coal combustion products. The rule does not regulate practices the meet the definition of a beneficial use of CCR. 80 Fed. Reg. 21301.

FIGURE E-4: TOTAL CCP UTILIZATION IS EXPECTED TO INCREASE BY 48 PERCENT



Fly ash utilization is forecast to increase 53 percent over the next 20 years, to 35.7 million short tons. Expanding use of fly ash in high volume applications, new concrete mixtures and future growth in the ready-mixed concrete market will drive increased utilization. Projected growth in the wallboard industry due to new housing starts will likely increase the demand for FGD gypsum. In addition, use of FGD material for agriculture to improve soil quality is one of the fastest growing utilization categories. FGD material utilization is projected to increase from 12.9 million short tons in 2013 to 22 million short tons in 2033.

The forecast production and utilization for the different types of CCPs is presented in Table E-1. As can be seen from the table, the projected average annual growth rate in total CCP utilization is two percent. CCP production is forecast to outpace utilization of fly ash, FGD material and bottom ash. Emerging beneficiation technologies, new products and markets can further increase the utilization of CCPs. As previously noted, even if CCP production were to experience low growth due to accelerated retirements of coal-fueled electricity generating units, production of fly ash and FGD material will still exceed forecast utilization through 2033.

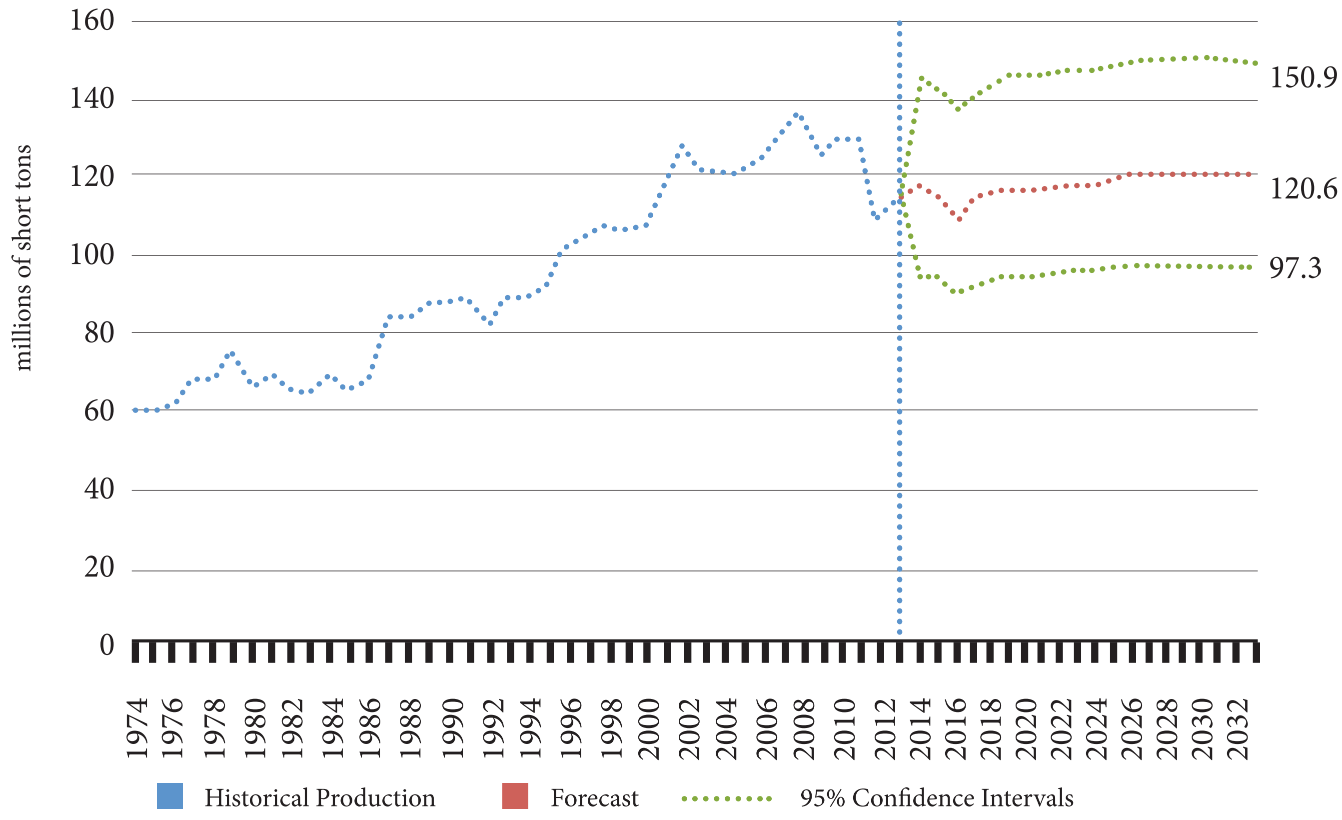
TABLE E-1: PROJECTED PRODUCTION AND UTILIZATION BY CCP CATEGORY (IN MILLIONS SHORT TONS)				
	VOLUME 2013	PROJECTED VOLUME 2033	PROJECTED TOTAL GROWTH	PROJECTED AVERAGE ANNUAL GROWTH RATE
Production				
Fly Ash	53.4	54.6	2.2%	0.1%
FGD Material	35.2	38.8	10.1%	0.5%
Bottom Ash	14.5	14.7	1.2%	0.1%
Boiler Slag	1.4	0.8	-43.2%	-2.8%
FBC Ash	10.3	11.8	14.5%	0.7%
Total Production	**114.7**	**120.6**	**5.2%**	**0.3%**
Utilization				
Fly Ash	23.3	35.7	53.1%	2.2%
FGD Material	12.9	22.3	72.9%	2.8%
Bottom Ash	5.6	7.2	28.4%	1.3%
Boiler Slag	0.9	0.8	-16.1%	-0.9%
FBC Ash	8.8	10.6	20.2%	-0.9%
Total Utilization	**51.6**	**76.5**	**48.3%**	**2.0%**

CCP PRODUCTION FORECAST

The total production of CCPs is expected to be steady over the next 20 years, growing five percent from 114.7 million short tons in 2013 to 120.6 million short tons in 2033, according the baseline forecast model.

Total CCP production is dependent on the volume of coal-fueled electricity generation and environmental regulatory compliance. The volume of coal-fueled electricity generation is affected by overall economic growth and changes in the energy market.

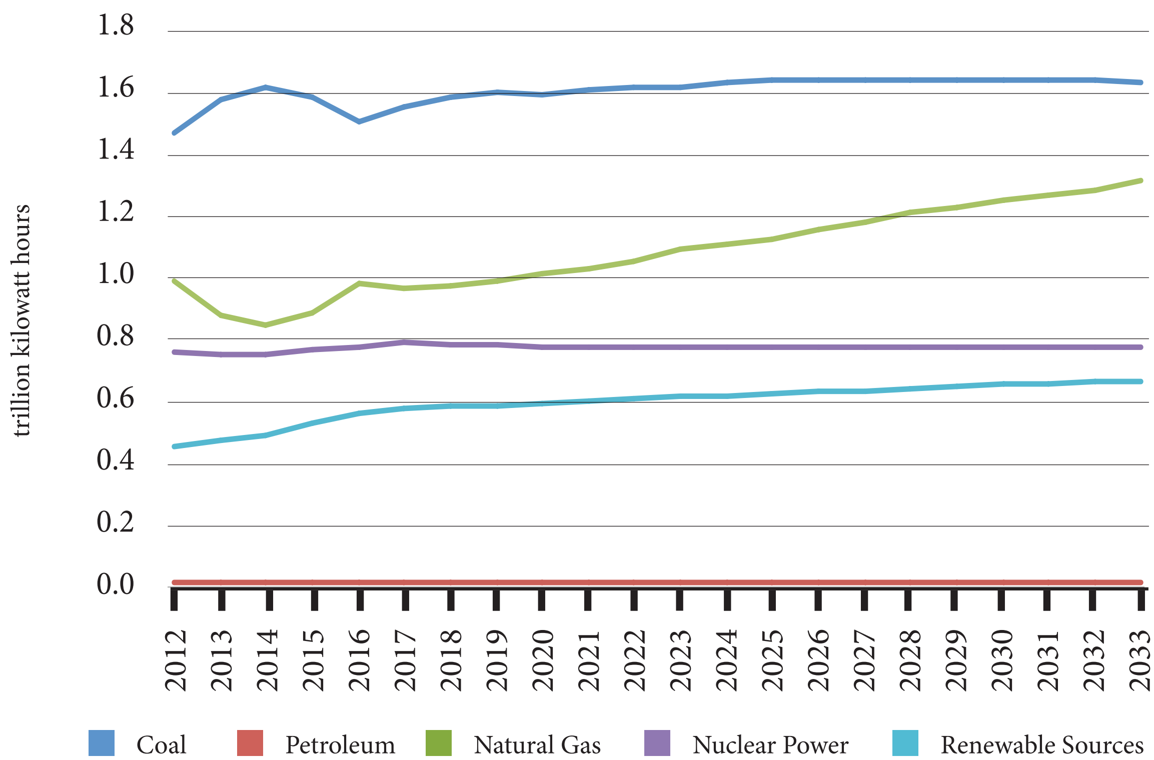
FIGURE 1-1: TOTAL CCP PRODUCTION, 1974 TO 2033



COAL-FUELED ELECTRICITY GENERATION

As a byproduct of the coal combustion process, CCP production is driven by the consumption of coal for electricity generation. Although the percentage of electric power from coal is expected to decline to 34 percent of total generation in 2033, down from 39 percent in 2013, coal-fueled electric generation is forecasted to grow by 3.4 percent from 2013 to 2033, according to the U.S. Energy Information Association.[3] U.S. economic growth along with increasing population will drive increasing demand for electricity.

FIGURE 1-2: NET ELECTRIC GENERATION BY ENERGY SOURCE



ENVIRONMENTAL REGULATORY COMPLIANCE

Each CCP baseline production forecast assumes that electric utilities will make adjustments to power generation operations to comply with current environmental regulations, including the federal Mercury and Air Toxics Standards (MATS) and Cross-State Air Pollution (CSAPR) rules.

The MATS rule for existing power plants was finalized on December 16, 2011. This regulation covers about 1,400 coal and oil-fueled units at 600 power plants across the country. The rule establishes new emission standards for mercury, acid gases and other hazardous air pollutants released by power plants. Approximately 40 percent of electric generating units do not have advanced pollution control equipment. Although the original compliance date is April 2015, criti-

[3]Outlook, Annual Energy. "Annual Energy Outlook, 2014." US Energy Information Administration, Early Release Overview (2014). http://www.eia.gov/forecasts/aeo/er/executive_summary.cfm

cal generating units that are still needed to "address a specific and documented reliability concern" may be issued an administrative order for one additional year to be in compliance.

Some of the widely-available control technologies to meet the new standards include utilization of existing electrostatic precipitators or fabric filter baghouses in conjunction with new systems for injection of activated carbon or other sorbents. FGD systems are also utilized in some cases for MATS compliance.[4]

Phase I of the Cross-State Air Pollution (CSAPR) rule is scheduled to be implemented in 2015. The CSAPR "requires 23 states to reduce annual sulfur dioxide (SO2) and nitrous oxide (NOx) emissions to help downwind areas" attain emissions standards.[5] Compliance with these measures is assumed to have occurred in the forecast's baseline production scenario. Compliance technologies include changes in power plant boiler operations and the use of FGD systems.

Although utilities may decide to retire some coal-fueled generating units rather than install emissions controls to comply with regulatory requirements, these facilities are usually "older, smaller, more polluting and not used extensively."[6] The generating units that are being retired usually lack controls for SO2 and NOx emissions.[7]

Over half of the 553 generators (for all fuel types) that utilities plan to retire between 2013 and 2022 began operations over 50 years ago.[8] Another 36 percent have been in operation for over 30 years. Coal-fueled generating units become less efficient as they age, mainly because of the mechanical wear "on a variety of components resulting in heat losses."[9] Some industry analysts, including ICF International and SNL Energy, project plant retirements in line with EIA's outlook. Others, such as Peabody Energy Corp., believe that the total volume total coal-fueled generation will actually be higher than what EIA is forecasting.[10]

Overall, the range of predictions for coal capacity retirements can range from five (5) to 40 gigawatts of capacity, depending on the assumptions made in the studies.[11] However, because these facilities are not used as often as more modern plants and are less efficient, the units account for just four percent of the nation's electric supply.[12]

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[4]EPA memorandum, December 16, 2011. http://www.epa.gov/mats/pdfs/EnforcementResponsePolicyforCAA113.pdf
[5]EPA, Cross-State Air Pollution Rule. http://www.epa.gov/airtransport/CSAPR/
[6]U.S. Government Accountability Office. "EPA Regulations and Electricity." GAO-14-672, (2014). http://www.gao.gov/products/GAO-14-672
[7]Lalit Batra and Vinay Gupta. "Fuel Economics Will Drive 2015 US Power Markets." (2015): 24-24. http://www.powermag.com/fuel-economics-will-drive-2015-u-s-power-markets/
[8]ARTBA analysis of EIA Form 860 data.
[9]Richard J. Campbell. "Increasing the Efficiency of Existing Coal-Fired Power Plants." Congressional Research Service, 43343 (2013). https://www.fas.org/sgp/crs/misc/R43343.pdf
[10]Rod Kuckro. "Power Markets: War on coal rhetoric belies robust forecast for coal-fired electricity." EnergyWire, (January 22, 2015). http://www.eenews.net/stories/1060012054
[11]Blair Beasley, et al. "Mercury and air toxics standards analysis deconstructed: changing assumptions, changing results." Resources for the Future Discussion Paper 13-10 (2013). http://www.rff.org/News/Features/Pages/Mercury-and-Air-Toxics-Standards.aspx
[12]Daniel Epps, "SNL Energy Coal Outlook 2014." March 6, 2014. http://www.stb.dot.gov/stb/docs/RETAC/2014/Mar/RETAC%20SNL%20%28coal%29%20Mar%206%202014.pdf

Conversely, utilities that invest in additional emissions controls to meet increased environmental regulatory requirements will have a powerful economic incentive to continue operating those power plants, which tend to be newer and larger than the facilities facing retirement.

There are several federal regulations that are in various stages of implementation or that have been proposed where utility compliance with these regulations has an impact on CCP production.

To the extent that new regulations increase the production of FGD materials or other CCPs, the total volume of CCPs will grow. On the other hand, if utilities shut down generating units rather than invest in new emissions controls to comply with regulations, then CCP production from those units would cease.

Some key environmental regulations that could impact the total volume of coal generated electricity, and thus CCP production, include:

- June 2, 2014, EPA introduced the Clean Power Plan proposal to set state-level carbon reduction targets that can be met through a variety of measures, including reducing reliance on coal-fueled electric power and deployment of low carbon energy technologies.[13]

- On December 19, 2014, EPA announced its Final Rule for Disposal of Coal Combustion Residuals from Electric Utilities under the Subtitle D "non-hazardous" section of the Resource Conservation and Recovery Act (RCRA). Under EPA's final rule, beneficial use of coal ash is specifically exempt from regulation and the Agency once again expressed its support for beneficial use activities, which restores regulatory certainty to the CCP market.[14]

- Revisions to the Steam Electric Power Generating Effluent Guidelines (ELG), first released in 1974. These rules cover the wastewater discharges from utility power plants. EPA has indicated that it plans to align the Effluent Limitation Guidelines with its just-completed Resource Conservation and Recovery Act Final Rule.[15]

The CCR and ELG rules will increase the supply of dry CCPs as utilities comply with the phase out of wet disposal. While carbon reduction targets under the Clean Power Plan could mean the retirement or curtailment of additional coal-fueled electric generation, the rule is in the proposal stage and faces an uncertain future due to legal challenges and potential legislative actions.

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[13] https://www.federalregister.gov/articles/2014/06/18/2014-13726/carbon-pollution-emission-guidelines-for-existing-stationary-sources-electric-utility-generating
[14] http://www.gpo.gov/fdsys/pkg/FR-2015-04-17/pdf/2015-00257.pdf
[15] http://www.gpo.gov/fdsys/pkg/FR-2013-06-07/pdf/2013-10191.pdf

FLY ASH PRODUCTION

Total fly ash production is forecasted to grow from 53.4 million short tons in 2013 to 54.6 million short tons in 2033, an increase of just under three percent.

Production is dependent on the total volume of coal-fueled electric generation by utilities. The baseline scenario assumes that electric utilities will make adjustment to power generation operations to comply with current environmental regulations, including the federal MATS and CSAPR rules.

The total volume of coal-fueled electric generation, taken from the EIA Annual Energy Outlook for 2014, will grow 3.8 percent over the forecast period from 1.59 trillion kilowatt hours in 2013 to 1.65 trillion kilowatt hours in 2033.[16]

FIGURE 1-3: FLY ASH PRODUCTION, 1974 TO 2033

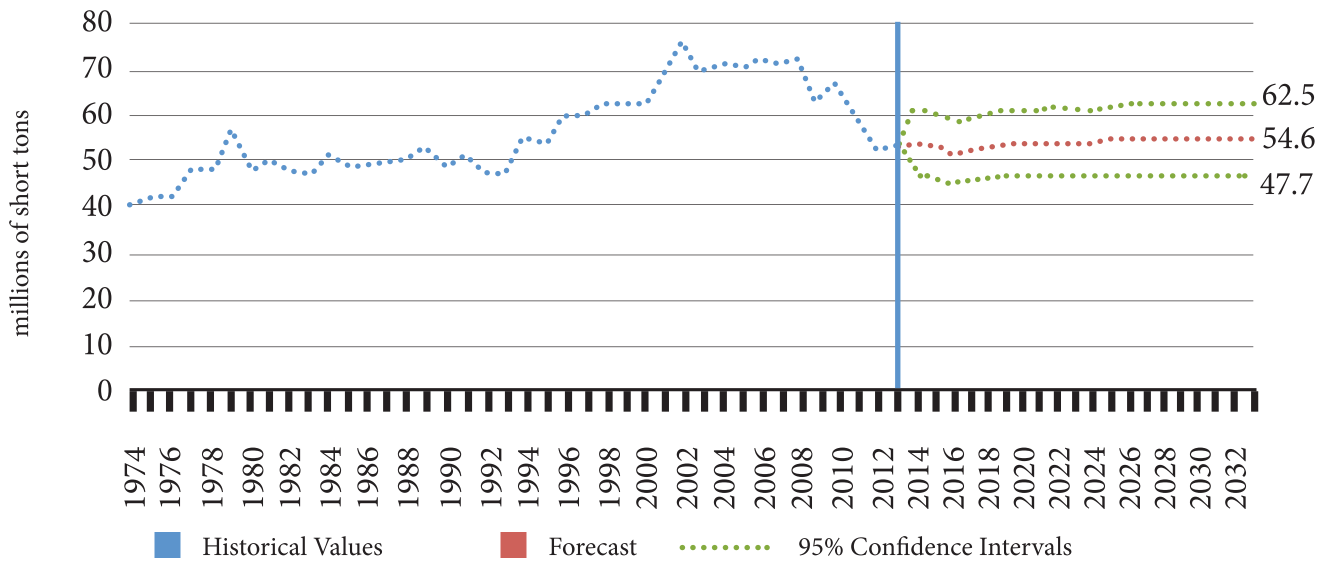
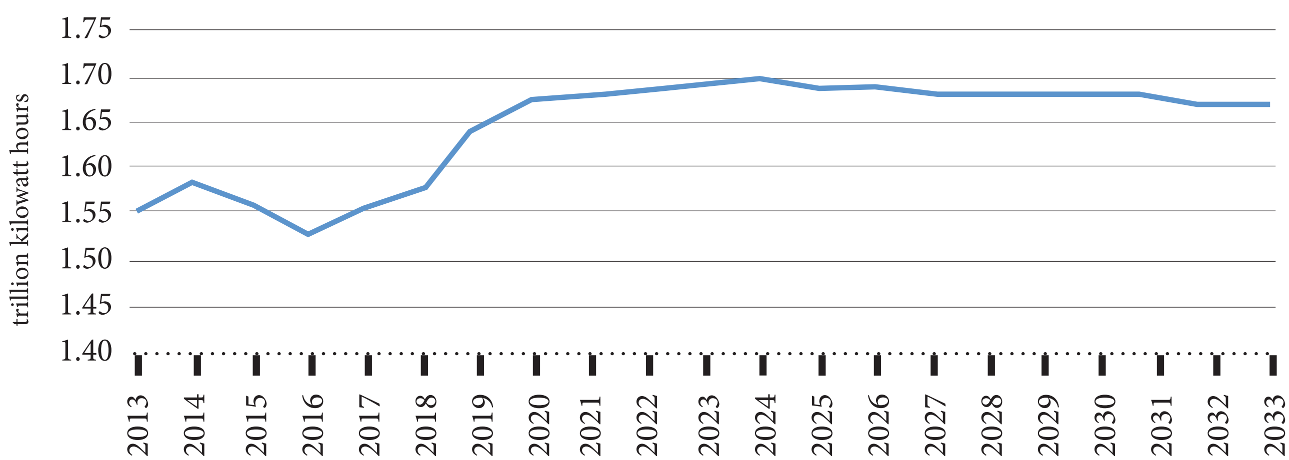


FIGURE 1-4: COAL GENERATED ELECTRICITY, 2013 TO 2033



[16]Outlook, Annual Energy. "Annual Energy Outlook, 2014." US Energy Information Administration (2014).

FGD MATERIALS PRODUCTION

FGD Materials production is forecasted to grow 10 percent over the next 20 years under a very conservative baseline scenario, increasing from 35.2 million short tons in 2013 to 38.8 million short tons in 2033.

As is the case with fly ash, production is dependent on the total volume of coal-fueled electric generation by utilities. However, as more utilities add scrubbers to comply with increasing environmental regulations, the volume of FGD material produced will increase at a faster rate.

The baseline scenario assumes that coal electricity generating utility plants will make production adjustments to comply with MATS and CSAPR rules.[17]

Nearly two thirds of coal-fueled generating capacity in the electric power sector uses FGD equipment and is currently already in compliance with the MATS requirements.[18] FGD equipment is planned for an additional 5.1 percent of generation capacity. Utilities are still undecided on retrofitting or retirements for an additional 20 percent of capacity. This means there are significant opportunities for equipment investment that would produce additional FGD material.

FGD scrubbers have "higher capital costs but lower operating costs" than alternative Dry Sorbent Injection systems.[19] Currently less than one percent of total generating capacity is in compliance with MATS regulations using a DSI system, and less than one percent of planned upgrades include an investment in DSI equipment. Although the DSI system costs less, it is "easier to recover the investment in the controls if the plant is not expected to operate frequently" and it is typically used for plants that burn lower sulfur coal or are not used on a regular basis. Therefore most operators are turning towards an FGD system for use with systems that are operating more often.

For compliance with CSAPR requirements, individual plants can decrease generation, purchase allowances, switch to fuels with lower sulfur content, retire units or retrofit equipment with pollution controls, including wet or dry FGD scrubbers.[20] Between 2005 and 2010, owners implemented 160GW of capacity with pollution control retrofits before the first compliance periods for the Clean Air Interstate Rules. The U.S. Department of Energy believes that "these technologies are among those expected to be used for compliance with CSAPR and MATS" and that there is "readily available manufacturing capacity and labor supply" to meet that growing demand.[21]

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[17]Outlook, Annual Energy. "Annual Energy Outlook, 2014." US Energy Information Administration, Early Release Overview (2014).
[18]Michael Leff. "Coal-fired power plant operators consider emissions compliance strategies." Today In Energy. March 28, 2014.
[19]Ibid.
[20]U.S. Department of Energy, "Resource Adequacy Implications of Forthcoming EPA Air Quality Regulations." (2011).
[21]Ibid.

FIGURE 1-5: FGD PRODUCTION, 1987 TO 2033

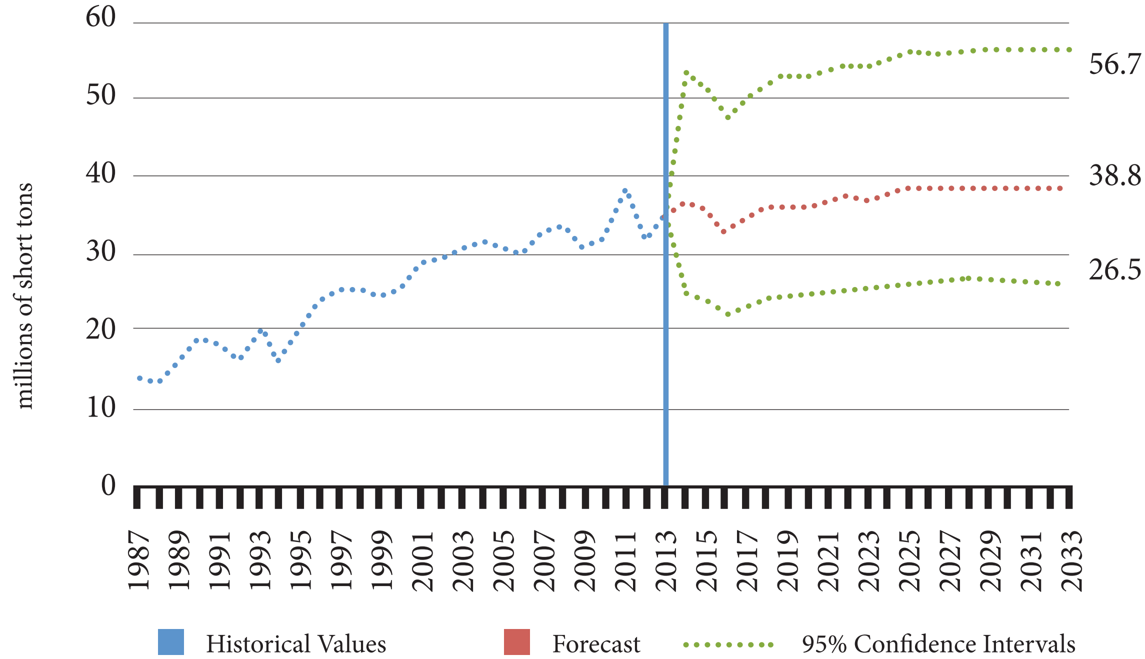
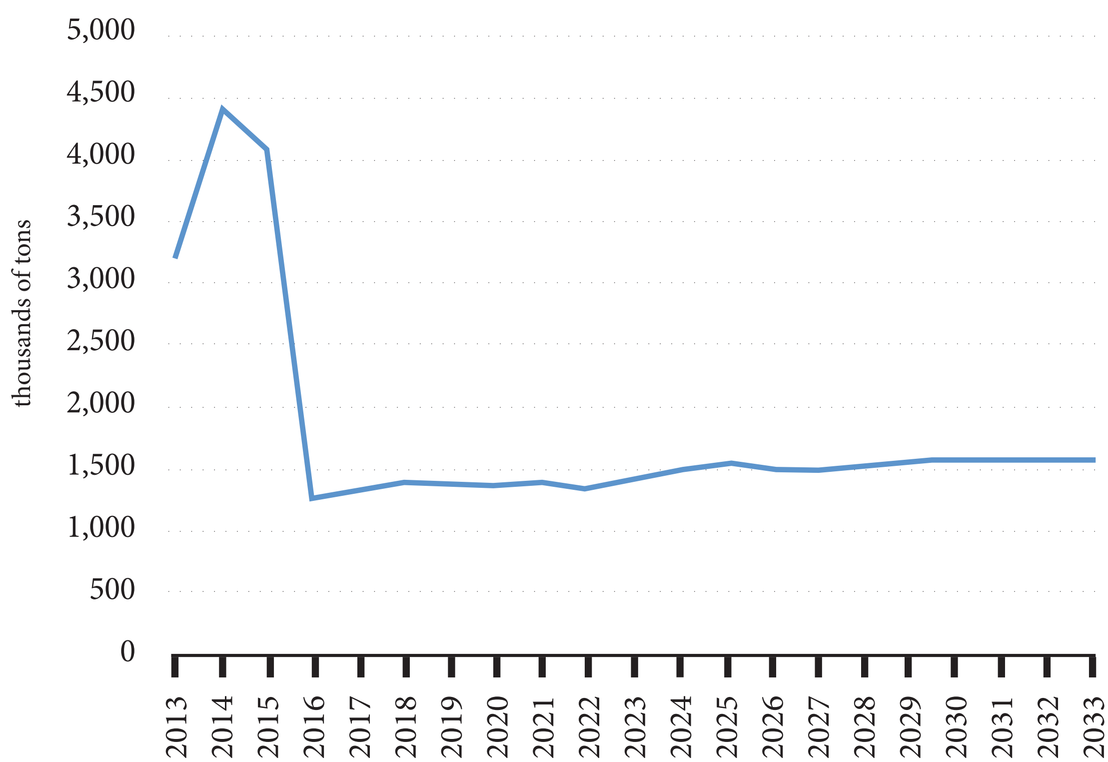


FIGURE 1-6: U.S. EMISSIONS OF SO_2



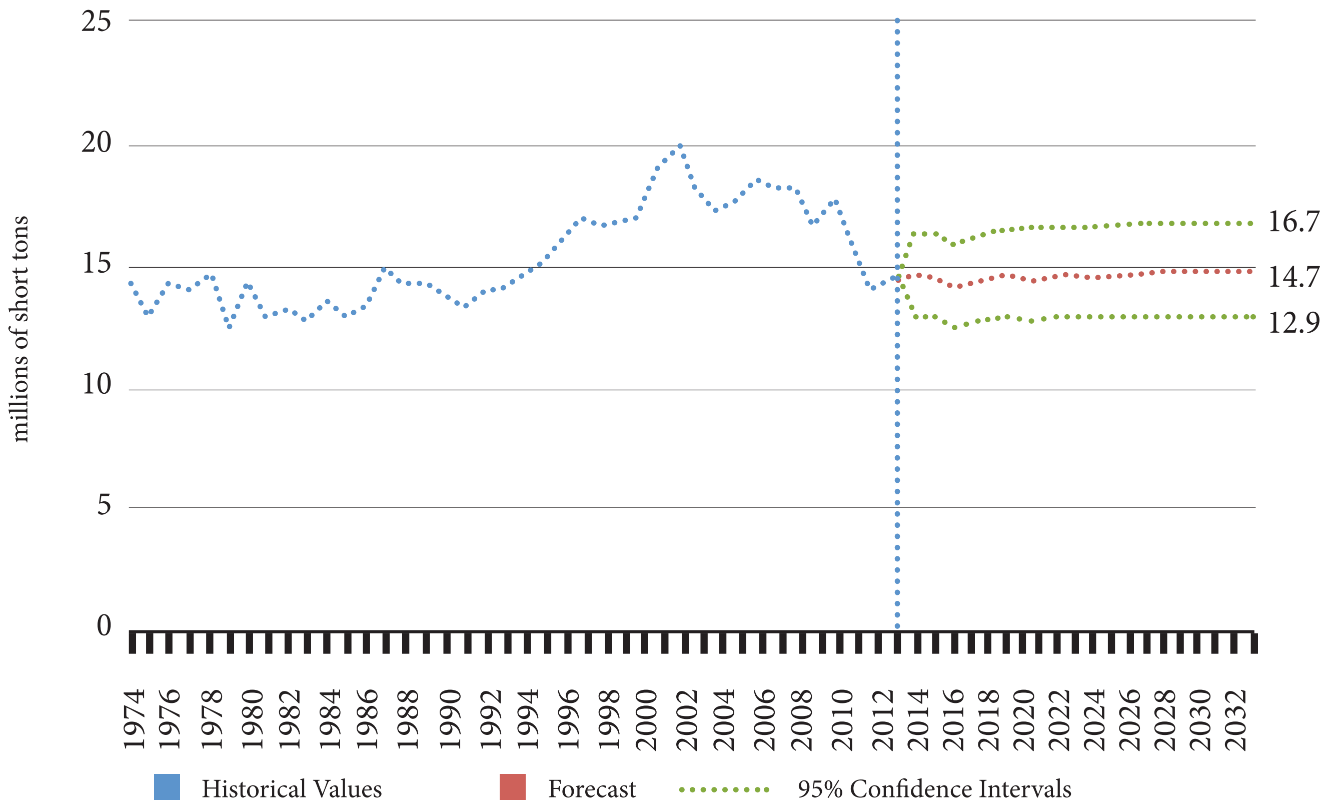
BOTTOM ASH PRODUCTION

Bottom ash production is forecasted to remain steady over the next 20 years, growing slightly from 14.5 million short tons in 2013 to 14.7 million short tons in 2033.

When pulverized coal is burned in a dry bottom boiler, about 80 percent of the ash flies up the flue gas and is recovered as fly ash, and the remaining 20 percent of the unburned material is bottom ash. Historically, bottom ash has averaged 21.5 percent of the total amount of fly and bottom ash produced.

Both fly ash and bottom ash are forecasted to grow at an average annual rate of 0.1 percent over the next 20 years.

FIGURE 1-7: BOTTOM ASH PRODUCTION, 1974 TO 2033



BOILER SLAG PRODUCTION

The production of boiler slag is forecasted to decline over the next 20 years, from 1.36 million short tons in 2013 to 0.8 million short tons in 2033, a decline of 43 percent.

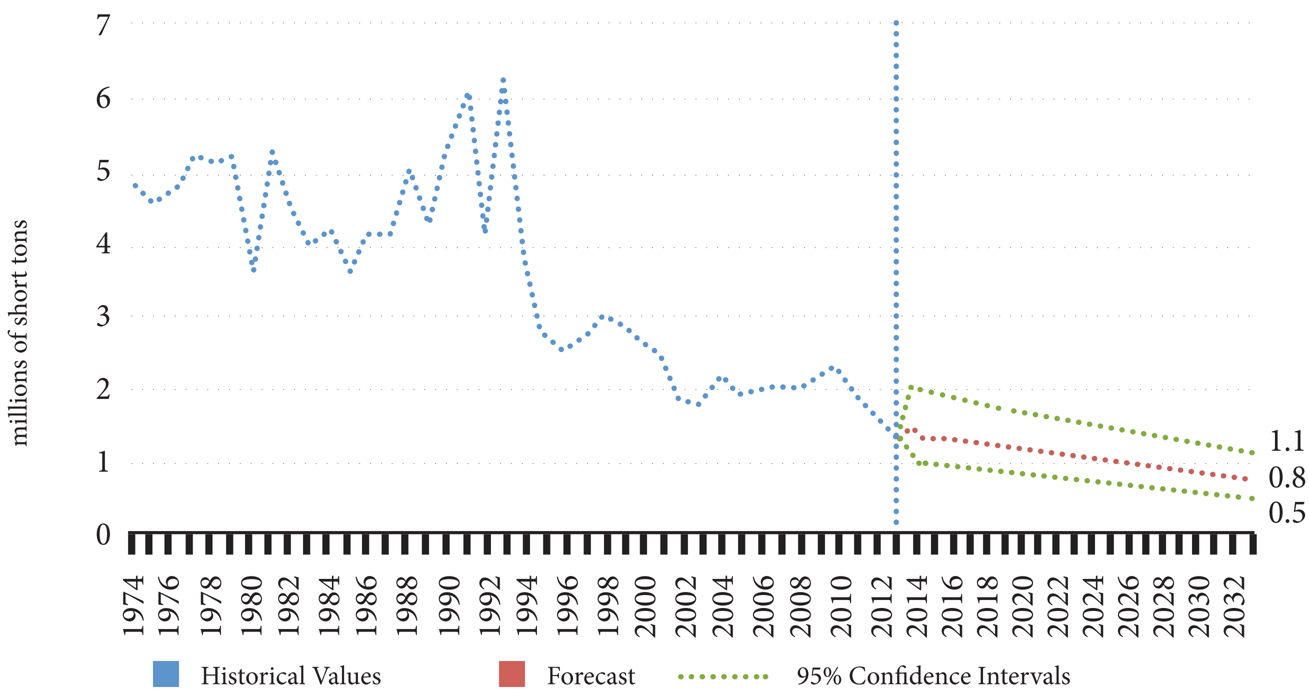
The overall production of boiler slag is being driven by a shift in the electric utility industry away from wet-bottom boilers that produce boiler slag.

The slag tap boiler and the cyclone boiler are the two types of wet-bottom boilers used in the U.S. When pulverized coal is burned, the ash that falls to the bottom is kept in a liquid state. Both of wet-bottom boilers contain quenching liquid that mixes with the molten ash to form a hard, black, angular, glassy material sometimes referred to as "Black Beauty."[22]

Wet-bottom boilers are more compact than pulverized coal boilers that are found at the larger utility electric generating plants. Thus they are used more often by industrial manufacturing plants and smaller utilities, some of which are not subject to the same environmental regulations as large steam electric generating stations.[23]

Although some new wet bottom boilers have come online in recent years, most plants are moving towards different equipment that produces fewer emissions. Most of the existing cyclone boilers in the U.S. were constructed before 1981. These boilers have high nitrogen oxide emission rates, and "no new cyclone boilers are expected to be built."[24] With fewer wet-bottom boilers being used, this will impact the production of boiler slag in the future.

FIGURE 1-8: BOILER SLAG PRODUCTION, 1974 TO 2033



[22]Warren Chesner, Robert J. Collins, and M. H. MacKay. User guidelines for waste and by-product materials in pavement construction. No. FHWA-RD-97-148. 1998.
[23]University of Kentucky, Center of Applied Energy Research.
[24]U.S. EPA. "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions From Coal-Fired Electric Generating Unites." (2010).

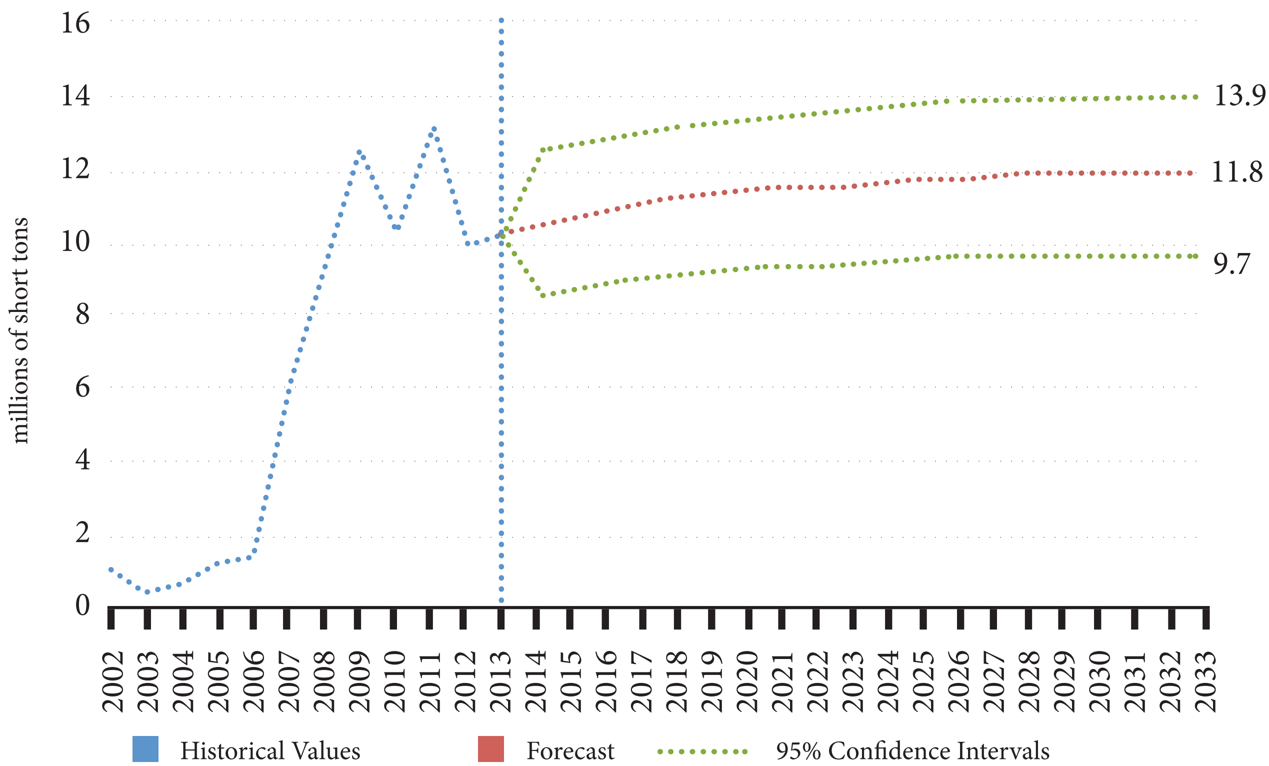
FBC ASH PRODUCTION

FBC ash is the fly ash and the bed ash produced by an fluidized bed combustion (FBC) boiler. The FBC fly ash is collected in the flue of the boiler with a baghouse filter or electrostatic precipitator. The bed ash is the residue that is removed from the bottom of the boiler.[25] FBC production is forecasted to grow from 10.3 million short tons in 2013 to 11.8 million short tons in 2033, an increase of nearly 15 percent.

As with other CCPs, the production of FBC ash over the next 20 years is highly dependent on the amount of coal consumed for electric generation. In addition, this market will be impacted by technology and equipment upgrades to comply with environmental regulations.

In an effort to meet emissions requirements, some utilities are using FBC technology, which allows operators to burn lower rank coals with a higher moisture and ash content while reducing nitrogen oxide emissions.[26]

FIGURE 1-9: FBC ASH PRODUCTION, 2002 TO 2033



[25]American Coal Ash Association. "Glossary of terms concerning the management and use of coal combustion products (CCPs)." American Coal Ash Association, Inc., Aurora, CO (2003). http://www.acaa-usa.org/Portals/9/Files/PDFs/ACAA_Glossary_of_Terms-Apri_2003.pdf

[26]Ibid.

ADDITIONAL SUPPLIES OF CCPs

In addition to on-going production, there are additional sources of CCPs that could have an impact on the overall supply of materials for beneficial use.

Some of these potential sources include:

RECLAMATION OF FLY ASH IN PONDS OR LANDFILLS: Currently there are research and demonstration projects focused on reclaiming fly ash that has been stored in either wet impoundments or dry disposal units. This could have significant impacts on the supply of fly ash. In 2012, there were 228 utility plants that disposed of 24.5 million short tons of fly ash in ponds and landfills.[27] Electric utilities have over 1,400 ponds and landfills across the country that could be potential sources of ash.

There are also potential changes to the storage of fly ash and other CCPs over the next decade. The December 19, 2014 Final Rule for Disposal of Coal Combustion Residuals from Electric Utilities under the RCRA will phase out the wet disposal of CCPs over the next decade.[28]

States are acting to restrict or prohibit the wet disposal of coal ash. Recently North Carolina passed legislation that prohibits any new coal ash ponds after October 1, 2014.[29] The measure also bans the wet disposal of ash beginning in 2020. As utilities convert from wet to dry handling of coal ash, beneficial use is facilitated.

TECHNOLOGIES TO INCREASE ASH QUALITY: Historically, a portion of the coal ash that was disposed was not beneficially used because it did not meet various quality standards. A suite of technologies have been demonstrated as commercially viable in improving ash quality—including a variety of systems for reducing the amount of unburned carbon in fly ash. Broader deployment of these technologies can increase the volume of ash suitable for beneficial use.[30] Technologies are also currently being deployed to mitigate ash quality impacts of various emissions control technologies.

INTERNATIONAL FLY ASH MARKETS: The international market for CCPs includes supply sources from Australia, Canada, China, Israel, Western Europe, Russia, the United Kingdom, and the Middle East, among others. Data from the 2013 World of Coal Ash Conference estimates coal ash production at more than 771 million metric tons, with over 415 million metric tons being utilized.

Although coal ash imports currently represent a negligible portion of U.S. supply, international supplies of CCPs that meet U.S. standards could be used as an input if domestic production cannot keep up with growing utilization over the next 20 years.

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[27] ARTBA analysis of EIA 923 data.
[28] http://www.gpo.gov/fdsys/pkg/FR-2015-04-17/pdf/2015-00257.pdf
[29] Sonal Patel. "Nation's First Coal Ash Law Takes Effect in North Carolina." Power Magazine. September 24, 2014. http://www.powermag.com/nations-first-coal-ash-law-takes-effect-in-north-carolina/
[30] Hank Keiper, P.E.. "Addressing Coal's Negative Impact – Beneficial Use of Fly Ash." The Virginia Engineer. (April 2011). http://vaeng.com/guestarticle/addressing-coal-s-negative-impact-beneficial-use-of-fly-ash

COUNTRY/REGION	CCPs PRODUCTION (METRIC TONS)	CCPs UTILIZATION (METRIC TONS)	UTILIZATION RATE %
Australia	13.1	6	45.8
Canada	6.8	2.3	33.8
China*	395	265	67.1
Europe (EU 15)	52.6	47.8	90.9
India	105	14.5	13.8
Japan	11.1	10.7	96.4
Middle East & Africa	32.2	3.4	10.6
United State of America	118	49.7	42.1
Other Asia*	16.7	11.1	66.5
Russian Federation	26.6	5	18.8
Totals	**777.1**	**415.5**	**53.8**

Utilization rates in the US were about 45% in 2013 and projected to increase to 63% by 2033. In Australia, while production fell 20 percent between 2007 and 2012, utilization has increased 44 percent and the quantity sold increased 23 percent. Almost all of CCP growth comes from growth in the fly ash market.

In Canada, between 2010 and 2012, about 6.4 million tons of CCP were produced, with about 4 million tons of fly ash and 1.8 million tons of bottom ash. Between 2004 and 2012, about 19.6 million tons of CCP were disposed or stored, although the Association of Canadian Industries Recycling Coal Ash (CIRCA) does not distinguish between those categories.

CCP production in China grew 150 percent between 2002 and 2010, as China expanded its usage of coal power. In 2009, over 375 million tons of coal ash was produced, up from 300 million tons in 2006.

Israel has seen explosive growth in the production of CCPs over the last thirty years, with fly ash production increasing 878 percent between 1982 and 2012, and bottom ash production increasing 1,207 percent. Over a shorter time span, between 2000 and 2012, fly production increased 18 percent and bottom ash production increased 51 percent. All told, in 2012, Israel produced 1.2 million tons of fly ash and 183,000 tons of bottom ash. Utilization is primarily directed towards concrete, cement and road fill, with a 98 percent fly ash utilization rate and a 62 percent bottom ash utilization rate.

Production of CCPs in Western Europe is not well documented, but according to the European Coal Combustion Products Association, in 2010 about 48.3 million tons of CCPs were produced. Fly ash comprises 65 percent of CCP production, and FGD gypsum production comprises 21 percent.

Russia has produced about 25 million tons of CCPs every year since 2000. While the ash content of Russian coal has been falling over the past twenty years, ash composes roughly one-quarter to one-fifth of coal in Russia.

CCP UTILIZATION FORECAST

Total CCP utilization is forecasted to increase over 48 percent, from 51.6 million short tons in 2013 to 76.5 million short tons in 2033. The total utilization rate will grow form 45 percent of production to 63 percent.

Total utilization is based on an environment of regulatory certainty, emerging technologies, continuation of industry standards, and overall demand from end markets.

With nearly two-thirds of CCPs used in construction related markets, the overall growth in the U.S. economy, housing starts and ready-mixed concrete demand will be major drivers of total utilization.

