Cryptocurrency mining noise: The cost of progress?

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ABSTRACT

Love it or loathe it, Bitcoin and other cryptocurrencies are here to stay. Yet do you know how crypto is "manufactured"? It turns out to be a very noisy operation! Hundreds, if not thousands of powerful computer servers and processors are needed to solve the vexing Bitcoin mining algorithms. And those computers generate heat, a lot of heat (!), that must be cooled and ventilated, thus creating noise. This paper will describe the noise assessment and control efforts performed on a major Bitcoin mining operation in Tennessee. Megawatts of power are needed to support the operations, and the ventilation noise was causing significant community complaints that threatened to shut down the mining operation. Fortunately, application of some traditional and custom-made noise mitigation measures solved the noise problem and allowed the mining operation to proceed around the clock. At the time of writing this abstract, 1 Bitcoin = $46,500.

1. INTRODUCTION

An expanding market for acousticians is cryptocurrency mining noise. Cryptocurrencies such as Bitcoin and Ethereum are "mined" by powerful computer processors solving various algorithms which then results in earning new crypto coinage. The operations can be as small as a few graphic cards in one's basement, to as large as thousands of processors running concurrently as shown in **Photo 1**. The electrical power required to operate these many processors is tremendous, with larger mining operations consuming on the order of 200 MW. And with that power consumption comes associated heat that must be removed through traditional cooling ventilation methods (i.e. fans). Ventilation noise on this scale can easily annoy neighboring communities or even exceed allowable noise regulation thresholds.

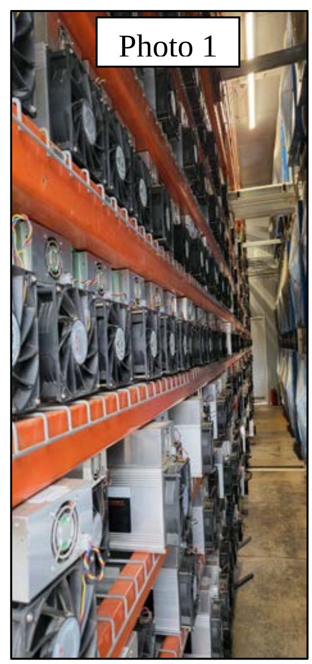
Photo 1

WSP is currently engaged in at least four cryptocurrency mining noise projects located all over the United States. The noise challenges are all generally the same, but the solutions will be project-specific of course. This paper will describe one such project and the successful ventilation noise control methods incorporated into it.

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2. PROJECT DESCRIPTION

A Bitcoin cryptocurrency mining company (client) currently operates two facilities in Tennessee and plans to expand their operations to include two additional facilities. The facilities involve "pods", as shown in **Photo 2**, housing hundreds of computer processors solving cryptocurrency mining algorithms on a 24-hour basis. As such, the processors generate a substantial amount of heat inside the pods that must be cooled through the use of forced air ventilation systems (fans). However, there is concern that the noise generated by the ventilation systems may be offending people living and working in surrounding communities.

One of the client's existing facilities consumes approximately 25 MW and the other facility consumes approximately 15 MW. It is expected that the future two facilities will consume a total of about 40 MW as well. The existing facilities cool their computer processors with multiple vane axial induction fans drawing in and blowing air through the pods. The pods are heavy gauge steel with a reflective interior surface. None of the pods' fans or open areas are treated with silencers.

The client has been operating for several years already, but has received several noise complaints from the neighboring community which were getting to be a political and public relations problem. And where the client wants to expend to add two more cryptocurrency mining facilities, it gave the local planning board the opportunity to re-examine and re-regulate the noise issue. Thus, the client needed to not only reduce noise emissions from its existing two facilities, but also had to convince the planning board that noise would be adequately controlled from their proposed two future facilities as well.

3. TECHNICAL APPROACH

The technical approach for this project involved four tasks, (1) understanding the project and potentially relevant noise regulations, (2) performing ambient noise and noise source emission measurements, (3) developing computer-based noise prediction models for both the existing and proposed facilities, and (4) developing ventilation noise control solutions to attenuate excessive noise emitted by the existing facilities.

3.1. Noise Measurements

Long-term ambient noise measurements, lasting approximately a week, were performed at several residential receptor locations surrounding each of the facilities. This was accomplished using Svantek SV-971 sound level meters that had been integrated into long-term environmental cases with extended battery capability. Noise source emission measurements were performed using a hand-held Larson Davis LD-831 at a distance of about 50 feet from the major noise producing sources in a subject pod. The long-term ambient noise level data served to help establish local noise ordinance limits as well as allowing for a comparative perspective of the significance of the facility noise relative to other community noise sources. The close proximity noise emission measurements served to provide target calibration levels for subsequently developed computer prediction models, as well as to serve as "before" condition sound levels to compare against "after" noise mitigation measures had been incorporated.

