Cost Estimates for the Mandatory Closure of Surface Impoundments Used for the Management of Coal Combustion Byproducts at Coal-Fired Electric Utilities

INTRODUCTION

This report generates a reasonable estimate of the cost of eliminating surface impoundments as a legal alternative for the management of coal combustion residuals (CCR) at commercial electric generating facilities. The paper focuses on real marginal increases in cost resulting from this change in waste CCR management opportunities. It seeks to ignore transfer payments and costs that would have occurred in the absence of a de facto ban on surface impoundments for CCR management (except as related to the timing of these expenditures relative to the baseline).

The estimates derived in this paper were based on the best, most current, reasonably available information. The estimates are not intended to be overly precise given the information available, but rather are intended to represent a reasonable estimate of the cost rather than any best or worst case estimate.

These estimates do not include the costs of compliance for all the components of EPA's proposed CCR rule. Significant costs – such as corrective action costs associated with obtaining a RCRA Subtitle C permit and upgrading and/or retrofitting CCR management units (*e.g.*, tanks and silos) to meet Subtitle C design standards – are not included in the analysis, and benefits are not addressed at all. This report focuses solely on the estimated costs specifically associated with the transition from wet to dry management of CCRs from a welfare economics perspective rather than as an engineering cost exercise.

In the summer of 2009, the EOP Group, Inc. prepared an estimate of the costs associated with the phase out of the use of surface impoundments for the management of CCRs by electric utilities. This report updates this information based on more recent data and a better understanding of the EPA CCR proposal – now that it has been published for pubic comment. Where no new information was available, we continue to rely on the information and conclusions of this earlier report.

Consistent with the earlier analysis, the EPA is proposing cessation of the use of surface impoundments for the management of CCRs. However, the EPA is proposing a much more aggressive timeline than we used in generating our estimates in 2009. As a result, we are updating this analysis to reflect this change. We have also received additional information from utilities with experience in converting from wet to dry management of CCR. We have used this information to update our estimates of conversion cost. In addition, we are updating the analysis to reflect the 2008 data that is now available through the Energy Information Agency.

The generation of CCR related to electricity generation fell slightly between 2005 (the data from EIA form 767 used by both EPA's Regulatory Impact Analysis and our 2009 report) and the most recent data reflecting utility operations in 2008 (EIA form 923). Total generation of CCR fell by roughly seven million tons from 141 million tons to 134 million tons. While the quantity of CCRs that went to beneficial uses continued to increase from 2005 to 2008 – to about 42 percent of total generation – the quantity managed in surface impoundments stayed remarkably consistent (staying at just over 22 million tons). Therefore, a regulatory mandate to close CCR surface impoundments would still affect a significant number of electric utility power plants. From an operational perspective, a CCR surface impoundment closure rule would require electric utilities currently using surface impoundments for CCRs to convert from the wet handling to the dry handling of these materials. This report also assesses the potential wastewater management implications to the electric utility industry of no longer being able to employ CCR surface impoundment for ancillary wastewater management and treatment at the affected facilities.

The cost estimates used in this report are derived from engineering cost estimates from power plants believed to be representative of the portion of the industry that uses CCR impoundments and the estimated conversion costs that these power plants would incur in converting from the wet to dry handling of CCRs. The data used in this report reflect further input from utilities where available. When developing these high level cost estimates, feasibility and implementation studies were not completed. The estimates in this report assume that land – and the permits to construct landfill capacity on that land – is available. This is a significant limitation in assessing the costs associated with the siting requirements in the proposed rule.

As discussed in the body of this report, a requirement that electric utilities close CCR surface impoundments would result in significant operational costs. Based on representative engineering and cost data, the report estimates that the present value cost to the electric utility industry of a regulation mandating the closure of CCR surface impoundments would be approximately $43[1] billion. Annualized over 20 years, this represents a cost of approximately $2.9 billion per year[2]. In some cases, these costs could be sufficiently high to render a facility, or some smaller generating units at facilities, uneconomic and result in facility or generating unit closure. Closure of this generating capacity could potentially affect system reliability as well as energy prices. Assuming that only one-third of this at-risk capacity needed to be replaced, the gross replacement costs could range from $12 to $37 billion. These costs are in addition to the $43 billion in present value costs to the electric utility industry of complying with a mandatory CCR surface impoundment closure rule[3]. While these numbers are not strictly additive (since the replacement cost numbers are in nominal rather than discounted dollars), it is fair to

[1] At a discount rate of three percent. The NPV cost of conversion is $35 billion using a discount rate of seven percent.
[2] At a discount rate of three percent. The annualized cost at seven percent is $3.3 billion.
[3] These numbers are not completely additive. First, the replacement costs for at-risk generation are presented in nominal rather than discounted dollars. Second, facilities that close rather than convert will not incur the full cost of compliance with the rule.

conclude that any rule that requires the accelerated phase out of surface impoundments on a five year timeframe will cost at least $50 to $70 billion[4].