FIGURE 2-1: TOTAL CCP UTILIZATION, 1974 TO 2033

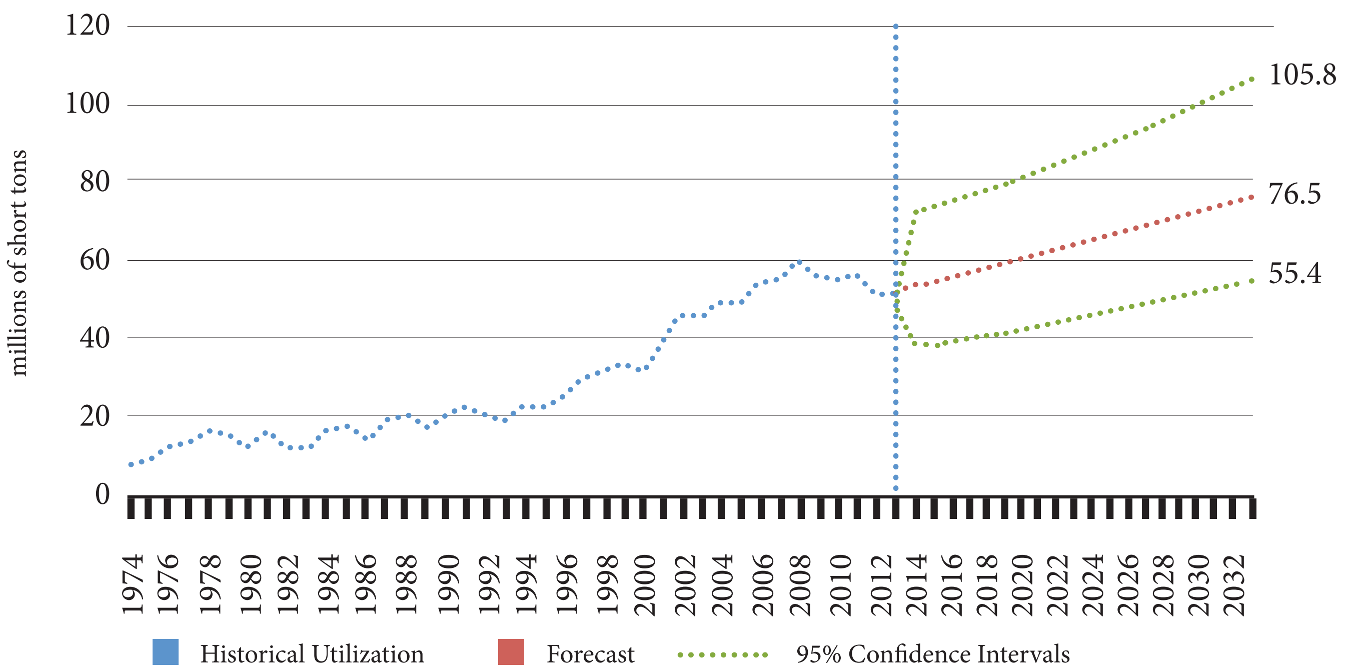
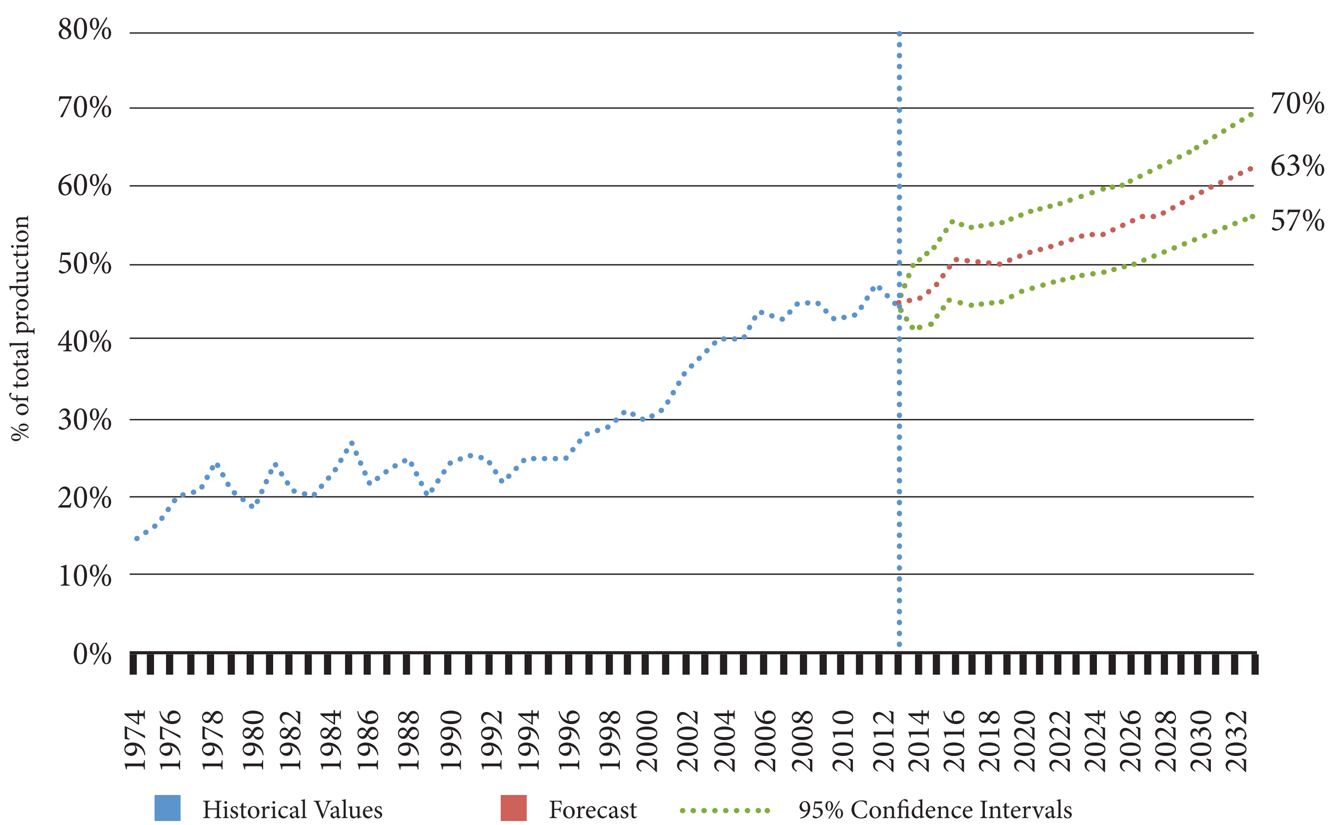


FIGURE 2-2: CCP UTILIZATION RATE, 1974 TO 2033



REGULATORY CERTAINTY

The decision by the EPA to revisit the potential classification of CCPs as a hazardous material after the coal ash spill in Kingston, Tennessee, in 2008 caused significant amounts of market uncertainty that led to a steady downturn in total utilization through 2012.

Some users said that even if EPA allowed the beneficial use of fly ash in concrete uses, there would still be a "negative stigma" if fly ash were classified as a hazardous waste and potential liability would be an issue.[31] Given historical patterns, fly ash utilization should have been growing in the years after the 2008 Great Recession as users looked for less expensive inputs.[32]

With regulatory uncertainty, consumers of fly ash begin to remove their materials from specifications because of potential legal liability, and commercial liability insurance policies are used for products containing fly ash and other CCPs.[33]

[31]Texas Department of Transportation. "Where has the Fly Ash Gone?" (April 2012). http://ftp.dot.state.tx.us/pub/txdot-info/cst/tips/fly_ash_0412.pdf
[32]Alison Premo Black. " The U.S. Coal Combustion Products Market: A Historical Market Analysis." (2015).
[33]John N. Ward. "Stigma and regulatory uncertainty: proposed coal ash disposal regulation effects on US beneficial use markets and practices." 2013 World of Coal Ash Conference. 2013. http://www.flyash.info/2013/033-Ward-2013.pdf

Although historically the use of FGD material has not been as affected by the regulatory uncertainty that characterized the CCP market between 2009 and 2013, there is the potential that future developments could have an impact. When EPA was considering regulating CCPs after the 2008 spill in Kingston, Tennessee, FGD gypsum used for wallboard manufacture was characterized as a "product" rather than a "waste or discarded material."[34]

Despite this view, FGD material is still a CCP and any overall uncertainty about the regulation of CCPs does have a negative stigma.

On December 19, 2014, EPA announced its Final Rule for Disposal of Coal Combustion Residuals from Electric Utilities under the Subtitle D "non-hazardous" section of the Resource Conservation and Recovery Act. Under EPA's final rule, beneficial use of coal ash is specifically exempt from regulation and the Agency once again expressed its support for beneficial use activities.[35] The resumption of regulatory certainty after a six-year hiatus should provide reassurance to utilization markets.

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[34]U.S. EPA. Proposed Rule, Federal Register, Vol. 75, No. 118, June 21, 2010 http://www.gpo.gov/fdsys/pkg/FR-2010-06-21/pdf/FR-2010-06-21.pdf
[35]http://www.gpo.gov/fdsys/pkg/FR-2015-04-17/pdf/2015-00257.pdf

FLY ASH UTILIZATION

Total fly ash utilization is forecasted to increase 53 percent over the next twenty years, from 23.3 million short tons in 2013 to 35.7 million short tons in 2033. The overall utilization would grow from 44 percent of production to 65 percent over that same time period.

With over 63 percent of fly ash being used for concrete, blended cement and related products in 2013, the utilization of fly ash will in part depend on future demand for ready-mixed concrete and the overall health of the U.S. construction market.

FIGURE 2-3: FLY ASH UTILIZATION, 1974 TO 2033

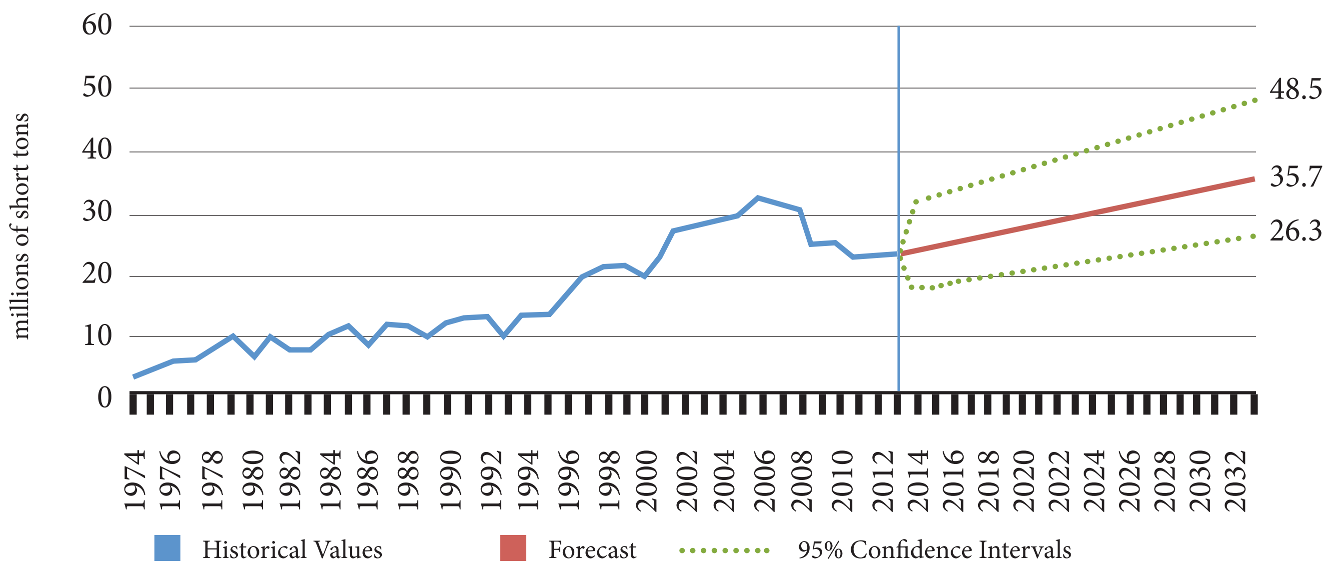
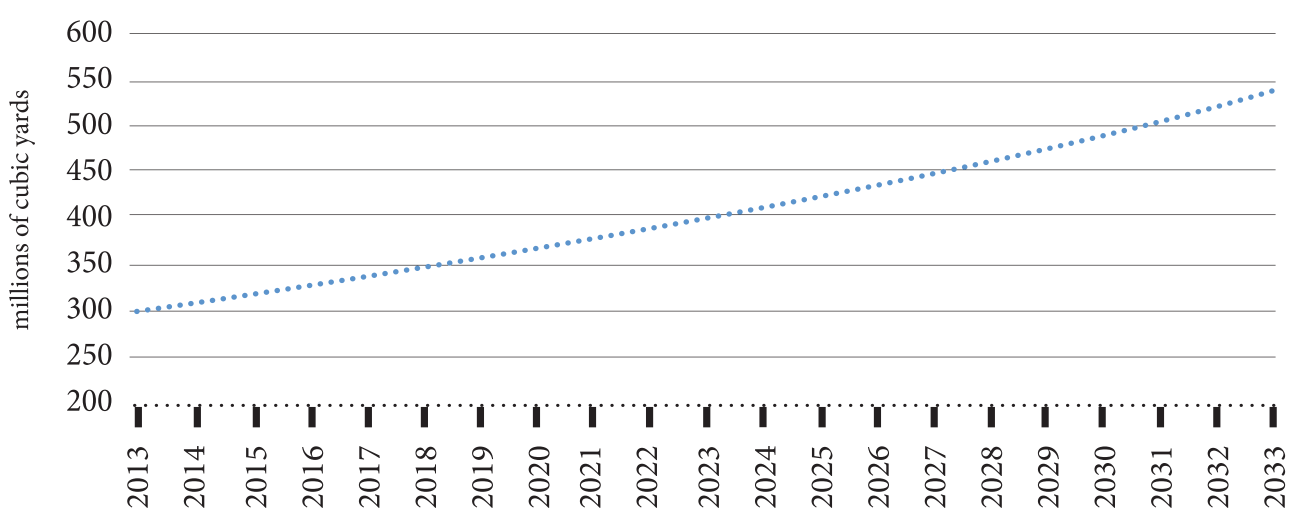


FIGURE 2-4: PROJECTED DEMAND FOR READY-MIXED CONCRETE WILL HELP DRIVE FLY ASH UTILIZATION



Factors that could impact the market outlook for fly ash utilization:

OUTLOOK FOR READY-MIXED CONCRETE AND THE U.S. ECONOMY: Historically, the production of ready-mixed concrete in the United States has grown at an average annual rate of three percent. Because it cannot travel for long distances before hardening, local demand for ready-mixed concrete is highly dependent on the dynamics of the local construction market, and can fluctuate from year to year. About half of all concrete is purchased by state and local governments.[36] If future growth continued along the historical trend, total ready-mixed concrete production would increase from 300.8 million cubic yards to over 543.3 million cubic yards in 2033.

HIGH VOLUME FLY ASH: New concrete mixtures with higher volumes of fly ash have significant potential to reduce costs, reduce energy content and improve long term performance when used for highway and bridge construction.[37] Some studies have shown that mixtures where 50 percent or more cement is replaced with fly ash have produced "sustainable, high performance concrete mixtures that show higher workability, higher ultimate strength and high durability."[38]

ASH QUALITY: To meet NOx emissions standards, some generating units use low NOx burners that can produce fly ash with a higher unburned carbon content. The coal ash marketing industry has successfully commercialized several technologies to address these issues, including chemicals that can be sprayed on the fly ash and mechanical, electrostatic and thermal processes.[39]

TRANSPORTATION AND LOGISTICS: The implementation of improved management practices for the beneficial use of fly ash and other CCPs will help support growing utilization. These include such factors as "corporate policies, financial decisions, subsidizing reuse," among others.[40] Plant shutdowns for maintenance or unforeseen circumstances can temporarily affect the supply of fly ash, which can be disruptive to customers.[41] Improved storage facilities would help regulate the supply of fly ash during times of lower power demand and routine shutdowns.

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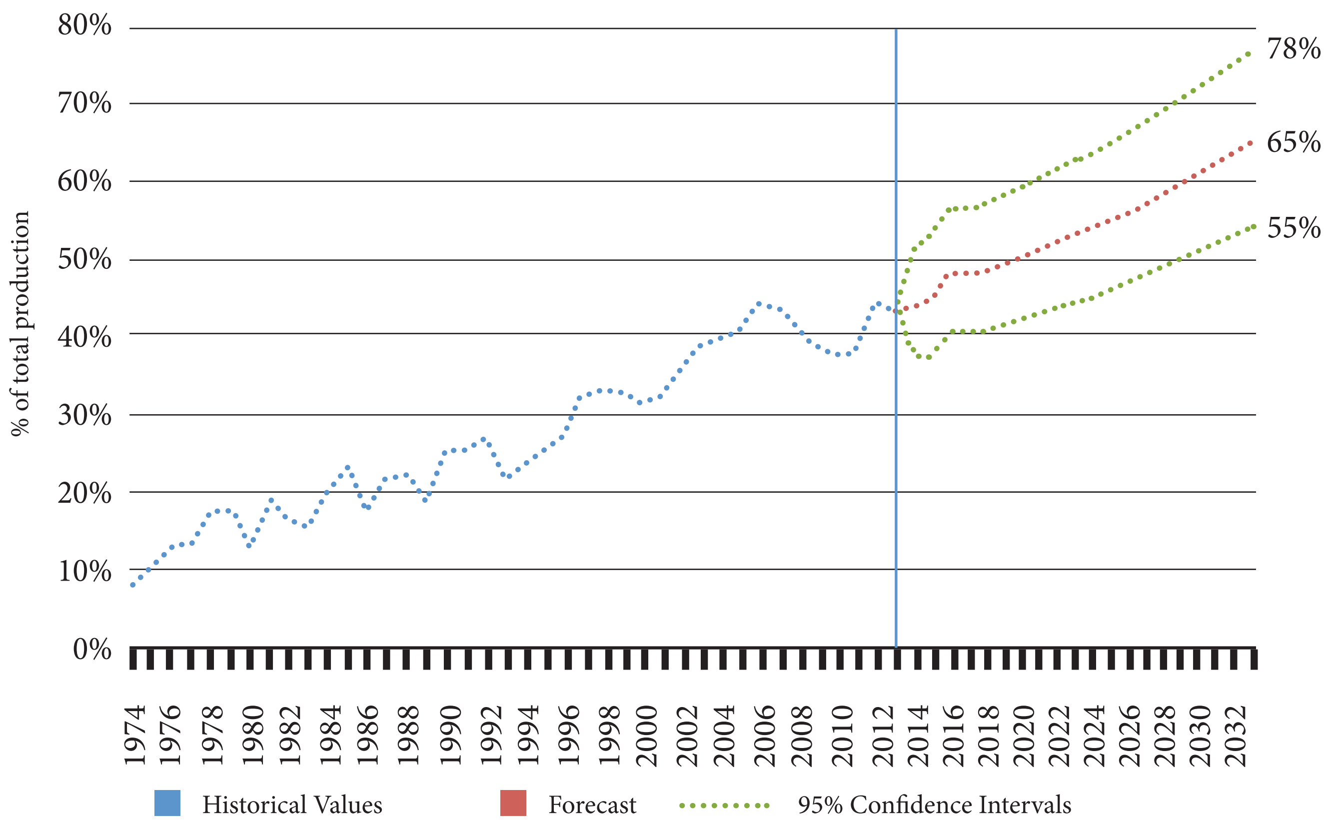
[36]Allan Collard-Wexler. "Demand Fluctuations in the Ready-Mix Concrete Industry." Econometrica 81.3 (2013): 1003-1037. http://pages.stern.nyu.edu/~acollard/ecta6877.pdf
[37]Federal Highway Administration. "Benefits of High Volume Fly Ash: New Concrete Mixtures Provide Financial, Environmental, and Performance Gains". FHWA-HRT-10-051. (2010). http://www.fhwa.dot.gov/advancedresearch/pubs/10051/
[38]Vanita Aggarwal, S. M. Gupta, and S. N. Sachdeva. "Concrete durability through high volume fly ash concrete (HVFC) a literature review." Int J Eng Sci Technol 2.9 (2010): 4473-4477. http://www.researchgate.net/publication/50346383_CONCRETE_DURABILITY_Through_High_Volume_Fly_ash_Concrete_%28HVFC%29_A_Literature_review
[39/40]Mark Rokoff, PE, Sheryl Smith, Tara V. Masterson & Michael E. Sutton. Benchmarking Study for CCP Beneficial Reuse: A View of the Market. 2013 World of Coal Ash Conference. http://www.worldofcoalash.org/2013/ashpdf/a070-Rokoff-2013.pdf
[41]Texas Department of Transportation. "Where has the Fly Ash Gone?" April 2012 http://ftp.dot.state.tx.us/pub/txdot-info/cst/tips/fly_ash_0412.pdf

RECLAMATION OF FLY ASH IN PONDS OR LANDFILLS: Currently there are demonstration projects focused on reclaiming fly ash that has been stored in either wet or dry disposal impoundments. This could have significant impacts on the supply and utilization of fly ash. One study examined the use of pond ash as a fine aggregate substitute in cement concrete.[42] Work has also been down on using ponded ash for clay-fired bricks.[43]

NEW MARKETS AND UTILIZATION: Changes in technology and new markets for fly ash will create more demand for utilization. In 1990, two Indian inventors created fly ash bricks, which use fly ash, lime and gypsum to create "high quality and strong bricks that do not require kiln firing."[44] The fly ash bricks are about 28 percent lighter than traditional clay bricks and can exceed their load capacity by as much as 25 percent.[45] This type of innovation will create significant new markets for fly ash in the coming years.

FIGURE 2-5: FLY ASH UTILIZATION RATE, 1974 TO 2033



[42]Arumugam, K. and D. James Manohar. "A study on characterization and use of Pond Ash as fine aggregate in Concrete." International Journal of Civil & Structural Engineering 2.2 (2011): 466-474. http://www.ipublishing.co.in/jcandsevol1no12010/voltwo/EIJCSE3038.pdf

[43]Sonawane, Prashant & Dr. Arun Kumar Dwivedi. "Technical Properties of Pond Ash – Clay Fired Bricks – An Experimental Study." American Journal of Engineering Research, Volume 2, Issue 9, (2013). http://www.ajer.org/papers/v2%289%29/P029110117.pdf

[44]Ed Dodge. "Can Coal Fly Ash Waste Be Put to Good Use?" Breaking Energy. February 18, 2014. http://breakingenergy.com/2014/02/18/can-coal-fly-ash-waste-be-put-to-good-use/

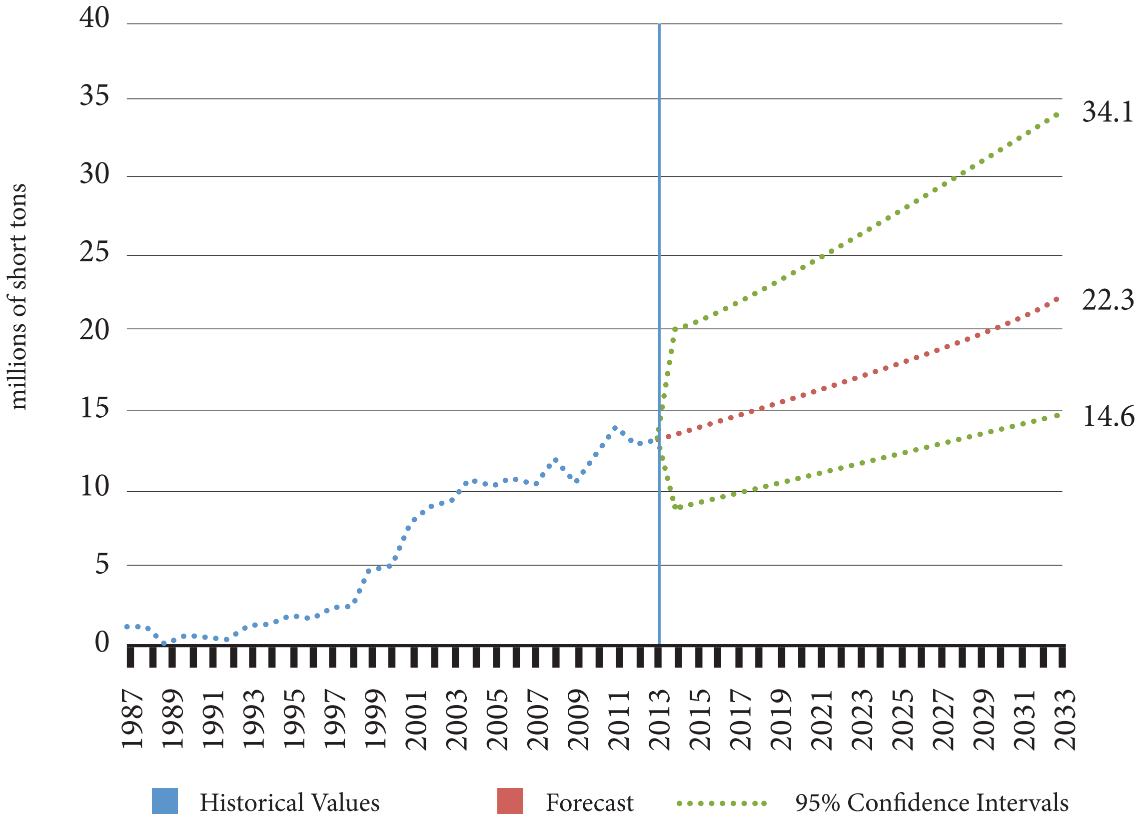
[45]Obada Kayali, "High Performance Bricks from Fly Ash" 2005 World of Coal Ash, http://www.flyash.info/2005/5kay.pdf

FGD UTILIZATION

Total FGD utilization is forecasted to grow at an average annual rate of nearly three percent over the next twenty years, from 12.9 million short tons in 2013 to 22.3 million short tons in 2033. The overall utilization would grow from 37 percent of production to 58 percent over that same time period.

As a substitute for natural gypsum, future demand for FGD material will be related to demand for gypsum wallboard and total U.S. construction activity. In recent years, wallboard manufacturers have recognized the superior properties of FGD material—they have shifted their production process and refitted manufacturing facilities to accommodate more FGD gypsum material.[46] Many of the technical challenges of using FGD material in gypsum have been solved, and operating changes necessary have been "relatively well established."[47]

FIGURE 2-6: FGD UTILIZATION, 1987 TO 2033



[46]Bob Bruce, PhD., "Impact of USA Flue Gas Desulfurization Programs on north American Gypsum Supply and Demand." (2004). http://www.innogyps.com/synthetic_gypsum_supply_demand.php
[47]Tera Berland. Review of handling and use of FGD material. Energy & Environmental Research Center, University of North Dakota, (2010). http://library.nd.gov/statedocs/EERC/FGDHandlingRpt-20111227.pdf

FGD material is attractive because it can be used as a complete substitute for mined gypsum in wallboard and drywall, since the primary chemical constituent is identical.[48] FGD gypsum may even have higher gypsum purity than mined gypsum because of the "greater control over the chemical composition of the final product."[49]

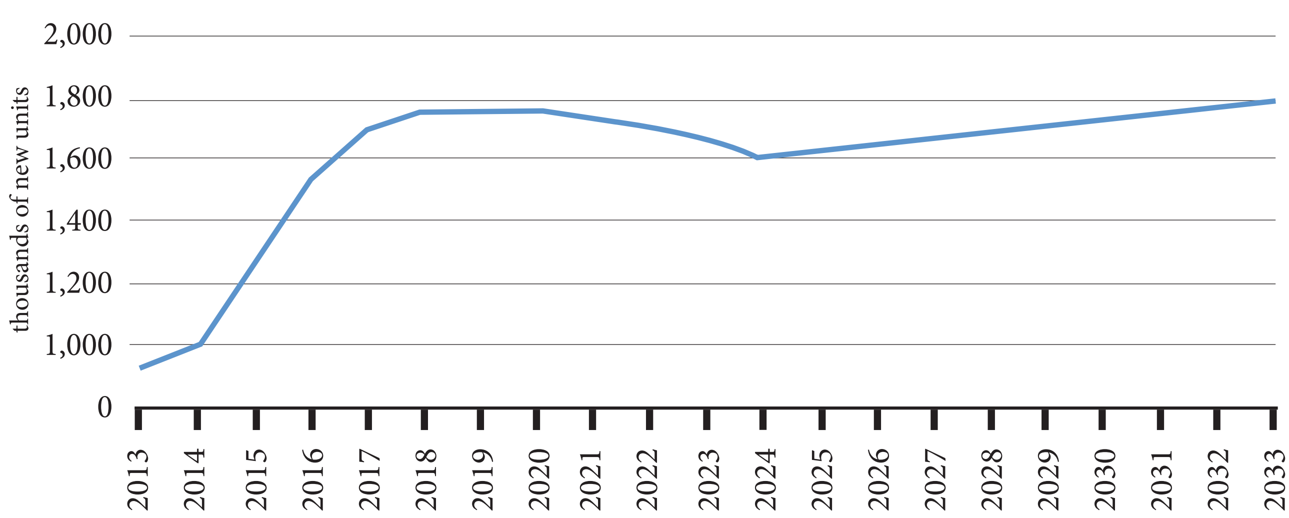
FGD material is also used as an input for blended cement and feed for clinker and in both mining and agricultural applications.

Additional factors that could impact the market outlook for FGD material:

HOUSING STARTS AND CONSTRUCTION MARKET ACTIVITY: The demand for gypsum wallboard is tied to the overall economy, housing starts and U.S. construction market activity. Although gypsum wallboard dates back to the 19th century, "the biggest technological trend in the gypsum wallboard industry in recent years has been the adoption of synthetic gypsum, made from byproducts of energy generation or industrial waste."[50]

Analysts expect the wallboard industry will continue to grow, but may have some "bumps" along the way.[51] Overall, the forecast for new housing starts is expected to grow from 925,000 units in 2013 to 1.79 million in 2033.[52]

FIGURE 2-7: OUTLOOK FOR U.S. NEW HOUSING STARTS



[48]EPA., "Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard." (2014). http://www.epa.gov/waste/conserve/imr/ccps/pdfs/ccr_bu_eval.pdf
[49]Ibid.
[50]Vance Cariaga. "Housing Rebound Boosts gypsum Wallboard Suppliers." Investor's Business Daily. April 25, 2014. http://www.nasdaq.com/article/housing-rebound-boosts-gypsum-wallboard-suppliers-cm347621
[51]Ibid.
[52]Forecast of housing starts through 2024 from "Congressional Budget Office, August 2014 Update to the Budget and Economic Outlook: Fiscal Years 2014 to 2024." Totals for 2024 to 2033 based on historical growth. https://www.cbo.gov/publication/45653

PRODUCT TRANSPORTATION, QUALITY AND STANDARDS: The commitment of gypsum suppliers for product quality, managing supply interruptions and lowering transportation costs are key elements for increasing the utilization of FGD material in the future.[53] Many of the technical challenges of "producing commercially viable FGD gypsum have been solved," but some operating challenges do remain.[54] The continued integration of relationships between producer and consumers and operational improvements to lower costs will help further increase utilization.

ENVIRONMENTAL REGULATIONS: Any federal or state regulations on landfills, impoundments or ash ponds would have an impact on the disposal of FGD material and could create new supply opportunities. There were over 11.2 million short tons of FGD material placed in landfills or ponds in 2012.[55]

One example includes recent legislation in North Carolina that prohibits new coal ash ponds after October 1, 2014 and bans wet disposal beginning in 2020.[56] If more states consider similar approaches to managing CCPs, there could be a substantial amount of FGD material that needs to be disposed that could be readily available for beneficial use.

ADDITIONAL MARKETS AND TECHNOLOGICAL ADVANCES: The use of FGD material in other markets, such as agricultural systems, will provide additional utilization opportunities.

Although gypsum was used for agriculture purposes as early as the 18th century, high extraction and transportation costs meant it was used only for a few crops.[57] Much like the wallboard industry, agriculture producers are finding that the availability of FGD gypsum, as well as the smaller and uniform particle sizing mean that the synthetic material is providing "greater soil improvements" than commercially mined gypsum.[58]

FGD gypsum improves soil quality by reversing the effects of compaction, improving the infiltration of rainfall and providing calcium and sulfur.[59] The use of CCPs for agriculture purposes is one of the fastest growing utilization categories, increasing from 14,681short tons in 1995 to over 598,105 short tons in 2013.[60] FGD gypsum can be used to manage crops, increase yields "while at the same time safeguarding the environment."[61]

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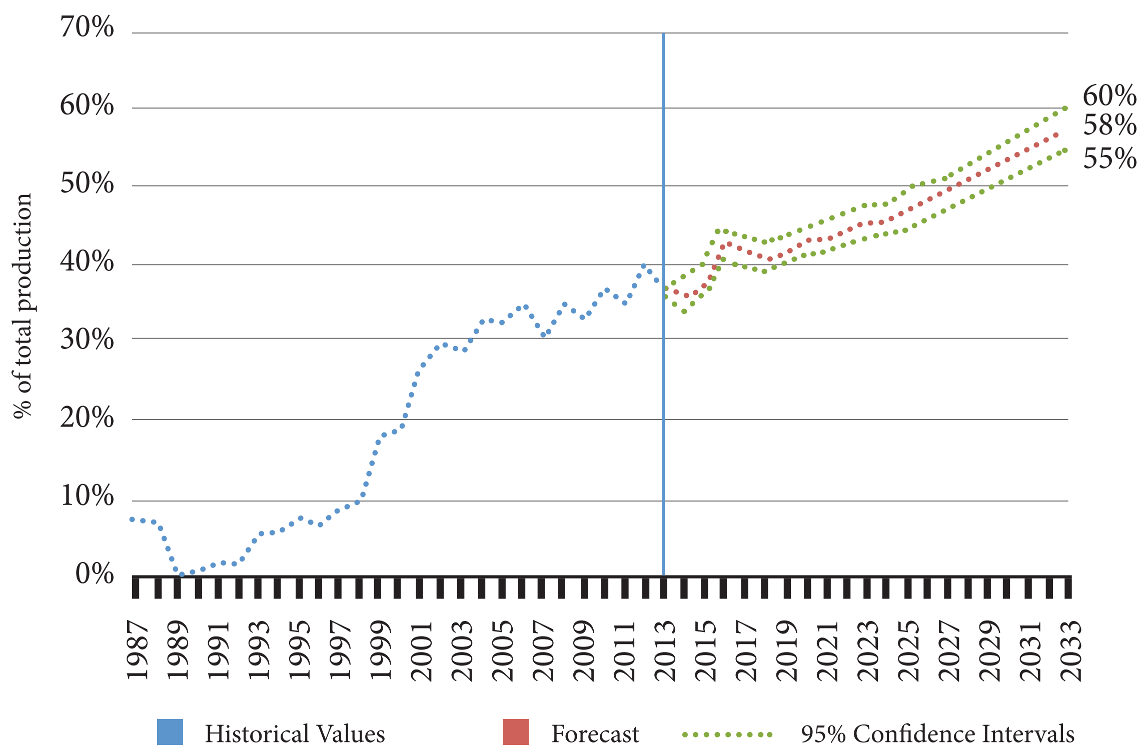
[53]Tera Berland. Review of handling and use of FGD material. Energy & Environmental Research Center, University of North Dakota, (2010). http://library.nd.gov/statedocs/EERC/FGDHandlingRpt-20111227.pdf
[54]Ibid.
[55]ARTBA analysis of EIA-923 data.
[56]Sonal Patel. "Nation's First Coal Ash Law Takes Effect in North Carolina," Power Magazine, September 24, 2014 http://www.powermag.com/nations-first-coal-ash-law-takes-effect-in-north-carolina/
[57]Dexter B. Watts and Warren A. Dick. "Sustainable Uses of FGD Gypsum in Agricultural Systems: Introduction." Journal of Environmental Quality, June 23, 2014. http://www.ncbi.nlm.nih.gov/pubmed/25602557
[58]Ibid.
[59]Dan Zinkand. "CCPs in Agriculture." Ash at Work, 1, (2012). http://www.acaa-usa.org/Portals/9/Files/PDFs/ASH01-2012.pdf
[60]Alison Premo Black. " The U.S. Coal Combustion Products Market: A Historical Market Analysis." (2015).
[61]Dexter B. Watts and Warren A. Dick. "Sustainable Uses of FGD Gypsum in Agricultural Systems: Introduction." Journal of Environmental Quality. June 23, 2014. http://www.ncbi.nlm.nih.gov/pubmed/25602557

FIGURE 2-8: FGD UTILIZATION RATE, 1987 TO 2033



BOTTOM ASH UTILIZATION

Bottom ash utilization is forecasted to grow from 5.6 million short tons in 2013 to 7.2 million short tons in 2033, an increase of 28 percent.

Bottom ash is mainly used as an input for blended cement, clinker and concrete products, structural fills and embankments, soil modification and snow and ice control.

Although bottom ash has a chemical composition that is similar to fly ash, the size of the material can range from "fine sand to large gravel," and thus it does not have any cementitous properties.[62]

Since bottom ash is not pozzolanic it has more limited applications in the cement and concrete industry than fly ash.[63] Bottom ash is typically used as a lightweight aggregate in precast concrete products, including concrete blocks and masonry units.[64] The final product is much lighter than when using conventional aggregates, such as sand and gravel, and is just as strong.[65]

The demand for bottom ash over the next 20 years will be dependent on the end use markets, especially U.S. construction market activity.

As new technologies and uses emerge, increasing amounts of bottom ash will continue to be used as an input for various construction materials.

Bottom ash is also being used to replace fine aggregate in hot-mix asphalt, with research being conducted to evaluate the material's performance, stability and moisture susceptibility.[66]

Bottom ash is also being studied as a replacement material in self compaction concrete a type of concrete "that will be leveled and compacted under its self-weight," with promising results.[67]

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[62]Texas Coal Ash Utilization Group, FAQ., "What are coal combustion products?" http://www.tcaug.org/faq/
[63]R.C. Joshi and R. P. Lohita. Fly ash in concrete: production, properties and uses. No. 2. CRC Press, 1997. https://books.google.com/books/about/Fly_Ash_in_Concrete.html?id=8ITxm7zHul4C
[64]G.J. Dienhart, B. R. Stewart, and S. S. Tyson. "Coal ash: innovative applications of coal combustion products." American Coal Ash Association, Alexandria, VA (1998).
[65]University of Kentucky, Center for Applied Energy Research
[66]Boo Hyun Nam. Evaluating the Use of Waste-to-Energy Bottom Ash as Road Construction Materials. Dissertation. University of Central Florida, 2014. http://www.dot.state.fl.us/research-center/Completed_Proj/Summary_SMO/FDOT-BDK78-977-20-rpt.pdf
[67]Aeslina Binti Abdul Kadir and Mohd Ikhmal Haqeem Hassan. "An Overview of Fly Ash and Bottom Ash Replacement in Self-Compaction Concrete." Key Engineering Materials 594 (2014): 465-470. http://www.scientific.net/KEM.594-595.465

FIGURE 2-9: BOTTOM ASH UTILIZATION, 1974 TO 2033

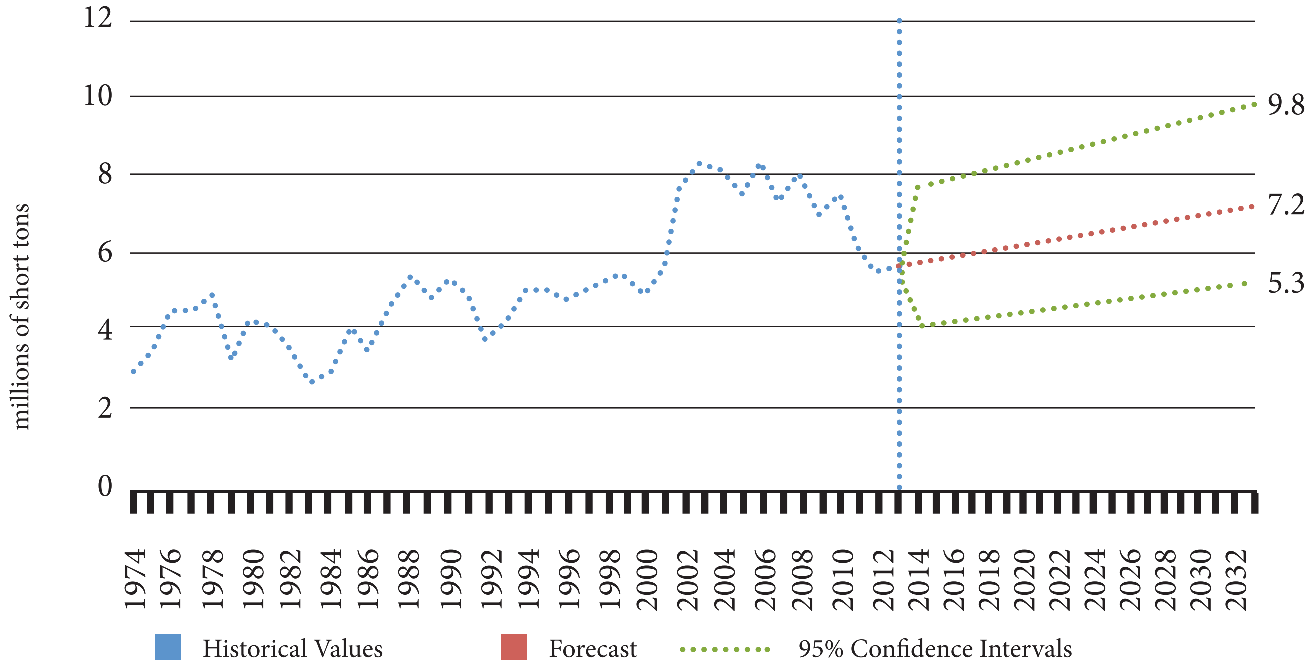
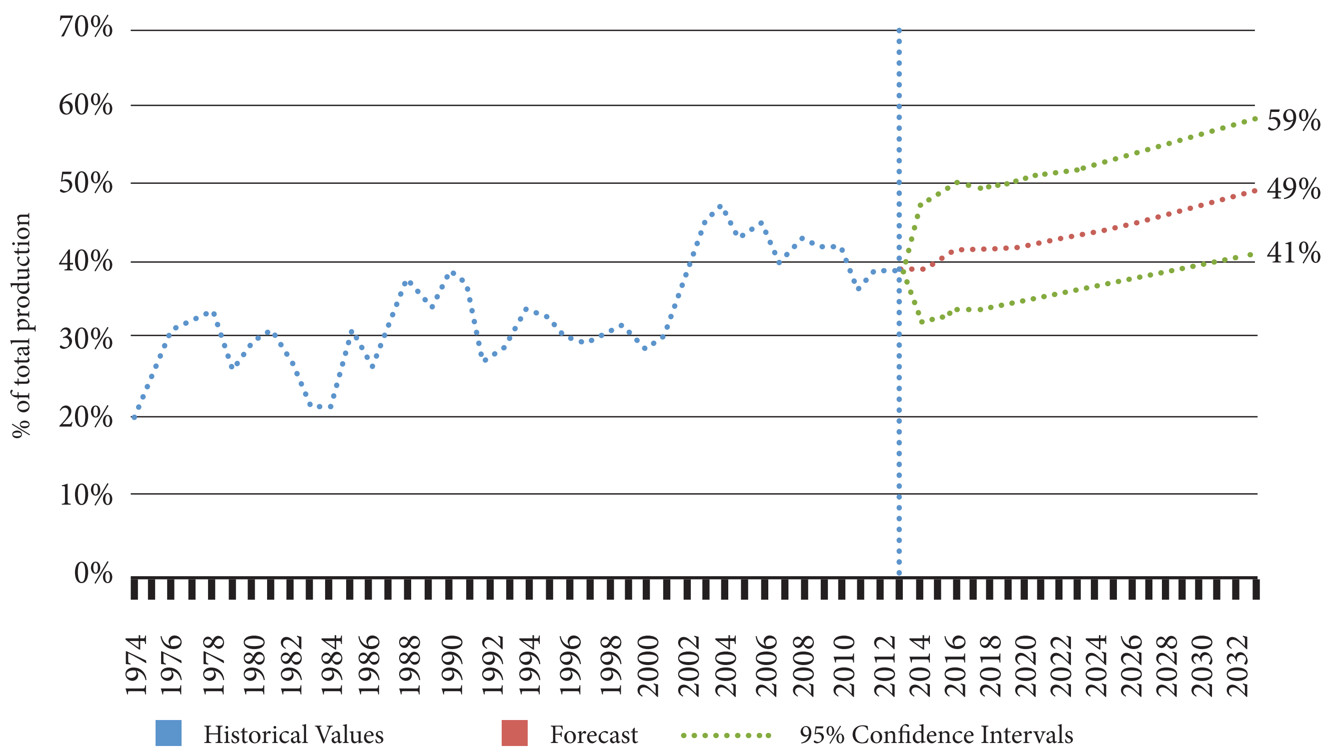


FIGURE 2-10: BOTTOM ASH UTILIZATION RATE, 1974 TO 2033



BOILER SLAG UTILIZATION

The utilization of boiler slag is expected to decline as supplies of the CCP are limited, decreasing from 909,000 short tons in 2013 to 755,366 million short tons in 2033.

In 2013, 98 percent of the boiler slag utilized was for roofing granules or blasting grit.

Overall levels of boiler slag utilization over the next 20 years will be limited by supply as more wet-bottom boilers are retired in years to come. As a result, the overall utilization rate will remain high in this niche market.

