Intelligent Process Cooling: Saving Money, Protecting the Environment & Curing Process Headaches

Process cooling with ambient air, closed loop cooling systems can save up to 25% on energy and water consumption in addition to eliminating chemical evaporation and the disposal of contaminated waste water.

Electrical Costs Are Rising

According to the Annual Energy Outlook (AEO) 2008, published by the Energy Information Administration, the trend for electrical costs is becoming more closely tied to the price of natural gas. The AEO 2008 shows that natural gas consumption has two major components – electrical power generation and industrial use. As the 2nd most popular fuel for electrical power generation, natural gas has a definite impact on the price of electricity.

All of the supply and demand models for natural gas, projected to 2030, show that natural gas prices will rise and have a definite impact on the cost of electricity because natural gas sources are limited, alternative fuels continue to be unattractive price alternatives, and the demand for electricity shows no decline.

In his book, "Energy Management in Plastics Processing – Strategies, targets, techniques and tools," Dr. Robin Kent points out that approximately 92% of a processing company's energy consumption is directly attributed to process machinery and the associated services. Not surprisingly, process cooling contributes 16% (chillers 11%, water pumps 5%) to a plant's total energy consumption. Comparatively, lighting, heating, and offices combine for only 8% of the total energy usage.

The world's current energy and water strain combined with processors' needs to operate faster, in more places and more cost effectively than ever before, poses a great challenge for industry.

A good place to start is with more efficient process cooling. For over 80 years cooling towers have been at the center of industrial cooling and are just accepted as the way things are. Until now, no one knew they had a choice and never considered life without the hassles and ongoing expense of water treatment, extended down time for heat-exchanger cleaning, difficult cold-weather operation, and large water consumption.

Cooling towers pose many disadvantages including: poor quality water to process; permanent contamination (solids, gases, algae, bacteria - legionella); scale accumulation; permanent oxidation; and fouling that changes heat transfer efficiency and performance. They require two sets of pipes throughout a factory for water distribution and return, ice up in the winter, and most importantly, are costly to operate and are destructive to the clean water supply and ground water in a community.

The Cooling Tower Alternative (How it works)

Because process cooling is a necessary evil and there was never an end in sight to the frustrations, it is often regarded as just a "utility." Traditional design constraints allow only incremental improvements, and many costs continue unchecked: water and energy usage, chemical treatment and maintenance.

Nearly all of this manufacturing, including plastic and rubber processing require process heating and cooling.

An economical and environmentally friendly process cooling system provides manufacturers with another way – one that uses ambient air (rather than evaporation) to cool clean process water and offers flexibility with easy installation.

Generally, process cooling systems are dirty and contaminated because traditional cooling towers rely on constant evaporation of water passing through the air, leaving concentrations of contaminants and dissolved solids.

An ambient air, closed-loop cooling system will replace a cooling tower so that water returning from the process is pumped into heat exchangers and cooled with ambient air flow. This process provides clean water at the right temperature to process machines year round.

Important to most manufacturers is maintaining water temperature below set point. This ensures their process runs properly and efficiently. With a traditional system, this task is both draining on their energy and water supply but is often not precise enough either. To maintain water below set point:

- "Adiabatic cooling" can be added to the ambient air system. . The system automatically switches into "adiabatic" mode when ambient air reaches 85°F or higher. In this mode, air passes through an adiabatic chamber before reaching the heat exchanger. A fine mist of city water is "pulsed" into the incoming air stream within the chamber.
- The pulsed water evaporates instantly, cooling the air before it reaches the cooling coils carrying the process water. The coil fins remain dry, hence the term "dry cooling." (This pulsed water is the only new water added to the system, it is very minimal and, in Chicago conditions, may only be needed 14.5 days a year – see Appendix 4)
- To ensure consistent cooling, an advanced control panel continuously adjusts the amount of water sprayed. The humidified air pre-cools the air passing over the coils in turn dropping the water temperature to, at or below, 95°F, even with ambient temperatures as high as 120°F. (See Appendix 2 for process diagram)

Under cold weather conditions, if ambient air falls below 32°F, a fully-automatic, self-draining system engages to the cooling water from freezing in the piping.