METHODOLOGY

The report uses both engineering estimates and recent historical data from a sample of facilities representative of facilities that rely on surface impoundments to manage some or all of their CCRs. The report used estimated component costs to derive estimates of the overall unit costs involved in a conversion to dry management of waste. For example, the report uses these estimates to derive a unit cost associated with installation of equipment to allow the dry management of bottom ash at each generating unit requiring conversion.

This report applies these unit costs to data from the 2008 Energy Information Agency (EIA) Form 923 database. Form 923 is used to collect information on plant design and pollution control equipment and expenses.

CAVEATS

There are two additional caveats that must be noted in interpreting these results.

First, our analysis assumes that conversion is technically, physically, administratively, and politically possible. We inherently assume that all facilities meet the siting requirements for both new landfills and, in the case of our Subtitle D analysis, new surface impoundments. EPA's analysis acknowledges that this is not the case, but estimating the extent of this cost was beyond the scope of this analysis. Similarly, facilities may have other difficulties (such as a lack of available land) in expanding onsite disposal capacity that have nothing to do with the regulatory requirements, but make it equally impossible for facilities to comply in the way assumed in this analysis

More importantly, this analysis also assumes that the state and EPA permitting capacity is up to the task of permitting all of the new units required under this rule with sufficient time to have them all online in five years time. In addition, it assumes that the public will be willing to allow siting of new "special waste" landfills onsite after all the negative publicity regarding the potential dangers of coal ash. Responses to the public hearings EPA is holding on this rule appear to suggest that the public does not support management of CCR in ponds, landfills, or beneficial uses. This suggests a quick permitting process may be unlikely.

If new management capacity is not available by the five year deadline, facilities will have to risk noncompliance or shut down generation until such capacity is available. If facilities have to shut down due to lack of CCR management capacity, the costs estimated in this report will seem trivial in comparison to the real costs of the rule.

[4] See caveat section for a discussion of why costs could be much higher than estimated here.

Second, this analysis does not account for any potential adverse impact to the beneficial use market. It is beyond the scope of this paper to address whether or not designation of CCR as a special waste will decrease its attractiveness on the beneficial use market. However, this report assumes that there will be no significant reduction in demand for CCR as a result of the rule. If this is not the case, more capacity will be required – at both wet and dry facilities – resulting in much higher costs than estimated here.

REGULATORY IMPACT

It should be noted at the outset that the EIA Form 923 database was not designed to provide a complete and comprehensive inventory of all surface impoundments used to manage CCRs. Therefore, use of this database is necessarily under-inclusive with respect to assessing the potential economic impact on the utility industry of complying with a mandatory CCR surface impoundment closure rule. Nonetheless, as noted above, the EIA database is being used in the report because it contains the best data available at this time.

The 2008 EIA Form 923 database reports 145 facilities that manage CCR in surface impoundments. Of these facilities, 100 report managing fly ash in surface impoundments, 121 report managing bottom ash in surface impoundments, 14 report managing gypsum, and five report managing FGD sludge in surface impoundments.

REGULATORY TIMING

The cost estimate calculated in our 2009 report was based on a ten year implementation period for complying with a mandatory CCR surface impoundment closure rule. This time period was based on several factors.

First, there are currently only a few domestic companies that manufacture the equipment necessary to convert wet ash handling systems to dry systems. Supply and demand for these system conversions, including design and supply for equipment, may result in new or expanded company capabilities, but vendor qualification will likely be an issue for adequate manufacturing capacity. Given the limited manufacturing capacity of key conversion equipment, the report estimates that it would take approximately ten years to manufacture and provide equipment sufficient to convert the affected components of the electric utility industry from wet to dry CCR handling.

A second significant timing factor involves the time necessary for constructing and permitting the dry units necessary to accommodate the CCRs that are diverted from wet to dry handling. As a general rule this will require constructing new landfills (onsite if possible) to replace the lost management capacity from the closed surface impoundments. Importantly, the construction and – more importantly – permitting of a landfill cannot be accomplished in short order. When considering siting studies, land options, land purchase, design, engineering, permitting, construction and quality assurance, it generally takes between five and six years under the best of circumstances. If state regulators are

confronted with multiple permit applications associated with a sudden change in regulatory requirements, or there is significant public opposition to the proposed site, this process will slow even further.

For these reasons, it is unreasonable to assume that the mandatory closure of all CCR surface impoundments could occur any faster than within ten years of promulgation of a mandatory closure rule. Therefore, the cost estimates in our previous report assumed a ten year implementation period.

