Air Permitting for Data Centers

MW AWMA Conference

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RAMBOLL

Bright ideas.
Sustainable change.

Agenda

1. Data Center Operations & Emission Sources
2. Air Permitting Considerations
3. Air Dispersion Modeling
4. Ongoing Compliance

Data Center Operations & Emission Sources

Data Centers – Who uses them and why?

According to GoogleAI…

- "Data Centers are used to store, process, and manage vast amounts of digital information, power cloud services, run AI, and support critical applications and operations"
- Utilized by:
  - Tech giants like Google and Amazon (hyperscalers)
  - Financial institutions
  - Healthcare providers
  - Governments
  - Manufacturers
  - Retailers
  - Educational bodies

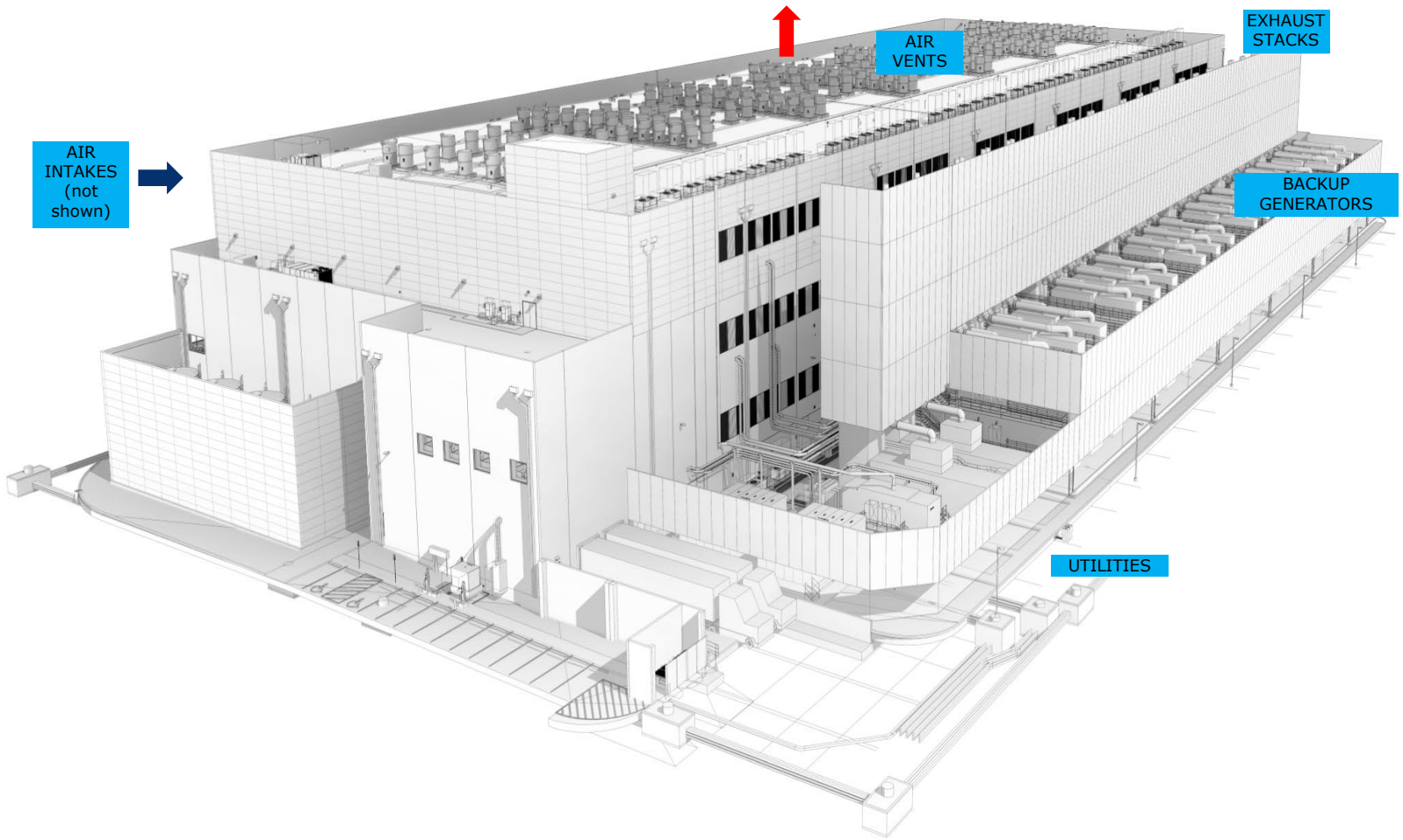
…and more!