The Water Problem

Most facilities' process water is far from ideal. One customer complained that their local water was filled with, "dust, lime, dandelions and even lily pads." That makes continuous water treatment for manufacturers challenging and expensive.

Continuous water consumption also becomes a costly issue for many facilities. High disposal costs for concentrated and contaminated fluids are being imposed by many local governments. In some areas, cooling tower waste water even requires specialized hazardous disposal handling. These practices are picking up momentum and will begin to play a larger role in purchasing decisions made by business owners.

Traditional towers' continuous water reliance and exposed design also cause maintenance and mechanical issues such as steam and icing as seen in Appendix 3.

An ambient air, closed loop cooling system is designed specifically to reduce water use dramatically, and to keep water it without continuous chemical treatment. The result: substantial savings on water, chemicals, energy and maintenance costs and minimal demand on a community's clean water supply – all things that have long been accepted as unavoidable with traditional cooling tower systems.

Central Chiller Alternative

An ambient air, closed loop system is designed to offer the flexibility to use with chiller/temperature control units for individual control of chilled or heated water at each process machine. This replaces large central chilling systems used with cooling towers.

Machine-side cooling process is simplified by using only a single set of un-insulated pipes to supply the process water, without heat loss, to the chiller/temperature control units at each machine. (See Appendix 1 for comparison of cooling tower/central chiller vs. ambient air, closed loop system plant layout).

This alternative to central chillers can save up to 80 percent on energy costs and improve processes the water is serving because of the precise water temperature delivered at individual process machines, positively affecting productivity.

Process Cooling (Productivity and scrap)

As briefly described above, an ambient air, closed loop cooling system outside of the building feeds water to smaller machine side units that adjust for needed temperature and pressure for that specific piece of manufacturing equipment. By controlling flow and temperature at the point of use, energy is conserved. For instance, if one machine needs 50°F water to produce or operate correctly and another machine needs 62°F and yet a third requires 66°F, a traditional central chilling system would distribute 50°F water to the whole plant.

It also takes more energy to bring water to that low of a temperature for every machine and is wasteful if something other than 50°F is needed. It also allows manufacturers to save a considerable amount of energy and floor space by not operating large pump tanks or having to send specifically pressurized water from a central source around the entire plant. Less floor space of course can lead to smaller factories, lessening their impact on the surrounding environment.

Machine side control allows process parameters to be optimized for that machine, allowing it to make better quality parts or operate in the most optimal way ensuring quality and no scrap from bad parts. No bad parts and less scrap material is a great environmental advantage to the system, especially in the plastics industry.

Not only is scrap reduced and quality enhanced by the machine side units but they allow companies to improve cycle times (how long it takes to make each part), greatly improving efficiency.

Automatic Controls

Automated controls can also help optimize equipment operation, conserve resources and maximize the life of the equipment.

An advanced control system controls the amount of water sprayed into the adiabatic chamber based on ambient temperatures and process set point. It ensures that water is only being sprayed to cool the air when necessary and continuous, automatic, adjustments are made based on condition changes.

Energy saving: When the leaving water temperature drops below the set point, the controller halts the pumps circulating to the outdoor heat exchanger, and the system automatically drains its water back to an indoor enclosed reservoir. The system then circulates cool water from this indoor tank until it becomes sufficiently warmed to permit sending it outdoors again to the heat exchanger.

It not only controls functions of the system but makes the adjustments needed for the system to run at optimum efficiency. Based on ambient temperature and process water temperature, the controller adjusts fan speed and initiates evaporative functions to generate the required cooling capacity in the most efficient way possible. It also manages the pumping stations to save energy and boost equipment longevity by controlling water pressure and pump rotation.

