Data Center Modeling Guidance

Data centers are unique sources of air emissions because they can potentially emit at a high rate, but only operate in a limited capacity. As such, their overall impact over the long-term is relatively small, but the simultaneous operation of multiple engines at one location (emergency or otherwise) presents an elevated risk of exceeding the short-term NAAQS. All projects will be evaluated on a case-by-case basis, but the DNR recommends the following guidance to allow operational flexibility while maintaining predicted attainment of the NAAQS.

Considerations for Specific NAAQS

1-hour NO_2 and SO_2

If the engines will be limited to operating for no more than 500 hours per year (or equivalent fuel-restriction) then DNR recommends using EPA's intermittent source guidance to justify not modeling 1-hour NO_2 and SO_2 since these sources operate at random and are limited in nature. Note, in order to qualify as an intermittent source, the DNR requires that scheduled engine test and maintenance be conducted between 9AM-4PM to the extent practicable as this represents the period of the day when the dispersive capacity of the atmosphere is usually most ideal.

24-hour $PM_{2.5}$ and PM_{10}

In most cases the 24-hour $PM_{2.5}$ NAAQS will present the biggest challenge. The 24-hour $PM_{2.5}$ NAAQS is based on the 98th percentile concentration. If you translate this into days, this means that the top seven days of each year may exceed the level of the NAAQS while the eighth-highest day, and all lower-ranked days, must be below the NAAQS. The DNR has incorporated this allowance as an operating restriction so full operation of data centers may occur up to seven days per year without modeling that operational scenario (i.e. High activity day, or HAD, limit). Instead, modeling is used to determine the maximum amount of operation that can be allowed before a day must be counted as one of the seven allowed high activity days. The maximum (H1H) concentrations must be used in the HAD analysis because the seven days of allowed full operation can be assumed to exceed the level of the NAAQS even on days without worst-case dispersion conditions. Therefore, it is necessary to find the worst-case dispersion conditions in order to make sure that the NAAQS are protected on all non-high activity days.

The HAD limit usually translates into a certain number of engine-hours the facility can operate in a day before one of the seven allowed days are consumed. There are several methods that may be used to determine the applicable HAD limit, but the DNR recommends the following methodology.

1. Model all engines that will have a HAD limit as operating continuously, and include each in its own source group.
2. Combine all sources that will not have a HAD limit into a separate source group.
3. Rank the engines in decreasing order by their maximum predicted concentration.
4. Begin a running total by adding the background concentration and the maximum impact from the non-HAD limit sources.
5. One at a time, add the highest-ranked engine concentrations to the running total until the NAAQS is exceeded.

The number of cumulative engines added prior to exceeding the NAAQS provides a conservative estimate of the number of engines that can operate continuously each day. Multiplying this number by 24 hours/day provides the allowable engine-hours per day. The following is an example calculation of a HAD limit for $PM_{2.5}$.

Table 1. Example HAD Limit Calculations

Source Group	Concentration	Running Total
Background	20	20
Non-HAD Sources (cooling tower cells)	0.9	20.9
ENGINE25	3.0	23.9
ENGINE24	2.9	26.8
ENGINE26	2.9	29.7
ENGINE23	2.8	32.5
ENGINE27	2.7	35.2
Etc...		

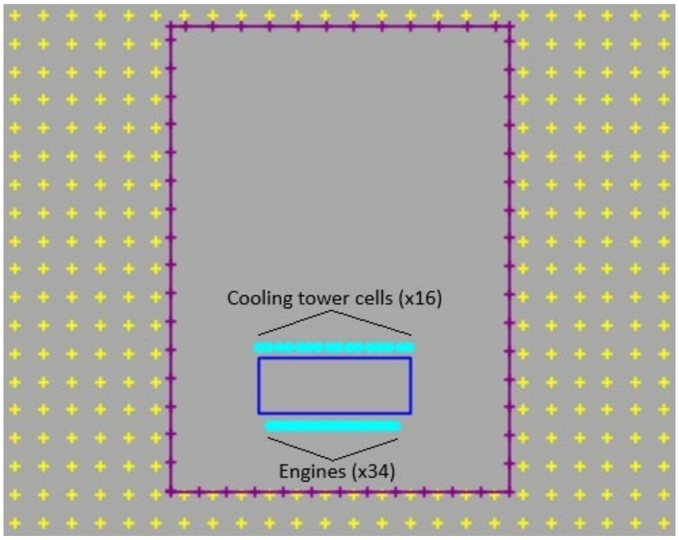

Figure 1. Example Individual Data Center Layout

In this example, the four engines with the highest impact could run 24 hours per day without their combined predicted impact ever exceeding the NAAQS (35). Therefore, a maximum of 96 engine-hours of operation could be allowed per day because no matter what combination of engines are actually operated, the combined predicted impact could not be higher than the result of the HAD analysis (32.5 in this example) which is less than the NAAQS. An operating restriction based on this example is provided below:

> The facility shall be allowed seven (7) *"High activity days"* per calendar year. A *"High activity day"* is defined as any calendar day in which any combination of engines are operated for more than a combined total of 96 hours per calendar day. A *"calendar day"* is defined as the twenty-four (24) hour period that begins at 12:00 AM (CST) and ends at 11:59 PM (CST).

Note, the example does not specify engine operation such as for purposes of testing and maintenance or an unplanned power outage and allows for engine operation any time of the day. As such, do not include operating restrictions (i.e. the 9AM-4PM test and maintenance window for intermittent sources) in this analysis unless the applicant is willing to accept those additional restrictions as part of the HAD limit.

The 24-hour PM_{10} NAAQS can also sometimes be challenging, but generally only for larger facilities. For smaller facilities DNR recommends assuming continuous operation. In cases where continuous operation results in predicted exceedances, then an additional PM_{10}-specific HAD limit may be developed. The method used to determine a PM_{10} HAD limit is similar to that described for $PM_{2.5}$ above. Note, only three PM_{10} high activity days will be allowed every three years due to the form of the PM_{10} NAAQS.

Annual $PM_{2.5}$, NO_2, and SO_2

Model the worst-case operational scenario and then use [DNR's Suggested Methodology for Modeling Restricted Hours of Operation] to incorporate the limited annual operation. Operational limits can be used as a surrogate for fuel usage limits if applicable.

3-hour SO_2, 1-hour CO, and 8-hour CO

Model the worst-case operational scenario that will be permitted (generally all sources operating simultaneously).

Multi-source Areas

If modeling is required for pollutants or averaging periods for which there are no HAD limits at any of the facilities being modeled, then traditional comprehensive modeling should be conducted for the applicable NAAQS. In these cases, use the DNR's PSD or non-PSD Modeling Guidelines (whichever is applicable). Otherwise, this section describes methodologies that may be used to evaluate the combined impact from a group of facilities[1] when one or more of them have HAD limits.

Project facility will have a HAD limit and the nearby facility does not

In this scenario, the emissions from the nearby facility can be added to the non-HAD source group in the HAD analysis for the facility being modeled. All other steps are the same as the methodology described above.

Project facility will have a HAD limit and the nearby facility has an existing HAD limit

The existing impacts from other sources in the area need to be considered when determining a HAD limit. The worst-case operational scenario allowed on non-high activity days at the nearby facility should be added to the background concentration before conducting the HAD analysis for the data center being permitted. It may be necessary to refine the HAD analysis so the results are paired spatially and/or temporally. As such, computational resources may limit the number of receptors and scenarios that can be evaluated. The DNR recommends the following method, in which the results from both facilities are paired spatially, and only those receptors where maximum concentrations may occur are included.

Example: A new data center (Facility B) is being constructed next to an existing data center (Facility A) which has existing HAD limits (as determined in the example above).

1. Model the maximum (H1H) 24-hour concentration on the shared ambient air (no receptors on either property) with the following source groups:
    - Each engine
    - All non-HAD sources combined
    - Each facility
    - Both facilities combined

    By using these source groups this model run will identify the receptor(s) where maximum concentrations may occur.