What is a Data Center, Anyway?

- A physical room, building, or facility where data is processed, organized, and stored
- Inside a data center:
  - Servers
  - Cooling
  - Power
  - Backup and Recovery
  - Security
- **Data centers require continuous power** (rule of 9s)
  - If high-line power goes down, power is *often* supplied by emergency generators
  - These generators require periodic maintenance and testing (M&T) to ensure they will operate as expected when needed

Different types of Data Centers

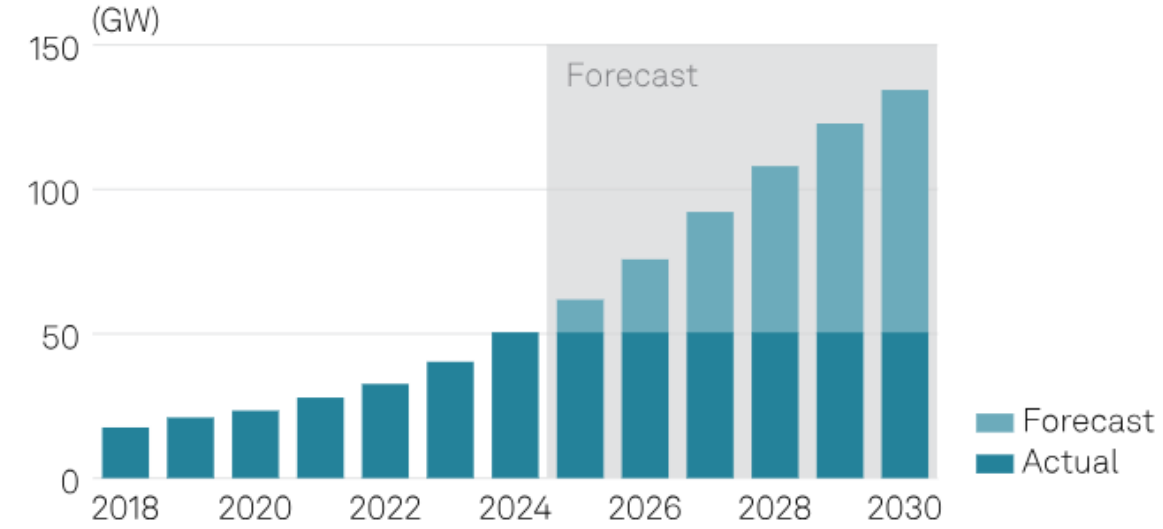
- On-premise
- Colocation / Wholesale
- Cloud
- Hyperscale
- Edge



Environmental Impact of Data Centers

- Water Consumption
- ***Energy Consumption***
- Noise Pollution
- Battery Usage
- Fuel Storage
- ***Air Pollution***
- Often large footprint

US power demand from data centers expected to more than double from current levels



Utility power represents actual and forecasted total electricity supplied to data centers from the power grid, including IT equipment, cooling, lighting, offices and security systems as of the market monitor release date.
Source: S&P Global Market Intelligence; 451 Research Data center Services & Infrastructure Market Monitor & Forecast: US focused released Sept. 24, 2025.