System saving: Important for the climate in Illinois is the built-in freeze protection. The ambient air, closed loop cooling system features a self-draining process to avoid icing when ambient air falls below 32°F or a power outage occurs in the winter. Gravity automatically drains the system’s copper pipes to protect the unit. The self-draining process requires no valves or any manual interaction, which leads to completely safe operation in extreme weather. This feature also allows the system to operate in many cases without the need for anti-freeze in the water further decreasing a manufacturer’s reliance on chemicals and further protecting the environment.

Free Cooling

Free cooling means using an ambient air, closed-loop fluid cooler or other non-refrigerant cooling methods to replace the chiller/refrigeration method. An ambient air, closed loop cooling system provides free cooling to a variety of processes/devices based on process set point and local ambient conditions. This feature alone can save up to 80 percent on energy costs and improve processes the water is serving because of the precise water temperature delivered at individual process machines, positively impacting productivity.

The amount of free cooling available is calculated using average temperatures in a particular region. In Chicago, for example, the ambient temperature is below 50°F for 50 percent of the year (See free cooling chart in Appendix 4). A process requiring 60°F cooling water (and assuming a ΔT of 10°F) would be able to take advantage of free cooling for an average of six months every year.

Economic Benefits

Energy/fuel saving
This is accomplished through efficient operation of efficient equipment. Economic impact of energy efficient equipment is increasing by the day with rising energy costs.

The energy savings seen with the ambient air system comes from the elimination of big pump tanks, use of fans only when needed, low thermal losses, efficient motors and intelligent control systems.

In addition to the system's ability to provide free cooling (another money saver), further energy savings come from the elimination of big pump tanks. A typical 100-ton central chiller system operates with about 0.8 to 1.2 kWh/ton energy consumption, with most of the energy going to the pumping system. Since there is substantially less pumping to circulate much less water, energy requirements are significantly lower.

An actual energy savings analysis is shown in Appendix 6

Maintenance time saved
Maintenance costs are variable and are based on water quality and chemical treatment. The more money spent on water treatment with chemicals and dumping water to lower suspended soils, the lower the maintenance cost. But you sacrifice lower maintenance with higher water and chemical bills. Looking at a typical plastics processing plant, companies will spend as much as 5-10 man hours in maintenance a week on cleaning heat exchangers, cleaning condensers on water cooled chillers and on temperature control repair of valves and heaters due to poor quality of the water. That comes to 20-40 hours a month which can then be translated into dollars and resources for other tasks quite easily.

Water cost savings
A 100-ton, cooling tower, system uses 1 to 1.5 million gallons per year while an ambient air cooler uses 20,000 to 40,000 gallons per year.

An actual water savings analysis is shown in Appendix 6. In this particular example, savings from energy, maintenance and water come to $117,745 per year.

Process improvements
When considering process improvements that manufacturers can expect to see up to a 20% increase in productivity while also improving quality. When factoring in process stability, increased line speed, and scrap reduction, payback can occur in less than two years - an excellent ROI for a capital equipment expense.

