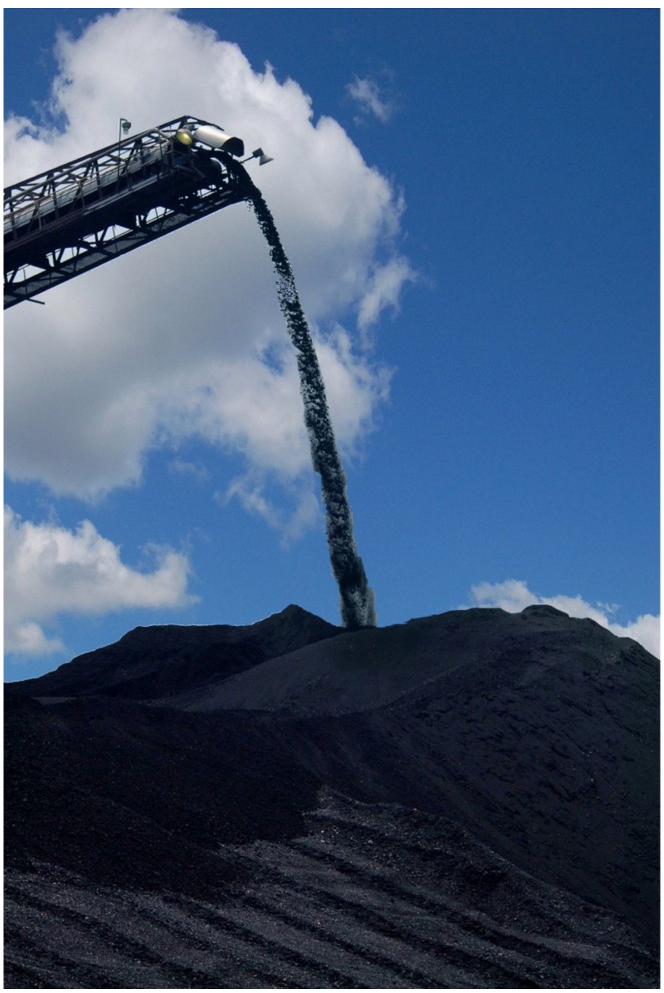
Fugitive Dust Emissions from Bulk Materials Handling at Power Plants

Summary

In 2015, EPRI completed a multi-year research project to develop and test a measurement-based method for estimating fugitive particulate material emissions from coal and ash handling at fossil fuel power plants. This work was novel in that it characterized emissions under real-world conditions at operating facilities. It used the regulatory model currently required for modeling fugitive emissions from power plants to estimate (back-calculate) the emissions from ambient concentrations. The study provided insight on the drivers and impacts of materials handling practices on these emissions. The results can also inform facility permitting applications and emissions compliance activities.



Introduction

Fugitive emissions from power plants are emissions of pollutants not released through fuel combustion stacks or waste streams. Examples include emissions from unpaved roads or materials handling piles (such as coal, ash, or limestone) that are disturbed through mechanical or wind action. The U.S. Environmental Protection Agency (EPA) published emission factors for estimating particulate matter (PM) fugitives in its AP-42 repository. Those emissions factors are uncertain because they were developed from measurements of proxy processes, such as the dumping of soil material off of large trucks or driving on unpaved (dirt or gravel) roads, rather than from the dumping or grading of coal and ash on storage piles. They do not necessarily account for all the important material characteristics, site-specific data, or current materials handling practices in use at power plant facilities.

This lack of representativeness could result in inaccurate emission estimates and affect facility permitting processes or power-plant related implementation strategies to meet air quality goals. There is increasing regulatory scrutiny of fugitive emissions needed to inform New Source Performance Standards, Prevention of Significant Deterioration, or New Source Review processes, as PM standards continue to be lowered. Therefore, it is critical to develop better estimates for fugitive emissions.

