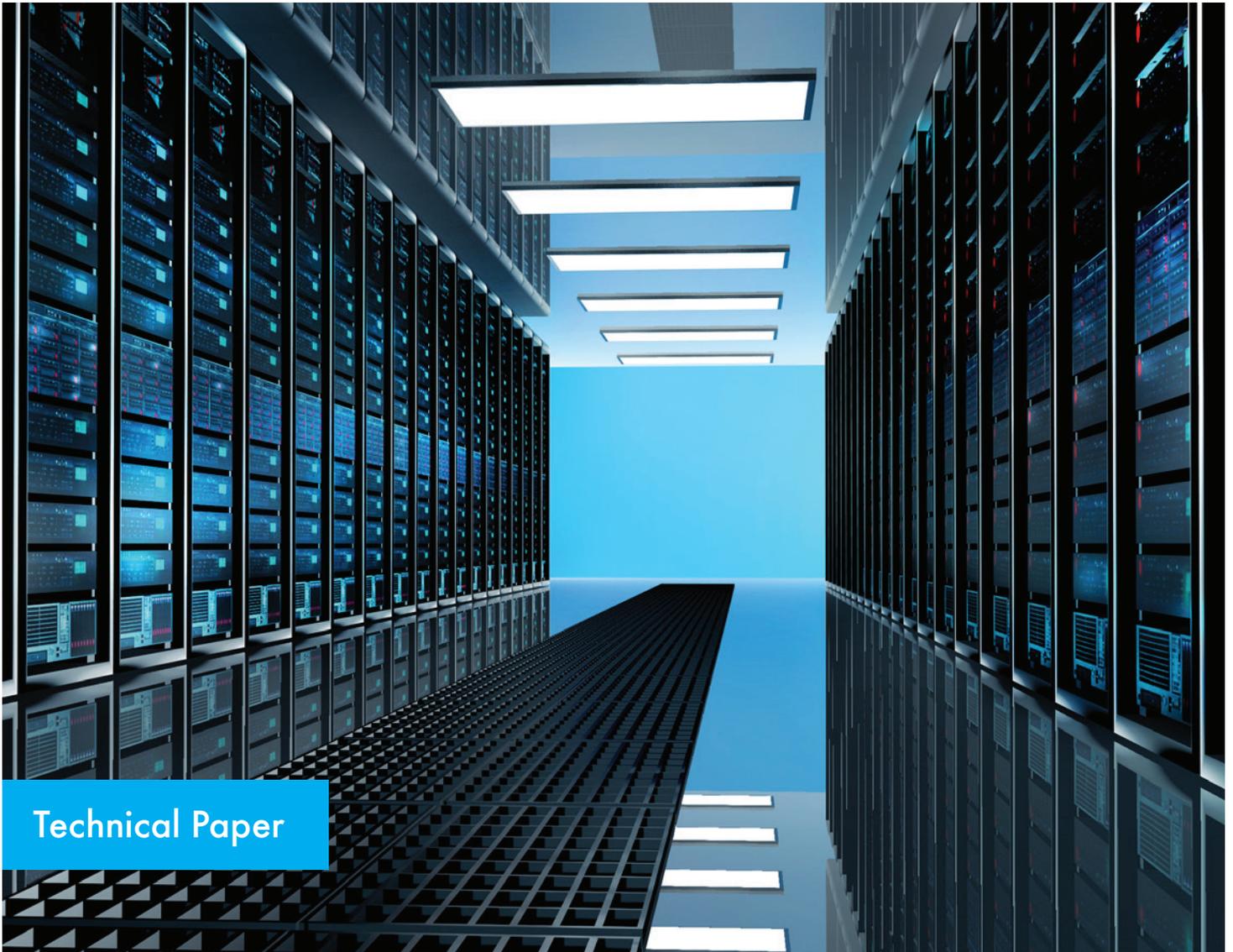


# Indirect Air Side Economizer (IASE) Cooling Solutions

Energy Studies and Leveling the Field



Technical Paper

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# Indirect Air Side Economizer (IASE) Cooling Solutions