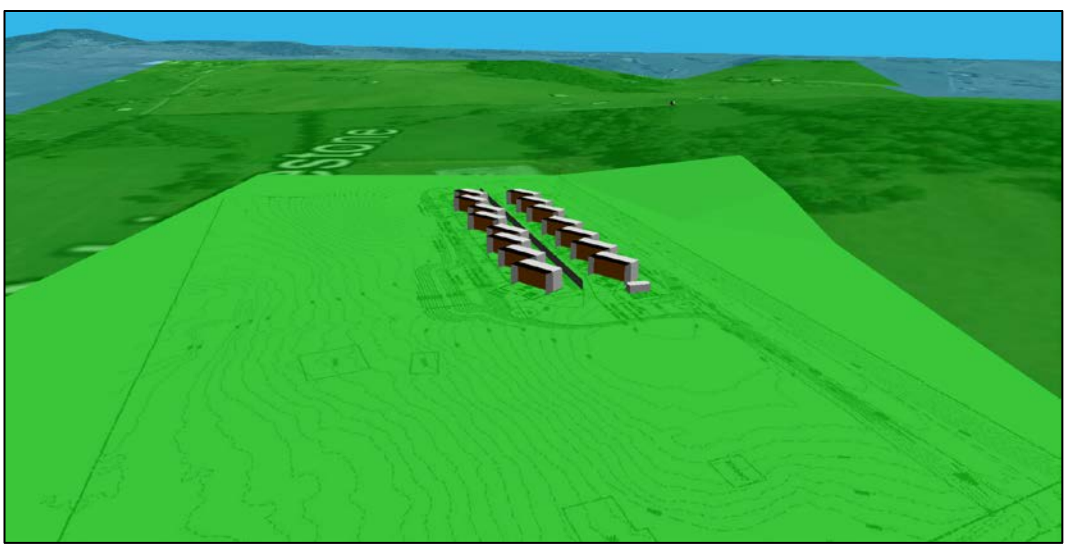
3.2. Noise Prediction Models

The Cadna-A® environmental noise model, developed by DataKustik, GmbH, was used for this project. The Cadna-A model implements ISO Standards 9613 and 17534 for environmental noise sources and outdoor sound propagation. It is a comprehensive, three-dimensional, ray-tracing model in which noise sources are assembled from point, line and/or area components each emitting sound power levels (PWL) in octave bands or broadband A-weighted format. Distance losses, elevation differences, ground attenuation, wind effects, building shielding, attenuation through walls, and barrier/berm effects are computed in the Cadna-A model, and the resulting sound pressure levels (SPL) are predicted at any number of receptors of interest. As is standard practice, all receptors were modeled at a height of 5 feet above the ground.

As shown in **Figure 1**, the model starts with a GoogleEarth® base map of the area in question extending out approximately a mile from each facility. Next, elevation topography data is retrieved from publically-available USGS data services and superimposed over the base map. This ensures that the model will take ground terrane elevation into account when propagating sound levels. The ground itself was assumed to be acoustically 'soft' due to the prevalence of forest and grass areas. Areas of conifer tree cover were then entered in the model to account for foliage absorption and shielding that can be expected year-round. And a "favorable wind condition" was assumed in the model in which a mild wind blows towards each receptor regardless of where the noise sources are located.

