R4 Ventures LLC

White Paper

Preliminary Temperature Performance Evaluation of New Cooling Technologies consisting of the Multistage Evaporative Cooling System (MECS) alone or combined with the Real Time Electronic Enclosure Cooling System (ISECS) in the Real Time Data Center Cooling System (RTDCCS) for Phoenix, AZ; San Jose, CA; and Washington DC.

Applications included in this evaluation include:

- ***Data Centers – Real Time Data Center Cooling System (MECS + ISECS)***
- ***Commercial/Industrial Buildings – MECS***
- ***Inlet Air Cooling for Nat Gas Turbines/CHP Systems – MECS***
- ***Process Cooling Water for Industrial & Food Processing Plants - MECS***

Introduction

R4 Ventures LLC (R4V) has developed and patented a disruptive …environmentally sound and responsible Green Technology, i.e. Green Cooling using the earth's natural water cycle. This disruptive technology replaces high energy consuming mechanical refrigeration system such as mechanical refrigeration equipment / systems using compressors and environmentally harmful refrigerants with a compressorless and refrigerantless cooling tower … water based system to meet process and comfort cooling applications in buildings, facilities, and industrial plants. Our patented Green Cooling Technologies (4 US patents granted and 1 US patent pending and provide significant cooling energy usage and cost savings of 40 to 85% over traditional cooling systems potentially saving commercial and industrial customers billions of dollars in electrical energy cooling costs, eliminating the use harmful refrigerants … while significantly reducing green house gas (GHG) emissions from fossil fuel utility power plants.

Patents

Mike Reytblat – Inventor and Chief Scientist The first foundational patented system in our patent portfolio is the Multistage Evaporative Cooling System (MECS). The USPTO granted a patent on our Advanced Multi-Purpose, Multi-stage Evaporative Cold Water/Cold Air Generating and Supply System – US Patent Number 8,899,061 on December 2, 2014. The second foundational patented system in our patent portfolio is the Real Time Individual Electronics Enclosure Cooling System (hereinafter Individual Server Enclosure Cooling System or ISECS). The Real Time Individual Electronic Enclosure Cooling System – US Patent Number 8,857,204 was granted on October 14, 2014. A Real Time Data Center Cooling System (RTDCCS) is created by combining ISECS with MECS.

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May 2018

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Executive Summary

R4V Ventures LLC (“R4V”) is using research, development, innovative technologies and the earth’s abundant natural and renewable resources to provide cooling to commercial and industrial buildings throughout the world. R4V is applying semi-conductor clean room process cooling methods to data center facilities through patent pending technologies providing significant cooling energy cost savings of 60 to 80% when compared to traditional mechanical cooling systems and technologies and significantly reducing green house gas (GHG) emissions. Data Centers (DCs) currently use 2.5% of the total electricity produced in the United States in the operation of DCs with 40% of this electricity being used for cooling. This equates to 1% of all the electricity produced in the United States.

In addition to commercial and industrial buildings and data centers, R4V technologies are targeting extremely high energy use markets including process cooling requirements in industrial and manufacturing applications, high cooling energy using commercial and industrial buildings, natural gas turbine inlet air cooling, and large industrial compressor inlet air cooling. R4V patents, commercializes and brings to market these unique cooling technologies through continued R&D, strategic partnerships, contract manufacturing relationships and engineering knowhow licensing and system distribution relationships.

R4 Ventures LLC has evaluated the cooled water and cooled air temperature performance of our **compressor-less … refrigerant-less cooling system technologies** in this White Paper to provide engineering analysis of what temperatures can be attained in three major markets in the United States. The applications evaluated are:

- Commercial/Industrial Buildings – MECS
- Data Centers – Real Time Data Center Cooling System (MECS + ISECS)
- Inlet Air Cooling for Nat Gas Turbines/CHP Systems – MECS
- Process Cooling Water for Industrial & Food Processing Plants - MECS Commercial/Industrial Buildings – MECS

This white paper evaluates the Multistage Evaporative Cooling System (MECS) (Commercial/Industrial Buildings, Turbine Inlet Air Cooling, and Process Cooling Water for Industrial & Food Processing Markets) and Real Time Data Center Cooling System (RTDCCS) (Data Center Market) and for three (3) major cities in the United States, Phoenix, AZ; San Jose, CA; and Washington DC. The RTDCCS consists of patent pending technology including the Multistage Evaporative Cooling System (MECS) which generates cold water (and cold supply air for the above described markets) coupled with the Individual Server Enclosure Cooling System (ISECS) which provides process cooling of the heat load at the rack level based on the ASHRAE Summer Design Conditions for evaporative applications for commissioning in a new or retro commissioned Data Centers. The evaluation contained herein details the cooled water temperature performance of the RTDCCS (MECS + ISECS) in Data Center White Space and the cooled supply air temperature performance of the MECS for the above described markets based on ASHRAE published Summer Design Conditions of .4% for evaporative applications, and the monthly Mean Dry Bulb and Wet Bulb Temperatures for each city’s closest airport (Phoenix, San Jose CA and Washington DC).

The tables and charts below for each of the cities identified show the temperature performance of the RTDCCS and MECS. The MECS tables and charts show the temperature performance based on the selected and operational components of the MECS based on achieving the desired comfort space temperatures in commercial and industrial buildings. The MECS tables and charts designed to supply cold air for Turbine Inlet Air (TIC) applications show the temperature performance based on meeting or approaching the desired inlet air temperatures of 59 °F (the temperature in which 100% name plate efficiency can be achieved) in natural gas turbine power generation systems and second, the selected and operational components of the MECS based on achieving the **lowest possible air temperature** entering the turbine or compressor. The evaluation also shows when a supplemental cooling module is necessary and the amount of “trimming” water temperature is required to meet the ideal 59 °F TIC application.

Summary of Temperature Performance of R4 Ventures LLC's New Cooling Technologies

Data Centers – Real Time Data Center Cooling System (MECS + ISECS)

1. Phoenix AZ
    a. ASHRAE published Summer Design Conditions of .4% for evaporative applications - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 76.8 °F completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining an ASHRAE TC 9.9 recommended set point temperature of 80.6 °F in the Data Center White Space.
    b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 75.5 °F in the hottest month of August completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining an ASHRAE TC 9.9 recommended set point temperature of 80.6 °F in the Data Center White Space.
2. San Jose CA
    a. ASHRAE published Summer Design Conditions of .4% for evaporative applications - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 74.39 °F completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining an ASHRAE TC 9.9 recommended set point temperature of 80.6 °F in the Data Center White Space.
    b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 73.56 °F in the hottest month of July completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining an ASHRAE TC 9.9 recommended set point temperature of 80.6 °F in the Data Center White Space.
3. Washington DC
    a. ASHRAE published Summer Design Conditions of .4% for evaporative applications - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 81.87 °F completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. For approximately 32 hours a year, the system would operate about 1.27 °F above the ASHRAE recommended white space temperature of 80.6 °F. The balance of the year or approximately 8,728 hours per year is well under the 80.6 °F threshold.
    b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Data Center White Space temperature (for the entire compute space) can be maintained at a set point temperature of 76.20 °F in the hottest month of July completely eliminating hot aisles and cold aisles. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining an ASHRAE TC 9.9 recommended set point temperature of 80.6 °F in the Data Center White Space.

Commercial/Industrial Buildings – MECS

1. Phoenix AZ
    a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – Commercial and Industrial Building cold supply air temperatures provided to the entire space to be cooled can be maintained at a set point temperature of 73.39 °F (includes sensible and adiabatic cooled air exiting the MU AHU) plus adjustment for space heat gain. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a cold supply air set point temperature of 74°F in the Commercial and Industrial Building.
    b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Commercial and Industrial Building cold supply air temperatures provided to the entire space to be cooled can be maintained at a set point temperature of 70.27 °F (includes sensible cooled air only exiting the MU AHU) in the hottest month of August plus adjustment for space heat gain. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a cold supply air set point temperature of 74 °F in the Commercial and Industrial Building.
    c. **The additional 4 °F to 10 °F set point temperature reduction is obtained by adding an adiabatic cooling section to the Make Up Air Handling Unit (MU AHU).**
2. San Jose CA
    a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – Commercial and Industrial Building cold supply air temperatures provided to the entire space to be cooled can be maintained at a set point

temperature of 70.22 °F (includes sensible cooled air only exiting the MU AHU) plus adjustment for space heat gain. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a cold supply air set point temperature of 74 °F in the Commercial and Industrial Building.