EPA's proposed rule – both the Subtitle D option and the Subtitle C "special waste" option – on the other hand, requires phase out of ponds within five years of the final rule. This has significant implications for the cost of compliance with a phase out of surface impoundments. First, it presumes that the regulatory infrastructure exists within the states and regions to permit over 100 new landfills in five years. If this is not the case, facilities will be left in a position where it is illegal to use their existing CCR management system with no alternative system in place. Second, accelerating the closure of ponds requires a fundamentally different approach to pond closure –relying on mechanical dewatering rather than dewatering in place. This increases the cost of closure above what was assumed in our 2009 analysis. Third, accelerating closure increases the stranded capacity of the existing system; it also increases the net present value cost of the phase out by shifting more spending into the short-term.

COST COMPONENTS

The costs presented in this report are associated with the following components:

- Capital Costs
    - There are changes in equipment required to shift from wet management of CCRs to dry management of these wastes. These capital costs occur in five areas:
        - Conversion of bottom ash handling systems from wet to dry
        - Conversion of fly ash handling systems from wet to dry
        - Conversion of FGD byproduct handling systems from wet to dry
        - Increased capital cost associated with rapid pond closure
        - Installation of waste water treatment capacity to replace services provided by surface impoundments
- Operating Costs
    - The dry handling of these waste streams is more reliant on mechanical equipment than the wet management of the same waste streams. As a result, the operations and maintenance costs associated with dry management of these streams is higher.
    - Operation and management costs associated with replacement waste water treatment.
- Stranded Capital
    - Capital expenditures on surface impoundments were made with an expectation of a certain useful life.

  - A premature phase-out of the use of surface impoundments requires replacement of that capacity with landfill capacity sufficient to manage the CCRs that would have gone into impoundments. Essentially requiring the same capacity to be built twice.
- Opportunity and Other Costs
  - The fixed costs associated with conversion may be sufficiently high to make some smaller affected units uneconomic – there is simply not enough capacity and useful life remaining in these units to be able to recover the cost of conversion.
  - Closure of these units will reduce revenues to the operators who own them and decrease reserve margins of the regional grids where such facilities are located.
  - In the medium to long term lost generating capacity will have to be replaced. The cost of this new capacity likely exceeds the cost of operating the closed units. This additional cost would be attributed to the regulatory change forcing the closure of these units.
  - Surface impoundments often provide environmental benefits in addition to management of CCR. They may provide storm water runoff surge capacity, other waste water benefits, and they can affect the ability to meet other environmental regulatory obligations and goals. Loss of the surface impoundments results in a loss of these benefits. Additional costs will be incurred replacing these services.
  - Some facilities may require additional space to facilitate new equipment, landfill space, and waste water treatment surface impoundments.

CAPITAL COSTS

Conversion to Dry Management of Bottom Ash

The EIA Form 923 database indicates that there are 121 facilities that manage some or all of their bottom ash in surface impoundments. There are 391 coal-fired boilers at these facilities. Management of bottom ash in surface impoundments does not necessarily indicate that the boilers at the facility are wet-bottom boilers. Management in surface impoundments may simply be more convenient if there are other significant high-volume CCRs managed in impoundments at the site. It is also possible that bottom ash streams from different boilers at the same site are managed in different ways.

There are two potential components to the cost of conversion of a boiler to facilitate dry management of bottom ash. One is the conversion of the bottom of the boiler itself to a dry removal system and the other is the conversion of the existing equipment to facilitate the dewatering and transporting of the waste stream to the dry waste management unit (i.e., a landfill). Even if a boiler is set up as a dry bottom boiler the wastes are hydraulically sluiced to a surface impoundment for final disposal. If this is the case, elimination of surface impoundments will not only require additional equipment to collect the bottom ash dry, but also to transport the dry wastes to a landfill for disposal.

Whether or not the boiler itself is a wet or dry bottom boiler, there are significant costs associated with modifying the ash handling system to facilitate dry management. Wet management involves simply hydraulically transporting the ash into a system that uses the water to carry the ash to the surface impoundment. A dry system relies on mechanical systems (such as augers) to move the ash out of the boiler; the ash then has to be conveyed to a centralized location where it can be transported to a landfill.

Based on engineering estimates across a number of affected utilities, capital costs associated with modifying these generating units, including the information provided in EPA's RIA on the estimates of the conversion of TVA facilities from wet to dry, averages approximately $20 million per unit. This is a reduction in ten million dollars per unit from our 2009 estimate. The total cost across all electricity generating units is, therefore, estimated at approximately $8 billion over five years.

Conversion to Dry Management of Fly Ash

Like bottom ash, the cost associated with conversion to dry management of these wastes is associated with the modification of solids collection and handling systems. However, fly ash from multiple boilers may be collected and managed together. As a result, our 2009 report computed a cost based on an average capital cost per ton of fly ash. However, we now realize that each unit will require modification to work with whatever overarching management system is installed. Both the initial engineering estimates supporting the 2009 paper and information we have received subsequently better support estimation of fly ash conversion costs on a per unit basis.