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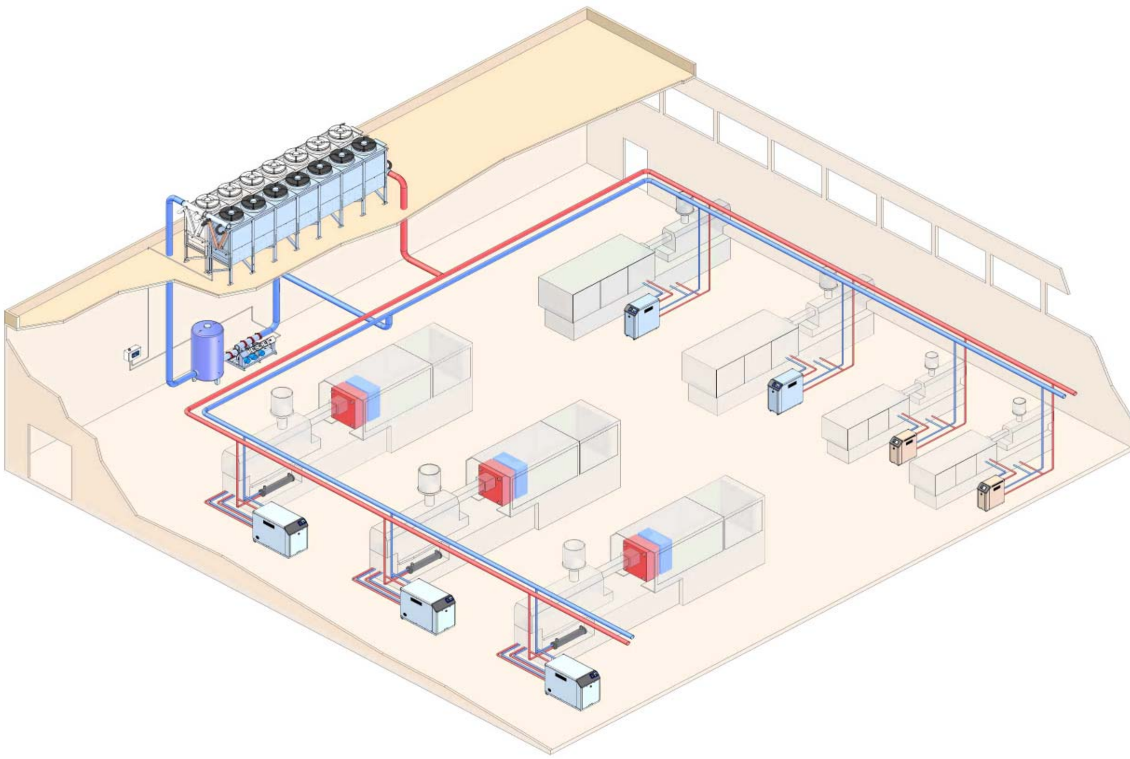