   b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Commercial and Industrial Building cold supply air temperatures provided to the entire space to be cooled can be maintained at a set point temperature of 68.03 °F (includes sensible cooled air only exiting the MU AHU) in the hottest month of July plus adjustment for space heat gain. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a cold supply air set point temperature of 74 °F in the Commercial and Industrial Building.
   c. **<u>The additional 4 °F to 10 °F set point temperature reduction is obtained by adding an adiabatic cooling section to the Make Up Air Handling Unit (MU AHU).</u>**

3. Washington DC
   a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – Commercial and Industrial Building cold supply air temperatures provided to the entire space to be cooled can be maintained at a set point temperature of 79.65 °F (includes sensible and adiabatic cooled air exiting the MU AHU) plus adjustment for space heat gain. No compressors and refrigerants are used in the system. For approximately X hours a year, the system would operate about 5.65 °F above a set point temperature of 74 °F. The balance of the year or approximately Y hours per year is well under the 74 °F threshold.
   b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - Commercial and Industrial Building cold supply air temperatures provided to the entire space to be cooled can be maintained at a set point temperature of 73.07 °F (includes sensible and adiabatic cooled air exiting the MU AHU) in the hottest month of July plus adjustment for space heat gain. No compressors and refrigerants are used in the system. Significant additional energy can be saved by maintaining a cold supply air set point temperature of 74 °F in the Commercial and Industrial Building.
   c. Significant energy can be saved by maintaining a cold supply air set point temperature of 74 °F in the Commercial and Industrial Building when using dehumidification in Make Up Air Handling Unit (MU AHU).

Process Cooling Water for Industrial & Food Processing Plants – MECS (Colder Water Temperatures can be achieved by consulting with R4 Ventures LLC on the specific application and client needs)

1. Phoenix AZ
   a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – For Process Cooling Water for Industrial & Food Processing Plants, cold supply water temperatures provided to the process cooling application can be maintained at a water temperature of 73.95 °F. No compressors and refrigerants are used in the system. To reach of the desired application water temperature, additional trimming water temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc.
   b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - For Process Cooling Water for Industrial & Food Processing Plants, cold supply water temperatures provided to the process cooling application can be maintained at a water temperature of 67.27 °F in the hottest month of August. No compressors and refrigerants are used in the system. To reach of the desired application water temperature, additional trimming water temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc.
2. San Jose CA
   a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – For Process Cooling Water for Industrial & Food Processing Plants, cold supply water temperatures provided to the process cooling application can be maintained at a water temperature of 67.22 °F. No compressors and refrigerants are used in the system. To reach of the desired application water temperature, additional trimming water temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc.
   b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - For Process Cooling Water for Industrial & Food Processing Plants, cold supply water temperatures provided to the process cooling application can be maintained at a water temperature of 65.03 °F in the hottest month of July. No compressors and refrigerants are used in the system. To reach of the desired application water temperature, additional trimming water temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any

other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc.

3. Washington DC
    a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – For Process Cooling Water for Industrial & Food Processing Plants, cold supply water temperatures provided to the process cooling application can be maintained at a water temperature of 79.87 °F. No compressors and refrigerants are used in the system. To reach of the desired application water temperature, additional trimming water temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc.
    b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - For Process Cooling Water for Industrial & Food Processing Plants, cold supply water temperatures provided to the process cooling application can be maintained at a water temperature of 74.20 °F in the hottest month of July. No compressors and refrigerants are used in the system. To reach of the desired application water temperature, additional trimming water temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc.

Inlet Air Cooling for Nat Gas Turbines/CHP Systems – MECS

Brief Introduction to Turbine Inlet Cooling (TIC) - The primary reason TIC is used to enhance the power output of combustion turbines (CTs) when ambient air dry bulb temperature is above 59 °F. The rated capacities of all CTs are based on the standard ambient conditions of 59 °F, 14.7 psia at sea level selected by the International Standards Organization (ISO). Example: for a typical aero derivative CT, as inlet air temperature increases from 59 °F to 100 °F on a hot summer day, its power output decreases to about 73 percent of its rated capacity. By cooling the inlet air from 100 °F to 59 °F, the 27% loss of rated generation capacity can be avoided. The engineering analysis provided in this White Paper shows the lowest Inlet Air Temperature available (includes sensible and adiabatic cooled air exiting the MU AHU).

Turbine Inlet Cooling

Information on Turbine Inlet Cooling or TIC is sourced from and can be found on the Turbine Inlet Cooling Association website http://www.turbineinletcooling.org/index.html

What is TIC?

TIC is cooling of the air before it enters the compressor that supplies high-pressure air to the combustion chamber from which hot air at high pressure enters the combustion turbine. TIC is also called by many other names, including combustion turbine inlet air cooling (CTIAC), turbine inlet air cooling (TIAC), combustion turbine air cooling (CTAC), and gas turbine inlet air cooling (GTIAC).

Why Cool Turbine Inlet Air?

The primary reason TIC is used is to enhance the power output of combustion turbines (CTs) when ambient air temperature is above 59°F. The rated capacities of all CTs are based on the standard ambient conditions of 59°F, 14.7 psia at sea level selected by the International Standards Organization (ISO). One of the common and unattractive characteristics of all CTs is that their power output decreases as the inlet air temperature increases as shown in Figure 1. It shows the effects of inlet air temperature on power output for two types of CTs: Aeroderivative and Industrial/Frame. The data in Figure 1 are typical for the two turbine types for discussion purposes. The actual characteristics of each CT could be different and depend on its actual design. The data in Figure 1 shows that for a typical aeroderivative CT, as inlet air temperature increases from 59°F to 100°F on a hot summer day (in Las Vegas, for example), its power output decreases to about 73 percent of its rated capacity. This could lead to power producers losing opportunity to sell more power just when the increase in ambient temperature increases power demand for operating air conditioners. By cooling the inlet air from 100°F to 59°F, we could prevent the loss of 27 percent of the rated generation capacity. In fact, if we cool the inlet air to about 42°F, we could enhance the power generation capacity of the CT to 110 percent of the rated capacity. Therefore, if we cool the inlet air from 100°F to 42°F, we could increase power output of an aeroderivative CT from 73 percent to 110 percent of the rated capacity or boost the output capacity by about 50 percent of the capacity at 100°F. The primary reason many power plants using CT cool the inlet air is to prevent loss of power output or even increase power output above the rated capacity when the ambient temperature is above 59°F.

What are the Benefits of TIC?

The primary benefit of TIC is that it allows the plant owners to prevent loss of CT output, compared to the rated capacity, when ambient temperature rises above 59°F or the plant is located in a warm/hot climate region. As discussed in the earlier section, TIC can even allow plant owners to increase the CT output above the rated capacity by cooling the inlet air to below 59°F.