Air Emissions from Data Centers

Typical Emission Sources:

- Diesel-fired generators
- Diesel belly tanks (VOCs)

Other Emission Sources:

- Natural-gas fired generators
- Turbines
- Cogeneration units
- Fuel cells
- Cooling Towers

Diesel-Fired Generators

Limiting Emissions

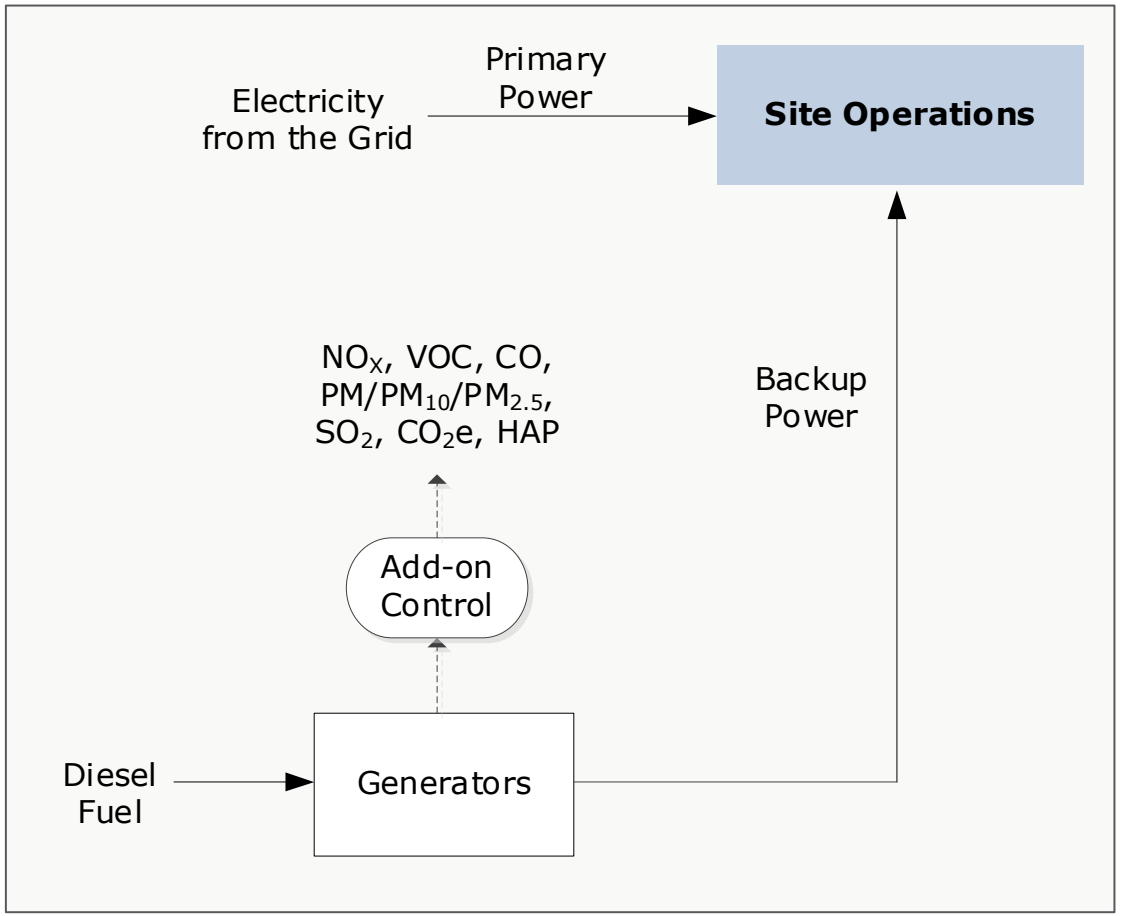
- Typically, NO_X is the most limiting pollutant
- If add-on controls exist, CO may be most limiting
- PM can be limiting from a modeling standpoint

Add-on Controls

- Selective Catalytic Reduction (SCR): NO_X
- Diesel Oxidation Catalyst (DOC): CO, VOC
- Diesel Particulate Filter (DPF): PM

Typical Operations

- Commissioning
- Maintenance and testing
  - Planned, routine [e.g., monthly, quarterly annual preventive maintenance]
  - Unplanned [e.g., equipment breakdown]
- Emergencies
- Other non-emergency operations



Air Permitting Considerations

Air Permitting for Data Centers

Historical Permitting Regime

- Emergency engines categorically "exempt" in many states
- Diesel belly tanks & cooling towers "hand-waved" due to magnitude of emissions
- Applicable regulations usually limited to RICE MACT and NSPS IIII/JJJJ

Why is this changing?