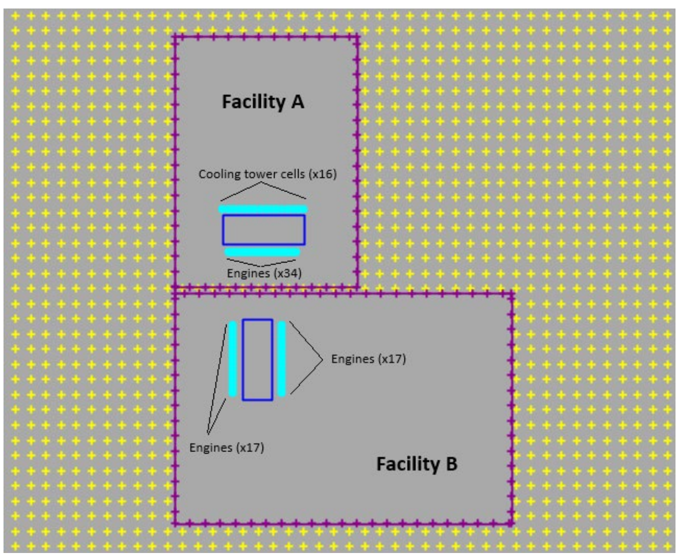

Figure 2. Example Multiple Data Center Layout

[1] Many data center complexes have multiple buildings that are each sometimes referred to as individual data centers. These are not considered separate facilities unless they have been determined to be separate stationary sources for the purposes of permitting. Multiple data center buildings at a single stationary source should be modeled as one facility.

2. Create a list of the receptors identified as possible locations of maximum concentration in the first step. Remove all receptors from the model that are not in the list, enable plot file output, then run the model again with the following source groups:
   - Each engine
   - All non-HAD sources combined

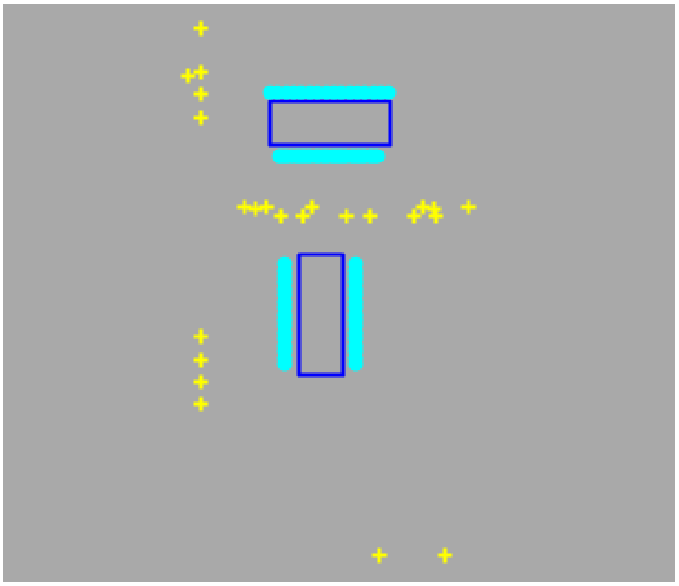

Figure 3. Maximum Impact Receptors

3. Calculate the HAD limit by combining the results from both facilities at each receptor (see Figure 4).
   - Sort the plot file data by receptor and by source group.
   - For each receptor, calculate the concentration from the engines at the nearby facility allowed by their existing HAD limit.
   - For each receptor, add up the following:
     - The background concentration
     - The non-HAD source group concentration
     - The HAD source concentration from the nearby facility calculated above
   - For each receptor, calculate a HAD limit for the facility being evaluated, by adding the sum calculated above at that receptor to the highest-ranked engines until the running total exceeds the NAAQS. The HAD limit is determined using the minimum number of engines that this calculation yields across all of the receptors. In this example, two engines could operate 24 hours/day before exceeding the NAAQS, so the HAD limit becomes 48 engine-hours.