To meet this need, EPRI embarked on a multiyear research effort to better characterize fugitive emissions from coal and ash handling. The goals were to (1) investigate an alternate approach to estimate fugitive dust emission factors, (2) obtain a better understanding of the emissions drivers to inform mitigation strategies, and (3) specifically assess active working sites of direct relevance to electric utilities, instead of simulated proxy activities upon which typical emissions factors are based.

Approach

Three project phases were performed, each at different power plants with operating materials piles. Phase 1 was performed in 2011 at the dry fly ash storage pile at Tennessee Valley Authority's (TVA's) Colbert Plant in Alabama. Phase 2 was conducted in 2012 to assess coal moving and grading on a pile at TVA's Gallatin Plant in Tennessee using sub-bituminous Powder River

Basin coal. Both were relatively simple sources with only occasional interferences from other activities or natural phenomenon. A more ambitious effort was undertaken in 2014 with the monitoring of coal operations at Tampa Electric Company's Big Bend Power Station in Florida using bituminous Illinois Basin coal. This host site had multiple dust sources at the coal pile, including barge and rail offloading, stockout, grading, and reclamation. This site was evaluated in part to determine the potential limits of applicability of the new emissions estimation approach. The methodology for all sites was based on data collected from an upwind (i.e., background) and at least one downwind site, meteorological monitoring, and an automated camera for surveillance at each power plant host site. Particulate material measurements were made with beta attenuation monitors, a method certified as a Federal Equivalent Monitor (FEM), for both $PM_{2.5}$ and PM_{10} size fractions. The downwind sites were located up to several hundred meters downwind of the source region. This was done to more accurately reflect the emissions plume that would leave the facility property and to be more relevant for permitting processes than if sites closer to the pile were chosen (due to gravitational settling and other potential loss processes near the source.)

Ambient data were combined with materials handling information (for example truck loads per day, time for grading each deposit) obtained from the facility and camera images. Data were carefully analyzed to segregate periods when various dust sources were active. In some cases this necessitated developing methods to remove confounding sources, such as dust from the roads surrounding the piles. The EPA AERMOD atmospheric dispersion model was then used to estimate (back-calculate) particle emission rates through the use of a normalized concentration and emission rate ratio determined from model runs representing the host site scenarios. Meteorological information on 10 minute periods was combined with concentration measurements to create a 1 hour average emission rate. A number of variations on this method were used to perform sensitivity analyses and assess the level of influence various methodological assumptions may have had on the results. For example, as the area of the ash pile, but not exact location, could be identified, a modeling procedure was used that conservatively estimated results based on the average disposal location instead of the exact source location relative to the receptor. Additional conservative assumptions were chosen whenever possible so that the resultant emission factors (EF) were not underestimated. Finally, the model-determined emission rates were compared to traditional formulations recommended by EPA.