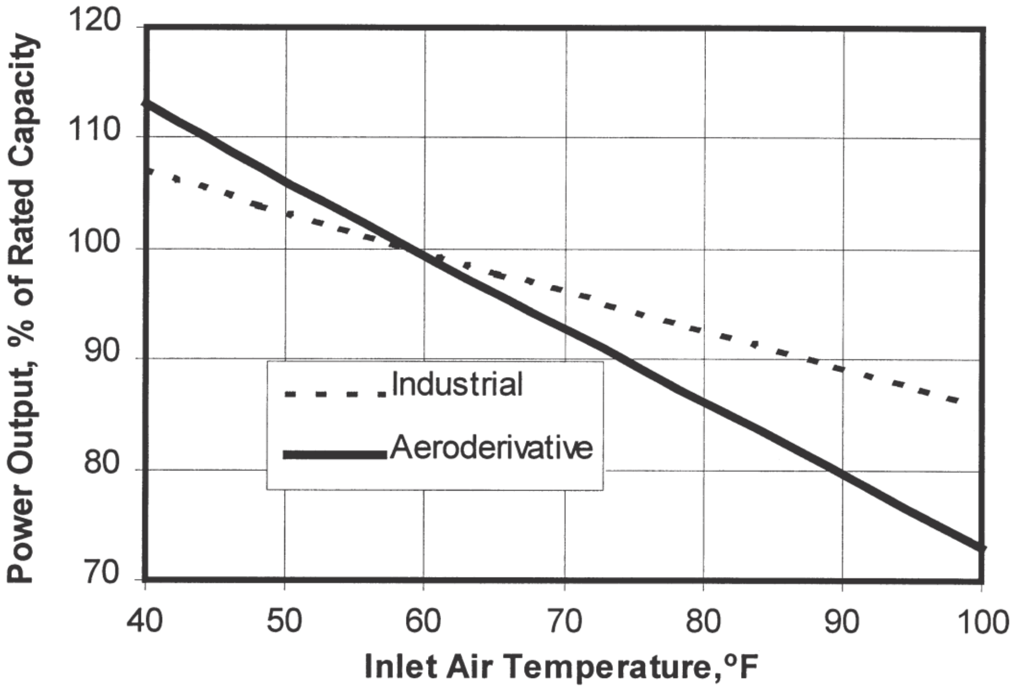


Figure 1. Effect of Inlet Air Temperature on Combustion Turbine Power Output

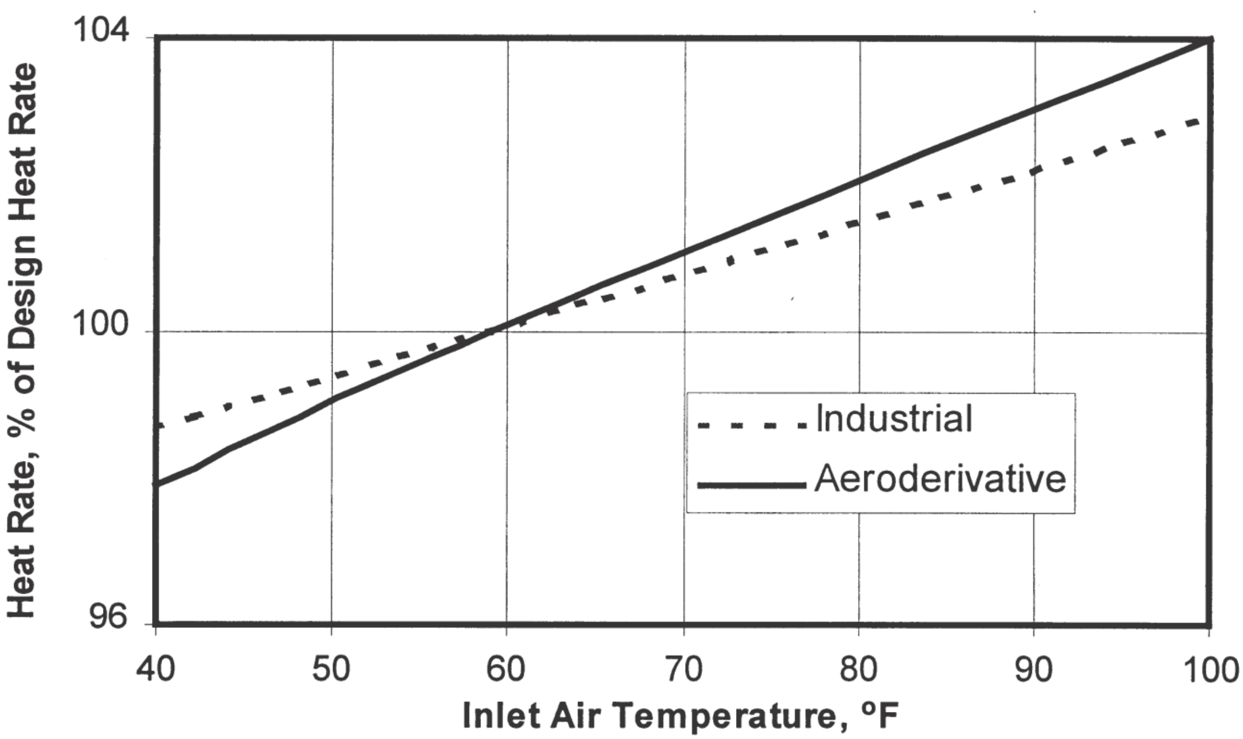


Figure 2. Effect of Ambient Temperature on Combustion Turbine Heat Rate

The secondary benefit of TIC is that it also prevents decrease in fuel efficiency of the CT due to increase in ambient temperature above 59°F. Figure 2 shows the effect of inlet air temperature on heat rate (fuel require per unit of electric energy) for the two types of CTs discussed in the earlier section. It shows that for an aeroderivative, CT increase in inlet air temperature from 59°F to 100°F increases heat rate (and thus, decreases fuel efficiency) by 4 percent (from 100 percent at 59°F to 104 per cent at 100°F) and that cooling the inlet air from 59°F to 42°F reduces the heat rate (increases fuel efficiency) by about 2 percent (from 100 percent to about 98 percent).

The other benefits of TIC include increased steam production in cogeneration plants, and increased power output of steam turbines in combined cycle systems.

In summary, there are many benefits of TIC when the ambient temperature is above 59°F:
• Increased output of CT
• Reduced capital cost for the enhanced power capacity
• Increased fuel efficiency
• Increased steam production in cogeneration plants
• Increased power output of steam turbine in combined cycle plants

How does TIC help increase CT output?
Power output of a CT is directly proportional to and limited by the mass flow rate of compressed air available to it from the air compressor that provides high-pressure air to the combustion chamber of the CT system. An air compressor has a fixed capacity for handling a volumetric flow rate of air. Even though the volumetric capacity of a compressor is fixed, the mass flow rate of air it delivers to the CT changes with changes in ambient air temperature. This mass flow rate of air decreases with increase in ambient temperature because the air density decreases when air temperature increases. Therefore, the power output of a combustion turbine decreases below its rated capacity at the ISO conditions (59°F, 14.7 psia at sea level) with increases in ambient temperature above 59°F. TIC allows increase in air density by lowering the temperature and thus, helps increase mass flow rate of air to the CT and results in increased output of the CT.

Compressed Air Systems

What is the effect of Air Intake on Compressor performance?
The effect of intake air on compressor performance should not be underestimated. Intake air that is contaminated or hot can impair compressor performance and result in excess energy and maintenance costs. If moisture, dust, or other contaminants are present in the intake air, such contaminants can build up on the internal components of the compressor, such as valves, impellers, rotors, and vanes. Such build-up can cause premature wear and reduce compressor capacity.

When inlet air is cooler, it is also denser. As a result, mass flow and pressure capability increase with decreasing intake air temperatures, particularly in centrifugal compressors. This mass flow increase effect is less pronounced for lubricant-injected, rotary-screw compressors because the incoming air mixes with the higher temperature lubricant. Conversely, as the temperature of intake air increases, the air density decreases and mass flow and pressure capability decrease. The resulting reduction in capacity is often addressed by operating additional compressors, thus increasing energy consumption.

Rules of thumb in designing Compressed Air Systems.
1. Air compressors normally deliver 4 to 5 CFM per horsepower at 100 psig discharge Pressure
2. Power cost for 1 horsepower operating constantly for one year at 10 cents per kWh is about $750 per year
3. Every 7°F rise in temperature of intake air will result in 1% rise in energy consumption.
4. It takes 7 to 8 hp of electricity to produce 1 hp worth of air force
5. Size air receivers for about 1 gallon of capacity for each CFM of compressor capacity
6. Compressor discharge temperatures are a key indicator of compression efficiency. Uncooled compressed air is hot, as much as 250 to 350 deg F!
7. Typical discharge temperature values before aftercooling are: Screw (175°F), Single Stage Reciprocating (350°F), Two Stage reciprocating (250°F)
8. Most water-cooled after coolers will require about 3 GPM per 100 CFM of compressed air at Discharge Air Temperature at 100 psig and will produce about 20 gallons of condensate per day.
9. Locate filters and a dryer in the airline before any pressure-reducing valve (i.e., at the highest pressure) and after air is cooled to 100°F or less (the lowest temperature).

10. Many tools require more CFM at 90 PSI than what is physically possible to get from the power available through a 120 VAC outlet. Beware, that the CFM figure given as the required air power on many tools (e.g., air chisels/hammers, sandblasters) is for an absurdly low duty cycle. You just can't run these constantly on anything but a monster compressor, but the manufacturer still wants you to believe you can, so you will buy the tool.
11. Depending on the size of the system, compressed air costs about 25 to 42 cents per thousand cubic feet of free air ingested by the compressor (including operating and maintenance costs).
12. A 50 horsepower compressor rejects approximately 126,000 BTU per hour for heat recovery.
13. The water vapor content at ~100° F of saturated compressed air is about two gallons per hour for each 100 CFM of compressor capacity.
14. Every ~20°F temperature drop in saturated compressed air at constant pressure, 50% of the water vapor condenses to liquid or at 100 psig every ~20°F increase in saturated air temperature doubles the amount of moisture in the air.
15. Every 2-psig change in pressure equals 1% change in horsepower.
16. Most air motors require 30 CFM at 90 psig per horsepower.
17. For every 10" water gauge pressure lost at the inlet, the compressor performance is reduced by 2%. Intake filters should be regularly cleaned well before dirt causes significant pressure restrictions.
18. A device, which will satisfactorily perform its function with 50 psig of air pressure, uses approximately 75% more compressed air when it is operated with compressed air at 100 psig.
19. As a general rule, for every 100 kPa reduction in operating pressure results in about 8% energy and cost savings.