## Energy Studies and Leveling the Field



An Indirect Air Side Economizer (IASE) is a system that cools 100% recirculated data center air, transferring heat to a separate outdoor air stream (scavenger air stream) by means of an air-to-air heat exchanger. This system often includes supplemental DX cooling for hot ambient conditions. Some IASE equipment manufacturers, including Munters, provide an analysis for applying their cooling equipment to a specific data center design. This analysis typically includes information on peak power requirements and annual power consumption and is based on specific criteria. To ensure the results are meaningful, the criteria for the analysis must be consistent when comparing different cooling solutions. The main design criteria are the following:

- ITE kW heat rejection
- Supply temperature
- Return temperature
- External static pressure
- Peak ambient dry bulb and wet bulb temperatures
- Altitude
- Weather bin data

While it is important that these values are consistent, there are other less obvious criteria that can significantly impact the results.

### Percent Data Center Load

Assuming the supply and return temperatures are maintained at constant values, the supply airflow from the cooling units is directly proportional to the data center load. For example, if the data center is 70% loaded, the cooling equipment supply fans will be at 70% airflow. The total static pressure will be reduced per the fan laws with a square relationship as follows:  $TSP = TSP_{max} * (Airflow / Airflow_{max})^2$ .

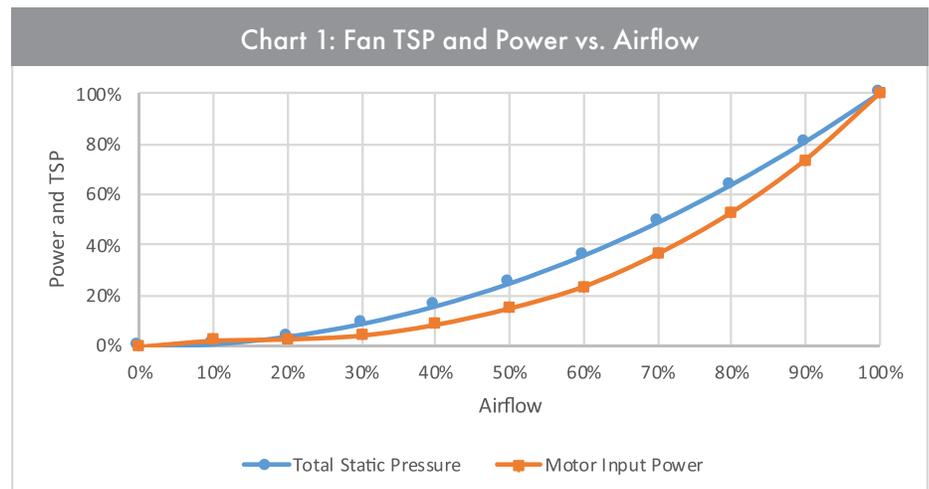
Fan output power will also be reduced per the fan laws with a cube relationship, but the motor input power is adjusted as the efficiency changes at the lower speeds.

CHART 1 shows how the total static pressure and motor input power are reduced as the fan airflow is reduced for a typical EC fan/motor. At 70% data center load, the supply fan input power is approximately 37% of its value at 100% data center load.

An important element in heat transfer through an air to air heat exchanger is the mass flow ratio. The mass flow ratio = Scavenger mass flow / Supply mass flow. See CHART 2 below for the relationship of mass flow ratio to the heat exchanger supply side efficiency for typical air-to-air heat exchangers. A reduced percent data center load reduces the supply airflow, which increases the mass flow ratio. This results in more kWh of cooling accomplished by economizer (lower compressor power consumption) and reduced scavenger airflow during economizer (lower scavenger fan power consumption).

Example:

- Supply air temperature: 75 degrees F
- Return air temperature: 95 degrees F
- Supply fan location: Blow through
- Supply fan heat: 2 degrees F
- Heat Exchanger: HX-B



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At a heat exchanger mass flow ratio of 1.0, the supply side efficiency is 42% as shown in CHART 2. The unit will be able to provide full economizer cooling without running compressors for ambient temperatures up to 44.6°F. At 70% data center load, the supply airflow is reduced to 70%, which increases the mass flow ratio to 1.43, and the heat exchanger supply side efficiency to 49%. At this efficiency, the unit will be able to provide full economizer cooling without running compressors for ambient temperatures up to 51.2°F. Additionally, less scavenger airflow will be required at cooler ambient conditions. For example, at 44.6°F ambient, the scavenger airflow will drop to approximately 70% of maximum airflow. CHART 1 shows the scavenger fan power will be approximately 37% of its maximum power.

