# Data Centers: Noise Modelling and Environment Constraints

Dr Francesca Remigi[1]
[1]*Independent Researcher, 3 Approach Road, London, SW20 8BA, United Kingdom*

**Abstract- Internet and business application play a key role in the modern society. The increasing demand for storage and computation has driven a fast growth of large data centers. In 2017 the global number of these massive server farms has reached the peak at 8.6 million. When business units require new applications it's fundamental for IT organizations to understand how is possible to develop these applications to fit within a proper building. The infrastructure that enables these complex operations needs in fact to be flexible to adapt quickly to evolving business requirements. Noise is one of the principal items with the potential to introduce physical constraint to the building design and regulatory constraint. This paper presents the key aspects in the noise modelling of a data centre**
**Keywords – Noise, Data Centers, Chillers, Diesel generators, HVA**

## I. INTRODUCTION

In the past two decades significant investment has been made in hyper scale data centers to support services as social networking, electronic commerce and cloud computing. Today internet connectivity is essential to our lives, it has revolutionized the way we communicate, consume information and conduct business [1].

Data Centers are employed in in every aspect of modern life, such as; food, clothing, shelter, transportation healthcare and social activities that cover the relationships among individuals within a society. Companies like Amazon, Google, Facebook and Microsoft invests 100s of millions of dollars per year to design, deliver and operate their data centers [2, 3].

According to the International Data Corporation 'mega data centers' built by the likes of Amazon and Microsoft will continue to increase in size in the future. In terms of volume, by 2018 such facilities will account for 72.6 percent of all service provider data centers construction projects.

There is plenty of room for discussion and debate on the real and/or perceived environmental impact of data centers and their associated technology, including servers, storage, networks, and facilities, as well as how they are managed [10].

Significant infrastructure supplying heating, ventilation, cooling (HVA) and power is required to facilitate optimal functioning of these facilities.

Uncontrolled noise is considered among the first causes of urban degradation and the potential impact on human health and environment quality is huge. Many studies have found that urban noise exposure may produce a number of direct and indirect effects other than hearing damage. These include interference on communication and sleep disturbance effects.

Work within a data center (as is the case in any industrial sector) has the potential if not managed properly to expose some employees to suboptimal working conditions. The issues related to such occupational noise, are not object of this paper

Controlling noise pollution in the data center sector is a priority for many organizations. It is essential that all such applications have the required noise control measures in place that ensures the facility meets with the relevant noise criteria.

In the past, noise assessments at industrial sites have been carried out just by the mean of short-term noise measurements on a limited number of noise receptors located in the surroundings of the site and by simplified quantitative analyzes.

Experience has shown that often, and especially in large installations, this type of approach doesn't allow obtaining clear vision of the real noise impact and doesn't produce enough information for the decision making.

In the last decade the fast development of noise mapping software has provided some valid solutions to this issue.

In fact, acoustic models are used to determine the contribution of individual sound sources in a define area under investigation, to forecast noise in the environment at design stage for a new settlement, to determine or compare the effectiveness of noise mitigation solutions.

## II. NOISE SOURCES AND MITIGATION MEASURES

What is it a Data Centers and how it works? A Data Center facilitates the electronic storage and handling of large quantities of data. Data Centers typically consist of servers, routers, switches, storages, tape systems, UPSs (uninterruptible power supplies) and cooling systems. Significant quantum of energy is required to facilitate optimal functioning of these facilities. A hyper scale Data Centre can require as much electricity as a small town [4, 5], ranging from 1MW to over 500MW. Backup power may consist of one or more uninterruptible power supplies, battery banks, and/or diesel / gas turbine generators. [6] [7]

A Data Center is a complex combination of facility systems and IT systems that operates typically without the potential for downtime for reconfiguration work, for this reason, flexibility in design is essential to allow future expansions and rezoning of loads.

Data Centers layout, vary according to the functional requirements of the operator, with large-scale operators often using an in-house core design globally to facilitate uniformity of operation. This core design is typically amended as required to local conditions, regulations and constraints.