Receptor:	-100, 350	-120, 330	130, 330	150, 350	-170, 330	175, 345	180, 330	-20, 330	-200, 350	200, -430	-225, 345	250, 350	-250, 350	30, 330
Background:	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Non-HAD Sources:	0.58	0.57	0.89	0.89	0.61	0.83	0.81	0.57	0.74	0.15	0.73	0.66	0.71	0.70
Facility A HAD Sources														
Highest-ranked engines (Existing HAD limit = 96 engine hours = top 4 engines):														
1	2.47	1.86	1.48	1.56	1.76	1.43	1.43	2.07	1.78	0.26	1.67	1.08	1.55	1.83
2	2.42	1.85	1.47	1.54	1.76	1.43	1.42	2.06	1.77	0.26	1.66	1.08	1.54	1.82
3	2.39	1.83	1.47	1.54	1.74	1.39	1.40	2.01	1.76	0.26	1.65	1.07	1.53	1.81
4	2.36	1.80	1.45	1.49	1.73	1.35	1.38	2.00	1.76	0.26	1.63	1.07	1.50	1.76
Total:	9.6	7.3	5.9	6.1	7.0	5.6	5.6	8.1	7.1	1.1	6.6	4.3	6.1	7.2
Facility B HAD Sources														
Highest-ranked engines (only top 10 displayed):														
1	1.63	1.80	1.06	0.96	1.69	0.94	1.05	1.36	1.56	0.77	1.61	0.88	1.56	1.27
2	1.63	1.78	1.06	0.95	1.68	0.93	0.98	1.35	1.55	0.77	1.61	0.84	1.55	1.27
3	1.63	1.78	1.05	0.94	1.67	0.91	0.98	1.34	1.53	0.75	1.56	0.82	1.53	1.26
4	1.62	1.76	1.02	0.92	1.66	0.91	0.98	1.32	1.49	0.75	1.56	0.81	1.49	1.26
5	1.61	1.72	1.02	0.92	1.65	0.90	0.94	1.27	1.48	0.75	1.47	0.81	1.45	1.26
6	1.60	1.72	1.01	0.92	1.62	0.90	0.94	1.24	1.47	0.75	1.46	0.81	1.41	1.25
7	1.59	1.68	1.01	0.91	1.59	0.89	0.93	1.24	1.45	0.75	1.45	0.80	1.35	1.23
8	1.57	1.66	1.01	0.91	1.58	0.89	0.93	1.24	1.43	0.75	1.45	0.79	1.35	1.22
9	1.45	1.65	0.99	0.91	1.57	0.89	0.91	1.24	1.41	0.74	1.44	0.79	1.34	1.21
10	1.43	1.64	0.98	0.91	1.56	0.88	0.91	1.20	1.41	0.74	1.43	0.78	1.33	1.21
Running Total (Background + non-HAD sources + Facility A HAD sources + X engines at Facility B)														
1 engine	31.9	29.7	27.8	28.0	29.3	27.4	27.5	30.1	29.4	22.0	28.9	25.8	28.4	29.2
2 engines	33.5	31.5	28.9	28.9	31.0	28.3	28.5	31.4	30.9	22.7	30.6	26.7	29.9	30.5
3 engines	35.1	33.3	29.9	29.9	32.6	29.2	29.5	32.8	32.5	23.5	32.1	27.5	31.5	31.7
4 engines	36.7	35.0	31.0	30.8	34.3	30.1	30.4	34.1	33.9	24.2	33.7	28.3	33.0	33.0
5 engines	38.4	36.8	32.0	31.7	36.0	31.0	31.4	35.3	35.4	25.0	35.1	29.1	34.4	34.2
6 engines	40.0	38.5	33.0	32.6	37.6	31.9	32.3	36.6	36.9	25.7	36.6	29.9	35.8	35.5
7 engines	41.5	40.2	34.0	33.5	39.2	32.8	33.3	37.8	38.3	26.5	38.1	30.7	37.2	36.7
8 engines	43.1	41.8	35.0	34.4	40.7	33.7	34.2	39.1	39.8	27.2	39.5	31.5	38.5	37.9
9 engines	44.6	43.5	36.0	35.3	42.3	34.6	35.1	40.3	41.2	28.0	41.0	32.3	39.9	39.1
10 engines	46.0	45.1	37.0	36.3	43.9	35.5	36.0	41.5	42.6	28.7	42.4	33.1	41.2	40.4

Figure 4. Example combined HAD limit calculations

This methodology may be further refined by using post file output to also pair the results temporally. However, depending on the number of sources and receptors, this may require significant computational resources.

Project facility will not have a HAD limit and the nearby facility has an existing HAD limit

When a facility with no HAD limits is modeled with a facility(s) that has a HAD limit, it will be necessary to include the impacts allowed by existing HAD limits in a comprehensive model.

For nearby facilities where a HAD limit has already been established, the maximum impacts from the full operation on high activity days may be assumed to occur on the worst-case days based on the form of the NAAQS. Therefore, only the operation permitted to occur on non-high activity days need be included in the analysis. Accordingly, the maximum value applicable to the NAAQS being evaluated should be used (H8H for $PM_{2.5}$ and H6H for PM_{10}). Due to the large number of source combinations available with HAD limits, the DNR recommends the following method when conducting the comprehensive analysis.