Engineering estimates from potentially affected utilities and those who have recently constructed dry fly ash management systems estimate that costs associated with wet to dry fly ash conversion average about $23 million per unit. There are 328 units that reported wet management of fly ash in 2008. Therefore, we estimate a total capital cost to utilities of $8 billion for the conversion from wet to dry fly ash handling systems

The average cost per unit represents a simple average of the estimates and historical data received. As one would expect, there was a significant variation between facilities, ranging from $6 million to $56 million[5]. It should be noted that the higher numbers used in the average tend to be from larger utilities that represent more of the potentially affected population, and the data based on real world experience rather than engineering estimates. In addition, two units with an estimated cost of conversion of $127 million were not included in the average because the conversion was addressing fly ash and FGD ash simultaneously and we did not have a way of separating out the costs attributable to each. For these reasons, it is reasonable to view $23 million as a conservative (on the low side) estimate of the unit cost of conversion of fly ash handling systems.

Conversion to Dry Management of FGD Solids

[5] This $56 million estimate was itself an average per unit cost from a utility with costs ranging as high as $90 million dollars at its most costly conversion.

Conversion of FGD solids handling systems to dry management involves the same capital intensive conversion. In 2005, only four facilities reported wet disposal of FGD solids. In 2008, however, 18 facilities reported managing FGD wastes (sludge or saleable gypsum) in surface impoundments. As a result, this report updates the cost numbers to include the capital costs associated with conversion of these FGD systems. The report continues to include the operations and maintenance costs associated with these solids in its O&M calculation.

Capital costs of converting to dry management of FGD wastes are estimated at $35 million per facility[6]. The total capital cost of converting these systems is estimated at $600 million.

Another important issue related to FGD operations is the use of surface impoundments to help manage FGD dewatering waste streams. Waters from gypsum dewatering and other processes are treated and augmented by other process water treated in surface impoundments. Closure of surface impoundments will require a significant change in the size and type of wastewater treatment equipment which means a significant increase in capital cost to manage the existing FGD wastewater streams. We have received no additional information that would enable us to reestimate these costs.

Wastewater Treatment

Surface impoundments are an integral part of overall site wastewater compliance for facilities that use surface impoundments. Loss of these impoundments will require additional capital and operating expenses to replace this lost capacity.

This cost is affected by whether or not the facility has an FGD impoundment. The costs of managing certain constituents in the FGD dewatering waste significantly increase the cost of the wastewater treatment system required to replace the functionality of the surface impoundments.

Using cost estimates developed from data provided by utilities, the average capital cost for a facility without a FGD is $80 million, and increases to $200 million for a facility with an FGD. The difference in cost is attributable to the fact that new FGD systems remove soluble salts and other constituents that are more expensive to treat prior to discharge.

Based on 2005 EIA Form 767 data, 155 facilities would require new wastewater treatment capacity, and of these 39 were FGD facilities. This translates into additional capital cost requirements of approximately $17 billion. This estimate remains unchanged from our previous paper.

OPERATING COSTS

[6] Again, this estimate does not include the estimate of $127 million per unit submitted by a facility that co-manages fly ash and wet scrubber solids.

Dry Handling

As noted above, wet management involves using gravity and water to move the solids into surface impoundments for management. Dry handling involves the use of mechanical systems such as silo, augers, trucks, and conveyors to get the wastes from point A to point B. These mechanical systems are inherently more expensive to operate and maintain.

Based on information received from utilities, the report estimates that the operating costs associated with dry management are approximately $2.00 per ton higher than the costs associated with wet management.

In 2008 facilities managed 12.9 million tons of fly ash, 5.1 million tons of bottom ash, and 4.1 million tons of gypsum (FGD solids) in surface impoundments. The 2008 data confirms our suspicion that the amount of FGD solids managed in surface impoundments had increased since 2005 due to the increased installation by coal-fired power plants of new pollution control equipment. The annual increase in operating costs associated with managing these wastes dry is, therefore, conservatively estimated to be $44.2 million.

Waste Water Treatment

The additional waste water treatment capacity that would be required to convert to dry handling systems would also result in increased operations and maintenance costs. For facilities without a FGD annual operating expenses are estimated to be approximately $3 million, and for a facility with an FGD this cost estimate increases to $4.5 million annually.

As noted above, the 2005 EIA Form 767 indicates that 155 facilities would require new wastewater treatment capacity, and of these 39 were FGD facilities. The resulting operating costs are roughly $525 million per year.