FIGURE 2-11: BOILER SLAG UTILIZATION, 1974 TO 2033

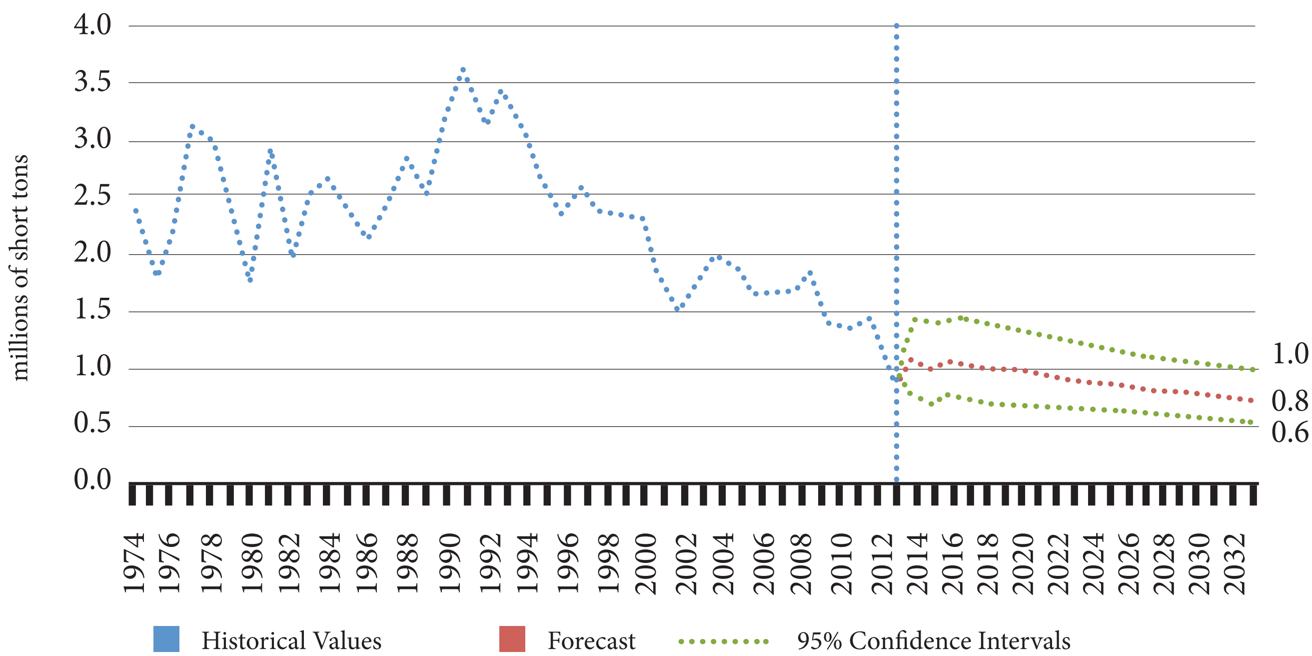
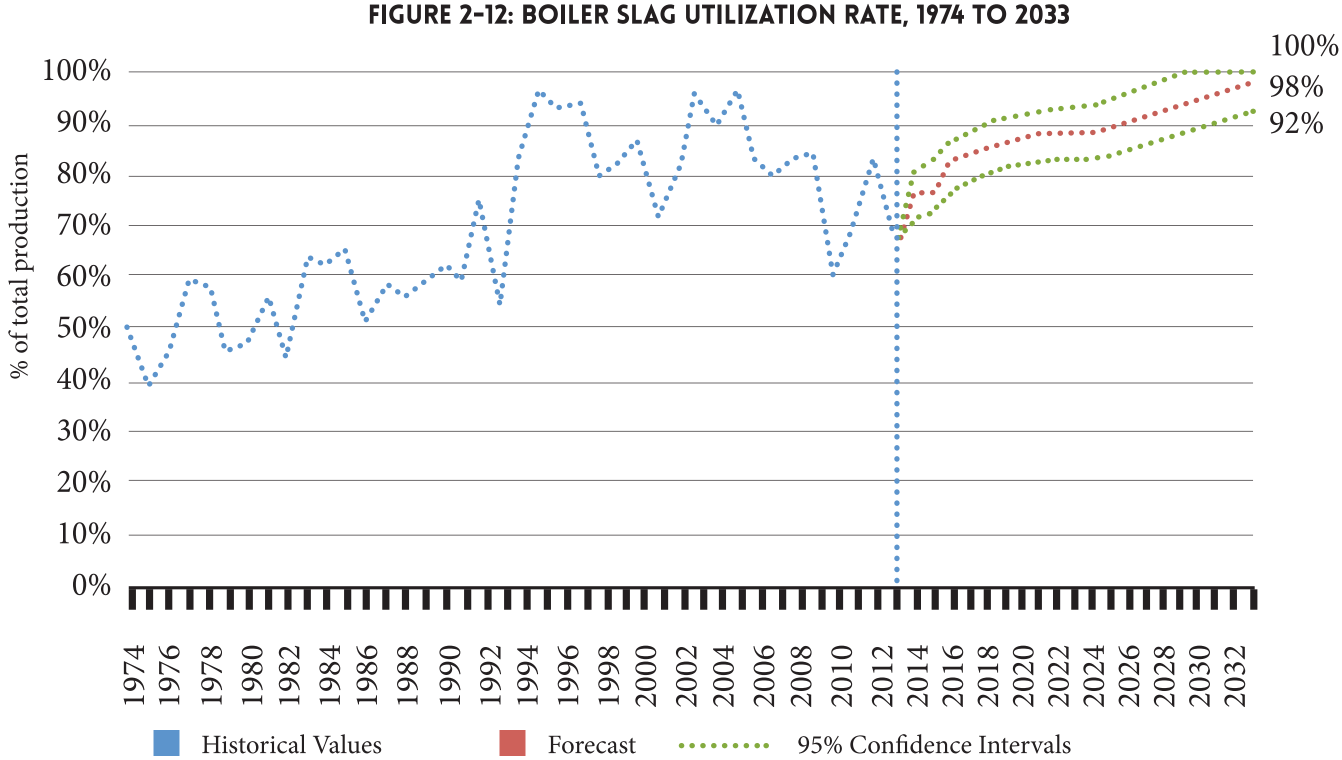


FIGURE 2-12: BOILER SLAG UTILIZATION RATE, 1974 TO 2033



FBC ASH UTILIZATION

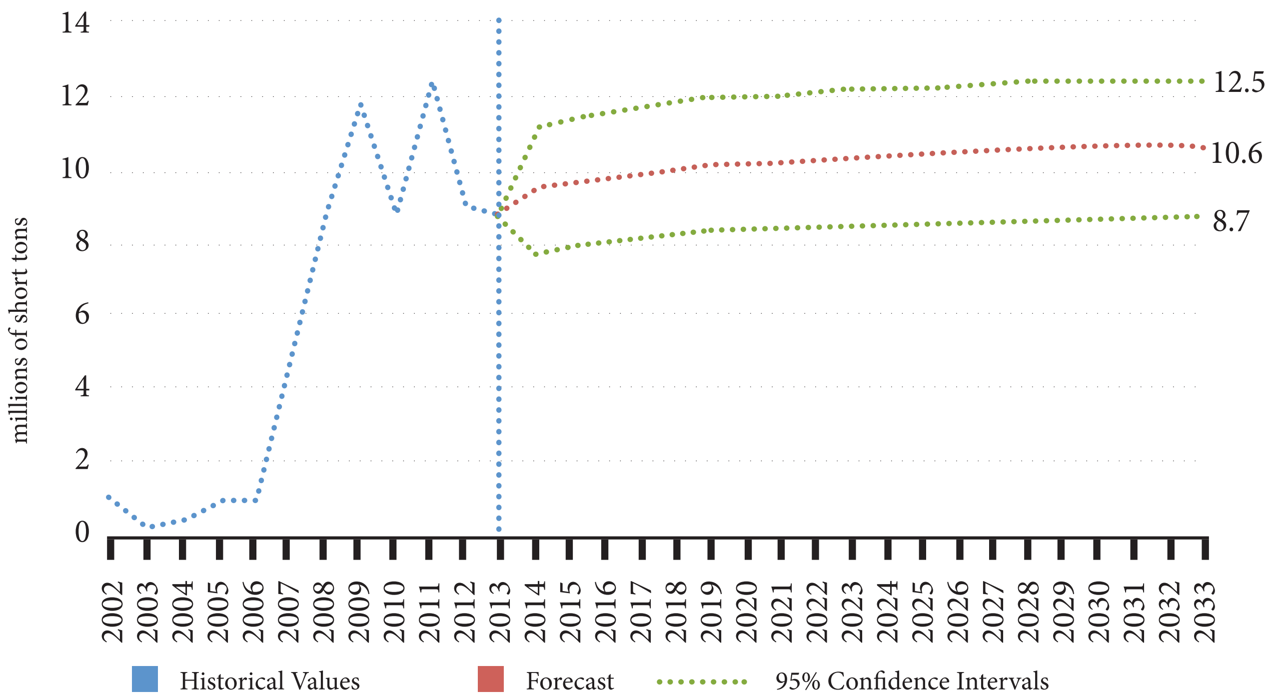
The utilization of FBC ash is expected to grow from 8.8 million short tons in 2013 to 10.6 million short tons in 2033, with a utilization rate constant at the historical average of 89 percent of production.

In 2013, over 95 percent of the FBC ash utilized was for mining applications. The remaining FBC ash was used in soil modification and stabilization, waste stabilization and aggregates.

FBC ash provides a number of environmental and economic benefits when used in mines, and has been placed in at least 20 sites across the country.[68] It is expected that utilization in these areas will continue in the future.

Most FBC ash has been used in surface mines to help restore the land to beneficial use. In several states FBC ash has also been used to fill underground mines, providing structural support.[69]

FIGURE 2-13: FBC ASH UTILIZATION, 2002-2033



[68]Ishwar P. Murarka, and Jim Erickson. "Use of coal combustion products in mine-filling applications: a review of available literature and case studies." (2006).
[69]Ibid.

ALTERNATIVE PRODUCTION SCENARIOS FOR FLY ASH AND FGD MATERIAL

Two additional outlooks for CCP production are included to show the potential growth in FGD material and fly ash, based on historical patterns and different modeling techniques.

TABLE 3-1: ALTERNATIVE SCENARIOS (IN MILLIONS SHORT TONS)

	VOLUME 2013	PROJECTED VOLUME 2033	PROJECTED TOTAL GROWTH	PROJECTED AVERAGE ANNUAL GROWTH RATE
FGD Material				
Baseline Forecast	35.2	38.8	10.2%	0.5%
High Growth Scenario	35.2	69.7	98.0%	3.5%
Low Growth Scenario	35.2	23.0	-34.7%	-2.1%
Fly Ash				
Baseline Forecast	53.4	54.6	2.2%	0.1%
High Growth Scenario	53.4	64.5	20.8%	0.9%
Low Growth Scenario	53.4	44.5	-16.7%	-0.9%
Total CCP Production				
Baseline Forecast	114.7	120.6	5.1%	0.3%
High Growth Scenario	114.7	161.5	40.8%	1.7%
Low Growth Scenario	114.7	94.8	-17.3%	-0.9%

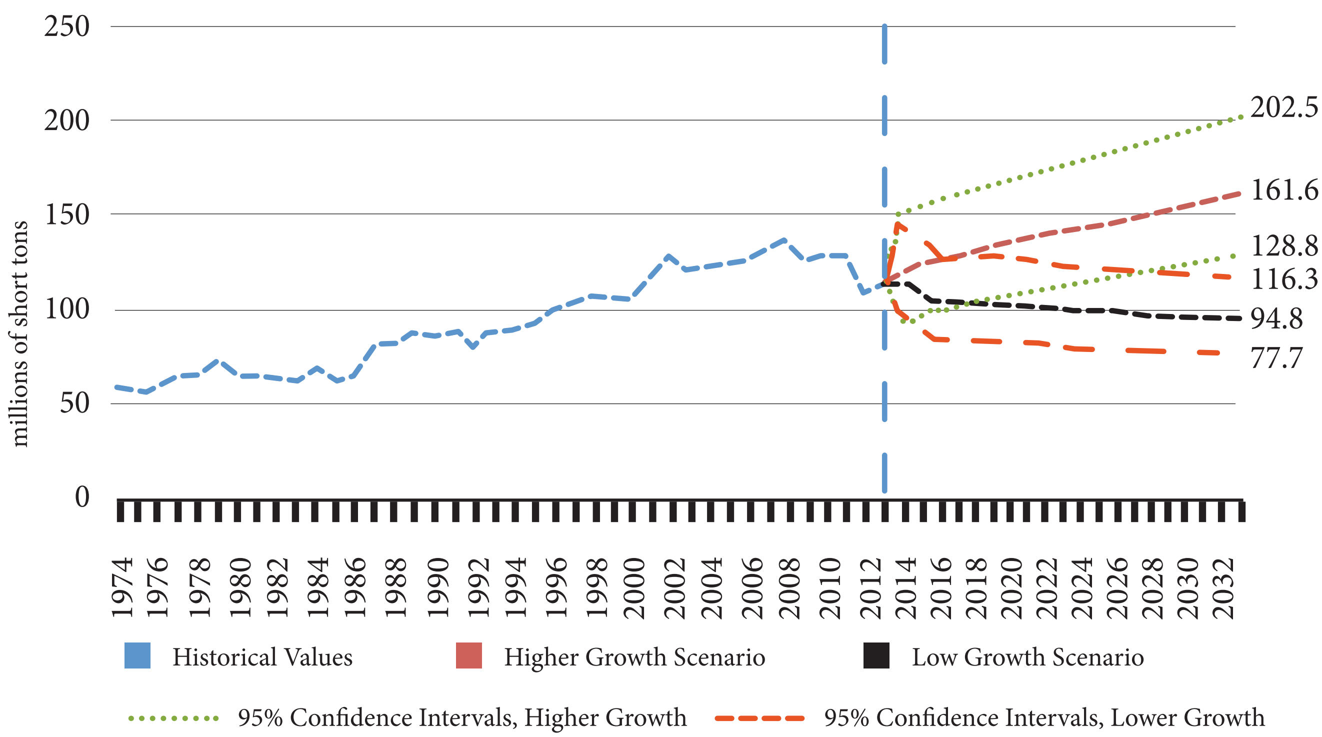
In the case of FGD material, the model still uses a Box-Jenkins methodology, but allows the forecast to put greater weight on the significant historical growth in FGD material production.

For fly ash production the alternative model recognizes a fundamental shift in the market after 1993 that is incorporated into the forecast. Testing shows that there is a break in the fly ash production data at this time—a significant increase in the mean of the series, as explained further in the methodology. Most likely this reflects a fundamental shift in the market after the enactment of the 1990 amendments to the Clean Air Act and the 1993 EPA regulatory determination that fly ash is not a hazardous waste.[70]

These alternative scenarios provide an additional upper and lower bound to the outlook, beyond the confidence intervals of the original forecast. Total CCP production ranges from 94.8 to 161.5 million short tons in 2033 under the different high and low growth outlooks.

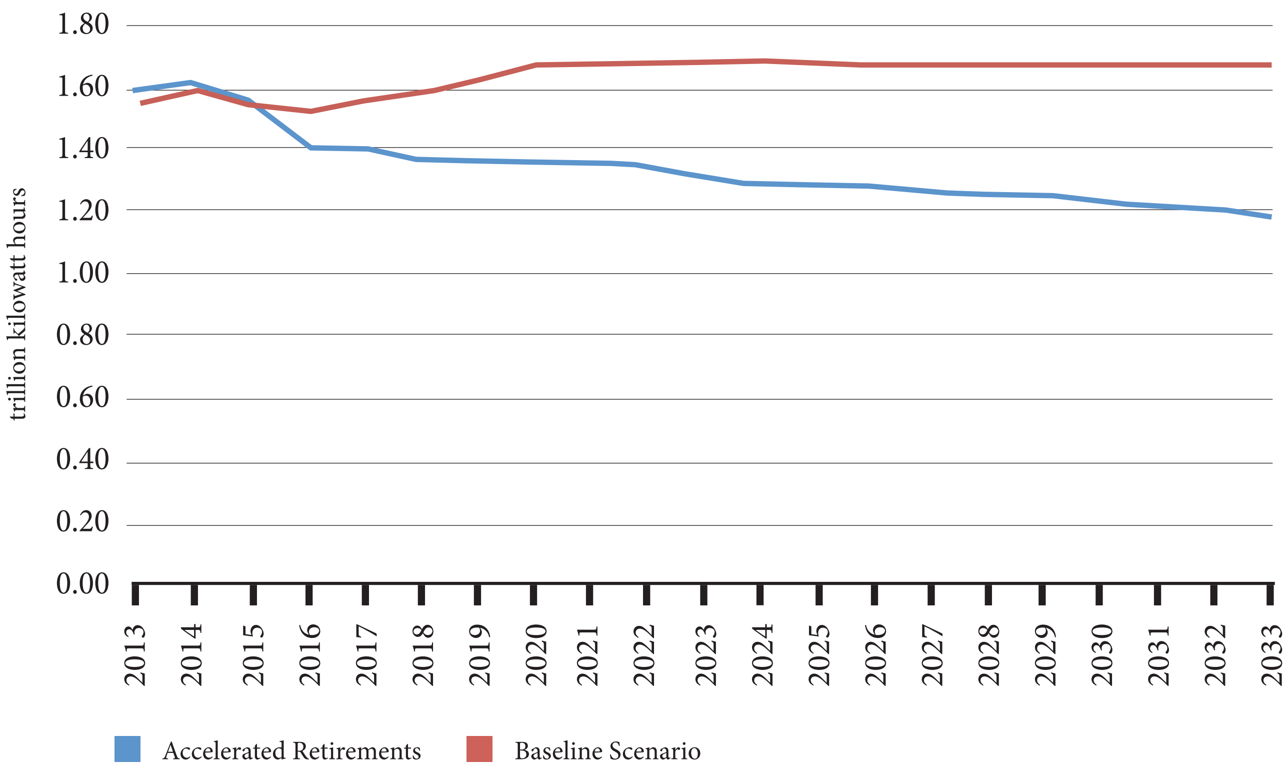
The alternative low growth scenario assumes that the total volume of coal-fueled electric generation declines further over the next 20 years, following the "accelerated retirements" scenario from the EIA Annual Energy Outlook 2014. Coal–fueled electric generation would decline at an average annual rate of 1.4 percent, falling from 1.59 billion megawatt hours in 2013 to 1.19 billion megawatt hours in 2033, a drop of nearly 25 percent.

FIGURE 3-1: HIGH AND LOW GROWTH SCENARIOS FOR CCP PRODUCTION, 1974 TO 2033



[70]http://www.epa.gov/osw/nonhaz/industrial/special/fossil/regs.htm

FIGURE 3-2: VOLUME OF COAL GENERATED ELECTRICITY



Under an alternative scenario, in which FGD production grows in line with its historical pattern, the model forecasts that production would reach 69.7 million short tons in 2033. This model does not take into account the outlook for coal-fueled electric generation, and represents an upper bound to the forecast.

Under a scenario of low growth and accelerated coal plant retirements and lower levels of coal-fueled electric generation, FGD production is forecast to fall to 23 million short tons. However this low growth scenario, given the importance of environmental regulations to the future of the energy industry, is very unlikely.

An alternative outlook for fly ash production is forecast to reach 64.5 million short tons in 2033. Under this scenario, fly ash production would grow at an average annual rate of one percent, which is just slightly above historical growth levels.

Using forecasted values for accelerated coal plant retirements from EIA, total fly ash production is forecast to fall to 44.5 million short tons in 2033 if total coal generated electricity falls more than expected.

FIGURE 3-3: HIGH AND LOW GROWTH SCENARIOS FOR FGD MATERIAL PRODUCTION, 1987 TO 2033

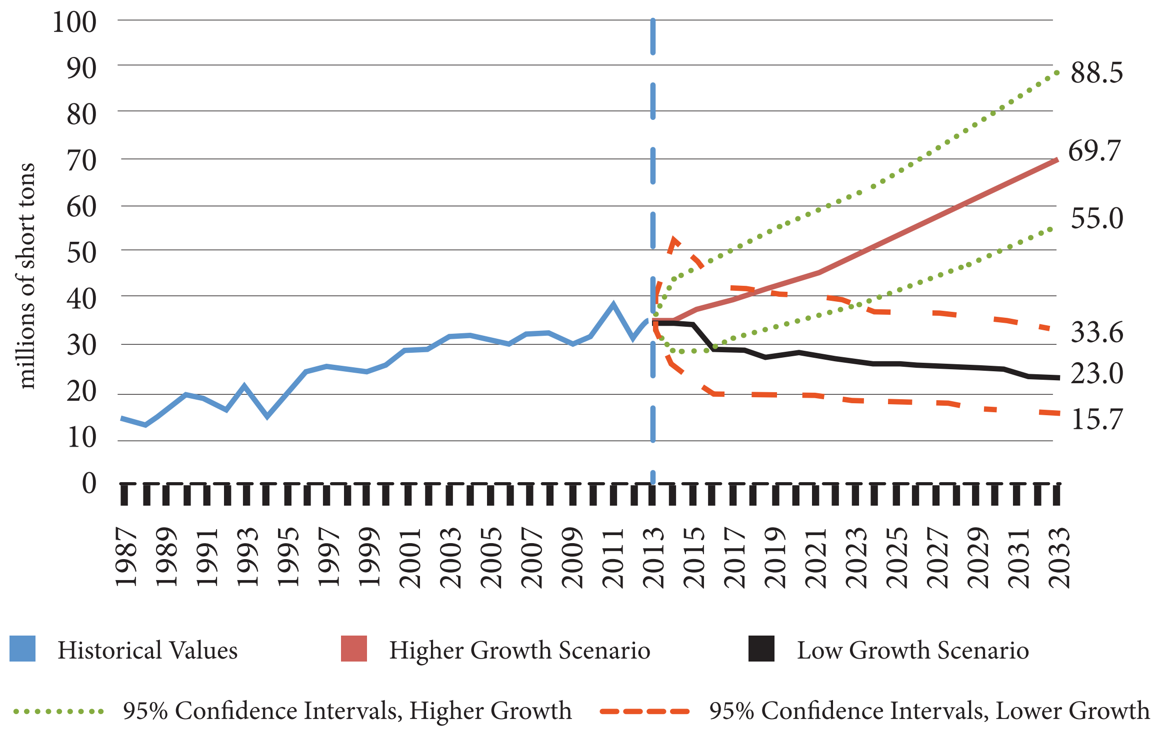
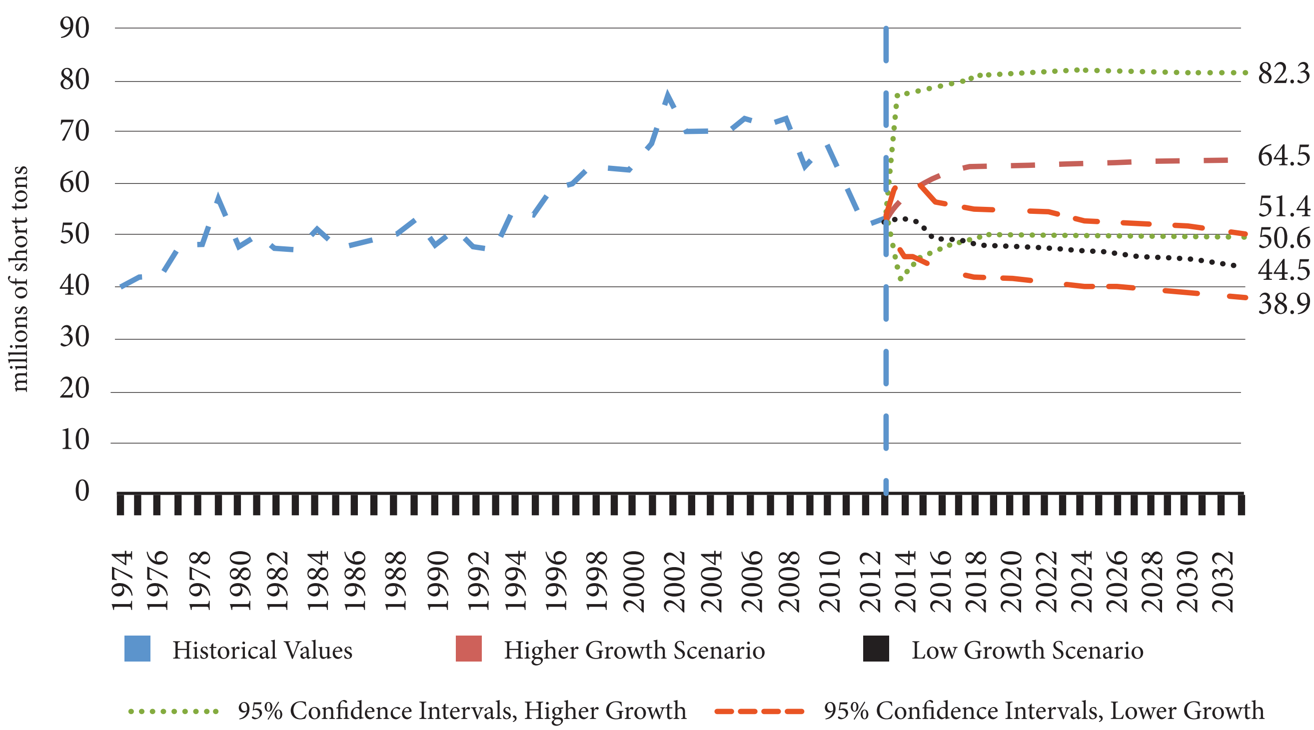


FIGURE 3-4: HIGH AND LOW GROWTH SCENARIOS FOR FLY ASH PRODUCTION, 1974 TO 2033



METHODOLOGY

A series of ten individual models were created for this study to forecast values for the production and utilization of fly ash, bottom ash, FGD material, boiler slag and FBC ash using Box-Jenkins methods.[71] Additional “high growth” and “low growth” scenarios for fly ash and FGD material production are included to reflect different forecasts of the total volume of coal-fueled electricity generation in the U.S. Energy Information Administration 2014 Annual Energy Outlook.

The total utilization and production volumes for the CCP market are the sum of the five individual coal combustion products types.

The steps for the Box-Jenkins models include model identification and selection, estimating parameters, forecasting and model validation. In most cases the type of model selected was an autoregressive integrated moving average (ARIMA) model, or an autoregressive and moving average model with exogenous variables (ARMAX).

ARIMA models are a special type of regression model where an independent variable is forecast based on prior values in the time series and errors made by the previous predications.

The following steps and testing methods were used to determine the appropriate model specification and data transformations for the individual production and utilization models:

- **DATA STATIONARITY:** The ACAA data on CCP production and use clearly follow an upward trend over time. The data were transformed to log format to create a stationary time series. The mean, variance and autocorrelations of a stationary data series are all constant over time.[72]

- **AUTOCORRELATIONS AND PARTIAL AUTOCORRELATION PLOTS (ACF AND PACF(:** The ACF and PACF plots were reviewed to identify evidence of autocorrelation, a correlation between a data point and its previous values. The autocorrelations plot can be useful to determine if moving average specification should be included in an ARIMA model.

- **DICKEY-FULLER UNIT ROOT TEST:** Data with a unit root in the series means that there is more than one trend. The Dickey-Fuller test is commonly used to determine if a data series is stationary. Analysis found that there was a unit root in the logged transformed data, and taking the first difference of the log was necessary to have a stationary time series for model estimation.

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[71] Box GEP, Jenkins GM., Time series analysis, forecasting and control. Holden-Day, San Francisco, CA, 1970.
[72] Walter Enders. Applied Econometric Time Series.

The independent variables were estimated using an ARIMA or ARMAX model. The general ARIMA (p,d,q) model forecasts a time series based on the weighted sum of previous values of the dependent variable (1 …p), known as the autoregressive term, and the weighted sum of the previous forecast errors (1 …q), known as the moving average term. Finally, (d) is the total number of differences applied to the series to achieve stationarity. The basic ARIMA (p,1,q) model for independent X_t may be written compactly as:[73]

$$X_t = a_0 + \varepsilon_t + \sum_{t=1}^{p} \beta_t X_{t-1} + \sum_{t=1}^{q} p_t \varepsilon_{t-1}$$

Where $X_t=X_t-X_{t-1}$, the first difference of the independent variable and $a_0\ \beta_1 \dots \beta_p$, and $\rho_1 \dots \rho_q$ are parameters to be estimated and the ε_{t-i} are error terms. he values for p and q are determined using plots from the ACF and PACF plots.

The ARMAX (p,q,b) model includes autoregressive terms (p), moving average terms (q) and a number of exogenous inputs (b) where η are the parameters of the exogenous inputs δ:

$$X_t = a_0 + \varepsilon_t + \sum_{t=1}^{p} \beta_t X_{t-1} + \sum_{t=1}^{q} \gamma_t \epsilon_{t-1} + \sum_{i=1}^{b} \eta_i \delta_{t-1}$$

A Dickey-Fuller unit root test on the residuals of the model results was implemented to test for cointegration.

[73]Ibid.

MODEL SPECIFICATION:

- **FLY ASH PRODUCTION:** An ARMAX (0,0,1) model where X_t is equal to the first difference of the log of the total annual volume of fly ash from 1974 to 2013. The exogenous input δ is the log of the total volume of coal generated electricity over the same time period from the U.S. EIA Annual Energy Outlook 2014 reference case scenario. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \eta_1 \delta_{t-1}$$

- **FGD MATERIAL PRODUCTION:** An ARMAX (1,0,1) model where X_t is equal to the first difference of the log of the total volume of FGD material from 1987 to 2013. The exogenous input δ is the log of the total volume of coal generated electricity over the same time period from the U.S. EIA Annual Energy Outlook 2014 reference case scenario. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1} \quad + \eta_1 \delta_{t-1}$$

- **BOTTOM ASH PRODUCTION:** An ARMAX (1,1,1) model where X_t is equal to the first difference of the log of the total volume of bottom ash from 1974 to 2013. The exogenous input δ is the log of the total volume of coal generated electricity over the same time period from the U.S. EIA Annual Energy Outlook 2014 reference case scenario. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1} \quad + \gamma_1 \epsilon_{t-1} \quad + \eta_1 \delta_{t-1}$$

- **BOILER SLAG PRODUCTION:** An ARIMA (1,1,0) model of the log of the total volume of boiler slag from 1974 to 2013 with a constant. The model is in growth rate and converted to levels.

$$X_t = a_0 + \varepsilon_t + \beta_1 X_{t-1}$$

- **FBC ASH PRODUCTION:** An ARIMA (1,1,0) model of the log of the total volume of boiler slag from 2002 to 2013. It should be noted that the given the expansion of the data on FBC ash and the short time period, the model essentially reverts to a stable trend and does not have the same power as the other forecast models. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1}$$

- **FLY ASH UTILIZATION:** An ARMAX (1,0,1) model where X_t is equal to the first difference of the log of the total utilization of fly ash from 1974 to 2013. The exogenous input δ is the log of the total volume of U.S. ready-mixed concrete production wich is an indicator of construction related demand. Historical values from 1974 to 2013 were provided by the National Ready-Mixed Concrete Association. Values for 2014 to 2033 were estimated using the historical average annual growth rate of three percent. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1} \quad + \eta_1 \delta_{t-1}$$

- **FGD MATERIAL UTILIZATION:** An ARMAX (1,0,1) model where X_t is equal to the first difference of the log of the total utilization of FGD material from 1987 to 2013. The exogenous input δ is the log of the real value of construction put in place from the U.S. Census Bureau, weighted with the consumer price index from the U.S. Bureau of Labor Statistics. Future values of the construction put in place are estimated to grow at an average rate of 3.5 percent, the average growth from 1994 to 2013. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1} \quad + \eta_1 \delta_{t-1}$$

- **BOTTOM ASH UTILIZATION:** An ARMAX (1,0,1) model where X_t is equal to the first difference of the log of the total utilization of bottom ash from 1974 to 2013. The exogenous input δ is the log of the total volume of U.S. ready mixed concrete production. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1} \quad + \eta_1 \delta_{t-1}$$

- **BOILER SLAG UTILIZATION:** An ARMAX (1,0,2) model where X_t is equal to the first difference of the log of the total utilization of boiler slag from 1974 to 2013. The exogenous input δ_1 is the log of total production of boiler slag. The exogenous input δ_2 is log of total housing starts. The historical value of housing starts from 1974 to 2013 is from the U.S. Census Bureau. Future values through 2024 are from the U.S. Congressional Budget Office. New Starts from 2025 through 2033 are based on historical growth. The model is in growth rates and converted to levels.

$$X_t = \varepsilon_t + \beta_1 X_{t-1} \quad + \eta_1 \delta_1 \quad + \eta_2 \delta_2$$

- **FBC ASH UTILIZATION:** The total volume of FBC ash utilized is assumed to be 89.4 percent of total FBC ash production. This ratio is based on the historical average of FBC ash utilization between 2007 and 2013.

ALTERNATIVE SCENARIOS FOR THE FORECAST:

Additional high and low growth scenarios are forecasted for the production and utilization of fly ash and FGD material.

The high growth FGD material production model is an ARIMA (1,1,0) model with a constant term that allows the forecast to take into account the historical growth of production.

$$X_t = a_0 + \varepsilon_t + \beta_1 X_{t-1}$$

The high growth fly ash production model is an ordinary least squares (OLS) model where the dependent variable is the log of fly ash production and the independent variables are the lagged value of the log of production and the log of megawatt hours of coal-fueled electricity generation.

$$X_t = a_0 + \beta_1 X_{t-1} \quad + \beta_2 \gamma_t$$

In time series analysis, a structural break in the data may make the results of a Dickey-Fuller test biased towards the nonrejection of a unit root.[74] In other words, there may be a one-time change or shock to a time series that would usually be stationary. This shock changes the mean of the series, and the results of the Dickey-Fuller test suggest there may be a unit root, when actually there is a structural break.

A visual examination of the data for the production of fly ash, as well as both a Chow test and Perron test for structural change, indicate there is a structural break in the data series in the year 1994. At this point in time, the total production of fly ash increases significantly, suggesting that the entire market has shifted to a new mean.

The null hypothesis of a Chow test is that all of the errors in the model are independent and identically distributed form a normal distribution. Based on the test statistic, we can reject the null hypothesis and conclude that there is a structural break in the model. To account for this break we can split the data into two sub-samples.

The resulting forecast includes data from the EIA Annual Energy 2014 outlook for low oil and gas resources. In this scenario, more coal-fueled electricity generation is used to meet energy demand.

The low growth FGD material and fly ash models are the same as the baseline models, but the forecast for the total megawatt hours of coal-fueled electricity generation was taken from the EIA Annual Energy Outlook 2014 scenario for accelerated coal plant retirements. Thus the lower amount of coal consumption by power plants would impact total production of FGD material and fly ash.

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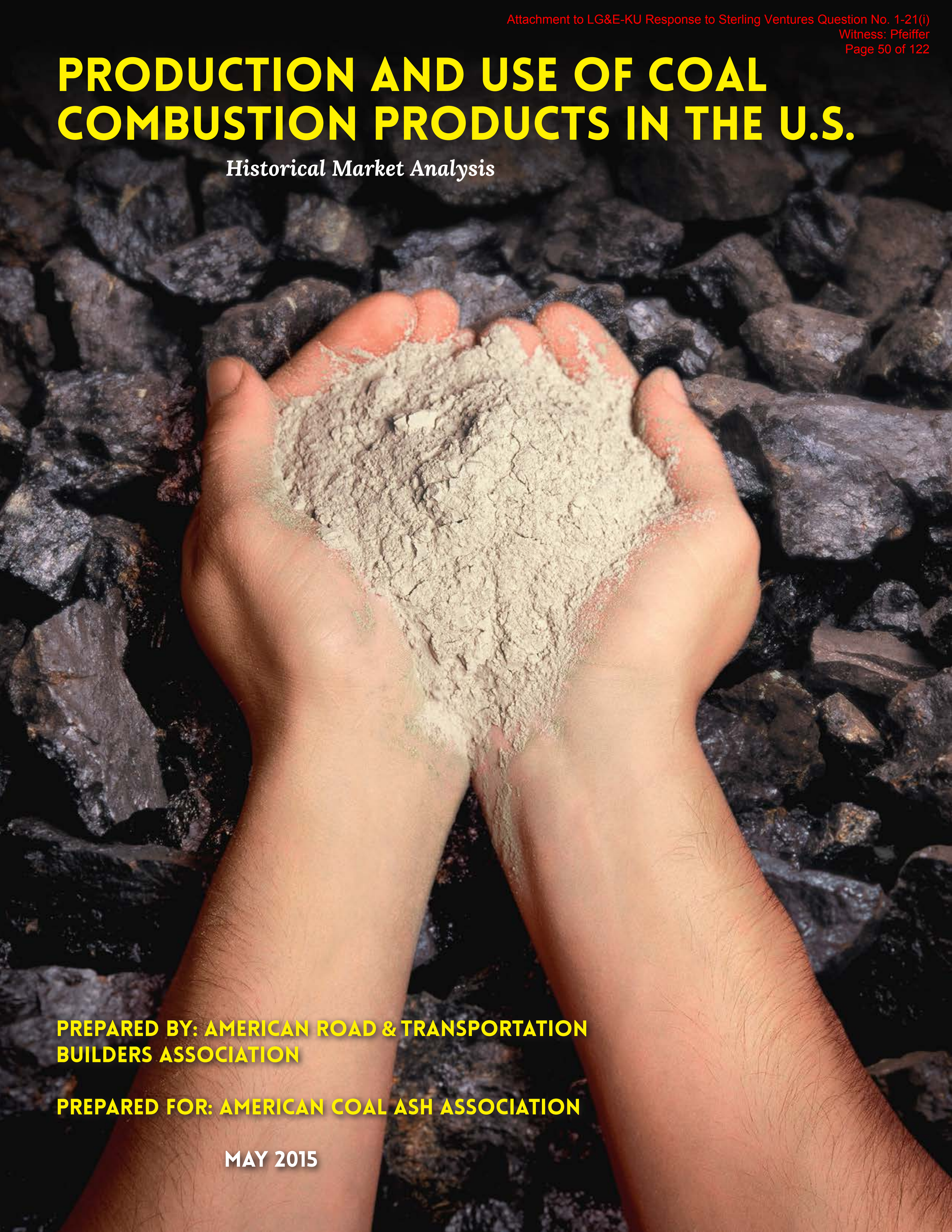
[74]Ibid.

PRODUCTION AND USE OF COAL COMBUSTION PRODUCTS IN THE U.S.

Historical Market Analysis



PREPARED BY: AMERICAN ROAD & TRANSPORTATION BUILDERS ASSOCIATION

PREPARED FOR: AMERICAN COAL ASH ASSOCIATION

MAY 2015

ABOUT ARTBA

Established in 1902, the American Road & Transportation Builders Association's (ARTBA) membership includes over 6,000 private and public sector representatives that are involved in the planning, designing, construction and maintenance of the nation's roadways, waterways, bridges, ports, airports, rail and transit systems.

ABOUT THE AUTHOR

This research was conducted by Dr. Alison Premo Black, senior vice president and chief economist for the American Road & Transportation Builders Association in Washington, D.C.

Dr. Black, who earned her PhD in Economics at The George Washington University in the Nation's Capital, also holds an M.A. in International Economics and Latin American Studies from the Johns Hopkins School of Advanced International Studies. She graduated magna cum laude from Syracuse University, where she was a member of Phi Beta Kappa and the Golden Key Honors Society, with majors in International Relations, Latin American Studies and Spanish. Since joining ARTBA in 2000, Dr. Black has led teams and authored over 75 studies examining state transportation funding and investment patterns and was responsible for the 2011 report "The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction."

ACKNOWLEDGMENTS

This study relied on historical data on coal combustion products (CCPs) compiled by the American Coal Ash Association (ACAA), considered the authoritative source for CCP production and use statistics in the U.S. ACAA conducts a voluntary annual survey of the coal-fueled electric utility industry to track quantities of CCPs produced and beneficially used. The annual CCP Production & Use Survey Report has been used by industry and government agencies including the Environmental Protection Agency and the Department of Energy.

This study relied on energy data related to electric generation, projected coal unit retirements, fuel costs, and CCP disposition from the U.S. Energy Information Administration (EIA). The EIA collects, analyzes and disseminates independent and impartial energy information for policymakers and public understanding. The EIA publishes the Annual Energy Outlook and data collected directly from generators on numerous annual survey forms.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Coal combustion products (CCPs) are valuable materials that have numerous applications, including the construction of dams, bridges and highways; building products; manufacturing; mining and agricultural uses. Products containing CCPs can be found in nearly every U.S. home, including gypsum wallboard, foundations, roofing shingles and concrete driveways. CCPs are the solid byproducts from burning coal to produce electricity. Although collectively known as "coal ash," CCPs are a class of materials that have varied chemical and physical characteristics and include fly ash, bottom ash, flue gas desulfurization (FGD) material, boiler slag and fluidized bed combustor (FBC) ash.

The use of coal ash in concrete (specifically fly ash) dates back to the construction of the Hoover Dam. By the 1970s, the use of fly ash was encouraged for roadway and interstate highway construction by the Federal Highway Administration (FHWA). The utilization of CCPs as replacement for mined or manufactured materials has been increasing over the last four decades. Since 1974, the American Coal Ash Association (ACAA) has collected data on the production and utilization of CCPs in the U.S. This study is the first to examine historical trends in annual production and utilization from 1974 to 2013.

This study was undertaken to examine the impacts of economic and regulatory factors on past CCP production and utilization. Relationships between the CCP data and other economic factors, including electricity demand and generation, U.S. recessions and changes in markets for CCPs, were analyzed using a variety of data sources and economic models. Details on this econometric analysis, which is the basis of a 20-year forecast for CCP production and use, can be found in a companion document.

Regulatory and policy factors include major environmental regulations affecting coal-fueled electricity generation, technologies for emissions reductions, regulatory uncertainty and standards and specifications pertaining to CCPs.

CCP PRODUCTION 1974 – 2013

Once accounting for over 50 percent of total electric generation, coal-fueled power generation has fallen to just over 40 percent in 2013 due to a number of factors. Environmental regulations, competition from natural gas power and relatively flat electricity demand has resulted in the retirement of coal-fueled capacity, reducing coal-fueled electricity generation, and thus, CCP production.

The overall production of CCPs grew at an average annual rate of 1.7 percent, from 59.5 million short tons in 1974 to 114.7 million short tons in 2013, as shown in Figure E-1. Production of fly ash and FGD material, which combined represent 77 percent of total CCP production by weight, have been positively impacted by capital investments from coal-fueled generating utilities to meet the requirements of the 1970 Clean Air Act and its amendments in 1977 and 1990. Production of fly ash has grown at an average annual rate of just under one percent, while production of FGD material has grown at an average annual rate of 3.5 percent, driven in large part by the development of technologies for reducing sulfur dioxide emissions in response to federal regulation.

CCP UTILIZATION 1974 – 2013

The growth in CCP utilization has been enabled by the development of standards for CCP use in construction and new techniques for using higher quantities of ash. CCP utilization has grown during three of the last five U.S. recessions since 1974, as shown in Figure E-2, as concrete producers and other end users have utilized CCPs as less expensive material substitutes to save on overall material costs. This includes the most recent recession that began in December 2007.

During periods following two regulatory determinations (1993 and 2000) by the U.S Environmental Protection Agency (EPA) that CCPs did not warrant regulation as a hazardous waste, CCP utilization increased significantly, as can be seen in Figure E-2. Fly ash utilization doubled from 10.5 million short tons in 1993 to 20.1 million short tons in 2000, growing at an average annual rate of 10 percent. Between 2000 and 2007, fly ash utilization increased 6.6 percent annually. Similarly, FGD material utilization grew by 23 percent annually from 1993 through 2000, and by 12 percent annually between 2000 and 2008.

EPA's decision to reconsider the classification of CCPs as a hazardous waste after the December 2008 coal ash spill in Kingston, Tennessee resulted in regulatory uncertainty for CCP markets. CCP utilization had been at its highest in 2008 at 60.6 million short tons following the 2007 recession. After EPA's reconsideration, CCP utilization declined by 15 percent from 2008 to 2013. Despite increased CCP utilization during previous recessions, regulatory uncertainty affected markets for CCPs, reducing overall utilization after 2008.

NEW MARKETS AND STANDARDS

Since 1974, markets and applications for CCPs have increased dramatically. Total CCP utilization has increased from 8.7 million short tons in 1974 to 51.6 million short tons in 2013, as shown in Figure E-3. This represents an increase of nearly 500 percent over that period, or an average increase of 5.1 percent annually, as shown in Figure E-4.

The development of industry standards and specifications for CCP utilization in various engineering applications has encouraged wider use of these materials. More than a dozen federal agencies have published articles, guidelines and standards on the beneficial use of CCPs. EPA has released a study supporting the use of fly ash in concrete and FGD gypsum in wallboard. Further, EPA's final rule for CCP disposal specifically exempts beneficial uses, which will impart regulatory certainty for markets in the years to come.[1]

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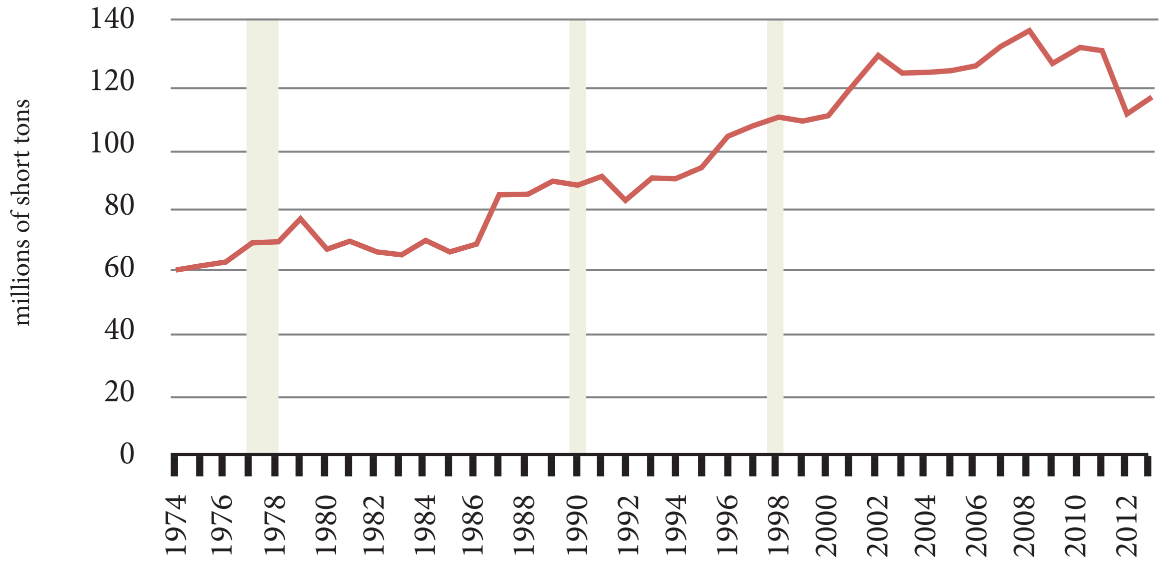
[1] The final rule, Disposal of Coal Combustion Residuals from Electric Utilities was published in the Federal Register on April 17, 2015 and uses the terminology coal combustion residuals (CCRs) rather than coal combustion products. The rule does not regulate practices that meet the definition of a beneficial use of CCR. 80 Fed. Reg. 21301.