MECS Temperature Performance on TIC Applications

1. Phoenix AZ
   a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – For Inlet Air Cooling for Nat Gas Turbines/CHP Systems, cold supply air temperatures provided to inlet of the combustion turbine can be maintained at an air temperature of 73.39 °F (includes sensible and adiabatic cooled air exiting the MU AHU). No compressors and refrigerants are used in the system. To reach of the desired CT inlet air temperature of 59 °F, approximately 14.39 °F of additional trimming air temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc .
   b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - For Inlet Air Cooling for Nat Gas Turbines/CHP Systems, cold supply air temperatures provided to inlet of the combustion turbine can be maintained at an air temperature of 66.38 °F (includes sensible and adiabatic cooled air exiting the MU AHU) in the hottest month of August. No compressors and refrigerants are used in the system. To reach of the desired CT inlet air temperature of 59 °F, approximately 7.38 °F of additional trimming air temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc .
2. San Jose CA
   a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – For Inlet Air Cooling for Nat Gas Turbines/CHP Systems, cold supply air temperatures provided to inlet of the combustion turbine can be maintained at an air temperature of 66.37 °F. No compressors and refrigerants are used in the system. To reach of the desired CT inlet air temperature of 59 °F, approximately 7.37 °F of additional trimming air temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc .
   b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - For Inlet Air Cooling for Nat Gas Turbines/CHP Systems, cold supply air temperatures provided to inlet of the combustion turbine can be maintained at an air temperature of 63.96 °F in the hottest month of August. No compressors and refrigerants are used in the system. To reach of the desired CT inlet air temperature of 59 °F, approximately 4.96 °F of additional trimming air temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc .
3. Washington DC
   a. ASHRAE published Summer Design Conditions of .4% for evaporative applications – For Inlet Air Cooling for Nat Gas Turbines/CHP Systems, cold supply air temperatures provided to inlet of the combustion turbine can be maintained at an air temperature of 79.65 °F. No compressors and refrigerants are used in the system. To reach of the desired CT inlet air temperature of 59 °F, approximately 20.65 °F of additional trimming air temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc .

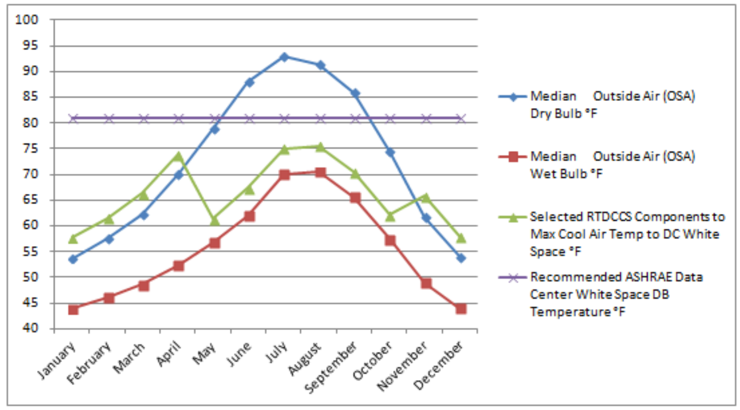
b. Based on the Monthly Mean Dry Bulb and Wet Bulb Temperatures - For Inlet Air Cooling for Nat Gas Turbines/CHP Systems, cold supply air temperatures provided to inlet of the combustion turbine can be maintained at an air temperature of 73.07 °F in the hottest month of July. No compressors and refrigerants are used in the system. To reach of the desired CT inlet air temperature of 59 °F, approximately 14.07 °F of additional trimming air temperature would be accomplished through a addition of a Supplemental Cooling Module (SCM) providing any other source of cold water, i.e. water from a small adsorption or absorption chiller; water from a lake, river, or ocean; ground water / geothermal, etc .

Phoenix, AZ

2001 Monthly Mean Dry Bulb and Wet Bulb Temperatures for Phoenix AZ (www.weatherexplained.com)

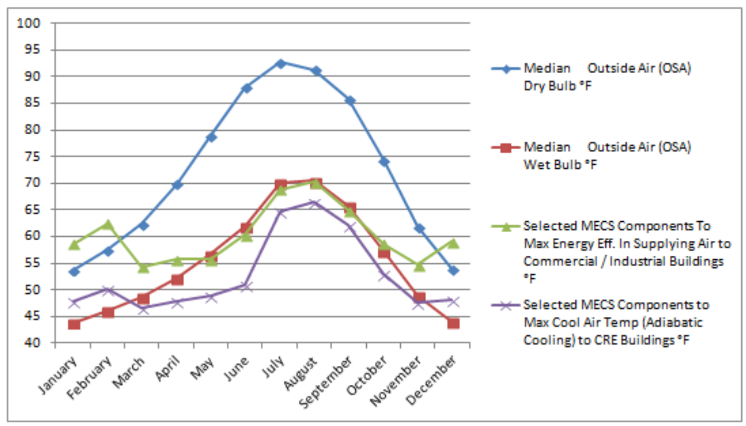
RTDDCS - Data Center White Space Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected RTDCCS Components to Max Cool Air Temp to DC White Space °F	Recommended ASHRAE Data Center White Space DB Temperature °F
January	53.70	43.90	57.70	81.00
February	57.50	46.10	61.50	81.00
March	62.30	48.60	66.30	81.00
April	69.90	52.30	73.90	81.00
May	78.90	56.70	61.42	81.00
June	88.00	62.00	67.42	81.00
July	92.80	70.00	75.00	81.00
August	91.30	70.50	75.50	81.00
September	85.90	65.70	70.53	81.00
October	74.40	57.40	62.15	81.00
November	61.80	49.00	65.80	81.00
December	54.00	44.00	58.00	81.00



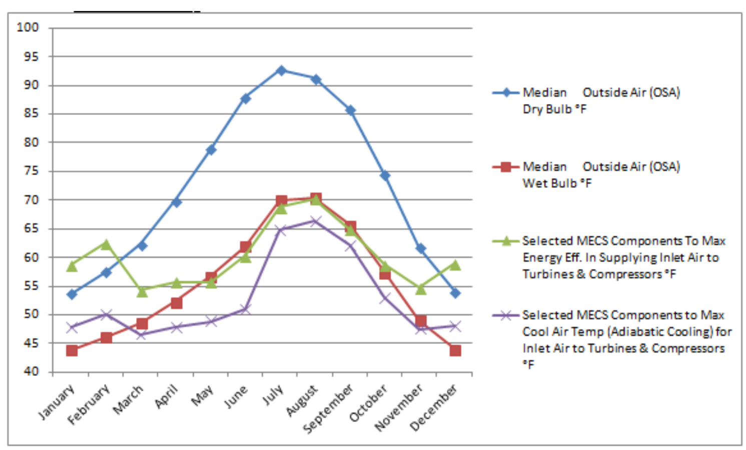
MECS - Building Space Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected MECS Components To Max Energy Eff. In Supplying Air to Commercial / Industrial Buildings °F	Selected MECS Components to Max Cool Air Temp (Adiabatic Cooling) to CRE Buildings °F
January	53.70	43.90	58.70	47.93
February	57.50	46.10	62.50	50.14
March	62.30	48.60	54.25	46.57
April	69.90	52.30	55.73	47.83
May	78.90	56.70	55.73	48.85
June	88.00	62.00	60.28	50.92
July	92.80	70.00	68.80	64.77
August	91.30	70.50	70.27	66.38
September	85.90	65.70	64.86	62.18
October	74.40	57.40	58.71	53.07
November	61.80	49.00	54.70	47.52
December	54.00	44.00	59.00	48.08



MECS - Turbine Inlet Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected MECS Components To Max Energy Eff. In Supplying Inlet Air to Turbines & Compressors °F	Selected MECS Components to Max Cool Air Temp (Adiabatic Cooling) for Inlet Air to Turbines & Compressors °F
January	53.70	43.90	58.70	47.93
February	57.50	46.10	62.50	50.14
March	62.30	48.60	54.25	46.57
April	69.90	52.30	55.73	47.83
May	78.90	56.70	55.73	48.85
June	88.00	62.00	60.28	50.92
July	92.80	70.00	68.80	64.77
August	91.30	70.50	70.27	66.38
September	85.90	65.70	64.86	62.18
October	74.40	57.40	58.71	53.07
November	61.80	49.00	54.70	47.52
December	54.00	44.00	59.00	48.08