### Redundancy

To reject the ITE (Information Technology Equipment) load, a certain number of units “N” are used plus additional unit(s) for redundancy. Frequently all units operate at reduced airflow unless a unit is offline for maintenance. An example would be  $N = 4$  units + 1 redundant unit. In this case, 5 units would be operating with each unit at 80% airflow. If the units are ducted in a way that the external static pressure is reduced per the fan laws, CHART 1 above would again apply. At 100% data center load, the units would be operating at 80% airflow, and the supply fan input power would be approximately 53% of the power at 100% airflow. If the units are operating with  $N=4+1$  redundancy and at a reduced data center load of 70%, the airflow from each unit would be reduced to 56% of maximum, and the fan input power would drop to approximately 20% of the power at 100% airflow. An increase in heat exchanger mass flow ratio and associated savings in compressor and scavenger fan power would also apply as described above. One additional consideration is that there are designs where the external static pressure will not be fully reduced per the fan laws when all units are operating (for example, units feed into a common plenum). In these cases, adjustments must be made to the analysis to avoid underestimating the power.

### Filter Pressure Drop

MERV 8 filters have a clean pressure drop of approximately 0.2"WG depending on the specific filter and face velocity (the pressure drop increases as the filter gets loaded). CHART 3 shows the fan power vs. total static pressure for a typical EC fan. Adding filter loading of 0.25" WG will result in approximately 10% increase in supply fan power.

Chart 2: Typical Cross Flow Heat Exchangers

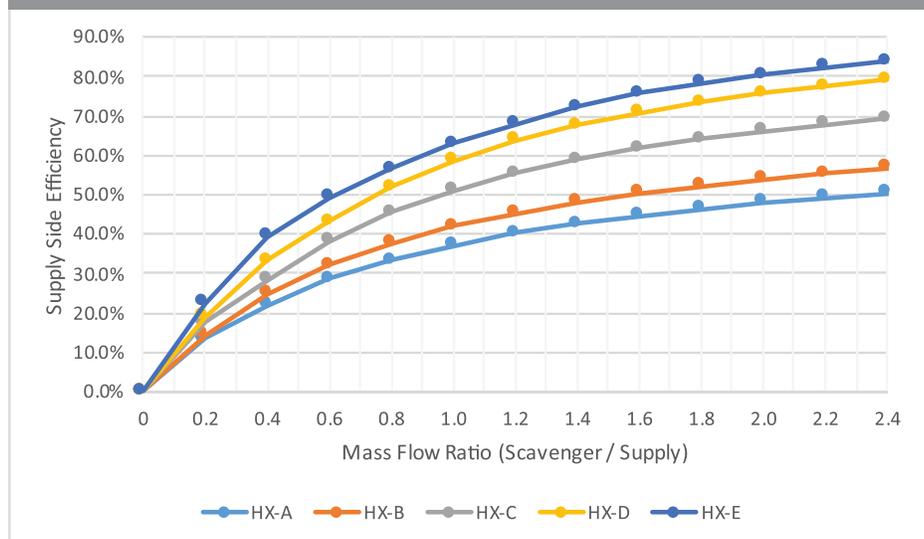
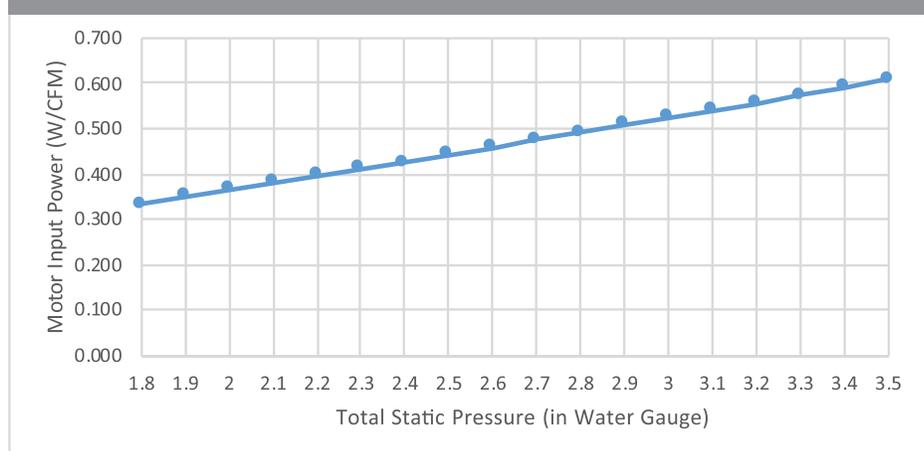


