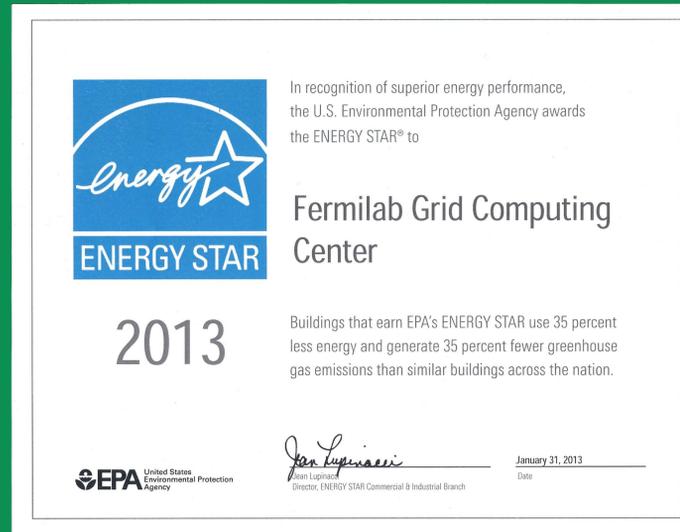


# Data Center Cooling Systems

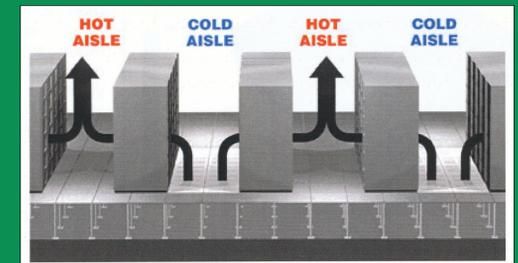
## Power Usage Effectiveness (PUE)

PUE is a measure of how efficiently a computer data center uses its power; specifically, how much of the power is actually used by the computing equipment (in contrast to cooling and other overhead). PUE is the ratio of total amount of power used by a computer data center facility to the power delivered to computing equipment.



## Hot Aisle – Cold Aisle Design

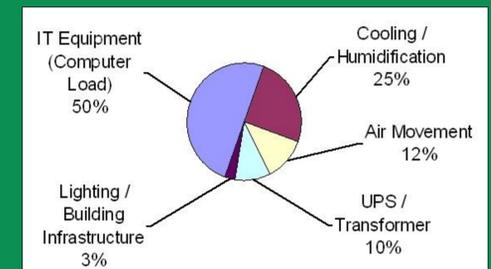
Equipment racks are positioned to face the cold aisles and cool air is drawn through racks by equipment fans and the warm air is exhausted from the back of the rack into the hot aisle. In this configuration, segregation of cool and warm air is one of the primary goals. Cold air is delivered to the rows of racks through the plenum under the raised floor. The warm air rises to the ceiling and is drawn back to CRAC units return air intake



Hot Aisle – Cold Aisle Cooling Schematic  
Facilities Engineering - Fermilab

The Grid Computing Center has been certified for the Energy Star Award three consecutive years. Buildings that achieve an ENERGY STAR energy performance score of 75 or higher—meaning they are in the top 25 percent for energy efficiency in the nation compared with similar buildings—and are professionally verified to meet current indoor environment standards are eligible to apply for the ENERGY STAR.

Example of Typical Data Center Energy Use



## DX Computer Room Air Conditioner System



- ✓ CRAC = Computer Room Air Conditioner
- ✓ 30 ton capacity - BTU/HR (kW) 350,900 (102.7)
- ✓ Air Cooled System
- ✓ 2 High Efficiency Semi-Hermetic Compressors
- ✓ Air Downflow is typical at GCC
- ✓ Infrared Humidifier
- ✓ Four-step cooling system reduces compressor cooling capacity and energy consumption during periods of low room load conditions
- ✓ Direct-drive propeller fan-type air-cooled condenser

## Air Management

Energy efficiency measures employed include hot and cold aisles, cold aisle containment on row ends, blanking and threshold panels, no cabling under raised floors, air conditioner ducting to hot air layer, matching air conditioning to temperature sensors in front of computer racks.

## Air Cooled Condenser



## Power Metering

The Lattice Computing Center, Grid Computing Center and Feynman Computing Center are 100% metered and the PUE can be calculated. Several power sub-meters were added to better monitor power usage in individual rooms.

PUE	Level of Efficiency
3.0	Very Inefficient
2.5	Inefficient
2.0	Average
1.5	Efficient
1.2	Very Efficient

$$PUE = \frac{\text{Total facility power}}{\text{IT equipment power}}$$

## Cooling Challenges

Many data centers are designed to operate at the highest efficiency when at 100% capacity. During the life

cycle the cooling specialists have to optimize the room with 'part load' inefficiencies at startup of the room. When servers start to be retired, cooling efficiency may be impacted by 'stranded' capacity. The goal is always to best match the cooling to the IT load.