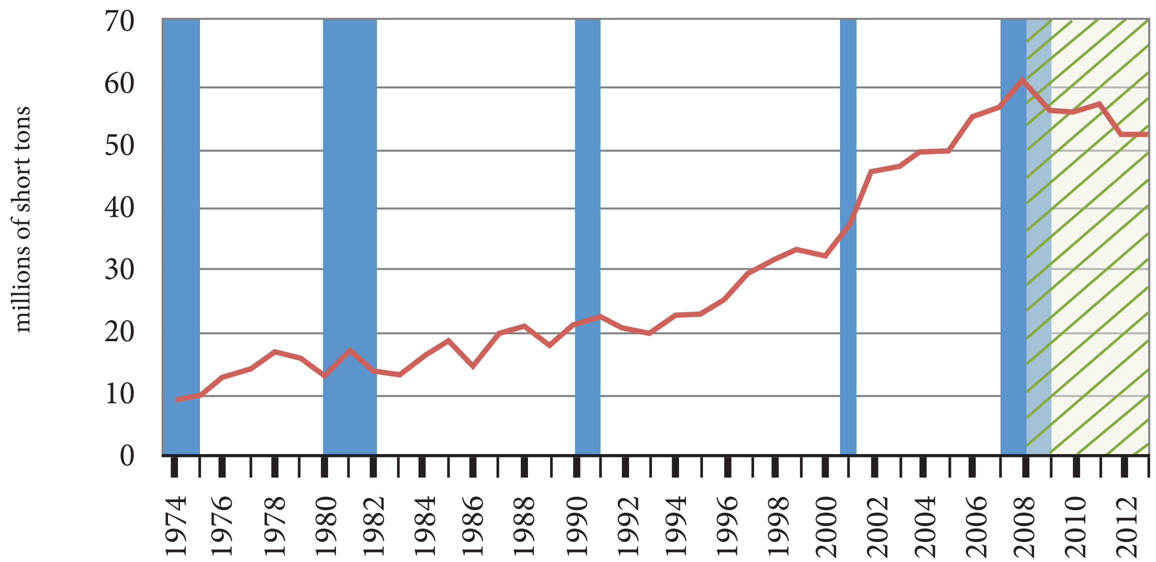
FIGURE E-1: PRODUCTION OF CCPs HAS GROWN AT AN AVERAGE ANNUAL RATE OF 1.7 PERCENT



Dates of Major Air Emissions Regulatory Activity
1977: Clean Air Act (CAA) Amendment
1978: EPA New Rules on Industrial Growth in Clean Air Areas
1990: CAA Amendment
1998: EPA NOx Transport Rule

Total CCP Production

FIGURE E-2: UTILIZATION OF CCPs HAS INCREASED DURING RECESSIONS, BUT DROPPED DURING A PERIOD OF REGULATORY UNCERTAINTY



U.S. Recession   CCP Regulatory Uncertainty   Total CCP Utilization

Major U.S. Recessions
November 1973 to March 1975
January to July 1980
July 1981 to November 1982
July 1990 to March 1991
March to November 2001
December 2007 to June 2009

CCP Regulatory Uncertainty:
December 2008 to April 2015
EPA decision to reconsider the classification of CCPs as a hazardous waste

FIGURE E-3: PRODUCTION OF CCPs HAS INCREASED WITH INSTALLATION OF POLLUTION CONTROL EQUIPMENT, AND USE OF CCPs HAS INCREASED AS NEW MARKETS EMERGE

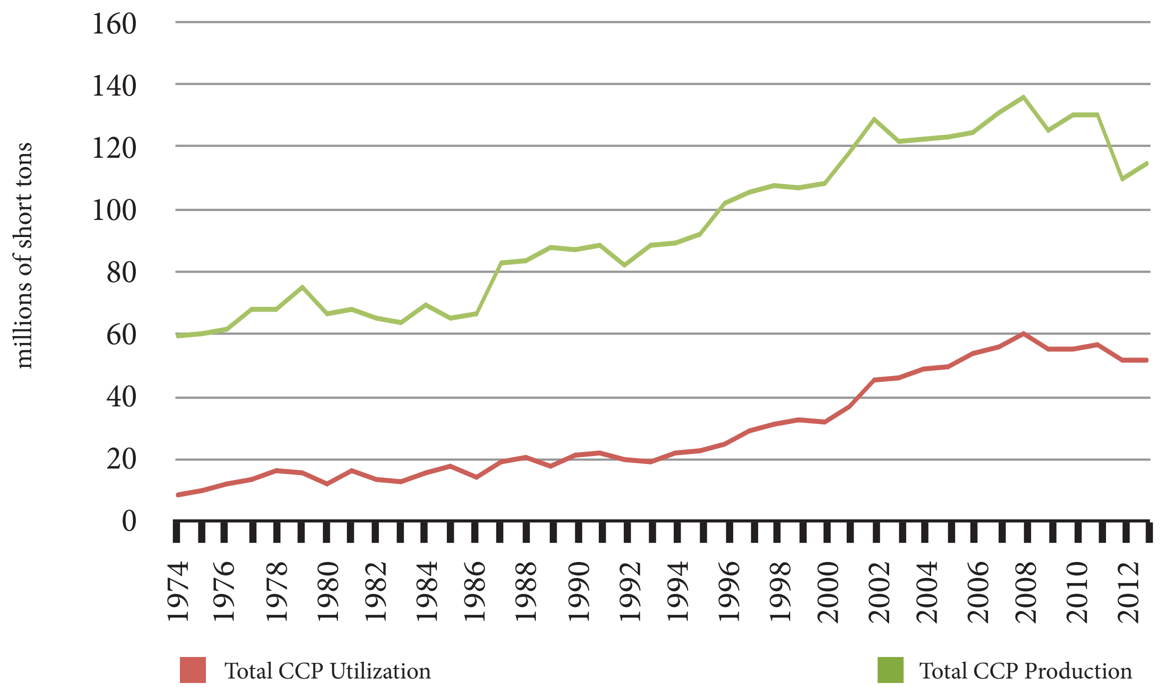
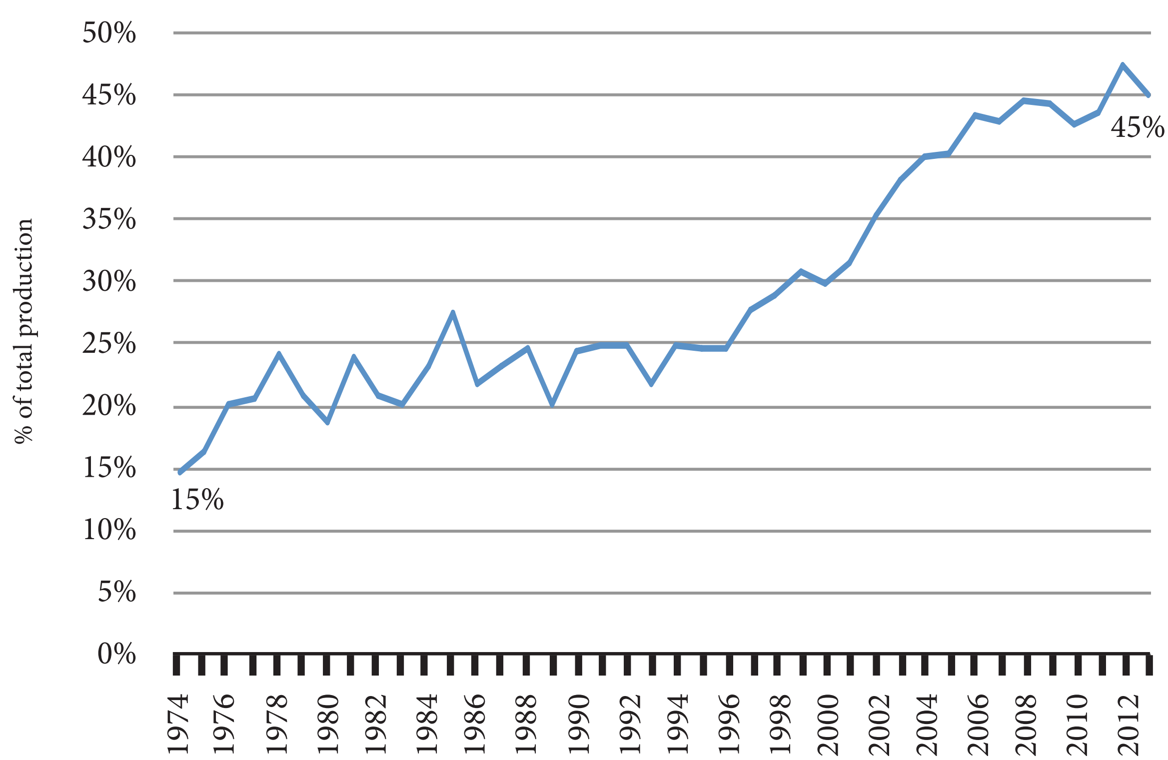


FIGURE E-4: THE PERCENTAGE OF CCPs UTILIZED HAS INCREASED SIGNIFICANTLY SINCE 1993



THE GENERATION OF COAL-FUELED ELECTRICITY

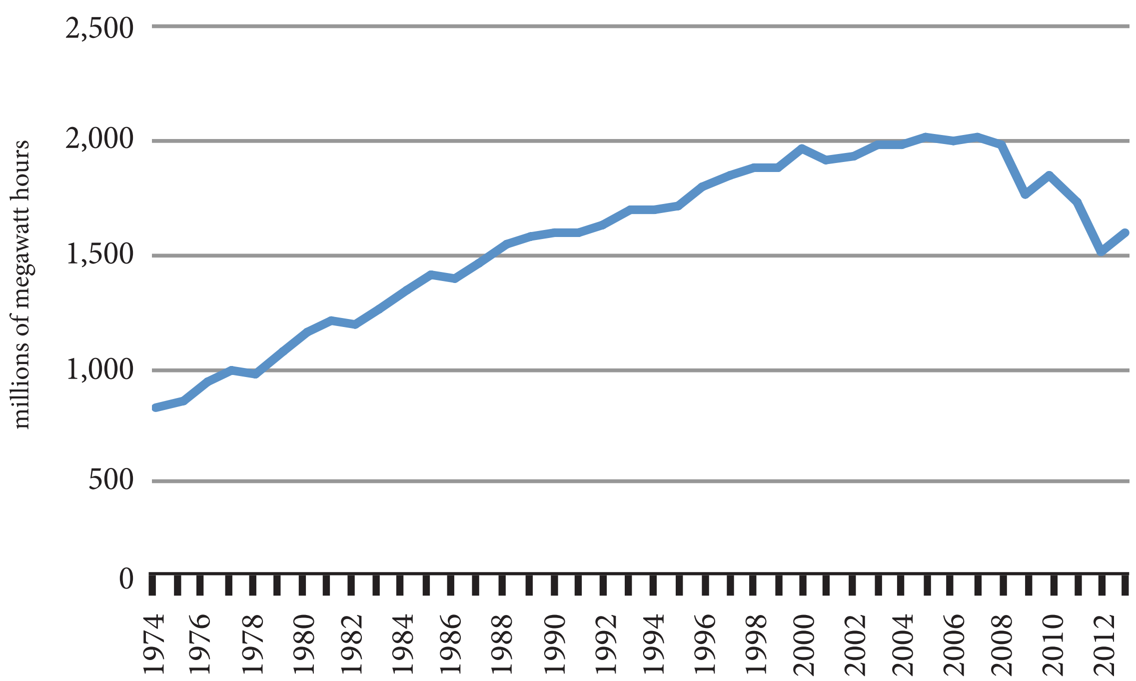
Coal is the largest energy source for generation of electricity in the United States, accounting for over 40 percent of electricity generation in 2013.[2] The share of coal generated electricity was 44 percent of total electricity in 1974, increasing to as high as 57 percent in 1988.

Although the share of coal generated electricity has declined since 1988, the overall consumption of coal by the power sector and the megawatt hours of coal generated electricity have remained high, resulting in the continued production of large volumes of CCPs.

The total consumption of coal for electricity grew from 391.8 million short tons in 1974 to a peak of just over 1 billion short tons in 2008. Since that time, consumption has declined to 858.4 million short tons.

There are a number of factors that have contributed to the recent decline in coal consumption for electricity. Environmental regulations have led to the closure of some coal-fueled generating capacity. Other contributing factors include competition from lower priced natural gas and a slower growth in electricity demand.[3]

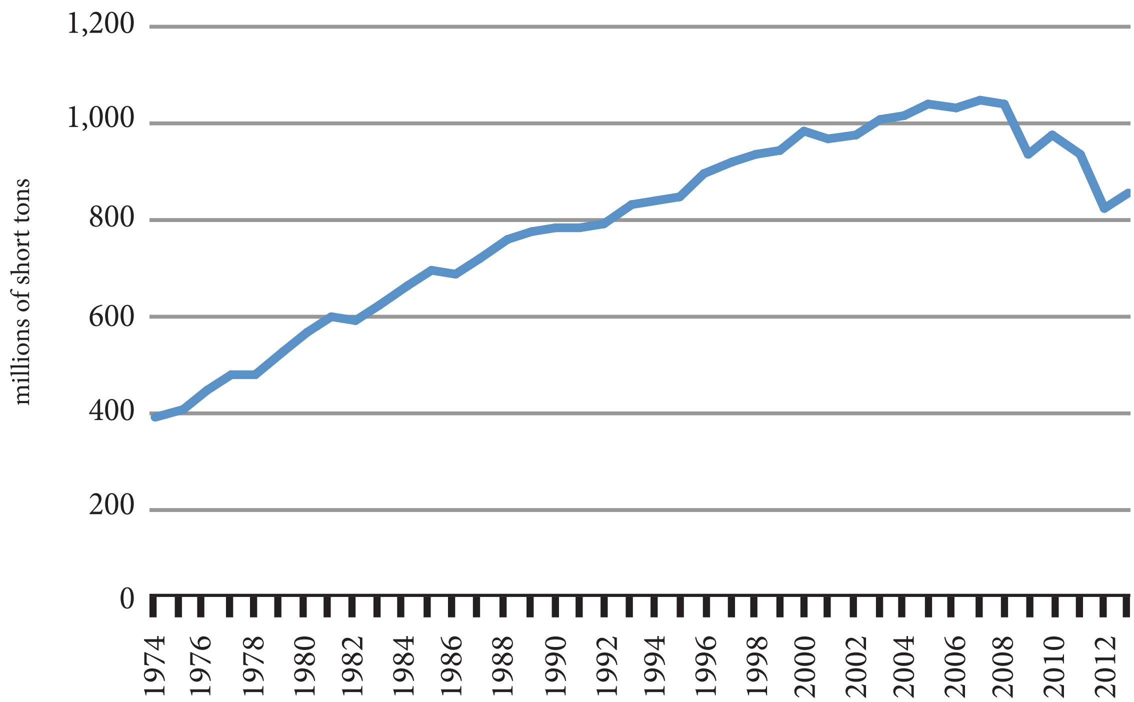
FIGURE 1-1: ELECTRICITY GENERATED FROM COAL IN THE U.S.



[2]Outlook, Annual Energy. "Annual Energy Outlook, 2014." US Energy Information Administration, Early Release Overview (2014). (http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm

[3]U.S. EIA. "AEO2014 projects more coal-fired power plant retirements by 2016 than have been scheduled." February 14, 2014. (http://www.eia.gov/todayinenergy/detail.cfm?id=15031)

FIGURE 1-2: COAL CONSUMPTION FOR ELECTRICITY IN THE U.S.



INCREASED COMPETITION

Economic drivers have impacted coal consumption by electric utilities since 2008, including increased competition from natural gas.

The more widespread use of high-volume, horizontal hydraulic fracturing techniques, commonly known as "fracking," have provided greater access to U.S. shale and natural gas reserves since the early 2000s and lowered the costs of withdrawing and producing natural gas. Shale gas reserves are located in a number of states, including Texas (49 billion cubic feet in 2013), Pennsylvania (44.3 billion cubic feet), West Virginia (18.1 billion cubic feet) and Arkansas (12.2 billion cubic feet).[4]

Fracking has led to a "revolution" in natural gas drilling.[5] As the price of natural gas has fallen relative to coal, utilities have used this energy source to generate a greater share of total electricity. In 1974, natural gas accounted for 17 percent of total U.S. net electricity generation. That grew to 27 percent in 2013.

The price of natural gas fell from $9.26 per thousand cubic feet in 2008 to $4.93 in 2009, according to data from the U.S. Energy Information Administration (EIA), a one-year decline of nearly 47 percent. The price continued to drop, reaching $3.54 in 2012.

[4]U.S. EIA data on Shale Gas Proved Reserves as of December 31, 2013 (http://www.eia.gov/dnav/ng/ng_enr_shale-gas_dcu_nus_a.htm)
[5]Kris Maher & Tom McGinty. "Coal's Decline Hits Hardest in the Mines of Kentucky." Wall Street Journal November 26, 2013. (http://www.wsj.com/articles/SB10001424052702304337404579212262280342336)

FIGURE 1-3: PRICE OF NATURAL GAS

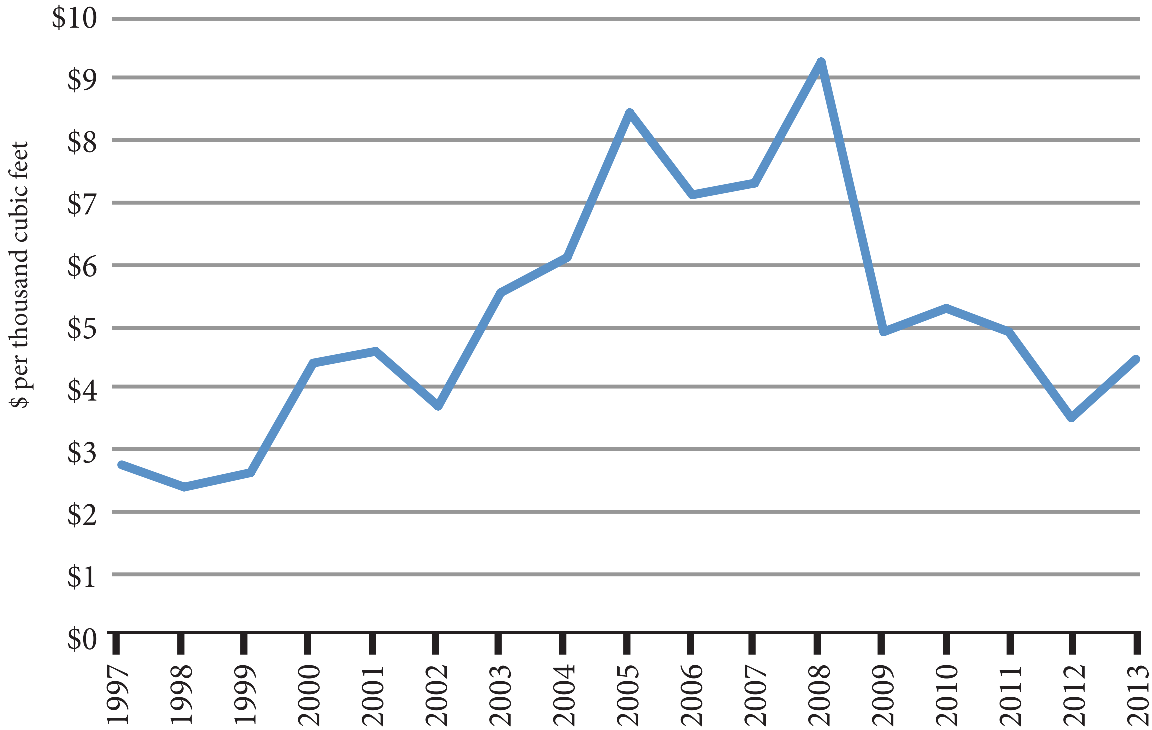
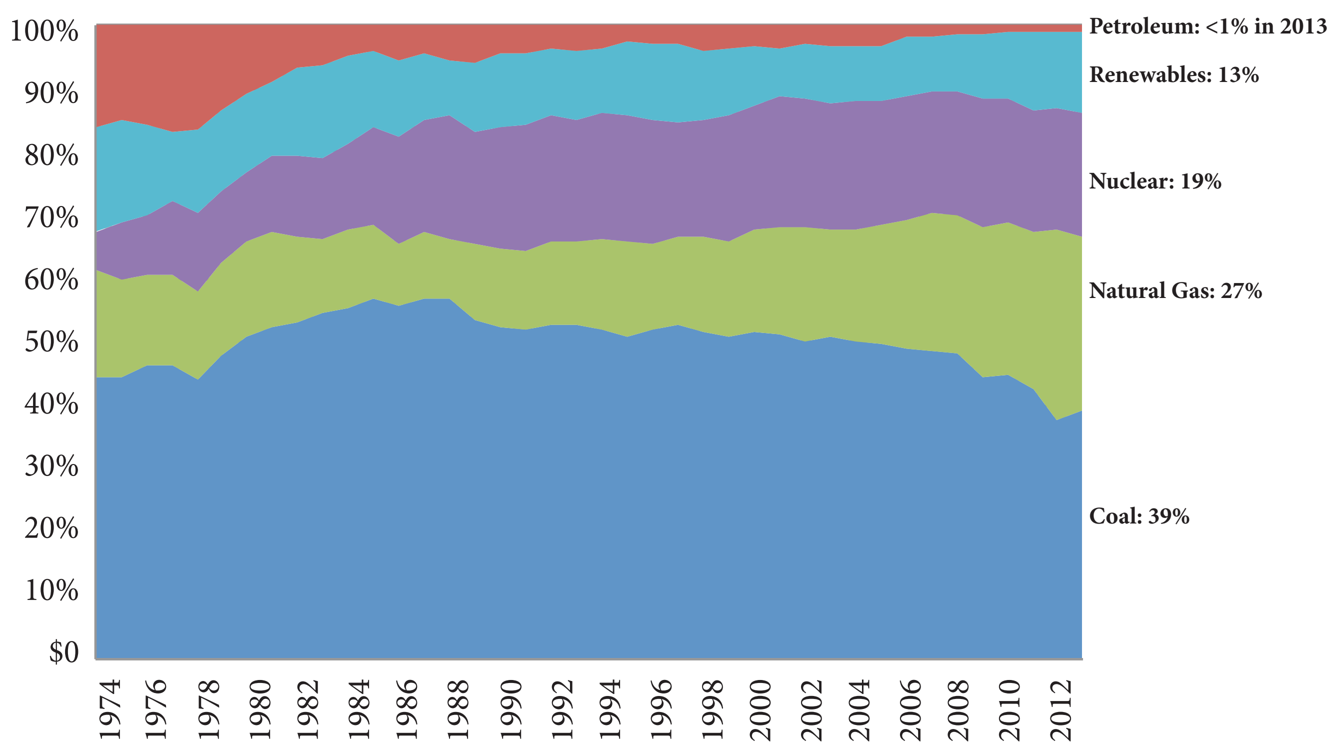


FIGURE 1-4: U.S. ELECTRICITY NET GENERATION BY SOURCE, 1974 TO 2013



DEMAND FOR ELECTRICITY

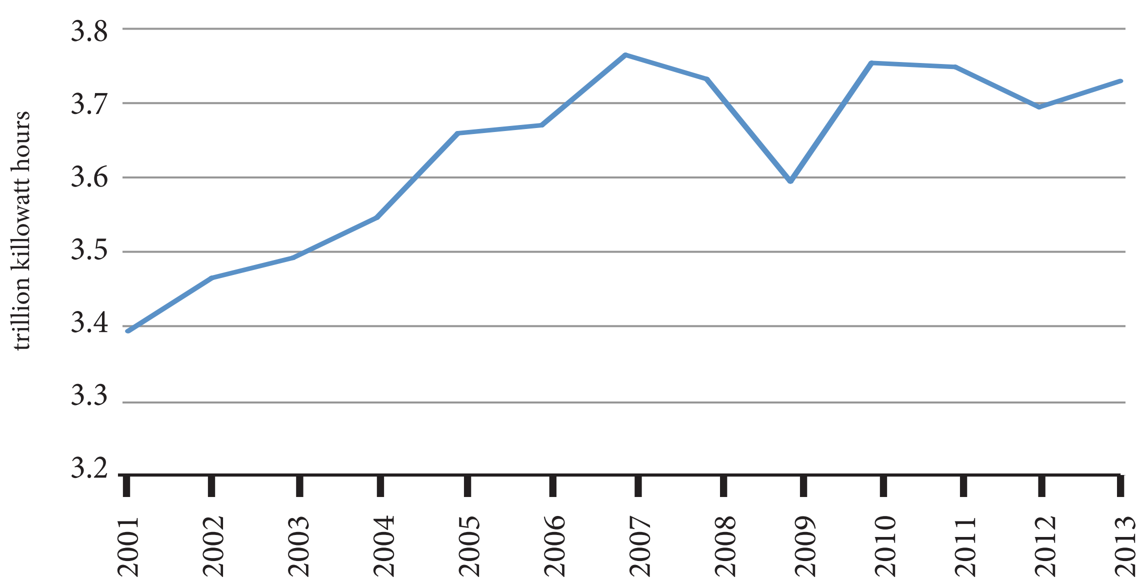
The overall demand for electricity has also impacted total coal consumption by utilities. Such factors as economic growth, income, tax changes, energy prices and weather drive residential and commercial demand.[6]

Americans consumed 3.73 trillion kilowatt hours of electricity in 2008, according to data from EIA. That fell 3.7 percent in 2009, during the recession, to 3.6 trillion kilowatt hours. A nine percent decline in industrial electricity consumption accounted for over two-thirds of the overall downturn.

Weather has the most significant impact on residential electricity demand, especially cold weather.[7]

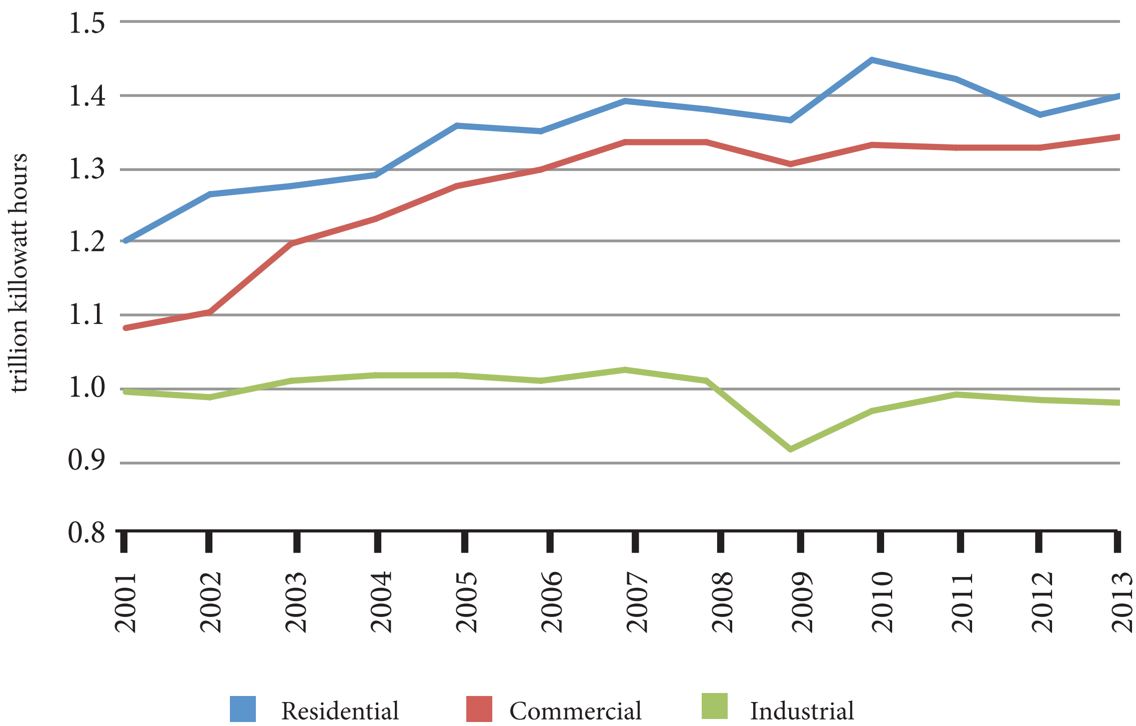
If the average temperature is higher, people don't use as much electricity to heat their homes. The average temperature for 2012 was the warmest on record since 1974, according to data from U.S. the National Climatic Data Center, followed by 2006, 1998 and 1999. In 2012, residential electricity demand was down 3.4 percent from 2011 levels, compared to a decline of less than one percent for the commercial and industrial sectors combined.

FIGURE 1-5: TOTAL U.S. RETAIL SALES OF ELECTRICITY



[6]Jay Zarnikau, "Functional form in energy demand modeling." Energy Economics, Volume 25 (2003). (http://www.sciencedirect.com/science/article/pii/S0140988303000434)
[7]David Kamerschen & David V. Porter. "The demand for residential, industrial and total electricity, 1973-1998." Energy Economics, Volume 26, Issue 1, (2004). (http://www.sciencedirect.com/science/article/pii/S0140988303000331)

FIGURE 1-6: TOTAL U.S. RETAIL SALES OF ELECTRICITY BY MAJOR SECTOR



PLANT CLOSURES AND ENVIRONMENTAL REGULATIONS

Electric utilities shut down coal-fueled units representing 8.1 gigawatts of generating capacity in 2013 and 2014, according to data from EIA.[8]

Although more closures are expected in the next few years, this is not expected to have a significant impact on CCP production. This is because most of the units that are being closed are older, smaller, and not as frequently utilized, and are therefore not producing a significant share of the total production of CCPs. EIA describes the units closed between 2010 and 2012 as "small, with an average size of 97 megawatts (MW), and inefficient, with an average tested heat rate of about 10,695 British thermal units per kilowatt-hour (Btu/kWh)."[9]

Historically, federal and state regulations have had a role in overall CCP production by requiring utilities to install equipment that capture the ash produced during the generation of electricity from coal. The major piece of legislation affecting the industry was the Clean Air Act, first introduced in 1963, with amendments in 1970, 1977 and 1990. The 1963 Clean Air Act was the first federal legislation involving air pollution, and provided funds for federal research, ambient monitoring studies and stationary source inspections.[10]

According to the U.S. Environmental Protection Agency (EPA), the 1970 amendment to the Clean Air Act "resulted in a major shift in the federal government's role in air pollution control." The legislation gave both federal and state governments the ability to limit emissions from stationary and mobile sources. The 1970 act required the following:[11]

- EPA was directed to establish national ambient air quality standards for the major criteria air pollutants.
- States were required to develop implementation plans on how they would establish limits for individual sources to meet and maintain the national standards.
- The legislation contained deadlines and strengthened enforcement of emission limitations.
- New sources were forced to meet standards based on the best available technology.

National Ambient Air Quality Standards (NAAQS) were established under the 1970 amendment to the Clean Air Act for the priority pollutants ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide and lead. The emission standards most affecting the utility industry were for particulate matter, nitrogen oxides and sulfur dioxide.

The implementation of technologies to meet the new emissions standards for particulate matter meant that power plants began to capture fly ash in emissions control equipment.

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[8]Outlook, Annual Energy. "Annual Energy Outlook, 2014." US Energy Information Administration, Early Release Overview (2014), (http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm), Table A9.
[9]U.S. EIA. "AEO2014 projects more coal-fired power plant retirements by 2016 than have been scheduled." February 14, 2014 (http://www.eia.gov/todayinenergy/detail.cfm?id=15031)
[10]U.S. EPA. "History of the Clean Air Act." (http://www.epa.gov/air/caa/amendments.html)
[11]U.S. EPA. "The Benefits and Costs of the Clean Air Act, 1970 to 1990." prepared for the U.S. Congress October 1997 (http://www.epa.gov/cleanairactbenefits/retro.html)

Emissions standards for new power plants were established by the EPA and required the latest technology that corresponded to a roughly 75 percent reduction from the average emissions rates at the time. Power plants could meet this standard by installing a Flue Gas Desulphurization ("FGD") system or burning low-sulfur coal.

U.S. manufacturing companies, privately and cooperatively owned electric utilities, publicly owned electric utilities and other non-manufacturing companies spent $2.24 billion on plants and equipment for air pollution abatement in 1972.[12]

EPA estimates that as a result of Clean Air Act compliance, particulate matter emissions from coal-fueled electricity generating plants decreased from 1.68 million short tons in 1970 to 941,000 short tons in 1979, and to 188,000 short tons in 2005.[13]

The 1977 amendment to the Clean Air Act established the New Source Review permitting program, requiring legal documents for facility owners and operators that want to construct new or modify existing factories, industrial boilers and power plants.[14]

In 1978, EPA followed up with new rules on industrial growth in clean air areas, requiring "large new pollution sources such as factories and power plants which build in these areas to install the best available pollution control technology."[15]

The Clean Air Act amendments of 1990 "substantially increased the authority and responsibility of the federal government" and implemented new regulatory programs and standards.[16] Prior to the amendment, EPA regulated air toxics "one chemical at a time." The new approach identified major industrial sources for 187 listed toxic air pollutants and steps to "reduce pollution by requiring sources to install controls or change production processes."

As part of the update, EPA issued a two-phase strategy to reduce nitrogen oxide emission from utilities that used coal boilers. Phase I took effect in January 1996 and required emissions levels from a group of dry-bottom wall-fired boilers and tangentially-fired boilers to reduce their emission by over 400,000 tons per year between 1996 and 1999.[17] The goal of the second phase, which began in 2000, was to reduce nitrogen oxide emissions by an additional 2 million tons per year.

EPA issued the NOx Transport Rule in 1998 that required 21 states and Washington, D.C. to use new and cleaner control strategies to further reduce nitrogen oxide emissions by one million tons by 2007. The rule allowed each state to determine how it planned to reduce its emissions.[18]

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[12]Cogan, Christine, "Pollution Abatement and Control Expenditures, 1972-94," Survey of Current Business (http://www.bea.gov/scb/pdf/national/niparel/1996/0996eed.pdf)

[13]EPA, "National Emissions Inventory, Trends for Electric Generating Utilities for 1970 to 2005", (2008).

[14]U.S. EPA, New Source Review (http://www.epa.gov/ttnchie1/trends/)

[15]EPA Press Release, June 13, 1978. (http://www2.epa.gov/aboutepa/epa-announces-new-rules-industrial-growth-clean-air-areas)

[16]EPA, History of the Clean Air Act, August 15, 2013. (http://www.epa.gov/air/caa/amendments.html)

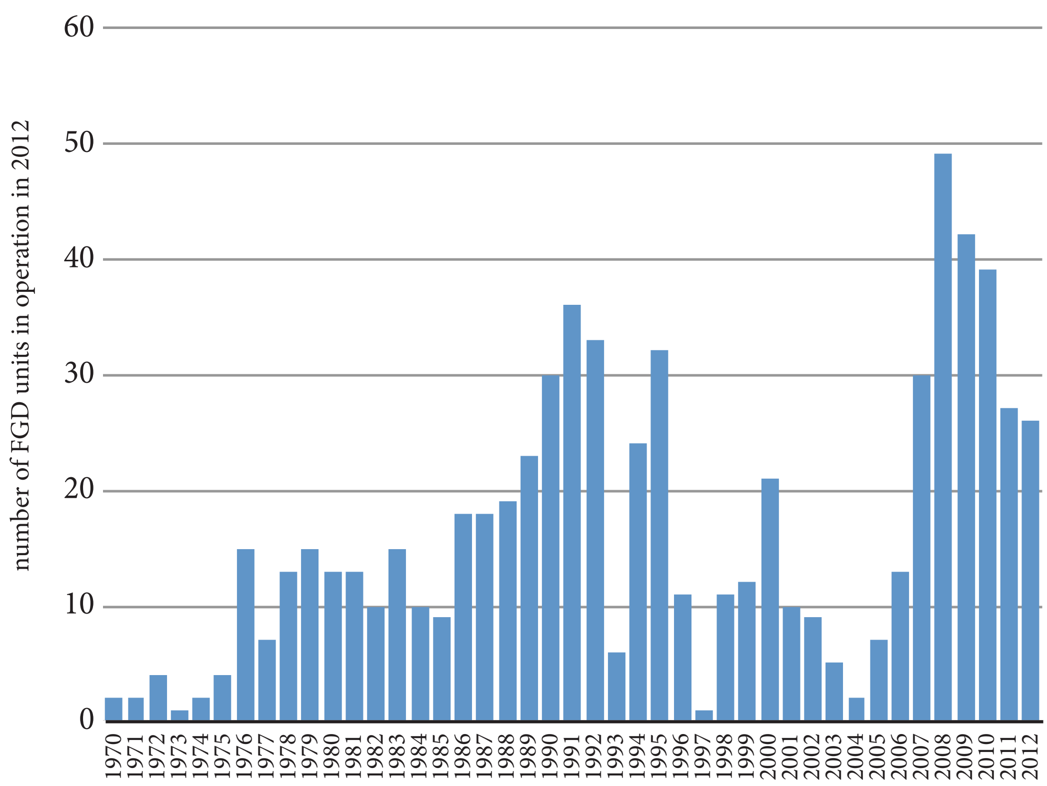
[17]Maroto-Valer, M. Mercedes, D. N. Taulbee, and J. C. Hower. "Characterization of Fly Ash Carbons Derived Due to the Implementation of NOx Clean Air Act Amendments." Prepr. Pap. Am. Chem. Soc., Div. Fuel Chem 45 (2000): 401-405. (https://web.anl.gov/PCS/acsfuel/preprint%20archive/Files/45_3_WASHINGTON%20DC_08-00_0401.pdf)

[18]EPA, "The Regional Transport of Ozone: New EPA Rulemaking on Nitrogen Oxide Emissions" (http://www.epa.gov/air/noxfacts.pdf)

The 1990 amendment to the Clean Air Act introduced a permanent cap on sulfur dioxide emissions from electric power plants across the country and implemented a cap and trade system. In order to comply with the new standards, utilities could either switch to low sulfur coal, add FGD scrubbers or other equipment to remove emissions, purchase permits from other utilities, or use some combination of those strategies.[19]

Of the operational FGD units in 2012, 219 began service between 1956 and 1990, 217 units began service between 1990 and 2000, and 259 units after 2001. A total of 183 operation units just began service in the last five years, between 2008 and 2012.

FIGURE 1-7: CURRENT OPERATIONAL FGD UNITS BY YEAR SERVICE BEGAN



[19]Institute for Energy Research. "The Facts About Air Quality and Coal-Fired Power Plants." (http://instituteforenergyresearch.org/studies/the-facts-about-air-quality-and-coal-fired-power-plants/)

CHANGES IN TYPE OF COAL

In addition to the volume of coal burned by electric utilities, changes in the types of coal consumed have had an impact on the historical production of CCPs.

There are four main classifications for coal, known as coal rank: anthracite, bituminous, subbituminous and lignite. Each type varies based on heating value, moisture, fixed carbon content, ash content, sulfur and chlorine.[20]

Utilities may burn one or more types of coal at a power plant to generate electricity, and may even blend different types of coal. Most coal-fueled electricity generating plants burn bituminous or subbituminous coals. The use of lignite coal is generally limited to utilities that are located near those coal supplies.[21] Anthracite coal is rarely used for electricity generation.

In 1974, over 84 percent of the coal deliveries to utilities was bituminous coal, with an average ash content of 14.6 percent. Subbituminous coal, with an average ash content of 8.3 percent, accounted for just over 12 percent of all deliveries.[22]

With the implementation of the Clean Air Act provisions, utilities began using more of the subbituminous coal, which has both a lower sulfur and ash content.

By 1990, subbituminous coal accounted for nearly 30 percent of deliveries. The average ash content of the coal that year was 6.2 percent. Bituminous coal, with an average ash content of 10.5 percent, accounted for 61 percent of deliveries, with lignite coal at just below 10 percent, with an ash content of 12.4 percent.

In 2005, subbituminous coal was 49 percent of deliveries and bituminous coal was 47 percent. That trend continued, with subbituminous coal accounting for 53.2 percent of deliveries in 2012, while bituminous coal was 38 percent.[23]

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[20]Purdue University, Indiana Center for Coal Technology Research. "CCTR Basic Facts File #8." (http://www.purdue.edu/discoverypark/energy/assets/pdfs/cctr/outreach/Basics8-CoalCharacteristics-Oct08.pdf)
[21]EPA. "Available and Emerging Technologies For Reducing Greenhouse Gas Emissions From Coal-Fired Electric Generating Units." October 2010. (http://www.epa.gov/nsr/ghgdocs/electricgeneration.pdf)
[22]ARTBA analysis of historic EIA form 423 and FERC-423 data. (http://www.eia.gov/electricity/data/eia423/)
[23]ARTBA analysis of EIA form 923 data.(http://www.eia.gov/electricity/data/eia923/)

TOTAL CCP PRODUCTION

The total production of CCPs has grown from 59.5 million short tons in 1974 to 114.7 million short tons in 2013, an increase of 93 percent. There were 413 plants that reported collecting CCPs in 2012.[24]

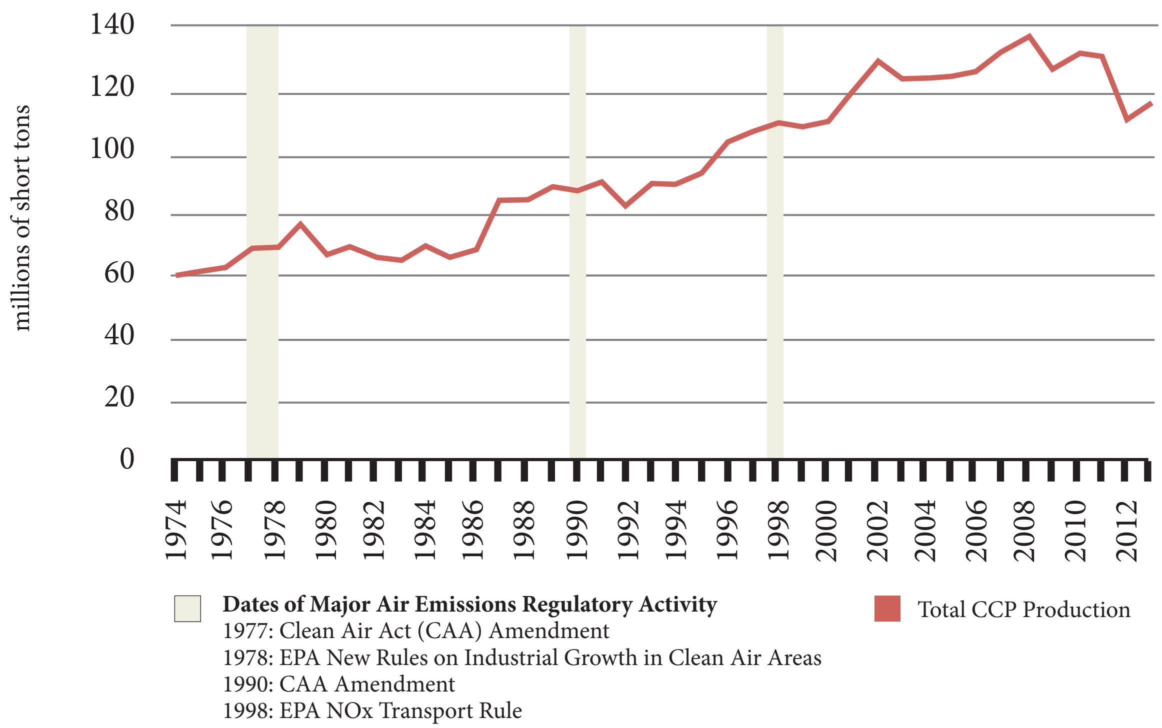
As a byproduct of the coal combustion process, CCP production is primarily driven by the consumption of coal for electricity generation. Although the overall impact can vary from year to year, this link is particularly evident during the sharp swings in the coal generated electricity market over the last few years. The most recent example of this was in 2012. CCP production fell in all the major product types when the total volume of coal generated electricity declined in response to lower natural gas prices and a very mild winter.[25]

Additional growth over the last 40 years, especially for fly ash and FGD material, is attributable to environmental regulations that required electric utilities to begin collecting CCPs.

In particular, the 1968 Clean Air Act, with amendments in 1970, 1977 and 1990 set regulations for nitrogen oxides, particulate matter and sulfur dioxide that required utility owners to install equipment and processes to capture CCPs. The legislation also allowed states to set additional emissions standards and required reduced output levels for key emissions with the construction of new utility generators and plants.

New developments in technology to meet these standards, such as the evolution of scrubber and boiler technology and the use of low sulfur coal, have had implications for individual CCP markets.

FIGURE 2-1: PRODUCTION OF CCPs HAS GROWN AT AN AVERAGE ANNUAL RATE OF 1.7 PERCENT



[24]ARTBA analysis of EIA form 923 data. (http://www.eia.gov/electricity/data/eia923/)
[25]U.S. EIA. "Monthly coal and natural gas-fired generation equal for first time in April 2012." July 6, 2012. (http://www.eia.gov/todayinenergy/detail.cfm?id=6990)

FLY ASH PRODUCTION

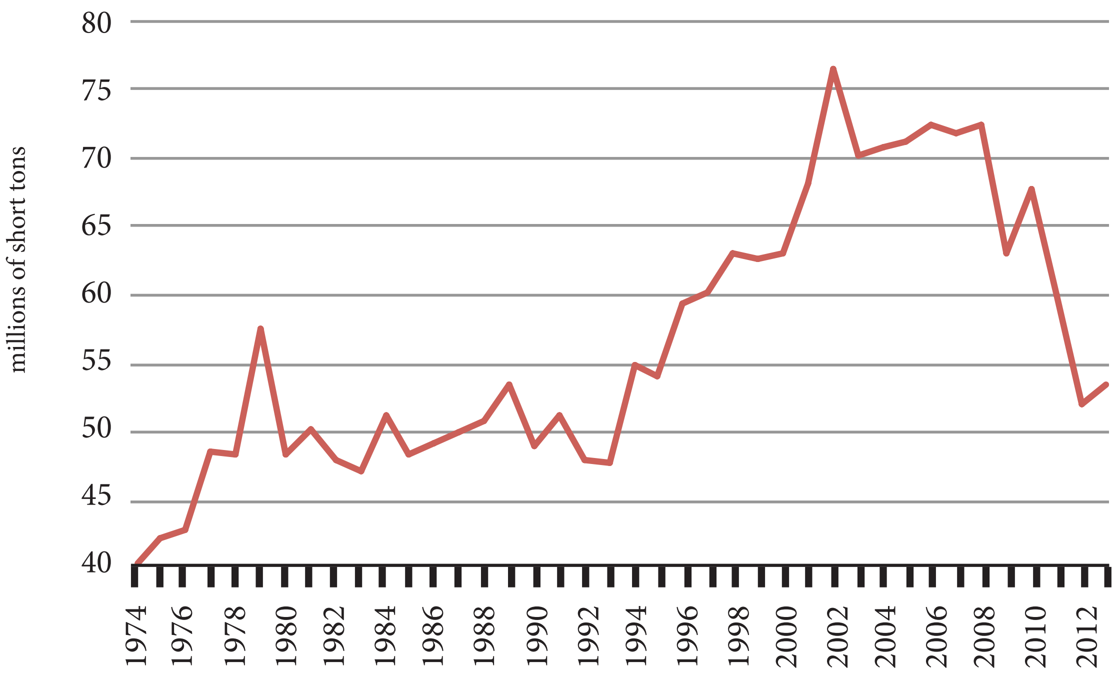
Since 1974, the production of fly ash has increased 29 percent from 40.4 million short tons to 53.4 million short tons in 2013, growing at an average annual rate of just under one percent.

As the non-combustible mineral portion of coal, the production of fly ash is wholly related to the volume of coal generated electricity. The capture of fly ash has also been impacted by the implementation of emission control regulations by coal-fueled electricity producing utility plants.

During the early years of the Clean Air Act, fly ash production grew from 40.4 million short tons in 1974 to 57.5 million short tons in 1979. Total fly ash production averaged 50 million short tons over the next decade, between 1980 and 1990.

Fly ash production grew at an average annual rate of 2.2 percent between 1990 and 2008, increasing from 48.9 to 72.5 million short tons. This rate of growth was higher than the average annual increase in coal consumption for electricity, which was 1.6 percent, and megawatt hours of coal generated electricity, which grew at a rate of 1.2 percent.

FIGURE 2-2: FLY ASH PRODUCTION



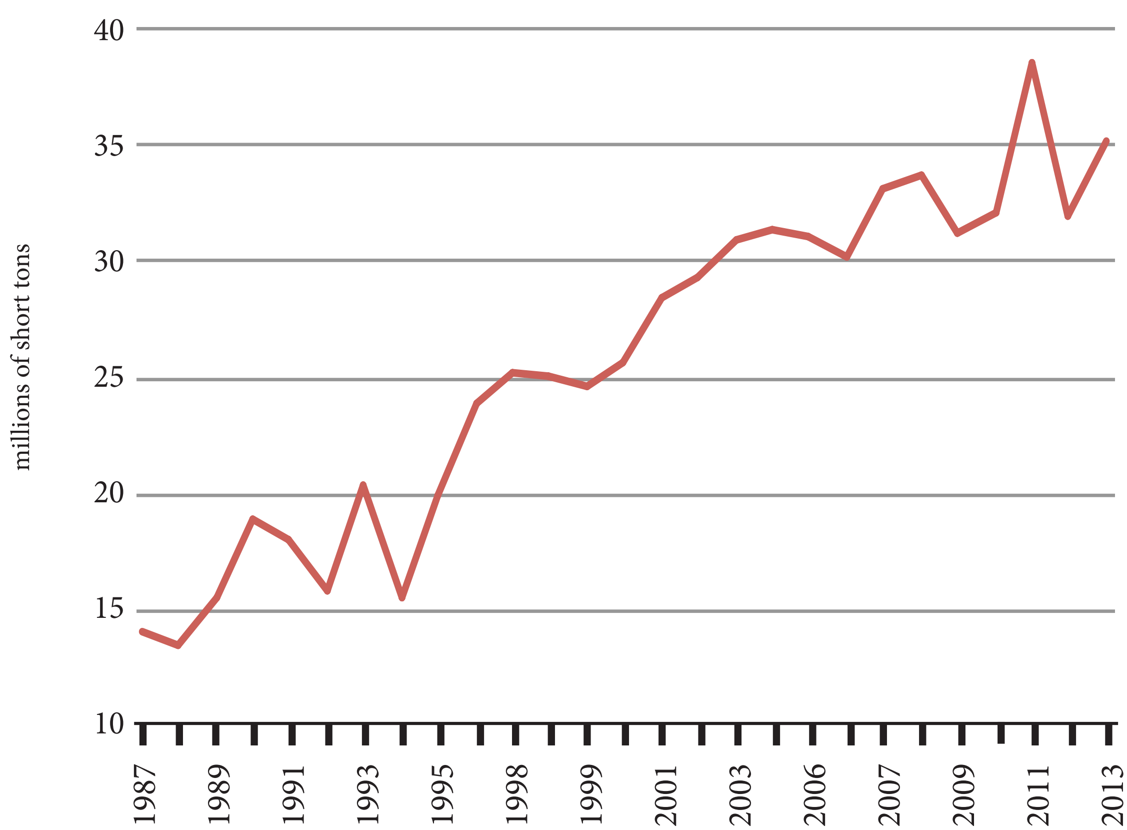
FGD MATERIAL PRODUCTION

The production of FGD material, including FGD gypsum, wet scrubber and dry scrubber material, has grown from 14.2 million short tons in 1987 to 35.2 million short tons in 2013, an increase of 148 percent. The average annual growth rate for FGD production was 3.5 percent over that time period, greater than the average annual growth rate in megawatt hours of coal generated electricity (0.3 percent), the consumption of coal for electricity generation (0.7 percent) and U.S. real GDP (2.6 percent).

A growing number of coal-fueled electricity generators use a FGD process to remove gaseous sulfur dioxide from the boiler exhaust gas. The primary types of FGD processes used are wet scrubbers, dry scrubbers and sorbent injections with lime, limestone, sodium-based compounds or high-calcium coal fly ash. Depending on the process used, the resulting FGD material can be a wet sludge or a dry powder.[26]

Historically, the production of FGD material has been dependent on changes in the technology and processes for capturing FGD material, environmental regulations for sulfur dioxide emissions and the overall volume of coal used by coal-fueled electricity generating plants.

FIGURE 2-3: FGD MATERIAL PRODUCTION



[26]American Coal Ash Association. "Glossary of terms concerning the management and use of coal combustion products (CCPs)." American Coal Ash Association, Inc., Aurora, CO (2003).