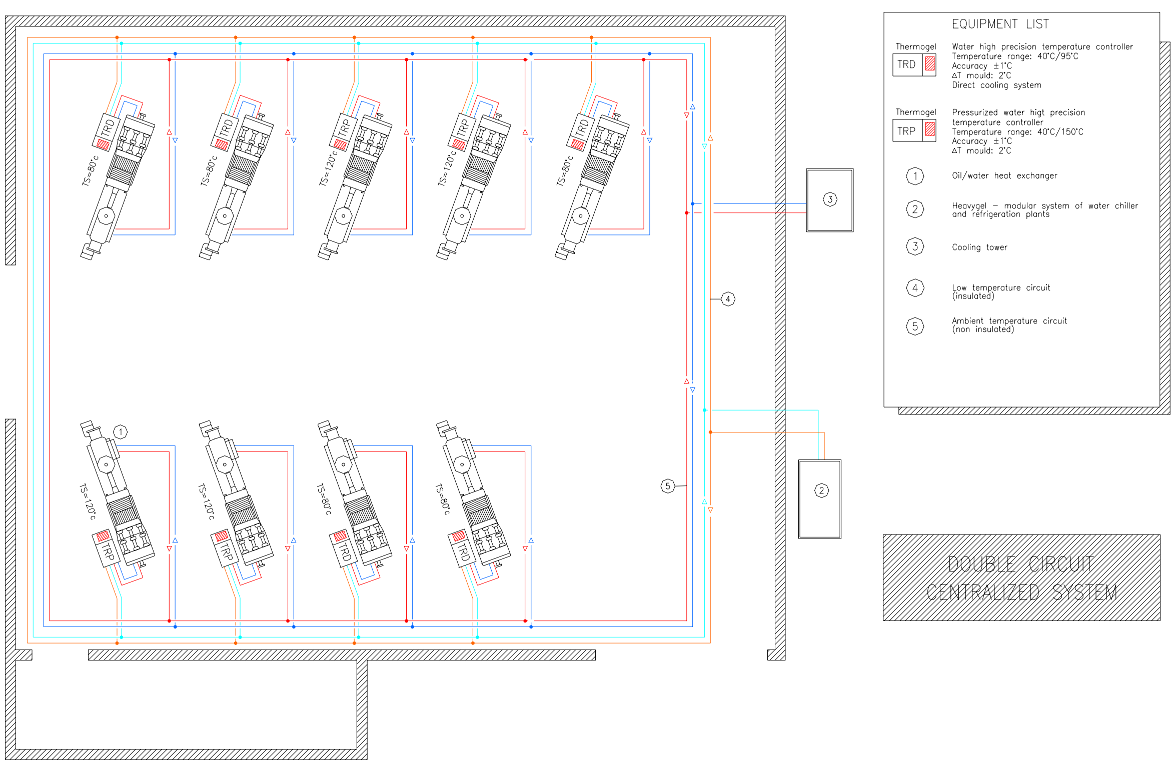
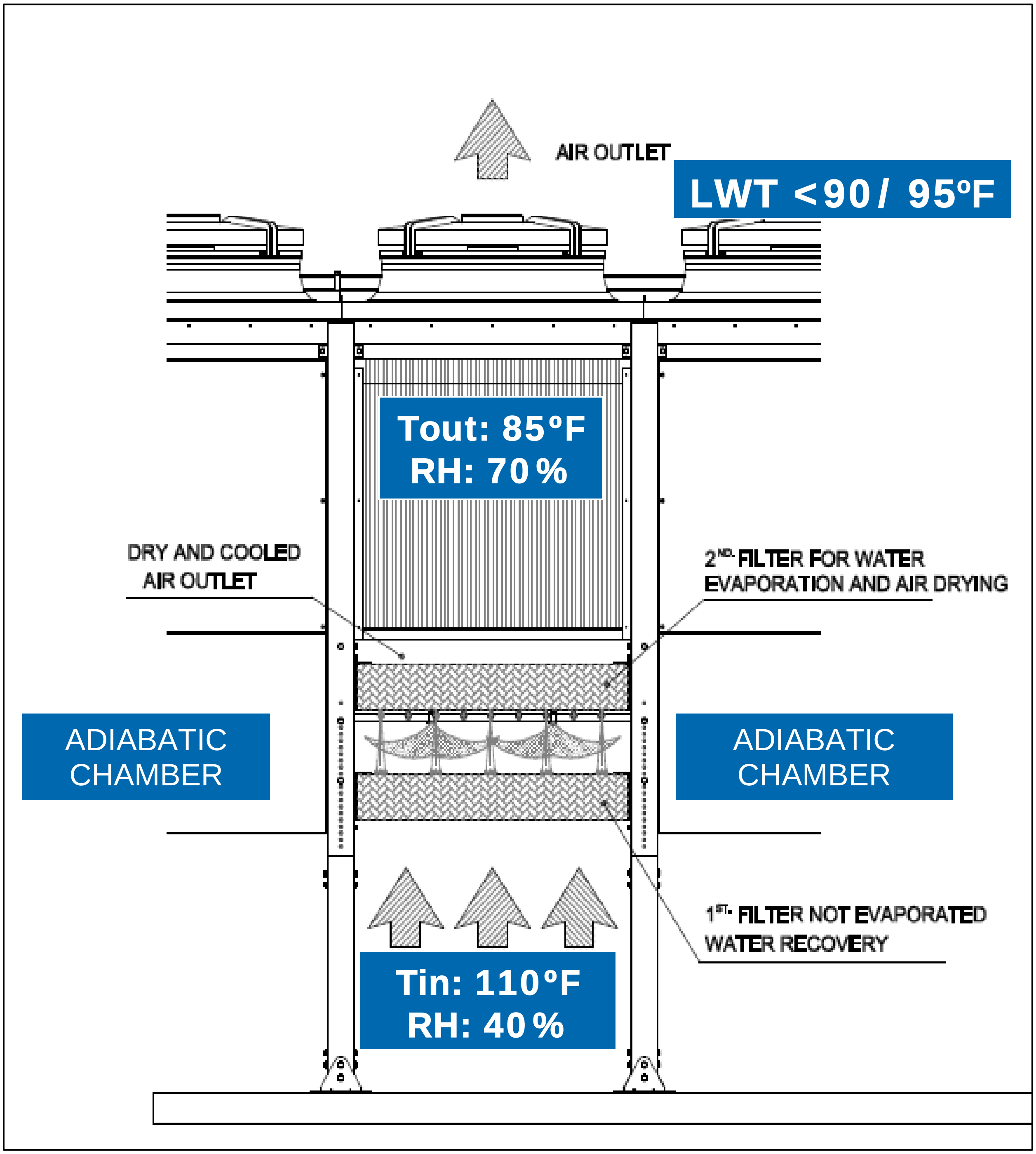
Appendix 1