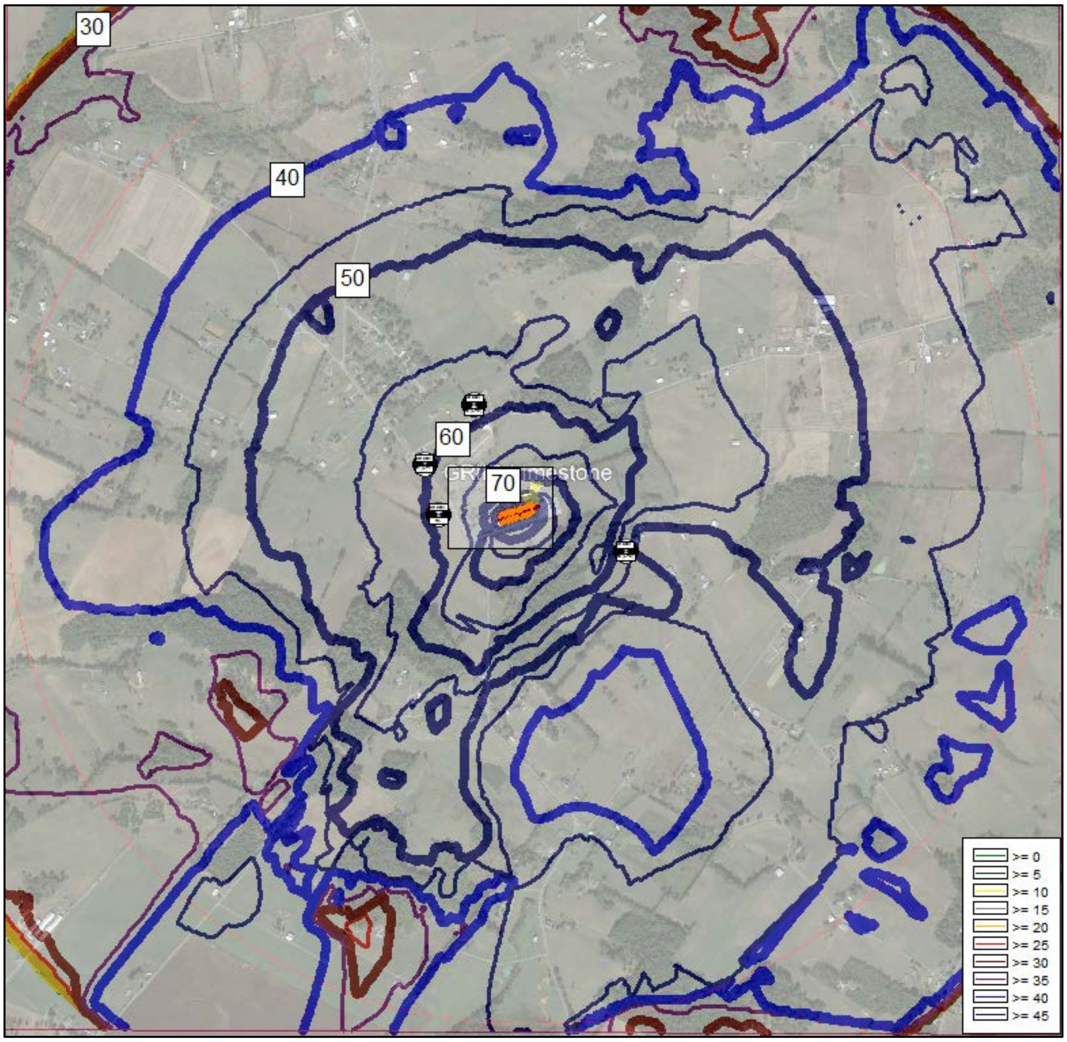
A scale drawing of the client's site layout was then imported into each model and geo-referenced to place it correctly. Physical structures, such as the processor pods and small office buildings, were then entered into the model to account for their acoustical shielding and reflection effects. Vertical area sound sources were then added to each pod to represent the intake side and exhaust side of the pods' ventilation systems. As mentioned above, the sound sources were modeled to match the measured sound emission levels obtained in the field.

Figure 1. Perspective view of Cadna-A noise model



The results of the Cadna-A modeling task for one of the existing cryptocurrency mining facilities is shown in **Figure 2**. Sound isopleth contour lines are shown in 5-decibel intervals radiating away from the facility and into the surrounding community. Sound levels at individual discrete residential receptor locations were also computed by the Cadna-A model, thus allowing for determination of compliance or not with local noise ordinance limits.

Figure 2. Sound isopleth contours for cryptocurrency facility



4. NOISE CONTROL OPTIONS

Noise control options were then developed and recommended to the client for consideration. Those options included, (1) Sound absorptive material inside the pods, (2) acoustical louvers for all pod ventilation openings, (3) substituting for quieter ventilation fans, and (4) erection of noise barriers in effective locations. It is noteworthy that in this case all four of the noise mitigation options could be "additive" because they effect noise at different points along the process. Quieter fans and pod absorption are source controls, while acoustical louvers and noise barriers are pathway controls. Thus, they could be used in combination to get an additive noise reduction benefit.

4.1. Sound Absorption Material

Sound absorption material installed inside the pods housing the mining processors will absorb a portion of the sound incident upon it, thus reducing the reverberant noise inside the pods and eliminating it as a potential for escaping to the environment. In general, the thicker the absorption material, the better it performs down to lower frequencies. In any case, it was recommended that the material should have a Noise Reduction Coefficient (NRC) of 0.7 or greater. In general, the elimination of reverberant noise within a container can reduce the sound levels escaping to the outside by 5 to 10 decibels. Care must be taken to ensure that the absorptive material is not flammable.