CHANGES IN FGD TECHNOLOGY & SCRUBBERS

There were 808 FGD units with 1,326 unit scrubber trains or modules installed at U.S. steam-electric power plants that had a capacity of 10 megawatt hours or more in 2012.[27] A total of 695 of these units are operational, 35 are under construction and 16 are expected to go into service within the next ten years. There are 30 units that have been retired and 15 that are out of service.

Over 69 percent of these units are classified as a spray type wet scrubber, a spray dryer type FGD or semi-dry FGD scrubber. In all, utilities have either spent or plan to invest approximately $57.4 billion for the purchase, installation, and planned upgrades on these units.

There has been a clear shift in the type of scrubbers being put into service by power plants over the last two decades that has coincided with increases in FGD production.

Dry scrubber technology for commercial utilities began appearing in the U.S. in the late 1970s and early 1980s. This type of scrubber has been primarily used to retrofit applications on units that burn low-sulfur coals.[28]

The growing popularity of wet scrubbers over the last forty years is in part due to the equipment's high removal efficiencies and the simplicity of the overall system. Wet scrubbers have become "state of the art methods for achieving removal efficiencies in the 90% to 98% range."[29]

Of the operational scrubbers that began service between 1990 and 2000, 122 were classified as spray dryer type, dry FGD or semi-dry FGD equipment. A total of 54 were classified as spray type wet scrubbers. In the last five years of available data, between 2008 and 2012, there were 29 dry scrubbers that were put into service and 84 wet scrubbers.

During this time, there has also been an increase in the number of utilities that have reported the recovery of a "salable byproduct" from their FGD equipment.[30] Of all the FGD units in operation today, utilities report that 194 units produce a byproduct material that is sold. Of that total, 130 units are wet scrubbers, of which 84 began service between 2008 and 2012.

These equipment changes have occurred as total FGD production, as measured in the ACAA survey has shown significant growth. Total annual FGD production averaged 21.2 million short tons between 1990 and 2000, and rose to an average of 33.5 million short tons between 2008 and 2012. In 2013, FGD production reached 35.2 million short tons.

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[27] ARTBA analysis of EIA-860 form data, Schedule 6 Part F.
[28] Paul S. Nolan. "Flue gas desulfurization technologies for coal-fired power plants." Coal Tech 2000 International Conference, Jakarta, Indonesia. 2000. (http://www.babcock.com/library/Documents/br-1709.pdf)
[29] Ibid.
[30] Ibid.

BOTTOM ASH PRODUCTION

The production of bottom ash grew one percent between 1974 and 2013, increasing from 14.3 to 14.5 million short tons. Production has increased and contracted over the years, reaching a high of 19.8 million short tons in 2002. The production of bottom ash is driven by the volume of coal generated electricity, total coal consumption by electric utilities and the type of coal being burned.

Bottom ash is comprised of the "ash particles formed in pulverized coal furnaces that are too large to be carried in the flue gases and impinge on the furnace walls or fall through open grates to an ash hopper at the bottom of the furnace."[31] Whereas fly ash is light enough to fly up the stack, bottom ash falls to the bottom of the furnace. If the boiler is a dry bottom boiler, the material is dry bottom ash. If the utility is using a wet-bottom boiler, the material is boiler slag.

When pulverized coal is burned in a dry bottom boiler, about 80 percent of the ash flies up the flue gas and is recovered as fly ash, and the remaining 20 percent of the unburned material is bottom ash. Since 1974, bottom ash has averaged 21.5 percent of the total amount of fly and bottom ash produced.

Of the 413 plants that reported collecting ash in 2012, 84 percent collected both fly ash and bottom ash. Just 34 utilities reported collecting fly ash with no bottom ash, and nine said they produced bottom ash without any fly ash.[32]

As is the case with fly ash, the production of bottom ash is related to coal consumption by electric utilities for the generation of electricity. Although changes in the production of bottom ash have mirrored the ups and downs of fly ash production, the bottom ash market has not seen the same level of overall growth since 1974. Further research in this area is needed to explore the reasons for the difference between fly ash and bottom ash production, given the traditional relationship between their production levels.

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[31] American Coal Ash Association. "Glossary of terms concerning the management and use of coal combustion products (CCPs)." American Coal Ash Association, Inc., Aurora, CO (2003). (http://www.acaa-usa.org/Portals/9/Files/PDFs/ACAA_Glossary_of_Terms-Apri_2003.pdf)
[32] ARTBA analysis of EIA form 923 data.

FIGURE 2-4: BOTTOM ASH PRODUCTION

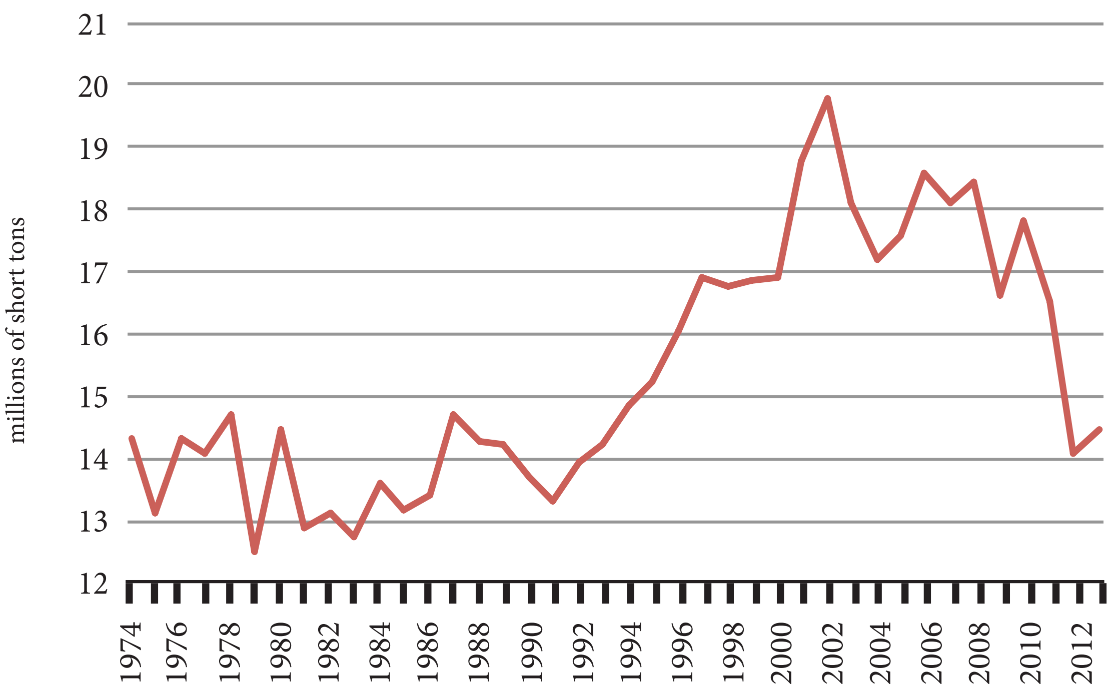
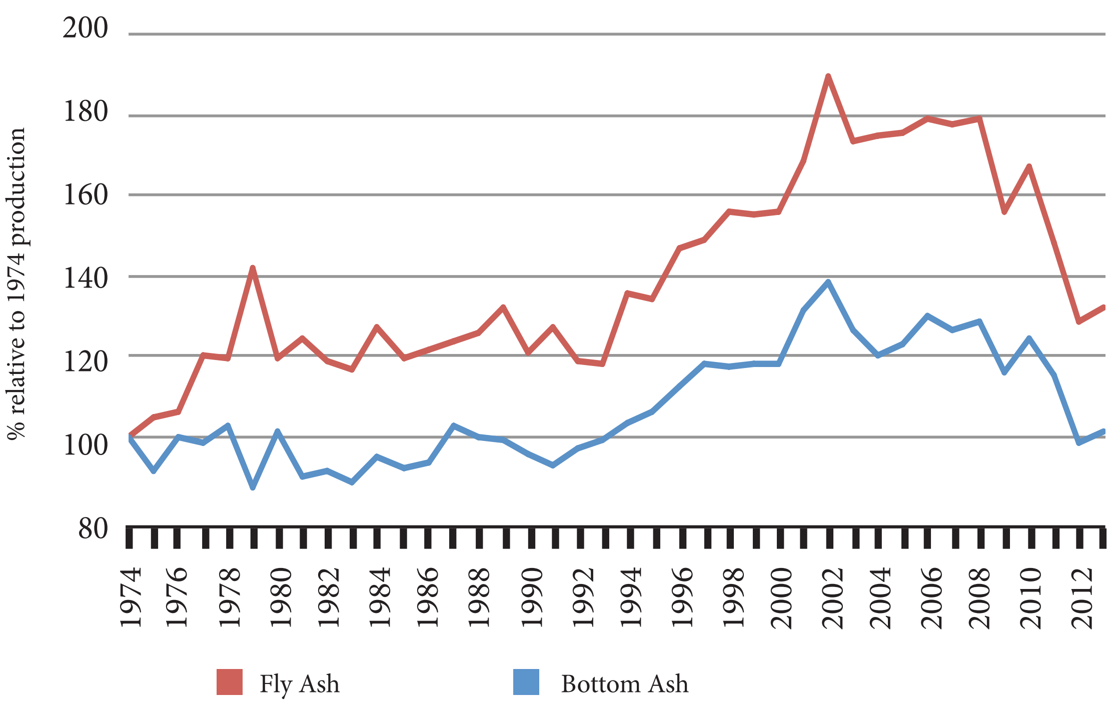


FIGURE 2-5: INDEX OF FLY ASH AND BOTTOM ASH PRODUCTION, 1974 TO 2013



BOILER SLAG PRODUCTION

Boiler slag production has dropped 72 percent from 4.8 million short tons in 1974 to 1.4 million short tons in 2013. The decrease in supply is largely due to the retirement of the wet-bottom boilers that produce this type of CCP.[33]

The slag tap boiler and the cyclone boiler are the two types of wet-bottom boilers used in the U.S. When pulverized coal is burned, the ash that falls to the bottom is kept in a liquid state. Both of the types of wet-bottom boilers contain quenching liquid that mixes with the molten ash to form a hard, black, angular, glassy material sometimes referred to as "Black Beauty."[34]

In a slag-tap furnace, as much as 50 percent of the ash becomes boiler slag. In a cyclone furnace, that total can be as high as 70 to 80 percent. The remaining ash in both cases leaves the furnace in the form of fly ash.[35]

Wet-bottom boilers are more compact than pulverized coal boilers that are found at the larger utility generating plants. Thus they are used more often by industrial manufacturing plants and smaller utilities.[36]

Most of the existing cyclone boilers in the U.S. were constructed before 1981. These boilers have high nitrogen oxide emission rates, and "no new cyclone boilers are expected to be built."[37] With fewer wet-bottom boilers being used, this has impacted the production of boiler slag.

Utilities are turning more to the fluidized-bed combustion boiler, which includes many of the benefits of wet bottom boilers, such as burning lower rank coals with higher moisture and ash contents. This alternative technology has less nitrogen oxide emissions.[38]

There were 147 wet-bottom boilers in operation in 1985 where coal was the primary fuel for the boiler, representing over 14 percent of the boilers mainly burning coal. By 1996, there were 128 such operational boilers. This downturn coincided with a sharp decline in boiler slag production, which fell from a high of 6.2 million short tons in 1993 to 2.7 million short tons in 1997.[39]

Since that time, the average annual production of boiler slag has been 2.2 million short tons, and the total for 2013 was a new low of 1.4 million short tons. Of the primarily coal burning boilers in operation in 2012, there were 137 wet-bottom boilers, the same number as in 2005. Utilities plan to retire 13 of the wet-bottom boilers between 2013 and 2020.[40]

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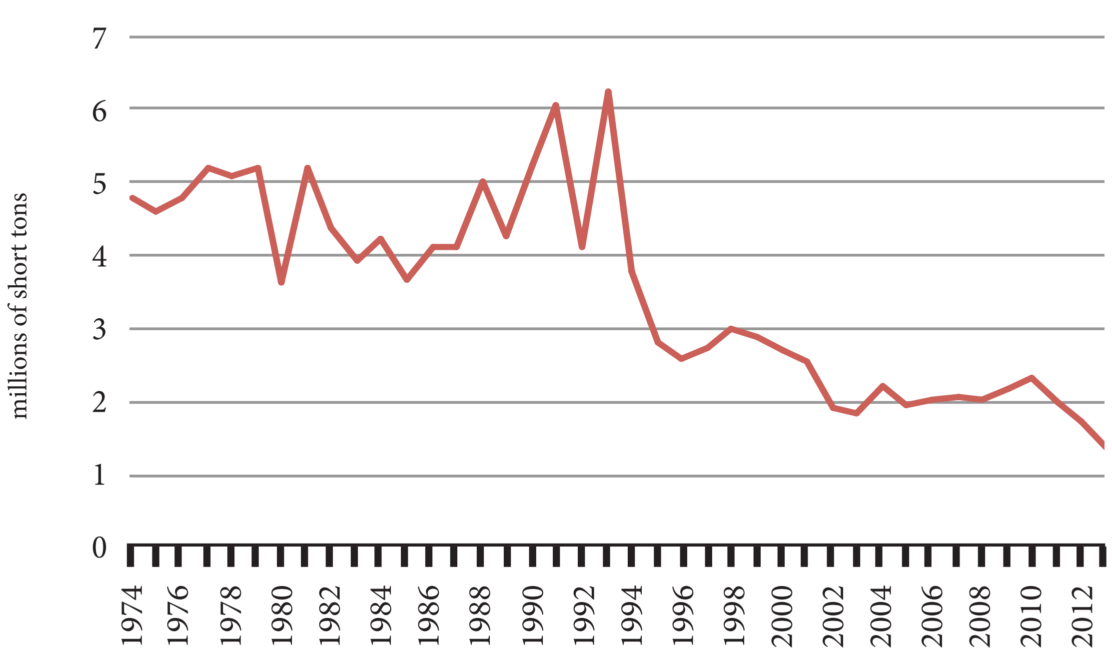
[33] Rusta S. Kayoncu and Donald W. Olson. Coal combustion products. US Department of the Interior, US Geological Survey, 2001. (http://pubs.usgs.gov/fs/fs076-01/fs076-01.pdf)
[34] Warren Chesner, Robert J. Collins, and M. H. MacKay. User guidelines for waste and by-product materials in pavement construction. No. FHWA-RD-97-148. 1998. (http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/intro.cfm)
[35] Ibid.
[36] University of Kentucky, Center of Applied Energy Research. (http://www.caer.uky.edu/kyasheducation/boilerslag.shtml)
[37] U.S. EPA. "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions From Coal-Fired Electric Generating Units." October 2010. (http://www.epa.gov/nsr/ghgdocs/electricgeneration.pdf)
[38] Ibid.
[39] ARTBA analysis of EIA report 767 data for operational boilers where the primary source of fuel is coal.
[40] ARTBA analysis of EIA Reports 923 and 860 data for operational boilers where the primary source of fuel is coal.

FIGURE 2-6: BOILER SLAG PRODUCTION



FBC ASH PRODUCTION

Total production of ash from fluidized bed combustion (FBC) has increased from 1.2 million short tons in 2002 to 10.3 million short tons in 2013. Part of this increase was the expansion of the ACAA production and use survey in 2007 to include data from the Anthracite Region Independent Power Producers Association (ARIPPA), comprised of non-utility alternative energy electric power generation stations that burn waste coal using FBC technology.

Since that time, the total production has grown from 6.1 million short tons in 2007, increasing at an average annual rate of nine percent.

The production of FBC ash is highly dependent on the volume of coal generated electricity, total coal consumption by electric utilities and the burning of waste coal. In addition, this market is impacted by technology and equipment upgrades to comply with environmental regulations.

FBC ash is the fly ash and the bed ash produced by an FBC boiler. The FBC fly ash is collected in the flue of the boiler with a baghouse filter or electrostatic precipitator. The bed ash is the residue that is removed from the bottom of the boiler.[41]

In an effort to meet emissions requirements, more utilities are building FBC boilers, which allows operators to burn lower rank coals with a higher moisture and ash content while reducing nitrogen oxide emissions.[42] FBC boilers operate at a lower temperature than conventional boilers, and this reduced temperature results in the reduction in nitrogen oxide emissions.

FBC technology is also used to convert coal refuse from current and past mining activities into energy. Many of these plants, captured in the ARIPPA data, are located in Pennsylvania. ARIPPA members have removed more than 212 million tons of coal refuse and restored more than 8,200 acres of damaged mine lands since 1988.[43]

There were 46 plants that produced FBC ash in 2012, with the largest volumes in Texas, Pennsylvania and Kentucky.[44]

FBC ash production fell sharply in 2012 from 13.2 to 9.8 million short tons, a decline of 26 percent. This was the same year that coal consumption for electricity fell 12 percent and the total megawatt hours of coal generated electricity was down 13 percent, once again highlighting how such dramatic shifts in these markets will impact CCP production.

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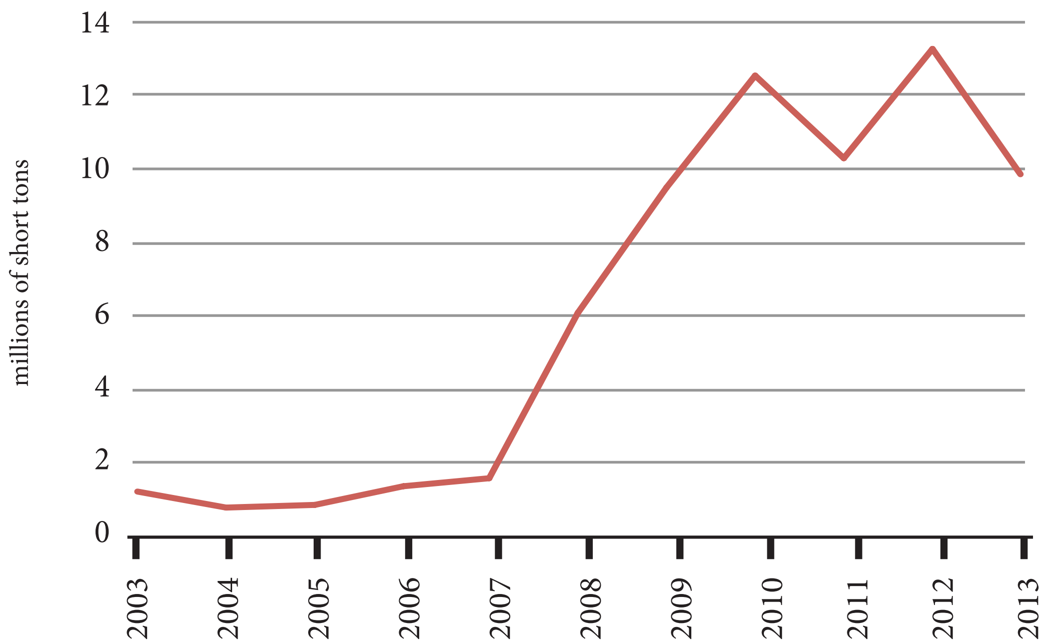
[41] American Coal Ash Association. "Glossary of terms concerning the management and use of coal combustion products (CCPs)." American Coal Ash Association, Inc., Aurora, CO (2003). (http://www.acaa-usa.org/Portals/9/Files/PDFs/ACAA_Glossary_of_Terms-Apri_2003.pdf)
[42] Ibid.
[43] "Environmental Win-Win, ARIPPA's Role: Cleaning Up Historic Coal Waste Sites, Restoring the Land Using Ash." Ash at Work 1 (2014). (http://arippa.org/documents/ACAA%20ARIPPA%20Environmental%20Win-Win%20Article.pdf)
[44] ARTBA analysis of EIA 923 form data.

FIGURE 2-7: FBC ASH PRODUCTION



TOTAL CCP UTILIZATION

Total CCP utilization increased from 8.7 million short tons in 1974 to 51.6 million short tons in 2013, an increase of nearly 500 percent. Utilization was as high as 60.6 million short tons in 2008.

Two of the largest beneficial uses of CCPs in the U.S. are fly ash as a replacement for portland cement in concrete and FGD gypsum as a replacement for mined gypsum in wallboard.[45]

Research and analysis has shown that the beneficial use of CCPs can "contribute significant environmental and economic benefits."[46] This can include reduced greenhouse gas emissions, reduced need for disposing of CCPs in landfills and the reduced use of virgin resources. The economic benefits include job creation in the end industries, reduced costs associated with CCP disposal, increased revenue from the sale of CCPs, and savings from using CCPs in place of other costly materials.

A number of factors have impacted CCP utilization over the last 39 years:[47]

- Regulatory certainty or uncertainty
- Demand from end markets, including production changes to incorporate a growing supply of CCPs
- Role of specifications and standards
- Logistics and infrastructure to support beneficial use as an alternative to disposal
- Role of technologies to improve ash quality
- Emerging utilization technologies
- Wider use and recognition that CCP material makes a superior product

As CCPs have become more widely used in construction materials, mining applications and agriculture, among other markets, and standards have been established, the focus has shifted to techniques for using increasingly higher quantities of ash. New industries have also emerged to help CCP producers improve, maintain and manage their supply.[48]

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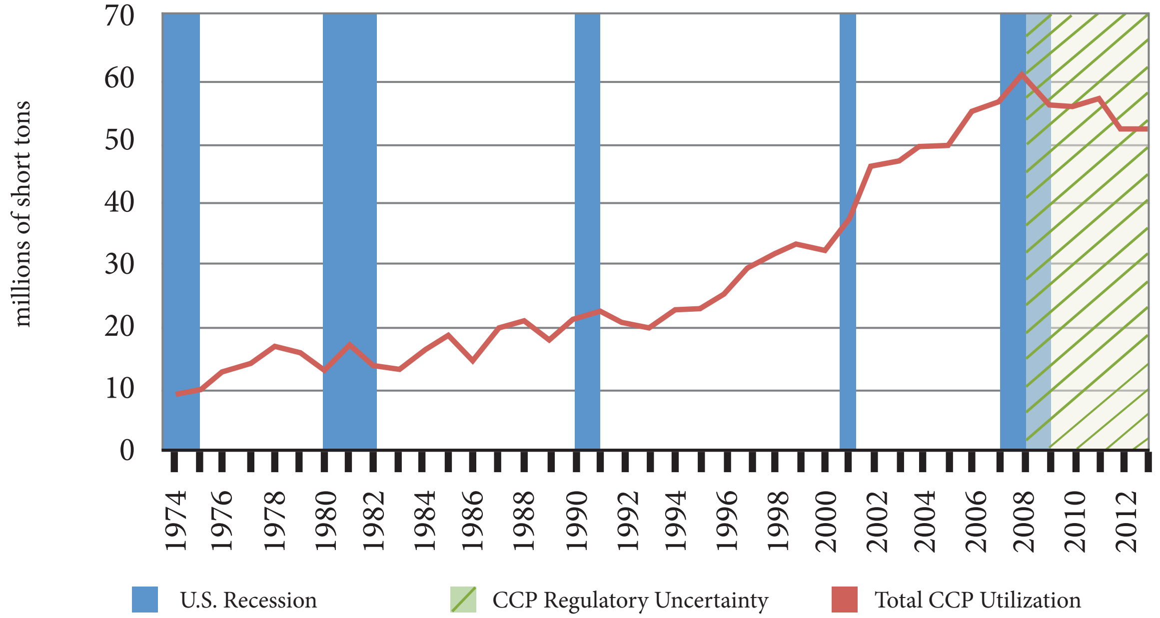
[45]U.S. EPA Office of Solid Waste and Emergency Response, Office of Resource Conservation and Recovery. "Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard." (February 2014) (http://www.epa.gov/waste/conserve/imr/ccps/pdfs/ccr_bu_eval.pdf)
[46]Ibid.
[47]John Ward & A. Steward. The value of coal combustion products: an economic assessment of CCP unitization for the US economy. American Coal Council, Phoenix, AZ (United States), (2010). (https://c.ymcdn.com/sites/www.americancoalcouncil.org/resource/resmgr/Docs/ACC_2010_CCP_ECON_ASSESSMENT.pdf)
[48]Ibid.

FIGURE 3-1: UTILIZATION OF CCPs HAS INCREASED DURING RECESSIONS, BUT DROPPED DURING A PERIOD OF REGULATORY UNCERTAINTY



Major U.S. Recessions
November 1973 to March 1975
January to July 1980
July 1981 to November 1982
July 1990 to March 1991
March to November 2001
December 2007 to June 2009

CCP Regulatory Uncertainty:
December 2008 to April 2015
EPA decision to reconsider the classification of CCPs as a hazardous waste

FLY ASH UTILIZATION

Fly ash utilization has grown from 3.4 million short tons in 1974 to 23.3 million short tons in 2013, an increase of 586 percent. The utilization rate of fly ash has grown from 8.4 percent of production in 1974 to 43.7 percent in 2013.

Although the overall demand for construction materials and ready-mixed concrete are main drivers of fly ash utilization, there are a number of regulatory incentives and disincentives that have historically impacted the market.

Between 1975 and 2013, fly ash utilization grew at an average annual rate of 4.4 percent, well above the average annual growth rate for ready-mixed concrete production at 1.5 percent and U.S. GDP, which increased at an annual rate of three percent.

The majority of fly ash is used as an additive to enhance the durability and strength of construction materials, including concrete. The physical and chemical properties of fly ash improve both the plastic and hardened properties of concrete. "Adding fly ash to concrete reduces the water required, improves pumpability, reduces segregation, yields higher ultimate strength, and is very effective at mitigating durability problems like alkali-silica reactivity and reinforcing steel corrosion."[49]

Fly ash has been used in many U.S. large-scale construction projects, beginning with the Hungry Horse Dam in Montana in 1948. Engineers with the U.S. Bureau of Reclamation were looking for a way to mitigate the heat of hydrating cement during the placement of concrete on the structure. That project alone used 120,000 metric tons (132,277 short tons of fly ash.[50] Between 1950 and 1970, concrete with fly ash content as high as 50 percent was used on over 100 major dam construction projects across the country.[51]

Other key uses of fly ash include structural fills and embankments, mining applications and waste stabilization and solidification.

Over time, the focus on fly ash utilization has shifted from education, demonstrating the usefulness of the material and establishing standards, to emerging technologies helping fly ash producers improve and maintain the quality of the product being utilized.[52]

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[49] Hank Keiper, P.E., "Addressing Coal's Negative Impact – Beneficial Use of Fly Ash," The Virginia Engineer, (April 2011). (http://vaeng.com/guestarticle/addressing-coal-s-negative-impact-beneficial-use-of-fly-ash)
[50] Ruta S. Kalyoncu and Donald W. Olson, "Coal Combustion Products," U.S. Geological Survey Fact Sheet 076-01. (http://pubs.usgs.gov/fs/fs076-01/fs076-01.html)
[51] Ibid.
[52] John Ward & A. Steward. The value of coal combustion products: an economic assessment of CCP unitization for the US economy. American Coal Council, Phoenix, AZ (United States), (2010). (https://c.ymcdn.com/sites/www.americancoalcouncil.org/resource/resmgr/Docs/ACC_2010_CCP_ECON_ASSESSMENT.pdf)

FIGURE 3-2: FLY ASH UTILIZATION

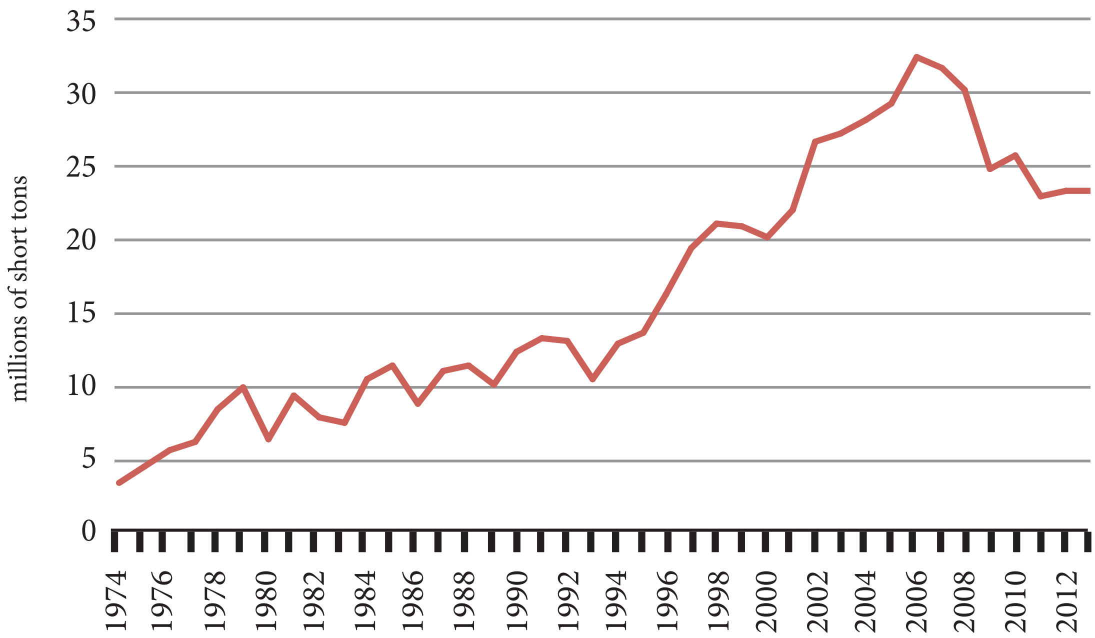
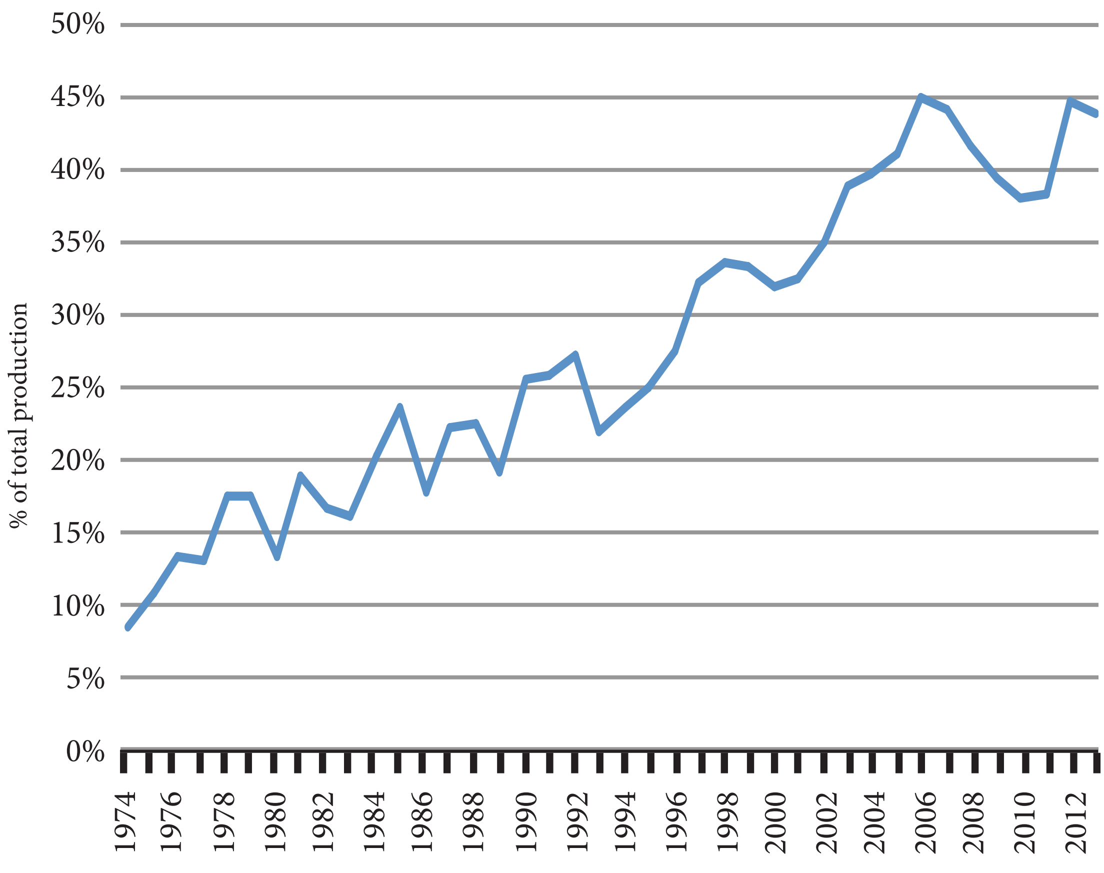


FIGURE 3-3: FLY ASH UTILIZATION RATE



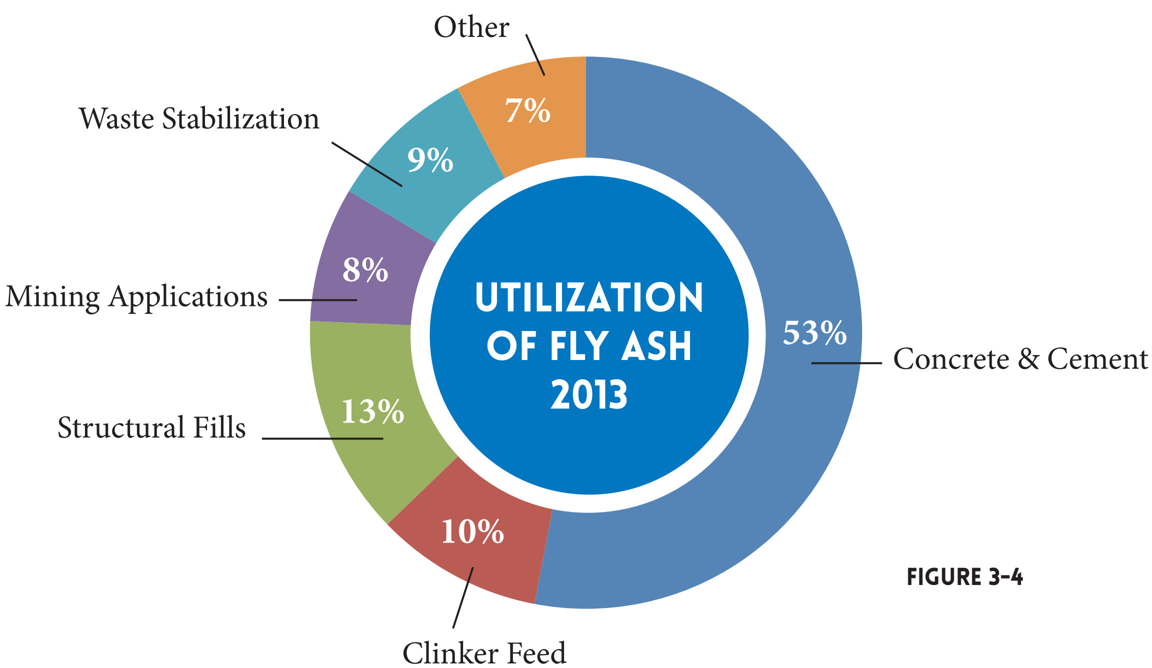
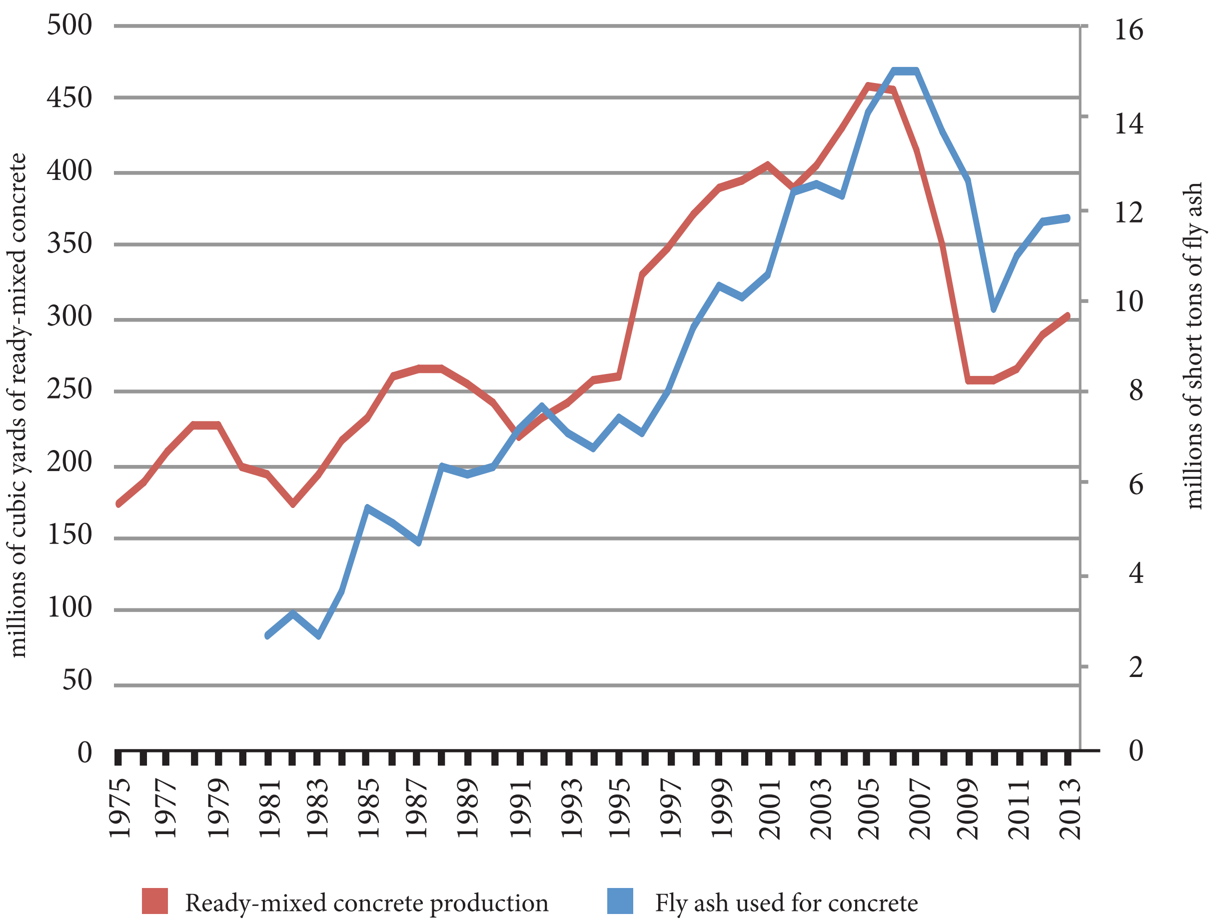


FIGURE 3-4

FIGURE 3-5: READY-MIXED CONCRETE PRODUCTION & FLY ASH USED FOR CONCRETE



REGULATORY CERTAINTY & GROWTH OF FLY ASH UTILIZATION
Historically, regulations regarding the classification of fly ash as either a solid waste or a hazardous material have had an impact on utilization.

The Resource Conservation and Recovery Act (RCRA), which amended the Solid Waste Disposal Act of 1965, is the primary law that governs the disposal of hazardous and solid waste in the United States.

RCRA Subtitle C establishes a "cradle to grave" system for controlling materials classified as hazardous waste. If a material is a solid waste but not considered hazardous, it is regulated under RCRA Subtitle D, which requires states to develop a comprehensive plan for managing nonhazardous solid waste.[53] In the original legislation, it was not clear if fly ash was considered a hazardous waste under Subtitle C or a solid waste under Subtitle D.

On October 12, 1980, Congress passed a law which amended RCRA. Fly ash and other CCPs were temporarily excluded from regulation under Subtitle C as a hazardous waste until further study and assessment. This regulatory exemption, known as the Bevill exemption, meant that CCPs were temporarily considered a solid waste under Subtitle D, thus subject to state regulations, until a formal report was conducted by EPA.

On August 9, 1993, EPA issued a regulatory determination that concluded that CCPs should continue to be exempt from Subtitle C of the RCRA because of the "limited risks posed by them and the existence of generally adequate State and Federal regulatory programs."[54]

Under this environment of regulatory certainty, fly ash utilization doubled from 10.5 million short tons in 1993 to 20.1 million short tons in 2000, growing at an average annual rate of 10 percent. During the same time period the production of ready-mixed concrete grew at an average annual rate of seven percent.

The EPA issued a Final Regulatory Determination on May 22, 2000 that retained the Bevill exemption for fly ash and other "fossil fuel combustion wastes," reaffirming the 1993 notice. EPA also determined that there would be no additional regulation for fly ash and the agency did "not wish to place any unnecessary barriers on beneficial use." EPA announced it would develop national standards for the disposal of fly ash and other CCPs in landfills, surface impoundments and mines.

This utilization of fly ash grew at an average annual rate of 6.6 percent between 2000 and 2007, compared to an average annual rate of growth of 0.7 percent for ready-mixed concrete production. Fly ash utilization grew from 20.1 million short tons in 2000 to 31.6 million short tons in 2007.

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[53]U.S. EPA, "History of RCRA" (http://www.epa.gov/osw/laws-regs/rcrahistory.htm)
[54]U.S. Federal Register Vol. 58, No. 151, 40 CFR Part 261, "Final Regulatory Determination on Four Large-Volume Wastes From the Combustion of Coal by Electric Utility Power Plants." (http://www.epa.gov/epawaste/nonhaz/industrial/special/mineral/pdfs/080993.pdf)

In the most recent recession, which began in December 2007 and ended June 2009, fly ash utilization declined slightly in 2007 and 2008, falling from 32.4 million short tons in 2006 to 31.6 million short tons in 2007 (a decline of 2.5 percent) and 30.1 million short tons in 2008 (a further decline of 4.7 percent).

GROWTH IN FLY ASH UTILIZATION AND READY-MIXED CONCRETE

	AVERAGE ANNUAL GROWTH RATE	
TIME PERIOD	FLY ASH UTILIZATION	READY-MIXED CONCRETE PRODUCTION
1974 to 1980	11.2%	3.5%
1981 to 1990	3.1%	2.5%
1991 to 2000	4.8%	6.8%
2000 to 2008	5.2%	-1.5%
2009 to 2013	-5.0%	-3.1%
Total for 1974 to 2013	**5.1%**	**1.6%**

Meanwhile, the U.S. production of ready-mixed concrete had started to fall even before the official start of the recession, declining from 458.3 million cubic yards in 2005 to 456.8 million cubic yards in 2006 and 414.6 million cubic yards in 2007.

It was not until 2009 that fly ash utilization fell to 24.7 million short tons, a decline of 18 percent from 2008 levels—one full year after the recession began in December 2007. Although total volumes of ready-mixed concrete in 2013 are still below their pre-recession levels, the market bottomed out in 2010 and production has increased annually since that time. Meanwhile, fly ash utilization continues to remain depressed.

INDUSTRY SPECIFICATIONS AND MATERIALS STANDARDS

Over the years, the development of guidelines, specifications and industry standards have encouraged wider use of fly ash in U.S. construction markets.

Guidelines for the use of fly as a concrete additive are part of standards ASTM C 618 and AASHTO M 295, ensuring that the final product conform to consistent, high quality physical and chemical properties.[55]

Additional standards address the particle size of fly ash (ASTM D 422 and AASHTO T88), the specific gravity (ASTM D 554 and AASHTO T 100) and the compaction (ASTM D 698 and AASHTO T 999 and T 180).

Other specifications for the use of CCPs for various manufacturing and engineering purposes have been developed separately. This includes standards for using fly ash with lime (ASTM C 593), blended hydraulic cements (ASTM C 595 and ASTM C 1157), for soil stabilization (ASTM D 5239), structural fills (ASTM E 2277-14), surface mine reclamation (ASTM E 2278 and ASTM E 2243-02) and other uses (ASTM D 5759).

More than a dozen federal agencies have published articles, guidelines and standards on the beneficial use of fly ash for construction and agricultural purposes. Many of these publications have been instrumental in educating a larger audience about the benefits of fly ash to improve material performance and reduce costs.

Some examples of U.S. federal support of fly ash utilization include:[56]

- **ENVIRONMENTAL PROTECTION AGENCY:** Over the years EPA has published a number of case studies and procurement guidelines that include information on using fly ash.[57]

  In 1993, President Clinton established a federal environmental executive at EPA to develop a federal plan "to encourage the acquisition of recycled and environmentally preferable products by the Federal Government." This included issuing guidance for federal agencies, which should consider the "elimination of virgin material requirements," life cycle costs, recyclability, waste prevention and the use of environmentally preferable products in the acquisition planning for all procurements and contract awards.[58]

  In 1997, EPA adopted the "Comprehensive Guideline for the Procurement of Products Containing Recovered Waste" and the "Recovered Materials Advisory Notice." The guidelines recommended that all federal agencies, state and local government agencies and contractors using federal funds revise their cement and concrete procurement to allow the use of fly ash and ensure that guide specifications "do not inappropriately or unfairly discriminate against

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[55]John Ward & A. Steward. The value of coal combustion products: an economic assessment of CCP unitization for the US economy. American Coal Council, Phoenix, AZ (United States), (2010). (https://c.ymcdn.com/sites/www.americancoalcouncil.org/resource/resmgr/Docs/ACC_2010_CCP_ECON_ASSESSMENT.pdf)

[56]Ibid.

[57]A full list of detailed historical documents is available from ACAA in the Compilation of Regulations, Standards, Guidelines, Websites and other References Pertinent to Coal Combustion Products, revised February 12, 2007. (http://www.epa.gov/epawaste/conserve/imr/pdfs/acaadoc.pdf)

[58]Executive Order 12873—Federal Acquisition, Recycling and Waste Prevention, October 20, 1993. (http://www.epa.gov/oppt/epp/pubs/eo12873.pdf)

the use of coal fly ash …"[59] Similar recommendations were made for the use of fly ash in flowable fills.

EPA recently conducted an evaluation of the beneficial use of fly ash as a direct substitute for portland cement in concrete. In the 2014 report Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard, the Agency concludes "the beneficial use of CCRs, when conducted in an environmentally sound manner, can contribute significant environmental and economic benefits" and "the agency supports the beneficial use of coal fly ash in concrete and FGD gypsum in wallboard."[60] The evaluation was based on the methodology developed by the Agency and published in 2013.[61]

- **FEDERAL HIGHWAY ADMINISTRATION (FHWA) GUIDELINES:** FHWA has published several documents and guidelines for using CCPs and fly ash in highway construction: Fly Ash Facts for Highway Engineers, Using Coal Ash in Highway Construction: A Guide to Benefits and Impacts and User Guidelines for Waste and Byproduct Materials in Pavement Construction.[62]

  FHWA has also published research information on high-volume fly ash mixtures and the associated benefits of this technology.[63]

- **ARMY CORPS OF ENGINEERS:** There are a number of Army Corps specifications and reports that discuss the use of fly ash in concrete for transportation and construction projects.[64] The Army Corps also allows fly ash to be used for sub-grade stabilization, embankments, flowable fill, soil amendment and asphalt filler.