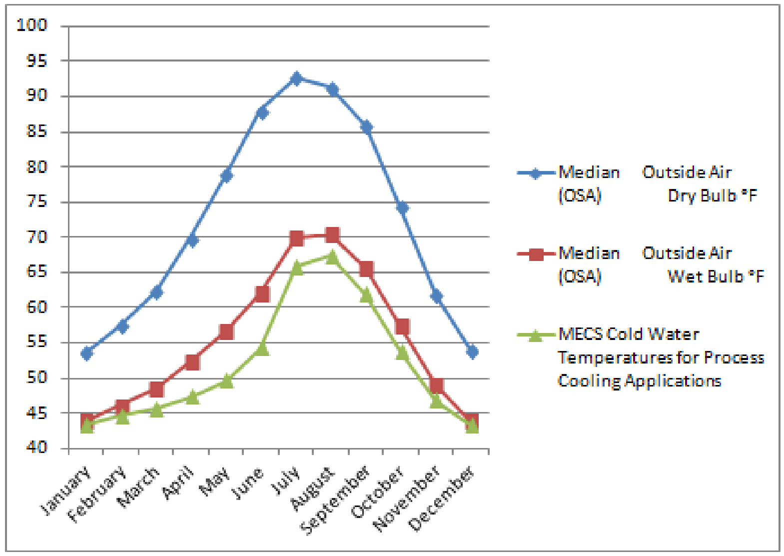


Phoenix, AZ Continued

2001 Monthly Mean Dry Bulb and Wet Bulb Temperatures for Phoenix AZ (www.weatherexplained.com)

MECS - Process Cooling Water Temps w/o Supplemental Cooling Module

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	MECS Cold Water Temperatures for Process Cooling Applications
January	53.70	43.90	43.35
February	57.50	46.10	44.55
March	62.30	48.60	45.68
April	69.90	52.30	47.26
May	78.90	56.70	49.63
June	88.00	62.00	54.12
July	92.80	70.00	65.80
August	91.30	70.50	67.27
September	85.90	65.70	61.86
October	74.40	57.40	53.75
November	61.80	49.00	46.78
December	54.00	44.00	43.30

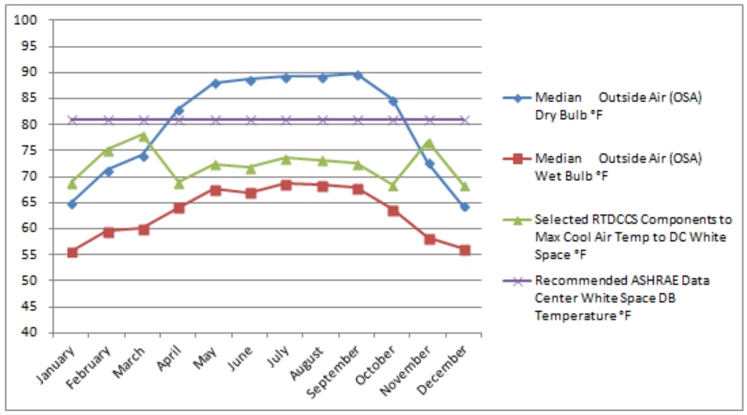


San Jose, CA

2005 ASHRAE Handbook - ASHRAE published Summer Design Conditions of .4% for evaporative applications.
http://cms.ashrae.biz/weatherdata/STATIONS/724945_s.pdf

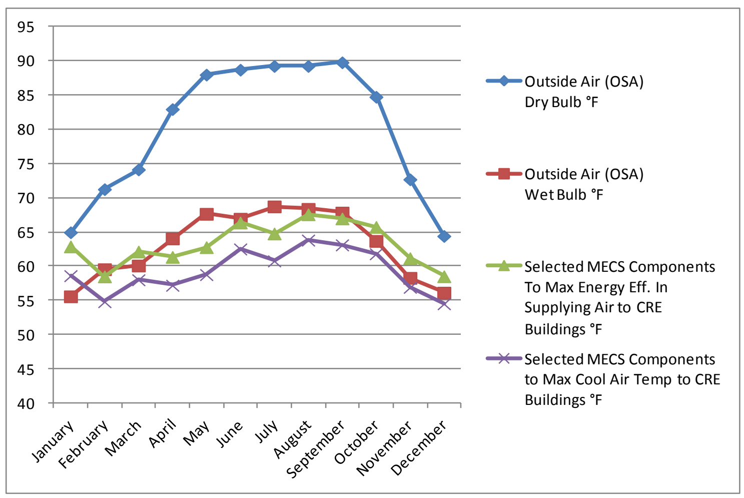
RTDDCS - Data Center White Space Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected RTDCCS Components to Max Cool Air Temp to DC White Space °F	Recommended ASHRAE Data Center White Space DB Temperature °F
January	64.94	55.58	68.94	81.00
February	71.24	59.54	75.24	81.00
March	74.12	60.08	78.12	81.00
April	82.94	64.04	68.85	81.00
May	87.98	67.64	72.48	81.00
June	88.70	66.92	71.73	81.00
July	89.24	68.72	73.56	81.00
August	89.24	68.36	73.20	81.00
September	89.78	67.82	72.64	81.00
October	84.74	63.68	68.46	81.00
November	72.68	58.28	76.68	81.00
December	64.40	56.12	68.40	81.00



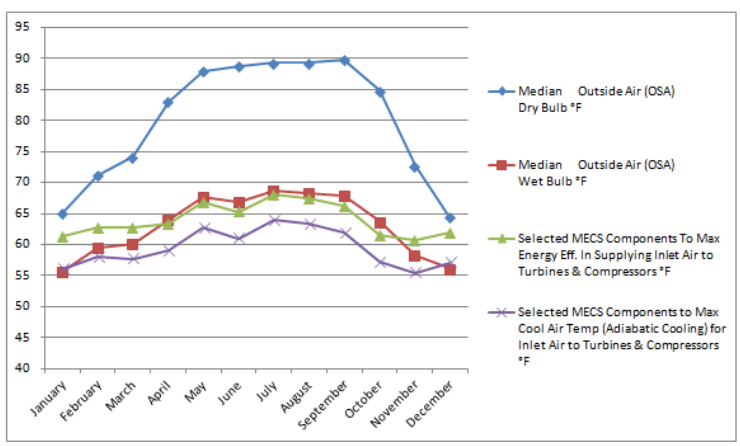
MECS - Building Space Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected MECS Components To Max Energy Eff. In Supplying Air to Commercial / Industrial Buildings °F	Selected MECS Components to Max Cool Air Temp (Adiabatic Cooling) to CRE Buildings °F
January	64.94	55.58	61.36	56.08
February	71.24	59.54	62.69	57.98
March	74.12	60.08	62.66	57.73
April	82.94	64.04	63.29	59.04
May	87.98	67.64	66.84	62.70
June	88.70	66.92	65.27	61.00
July	89.24	68.72	68.03	63.96
August	89.24	68.36	67.43	63.32
September	89.78	67.82	66.13	61.98
October	84.74	63.68	61.55	57.14
November	72.68	58.28	60.61	55.45
December	64.40	56.12	61.90	57.08



MECS - Turbine Inlet Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected MECS Components To Max Energy Eff. In Supplying Inlet Air to Turbines & Compressors °F	Selected MECS Components to Max Cool Air Temp (Adiabatic Cooling) for Inlet Air to Turbines & Compressors °F
January	64.94	55.58	61.36	56.08
February	71.24	59.54	62.69	57.98
March	74.12	60.08	62.66	57.73
April	82.94	64.04	63.29	59.04
May	87.98	67.64	66.84	62.70
June	88.70	66.92	65.27	61.00
July	89.24	68.72	68.03	63.96
August	89.24	68.36	67.43	63.32
September	89.78	67.82	66.13	61.98
October	84.74	63.68	61.55	57.14
November	72.68	58.28	60.61	55.45
December	64.40	56.12	61.90	57.08

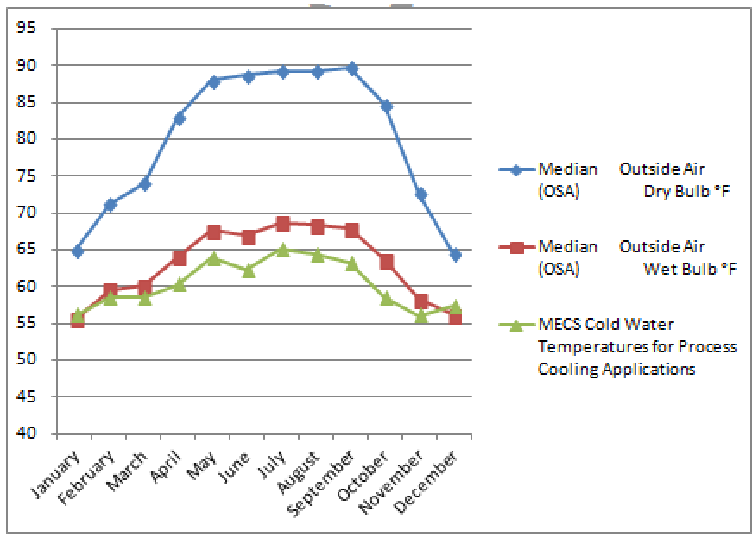


San Jose, CA Continued

2005 ASHRAE Handbook - ASHRAE published Summer Design Conditions of .4% for evaporative applications.
http://cms.ashrae.biz/weatherdata/STATIONS/724945_s.pdf