- Previous regulations not well-suited to facilities permitting ~100s x ~3 MW emergency engines at once
- More data centers are expanding above major source thresholds
  - More need for prime power
  - Federal construction permitting (i.e., BACT/LAER) establishing new precedent

How is this changing?

- States are trying to react with new regulations and "best permitting practices"
- Observing a shift for:
  - dispersion modeling
  - need for emissions controls
  - complex permit conditions

Federal Regulations Related to Generators

- **40 CFR 63, Subpart ZZZZ**
  - Also known as RICE MACT or RICE NESHAP

- **40 CFR 60, Subpart IIII**
  - Also known as NSPS IIII
  - Compression Ignition (CI) engines – Diesel

- **40 CFR 60, Subpart JJJJ**
  - Also known as NSPS JJJJ
  - Spark Ignition (SI) engines – Natural gas, gasoline, propane

- Combined, these regulations cover the stationary engines in the United States

- For emergency engines: Hour meter, specific maintenance required engine after certain hours of runtime, logging times/type of operation

Data Center Air Permitting Considerations

- Location
  - Attainment/non-attainment – major source thresholds
  - Source status, future full-build
  - Site aggregation – other data centers, power generation
    - Common control
    - SIC
    - Continuous or adjacent
- Source types & emissions
  - Emissions data from engine manufacturer
  - Confirm adequate runtime availability
  - Determine if controls are needed
- Limiting pollutant is typically NOx (but may be CO if controls exist)
  - In attainment areas, data centers will typically take limitations:
    - < 100 tpy for regulated pollutants for Title V
    - < 250 tpy for PSD
- Is modeling required? If so, how/what is modeled?
- Permit limits
  - Emission-based, hours-based, fuel-based, time of day restrictions

Permit Terms

- Limits:
  - Emission-based
  - Hours-based
  - Fuel-based
- Best management practices:
  - Limits on time-of-day for M&T activities
  - Limits on hours per year for M&T

Pollutant	Hourly Emissions per UNCONTROLLED Generator (lb/hr/gen)						Hourly Emissions per CONTROLLED Generator (lb/hr/gen)					
	100% Load	75% Load	50% Load	25% Load	10% Load	Maximum	100% Load	75% Load	50% Load	25% Load	10% Load	Maximum
NO_x	70.72	47.91	26.93	14.03	11.93	**70.72**	7.07	7.19	4.04	5.61	7.75	**7.75**
Notes	*Wide variation across loads. Obtaining an hours-based limit here would leave runtime flexibility on the table.*						*Low variation across loads. Obtaining an hours-based limit here would be favorable.*					

