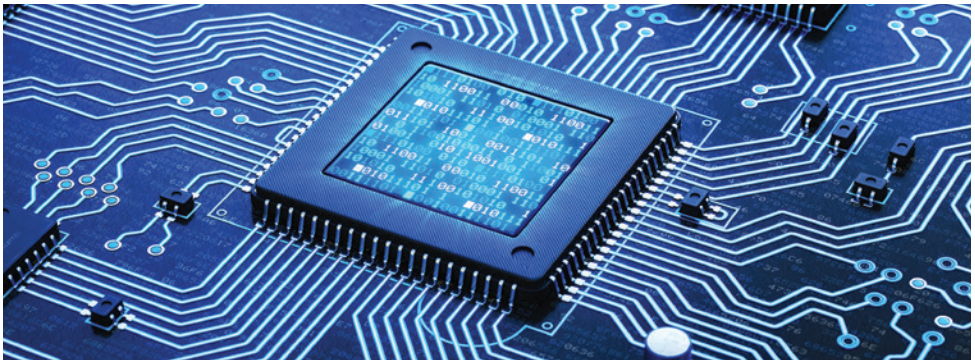
CASE STUDY

Semiconductor manufacturer achieves 18% energy savings and reduced CO_2 emissions with COIL-FLO program

eROI℠ by Ecolab



BACKGROUND

The air-handling units (AHU) in a semiconductor fab perform a critical role: delivering reliable temperature and relative humidity control to the manufacturing environment. Even slight variations in a fab's air temperature and humidity can profoundly affect chip quality, and the cost of downtime is extremely high.

Air-handling systems are also among the largest energy consumers in a fab. AHUs perform by moving air through filters and across heat-exchange coils, cooling or warming the air to adjust the air's relative humidity and/or temperature. As with any other heat-exchange surface, coil cleanliness directly impacts the efficiency, coil life and energy used in the heat-exchange process. Many facilities clean air-handling coils too infrequently, clean them poorly or clean them at irregular intervals.

As a semiconductor fab in the northeastern United States sought ways to reduce their energy consumption, air handlers were a natural place to focus. However, the fab had two important caveats in wanting to clean the air coils: to clean the coils without damaging them, and to document the impact of the cleaning to confirm a positive return on the economic investment. The project scope included 137 AHU coils; most units had both hot and chill coils.

SOLUTION

Historically, there are three cleaning methods used most often in air-coil cleaning, each with unique benefits and risks:

- High-pressure water: Removes dirt efficiently, but can also drive dirt deeper into the coil pack and bend delicate coil fins
- Low-pressure water: Lessens the risk of damaging coil fins but can be less effective at removing dirt and microbial film. This may also increase cleaning time and chemical exposure risk for workers
- Aggressive chemical applications: Chemical brighteners remove metal oxides to create a "shiny clean" look but may not fully remove dirt and microbial film. Harsh chemistry can also increase exposure risk for workers and compromise long-term coil life.

ANNUAL SAVINGS

ENERGY

1.22 million kWh
per year

GREENHOUSE GASES

Reduced CO_2 emissions by
900 tons
per year

COSTS

Energy savings
$117,902
per year

VALUE DELIVERED

$117,902 ANNUALLY

NALCO Water
An Ecolab Company

"Energy Savings by Air Coil Efficiency Improvement" originally presented at SESHA (Semiconductor Environmental, Safety & Health Association) Annual Symposium.

To overcome many of the disadvantages of other cleaning methods, the fab chose Nalco Water's patented COIL-FLO program. COIL-FLO consists of the following capabilities:

- A balanced mix of 500 psi pressure with low water consumption, which reduces the risk of coil damage and cuts disposal volumes
- Low-alkalinity/surfactant cleaner blend minimizes the volume of water and chemistry needed and reduces risk of driving dirt into the coil pack. In most cases, the wash water is sent to the fab's sanitary or wastewater facility after cleaning
- Post-cleaning biocide applied to coil surface and drain pan helps prevent quick recurrence of microbial films, helps lessen corrosion risk and extends time between cleanings

COIL-FLO cleanings are conducted by trained, qualified service personnel, using appropriate personal protective equipment (PPE) and safety procedures.

The largest value-added aspect of the COIL-FLO program, however, is the before, after and periodic monitoring of representative AHUs. These steps establish performance benchmarks, quantify operational improvements and energy savings, and confirm the length of the operating life cycle, all of which were important metrics to confirm a positive return on the customer's investment.

For this customer, performance of the COIL-FLO program was validated as follows:

1. Eight representative AHUs were identified and surveyed; direct and indirect measurements were taken before cleaning began
2. After cleaning was complete, direct and indirect measurements were taken on the same eight AHUs
3. Based on this representative sample, overall projections were calculated to project annual savings or reductions in annual cooling energy, annual fan energy, total annual energy and greenhouse gas reductions

Data from the performance validation was collected and summarized in tabular form, as exemplified in Table 1.