STRANDED COSTS

Accelerated Closure of Surface Impoundments

The long term management of landfills and surface impoundments are similar. A unit with a given capacity is constructed, CCRs are managed in the unit until the capacity is reached, and the waste unit is then capped and enters long term management and monitoring.

Construction costs for the two types of units are roughly similar. Operation costs for the landfill are slightly higher than for surface impoundments due to the need for dust control, the cost to transport the waste to the landfill as compared to wet sluicing and other issues related to dry wastes, but these costs are accounted for in the $2.00 per ton

O&M increase already discussed. Costs of closure of the units are already required whether the surface impoundments are allowed or not in the future.

Therefore, if a facility reached the capacity of its surface impoundments before the surface impoundment was required to be closed, there would be no additional closure costs attributable to the phase out of surface impoundments. However, if the surface impoundments are required to be closed before they reach capacity, the cost of new capacity and accelerated closure costs would be attributable to the change in regulation.

Put another way, any capacity remaining in surface impoundments when they are closed represents a stranded cost equal to the cost of replacing that capacity with landfills. In addition, the rapid acceleration of the closure of surface impoundments is likely to result in changes to the procedure used to close those impoundments that are more costly than originally planned for that unit. This change in closure cost and the acceleration of the timing of expenditures will both increase the present value of closure costs of surface impoundments relative to the baseline.

Looking across a variety of units, the report estimates that one acre of landfill capacity is required for every 75,000 tons of CCR. As noted previously, about 22 million tons of CCR are currently managed in surface impoundments each year. Therefore, there is an annual requirement for 290 acres of landfill capacity to manage these wastes.

In 2005 DPRA Incorporated conducted an analysis for the EPA evaluating potential costs associated with management of CCRs under the municipal solid waste landfill rules under Part 258 of RCRA. In this analysis, DPRA assumed that surface impoundments had an expected useful life of 40 years. Assuming this to be true, the current fleet has an average remaining life of approximately 20.5 years of capacity. Our 2009 report assumed a ten year phase in period, the existing fleet would be expected to have 15.5 years of remaining capacity still in use at the time surface impoundments were closed – assuming no new surface impoundments built in the interim[7].

If all existing surface impoundments were closed within ten years, the amount of unused capacity that would be stranded equates to about 4,500 acres of landfill space. At a cost of roughly $1 million per acre, this represents a stranded cost of $4.5 billion in year ten. A more rapid phase in would increase nominal costs by $280 million for each year closure is accelerated. A full phase out in year five would strand 18 years of capacity valued at approximately $5.2 billion.

Acceleration of closure also results in two additional costs that were not estimated in the 2009 report. First, both closure cost and construction of new landfill capacity are accelerated in time. This is likely to have a significant impact on the NPV of costs to operate the CCR management system relative to the baseline. The acceleration of construction spending relative to the baseline adds $2 billion to the present value cost of

[7] This assumption already includes movement away from the baseline in anticipation of regulatory action. In a true baseline, surface impoundments would be rebuilt as they are retired such that stranded capacity always remains at 20.5 years irrespective of the effective date of the rule.

the rule under a ten year phase out and $3 billion under a five year phase out[89]. Second, accelerated closure is likely to result in fundamentally different technical approaches to closure that will be more expensive. As a sensitivity analysis we estimated how large an effect on the final cost of pond phase out a 30 percent increase in costs would have. This presumed increase in cost shifted the total cost of the rule by less than $100 million, which in the context of this particular rule is not significant. As a result, we did not pursue a more detailed analysis of these costs.

TOTAL QUANTIFIED COSTS

For purposes of calculating present value and annualized costs, our 2009 report assumed that the capital costs were incurred evenly over the ten year implementation period, and that surface impoundment stranded costs were incurred in year 10. The report used a 20 year annualization period and a discount rate of three percent.

In this update, we assume that the majority of capital expenditures take place in year five. We make this assumption because it is not reasonable to assume that surface impoundments and systems associated with their operation will be able to be closed until a legally permitted alternative exists. While we still believe it quite possible that states and regions will be incapable of permitting replacement capacity within five years (especially under a Subtitle C regime), we have to make the assumption that they will do so to avoid shutting down the production of electricity. Nevertheless, five years is the soonest possible date that we can imagine permits will be in place.

The present value cost to the electric utility industry of a mandatory CCR surface impoundment closure rule is $43 billion. If annualized over 20 years at a discount rate of three percent, this represents a cost of approximately $2.9 billion per year.

It is also worthy to note that the cost estimates were developed in absence of engineering feasibility studies. The cost estimates, however, include contingency factors to reflect the unknown costs and variables associated with any conversion program of this magnitude.