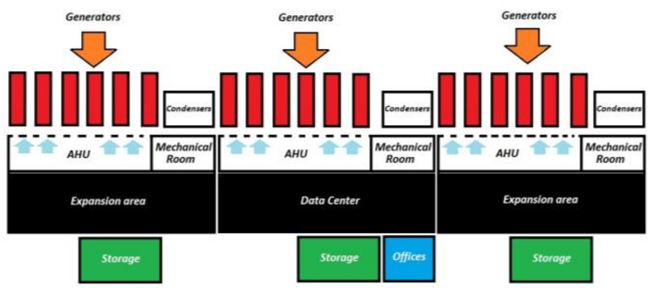
Usually a Data Centre is a single store multi-store large scale operations are relatively rare. The data hall, which hosts the IT equipment, the office space and the storage area are located at the ground floor of the building. The mechanical room and the electrical room are in close proximity to the data hall to minimize the routing of piping through non-mechanicals spaces and to minimize the lengths of copper feeders from the electrical distribution to the ITE to the data hall.

For all the data centers that utilize battery-based powered via uninterruptible power supplies (UPS) next to the electrical room is located the battery room.

Chillers and condensers due to their high amount are often located at roof level.

The generators can be either located inside the building or externally on the site. External generators will typically be housed within an acoustic enclosure

In case of two-dimensional image, after a DWT transform, the image is divided into four corners, upper left corner of the original image, lower left corner of the vertical details, upper right corner of the horizontal details, lower right corner of the component of the original image detail (high frequency). You can then continue to the low frequency components of the same upper left corner of the 2nd, 3rd inferior wavelet transform.




General scheme of a Data Center

There are typically two principal sources of external noise associated with data center operations:

Generators; and

## III. HEATING AND COOLING SYSTEM EQUIPMENT.

### *3.1. Generators*

A Data Center is usually powered via mains grid connection. Most large scale Data Center has also standby generators for power interruptions, emergencies and disaster recovery.

Generators, typically diesel powered, which are the noisiest pieces of equipment in a Data Centre, can run for extended periods in some scenarios.

The main sources of noise from a diesel generator are:

Engine noise;

Engine exhaust noise;

Cooling fan noise; and

Engine structural vibration.

Acoustic mufflers are a valid solution to attenuate the exhaust system noise. For the other sources of noise, an enclosure is often the most practical solution to control acoustic emission levels. Reductions in these levels up to 30 dB are achievable with acoustic enclosures.

Where the generators are located inside the building, an expansion chamber muffler can be employed to reduce the noise. The expansion volume acts as a resonator to provide an acoustic mismatch for the acoustic energy being transmitted along the main duct.

The design of plant rooms housing any live generators must ensure the sufficient and efficient airflow, whilst maintaining the target acoustic specification [7].

Any potential attenuation required on either the intake and/or exhaust, must be specified and validated through modelling in the design phase, before the scheme goes to construction.

Inlet and outlet Air attenuators can reduce the noise produced by the cooling air. The generator connections (anchors, radiator discharge air ducts, exhaust piping etc.) have the potential without sufficient isolation (vibration isolators/flexible joints) to transmit vibration to the building structure. To reduce the noise transmission it is fundamental to fit all the connections, fuel lines and wiring conduit, with flexible joints.

The construction of the plant room itself also needs acoustic design reduce potential for noise breakout to adjoining rooms within the Data Centre. [7]

*3.2 Heating and Cooling System Equipment*

Simply put, the HVAC equipment takes the heat from the Data Center, treats it and transfers to atmosphere. The outdoor conditions (temperature and humidity) play a significant role in the cooling process. Outdoor air temperature is proportional to the work required of the compressors to lower the air temperature back down to the target levels in the Data Center. [7]

There are different types of cooling system equipment generally central plants are the more common for large Data Center because they have the capability for future expansion. A central plant consists of primary equipment such as chillers and cooling towers, piping, pumps, heat exchangers, and water treatment systems. The cooling systems are connected to a central cooling plant that generates chilled water or condenser water for use in the remote air-handling units or CRAHs.

Usually the air handling system is the primary source of noise within the server halls with large volumes of conditioned air being-passed into and out of the racks 24/7. Due to the large volumes of conditioned air required to cool Data Center halls, mechanical plant such as chillers and condensers are usually located at roof level.

Acoustic louvres provide noise reduction whilst maintaining required airflow to the equipment. Where airflow is less of an issue, acoustic barriers and fans mounted silencers provide a reduction of noise if required.

External mechanical compounds located at ground level typically need additional attenuation in the form of barriers and screens, depending on their location within the perimeter of the site. By placing a compound as far away as possible from potential noise receptors, this will improve the levels of noise emitted and reduce the need for specialist attenuation.