- **ADDITIONAL FEDERAL AGENCIES:** Additional material has been published by the Federal Aviation Administration, the U.S. Department of Agriculture, the U.S. Geological Survey and the U.S. Department of Energy.[65]

State Departments of Transportation (DOTs) also maintain specifications for fly ash used in concrete. Although specifics may vary regionally, nearly all of the standards are based on ASTM C618 or AASHTO M295.[66] An average of 75 percent of all the concrete poured on U.S. highways,

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[59]U.S. EPA. "Consolidated Recovered Materials Advisory Notice (RMAN) For the Comprehensive Procurement Guideline (CPG)," Compiled December 1997, revised as recently as September 2007. (http://www.epa.gov/epawaste/conserve/tools/cpg/pdf/consolrman.pdf)
[60]U.S. EPA Office of Solid Waste and Emergency Response, Office of Resource Conservation and Recovery. "Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard." (February 2014) (http://www.epa.gov/waste/conserve/imr/ccps/pdfs/ccr_bu_eval.pdf)
[61]U.S. EPA Office of Solid Waste and Emergency Response, Office of Resource Conservation and Recovery. "Methodology for Evaluating Encapsulated beneficial Uses of Coal Combustion Residuals." (September 2013) http://www2.epa.gov/sites/production/files/2014-12/documents/ccr_bu_method.pdf
[62]FHWA Reports # FHWA-IF-03-019, # EPA-530-K-05-002 and # FHWA-RD-97-148. (http://www.fhwa.dot.gov/pavement/recycling/fafacts.pdf)
[63]FHWA-HRT-12-062. "Benefits of High Volume Fly Ash: New Concrete Mixtures Provide Financial, Environmental and Performance Gains." FHWA-HRT-10-051 (http://www.fhwa.dot.gov/advancedresearch/pubs/10051/)
[64]Toy S. Poole. Use of Large Quantities of Fly Ash in Concrete. No. WES/TR/SL-95-9. ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS STRUCTURES LAB, 1995. (http://acwc.sdp.sirsi.net/client/en_US/default/search/detailnonmodal/ent:$002f$002fSD_ILS$002f0$002fSD_ILS:282653/ada/?rt=CKEY%7C%7C%7CCKEY%7C%7C%7Cfalse)
[65]ACAA, "Compilation of Regulations, Standards, Guidelines, Websites and other References Pertinent to Coal Combustion Products," (2007). (http://www.epa.gov/epawaste/conserve/imr/pdfs/acaadoc.pdf)
[66]Bruce A. Dockter and Diana M. Jagiella. "Engineering and Environmental Specifications of State Agencies for Utilization and Disposal of Coal Combustion Products." World of Coal Ash Conference, Lexington Kentucky. 2005. (http://www.worldofcoalash.org/2005/ashpdf/136doc.pdf)

valued at nearly $10 billion, utilizes fly ash as a partial cement replacement blend.[67]

A recent report by the Transportation Research Board, which included a survey of state DOTs and a literature review, suggested a need for "refining the existing classification method to include properties known to affect performance."[68] As one example the authors noted that the classification of fly ash does not include reporting calcium content, which is important for alkali-silica reaction mitigation practices.

FGD MATERIAL UTILIZATION

The utilization of FGD material has grown from 1.02 million short tons in 1987 to 12.9 million short tons in 2013, increasing at an average annual rate of 10.3 percent.

Most of the FGD material, 7.4 million short tons, was used in gypsum panel products in 2013. Known as FGD gypsum or synthetic gypsum, this material can be used as a full substitute for mined gypsum in wallboard and drywall because the primary chemical constituent is identical.[69] FGD gypsum may even have higher gypsum purity than mined gypsum because of the "greater control over the chemical composition of the final product."[70]

FGD material is also used as an input for blended cement and feed for clinker and in both mining and agricultural applications.

The total utilization of FGD material has grown from 7.2 percent of total material produced in 1987 to 37 percent in 2013.

As a substitute for natural gypsum, demand for FGD material has historically been related to demand for gypsum wallboard and total U.S. construction activity. But as wallboard manufacturers have recognized the superior properties of FGD material—they have shifted their production process to further reduce the costs of using the synthetic material.

As overall demand for gypsum has increased with U.S. construction activity, the use of FGD synthetic gypsum has coincided with a decline in gypsum imports.

The growth in the utilization of FGD over the last 27 years is supported by increased production, the commercialization of the product and the ease of substitution with the virgin material. FGD material has become the "preferred feedstock" for wallboard manufactures because its "uniform properties simplify manufacturing operations for existing users."[71] In addition, many wallboard manufacturers have located new facilities near coal-fueled power plants to have access to FGD gypsum.

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[67] Alison Premo Black, et al. "The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction." (2011). (http://trid.trb.org/view.aspx?id=1123544)
[68] Lawrence L. Sutter, R. Douglas Hooton, and Scott Schlorholtz. Methods for Evaluating Fly Ash for Use in Highway Concrete. Vol. 749. Transportation Research Board, 2013. (http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_749.pdf)
[69] EPA. "Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard." (February 2014). (http://www.epa.gov/waste/conserve/imr/ccps/pdfs/ccr_bu_eval.pdf)
[70] Ibid.
[71] U.S. Department of Energy National Energy Technology Laboratory, DOE/NETL-2001/1158. "Advanced Flue Gas Desulfurization Demonstration Project, A DOE Assessment." (August 2001). (http://www.netl.doe.gov/research/coal/major-demonstrations/clean-coal-technology-demonstration-program/bectso-adflug)

FIGURE 3-6: FGD MATERIAL UTILIZATION

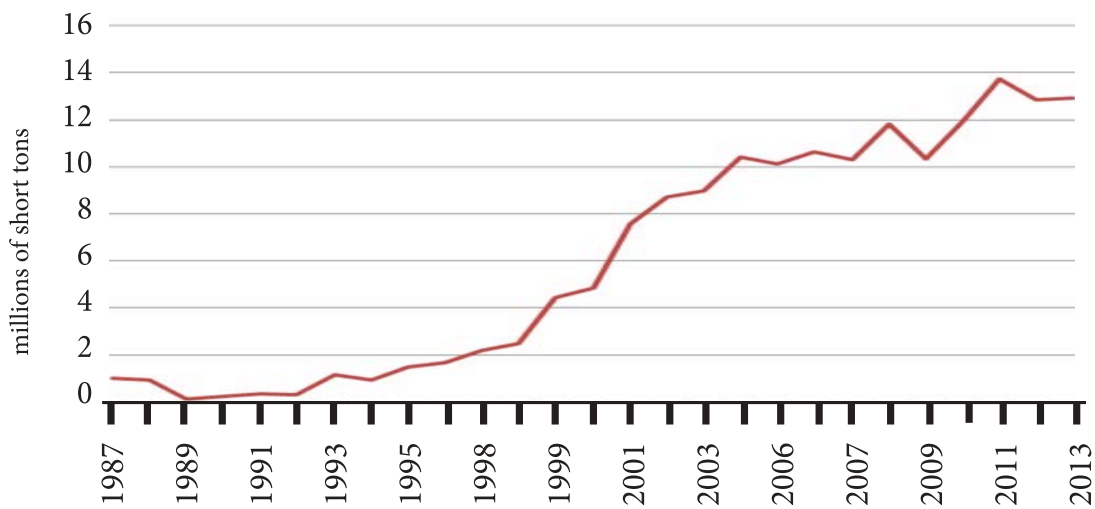
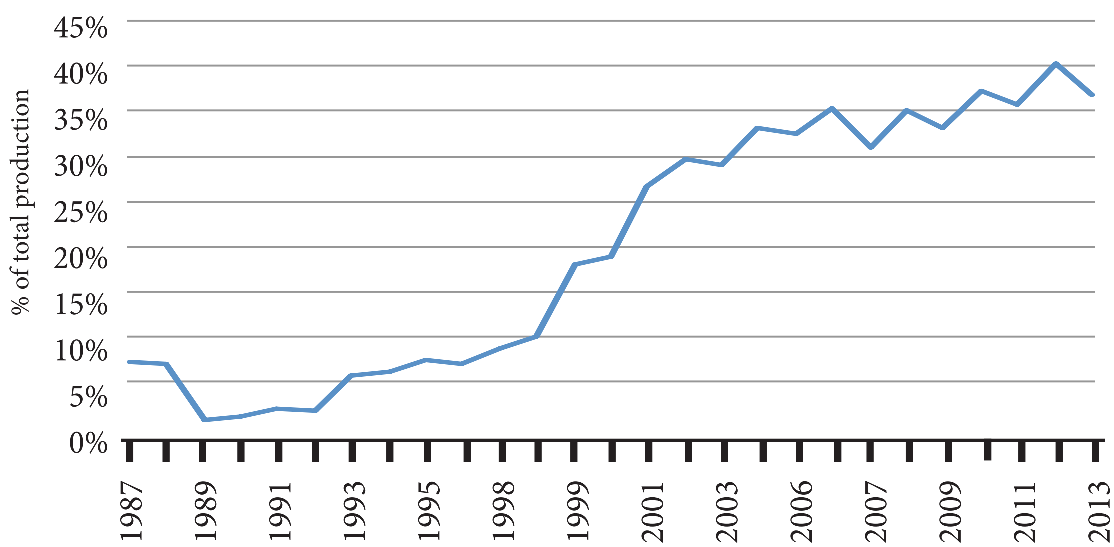


FIGURE 3-7: FGD MATERIAL UTILIZATION RATE



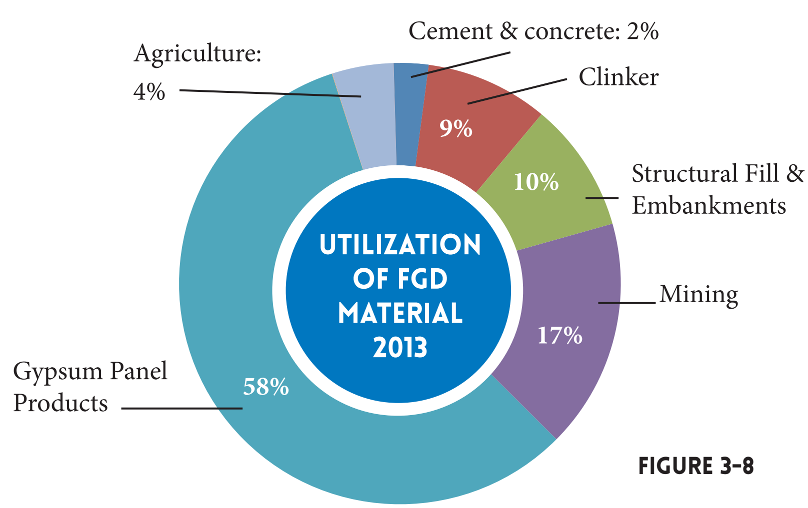


FIGURE 3-8

GROWTH IN FGD MATERIAL UTILIZATION—1987 TO 2008

Between 1987 and 1992 the utilization of FGD material averaged 486,500 short tons per year. In the U.S. gypsum market, "byproduct gypsum" accounted for 4.2 percent of total domestic production in 1987 and 2.6 percent of U.S. consumption. The U.S. Geological Survey noted that there were seven companies that sold byproduct gypsum "principally for agricultural use, but some for gypsum wallboard manufacturing."[72]

The utilization of FGD material began increasing significantly after 1993, growth that coincided with the regulatory certainty provided by the EPA. FGD material was one of the CCPs being reviewed by EPA for regulation under RCRA Subtitle C or Subtitle D and was included in the Bevill exemption in 1980.

The EPA final regulatory determination that concluded CCPs and FGD gypsum should continue to be exempt from Subtitle C of the RCRA and regulated as a solid waste, issued on August 9, 1993, provided regulatory certainty for utilization.

Between 1993 and 2000, utilization grew at an average annual rate of 23 percent, increasing from 1.2 million short tons in 1993 to 4.8 million short tons in 2000.

During this same time, total domestic gypsum production grew at an average annual rate of 5.7 percent, crude gypsum mining grew at a rate of 3.1 percent and total U.S. domestic gypsum consumption grew at a rate of 5.0 percent. The total million square feet of wallboard products sold increased at an average annual rate of 1.7 percent.

Synthetic gypsum grew from 4.8 percent of total domestic gypsum production to 20.2 percent. As a percentage of total consumption, synthetic gypsum increased from 2.9 percent of the market to 14.7 percent.

Although the U.S continued to import more gypsum to meet growing demand, as a percentage of total production, imports declined from 31 percent of the market in 1993 to 27 percent in 2000. The use of imports continued to decline over the next decade, both in terms of volume and market share, with additional regulatory certainty and the increased use of FGD material.

The EPA issued another Final Regulatory Determination on May 22, 2000 that retained the Bevill exemption for FGD material, reaffirming the 1993 notice and determined that there would be no additional regulation. At this point, FGD material was "becoming very important as a substitute for mined gypsum in wall board manufacturing, cement production and agricultural applications."[73]

Between 2000 and 2008, FGD material utilization grew at an average annual rate of 12 percent, more than doubling from 4.8 million short tons to 11.8 million short tons as the overall U.S. gypsum market was in decline.

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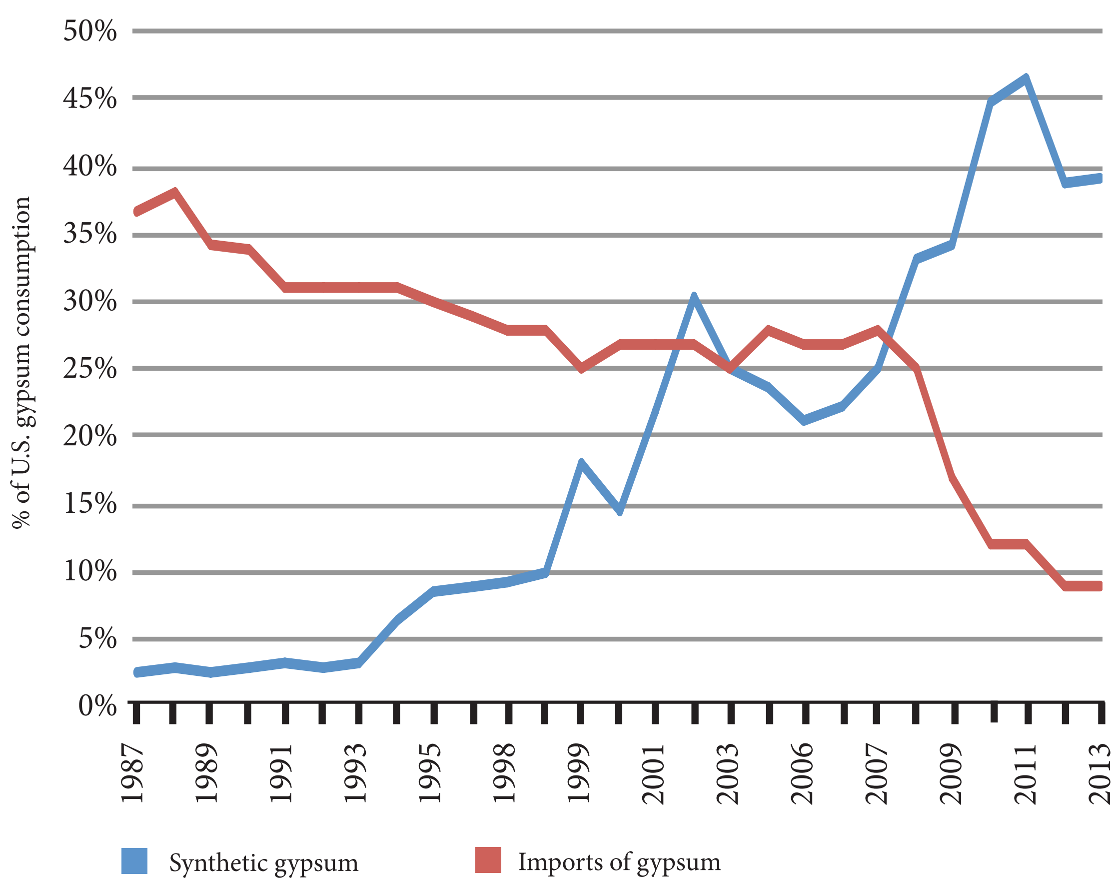
[72]U.S. Geological Survey. "Gypsum." Minerals Yearbook (1987) (http://minerals.usgs.gov/minerals/pubs/commodity/gypsum/)
[73]U.S. Geological Survey. "Mineral Commodity Summaries." (2002) (http://minerals.usgs.gov/minerals/pubs/mcs/2002/mcs2002.pdf)

FGD material was increasingly used as a substitute for U.S. mined crude gypsum and gypsum imports. U.S. production of crude gypsum declined at an average annual rate of 5.2 percent between 2000 and 2008, falling from 19.5 million metric tons to 12.7 million metric tons. Total domestic gypsum production declined at a rate of 1.1 percent and total gypsum consumption fell at a rate of 1.8 percent. This decline was driven by lower demand for gypsum products: total volume of wallboard products sold in the United States declined at an average annual rate of 2.9 percent.

Synthetic gypsum from FGD plants grew at an average annual rate of 8.7 percent between 2000 and 2008 as imports of gypsum declined at a rate of 2.8 percent.

The availability of FGD material as a substitute for mined gypsum continued to change the fundamentals of the domestic industry. To take advantage of the FGD material, "much of the production at new and expanded facilities will consume synthetic gypsum produced by scrubbing emission from coal-fired electric power plants."[74]

FIGURE 3-9: SYNTHETIC (FGD) GYPSUM HAS BEEN REPLACING GYPSUM IMPORTS



74U.S. Geological Survey. "Gypsum." Minerals Yearbook (2007)

FIGURE 3-10: TOTAL U.S. GYPSUM PRODUCTION & UTILIZATION

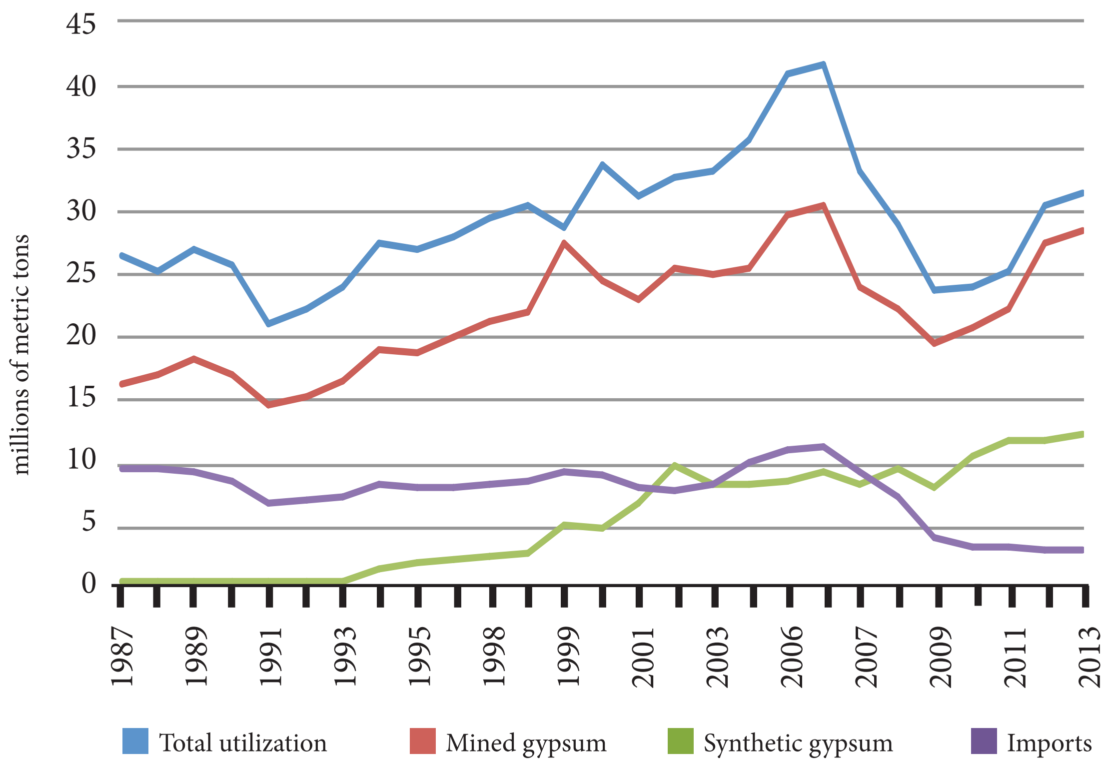
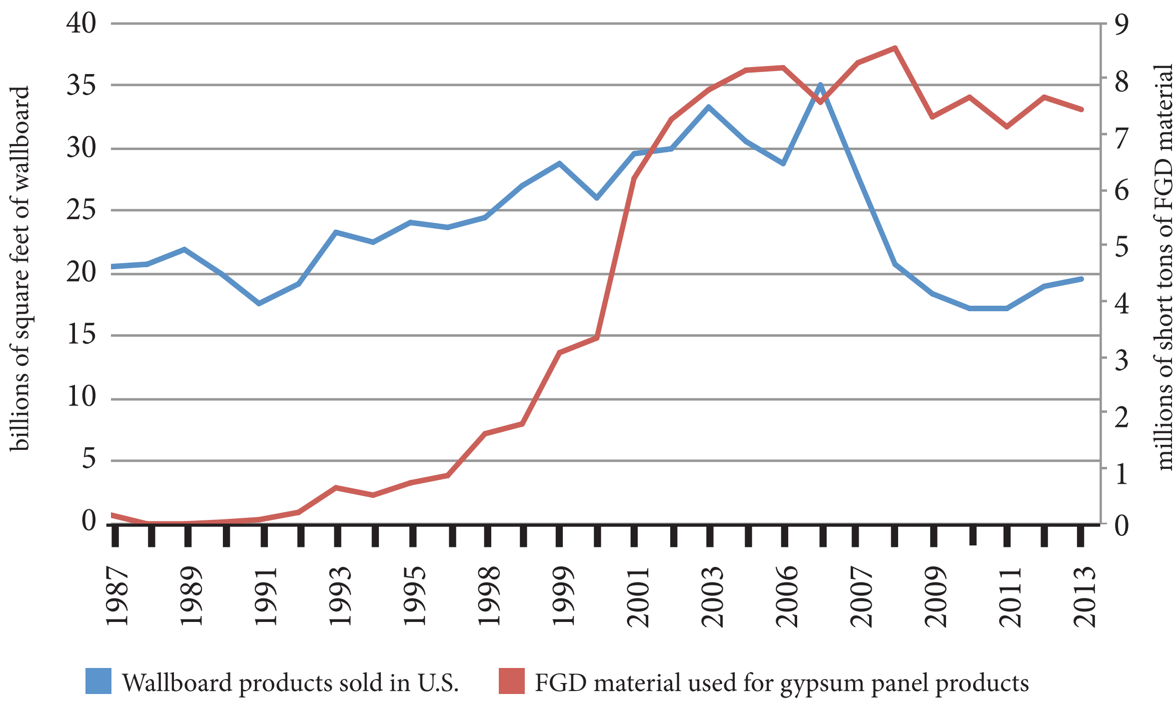


FIGURE 3-11: SALES OF WALLBOARD PRODUCTS & FGD MATERIAL UTILIZATION



RECENT DEVELOPMENTS IN FGD MATERIAL UTILIZATION—2008 TO 2013

Recent development in the utilization of FGD material have been largely driven by overall demand for gypsum wallboard and the supply of FGD material.

FGD material utilization continued to grow between 2008 and 2013, increasing from 11.8 million short tons to 12.9 million short tons. But the rate of average annual growth has slowed to two percent.

Total U.S. gypsum production and consumption declined in 2008 and 2009 as "the housing and construction markets continued to falter."[75] The utilization of FGD material also declined from 11.8 million short tons in 2008 to 10.3 million short tons in 2009, following the U.S. recession.

FGD material utilization began to grow in 2010, even as sales of wallboard products and total U.S. gypsum production declined further. The increase in FGD material helped to meet a slight increase in overall domestic gypsum consumption in 2010.

The utilization of FGD material for agriculture and mining applications has grown significantly since 2008. Total utilization for mining nearly doubled from 794,745 short tons in 2008 to 1.5 million short tons in 2013.

The use of FGD material for agriculture applications was 281,752 short tons in 2008. That has grown to 655.6 thousand short tons in 2013. Although gypsum was used for agriculture purposes as early as the 18th century, high extraction and transportation costs meant it was used only for a few crops.[76] Much like the wallboard industry, agriculture producers are finding that the availability of FGD gypsum, as well as the smaller and uniform particle size mean that the synthetic material is providing "greater soil improvements" than commercially mined gypsum.[77]

INDUSTRY SPECIFICATIONS AND MATERIALS STANDARDS

There are several standards and specifications that have helped support the growing utilization of FGD materials.

FGD gypsum used for wallboard and related materials are produced in compliance with ASTM C1396, ASTM C 1395, ASTM C 1278 and ASTM C1179, among others.[78]

FHWA published guidelines for using FGD material in pavement construction as a subbase material in 1997.[79]

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[75]U.S. Geological Survey., "Gypsum." Minerals Yearbook (2008)
[76]Dexter B. Watts and Warren A. Dick. "Sustainable uses of FGD gypsum in agricultural systems: Introduction." Journal of environmental quality 43.1 (2014): 246-252.
[77]Ibid.
[78]Gypsum Association. "Gypsum Panel Products Types, Uses, Sizes and Standards (GA-223-04)." (https://www.gypsum.org/wp/wp-content/uploads/2011/11/223-04.pdf)
[79]Warren H. Chesner, Robert J. Collins, and M. H. MacKay. User guidelines for waste and by-product materials in pavement construction. No. FHWA-RD-97-148. 1998. (http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/intro.cfm)

BOTTOM ASH UTILIZATION

Bottom ash utilization has grown from 2.9 million short tons in 1974 to 5.6 million short tons in 2013, an increase of 95 percent. The utilization rate of bottom ash has grown from 20.3 percent of production in 1974 to 39 percent in 2013.

Bottom ash is mainly used as an input for blended cement, clinker and concrete products, structural fills and embankments, soil modification and snow and ice control.

Although bottom ash has a chemical composition that is similar to fly ash, the size of the material can range from "fine sand to large gravel," and thus it does not have any cementitous properties.[80] Since bottom ash is not pozzolanic it has more limited applications in the cement and concrete industry than fly ash.[81] Bottom ash is typically used as a lightweight aggregate in precast concrete products, including concrete blocks and masonry units.[82] The final product is much lighter than when using conventional aggregates, such as sand and gravel, and is just as strong.[83]

Two-thirds of the bottom ash utilized in 2013 was for concrete, blended cement/feed for clinker and structural fills and embankments.

In terms of highway embankments, subgrades and sub-bases, bottom ash has properties that "compare favorably with conventional highway materials" and meet the same specification requirements in testing.[84] Research also shows that there is "no difference in performance" when bottom ash is incorporated into asphalt mixtures.[85] Some mixes with bottom ash are improved by showing "high-temperature rutting and low-temperature cracking characteristics" and require less compactive effort to achieve "desired optimum densities."[86]

The same regulatory incentives and disincentives that have impacted fly ash utilization have also had an effect on the utilization of bottom ash.

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[80]Texas Coal Ash Utilization Group, FAQ. "What are coal combustion products?" (http://www.tcaug.org/faq/)
[81]R.C. Joshi and R. P. Lohita. Fly ash in concrete: production, properties and uses. No. 2. CRC Press, 1997. (https://books.google.com/books/about/Fly_Ash_in_Concrete.html?id=8ITxm7zHul4C)
[82]G.J. Dienhart, B. R. Stewart, and S. S. Tyson. "Coal ash: innovative applications of coal combustion products." American Coal Ash Association, Alexandria, VA (1998).
[83]University of Kentucky, Center for Applied Energy Research (http://www.caer.uky.edu/kyasheducation/bottomash.shtml)
[84]Wsei-Hsing Huang, "The use of bottom ash in highway embankments, subgrades, and subbases." (1990). (http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1782&context=jtrp)
[85]Khaled Ksaibati and Jason Stephen. Utilization of bottom ash in asphalt mixes. No. MCP Report No. 99-104A. Department of Civil and Architectural Engineering, University of Wyoming, 1999. (http://trid.trb.org/view.aspx?id=502631)
[86]Ibid.

FIGURE 3-12: BOTTOM ASH UTILIZATION

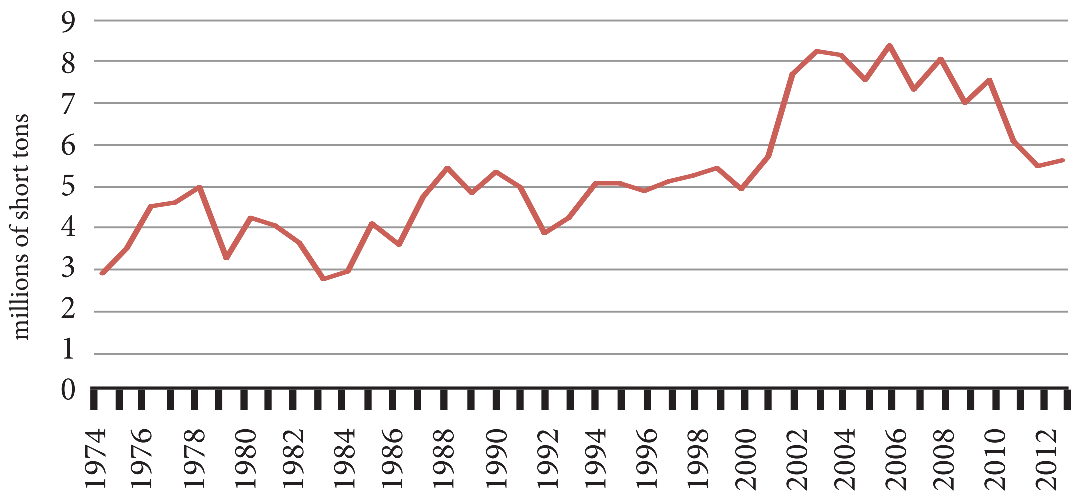
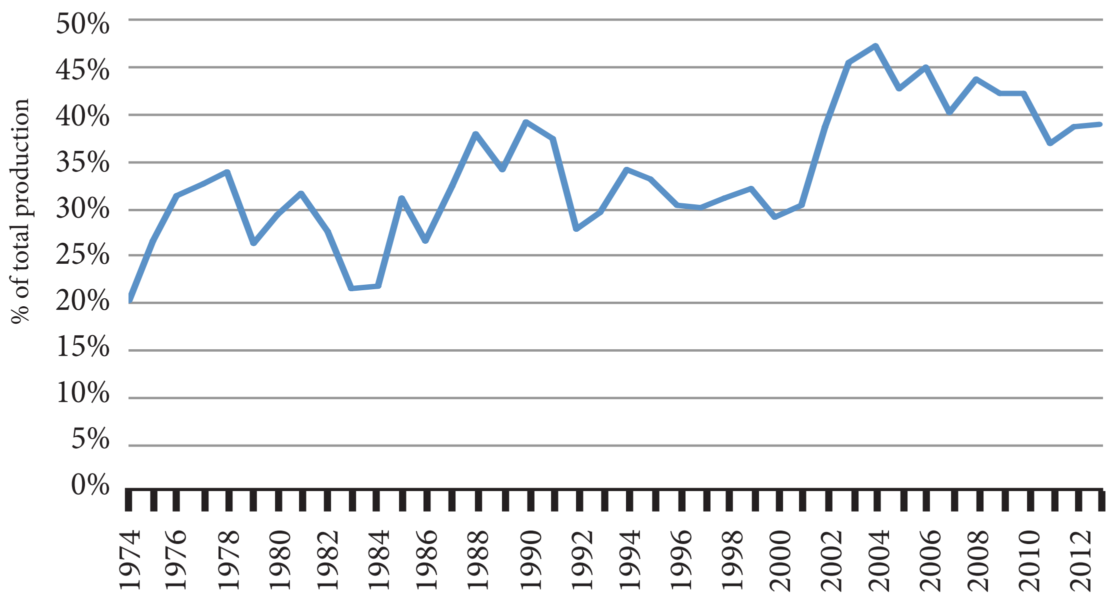


FIGURE 3-13: BOTTOM ASH UTILIZATION RATE



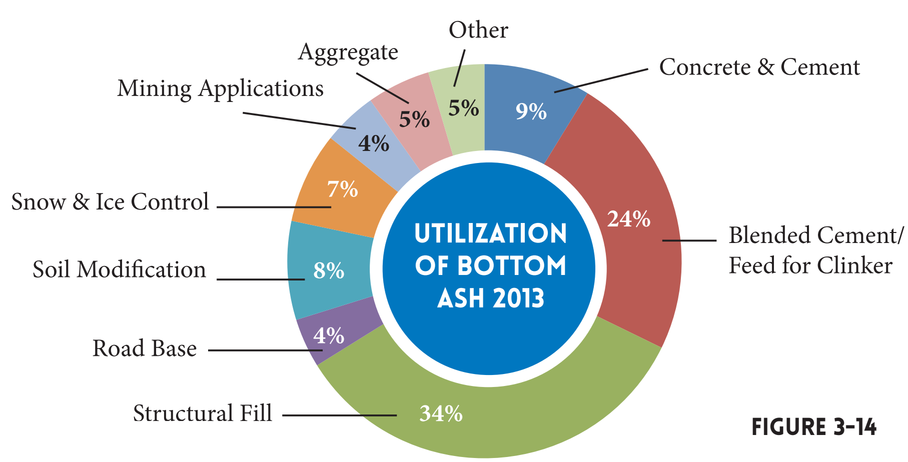


FIGURE 3-14

REGULATORY CERTAINTY & BOTTOM ASH UTILIZATION—1974 TO 2007

Bottom ash was one of the "four Bevill CCR wastes" along with fly ash, boiler slag and FGD materials, that was being considered a coal combustion residual under the RCRA and the Bevill Amendment exemption.[87]

The utilization of bottom ash grew at an average annual rate of two percent between 1974 and 1993, outpacing bottom ash production, which was fairly flat over the same time period, declining slightly from 14.3 million short tons in 1974 to 14.2 million short tons in 1993.

The utilization of bottom ash continued to grow at an average annual rate of two percent between 1993 and 2000, after the August 9, 1993 EPA Regulatory Determination that concluded bottom ash and CCPs should continue to be exempt from Subtitle C of the RCRA and not be classified as a hazardous waste.

Total bottom ash utilization grew from 4.2 million short tons in 1993 to 4.9 million short tons in 2000.

The Final Regulatory Determination issued by EPA on May 22, 2000 that retained the Bevill exemption for bottom ash ushered in a new era of regulatory certainty.

Between 2000 and 2008, the utilization of bottom ash grew at an average annual rate of six percent, growing from 4.9 million short tons to 8.0 million short tons. This increase in volume reflects higher demand for bottom ash as an input for blended cement and concrete and structural fills/embankments.

This growth occurred at a time when the real value of pavement work, which is a major end market for bottom ash in structural fills, actually declined slightly from $57.2 billion in work to $56.9 billion. U.S. production of ready-mixed concrete fell at an average annual rate of one percent between 2000 and 2008, and housing starts declined at an average annual rate of four percent. This points to the increased value of bottom ash as a less expensive substitute for traditional building materials, especially during a time when the construction markets are beginning to weaken.

Bottom ash utilization has declined at an average annual rate of seven percent between 2008 and 2013, falling from 8 million short tons to 5.6 million short tons in the environment of regulatory uncertainty.

GROWTH IN BOTTOM ASH UTILIZATION	
TIME PERIOD	AVERAGE ANNUAL GROWTH RATE
1974 to 1980	6.6%
1981 to 1990	3.1%
1991 to 2000	-0.1%
2000 to 2008	6.3%
2009 to 2013	-6.9%
Total for 1974 to 2013	**1.7%**

[87]EPA, June 21, 2010, Proposed Rule, "Hazardous and Solid Waste Management System; Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals From Electric Utilities." (http://www.epa.gov/epawaste/non-haz/industrial/special/fossil/ccr-rule/ccr_propsd_rul.htm)

BOILER SLAG UTILIZATION

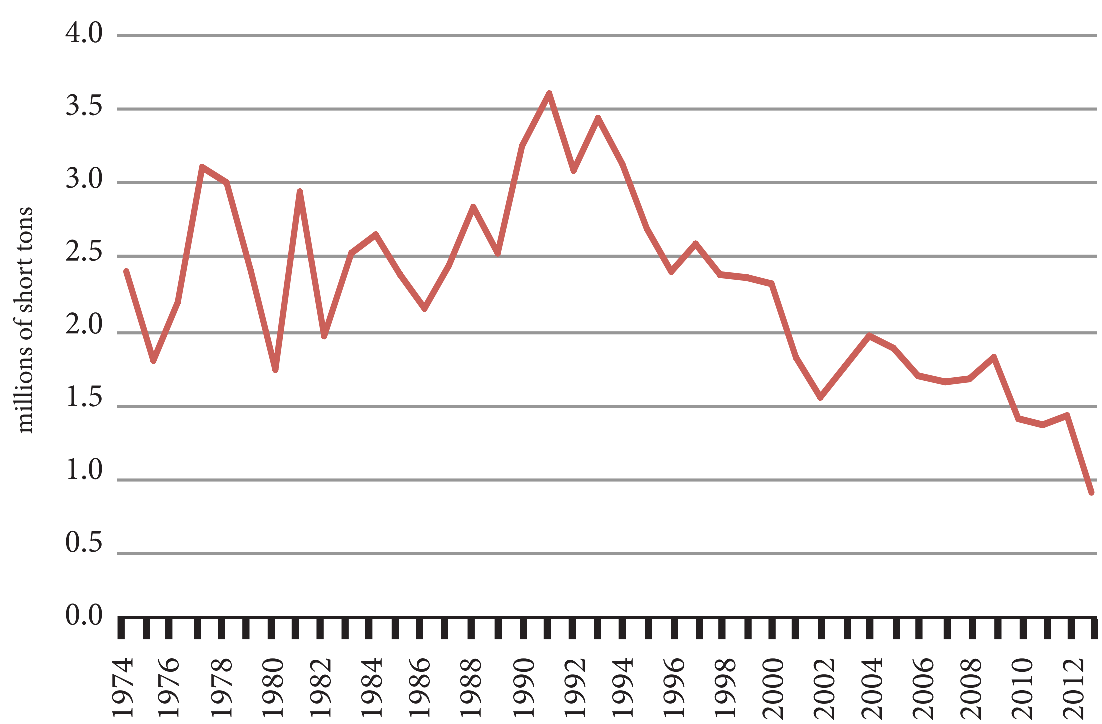
The utilization of boiler slag has declined at an average annual rate of 2.5 percent, falling from 2.4 million short tons in 1974 to 909,066 short tons in 2013. Despite this decline, the utilization rate of boiler slag remained high compared to other CCPs, averaging 70 percent over the same time period.

In 2013, 98 percent of the boiler slag utilized was for roofing granules or blasting grit. The use of boiler slag in the cement and concrete industry, as well as embankments, road base or subbase, is limited.[88]

The decline in boiler slag utilization is due in large part to a decline in production and availability. Boiler slag production peaked at 6.2 million short tons in 1993 and fell sharply to 3.8 million short tons in 1994 as more wet-bottom boilers began to be retired.

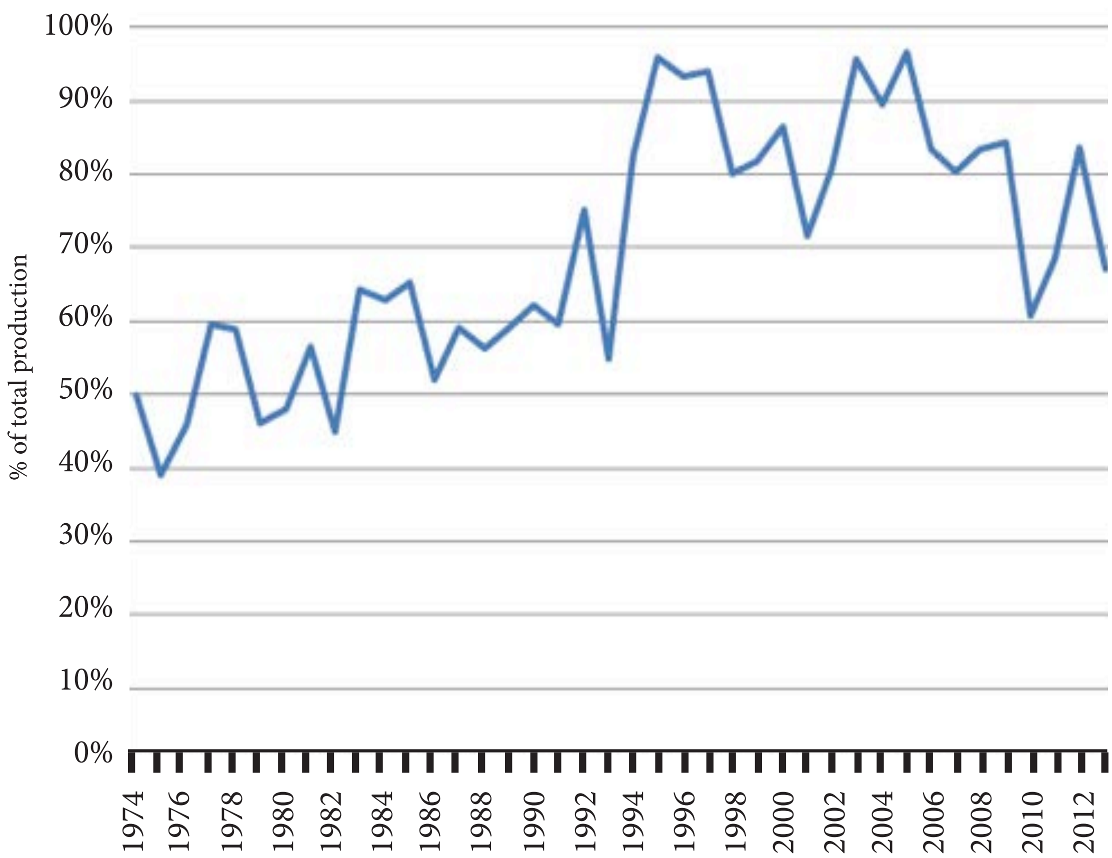
So although boiler slag continues to be utilized at a high rate after that time, the overall utilization has fallen in line with production. Overall, boiler slag is a unique product that is used in a niche market. The future availability and utilization of boiler slag is questionable given the continued replacement of older, wet bottom boilers that produce the material.

FIGURE 3-15: BOILER SLAG UTILIZATION



[88]R.C. Joshi and R. P. Lohita. Fly ash in concrete: production, properties and uses. No. 2. CRC Press, 1997. (https://books.google.com/books/about/Fly_Ash_in_Concrete.html?id=8ITxm7zHul4C)

FIGURE 3-16: BOILER SLAG UTILIZATION RATE



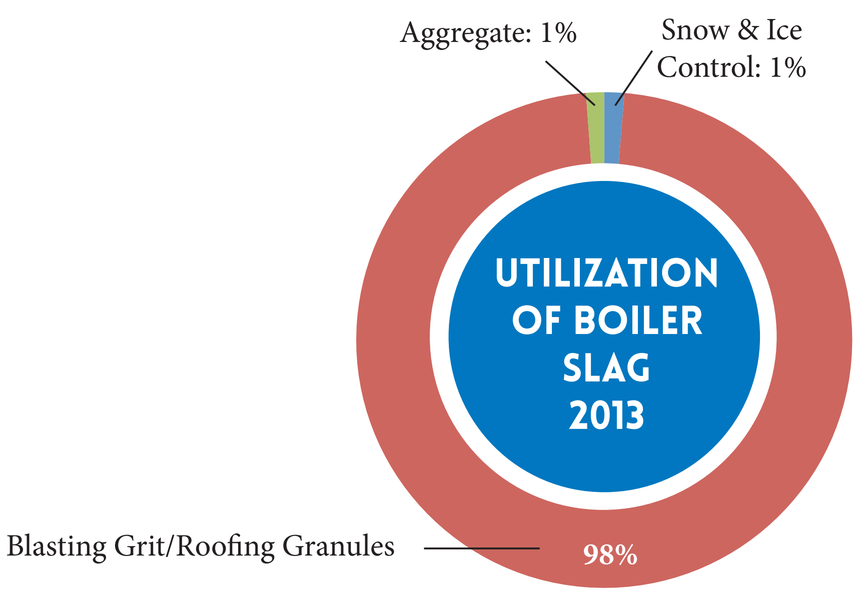


FIGURE 3-17

FBC ASH UTILIZATION

The utilization of FBC ash has increased from 953,410 short tons in 2002 to 8.8 million short tons in 2013. In 2013, over 95 percent of the FBC ash utilized was for mining applications. The remaining FBC ash was used in soil modification and stabilization, waste stabilization and aggregates.

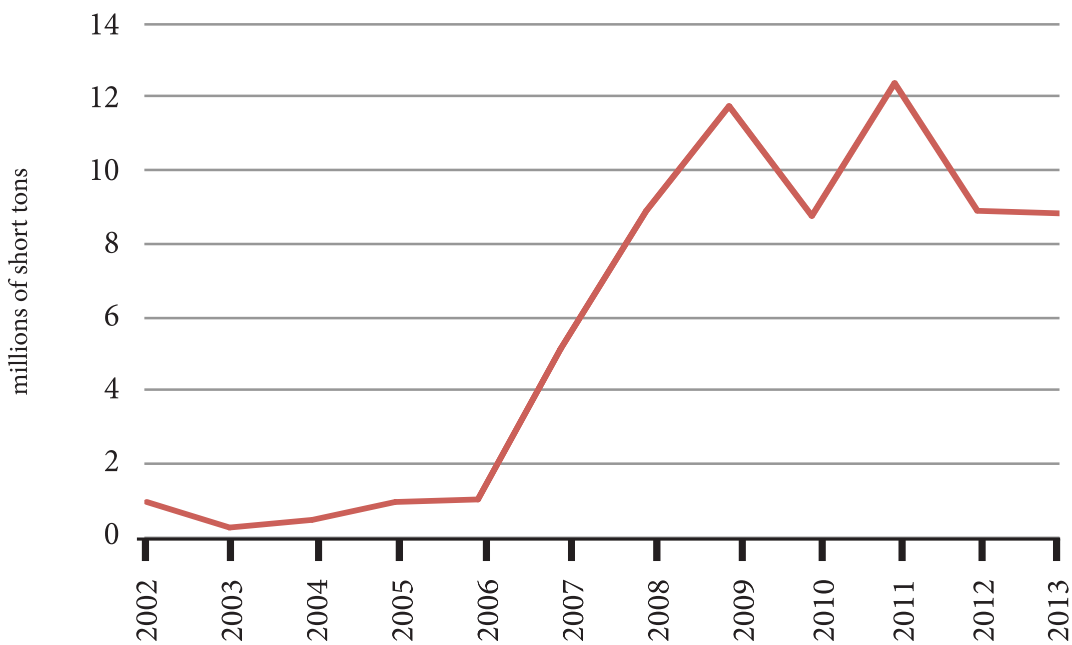
In 2007, ACAA expanded the production and use survey to include data from the ARIPPA, a group of non-utility alternative energy electric power generation stations that burn waste coal using FBC technology.

FBC ash provides a number of environmental and economic benefits when used in mines, and has been placed in at least 20 sites across the country.[89]

Most FBC ash has been used in surface mines to help restore the land to beneficial use. In several states FBC ash has also been used to fill underground mines, providing structural support.[90]

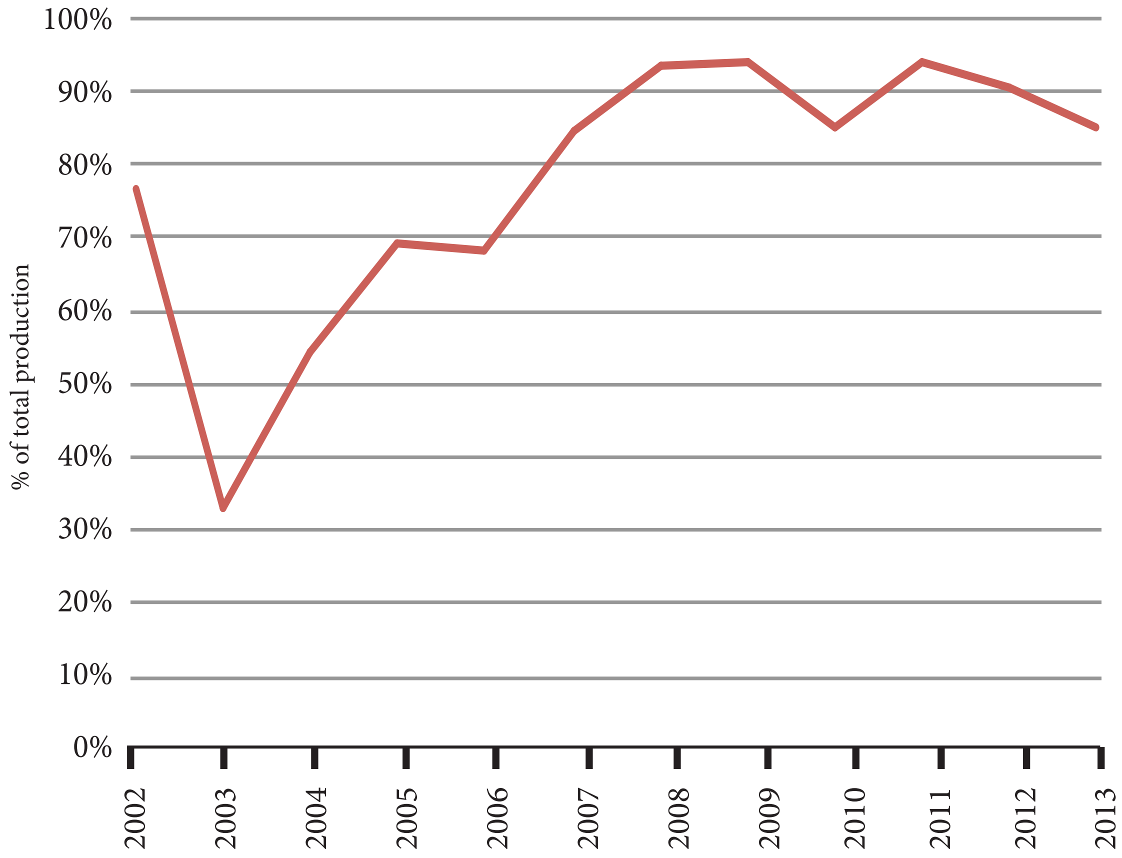
In the case of Clinton County, Pennsylvania, the use of FBC ash had a positive impact on the water quality. The alkaline FBC ash neutralized the acidic waters, resulting in "precipitous decreases in arsenic, cadmium, and aluminum concentrations..."[91]

FIGURE 3-18: FBC ASH UTILIZATION



[89]Ishwar P. Murarka and Jim Erickson. "Use of coal combustion products in mine-filling applications: a review of available literature and case studies." (2006). (http://wvwri.org/wp-content/uploads/2012/05/99-EC-W05.pdf)
[90]Ibid.
[91]Ibid.