COIL-FLO® Large Systems Assumptions & Measurements

I-P Units

SYSTEM (▸Data Inputs)	1	2	3	4	5	6	7	8
Description	AHU#6	AHU#4	AHU#9	AHU#30	AHU#20	AC-1	AHU#39	AHU#25
COOLING SYSTEM ASSUMPTIONS								
Coil Face Area (Sq. Ft.)	24	258	114	80	50	60	60	60
CFM at Design (Calculated)	12,000	128,750	57,000	40,000	25,000	30,000	30,000	30,000
Annual Cooling Hours	4,380	1,108	4,380	4,380	4,380	4,380	4,380	4,380
System Efficiency:	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Select Units	kW/Ton	kW/Ton	kW/Ton	kW/Ton	kW/Ton	kW/Ton	kW/Ton	kW/Ton
Coefficient of Performance (COP)	4.69	4.69	4.69	4.69	4.69	4.69	4.69	4.69
FAN SYSTEM ASSUMPTIONS								
Air Delivery Method	Variable	Variable	Variable	Variable	Variable	Variable	Variable	Variable
Fan System Efficiency (default 75%)	75%	75%	75%	75%	75%	75%	75%	75%
Annual Fan Hours	8,760	2,216	8,760	8,760	8,760	8,760	8,760	8,760
COIL MEASUREMENTS - BEFORE								
Outdoor Air Temperature (°F-db)	63.0	79.4	56.0	86.2	65.0	68.6	37.0	37.0
VSD Fan Set-Point (Hz or rpm)	n/a	n/a	n/a	1.0	n/a	n/a	n/a	n/a
Coil Face Velocity (ft/min)	500	233	570	377	595	500	526	418
Normalized to After Clean Velocity	500	233	570	377	595	500	526	418
Calculated Air Flow (CFM)	12,000	59,998	64,980	30,160	29,750	30,000	31,560	25,080
Static Pressure Drop (Inches WG)	0.70	0.04	0.50	0.40	0.18	0.74	1.06	0.23
Normalized to After Clean Pressure Drop	0.70	0.04	0.57	0.42	0.18	0.74	1.06	0.23
Entering Air Temp (°F-db)	72.9	73.9	64.6	77.4	77.4	67.6	76.1	56.4
Leaving Air Temp (°F-db)	55.2	52.9	64.3	56.6	57.2	65.1	53.7	45.4
Temperature Drop	17.7	21.0	0.3	20.8	20.2	2.5	22.4	11.0
COIL MEASUREMENTS - AFTER								
Outdoor Air Temperature (°F-db)	73.0	85.6	77.0	92.7	65.0	72.1	37.0	37.0
Coil Face Velocity (ft/min)	500	235	610	388	602	500	527	418
Calculated Air Flow (CFM)	12,000	60,513	69,540	31,040	30,100	30,000	31,620	25,080
Static Pressure Drop (Inches WG)	0.51	0.04	0.48	0.28	0.14	0.54	1.01	0.21
Entering Air Temperature (°F-db)	76.2	74.0	63.4	80.2	77.4	69.4	75.5	61.9
Leaving Air Temperature (°F-db)	56.7	52.6	63.0	58.7	56.3	66.5	52.8	50.2
Temperature Drop	19.5	21.4	0.4	21.5	21.1	2.9	22.7	11.7
PERFORMANCE CHANGE								
Coil Face Velocity (ft/min)		2	40	11	7		1	
Air Flow (CFM)		515	4,560	880	350		60	
Static Pressure (Inches WG)	0.19	0.00	0.09	0.14	0.04	0.20	0.05	0.02
Leaving Air Temperature (°F-db)	1.8	0.4	0.1	0.7	0.9	0.4	0.3	0.7
ANNUAL COOLING ENERGY								
BTU/h BEFORE Cleaning	229,392	1,360,743	21,054	677,514	649,026	81,000	763,500	297,950
BTU/h AFTER Cleaning	252,720	1,398,565	30,041	720,749	685,919	93,960	775,196	316,911
Sensible Capacity Change	23,328	37,822	8,988	43,235	36,893	12,960	11,696	18,960
Percent Change	10.2%	2.8%	42.7%	6.4%	5.7%	16.0%	1.5%	6.4%
Tons	1.94	3.15	0.75	3.60	3.07	1.08	0.97	1.58
kW	1.46	2.36	0.56	2.70	2.31	0.81	0.73	1.19
kWH	6,386	2,619	2,460	11,835	10,099	3,548	3,202	5,190
Estimated Cost Savings (USD)	574.74	235.72	221.44	1,065.19	908.95	319.30	288.17	467.14
ANNUAL FAN ENERGY								
Power (kW) BEFORE Cleaning	1.314	0.385	6.230	2.057	0.868	3.473	5.263	0.902
Power (kW) AFTER Cleaning	0.957	0.379	5.222	1.360	0.659	2.534	4.996	0.824
Power Change (kW)	0.357	0.007	1.008	0.698	0.208	0.939	0.267	0.078
Annual Power Change (kW)	3,125	14	8,828	6,112	1,826	8,223	2,341	687
Estimated Cost Savings (USD)	281.22	1.30	794.56	550.09	164.32	740.04	210.73	61.87
TOTAL ANNUAL ENERGY								
Estimated Cost Savings (USD)	855.96	237.03	1,016.00	1,615.28	1,073.26	1,059.34	498.90	529.01