MECS - Process Cooling Water Temps w/o Supplemental Cooling Module

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	MECS Cold Water Temperatures for Process Cooling Applications
January	64.94	55.58	56.08
February	71.24	59.54	58.57
March	74.12	60.08	58.53
April	82.94	64.04	60.29
May	87.98	67.64	63.84
June	88.70	66.92	62.27
July	89.24	68.72	65.03
August	89.24	68.36	64.43
September	89.78	67.82	63.13
October	84.74	63.68	58.55
November	72.68	58.28	56.09
December	64.40	56.12	57.28

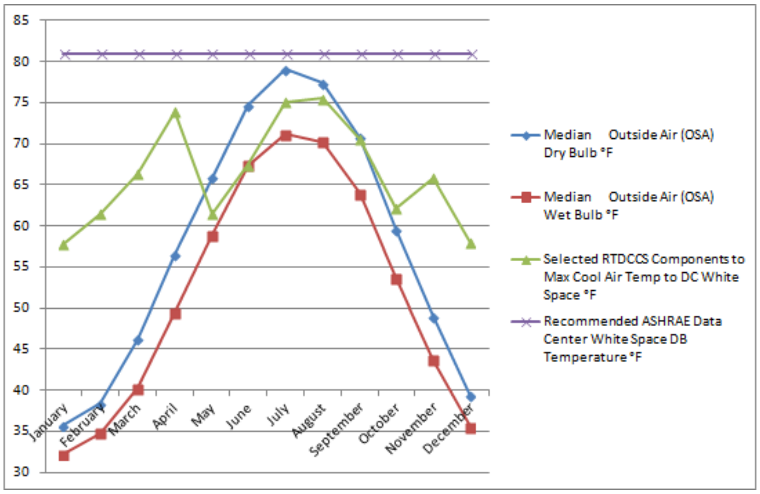


Washington DC

2001 Monthly Mean Dry Bulb and Wet Bulb Temperatures for Washington DC. http://www.weatherexplained.com/Vol-2/2001-Washington-D-C-Ronald-Reagan-National-Airport-DCA.html#ixzz56SMoaq1X

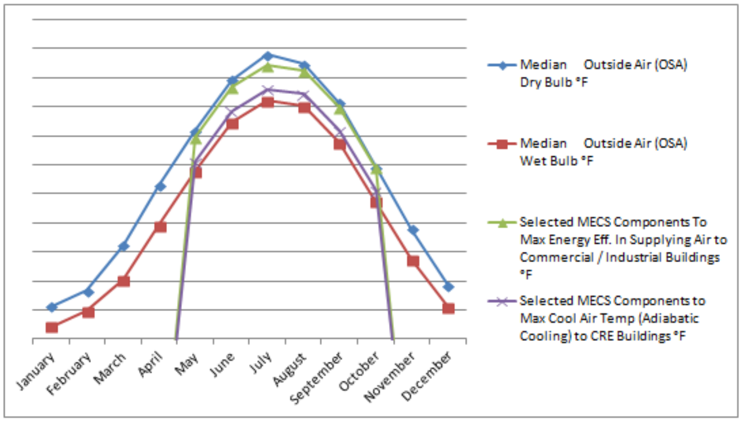
RTDDCS - Data Center White Space Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected RTDCCS Components to Max Cool Air Temp to DC White Space °F	Recommended ASHRAE Data Center White Space DB Temperature °F
January	35.70	32.20	57.70	81.00
February	38.40	34.80	61.50	81.00
March	46.20	40.20	66.30	81.00
April	56.50	49.50	73.90	81.00
May	65.90	58.90	61.42	81.00
June	74.70	67.40	67.42	81.00
July	79.10	71.20	75.00	81.00
August	77.40	70.20	75.50	81.00
September	70.70	63.90	70.53	81.00
October	59.60	53.70	62.15	81.00
November	49.00	43.70	65.80	81.00
December	39.30	35.50	58.00	81.00



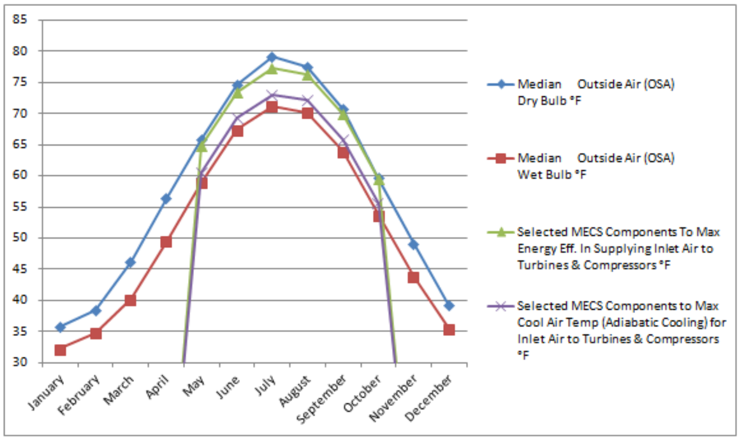
MECS - Building Space Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected MECS Components To Max Energy Eff. In Supplying Air to Commercial / Industrial Buildings °F	Selected MECS Components to Max Cool Air Temp (Adiabatic Cooling) to CRE Buildings °F
January	35.70	32.20	-	-
February	38.40	34.80	-	-
March	46.20	40.20	-	-
April	56.50	49.50	-	-
May	65.90	58.90	64.75	60.57
June	74.70	67.40	73.40	69.32
July	79.10	71.20	77.20	73.07
August	77.40	70.20	76.20	72.26
September	70.70	63.90	69.90	65.87
October	59.60	53.70	59.48	55.58
November	49.00	43.70	-	-
December	39.30	35.50	-	-



MECS - Turbine Inlet Cooling

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	Selected MECS Components To Max Energy Eff. In Supplying Inlet Air to Turbines & Compressors °F	Selected MECS Components to Max Cool Air Temp (Adiabatic Cooling) for Inlet Air to Turbines & Compressors °F
January	35.70	32.20	0.00	0.00
February	38.40	34.80	0.00	0.00
March	46.20	40.20	0.00	0.00
April	56.50	49.50	0.00	0.00
May	65.90	58.90	64.75	60.57
June	74.70	67.40	73.40	69.32
July	79.10	71.20	77.20	73.07
August	77.40	70.20	76.20	72.26
September	70.70	63.90	69.90	65.87
October	59.60	53.70	59.48	55.58
November	49.00	43.70	0.00	0.00
December	39.30	35.50	0.00	0.00

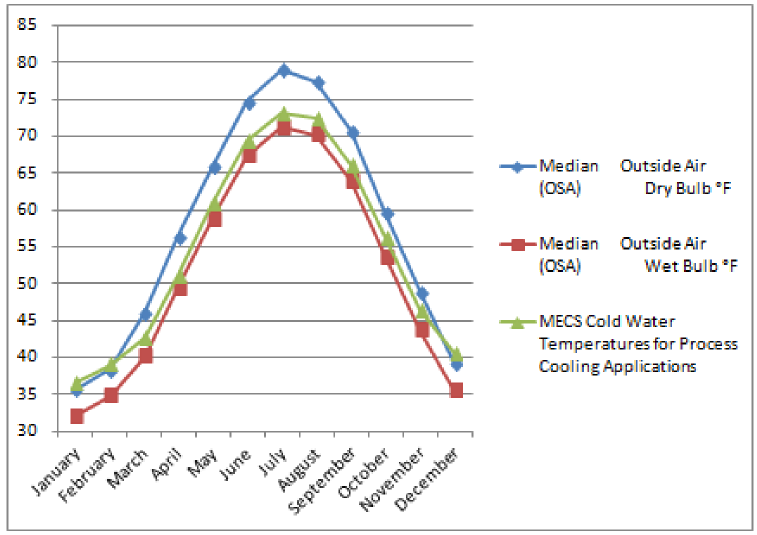


Washington DC Continued

2001 Monthly Mean Dry Bulb and Wet Bulb Temperatures for Washington DC. http://www.weatherexplained.com/Vol-2/2001-Washington-D-C-Ronald-Reagan-National-Airport-DCA.html#ixzz56SMoaq1X