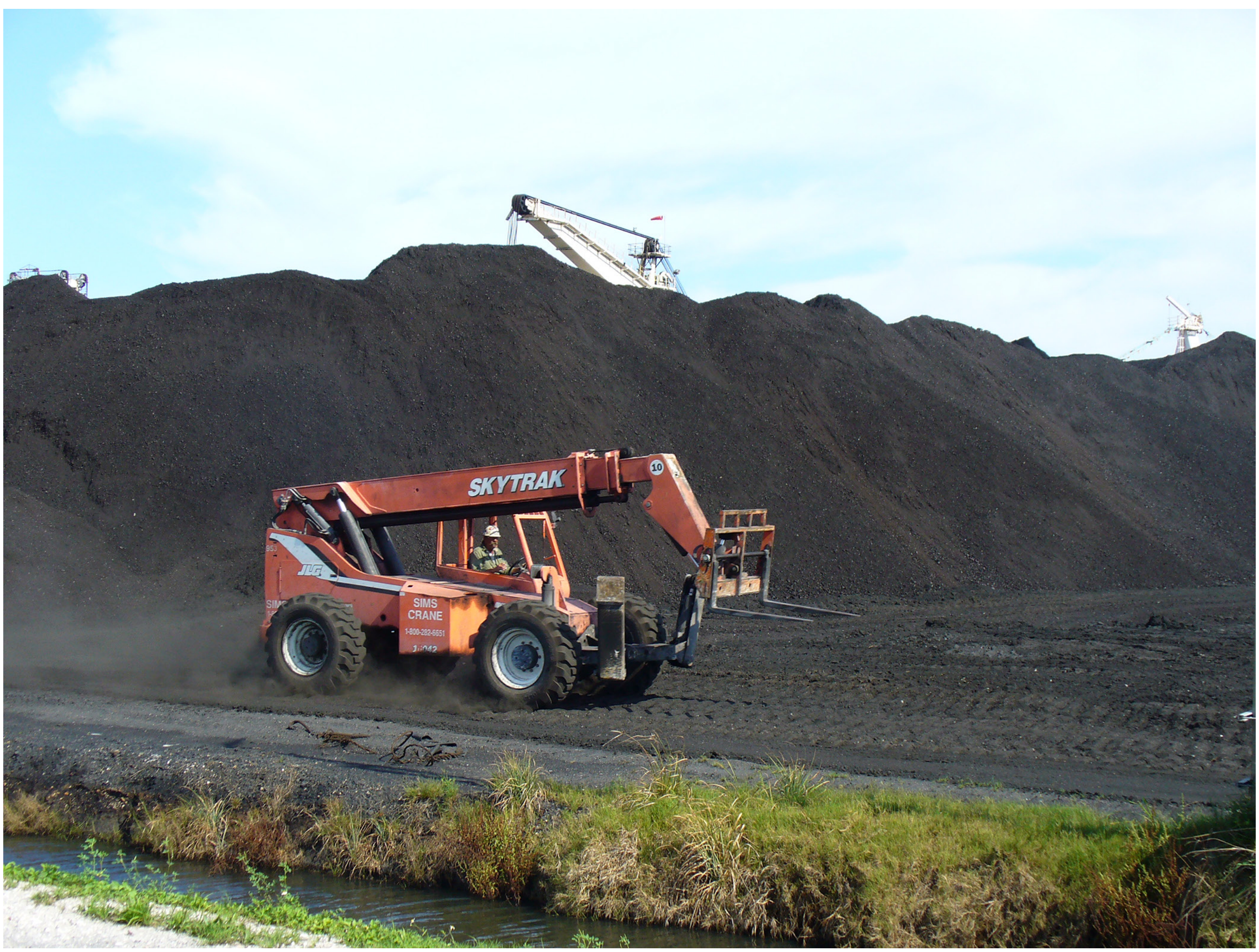
Project Results

The Phase 1 study at a dry fly ash pile successfully demonstrated the feasibility of the new emissions estimation method for fly ash handling on the storage pile. In addition, road dust emissions were also estimated successfully. This was done with the use of rates of change of light scattering profiles for the purpose of removing them from datasets. Strongly skewed distributions of emissions were found with long tails at higher values (i.e., very few cases of very high emissions). The mean and median EF for $PM_{2.5}$ and PM_{coarse} from fly ash, and $PM_{2.5}$ from road dust, were considerably lower than the corresponding emissions calculated based on AP-42. For example, the median PM_{coarse} in this study was a third of the value calculated from AP-42. This was true even when scenarios were considered that would bias emissions high. PM_{coarse} emissions from road dust fell between the values calculated based on two different AP-42 methods, for public roads and for unpaved industrial roads (Mueller et al., 2013; EPRI, 2012). The differences were due in part to the AP-42 formulations being developed for different materials (with different silt and moisture contents) and for a different range of conditions that was tested (e.g., vehicle speeds at the power plants were much lower than for AP-42 proxy tests).