UNQUANTIFIED AND OTHER COSTS

Loss of Additional Environmental Benefit

Existing surface impoundments also provide storm water surge capacity that assists facilities in the management of runoff. If the ash management surface impoundments are closed at these facilities, new surface impoundment or tank capacity will be required to

[8] Assuming a uniform rate of replacement, a 40 year useful life and a three percent discount rate.
[9] Some states allow surface impoundments to remain open even after they have stopped receiving wastes. Also the useful life of surface impoundments can be extended through dredging. This analysis assumes that all surface impoundments are operated as traditional waste management units (i.e. they close when they reach capacity). As a result, the accelerated closure cost estimate may be low relative to actual operation.

replace lost volume treatment capacity. The size of these replacement surface impoundments will, of course, vary by a number of factors such as facility footprint, rainfall, site topography, existing controls, etc. Facilities that provided information on the amount of necessary replacement capacity stated needs ranging from zero to 70 acres of new surface impoundment capacity. These facilities also estimate a cost of one million dollars per acre for construction and operation of these surface impoundments. This adds an additional $4.5 billion in costs to the phase out of CCR management surface impoundments.

Land Acquisition

A significant number of facilities evaluated would have to acquire additional land to facilitate the installation of equipment or the construction of landfill or wastewater surface impoundment capacity. The cost of such land acquisition is, of course, location specific. Some facilities have adequate space at the facility; others are in rural locations where land adjacent to the facility may be available and relatively inexpensive. Facilities in urban areas, on the other hand, may face absolute constraints on growth or very expensive land prices. It must be noted that even if suitable land is currently owned by facility operators, the value of its current use will be lost if converted to landfill space, so its use cannot be considered free. Another key point is that if land use restrictions require new off-site landfill capacity, the associated CCR management costs will be even higher.

In addition, it is not always obvious what portion of these costs would be attributable to a rule requiring phase out of surface impoundments. Facilities that were originally designed with surface impoundment capacity sufficient to accommodate the full useful life of the facility face a real economic cost if a rule would require them to acquire new land to accommodate landfill construction. On the other hand, facilities that would have to acquire additional land to facilitate the next expansion of waste storage capacity (wet or dry) can not legitimately argue that the next purchase is a result of the new rule.

For these reasons, the report does not attempt to derive a national estimate of the cost of land acquisition associated with the rule, though it is important to note that these acquisition costs for individual facilities could be in the millions of dollars.

The report did a screening level analysis of potential land acquisition costs by looking at a variety of individual facilities in different circumstances – rural locations, urban locations, sufficient existing space, moderate additional land requirements, significant new land requirements, etc. – and standardized the estimated requirements for these facilities to annual tons of CCR managed in existing surface impoundments (the only variable for which data were available for all facilities). Using this methodology, the reports estimates total costs to all facilities at roughly $100 million dollars over the ten year implementation period. While this cost does not change the overall estimate of costs, it is not insignificant and tends to be concentrated at a small subset of individual facilities with much higher than average costs.

At-Risk Capacity

For some smaller units and/or units with limited remaining useful life, the fixed costs associated with the conversion to dry management of CCRs may, depending on a range of factors, be too high to allow the facility to recover the conversion costs given the limited capacity of these units. The most cost-effective compliance solution for generators with such units may be to terminate operations and purchase replacement power from elsewhere. Based on discussions with utilities, the report concludes that units with below 230 MW of generating capacity have the greatest potential risk of ceasing operations if required to undertake the mandatory closure of CCR surface impoundments. This does not mean that such units will close, but rather that units below this MW generating capacity cutoff are at greater risk of no longer being economically viable.

The report looks at this potential on a per unit basis due to the significant capital cost associated with converting bottom ash handling systems. There are 397 generating units operating at facilities that manage bottom ash in surface impoundments. As much as 20 percent (~35,000 MW) of the generating capacity of at these facilities is below 230 MW and thus face the greatest potential risk of ceasing operations if required to undertake the mandatory closure of CCR surface impoundments.

Units that are at-risk were responsible for the generation of 18 percent of all coal-fired generation in 2005. This represents over four percent of all electricity generated in the United States.

Costs of Replacement Power

Another cost is that of utilities having to purchase replacement power for those plants that would be at risk of ceasing operations due to the economic burdens of complying with a mandatory surface impoundment closure rule. For example, if older plants are retired before they are fully depreciated, regulated utilities will need to request rate increases to recover the un-depreciated portion of the plants, including any uncollected removal costs. The cost of retiring these older, smaller units (<~230 MW) prematurely could be significant. Replacement capacity would have to be built to supply the lost generation and to maintain generating capacity margins required of regulated electric utilities by the state Public Utility Commissions. Those new units would be added to the rate base and would increase the price of electricity to the customer, so the rate payer would be paying twice; once for the remaining, stranded cost of the older unit being retired early and then for construction of the replacement capacity.