Depending on the specific equipment requiring treatment, acoustic louvres, enclosures, barriers and containers can provide a reduction of noise.

## IV. NOISE LAWS AND REGULATIONS

Noise regulations vary geographically which regard to what is considered to be the appropriate target, and operators must be mindful of these variations in selecting a location and ultimately in designing the Data Centre.

Standard practice internationally in the planning/permitting process for mission critical projects is to model:

Standard operating Scenario; and

Emergency operating Scenario

*4.1 Standars Operating Scenario*

This typically includes the normal day to day operation of the proposed facility inclusive of all external (including roof mounted) noise producing plant. It may also include the running in the noise model of a single back up diesel generator 'on test', as it is typically a requirement of the operator to run routine maintenance checks on the gen sets. This maintenance check cannot be considered an emergency as it is routine and pre-planned.

*4.2 Emergency Operating Scenario*

This scenario typically caters for a major power outage to the facility where the main site power comes from the "emergency" on site generators. This typically represents a significant increase in noise output from the site, and it is often very challenging to meeting the noise emission conditions for the site in this scenario.

In recognition of the above difference, it is typical in countries with developed power grids, for the emergency operation of the proposed facility not to be governed by noise limits, and to be treated differently to the standard operating scenario, which is typically limited in noise emission.

In some jurisdictions where this premise has not been considered in detail before, where the power grid is relatively unstable, or where the planning authority has not developed considerable experience in acoustic modelling and planning, there can be difficulties in establishing the above scenario distinction. In this instance the planning authority can, through a lack of understanding of the issues at hand, condition the emergency operations to the same limitations as the standard operating scenario.

In the EU and the US the argument for the likelihood of the site losing first line (and often also independent back up) mains grid power feed is extremely remote, and even if it were to happen the downtime would be very restricted due to the national reliance on repair efforts. For example, in UK, Data Center can be connected to the transmission network directly, and not to the distribution network as would be typical for non-mission critical projects.

As such the planning authorities are typically comfortable in exempting the emergency scenario from noise limits. However in jurisdictions with less reliable power grids, failures of the grid, including the transmission system can be of such regularity that they are commonplace. In these areas the planning authorities do not consider the loss of power to the project to be an emergency they fully expect it to happen.

As regards the European Countries, the current noise regulation for the generators is the 2000/14/EC (stage II).

In not-European Countries, states and local codes establish maximum noise levels that are allowed at the property line.

Among the factors that come into play in evaluating a potential Data Centre site are the cost, the availability of power and the environmental constrains.

Data Centre can potentially generate large amounts of noise if not controlled appropriately, which is why it is important to consider various methods to lower noise and vibration for sensitive receptors in the building or the surrounding area. State and local codes establish maximum noise levels allowed at property line or at sensitive receptors.

## V. NOISE MODELLING

The use of numerical models allows managing the environmental configuration by the identification of significant noise sources, the characterization of the sources (generation models), the study of the spread between source and receiver (propagation models). It is also very important to provide a reliable topographical description of the area (topography receptors).

Numerical methods are based on analytical formulas that describe the physical phenomena related to the acoustic propagation starting from source sound power data.

Source type (point, line, areas) defines the acoustic properties of any source in terms of source height from the ground, sound power, and spatial distribution of the sound radiation (directivity).

Generators and AHU can be modelled as structures with horizontal and vertical area sources.

Chillers/ extract fans, condensers and generator exhaust can be modelled as point sources.

The acoustic model accounts for equal sound radiation of noise sources in all directions.

The noise data for the different noise sources are usually provided by the manufacturers.

As regards the propagation model, noise mapping software use the ISO 9613: 1996 Acoustics – Attenuation of Sound during Propagation Outdoors noise prediction methodology for the prediction of industrial noise in and around the site under investigation. This methodology is accepted as the industry standard for the assessment of industrial noise propagation. ISO 9613-2 gives the estimated accuracy of the noise model as ±3 dB, for the calculation of broadband A-weighted sound levels, for receiver distances of up 1 km

## VI. CONCLUSION

A Data Center is a very complex environment and many of the noise sources typically present on site have similar acoustic characteristics. Acoustic mapping as part of the design process allows optimizing the noise mitigations. The acoustic models allow the identification of the contributions of the different noise sources to the overall ambient noise level and it is a useful resource for the formulation of different noise control strategies.

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