4.2. Acoustical Louvers

Acoustical louvers to reduce ventilation noise escaping out through the pods' intake and exhaust openings could be installed in place of standard window louvers. Acoustical louvers have a sound absorptive material applied under each vane impeding the escaping airflow and absorbing some of the noise contained in it. In general, the thicker the absorption material, the better it performs down to lower frequencies. In any case, it was recommended that the material should have a Noise Reduction Coefficient (NRC) of 0.7 or greater. In general, acoustical louvers can reduce sound levels escaping through the ventilation openings by 5 to 10 decibels. Care must be taken to ensure that the added airflow backpressure caused by the acoustical louvers does not adversely affect the cooling capability of the ventilation system.

4.3. Quieter Ventilation Fans

Quieter ventilation fans installed for each pod to replace the fans currently in use could reduce ventilation noise at its source. Source control options avoid excessive noise from being generated in the first place, and are always more effective than other mitigation options applied once the noise has been generated. Quieter fans make use of specially curved blades to reduce air turbulence and vortex shedding, and variable speed motors allow the fans to not operate at full power all the time. The noise reduction potentially achievable with quieter fans could be approximately 10 decibels.

4.4. Noise Barriers

Noise barriers act as shields that redirect unwanted noise to other less-offensive directions. Their effectiveness is a function of their height, length, and position relative to the noise source and receptor. As long as the barrier's height breaks the line-of-sight between the source to the receptor, and that the barrier has a material surface density of at least 4 lbs/SF, then the propagating sound will not pass through the barrier, thus making the barrier's height the key determinant. In general, the taller a barrier, the better its noise reduction performance. However, there are practical limitations as to how tall barriers can be constructed due to wind load and anchoring system considerations. Nevertheless, a well-designed noise barrier can reduce noise levels for receptors behind the barrier by 10 to 20 decibels. That said, barriers reflect noise as well, so the sound energy is still available to propagate in the reflected directions. Barriers with an absorptive face treatment are available to reduce unwanted reflections.

5. NOISE CONTROL INSTALLED

The client opted to install two of the four suggested noise control options, namely installing acoustical louvers in the ventilation openings, and erecting noise barriers around the facility. The client had access to their own manufacturing shop so they decided to fabricate their own acoustical louvers. And 20-foot tall noise barriers were purchased and installed using ECHO Model H2 absorptive barriers. Follow-up noise measurements were then preformed again in the same locations "after" the noise mitigation treatments had been put in place.

5.1. Acoustical Louvers Installed

The client fabricated and installed their own acoustical louvers, with guidance provided by WSP. As shown in **Photo 3**, the acoustical louvers consisted of 25 inch tall horizontal vanes with a 14 inch downward open air pathway. Two-inch thick rockwool panels were applied to the undersides of the louver vanes, thus protecting the rockwool from rain and ensuring existing sound would impinge on the rockwool and be partially absorbed before escaping to the community.

5.2. Noise Barriers Installed

The client purchased and installed ECHO Model H2 absorptive barriers along the fence line around the facility to a height of 20-feet tall, as shown in **Photo 4**. The barriers have a Sound Transmission Class (STC) rating of 18 and an absorptive side with a Noise Reduction Coefficient (NRC) rating of 0.6. Again, the client was able to perform the installation work themselves.