Example: A new manufacturing facility (Facility C), with no HAD limits, is being constructed near two existing data centers (Facilities A and B), with existing HAD limits (as determined in the examples above).

1. Model all sources that **do not** have HAD limits and determine the receptor where the maximum (H1H) impact is predicted to occur.

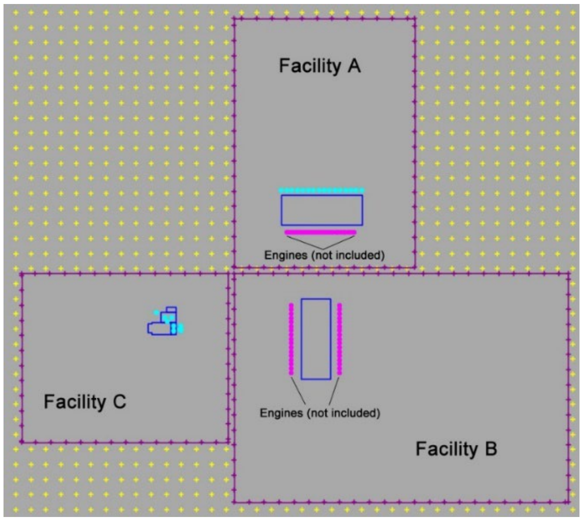

Figure 5. Example Multi-Source Area, Model non-HAD Sources

2. Model only the receptor identified above and only the sources **with** HAD limits to determine the maximum (H1H) impact for each source (include each source in its own source group).

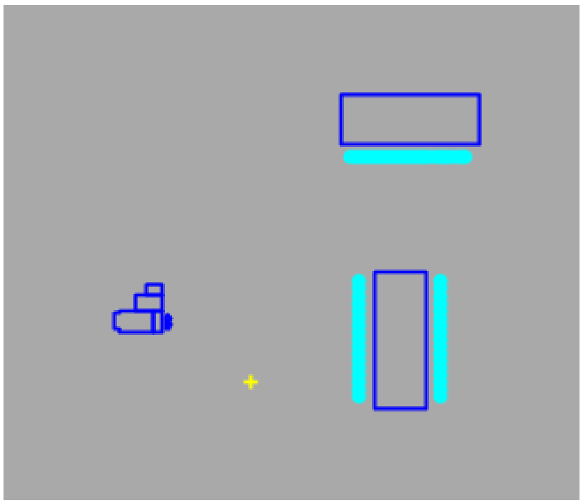

Figure 6. Example Multi-Source Area, Model HAD Sources at Max Receptor

3. Determine the source, or sources, that have the potential to cause the highest impact at the receptor based on the amount of operation allowed under the HAD limits. In this example, the HAD limit for Facility A allows 96 engine-hours and the HAD limit for Facility B allows 48 engine-hours. Therefore, the top four engines at Facility A and the top two engines at Facility B should be identified.

4. Model the entire receptor grid and include the sources identified above along with all sources at each facility that do not have HAD limits. This final model should be based on the actual form of the NAAQS being evaluated (H8H for $PM_{2.5}$ or H6H for PM_{10}).

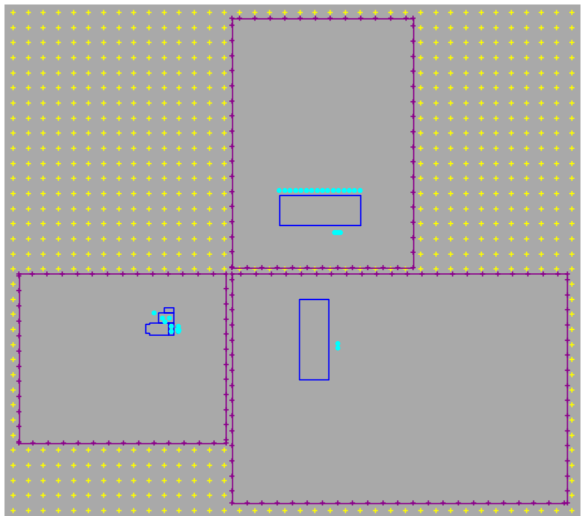

Figure 7. Example Multi-Source Area, NAAQS Analysis