MECS - Process Cooling Water Temps w/o Supplemental Cooling Module

	Median Outside Air (OSA) Dry Bulb °F	Median Outside Air (OSA) Wet Bulb °F	MECS Cold Water Temperatures for Process Cooling Applications
January	35.70	32.20	36.59
February	38.40	34.80	39.04
March	46.20	40.20	42.67
April	56.50	49.50	51.19
May	65.90	58.90	60.88
June	74.70	67.40	69.44
July	79.10	71.20	73.10
August	77.40	70.20	72.35
September	70.70	63.90	66.08
October	59.60	53.70	56.17
November	49.00	43.70	46.48
December	39.30	35.50	40.64



Spreadsheet Notes and Guide to Completing Calculations

Notes describing MECS components and functionality and a complete guide to developing the temperature performance tables and spreadsheet calculations are provided at the end of this document. This document is only showing guide for Phoenix AZ but the actual spreadsheets for each location have guides for that specific location. If requested, the actual spreadsheets will be provided containing all the data. Please contact me at Darrell@r4ventures.biz and request to data.

R4 Ventures LLC is working with a software company to fully automate the spreadsheets shown herein and will launch 2 website platforms to assist potential customers, mechanical engineering firms, and mechanical contractor in determining if MECS and RTDCCS is a viable option for the specific application requested. These platforms will be Green Cooling Platform as a Service (www.gcpaas.com) and Green Data Center Platform as a service (www.gdcpaas.com).

Phoenix AZ

Real Time Data Center Cooling System (RTDCCS) consisting of the Multistage Evaporative Cooling System (MECS) and Individual Server Enclosure Cooling Systems for each Rack (ISECS)

Cold Water & DC White Space Temp Performance in Phoenix AZ

ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for <u>Evaporative Applications (35 hours per year)</u>

Phoenix International Airport (PHX)

Energy Recovery Unit and / or Cooling Towers of the MECS Serving the RTDCCS

- ERU, Cooling Towers (CT-1,CT-2, CT-3) and MU AHU commissioned to provide Cold Supply Air (green)
- ERUs and Cooling Towers that are not necessary to meet Mean Monthly Ambient Air Temps to generate cold makeup air (red)
- Selected Cold Water or Air Temps from ERU or Cooling Towers serving the application or the Supplemental Cooling Module (SCM) (yellow)

Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,899,061)

Real Time Individual Electronic Enclosure Cooling System (also know as Real Time Data Center Cooling System or RTDCCS) (US Patent # 8,857,204)

						Multistage Evaporative Cooling System (MECS) - Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,899,061)					Real Time Individual Electronic Enclosure Cooling System (also know as Real Time Data Center Cooling System or RTDCCS) (US Patent # 8,857,204)				
						Energy Recovery Unit (ERU) Cold Water Temp Leaving ERU, °F Without Outside Air (OSA) Humidification and With OSA Humidification		Multistage Evaporative Cooling System Cold Water Temp Leaving Cooling Towers (CT), °F			Real Time Data Center Cooling System				
						Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
	DB °F	WB °F	Calculated Enthalpy (btu/lb)	Calculated Humidity Ratio (grains/lb)	Calculated Specific Volume (cu ft/lb) (ft3//lb) (used to determine mass flow rate in Turbine Inlet Cooling applications)	ERU without OSA Humidification	ERU with OSA Humidification to 95% RH (ERU w/H) Adiabatic Cooling(AC))	CT-1	CT-2	CT-3	Water Temp from ERU, ERU w/AC or CT-1, CT-2 or CT-3 (Source shown in RED) entering the Plate and Frame Heat Exchangers HX-1 and HX-2 (only HX-1 is needed in Phoenix AZ)	Estimated Cold Water Temp Leaving Plate & Frame HX Served by Selected Stage of MECS	Estimated Cold Air Temp Leaving Fan Coil Unit with only the PCC (FCC not necessary) serving each rack (ISECS) providing cooled air to the Data Center White Space	Lowest Achievable Data Center White Space Temperature (Temp can be set to ±78 °F in cooler months to save significant energy costs through proper configuration of the Monitoring and Control hardware and software)	Optimal Data Center White Space Temperature 80.6 °F DB saving significant energy costs through proper configuration of the Monitoring and Control hardware and software
ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)	96.40	76.10	40.46	109.72	15.01	98.40	79.07	79.10	74.80	73.59	74.80 / CT-2	75.80	76.80	**76.80**	**80.6**
ASHRAE or Local Airport Mean Monthly DB and WB Temperatures															
January	53.70	43.90	17.36	28.86	13.60	55.70	46.53	46.90	44.54	43.35	55.70/ ERU	56.70	57.70	**57.70**	**80.6**
February	57.50	46.10	18.49	30.22	13.71	59.50	48.75	49.10	46.05	44.55	59.50 / ERU	60.50	61.50	**61.50**	**80.6**
March	62.30	48.60	19.83	31.36	13.83	64.30	51.25	51.60	47.61	45.68	64.30 / ERU	65.30	66.30	**66.30**	**80.6**
April	69.90	52.30	21.94	33.03	14.04	71.90	54.98	55.30	49.82	47.26	71.90 / ERU	72.90	73.90	**73.90**	**80.6**
May	78.90	56.70	24.65	36.41	14.29	80.90	59.42	59.70	52.73	49.63	59.42 / ERU w/AC	60.42	61.42	**61.42**	**80.6**
June	88.00	62.00	28.27	45.41	14.57	90.00	65.42	65.00	57.28	54.12	65.42 / ERU w/AC	66.42	67.42	**67.42**	**80.6**
July	92.80	70.00	34.69	78.73	14.81	94.80	72.85	73.00	67.58	65.80	73.00 / CT-1	74.00	75.00	**75.00**	**80.6**
August	91.30	70.50	35.15	83.98	14.79	93.30	73.39	73.50	68.78	67.27	73.50 / CT-1	74.50	75.50	**75.50**	**80.6**
September	85.90	65.70	31.12	66.83	14.58	87.90	68.53	68.70	63.65	61.86	68.53 / ERU w/AC	69.53	70.53	**70.53**	**80.6**
October	74.40	57.40	25.13	46.51	14.21	76.40	60.15	60.40	55.71	53.75	60.15 / ERU w/AC	61.15	62.15	**62.15**	**80.6**
November	61.80	49.00	20.06	33.58	13.83	63.80	51.70	52.00	48.46	46.78	63.80/ ERU	64.80	65.80	**65.80**	**80.6**
December	54.00	44.00	17.41	28.71	13.61	56.00	46.64	47.00	44.54	43.30	56.00 / ERU	57.00	58.00	**58.00**	**80.6**

****** 1. Year round operation of RTDCCS incorporating MECS and ISECS together (Process Cooling) can provide the required cooling for the IT equipment (server racks). 2. Building HVAC system is serving the entire building and providing required heating, cooling, humidification, dehumidification and pressure control. The column on the right in green does not take into consideration any positive or negative affects of the Building HVAC system. ASHRAE TC 9.9 increased indoor data center White Space temperatures to 18-27°C (64-81°F).***

<u>Phoenix International Airport (PHX)</u>

http://www.weatherexplained.com/Vol-2/2001-Phoenix-Arizona-PHX.html#ixzz2XMUi3ldJ

Phoenix AZ

Process Cooling, Building Cooling and Natural Gas Turbine Inlet Air Cooling (Turbine Inlet Cooling or TIC) "cold supply air" provided by the Multistage Evaporative Cooling System (MECS) serving Commercial and Industrial facilities and plants

Temp Performance for Cold Supply Air for Commercial & Industrial Applications in Phoenix AZ
ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)

Phoenix International Airport (PHX)

MECS Including ERU, Cooling Towers and Makeup Air Handling Unit (MU AHU) Supplying Cold Fresh Air

- ERU, Cooling Towers (CT-1,CT-2, CT-3) and MU AHU commissioned to provide Cold Supply Air (green)
- ERUs and Cooling Towers that are not necessary to meet Mean Monthly Ambient Air Temps to generate cold makeup air (red)
- Selected Cold Water or Air Temps from ERU or Cooling Towers serving the application or the Supplemental Cooling Module (SCM) (yellow)

Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,857,204)