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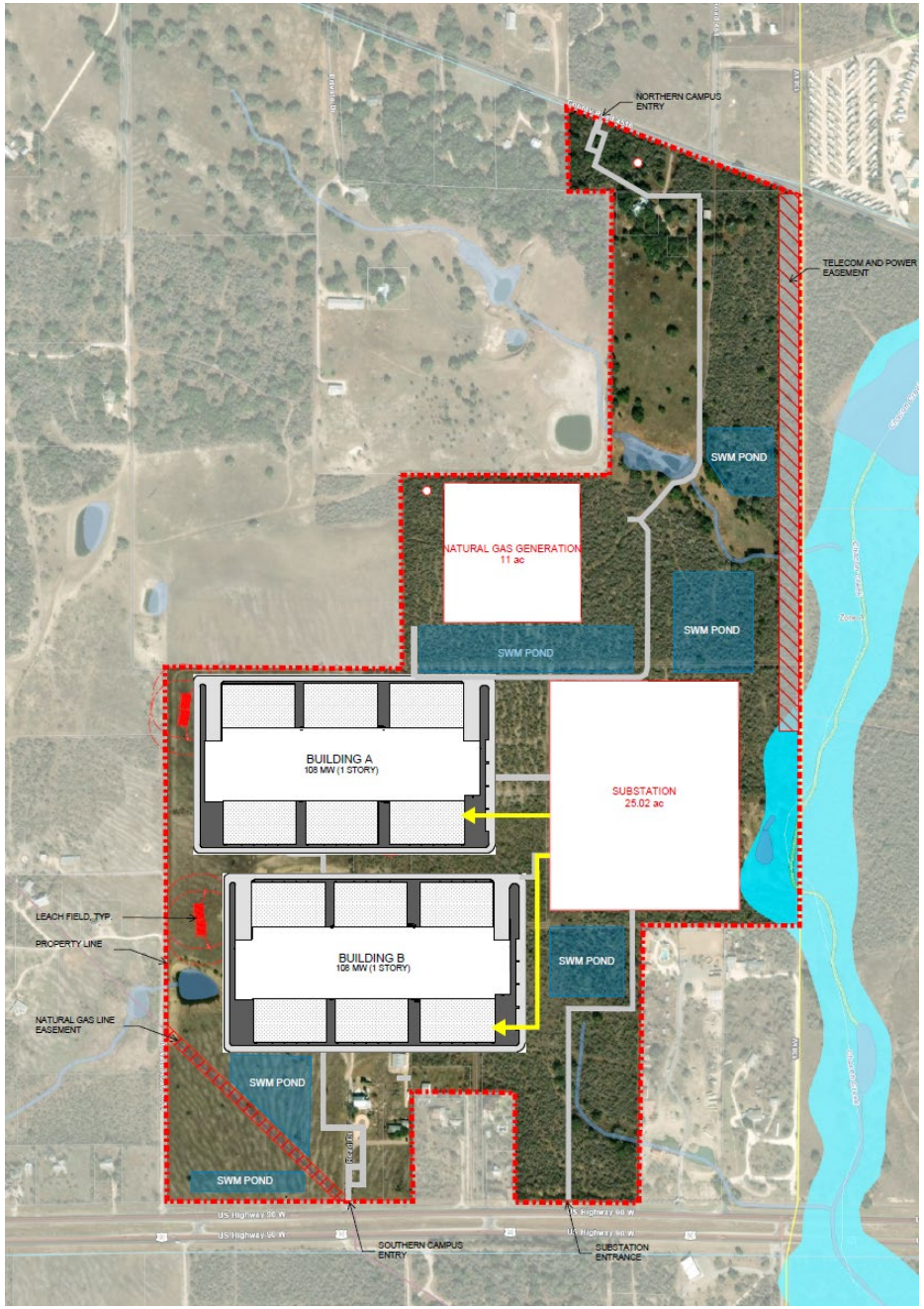
NO_x	0.34	0.31	0.25	0.27	0.58	**0.58**	0.03	0.05	0.04	0.11	0.37	**0.37**
Notes	*Low variation across loads. Obtaining a fuel-based limit here would be favorable.*						*Wide variation across loads. Obtaining a fuel-based limit here would leave runtime flexibility on the table.*					

Air Dispersion Modeling

Modeling Challenges for Data Centers

- AERMOD has a degree of conservatism
- **Stringent 1-hour NO_2 NAAQS**
- Lowering $PM_{2.5}$ standards
- Intermittent sources
- NOx chemistry
- Potentially complex source operation
  - Different M&T scenarios
  - Tier 2 vs. Tier 4 engines
- Cumulative modeling
- **Lag of guidance**



Federal 1-Hour NO_2 Modeling Guidance

- From Tyler Fox Memo (March 2011)

"…The potential overestimation in these cases results from the implicit assumption that worst-case emissions will coincide with worst-case meteorological conditions … In fact, the probabilistic form of the standard is explicitly intended to provide a more stable metric for characterizing ambient air quality levels by mitigating the impact that outliers in the distribution might have on the design value" … this "effectively impose(s) an additional level of stringency beyond that intended by the level of the standard itself."