Plant layout example of a traditional tower and chiller plant vs. ambient air, closed-loop cooling system





Appendix 2
Adiabatic cooling process



Appendix 3
Traditional cooling tower evaporation and icing in winter

Appendix 4
Free cooling availability (based on Chicago, IL weather data)

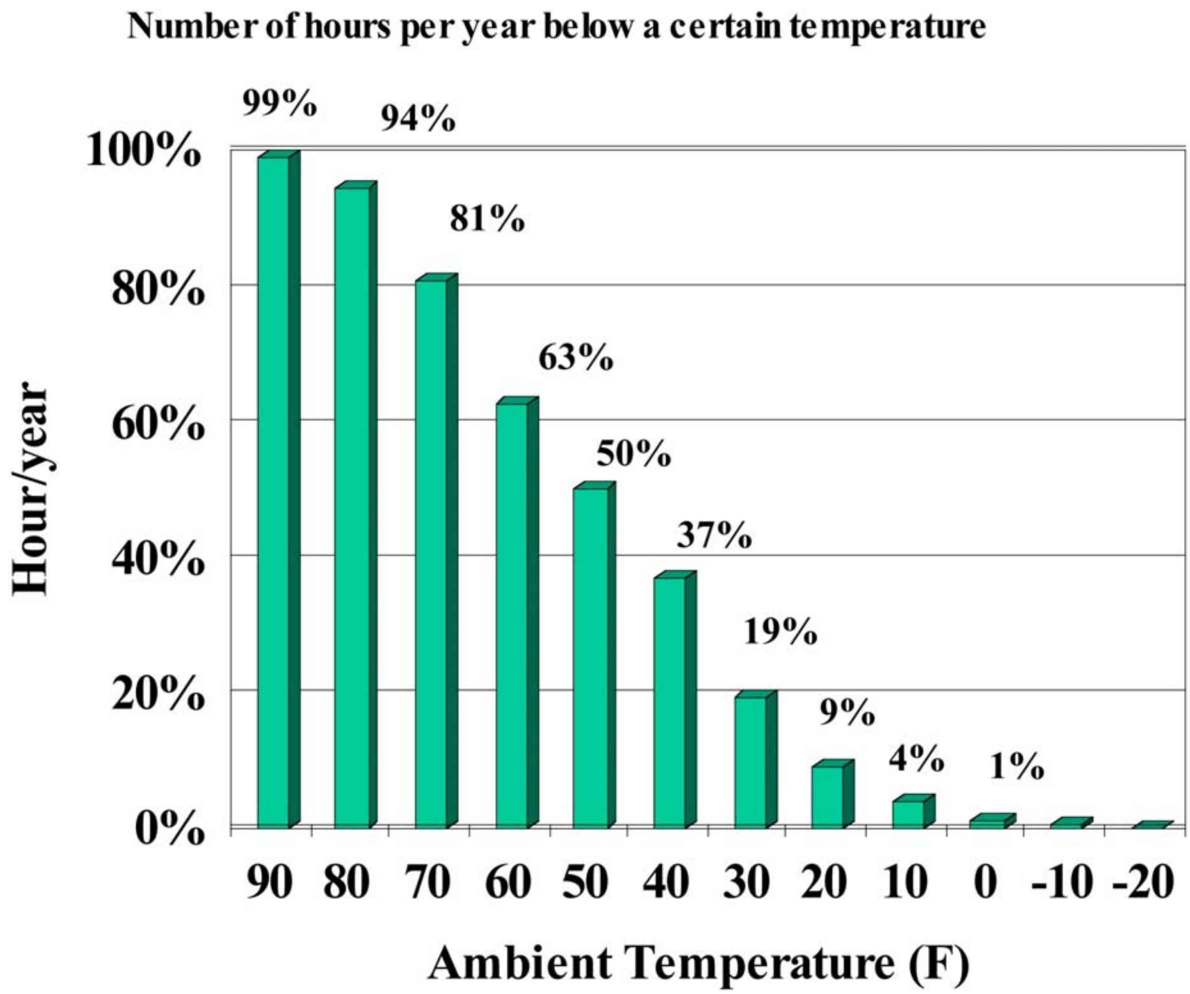
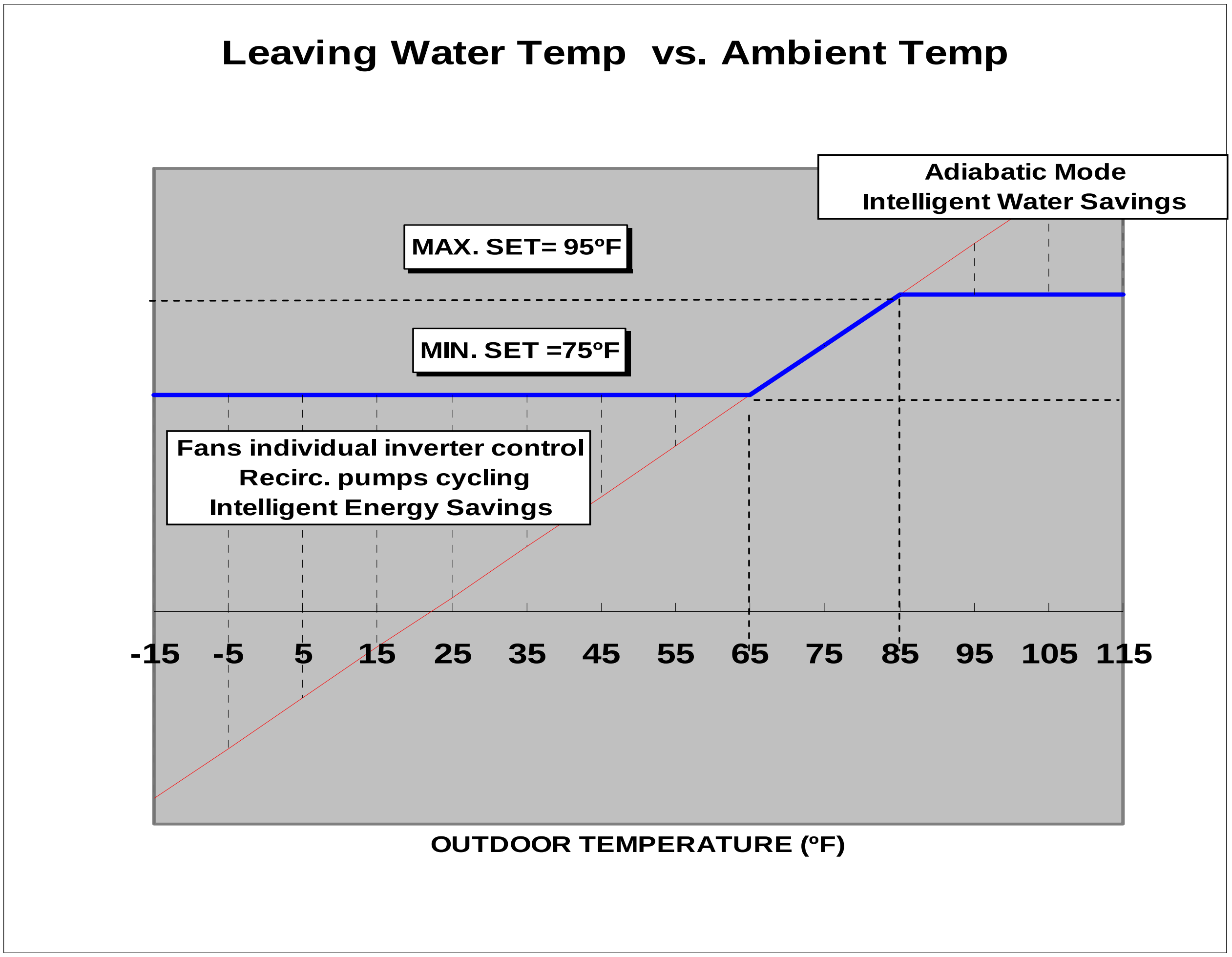