Photo 3


Photo 4

6. MEASURED NOISE REDUCTION

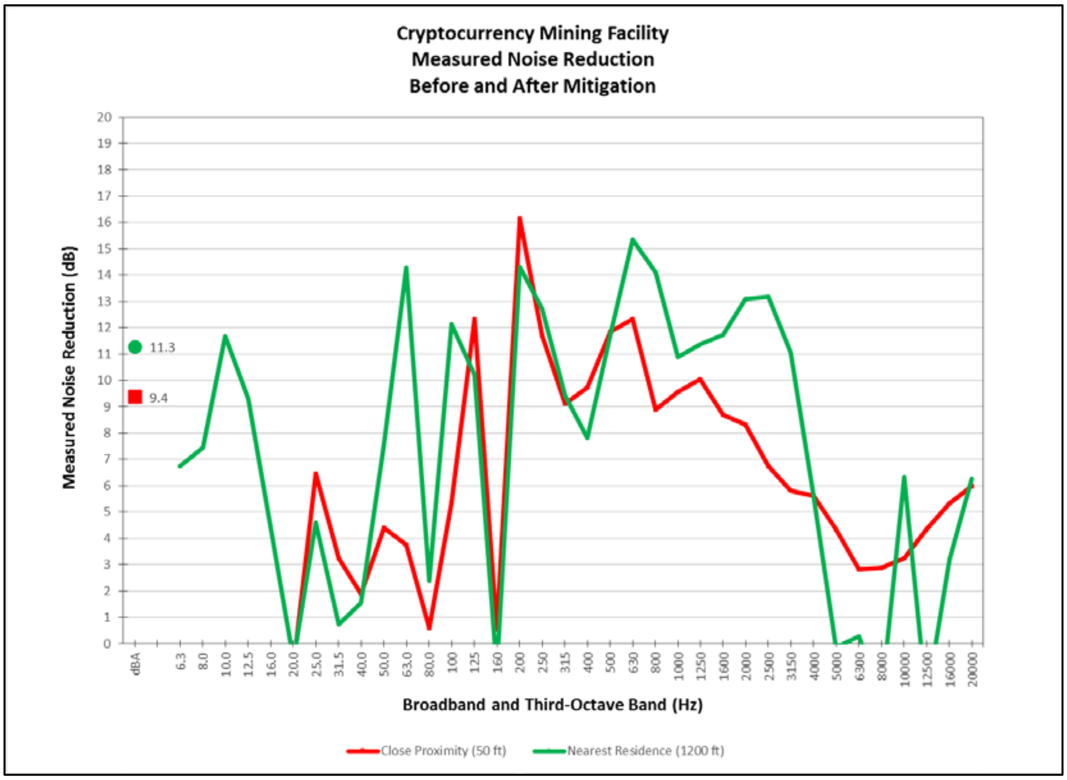
WSP returned to the client's facility site after the two forms of noise mitigation had been installed to perform post-installation noise reduction measurements. Again, a Larson Davis LD-831 sound level meter was used to perform the "after" measurements at the same close proximity locations as had been measured in the "before" mitigation condition. Mitigated sound levels at one community residential receptor were also measured.

The results shown in **Figure 3** summarize the measured noise reduction at both a close proximity location (50 feet) as well as at a more distant community receptor location (1,200 feet). The close proximity measurement only takes into account the effects of the new acoustical louvers. The more distant community measurement is affected by both the new acoustical louvers as well as the 20-foot tall noise barrier on the facility's fence line.

As can be seen, appreciable noise reduction was achieved in the frequency range of about 50 Hz to 5,000 Hz, which easily spans the frequency range of loudest noise emissions. The broadband A-weighted noise reduction at the close proximity site was 9.4 dBA NR, and at the more distant residence the A-weighted broadband noise reduction was 11.3 dBA NR. It was thus concluded that the acoustical louvers had fulfilled their intended function, and that noise reduction benefits of the noise barrier, although minimal, certainly contributed as well. It is likely that the effects of the noise barrier would have been more dramatic at other receptor locations where the receptor was not located uphill relative to the cryptocurrency facility.

The client was pleased with these noise control results, and the data shown in this paper was presented to the local planning board to convince them as well that the client could indeed manage their noise not only at their two existing facilities but also at their two future facilities.

Figure 3. Measured Noise Reduction Before vs After Mitigation



7. CONCLUSIONS

A relatively new and expanding field for acousticians can be found in evaluating and designing noise control solutions for cryptocurrency mining operations. Ventilation noise produced by the fans needed to cool the numerous computer processors can adversely disturb the surrounding community, especially when the mining operations continue 24-hour day and night. Fortunately, community noise assessments and ventilation noise control are fairly well understood and achievable with tried and proven methods.

In this case, an existing cryptocurrency mining company not only needed to reduce noise from their existing two facilities, but also needed to convince the local planning board that they could adequately control noise from two future proposed facilities. Four methods of noise control were recommended for consideration including (1) Sound absorptive material inside the pods, (2) acoustical louvers for all pod ventilation openings, (3) substituting for quieter ventilation fans, and (4) erection of noise barriers in effective locations. Of these options, the client opted to install the acoustical louvers and to erect a 20-foot tall noise barrier along their fence line.

Post-installation sound measurements confirmed that the two forms of noise mitigation installed in one of the existing facilities were providing approximately 10 decibels of noise reduction. The client was pleased with these noise control results. The data shown in this paper was presented to the local planning board to convince them as well that the client could indeed manage their noise not only at their two existing facilities but also at their two future facilities.

8. ACKNOWLEDGEMENTS

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