FIGURE 3-19: FBC ASH UTILIZATION RATE



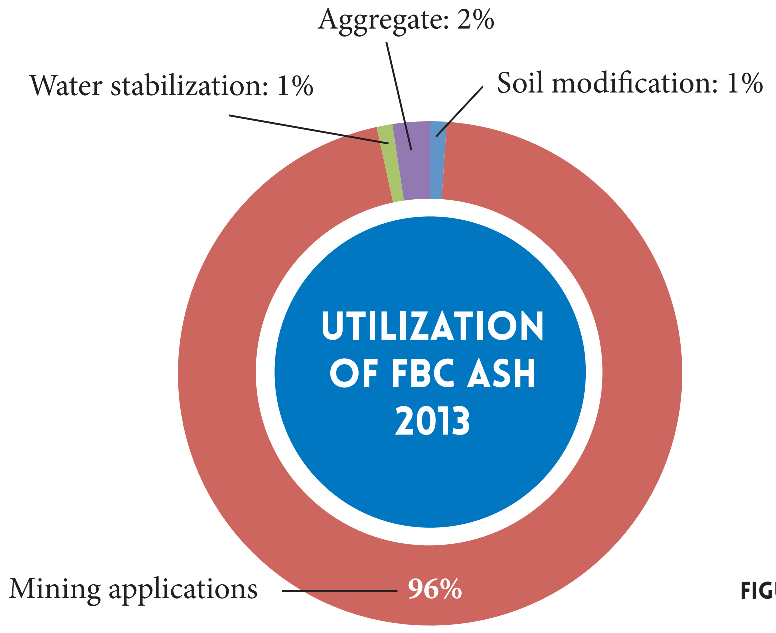


FIGURE 3-20

REGULATORY UNCERTAINTY AND CCP UTILIZATION

On December 22, 2008, a containment dike at a Kingston, Tennessee power plant's coal ash disposal facility failed, flooding more than a billion gallons of ash slurry into an area of 300 acres. Following the incident, coal ash disposal received renewed interest from Congress, which held several hearings on the issue.

The EPA looked for ways to obtain federal RCRA jurisdiction over coal ash disposal and discussed reversing the 2000 Final Regulatory Determination, possibly classifying coal ash as a hazardous waste under Subtitle C. On June 21, 2010, EPA published a proposed rule to regulate fly ash and other CCPs for the first time under either Subtitle C or Subtitle D of RCRA. The rule would not be finalized until December 19, 2014, resulting in six years of uncertainty about the status of fly ash, bottom ash, FGD material and other CCPs as a nonhazardous waste under RCRA Subtitle D, as clarified in the exemptions of the Bevill Amendment.

In October 2010, the EPA Office of Inspector General published a review of the agency's Coal Combustion Products Partnership (C2P2) website, concluding that it conflicted with agency policies and positions as proposed in the proposed rule. The C2P2 program was created in 2001 by the EPA's Resource Conservation Challenge voluntary program to actively promote the beneficial use of CCPs. The removal of the website was another indicator over the questionable status of coal ash's classification as a hazardous material, further contributing to market uncertainty.

EPA noted that the website "presented an incomplete picture regarding actual damage and potential risks that can result for large-scale placement" and the site "gave the appearance that EPA endorses commercial products."[92] The report also noted the December 2008 incident in Kingston, Tennessee as part of the background on the issue.

Revisiting the classification of fly ash under RCRA Subtitle C or Subtitle D created a new level of uncertainty, putting a damper on the utilization of fly ash and other CCPs.

The downturn in CCP utilization during this uncertainty coincided with the U.S. recession from December 2007 to June 2009. The contraction in U.S. construction market activity impacted overall demand for construction materials, including ready-mixed concrete, but this was not solely responsible for the sharp decline in CCP utilization.

Historically, the use of CCPs has grown during economic downturns as concrete and other construction material producers turn to less expensive products to save on overall costs. Typically, CCPs are less expensive than the materials they replace.

Bottom ash utilization increased following the beginning of every U.S. recession since 1973, including the most recent economic downturn.

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[92]EPA Office of Inspector General. "Early Warning Report: Website for Coal Combustion Products Partnership Conflicts with Agency Policies." Report No. 11-P-0002, October 13, 2010 (http://www.epa.gov/oig/reports/2011/20101013-11-P-0002.pdf)

Fly ash utilization increased in three of the last five U.S. recessions:

- **NOVEMBER 1973–MARCH 1975.** Total tons of utilized fly ash increased steadily from 3.4 million tons in 1974, during the height of the recession, to 4.5 million short tons in 1975 and 5.7 million short tons in 1976.

- **JULY 1990–MARCH 1991.** Fly ash utilization, which was 10.2 million short tons in 1989, increased in both 1990 and 1991, even as the total U.S. production of ready-mix concrete declined. Total volumes of ready-mixed concrete production would not return to the 1989 pre-recession levels until 1994.

- **MARCH 2001–NOVEMBER 2001.** Fly ash utilization grew from 20 million short tons in 2000 to 22 million short tons in 2001, and continued to grow steadily over the next seven years. U.S. production of ready-mixed concrete grew in 2001, but dropped in 2002 and 2003, gradually returning to pre-recession levels in 2004.

Fly ash utilization declined during the double-dip recession that occurred from January to July of 1980 and July 1981 to November 1982 (counted as one recession for this analysis), but began to recover before the U.S. ready-mixed concrete market. Total fly ash utilized dropped from 10 million short tons in 1979 to 6.4 million short tons in 1980. The market began to recover, increasing to 9.4 million short tons in 1981 before falling back to 8 million short tons in 1982. In 1984, the total volumes of fly ash utilized recovered to pre-recession 1979 levels, after nearly five years. During the recession total cubic meters of U.S. ready-mixed concrete produced declined, climbing back to pre-recession levels in 1985, one year after the fly ash market.

In the most recent recession, which began in December 2007 and ended June 2009, fly ash utilization declined slightly in 2007 and 2008, falling from 32.4 million short tons in 2006 to 31.6 million short tons in 2007 (a decline of 2.5 percent) and 30.1 million short tons in 2008 (a further decline of 4.7 percent).

Meanwhile, the U.S. production of ready-mixed concrete had started to fall even before the official start of the recession, declining from 458.36 million cubic yards in 2005 to 456.8 million cubic yards in 2006 and 414.6 million cubic yards in 2007.

It was not until 2009 that fly ash utilization fell to 24.7 million short tons, a decline of 18 percent from 2008 levels—one full year after the recession began in December 2007. Although total volumes of ready-mixed concrete in 2013 are still below their pre-recession levels, the market bottomed out in 2010 and production has increased annually since that time. Meanwhile, fly ash utilization continues to remain depressed.

Given historical patterns, we would expect fly ash utilization to show signs of recovery before the turnaround in the ready-mixed concrete market. The sharp drop in fly ash utilization in 2009 and the continued low levels of activity despite the uptick in ready-mixed concrete production point to another factor impacting the market—the uncertainty over the regulatory environment.

Bottom ash utilization in the most recent recession, which began in December 2007 and ended June 2009, actually grew in 2008 to eight million short tons from 7.3 million short tons in 2007.

Total utilization dropped sharply to seven million short tons in 2009, after the Kingston, Tennessee accident and declined further to 5.6 million short tons in 2013.

Given the historical relationship between bottom ash utilization and the overall U.S. economy, we would have expected the utilization in 2013 to be higher than pre-recession levels.

Regulatory uncertainty has not had a significant impact on the utilization of FGD material because of the close distribution ties between suppliers and wallboard manufacturers.

There are currently a few large, vertically integrated companies that mine gypsum and manufacture wallboard and related products, with seven companies producing 62 percent of U.S. crude gypsum.[93]

FIGURE 4-1: ANNUAL PERCENT CHANGE IN U.S. FLY ASH UTILIZATION VERSUS PRE-RECESSION LEVELS

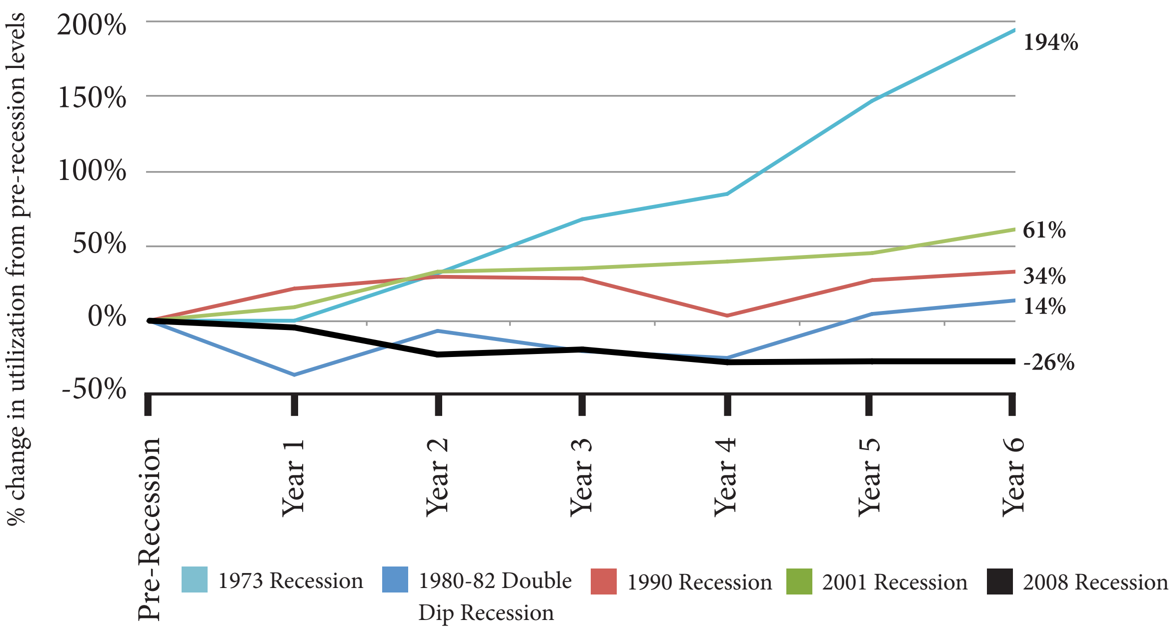
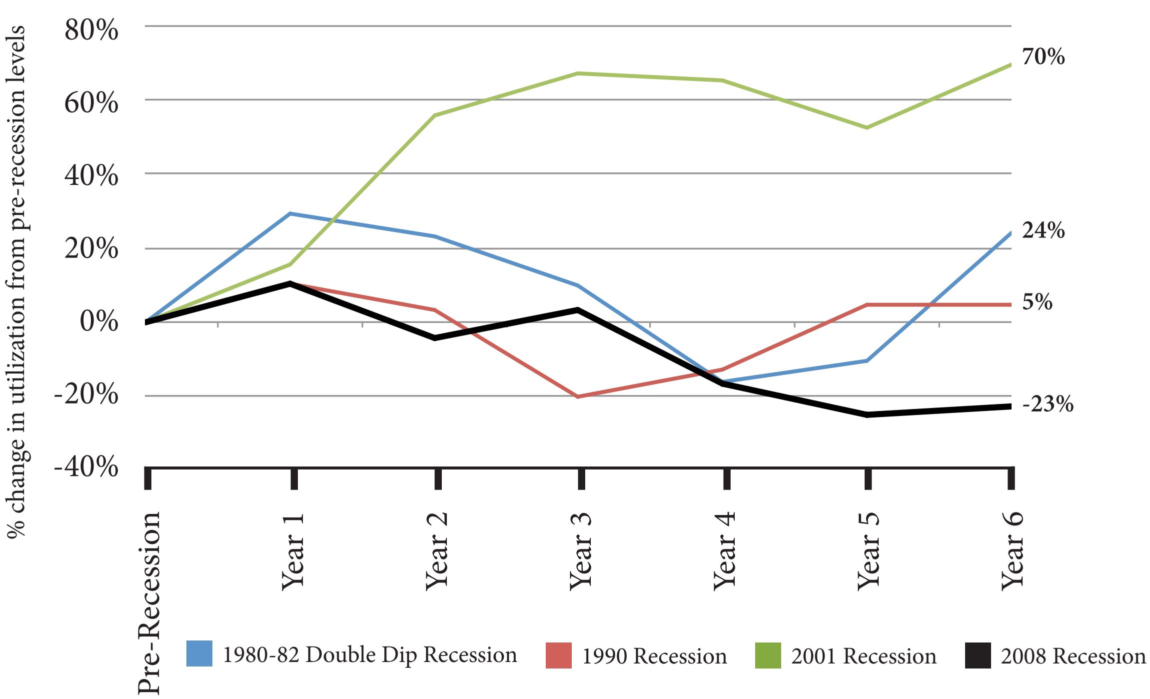


FIGURE 4-2: ANNUAL PERCENT CHANGE IN U.S. BOTTOM ASH UTILIZATION VERSUS PRE-RECESSION LEVELS



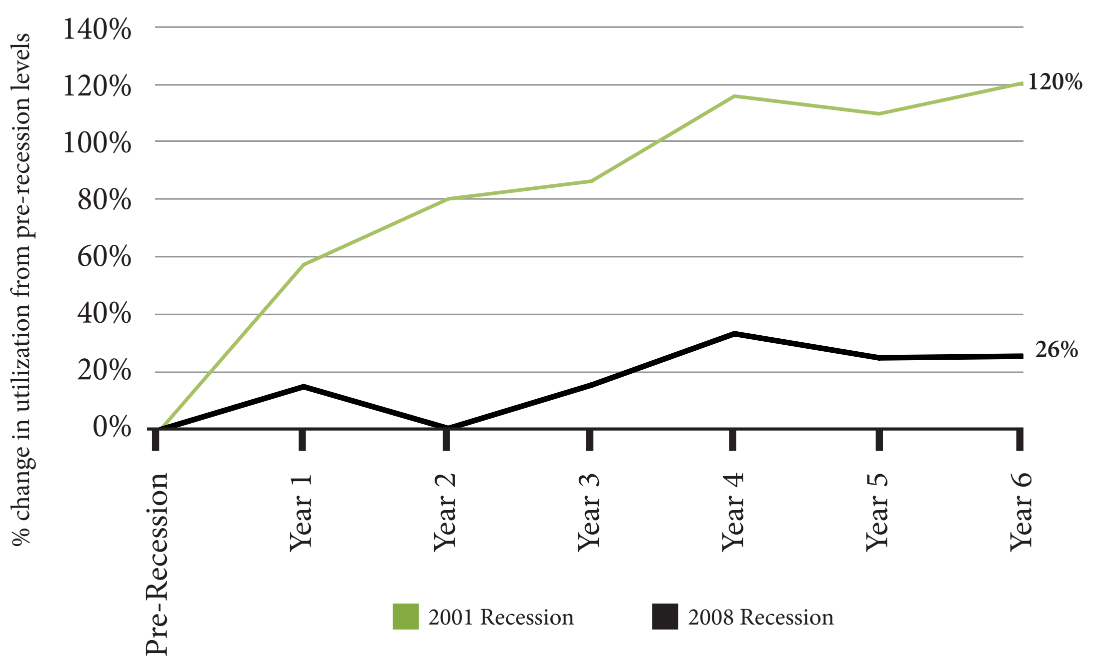
[93]U.S. Geological Survey. "Gypsum." Minerals Yearbook (2012) (http://minerals.usgs.gov/minerals/pubs/commodity/gypsum/)

With close commercial ties and manufacturing facilities located near plants that supply FGD material, these firms are less impacted by the regulatory uncertainty surrounding the CCP market compared to fly ash.

This means that the utilization of FGD material has been impacted by larger market supply and demand and new areas for beneficial use.

FIGURE 4-3: ANNUAL PERCENT CHANGE IN U.S. FGD MATERIAL UTILIZATION VERSUS PRE-RECESSION LEVELS

FIGURE 4-4: ANNUAL PERCENT CHANGE IN U.S. FGD MATERIAL UTILIZATION VERSUS PRE-RECESSION LEVELS FOR 2001 AND 2008



MAJOR MARKETS FOR THE BENEFICIAL USE OF CCPs

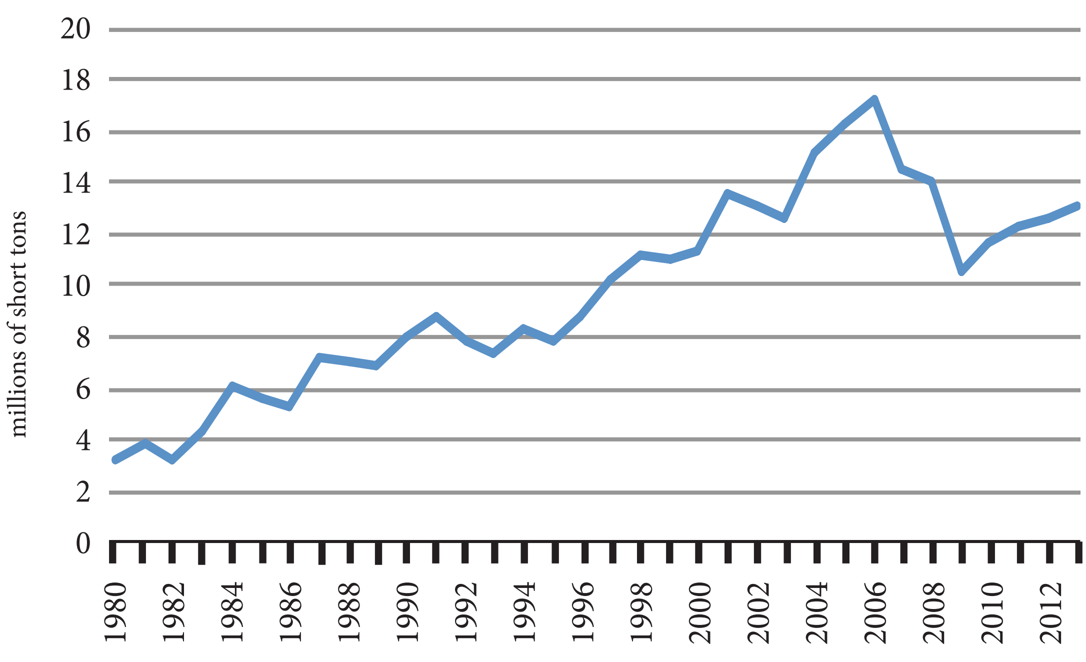
CEMENT AND CONCRETE PRODUCTS

The beneficial use of CCPs as an input for cement and concrete products has historically been one of the primary uses of CCPs. Fly ash, the largest volume CCP, is a "pozzolan" that when mixed with calcium hydroxide produced during cement hydration, takes on many of the same properties as cement. Thus utilizing fly ash with cement in concrete mixtures produces concrete that is stronger, more durable, easier to work with, and is more economical.

Some of the key insights into this end use market:

- A total of 3.2 million short tons CCPs were utilized for cement and concrete products in 1980. This grew to 13.1 million short tons in 2013, an increase of 306 percent.
- The use of CCPs in this industry grew at an average annual rate of 4.3 percent between 1980 and 2013.
- Fly ash is the main type of CCP used, accounting for 94 percent of the total amount of CCPs utilized for concrete and cement products in 2013.
- The overall use of CCPs in the cement and concrete market is closely correlated with total U.S. ready-mixed concrete production and consumption, which is tied to the U.S. economy and construction markets.

FIGURE 5-1: CCPs UTILIZED FOR CONCRETE AND CEMENT PRODUCTS



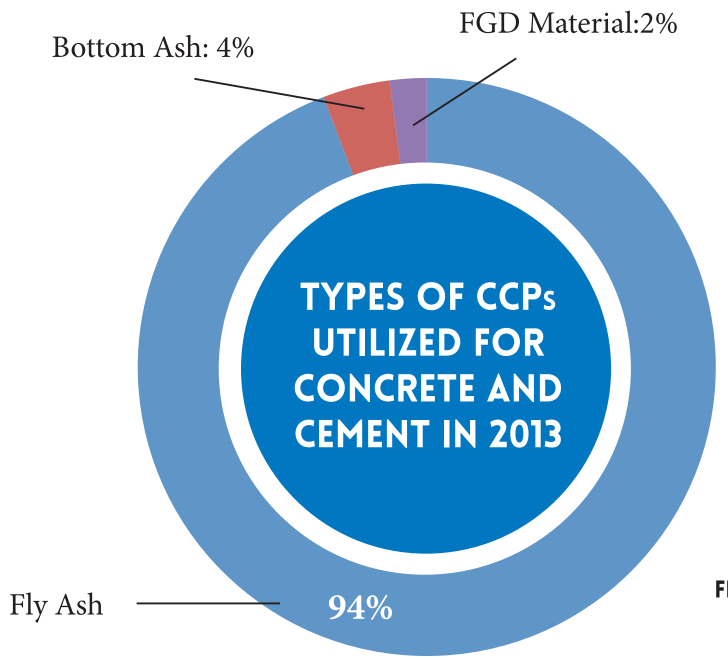


FIGURE 5-2

FIGURE 5-3: OVERALL DEMAND FOR READY-MIX CONCRETE IS A MAJOR DRIVER OF CCPs UTILIZED FOR CONCRETE/CEMENT

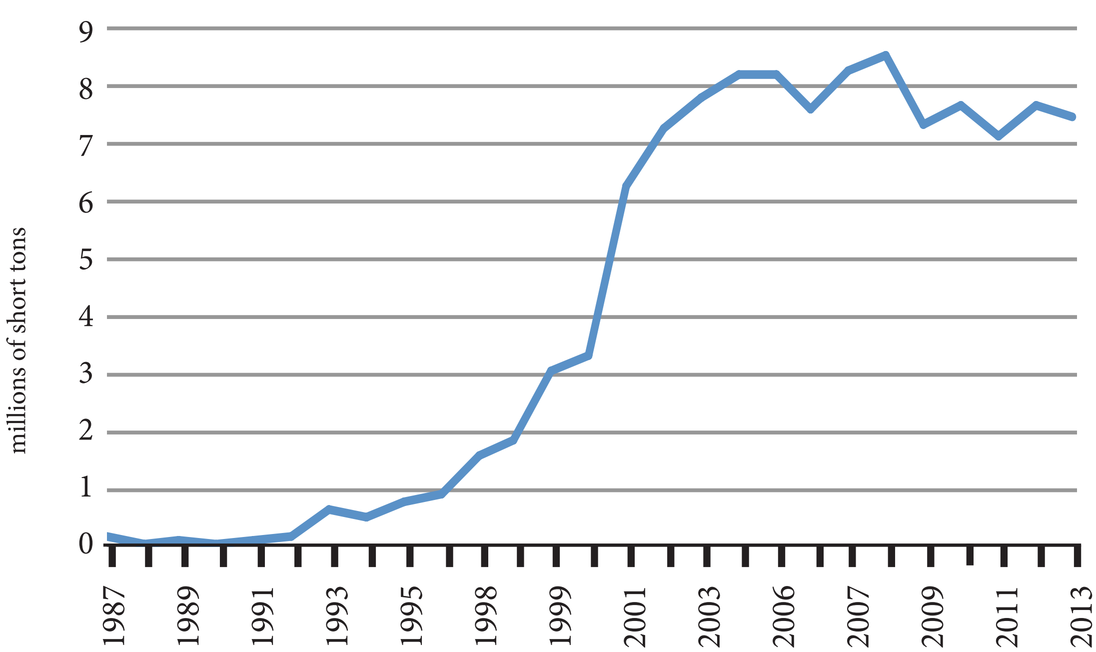
GYPSUM PANEL PRODUCTS

Over forty percent of the gypsum panel products manufactured in the United States, including wallboard, ceiling board and backing board, contain CCPs.[94] The primary type of coal ash used for this market is dry FGD material, either in the form of dry scrubber material or FGD gypsum, a fine particulate matter. Wet FGD material can also be used in making wallboard after it has dried out.

ACAA began collecting data on the beneficial use of CCPs for gypsum panel products in 1987. Some of the key insights into this end use market:

- Just over 157,000 tons of CCPs were used for gypsum panel products in 1987. This grew to 7.4 million short tons in 2013.
- The use of CCPs in this industry grew at an average annual rate of 16 percent between 1987 and 2013.
- FGD gypsum material and FGD material from wet and dry scrubbers were the only CCPs utilized for gypsum panel products in 2013. Historically, small amounts of fly ash, bottom ash and even boiler slag have been recorded in the ACAA data.
- An estimated 90 percent of domestic gypsum consumption is accounted for by manufacturers of wallboard and plaster products, according to the U.S. Geological Service. The demand for gypsum is correlated with the strength of the construction industry.

FIGURE 5-4: CCPs UTILIZED FOR GYPSUM WALLBOARD AND OTHER MATERIALS



[94] "Beneficial Use of Coal Combustion products An American Recycling Success Story." Ash at Work 1 (2013). (http://www.acaa-usa.org/Portals/9/Files/PDFs/ASH01-2013.pdf)

FIGURE 5-5: SYNTHETIC GYPSUM AS PERCENT OF TOTAL GYPSUM PRODUCTION

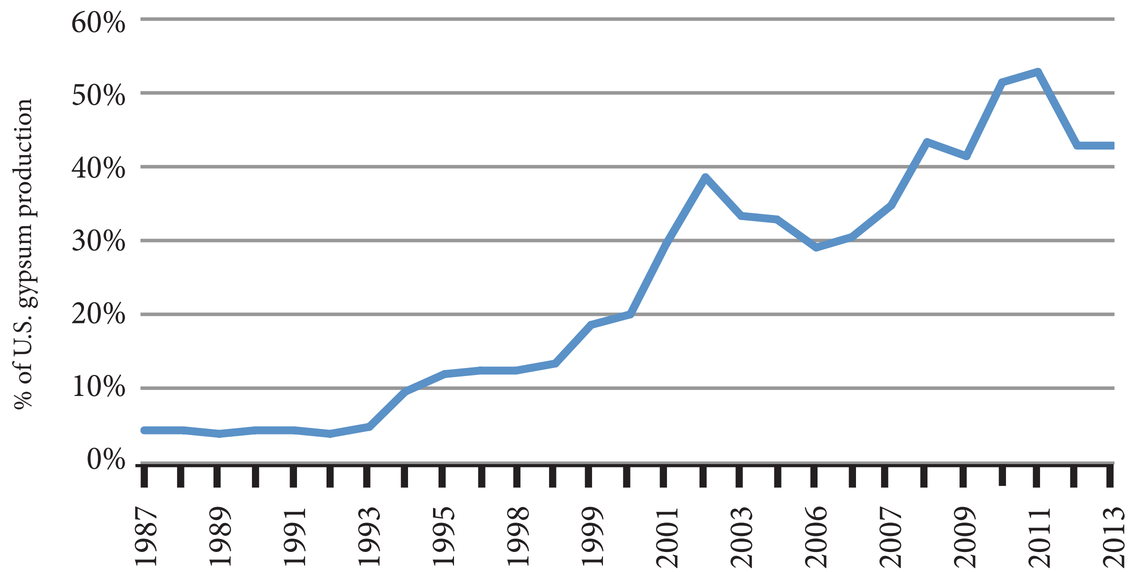
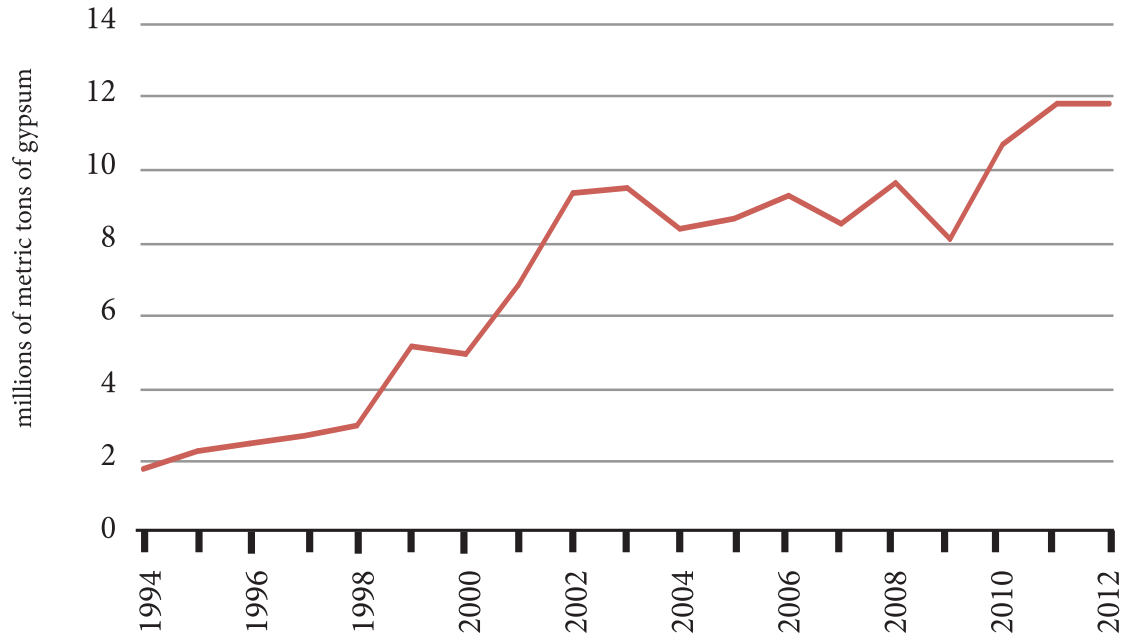


FIGURE 5-6: OVERALL U.S. SALES OF SYNTHETIC GYPSUM



MINING APPLICATIONS

The mining industry uses CCPs in a variety of ways, including as a fill material for mine sites to restore original land contours. In Pennsylvania, CCPs are used as a low permeability material to pave pit floors, cap materials, encapsulate rejected material and even cap entire sites.[95] A study by the National Academy of Sciences recommended that placing CCPs in mines as part of the reclamation process was a "viable option" for utilizing coal ash material.[96]

Some highlights of the use of CCPs in mining applications:

- A total of 160,000 short tons of CCPs were utilized for mining applications in 1980. This increased to over 1.1 million short tons in 2006. The average annual growth in the utilization of CCPs by the mining industry was 9.3 percent over that 26 year period.
- In 2007, ACAA began including data on the beneficial use of FBC ash for mining purposes collected by ARIPPA, a Pennsylvania association of 14 power plants that utilize waste coal for fuel.
- With the new data, the total beneficial use of CCPs for mining applications was 6.7 million short tons in 2007.
- Average annual growth in the use of CCPs in this area grew at an average annual rate of 11.2 percent since 2007, reaching 12.7 million short tons in 2013.
- Historically, fly ash was the main type of CCP utilized for mining applications, accounting for 75 percent of the market in 1980.
- With the inclusion of the ARIPPA data, FBC Ash now accounts for over 66 percent of the CCPs utilized for mining applications.
- Regardless of the change in methodology, the beneficial use of CCPs for mining applications has been growing since 1980.

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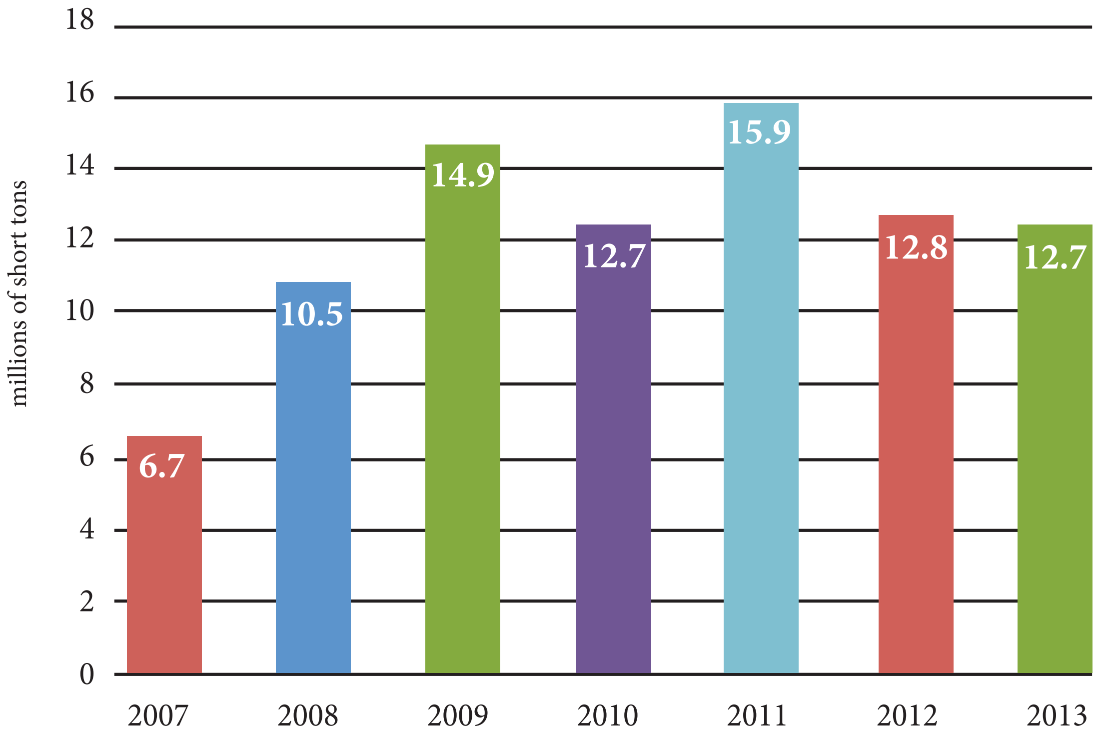
[95]Dalberto, et al. "Overview: Coal Ash Beneficial Use and Mine Land Reclamation." Pennsylvania Department of Environmental Protection (http://www.depweb.state.pa.us/portal/server.pt/document/1239456/chapter_1_final_pdf.)
[96]National Research Council. Managing Coal Combustion Residues in Mines. The National Academies Press. Washington, DC. 228 p. (2006). (http://www.nap.edu/catalog/11592/managing-coal-combustion-residues-in-mines)

FIGURE 5-7: CCPs RECYCLED FOR MINING APPLICATIONS



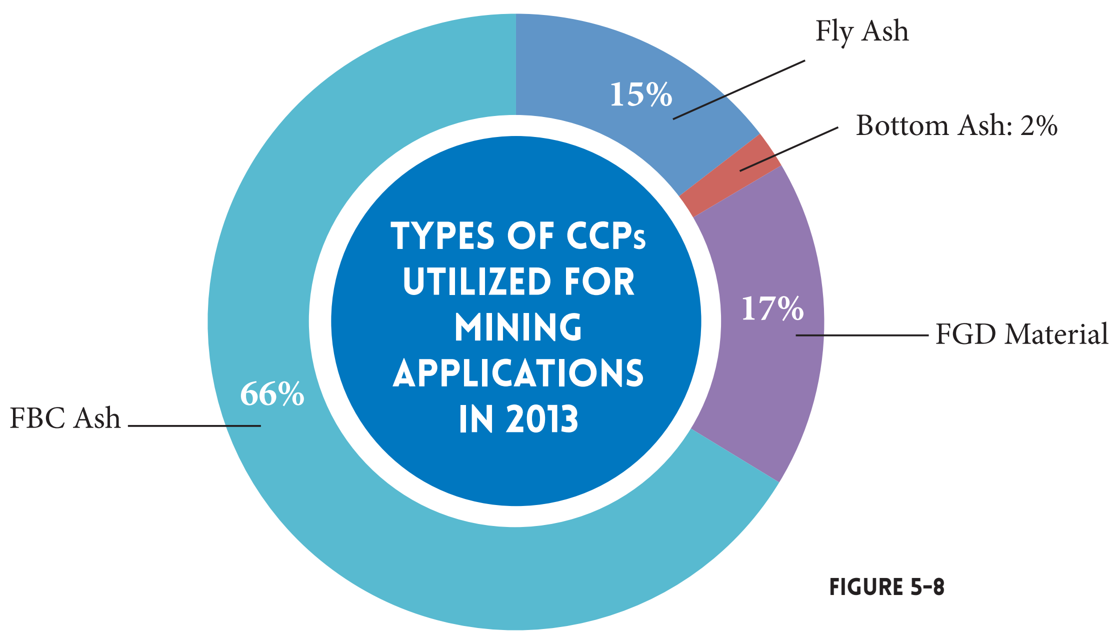


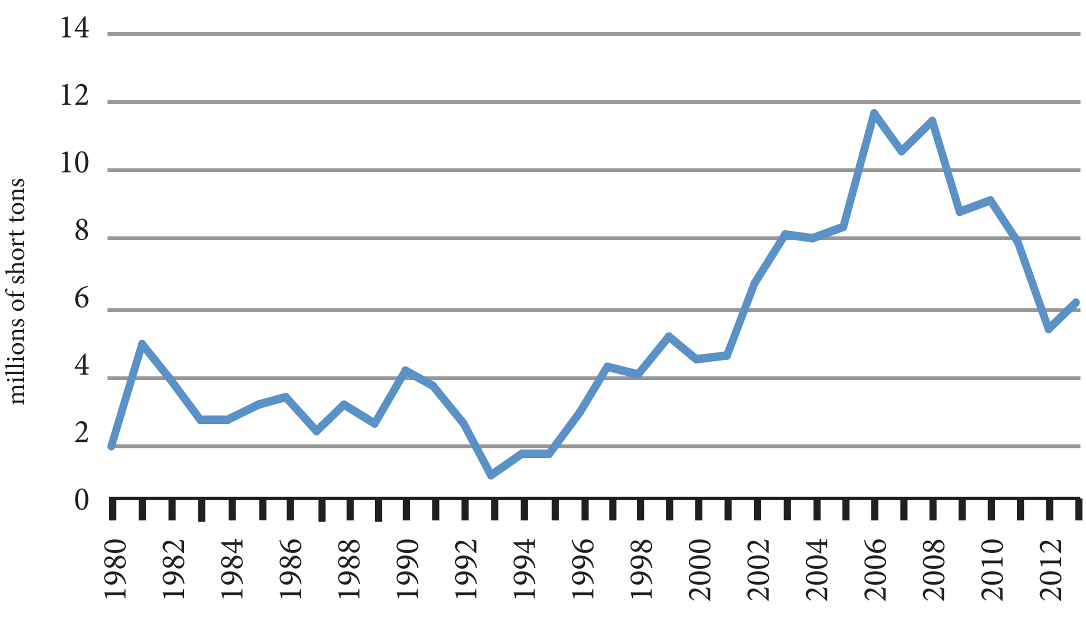
FIGURE 5-8

STRUCTURAL FILLS AND EMBANKMENTS

CCPs improve the strength and durability of structural fills and embankments, creating a stable base for construction projects, trench filling and other excavations, especially for road construction. Some of the beneficial engineering properties include its moisture-density relationships, the particle size distribution, sheer strength, bearing strength, permeability and consolidation characteristics.[97]

- Just under 2.0 million short tons of CCPs were utilized for structural fills and embankments in 1980. This grew to 6.2 million short tons in 2013, an increase of 209 percent.
- The use of CCPs in this industry grew at an average annual rate of 3.5 percent between 1980 and 2013.
- Fly ash is the main type of CCP used, accounting for 49 percent of the total amount of CCPs utilized for structural fills and embankments in 2013. This is compared to 50 percent in 1980. Bottom ash accounted for 31 percent of the utilized material in 2013, down from 41 percent in 1980.
- The highway and bridge construction industry is one of the main sectors using CCPs for structural fills and embankments. The downturn in this beneficial use since 2008 mirrors the decline in the real value of U.S. pavement work over the same time period.

FIGURE 5-9: CCPs UTILIZED FOR STRUCTURAL FILLS AND EMBANKMENTS



[97]Warren H. Chesner, Robert J. Collins, and M. H. MacKay. User guidelines for waste and by-product materials in pavement construction. No. FHWA-RD-97-148. 1998. (http://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/intro.cfm)

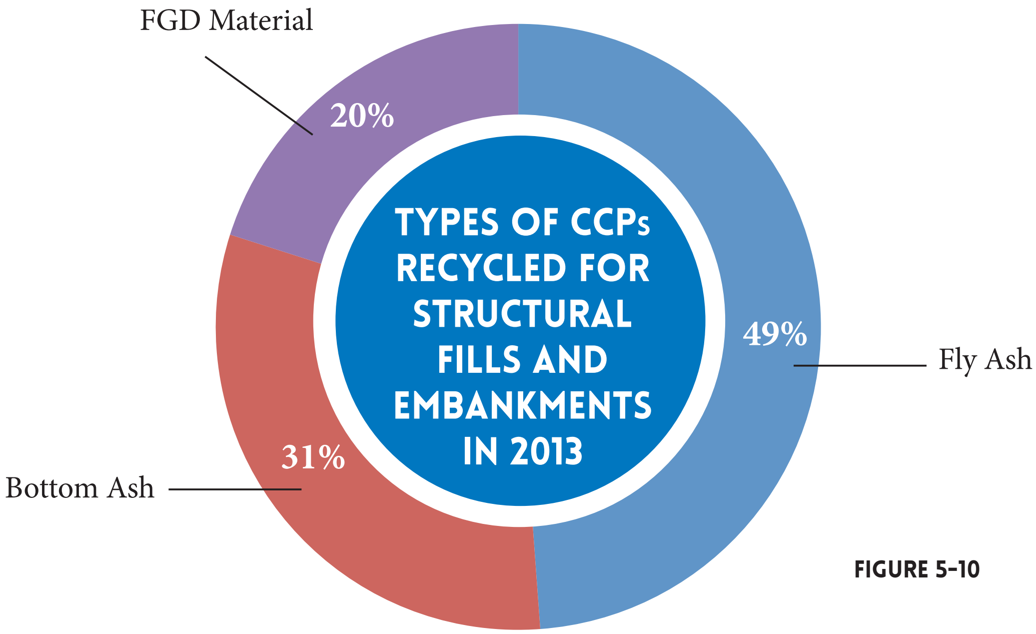
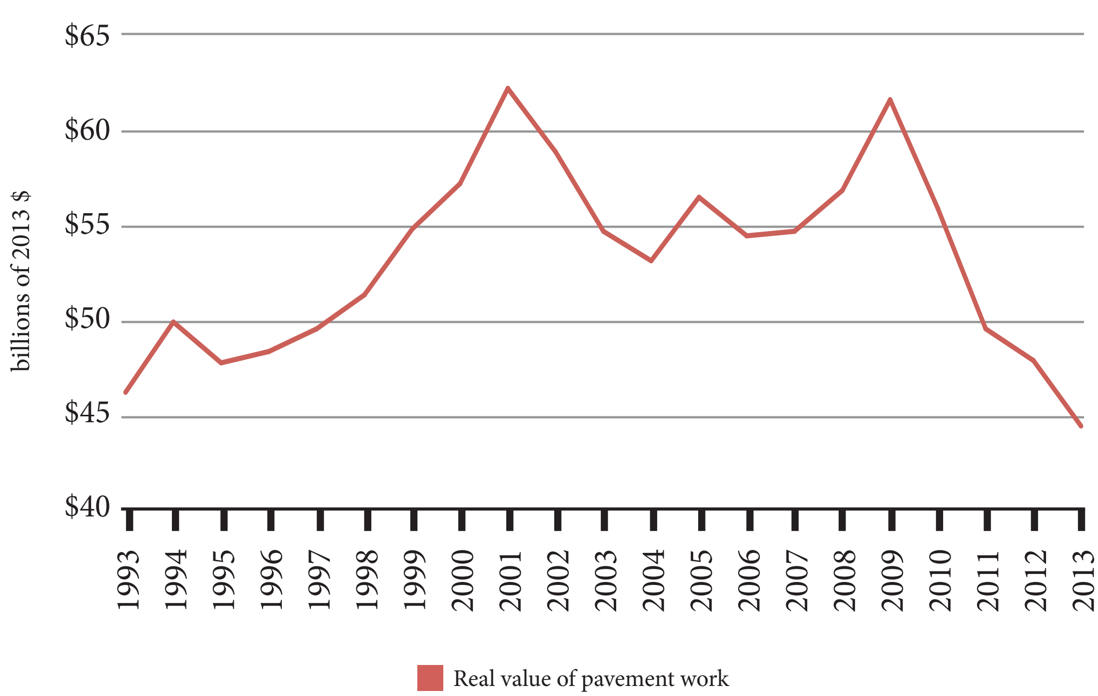


FIGURE 5-10

FIGURE 5-11: HIGHWAY CONSTRUCTION IS A MAJOR END MARKET FOR THE BENEFICIAL USE OF CCPs IN STRUCTURAL FILLS AND EMBANKMENTS



ADDITIONAL BENEFICIAL USE MARKETS

Other beneficial use markets, including agriculture, aggregates, oil field services, blended cement/clinker feed and waste stabilization, utilize significant volumes of CCPs.

AGRICULTURE: ACAA began collecting data on the beneficial use of CCPs for agriculture in 1995. This market had grown from 14,681 short tons in 1995 to 598,105 short tons in 2013. Although it is just one percent of the total utilization of CCPs, the increase in use has been significant. The major CCP types utilized for agriculture are FGD, fly ash and bottom ash.

BLENDED CEMENT/FEED FOR CLINKER: Since 1999, the use of CCPs for this industry has grown from 1.4 million short tons to 4.8 million short tons, an increase of 235 percent. The amount of CCPs utilized for blended cement and feed for clinker were nine percent of total utilization reported by ACAA in 2013.

WASTE STABILIZATION/SOLIDIFICATION: This end use market has grown from utilizing 400,000 short tons of CCPs in 1991 to over 2.2 million short tons in 2013, an increase of 447 percent. This beneficial use represented four percent of total CCP utilization in 2013.