Phase 2 investigated fugitive emissions from a Powder River Basin (PRB) sub-bituminous coal storage pile. Variations on the method developed in Phase 1 were applied to the purposeful movement of the coal through the grading actions of bulldozers (human activity) and a natural source. Enhanced particulate levels were measured downwind with and without human activity on the pile. The PM_{10} emissions from coal moving were usually larger than from other sources. However, natural emissions (dust clouds observed during periods of no human activity) also had an important role in determining downwind concentrations. The estimated EF for bulldozer movement and grading were much closer to estimates based on AP-42 parameterizations than was observed for fly ash, when the AP-42 formulation for driving over unpaved roads was used. This likely occurred because the coal characteristics were more frequently within range of those used to develop AP-42 equations than was true for fly ash (Mueller et al., 2015a). Wind erosion was identified as one natural source for PM_{10}. However, it occurred only a fraction of the time natural sources were observed; the majority of the time wind speeds were below the threshold for windborne dust. During these times the action of microscale turbulence (such as dust devils) on the coal pile was found to be the most probable natural source, likely driven by solar heating of the coal combined with airflow across the pile (Mueller et al., 2015b).

Moisture content had a substantial role in PRB coal dust emissions; emissions dropped by two orders of magnitude as coal moisture content increased from 21 to 33%. Power plant sites with PRB coal that experience significant precipitation over a year would likely overestimate fugitive coal dust emissions if using AP-42, which does not consider moisture effects. Therefore, an approach was developed using local meteorological and other data from multiple host sites over several seasons to estimate coal moisture content at other PRB sites.

The final site tested in Phase 3 was a large storage pile of bituminous Illinois Basin coal. Due to many sources of dust at the site, it was more difficult to clearly separate and quantify the various sources at this location compared to the Phase 1 and Phase 2 sites. The two largest sources were coal stockout, the unloading of material onto the pile, and reclamation. The moving/grading and barge unloading sources had substantially smaller emissions. The coal moving and grading by bulldozer was evaluated, but it was not possible to clearly discern those emissions from the background PM. Most of the analyses focused instead on coal stockout. The resulting emissions were high, and geometric mean values were found to be substantially higher (50 times) than AP-42 estimates for the most relevant equations. This was likely due in part to the type of coal, which had a limited ability to retain water after a number of precipitation events. This result also implies that watering of the pile surface likely does little to suppress Illinois Basin coal emissions. The emissions also are



likely influenced by the high diffuse background concentrations that were observed throughout the Phase 3 campaign (but not in other project phases). The source of the background concentrations likely originated out of the camera view. Two possibilities include a nearby coal coke blending building and/or on-site road dust. Additionally, the stockout emissions were clearly observed to be highest when the coal stockout rate was slowest. This non-intuitive result could not be explained further. It may be that the complexity of sources at the site plays a confounding role in the analysis that can not be clearly explained. A rich database of information was collected at this site that extends beyond the dust sources analyzed to include coal reclamation, barge unloading, and mixtures of all sources. This dataset will be kept available for further analysis in the future.

The results of this multi-year research project could be used as alternative or additional input into estimates of fugitive coal or ash dust emissions if the handling and materials characteristics are similar to those tested. The insights gained in this work imply a closer look should be taken at existing emissions factors for fugitive dust as applied to power plant bulk materials handling processes to understand their relevance and limitations. The creation of new emissions factor parameterizations though additional real world host site monitoring should be considered. Detailed information on the methodologies used and the results obtained can be found in the EPRI Technical Reports and peer-reviewed journal publications listed below.

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For More Information

For more information, contact the EPRI Customer Assistance Center at 800.313.3774 (askepri@epri.com).

Contacts

Stephanie Shaw, Senior Technical Leader, Environment
sshaw@epri.com, 650.855.2353.

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Electric Power Research Institute
3420 Hillview Avenue, Palo Alto, California 94304-1338 • PO Box 10412, Palo Alto, California 94303-0813 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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