New, base-loaded generation to replace the lost units could be added at capital costs ranging between $1,186 per installed kW for natural gas combined cycle to $2,485 per installed kW for supercritical, pulverized coal. Other generating technologies that would be practicable in the 600 MW size units would include nuclear at a capital cost of $3,682 per installed kW and perhaps Integrated Gasification Combined Cycle at $3,359 per installed kW, depending on the timing. *(Congressional Research Service Report for Congress, Power Plants: Characteristics and Costs*, Stan Kaplan, November 13, 2008). Using those government cost figures, the capital cost for a replacement 600 MW unit

would be in the $0.7 billion to $2.2 billion range. If only 10,000 MW of the 35,000 MW at-risk capacity needed to be replaced, the gross replacement costs would be in a range of between $12 and $37 billion. These costs are in addition to the $43 billion in quantified costs discussed above.

If the lost generating capacity were replaced with technologies having a lower capacity factor than the 230 MW units they were replacing, then wind (at $1,896 per installed kW), solar thermal (at $2,836 per installed kW) and solar photovoltaic (at $5,782 per installed kW) plants /cells could come into play. However all of these alternatives necessitate increasing costs for customers. (Capacity factor is the ratio of the amount of power generated by a unit for a period of time - typically one year - to the maximum power output of the unit if it were to run all the time and at full power. Capacity factor ranges from about 20% for solar photovoltaic to about 90% for nuclear.)

COMPARISON TO EPA COST ESTIMATES

One must be cautious in comparing these estimates to those generated by the EPA in their RIA. EPA chose to compare the total cost from our 2009 report to their initial estimate of conversion costs. This somehow suggests that EPA is measuring the same costs and that our number was just twice as high as EPA's cost number. In fact, the EPA analysis leaves out a number of important costs that more than account for the difference between the two estimates.

EPA's estimate is intended to account for the conversion cost and the increase in future operating costs associated with the shift to dry management. Their initial present value estimate of these costs was approximately $23 billion. Our present value estimate for these same costs is only about $15 billion. However, EPA's estimate accounts for the value of the stranded asset differently from ours and does not account for the wastewater treatment implications of its proposal at all (it is unclear whether EPA's analysis appropriately assesses the timing of investment relative to the baseline, but we give them the benefit of the doubt). These missing costs account for $27 billion of our cost estimate. A comparison of the estimates in this report to the EPA's without understanding the differences in what they measure would be a mistake and is inaccurate.

EPA further muddies the water by trying to account for an overall trend toward dry conversion in the industry. However, EPA uses 2005 data that reported 22.4 million tons of CCR disposed of in surface impoundments that year. EIA form 923 reports that in 2008 22.3 million tons were disposed of in surface impoundments, suggesting that the trend may have slowed down or stopped. In fact, as a proportion of the total CCR managed, wet disposal actually increased over this time period. This may suggest that the facilities for which conversion made sense have already undertaken such conversions and those facilities still managing CCR in surface impoundments face higher than average conversion costs or other restrictions.

IMPLICATIONS OF EPA'S THREE REGULATORY ALTERNATIVES FOR THESE COST ESTIMATES

The $50-80 billion estimate of costs of pond closure applies to any rule that would mandate closure of current surface impoundments and prohibit future management of CCR in surface impoundments. Of the three options in EPA's proposal only the Subtitle C option effectively prohibits the future use of surface impoundments to manage CCR through application of the Subtitle land disposal treatment standards for CCRs wastewaters.

Both Subtitle D approaches would make it less likely that facilities would continue to operate surface impoundments in the future due to increased costs and potentially prohibitive siting restrictions. However where the cost of conversion to dry management was sufficiently high, wet management would remain a legal option, provide the CCR surface impoundment meet the applicable Subtitle D operating standards.

The Subtitle C proposal would require the conversion of all facilities from wet to dry management, closure of all existing ponds, acceleration of landfill construction to provide necessary capacity for management of the dry waste stream, and addition of new wastewater treatment capacity to address wastewater stream from scrubbers and provide other environmental services currently provided by surface impoundments. As stated earlier, we estimate these costs at a net present value of $43[10] billion.

The Subtitle D approach, on the other hand, would allow for the continued use of surface impoundments, if those surface impoundments met the ground water performance and design criteria proposed in the rule[11]. As a result, fly ash, bottom ash, and FGD residuals would only be converted to dry management if doing so was more economical in the long run than continued wet management. Similarly, wastewater treatment costs would only be incurred if doing so reduced costs relative to reconstruction of compliant surface impoundments. Under the Subtitle D option, facilities would still be required to close existing surface impoundments[12], stranding the remaining capacity in existing ponds. As with Subtitle C, we estimate the value of this stranded asset at four billion dollars. In addition, the acceleration of the construction of new capacity and pond closure costs results in an increase in present value cost of three billion dollars. So, we estimate the total incremental cost of the Subtitle D option at about seven billion dollars – with an annualized estimate of $500 million at a discount rate of three percent. This is $36 billion ($2.4 billion per year) lower than the Subtitle C alternative.