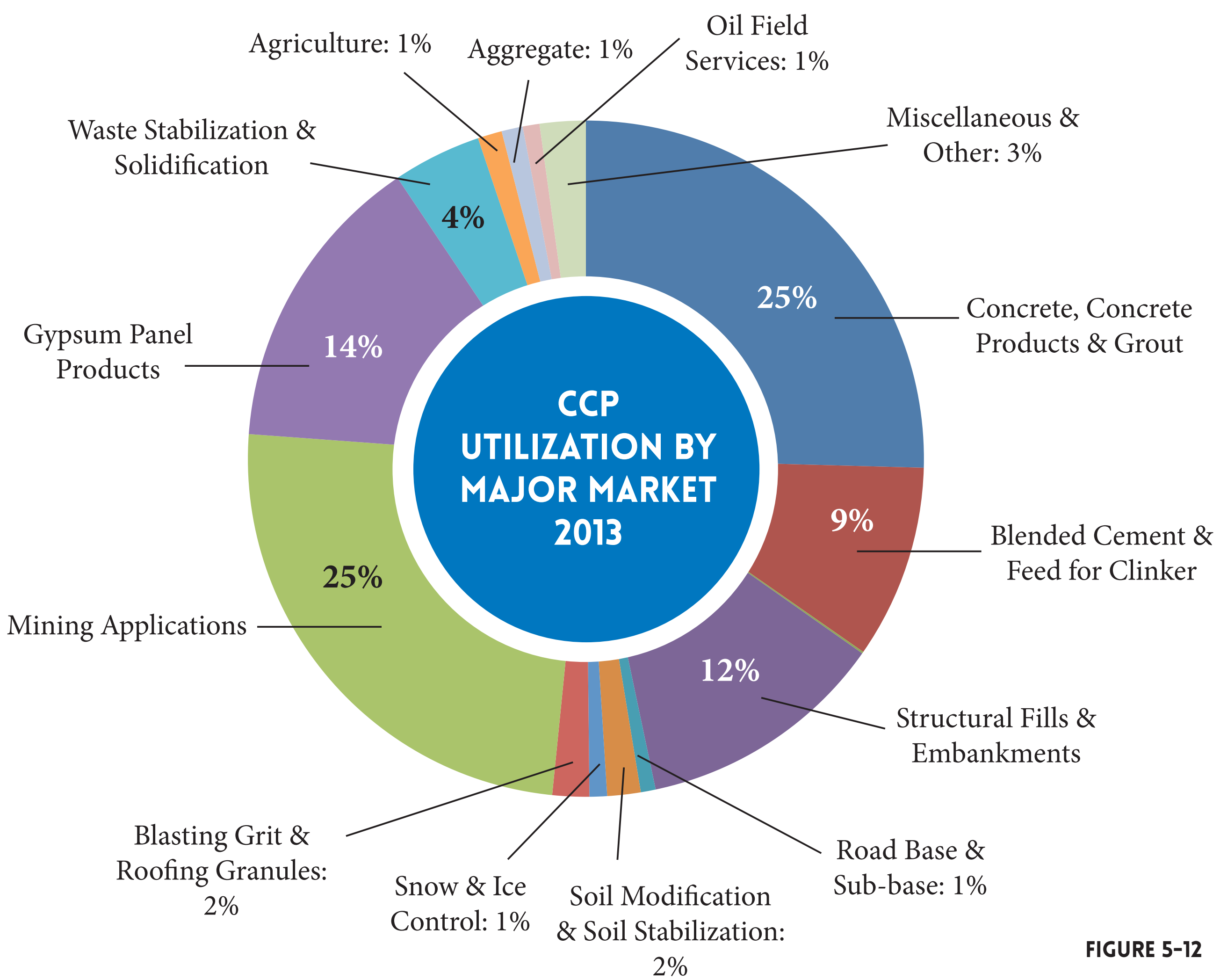


FIGURE 5-12

APPENDIX: HISTORICAL DATA TABLES

CCP TOTAL PRODUCTION (IN SHORT TONS)

YEAR	FLY ASH	BOTTOM ASH	BOILER SLAG	ALL FGD MATERIALS	FBC ASH	TOTAL CCPs
1974	40,400,000	14,300,000	4,800,000			59,500,000
1975	42,300,000	13,100,000	4,600,000			60,000,000
1976	42,800,000	14,300,000	4,800,000			61,900,000
1977	48,500,000	14,100,000	5,200,000			67,800,000
1978	48,300,000	14,700,000	5,100,000			68,100,000
1979	57,500,000	12,500,000	5,200,000			75,200,000
1980	48,310,000	14,450,000	3,640,000			66,400,000
1981	50,260,000	12,870,000	5,180,000			68,310,000
1982	47,910,000	13,130,000	4,370,000			65,410,000
1983	47,150,000	12,730,000	3,940,000			63,820,000
1984	51,320,000	13,620,000	4,210,000			69,150,000
1985	48,310,000	13,150,000	3,650,000			65,110,000
1986	49,260,000	13,410,000	4,130,000			66,800,000
1987	50,113,178	14,715,570	4,115,899	14,204,638		83,149,285
1988	50,905,161	14,272,459	5,025,540	13,526,701		83,729,861
1989	53,383,591	14,205,221	4,267,563	15,603,436		87,459,811
1990	48,931,722	13,705,653	5,234,316	18,932,688		86,804,379
1991	51,300,000	13,300,000	6,050,000	18,100,000		88,750,000
1992	48,061,898	13,917,623	4,112,796	15,883,538		81,975,855
1993	47,756,492	14,215,711	6,228,523	20,340,130		88,540,856
1994	54,835,570	14,827,165	3,785,852	15,545,068		88,993,655
1995	54,166,769	15,224,269	2,806,557	19,974,829		92,172,424
1996	59,355,009	16,060,762	2,568,349	23,854,328		101,838,448
1997	60,264,791	16,904,663	2,741,614	25,163,394		105,074,462
1998	62,995,872	16,760,091	2,980,627	25,002,877		107,739,467
1999	62,699,947	16,875,991	2,890,843	24,608,099		107,074,880
2000	62,943,732	16,915,826	2,684,889	25,652,994		108,197,441
2001	68,123,551	18,788,004	2,536,195	28,482,792		117,930,542
2002	76,500,000	19,800,000	1,919,579	29,235,394	1,248,599	128,703,572
2003	70,150,000	18,100,000	1,836,235	30,861,618	796,718	121,744,571
2004	70,800,000	17,200,000	2,202,296	31,395,426	867,397	122,465,119
2005	71,100,000	17,600,000	1,957,392	31,102,263	1,366,438	123,126,093
2006	72,400,000	18,600,000	2,026,066	30,188,146	1,580,912	124,795,124
2007	71,700,000	18,100,000	2,072,695	33,162,242	6,092,756	131,127,693
2008	72,454,230	18,431,297	2,028,455	33,672,068	9,487,057	136,073,107
2009	63,000,000	16,600,000	2,176,054	31,181,736	12,524,796	125,482,586
2010	67,700,000	17,800,000	2,332,944	32,080,506	10,267,914	130,181,364
2011	59,900,000	16,500,000	2,002,764	38,428,388	13,246,123	130,077,275
2012	52,100,000	14,100,000	1,720,945	31,985,517	9,843,922	109,750,384
2013	53,400,000	14,450,000	1,355,939	35,159,926	10,326,745	114,692,610

APPENDIX: HISTORICAL DATA TABLES

CCP TOTAL UTILIZATION (IN SHORT TONS)							
YEAR	FLY ASH	BOTTOM ASH	BOILER SLAG	ALL FGD MATERIALS	FBC ASH	TOTAL CCPs	UTILIZATION RATE - TOTAL CCPs
1974	3,400,000	2,900,000	2,400,000			8,700,000	14.6%
1975	4,500,000	3,500,000	1,800,000			9,800,000	16.3%
1976	5,700,000	4,500,000	2,200,000			12,400,000	20.0%
1977	6,300,000	4,600,000	3,100,000			14,000,000	20.6%
1978	8,400,000	5,000,000	3,000,000			16,400,000	24.1%
1979	10,000,000	3,300,000	2,400,000			15,700,000	20.9%
1980	6,420,000	4,260,000	1,750,000			12,430,000	18.7%
1981	9,410,000	4,070,000	2,930,000			16,410,000	24.0%
1982	7,950,000	3,630,000	1,970,000			13,550,000	20.7%
1983	7,520,000	2,760,000	2,530,000			12,810,000	20.1%
1984	10,430,000	2,960,000	2,650,000			16,040,000	23.2%
1985	11,390,000	4,100,000	2,380,000			17,870,000	27.4%
1986	8,776,000	3,585,000	2,145,000			14,506,000	21.7%
1987	11,049,576	4,769,054	2,436,178	1,021,032		19,275,840	23.2%
1988	11,364,244	5,433,161	2,833,348	930,210		20,560,963	24.6%
1989	10,153,399	4,848,288	2,518,306	112,635		17,632,628	20.2%
1990	12,420,163	5,360,104	3,252,220	215,852		21,248,339	24.5%
1991	13,200,000	5,000,000	3,600,000	350,000		22,150,000	25.0%
1992	13,071,114	3,870,241	3,089,714	289,774		20,320,843	24.8%
1993	10,507,824	4,231,249	3,424,017	1,163,076		19,326,166	21.8%
1994	12,930,690	5,082,966	3,117,838	944,182		22,075,676	24.8%
1995	13,562,813	5,068,493	2,689,309	1,476,662		22,797,277	24.7%
1996	16,234,488	4,868,253	2,396,070	1,656,132		25,154,943	24.7%
1997	19,317,362	5,096,905	2,578,851	2,183,363		29,176,481	27.8%
1998	21,105,468	5,239,184	2,387,737	2,494,262		31,226,651	29.0%
1999	20,793,473	5,420,676	2,363,464	4,452,405		33,030,018	30.8%
2000	20,076,909	4,937,908	2,321,568	4,824,727		32,161,112	29.7%
2001	22,004,955	5,712,398	1,818,473	7,583,495		37,119,321	31.5%
2002	26,628,881	7,689,589	1,549,972	8,701,404	953,410	45,523,256	35.4%
2003	27,136,524	8,247,273	1,756,004	8,980,981	263,623	46,384,405	38.1%
2004	28,068,970	8,152,469	1,973,385	10,421,603	473,391	49,089,818	40.1%
2005	29,118,454	7,541,972	1,890,809	10,116,747	944,559	49,612,541	40.3%
2006	32,423,569	8,378,494	1,690,999	10,631,817	1,078,291	54,203,170	43.4%
2007	31,626,037	7,303,538	1,663,980	10,302,014	5,143,436	56,039,005	42.7%
2008	30,142,274	8,076,255	1,689,892	11,820,549	8,864,690	60,593,660	44.5%
2009	24,716,665	7,000,665	1,834,257	10,342,050	11,748,374	55,642,011	44.3%
2010	25,723,217	7,541,732	1,418,996	11,921,473	8,732,008	55,337,426	42.5%
2011	22,975,450	6,082,407	1,374,716	13,733,186	12,406,559	56,572,318	43.5%
2012	23,205,204	5,474,167	1,437,556	12,855,313	8,914,774	51,887,014	47.3%
2013	23,321,230	5,640,693	909,066	12,934,146	8,794,240	51,599,375	45.0%

Includes both internal and external utilization, which was captured separately through 1994.

APPENDIX: HISTORICAL DATA TABLES

UTILIZATION OF CCPs BY MAJOR MARKET (IN SHORT TONS)

YEAR	CONCRETE, CONCRETE PRODUCTS & GROUT	BLENDED CEMENT, FEED FOR CLINKER	FLOWABLE FILL	STRUCTURAL FILLS & EMBANKMENTS	ROAD BASE & SUB-BASE	SOIL MODIFICATION & STABILIZATION	SNOW AND ICE CONTROL	BLASTING GRIT & ROOFING GRANULES
1980	3,230,000			1,990,000	860,000			1,810,000
1981	3,920,000			4,950,000	930,000		1,110,000	1,180,000
1982	3,190,000			3,930,000	1,075,000		1,350,000	750,000
1983	4,372,000			2,780,000	932,000		651,000	1,560,000
1984	6,130,000			2,740,000	847,090		1,114,000	1,240,000
1985	5,665,000			3,230,000	1,228,000		984,000	1,412,000
1986	5,340,000			3,411,000	1,099,000		734,000	1,591,000
1987	7,255,559			2,377,390	772,385		883,915	1,604,985
1988	7,101,759			3,190,085	663,268		1,151,338	1,934,023
1989	6,884,289			2,651,372	1,391,804		719,769	1,807,418
1990	7,987,651			4,176,336	2,064,815		1,717,304	1,836,845
1991	8,725,000			3,700,000	1,875,000		1,900,000	1,966,666
1992	7,896,343			2,688,955	2,385,363		793,823	2,062,656
1993	7,431,940		383,003	1,142,350	2,756,085		1,203,600	2,720,718
1994	8,334,138		741,860	1,776,549	1,710,108		1,019,875	2,719,558
1995	7,813,821		357,263	1,760,889	1,204,122		719,875	2,185,990
1996	8,860,150		367,579	2,940,755	1,590,527		780,245	2,342,450
1997	10,239,786		401,418	4,346,622	2,722,774		779,672	2,448,330
1998	11,215,311		399,031	4,042,372	3,134,635		767,320	2,359,872
1999	11,086,908	1,425,027	860,456	5,219,512	2,342,026	110,634	1,162,262	2,289,131
2000	11,357,204	1,307,724	759,085	4,545,144	2,137,850	139,803	892,990	2,245,560
2001	13,628,275	1,226,678	811,142	4,574,749	1,675,785	850,548	871,707	1,530,028
2002	13,090,433	2,806,977	455,018	6,686,630	2,247,131	1,003,254	778,712	1,640,125
2003	12,679,134	3,954,504	156,945	8,187,469	1,661,388	773,076	788,184	1,497,744
2004	15,239,721	3,482,892	179,735	8,085,768	1,587,290	712,173	923,603	1,817,550
2005	16,353,334	4,215,234	250,234	8,349,999	1,461,992	1,139,640	547,541	1,633,407
2006	17,194,884	5,358,457	109,357	11,702,561	1,648,451	1,018,943	372,656	1,759,940
2007	14,515,690	4,989,988	114,979	10,598,118	1,179,509	1,371,228	781,346	1,449,561
2008	14,015,616	4,198,198	74,794	11,501,247	1,802,025	1,251,968	700,913	1,637,867
2009	10,610,410	3,577,726	398,198	8,856,396	968,291	957,116	302,827	1,743,621
2010	11,669,321	4,133,191	201,733	9,116,218	964,455	966,806	590,714	1,363,969
2011	12,282,718	4,209,009	210,288	7,883,521	1,153,675	1,112,438	464,444	1,390,457
2012	12,580,260	5,324,445	150,544	5,403,116	547,511	510,254	256,128	1,183,854
2013	13,120,252	4,774,924	44,142	6,152,569	366,861	823,017	432,884	906,683

Note: Data for 1980 does not include 2.67 million short tons for "other uses" that is included in the total utilization number. This was the only year that included this additional category.

APPENDIX: HISTORICAL DATA TABLES

UTILIZATION OF CCPs BY MAJOR MARKET (IN SHORT TONS)

YEAR	MINING APPLICATIONS	GYPSUM PANEL PRODUCTS	WASTE STABILIZATION & SOLIDIFICATION	AGRICULTURE	AGGREGATE	OIL FIELD SERVICES	MISC.	GROUT	ASPHALT	TOTAL UTILIZATION
1980	160,000						1,190,000	360,000	160,000	12,430,000
1981	70,000						3,730,000	390,000	130,000	16,410,000
1982	110,000						2,700,000	290,000	160,000	13,555,000
1983	170,000						2,070,000	170,000	104,000	12,809,000
1984	120,000						3,050,000	670,000	134,000	16,045,090
1985	1,020,000						3,980,000	290,000	80,000	17,889,000
1986	27,000						1,905,000	190,000	209,000	14,506,000
1987	444,579	157,147					5,509,420	129,124	141,339	19,275,844
1988	613,025	16,951					5,327,323	175,813	387,397	20,560,982
1989	22,190	72,277					3,632,956	242,341	208,211	17,632,628
1990	61,798	43,947					2,871,062	338,864	149,705	21,248,328
1991	216,663	100,000	400,000				2,850,000	200,000	216,666	22,149,996
1992	83,395	202,858	545,362				3,168,148	35,718	458,222	20,320,844
1993	29,692	633,526	736,938				1,984,847	146,299	157,168	19,326,166
1994	257,724	533,941	254,359				4,476,325	17,044	234,195	22,075,676
1995	726,753	741,616	980,683	14,681			6,155,832		135,752	22,797,276
1996	843,506	887,064	2,241,686	27,089			4,026,240		247,651	25,154,942
1997	1,680,895	1,603,762	3,339,743	98,412			989,800		525,264	29,176,478
1998	2,163,365	1,814,944	3,641,421	102,812			1,158,302		427,266	31,226,652
1999	1,923,216	3,053,268	2,013,749	137,052			1,172,852		233,925	33,030,018
2000	1,700,949	3,328,651	2,043,095	94,649			1,373,926		234,482	32,161,112
2001	1,078,264	6,224,872	1,555,595	157,199			2,806,031		128,448	37,119,320
2002	3,841,080	7,247,856	3,467,327	86,021	687,525		1,240,415		240,739	45,519,244
2003	2,330,032	7,780,906	3,999,623	50,487	687,839		1,741,411		84,010	46,372,752
2004	1,692,313	8,148,078	2,774,563	216,012	458,856		3,630,015		129,975	49,078,544
2005	1,132,945	8,178,079	2,839,954	415,741	872,776		2,071,154		140,838	49,602,868
2006	1,338,391	7,579,187	2,796,015	251,775	918,788		2,052,953		90,970	54,193,328
2007	6,701,910	8,254,849	2,800,031	180,100	1,013,373		1,973,173		102,723	56,039,005
2008	10,466,272	8,533,732	3,784,546	320,863	901,462		1,120,232		265,587	60,575,320
2009	14,897,415	7,288,755	3,738,799	388,990	574,083		1,323,172			55,625,800
2010	12,723,659	7,661,636	3,410,941	508,721	588,912		1,437,150			55,337,424
2011	15,897,089	7,110,921	2,751,974	612,365	624,806		868,613			56,572,320
2012	12,812,131	7,641,625	3,053,301	683,610	393,692	602,339	744,204			51,887,016
2013	12,676,264	7,446,839	2,186,926	598,105	524,088	413,210	1,132,611			51,599,375

Note: Data for 1980 does not include 2.67 million short tons for "other uses" that is included in the total utilization number. This was the only year that included this additional category.

METHODOLOGY AND SOURCES

The primary source of data on CCP production and utilization is the American Coal Ash Association (ACAA), which began collecting data in 1966. ARTBA used the published reports from 1977 through 2013 to analyze the overall market. Relationships between the CCP data and other economic factors, including electricity demand and generation, U.S. recessions and changes in markets for CCPs, were analyzed using economic models. Although this study does not include the results of this econometric analysis, they were used as the basis for a 20-year forecast for CCP production and use in a companion document.

In the original 1977 report, data was reported on fly ash, bottom ash and boiler slag. Through the 1994 report, utilization was reported for internal and external (or commercial) use. In this analysis we have combined these two categories, since the goal is to capture the total beneficial use.

In the 1980 report, ACAA captured two additional utilization categories, entitled "Ash Removed From Plant Sites At No Cost to Utility" and "Ash Utilized After Disposal Costs." Both of these totals are included with the commercial and internal utilization for the grand total of CCPs utilized in that year. This was the only year those two additional categories were included. Thus the total utilization categories in the appendix in 1980 do not add up to the final utilization number that year.

Although ACAA captures the beneficial use of CCPs by detailed end markets prior to 1980, the categories differ from future reports. Thus most of the end market analysis in the report, for the beneficial use, is for 1980 to 2013.

In the 1984 report ACAA listed comparative results at the bottom of the report and included total CCPs produced and utilized in previous years. On this report, the 1983 totals are different form the published 1983 report. There is no note of a revision, so we have included data from the original 1983 report for this analysis.

In 1987 ACAA began capturing data on FGD sludge. This category was renamed FGD by-product in 1988, FGD sludge in 1989 and FGD material in 1990. In 2002, ACAA classified FGD materials as FGD Gyspum, FGD Material Wet Scrubbers, FGD Material Dry Scrubbers and FGD Other. For the purposes of this report, we have combined all FGD related categories into one total.

There are a few minor discrepancies in the 1988 published ACAA report, where individual totals for fly ash, bottom ash, boiler slag and FGD gypsum utilization in the external markets are slightly different from the published subtotals. In most cases, the subtotals are off by less than ten tons of material. We have used the sum of the utilization reported, so the total we include in the year 1988 for utilization is slightly different (20,560,982 short tons versus the original 20,560,963 short tons) that was in the original report.

Several external and internal utilization totals were estimated by ARTBA for the 1991 analysis. For several end use markets, the ACAA published report includes "<50,000" or "<100,000" instead of specific totals. We estimated these numbers based on the total utilization reported, so all final totals add up to the total production and utilization reported for the year.

The 1994 ACAA report (as well as the 1999 and 2001 report) split CCPs into dry and ponded categories. The data reported for that year in this analysis is for the combined total in the ACAA published report.

In 2007, ACAA included data on FBC ash collected by a Pennsylvania association of 14 power producers, ARIPPA. The published report included total utilization and production both with and without the additional FBC Ash totals. We included the ARIPPA data in the 2007 numbers. From 2008 onward, the ARIPPA totals were not reported separately, and folded into the total ACAA report.

In 2013, the total utilization numbers used in this report for boiler slag, FGD material and FBC ash are slightly different from the published totals in the ACAA annual survey. The total utilization numbers reported by ACAA are different from the individual sum of utilization by major category. This report uses the sum of all the individual utilizations listed on the ACAA report as the total utilization for boiler slag, FGD material and FBC ash. For example, the boiler slag total utilization reported by ACAA in 2013 is 897,185 short tons, but adding up the individual ACAA published numbers for boiler slag utilization in the soil stabilization (1,000), snow and ice (11,797), blasting grit (884,861), waste (727) and aggregate (10,681) categories, the total utilization would be 909,066 short tons.

Additional market data is from the U.S. Energy Information Association, the U.S. Geological Survey and the U.S. Census Bureau.

For additional information please contact:

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KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 22

Witness: John N. Voyles/R. Scott Straight

Q-22. With respect to the Trimble County fly ash barge loading facility, please answer the following. Please provide copies of all equipment specifications, calculations, work papers, spreadsheets and any other supporting documents, used in support of your responses.

a. What is the maximum capacity per hour of the barge loading facility?

b. What is the maximum annual capacity of the barge loading facility?

c. Based on the current volume of fly ash processed though the barge loading facility, what is the remaining capacity?

d. How fly ash is currently transported to the barge loading facility, and from where on plant property?

e. After completion of the proposed CCRT, will fly ash be processed at the CCRT before being transported to the fly ash barge loading facility, or will the current process be continued?

f. Who owns the barges and tugs currently used to transport fly ash from the barge loading facility?

g. Does LG&E and/or KU currently own any barges or tugs used to transport fly ash from the barge loading facility to end users? If so, how many?

h. What is the moisture content of Trimble fly ash loaded through the barge loading facility?

i. What is the minimum and maximum moisture content of fly ash that can be loaded through the barge loading facility?

j. Please describe the specific capacity limiting factors at the fly ash barge loading facility?

A-22. a. The system design guarantee was 120 tons per hour (tph).

b. See the response to SV 1-20. Average loading rate for one barge is 16 hours (two eight hour days for one barge or 2 barges per week).

Loading Rate (Tons/Hour)	Operating Time (Hours/Day)	Loaded (Tons/Day)	Annual Operating Days (Days Per Year) (4 days per week @ 52 weeks year)	Maximum Calculated Capacity (Tons /Year)	Barges Per Year (Barge Capacity = 1,550 tons)
100	8	800	208	166,400	107

c. Refer to the responses to part b above and SV 1-4 and SV 1-5 whereby in 2013 and 2014 the Companies operated the barge unloading facility an average of 82 days.

Based on the current volume (average days from 2013 and 2014) of fly ash processed though the barge loading facility, the calculated remaining maximum capacity is 100,800 tons of fly ash. See table below.

Description	Category of Operating Days	Calculated Capacity (Tons /Year)
Total Annual Operating Data: Days or Calculated Capacity	208	166,400
TC 2013-2014 Average (from SV #4 and #5) (79+84)/2	- 82	- 65,600
Total Calculated Remaining Days (208-82) (from b. above) and Total Calculated Remaining Capacity	126	100,800

d. Fly ash from Unit 1 (sized at 60 tph) and Unit 2 (60 tph) for a total of 120 tph is currently transported to the barge loading facility from the 5000 ton silo via a dense phase pressure transport system (double wall pipe to avert a leak). The 5000 ton silo is located southwest of Unit 1.

e. The current processes will change. After completion of the CCRT, fly ash will be able to be sent to the 5000 ton silo (currently occurs) or to the two new CCRT intermediate storage silos. From these two new intermediate storage silos, the dry fly ash can either be conditioned (i.e. moisture added) by pug mills prior to loading the pipe conveyor (normal) or articulated dump trucks (pipe conveyor maintenance outage) for transport to the landfill, or can by-pass the pug mills and be loaded dry directly into fully enclosed "tanker-type trucks" for beneficial use.

f. The barges and tugs used to transport fly ash from the barge loading facility are owned by third parties.

g. The Companies do not currently own any barges or tugs.

h. The requested information is considered to be confidential and proprietary. See the response to PSC 1-8b(2).

i. See the response to part h above.

j. The dense phase pressure transport system (i.e., piping, blowers, emissions control, etc.) is sized for 120 tph.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 23

Witness: Caryl M. Pfeiffer/Counsel

Q-23. With respect to the Holcim contract please answer the following. Please provide copies of all equipment specifications, calculations, work papers, spreadsheets and any other supporting documents, used in support of your responses:

a. What is the contract period of the Holcim contract, and terms under which the contract can be extended by either party?

b. What is the minimum and maximum purchase tons in the Holcim contract? If the contract has a deferral period, please explain the deferral period contractual terms.

c. What are the penalties for Holcim not buying the minimum contracted purchase amount?

d. Does the Company have any knowledge or reason to believe that Holcim would not be able to meets its obligations under the contract?

e. Please explain in detail why it is not reasonable to assume that the contract with Holcim will continue, or that Holcim will not perform as set forth in the agreement.

f. Please explain why it is not reasonable to assume that the current volume of beneficial use of Trimble County's fly ash production by Holcim or any other beneficial use party will not continue in the future.

g. If it is reasonable to assume that some beneficial use of Trimble County's fly ash production will continue in the future by Holcim and/or other beneficial users, please provide the amount of beneficial use that it is reasonable to assume will continue.

h. Has the Company investigated or had discussions with Holcim or any other party as to whether anticipated closings of coal-fired power plants and/or the conversion of coal-fired power plants to natural gas will have an impact on future demand for gypsum and/or fly ash from Ghent or Trimble County? If so, please provide all e-mails, correspondence, PVRR analyses, spreadsheets, documentation, internal or external presentations, business cases, forecasts and any other information prepared, reviewed or discussed with respect to anticipated future demand.

A-23. a. The requested information is considered to be confidential and proprietary. See the response to PSC 1-8b(2).

b. See the response to part a above.

c. See the response to part a above.

d. No.

e. The Companies believe Holcim will meet contract obligations.

f. SO_3 in the Trimble County fly ash has been higher than expected causing the material to be nonconforming to the specifications outlined in the Holcim contract. This higher sulfur content has limited the amount of fly ash that Holcim has been able to use. Changes in the future to the sulfur content in the Trimble County fly ash could also change the volume that Holcim will beneficially use.

g. The Companies expect similar volumes of fly ash to be sold in the future as has been sold in the past. However, the amount of beneficial use is always subject to change based on market conditions, by-product quality, changes in environmental compliance requirements, etc.

h. General discussions have taken place on what impact plant closings could have on the marketability of by-product; however, no conclusive action has taken place. See the response to SV 1-21i.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 24

Witness: Caryl M. Pfeiffer

Q-24. Please provide any and all projections and/or forecasts of anticipated beneficial use provided to LG&E and/or KU from any party beneficially using CCR from Ghent and Trimble County.

A-24. Holcim projected in December of 2014 that their utilization of fly ash from Trimble County Station would be 115,000 tons in 2015. No other formal forecasts of anticipated beneficial use have been provided to the Companies.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 25

Witness: Caryl M. Pfeiffer

Q-25. Please provide the average number of days supply of limestone in Trimble County's limestone storage piles for the last three years and the most recent period available for 2015. Please provide copies of all calculations, work papers, spreadsheets and any other documents, used in support of your response.

A-25.

Year	Average Number of Days Supply[1]
2012	73
2013	60
2014	77
Jan-Jun15	57

1 – Average is calculated using calendar days per year (see supporting detail below)

CALCULATION FOR AVERAGE NUMBER OF DAYS SUPPLY OF LIMESTONE IN TRIMBLE COUNTY'S LIMESTONE STORAGE PILE

		Usage (tons)
January	2012	28,275
February	2012	32,838
March	2012	28,239
April	2012	12,135
May	2012	17,992
June	2012	25,675
July	2012	29,667
August	2012	31,748
September	2012	22,860
October	2012	29,061
November	2012	14,293
December	2012	13,633
Total Tons Usage		286,416
Total Days		366
Ave Usage per day		**783**

		Usage (tons)
January	2013	24,688
February	2013	24,773
March	2013	22,724
April	2013	16,589
May	2013	15,715
June	2013	27,241
July	2013	30,911
August	2013	30,969
September	2013	29,924
October	2013	18,004
November	2013	23,148
December	2013	25,766
Total Tons Usage		290,452
Total Days		365
Ave Usage per day		**796**

		Usage (tons)
January	2014	29,726
February	2014	15,632
March	2014	14,406
April	2014	12,401
May	2014	14,281
June	2014	27,375
July	2014	22,362
August	2014	29,496
September	2014	29,601
October	2014	29,467
November	2014	28,001
December	2014	30,294
Total Tons Usage		283,042
Total Days		365
Ave Usage per day		**775**

		Usage (tons)
January	2015	32,086
February	2015	28,411
March	2015	27,958
April	2015	18,704
May	2015	30,485
June	2015	27,275
Total Tons Usage		164,919
Total Days		181
Ave Usage per day		**911**

		Inventory (tons)
January	2012	72,558
February	2012	66,245
March	2012	59,499
April	2012	62,150
May	2012	60,538
June	2012	54,843
July	2012	56,196
August	2012	50,474
September	2012	52,007
October	2012	49,272
November	2012	51,443
December	2012	52,795
Average Inventory		57,335
		783
Ave # of days supply		**73**

		Inventory (tons)
January	2013	49,147
February	2013	49,102
March	2013	54,390
April	2013	52,658
May	2013	51,798
June	2013	41,166
July	2013	43,196
August	2013	35,222
September	2013	42,548
October	2013	52,528
November	2013	50,893
December	2013	53,434
Average Inventory		48,007
		796
Ave # of days supply		**60**

		Inventory (tons)
January	2014	47,063
February	2014	62,509
March	2014	63,852
April	2014	66,246
May	2014	60,189
June	2014	61,070
July	2014	58,581
August	2014	55,511
September	2014	64,150
October	2014	62,673
November	2014	54,365
December	2014	63,956
Average Inventory		60,014
		775
Ave # of days supply		**77**

		Inventory (tc
January	2015	58,080
February	2015	52,668
March	2015	55,387
April	2015	54,918
May	2015	42,531
June	2015	46,707
Average Inventory		51,715
		911
Ave # of days supply		**57**

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 26

Witness: Gary H. Revlett

Q-26. Please identify, and provide any correspondence or documentation from, all regulatory officials or other parties that the Company contacted in connection with its statement in footnote 13 on page 14 of the Joint Application for Declaratory Order concerning the use of Sterling's mine after the effective date of the new CCR regulations.

A-26. No such documents exist.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 27

Witness: David S. Sinclair

Q-27. In Exhibit 5, page 4 of 13, to the Company's Joint Application for Declaratory Order in this case, it stated that: "over the past three years, the Trimble County coal units produced an average of 743,000 tons of CCR annually. Approximately 234,000 tons of the station's CCR were beneficially reused each year... ."

a. Assuming that level of production and beneficial use continues in the future, what would be the cost per ton and per cubic yard (based upon including expected return on environmental rate base, depreciation, O&M costs, and other applicable costs) to place the remaining 509,000 in the Trimble Landfill?

b. Please explain why it is not reasonable for the Company to assume that the net CCR capacity requirements after beneficial use for the proposed Trimble Landfill is not approximately 500,000 tons.

A-27 a. In February 2015, the Companies compared the cost of the onsite landfill to the Sterling Ventures proposal over CCR storage scenarios ranging from 350,000 cubic yards per year to 900,000 cubic yards per year. A summary of this analysis ("Evaluation of Trimble County Coal Combustion Residual Storage Options") was provided as a handout at the Informal Conference on June 19, 2015. Table 8 at page 10 of the handout contains the levelized cost per ton of CCR stored for both alternatives over the range of the CCR storage scenarios. Compared to the Sterling Ventures alternative, the levelized cost per ton of CCR stored for the onsite alternative is $14 to $22 lower.

b. As the Companies have discussed previously, it is not reasonable to assume that beneficial use opportunities will be continuously available to reduce the net annual CCR capacity requirements. Furthermore, total CCR production at Trimble County is expected to rise from the levels of recent years. Over the past three years, Trimble County 2 has been unavailable for periods of time to address issues related to its burners. In 2014, for example, the unit was unavailable for a period of 15 weeks while new burners were being installed. Now that the burner issues have been resolved, the availability of Trimble County 2 and its CCR production is expected to increase. See the response to part a.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 28

Witness: John N. Voyles/R. Scott Straight

Q-28. Exhibit S attached to Sterling's Complaint is a PVRR calculation for Sterling's proposal to use an industrial site with an existing barge permit on the northern edge of Warsaw, Kentucky approximately 9 miles south of Sterling's mine as a site for a barge unloading facility (the "Warsaw barge site"). Attached to Exhibit S are the assumptions on which the PVRR calculation is based (the "Support Document").

a. Attached as Attachment A to this Data Request is details of the barge site Sterling referred to in its emails to Scott Straight on December 5th, December 11th and December 30th of 2014.

   i. Please explain why the Company chose not to meet, discuss or pursue this alternative with Sterling.

   ii. Please provide copies of all e-mails, correspondence, PVRR analyses, spreadsheets, documentation, internal or external presentations, business cases and any other information prepared and reviewed or discussed with respect to the option of using the Warsaw barge site in connection with Sterling's proposal for beneficial use of Trimble County's CCR.

   iii. With the understanding that the difference between the proposed annual lease payment of $120,000 per year, and the $200,000 per year Sterling used in Exhibits S, U, V and W of its Complaint (see Row 20) is to cover the cost of available office space at the site and taxes, please identify the cost reductions from using the Warsaw barge site instead of the barge site and the related infrastructure, land and other cost contemplated in the Sterling alternative detailed in the December 2014 Supplement to Alternatives Analysis.

b. Please specifically identify any errors in the Support Document and/or the PVRR calculation, and fully explain the error. By way of example, if the depreciation assumptions in the Support Document are incorrect, please provide an explanation of the error in book or tax depreciable life assumptions and supply the correct assumptions for book and tax depreciation, with supporting documentation.

c. If the Company has identified errors in the Support Document, cost data and assumptions and the corresponding PVRR calculation, please provide in a working electronic format with cell formulas and file linkages intact an excel spreadsheet with a PVRR calculation of Sterling's proposal using the Company's corrected assumptions and cost data. Please provide copies of all calculations, work papers, spreadsheets and any other supporting documents, including but not limited to the calculation of depreciation, useful life of landfill component asset cost and deferred tax used in the PVRR calculation.

A-28 a. i. Attachment A is a site photograph and lease proposal information regarding the Warsaw river access site. It provides no details as to the site's viability for use as a long term barge unloading facility, including no river depth information. However, the provided information does confirm the site has no existing barge unloading capabilities to support the CCR disposal project. The Companies determined that the Warsaw barge site was not practicable in that it would have greater associated project costs and feasibility concerns than the barge unloading site evaluated in the December 2014 Supplement case study. The proposed barge site has limited area, is restricted by the presence of a large office or warehouse, and would require the construction of a barge unloading facility and material storage and handling areas subject to Army Corps 404 permitting. Moreover trucks leaving the facility would enter Route 42 across from Gallatin County High School, which is located directly across Route 42. That would create significant safety concerns and long term impacts on the local community given the frequency of CCR transport trucks leaving and entering the facility during weekday business hours (a truck would leave and return to the facility every few minutes). The Companies' experience with transporting CCRs is that pipe conveyors are more cost effective and safe, less intrusive, and a more environmentally sound means of conveying CCR. The Warsaw barge facility would require a nearly 10 mile one-way haul to Sterling Ventures' mine. Therefore meeting with Sterling Ventures regarding the Warsaw facility would not have served any project goal or purpose.

ii. See the attached documents. Counsel for the Companies is continuing to undertake a reasonable and diligent search for other such documents and will reasonably supplement this response no later than Monday, July 20, 2015.

Certain documents responsive to this request are not being provided because they contain communications with counsel and the mental impressions of counsel, which information is protected from disclosure by the attorney-client privilege and the work product doctrine. The Companies will file no later than Monday, July 20, 2015, a privilege log describing the responsive documents the Companies are not producing on the ground of attorney-client or work product privilege.

iii. LG&E determined there would be no cost reductions associated with the use of the Warsaw barge site and also determined obtaining approvals to do so due to the required truck traffic through Warsaw was speculative.

b. The Companies contend that Sterling Ventures' Support Document is not representative because it assumes that CCR may be disposed in the mine over a 37 year period as beneficial use that is exempt from regulation as a new CCR Landfill under 40 CFR Part 257. Available evidence shows the activity is not beneficial use, but rather is commercial disposal for a tipping fee. See response to PSC 1-14. Beyond the failure to address how compliance with the CCR rule would be achieved and the associated cost at Sterling's mine, the Companies have not been provided sufficient evidence of Sterling Venture's surface and underground CCR handling plan, including capital equipment needs and operating costs, to evaluate the PVRR information, It is not even clear how Sterling Ventures would transport CCR into the mine, although based upon available information on the slope entrance into the mine, the Companies believe long term safe operation would require vertical mine shafts to be constructed. An additional factor affecting the Sterling Ventures' PVRR analysis is whether Sterling Ventures can create sufficient mine voids for disposal of CCR over the project life, which has not been established and will turn on future market conditions and Sterling Ventures' costs of mining operations as well as the extent and quality of its reserves. In sum, the Support Document and PVRR calculation Sterling Ventures has prepared contains numerous inputs, assumptions, and calculations for which the origin and support are unknown to the Companies, rendering this request incapable of completion at this time. The Companies' analysis of Sterling Ventures' allegations is ongoing. The Companies will disclose their positions with respect to the claims regarding the PVRR calculation in accordance with the procedural schedule herein provided sufficient information on the CCR management and capital investment requirements associated with disposal of the CCR at the mine are disclosed along with reserve and other feasibility reports.

c. See the response to b.

From: John Walters(johnwalters@sterlingventures.com)
To: Straight, Scott
CC:
BCC:
Subject: Re: Sterling Ventures CCR Storage
Sent: 12/11/2014 02:07:49 PM -0500 (EST)
Attachments:

Scott

Does LGE/KU want to sit down and discuss the specifics of a barge option? We have looked at the projected cost of barging CCPs to Sterling, compared to the landfill construction cost as out lined in your most recent PSC filling, and the PVRR cost saving appear to be significant.

John

John W. Walters, Jr.
Sterling Ventures, LLC
376 South Broadway
Lexington, KY 40508
Phone (859) 259-9600
Fax (859) 259-9601

johnwalters@sterlingventures.com

On Fri, Dec 5, 2014 at 4:26 PM, John Walters <johnwalters@sterlingventures.com> wrote:

> Scott
>
> We have found a site that already has an approved permit, but does not have any of the in-river infrastructure (i.e dolphins, cells or piers). The permit would need to be modified for the contemplated new use, which, according to the Army Corp, would take about six months. The site already is rip-rapped and has a concrete ramp and siding. Anticipated transportation cost from barge facility to mine of approximately $2.50/ton.
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>> John
>>
>> I am out of town this week on business, so my apologies for not getting back sooner. Are you saying you know of a plot of land available to site a barge load-out facility or a site that already has equipment installed that could serve as a barge unloading facility

of CCR?

Scott Straight
Director Project Engineering
LG&E and KU Energy

On Dec 1, 2014, at 12:13 PM, John Walters <johnwalters@sterlingventures.com> wrote:

Scott

A barge load/unload site near our mine is potentially available if you are interested in discussing barge options for Trimble or Ghent CCPs.

John

John W. Walters, Jr.
Sterling Ventures, LLC
376 South Broadway
Lexington, KY 40508
Phone (859) 259-9600
Fax (859) 259-9601

johnwalters@sterlingventures.com

On Fri, Oct 31, 2014 at 2:29 PM, Straight, Scott <Scott.Straight@lge-ku.com> wrote:

John,

We appreciate your responses of October 24th to our questions regarding the potential disposal of CCR from LG&E's Trimble County Station at Sterling Venture's limestone mine in Gallatin County. At this time, we believe we have all the information needed from Sterling Ventures to allow us to continue our evaluation of the project.

Thanks again.

Scott Straight

Director Project Engineering

LG&E and KU Energy, LLC

502-627-2701

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From: John Walters(johnwalters@sterlingventures.com)
To: Straight, Scott
CC:
BCC:
Subject: Sterling Ventures alternative to Trimble County Landfill
Sent: 12/30/2014 12:25:31 PM -0500 (EST)
Attachments:

Scott

I have not heard anything in response to my December 11 e-mail asking if LG&E would like to sit down and talk about the options and logistical issues of barging CCRs to our facility as an alternative to the building the new Trimble County Landfill. Is this an alternative that LG&E wants to explore?

John

John W. Walters, Jr.
Sterling Ventures, LLC
376 South Broadway
Lexington, KY 40508
Phone (859) 259-9600
Fax (859) 259-9601

johnwalters@sterlingventures.com

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> Sterling Ventures, LLC
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Director Project Engineering
LG&E and KU Energy

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Thanks again.

Scott Straight

Director Project Engineering

LG&E and KU Energy, LLC

502-627-2701

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KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 29

Witness: Caryl M. Pfeiffer

Q-29. With respect to the Charah contract identified in Exhibit Q attached to Sterling's Complaint.

a. Please identify the term and any renewal period of the contract.

b. Does the contract have any minimum or maximum purchase requirements of CCR?

c. Does KU and/or LG&E have any reason to believe that Charah would not be able to meets its obligations under the contract?

d. Please explain in detail why it is not reasonable to assume that the contract with Charah will continue, or that Charah will not perform as set forth in the contract. Please provide copies of all documents, work papers, studies or other information supporting your response.

e. Please explain why it is not reasonable to assume that the Charah contract will not increase the current volume of beneficial use of Trimble County's CCR production. Please provide copies of all documents, work papers, studies or other information supporting your response.

f. If it is reasonable to assume that the Charah contract will increase the future beneficial use of Trimble County's CCR production, please provide the amount of increased beneficial use that it is reasonable to assume will result from the Charah contract. Please provide copies of all documents, work papers, studies or other information supporting your response.

g. If it is not reasonable to assume that the Charah contract will increase the future beneficial use of Trimble County's CCR production, please explain the reason for choosing Charah as the party to market CCR production from Trimble County.

h. If Charah is able to obtain new future uses of Trimble County's CCR production, will the Trimble gypsum barge loading facility and/or Trimble fly ash barge loading facility be available for that new beneficial user?

i. If Charah is able to obtain new future uses of Trimble County's CCR production, will the new beneficial user be allowed to truck CCR from Trimble County? If so, will the Company limit the amount of sales by truck from Trimble County?

j. If truck sales of CCR would be limited from Trimble, please provide the amount of CCR beneficial use that Trimble would be willing to forgo as a result of Company limitations imposed on truck transportation from Trimble. Please provide copies of all documents, work papers, studies or other information supporting your response.

A-29. a. The requested information is considered to be confidential and proprietary. See the response to PSC 1-8b(2).

b. See the response to part a above.

c. No.

d. The Companies believe Charah will perform as per the contract. The Companies cannot speculate beyond the term of the contract.

e. It is reasonable to assume the Charah contracts will maximize the amount of fly ash beneficially used from the Companies fleet of power stations, which may or may not come from Trimble County depending on market opportunities.

f. See the response to part e above.

g. See the response to part e above.

h. For gypsum, SynMat owns the barge loading facility and so any Trimble County Station gypsum that is loaded into barges must go through them. For fly ash, Trimble County Station owns that barge loading facility and Charah would have potential access to load fly ash through it.

i. The Companies would potentially allow new future uses of Trimble County Station's CCR production to be shipped by truck. However, many factors would be considered including: number of trucks required, weight restrictions, hours of hauling, safety record of trucker, hours of school bus traffic, etc.

j. Any limit on the number of trucks has not been determined at this time and would be evaluated on a case by case basis.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 30

Witness: Caryl M. Pfeiffer

Q-30. The Company has a contract with Crounse Corporation as the exclusive barging supplier for coal and limestone at Ghent and Trimble County. Does Crounse also transport gypsum or fly ash from the Trimble barge loading facility? If so, does Crounse own the barges and tugs used for that gypsum or fly ash transportation?

A-30. No, Crounse does not transport gypsum or fly ash from the Trimble barge loading facility.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
Dated July 2, 2015

Case No. 2015-00194

Question No. 31

Witness: John N. Voyles/R. Scott Straight/Gary H. Revlett/Counsel

Q-31. With respect to the regulatory permits necessary to construct the Trimble Landfill, please answer the following.

a. Can the Company guarantee that all permits necessary for construction of the Trimble Landfill will be granted, or that construction will be completed prior to exhaustion of current on-site landfill capacity? If yes, please explain and support the answer.

b. If the Company cannot guarantee that it will receive all permits necessary to construct the Trimble Landfill, or that construction will be completed before exhaustion of current on-site landfill, please describe the Company's contingency plans for disposal of Trimble County CCR.

c. Can the Company guarantee that they will receive Kentucky PSC approval to construct later phases of the Trimble County Landfill? If yes, please explain and support the answer. Can the Company guarantee that they will receive necessary regulatory permits (other than the PSC) to construct later phases of the Trimble County Landfill? If yes, please explain and support the answer.

d. Based upon prior representations to the PSC as to the dates that the Company believed it would begin construction of the Trimble Landfill, please explain why it is reasonable to believe that they will receive all permits necessary to begin construction of the Trimble Landfill by the spring of 2016.

e. Has the Company been in contact with the Sierra Club, the Kentucky Resources Council or any other environmental group concerning whether litigation challenging the permits issued by governing regulatory agencies will be challenged in court?

f. Please provide copies of all documents, work papers, studies or other information supporting the Company's assertion that litigation of issued regulatory permits will not exceed one year.

A-31 a. The Companies anticipate that, based on its prior permitting experience, all of the required permits for the Trimble County landfill will be obtained and construction completed within timeframes consistent with the project schedule. While all projections for issuance of permits in the future reflect the Companies' best estimates based on currently available information, it is not reasonable to guarantee actions of third parties such as issuance of permits by regulatory agencies.

b. See the response to PSC 1-1.

c. The existing CPCN authorizes the Companies to construct all phases of the Trimble County landfill. The regulatory permits (other than the KPSC) are for the construction of all landfill phases.

d. Based on the Companies' past experience in obtaining the necessary permits for CCR landfills from the various state and federal agencies and its consideration of the current stage of the permitting proceedings, the Companies anticipate issuance of the required permits within the next six to nine months. All projections for issuance of permits in the future reflect the Companies' best estimates based on currently available information.

e. The Companies have had no such contact with environmental groups on their possible challenge of the Trimble County landfill permits.

f. The Companies have not asserted that litigation challenging issued permits will not exceed one year in duration. The Companies included an estimate of litigation one year in duration in its business plan. There are no documents supporting the Companies' estimate.

KENTUCKY UTILITIES COMPANY
LOUISVILLE GAS AND ELECTRIC COMPANY

First Data Request for Information to Sterling Ventures, LLC
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Question No. 32

Witness: David S. Sinclair

Q-32. Based upon the Company's experience transporting and placing CCR in landfills, ponds and stacking facilities:

a. Does the Company have any reason to believe that Sterling's proposed price for placing Trimble County's net CCR production in the Sterling underground mine would not be a profitable project for Sterling? Please provide copies of all documents, work papers, studies or other information supporting your response.

b. If not, please provide a price that the Company believes would make the project a profitable venture for Sterling. Please provide copies of all documents, work papers, studies or other information supporting your response.

c. Does the Company have any reason to believe that Sterling's proposed price for placing Trimble County's net CCR production in the Sterling underground mine is excessive or would result in unreasonable profits to Sterling? Please provide copies of all documents, work papers, studies or other information supporting your response.

A-32. a. See the response to SV 1-28a. The Companies do not have the basic financial information necessary to determine whether Sterling Venture's proposals would be profitable.

b. See the response to part a above.

c. See the response to part a above.