TABLE 1: SUMMARY OF AIR SIDE HEAT TRANSFER MEASUREMENTS AND CALCULATIONS

RESULTS

Air-side chill coil measurements resulted in an average heat transfer improvement of 24,235 BTU/h or 11.5% per AHU. This equates to estimated annual cost savings of $69,881.

Energy efficiency improved in the fan systems as well, by an average of 0.45 kWh or 17.95% per AHU. For this fab, that translates to estimated annual cost savings of $48,021.

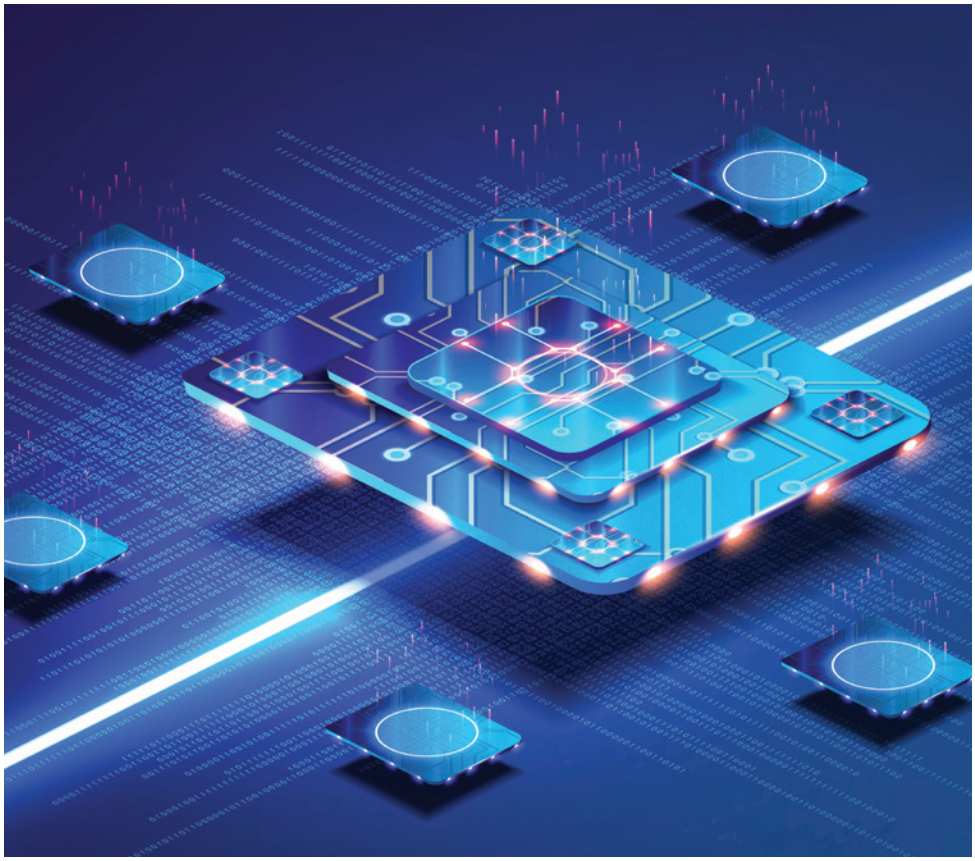
Taken together, the COIL-FLO program helped this customer achieve 1.22 million kWh per year in energy savings, valued at $117,902, plus a 900-ton reduction in CO_2 emissions. Direct ammeter readings showed a total amp reduction of 194.8 amps.

See Table 2 for more details regarding calculated savings. Note that these readings do not include additional savings derived from a reduction in chilled water requirements.

Total Amp Reduction Realized	194.8
Total kWh Reduced	1.22 million
Total Number of AHU Coils Cleaned	137
Energy Savings	$117,902
Return on Investment*	1.1 years
Reduction in CO_2 Emissions	900 tons

**Savings do not include the added benefit of reduced chilled water demand*

TABLE 2: SUMMARY OF DIRECT AMMETER READINGS, ENERGY AND CO_2 REDUCTION



CONCLUSION

COIL-FLO provided significant value to this semiconductor fab in the form of energy, greenhouse gas and cost savings. The customer achieved a return on their economic investment in just 1.1 years and, in addition, advanced their defense against operating inefficiency and unplanned downtime for emergency AHU cleanings.

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