This seven billion dollar estimate represents the lowest allowable compliance cost attributable to the Subtitle D option because it assumes, as does EPA's analysis of Subtitle D, that all facilities choose to replace existing surface impoundment capacity with new or retrofitted ponds. However, plant operators have argued that there are a number of non-quantified costs and other factors (e.g. land availability, ease of permitting, local public concern, long-term liability, etc.) that also affect the decision of

[10] Not including any costs associated with replacement of at risk capacity.
[11] Surface impoundments would be allowed in the future under this alternative. However, existing impoundments would still need to close or retrofit within five years.
[12] EPA's RIA assumes that no surface impoundments currently in use meet the Subtitle D design requirements proposed in the rule.

whether to construct new surface impoundments or convert to dry management. Discussions with plant operators and environmental managers suggest that mandatory closure of surface impoundments under either the Subtitle C or D options will be the precipitating event that causes them to convert to dry management of CCR. In fact, they suggest that all facilities would choose to convert to dry management of fly ash and 50 percent of facilities would choose to convert to dry management of FGD residuals and bottom ash. The primary driver of this decision appears to be the availability of sufficient land to allow construction of replacement surface impoundments.

Under this alternative set of assumptions, the costs of the Subtitle D option are much closer to the costs of the Subtitle C option. Wet to dry conversion capital costs for fly ash, bottom ash, and FGD residuals would be $8 billion, $4 billion, and $0.3 billion respectively. Greater wet to dry conversion also increases the estimated operations and maintenance costs of the Subtitle D option to $39 million per year. This is based on 100 percent of the 2008 fly ash generation being managed dry and 50 percent of FGD residual and bottom ash being managed dry. Under this set of assumptions 19.5 million of the 22.1 million tons of ash managed wet in 2008 would be managed dry as a result of the rule.

Estimation of wastewater treatment costs under this alternative set of assumptions is slightly more complicated. We assume that all facilities that convert to dry management of fly-ash will incur the same wastewater treatment costs under the Subtitle D option that they would under the Subtitle C option. Facilities that continue to manage FGD residuals or bottom ash in surface impoundments avoid the increase in wastewater treatment costs only if fly ash is not currently managed wet at the same facility. Of the nine facilities expected to continue using surface impoundments to manage FGD residuals, seven are facilities that manage no fly ash in surface impoundments. This results in a potential savings of $1.4 billion relative to the Subtitle C option. The remaining two FGD plants would lower their capital cost requirements for wastewater treatment from $200 million to $80 million, resulting in a total savings of $1.6 billion relative to Subtitle C for all FGD plants. Similarly, there are 38 facilities where bottom ash is managed in surface impoundments and fly ash is not. This results in a potential savings of $760 million relative to the Subtitle C alternative. The reduction in wastewater treatment operations and maintenance costs associated with the reduction in wet to dry conversions under the D option is approximately $155 million per year.

Using this alternative set of assumptions, the 20 year net present value costs of the Subtitle D option are $34 billion at a discount rate of three percent (roughly $2.4 billion per year)[13].

Due to some of the assumptions made in this analysis, this estimate for Subtitle D (and for Subtitle D prime discussed below) may be slightly lower than it should be. Specifically, our assumption that costs for future landfill and surface impoundment capacity are equal and based on the design requirements included in the rule masks any marginal increases in the cost of constructing surface impoundments relative to the

[13] The estimates using a seven percent discount rate are $29 billion and $2.8 billion respectively.

baseline. In some cases, additional design and construction costs may be incurred to engineer a surface impoundment that complies with all of the siting criteria – the incremental costs of such a surface impoundment would be attributable to the rule. Also, we do not account for those instances where location makes it impossible to construct a compliant surface impoundment on site.

The Subtitle D prime alternative discussed in the notice of proposed rulemaking would, according to our methodology, impose no additional costs relative to the baseline. As with the Subtitle D option, conversion from wet to dry would only occur where it reduced costs (including permitting or public goodwill costs) relative to construction of new surface impoundments. In addition, by allowing a natural phase out of existing capacity, there are no stranded assets and no acceleration of construction spending. The costs of the D prime proposal would not actually be zero. Existing surface impoundments would only be allowed to remain open if they could demonstrate compliance with groundwater protection performance standards. Undoubtedly, there will be facilities that cannot make such a demonstration – these facilities would still face the costs associated with premature closure of existing capacity. The cost for the D prime option is therefore somewhere between zero and $34 billion dollars.

We do not attempt to assess the relative impact of these three alternatives on at risk capacity. However, it is obvious that lower costs will put less pressure on these at risk facilities, reducing the number of premature closures