Chart shows what percentage of the year you can start to take advantage of free cooling.
Source: Dry-bulb temperature hours of an average year. Period of record: last 25 years. (Engineering Weather Data – EWD)

Appendix 5
Intelligent water and energy savings



High water savings
Only during high outdoor temperatures (over 85°F) does the system switch to adiabatic mode, thus keeping leaving water temperature on the maximum set. Combining the information in this chart with the average temperature in Chicago shown in Appendix 4 you can determine that a system in these conditions would need to use the water spraying adiabatic mode 4% of the year.

High energy savings
During low outdoor temperatures or partial load operation, the ambient air system automatically reduces the speed of fans keeping leaving water temperature on the minimum set. Combining the information in this chart with the average temperature in Chicago show in Appendix 4 you can determine that fans and pumps can operate in Intelligent Energy Savings mode for 72% of the year.

Appendix 6
In this example, the customer will have payback in just over 2 years.

Water Savings Analysis (compared to traditional cooling tower)

Cooling requirements* *assuming 95% of maximum requirements	469	tons	Price of water	0.020	$/cu ft
Maintenance cost per month	1300	$/month	Working hours per year	8600	hr

Running costs analysis

		Cooling Tower	Ambient Air System
Water temperature (max)	°F	90	95
Ambient Temperature for Total Water Savings	°F	-	85
Water saving period (according to location weather records*)		0%	97.0%
Water consumption/cooling capacity (annual average)	cu ft/hr/ton	0.35	0.25
Water consumption (annual average)	**cu ft/hr**	**164.06**	**3.52**
Water consumption per year	cu ft/year	1,410,925	30,234
Water cost per year	$/year	28,218	605
Maintenance costs per year	$/year	15,600	0
Total running costs	**$/year**	**43,818**	**605**
ANNUAL NET SAVINGS	$/year	43,214	99%

Energy Savings Analysis (Free-cooling with 20-25% anti-freeze)

Cooling requirements (molds cooling) *assuming 95% of maximum requirements	255	tons	Energy unit price	0.074	$/kwh
Chiller cooled with	WATER		Working hours per year	8600	hr

Energy analysis

		CHILLER	Ambient Air System
Average Water temperature required within proceses	°F	55	55
Average Ambient Temperature for Free-Cooling	°F	45	45
Energy saving period (according to location weather records*)		0%	49.4%
Electrical consumption/cooling capacity (annual average)	kw/ton	1.0	0.07
Absorbed power (annual average)	**kw**	**254.92**	**137.80**
Energy consumption per year	kwh/year	2,192,283	1,185,105
Energy cost per year	$/year	162,229	87,698
Annual energy saving	**kwh/year**	**1,007,179**	**46%**
ANNUAL NET ENERGY SAVINGS	$/year	74,531	46%