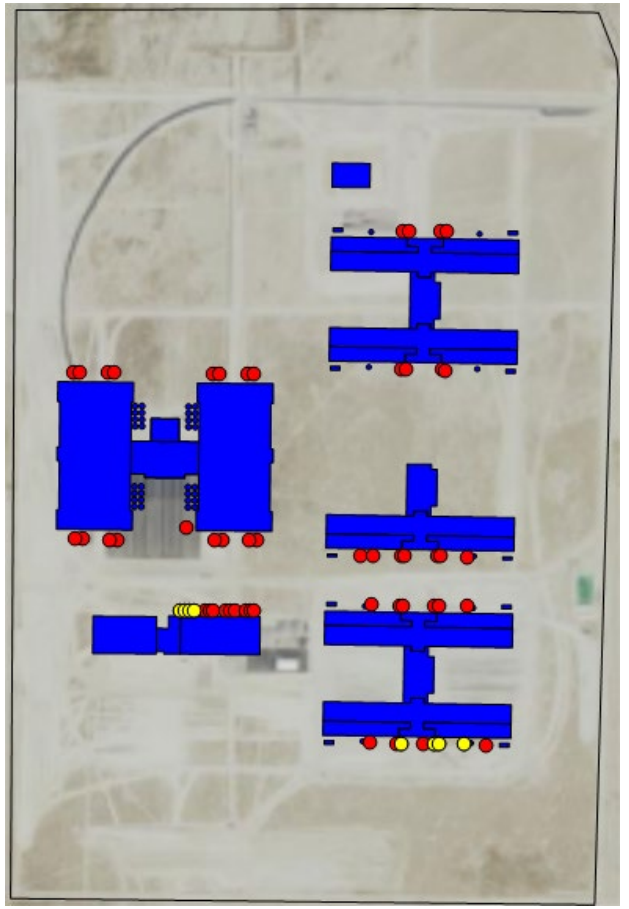
(EPA, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour $N0_2$ National Ambient Air Quality Standard, 2011)

  - Provides discretion for reviewing authorities to exclude intermittent emissions or annualize emissions from emergency generators from short-term modeling (1-hr NO_2)
- June 2021 Regional, State, and Local Conference Round Table EPA stated that:
  - Prior memo was not developed with emergency generators at data centers in mind
- Since data centers to-date have remained minor sources, EPA has not intervened but also no further guidance on handling short term standards

Potentially inconsistent permitting between states

Traditional Approaches for NO_2 and $PM_{2.5}$ Modeling

- On practical level, impossible for all but the smallest facilities to pass attempting to model all engines running simultaneously
- For sites with a large number of generators (like data centers), a screening approach is often used
- Example on right: Data center on right has approximately 60 generators
  - Screening modeling was performed to determine eight generators causing the worst ambient impacts – four from the west half or the facility, four from the east half
  - A final run with emissions from only those eight engines showed compliance against the NAAQS
  - Of course, the condition that only eight engines (four west/four west) can be tested at once became a permit condition for this facility
- Some facilities want more operational flexibility…



Data Center Modeling

- Many data center clients are using different loads and durations in their testing and maintenance programs – for example:
  - 10% load for 10 minutes, once per month
  - 50% load for 30 minutes, once per quarter
  - 100% load for an hour, once per year
- Different loads = different emissions = different stack parameters = different impacts
- How to think about compliance with the different loads and impacts?
- Allows for less operational restrictions

Possible Refinements

- Refinements that can be made in compliance demonstrations:
  - Time of day limitations (enhanced dispersion during daytime)
  - Adding controls
  - Adjusting stack parameters
  - Limitations on generators running concurrently
  - Refined NO_X to NO_2 chemistry (ARM2 v. OLM, PVMRM, GRSM)
  - Refined NO_2 backgrounds (March 2011 Tyler Fox memo)
  - In-stack ratios (ISR)
  - Monte Carlo Analysis

Ongoing Compliance

Compliance is Complicated

- Historically, data centers demonstrated compliance with a spreadsheet
- Data centers often have limited EHS personnel
- Many are increasingly using more complex compliance systems
  - Enablon, Tableau, custom solutions

- NSPS regulations
- State regulations
- Air permit limitations:
  - Recordkeeping – hours, reason in operation, load, fuel use, etc.
  - Maintenance records
  - Reports
  - Stack testing (if req'd)

- One of the biggest issues → What is emergency operation?

Questions?

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