Chart 3: Fan Power vs. TSP with fixed CFM



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### Isolation Dampers

Depending on the system design, supply and / or return air dampers may be included in the cooling units or the ducts to isolate each unit when it is not in operation. The pressure drops for these dampers must be accounted for in the analysis. Adding supply and return air isolation dampers at 0.2" WG pressure drop for each will result in approximately 15% increase in supply fan power consumption.

### Comparing pPUE

Mechanical Partial PUE, or pPUE, is the industry standard for evaluating data center cooling system efficiency and is defined by the following formula:

$$\text{pPUE} = (\text{ITE kW} + \text{Cooling System kW}) / \text{ITE kW}$$

which can be simplified to:

$$\text{pPUE} = 1 + \text{Cooling System kW} / \text{ITE kW}$$

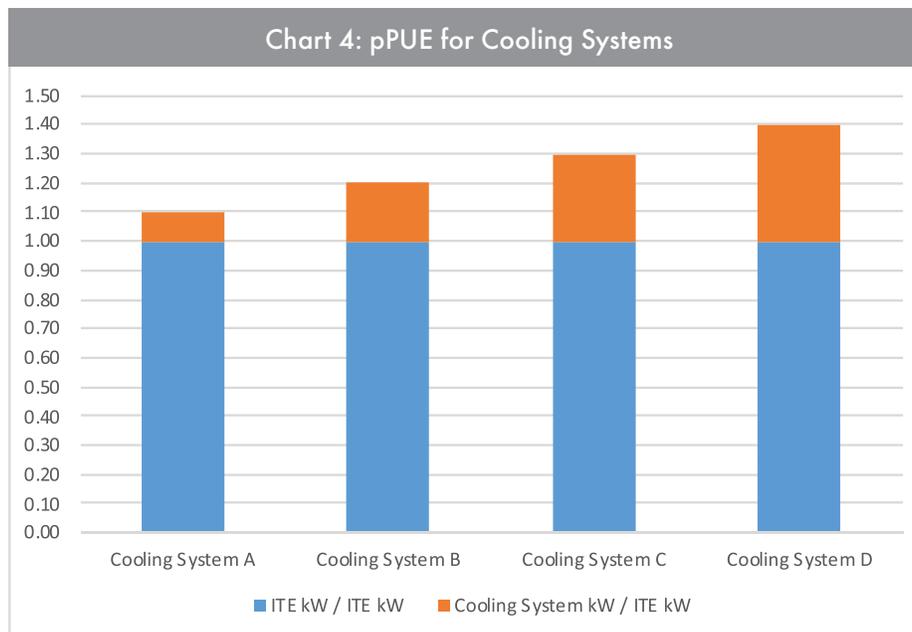
So when comparing different cooling systems, the following formula applies:

$$\text{Cooling System A kW} / \text{Cooling System B kW} = (\text{pPUE of Cooling System A} - 1) / (\text{pPUE of Cooling System B} - 1)$$

For the systems in CHART 4 below:

$$\text{Cooling System A kW} / \text{Cooling System B kW} = (1.1 - 1) / (1.2 - 1) = 0.5 = 50\%$$

In this case, Cooling System A (1.1 pPUE) uses half the power of Cooling System B (1.2 pPUE).



In summary, when comparing different cooling systems, it is critical that all criteria is the same for each system. Small differences can have a significant impact on the results.