20170010029 Adding Supplemental Cooling Module (SCM)

						Energy Recovery Unit (ERU) Stage Cold Water Temp Leaving ERU, °F Without Outside Air (OSA) Humidification and With OSA Humidification		Cooling Tower Stage Cold Water Temp Leaving Cooling Towers (CT), °F			Make Up Air Handling Unit (MU AHU) Stage Leaving MU AHU, °F					Cold Air Temp	Conditioned Air Temperatures by Month and ΔT delivered by MECS		Supplemental Cooling Module (SCM) (uses cold water from any other cold water source to provide trimming of final cold water temps required in cooling applications) provides cooled air as described in the R4 Ventures LLC US Continuation in Part Patent (link above)	
						Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Addt'l Data	Addt'l Data	Addt'l Data	Column 7	Column 8	Column 9	Column 10	Column 11	Column 12
	OSA DB °F	WB °F	Calculated Enthalpy (btu/lb)	Calculated Humidity Ratio (grains/lb)	Calculated Specific Volume (cu ft/lb) (ft3//lb) (used to determine mass flow rate in Turbine Inlet Cooling applications)	ERU-1A without OSA Humidification (Cold Water Produced)	ERU-1B with OSA Humidification to 95% RH (Adiabatic Cooling (AC)) (Cold Water Produced)	CT-1 (Cold Water Produced)	CT-2 (Cold Water Produced)	CT-3 (Cold Water Produced)	Temperature of cold water from the selected stage of MECS either ERU, CT-1, CT-2 or CT-3 entering sensible pre-cooling coil of the MU AHU, ˚F / source (Source shown in Red)	DB temperature of OSA leaving sensible pre-cooling coil of the MU AHU, ˚F	Enthalpy of OSA leaving sensible pre-cooling coil of the MU AHU, btu/lb	DB temperature of OSA leaving Adiabatic Cooling stage (AC) of the MU AHU at 95% RH, ˚F	DB temperature of sensible (only) cooled OSA (including 2.0˚F fan heat) the MU AHU discharges, ˚F	DB temperature of sensibly & adiabatically cooled OSA (included 2.0˚F fan heat) the MU AHU discharges, ˚F	Lowest Achievable Cold Supply Air Temperature	Maximum Air DB temperature reduction (ΔT) provided by MECS vs ambient air DB conditions for the specified month without applying Supplemental Cooling Module (SCM) shown in Columns 11 and 12	Desired Air DB Temperature of Inlet Air Entering the Natural Gas Combustion Turbines (Turbine Inlet Cooling or TIC) (Target Air DB Temp Is 59 °F or lower)	Delta (Δ) showing the amount of trimming of final cold water temperatures to provide the TIC air DB temperature to meet the desired 59 °F. This trimming is provided via Supplemental Cooling Module (SCM)
Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours	96.40	76.10	40.46	109.72	15.01	98.40	79.07	79.10	75.07	73.95	73.95/ CT-3	74.95	35.15	71.39	76.95	73.39	73.39	23.01	59.00	14.39
ASHRAE or Local Airport Mean Monthly DB and WB Temperatures																				
January	53.70	43.90	17.36	28.86	13.60	55.70	46.53	46.90	44.54	43.35	55.70 / ERU	56.70	18.08	45.93	58.70	47.93	47.93	5.77	59.00	NA
February	57.50	46.10	18.49	30.22	13.71	59.50	48.75	49.10	46.05	44.55	59.50 / ERU	60.50	19.22	48.14	62.50	50.14	50.14	7.36	59.00	NA
March	62.30	48.60	19.83	31.36	13.83	64.30	51.25	51.60	47.61	45.68	51.25 / ERU w/AC	52.25	17.37	44.57	54.25	46.57	46.57	15.73	59.00	NA
April	69.90	52.30	21.94	33.03	14.04	71.90	54.98	55.30	49.82	47.26	54.98 / ERU w/AC	53.73	18.01	45.83	55.73	47.83	47.83	22.07	59.00	NA
May	78.90	56.70	24.65	36.41	14.29	80.90	59.42	59.70	52.73	49.63	52.73 / CT-2	53.73	18.54	46.85	55.73	48.85	48.85	30.05	59.00	NA
June	88.00	62.00	28.27	45.41	14.57	90.00	65.42	65.00	57.28	54.12	57.28 / CT-2	58.28	19.64	48.92	60.28	50.92	50.92	37.08	59.00	NA
July	92.80	70.00	34.69	78.73	14.81	94.80	72.85	73.00	67.58	65.80	65.80 / CT-3	66.80	28.30	62.77	68.80	64.77	64.77	28.03	59.00	5.77
August	91.30	70.50	35.15	83.98	14.79	93.30	73.39	73.50	68.78	67.27	67.27 / CT-3	68.27	29.48	64.38	70.27	66.38	66.38	24.92	59.00	7.38
September	85.90	65.70	31.12	66.83	14.58	87.90	68.53	68.70	63.65	61.86	61.86 / CT-3	62.86	25.48	60.18	64.86	62.18	62.18	23.72	59.00	3.18
October	74.40	57.40	25.13	46.51	14.21	76.40	60.15	60.40	55.71	53.75	55.71 / CT-2	56.71	20.83	51.07	58.71	53.07	53.07	21.33	59.00	NA
November	61.80	49.00	20.06	33.58	13.83	63.80	51.70	52.00	48.46	46.78	51.70/ ERU w/AC	52.70	17.85	45.52	54.70	47.52	47.52	14.28	59.00	NA
December	54.00	44.00	17.41	28.71	13.61	56.00	46.64	47.00	44.54	43.30	56.00 / ERU	57.00	18.14	46.08	59.00	48.08	48.08	5.92	59.00	NA

***** NOTE *** If the negative pressure at the turbine compressor inlet allows for the elimination of the fan in the MU AHU, the temperature can be reduced by an additional 2 °F.**

Phoenix International Airport (PHX) http://www.weatherexplained.com/Vol-2/2001-Phoenix-Arizona-PHX.html#ixzz2XMUi3ldJ Source: Weather Explained, Weather Almanac, Vol 2, 2001, Phoenix, AZ (PHX)

San Jose CA

Real Time Data Center Cooling System (RTDCCS) consisting of the Multistage Evaporative Cooling System (MECS) and Individual Server Enclosure Cooling Systems for each Rack (ISECS)

Cold Water & DC White Space Temp Performance in San Jose CA

ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)

San Jose International Airport (SJC)

Energy Recovery Unit and / or Cooling Towers of the MECS Serving the RTDCCS

ERU, Cooling Towers (CT-1,CT-2, CT-3) and MU AHU commissioned to provide Cold Supply Air

ERUs and Cooling Towers that are not necessary to meet Mean Monthly Ambient Air Temps to generate cold makeup air

Selected Cold Water or Air Temps from ERU or Cooling Towers serving the application or the Supplemental Cooling Module (SCM)

Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,899,061)

Real Time Individual Electronic Enclosure Cooling System (also know as Real Time Data Center Cooling System or RTDCCS) (US Patent # 8,857,204)

						Multistage Evaporative Cooling System (MECS) - Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,899,061)					Real Time Individual Electronic Enclosure Cooling System (also know as Real Time Data Center Cooling System or RTDCCS) (US Patent # 8,857,204)				
						Energy Recovery Unit (ERU) Cold Water Temp Leaving ERU, °F Without Outside Air (OSA) Humidification and With OSA Humidification		Multistage Evaporative Cooling System Cold Water Temp Leaving Cooling Towers (CT), °F			Real Time Data Center Cooling System				
						Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
	DB °F	WB °F	Calculated Enthalpy (btu/lb)	Calculated Humidity Ratio (grains/lb)	Calculated Specific Volume (cu ft/lb) (ft3//lb) (used to determine mass flow rate in Turbine Inlet Cooling applications)	ERU without OSA Humidification	ERU with OSA Humidification to 95% RH (ERU w/H) Adiabatic Cooling(AC))	CT-1	CT-2	CT-3	Water Temp from ERU, ERU w/AC or CT-1, CT-2 or CT-3 (Source shown in RED) entering the Plate and Frame Heat Exchangers HX-1 and HX-2 (only HX-1 is needed in San Jose CA)	Estimated Cold Water Temp Leaving Plate & Frame HX Served by Selected Stage of MECS	Estimated Cold Air Temp Leaving Fan Coil Unit with only the PCC (FCC not necessary) serving each rack (ISECS) providing cooled air to the Data Center White Space	Lowest Achievable Data Center White Space Temperature (Temp can be set to ±78 °F in cooler months to save significant energy costs through proper configuration of the Monitoring and Control hardware and software)	Optimal Data Center White Space Temperature 80.6 °F DB saving significant energy costs through proper configuration of the Monitoring and Control hardware and software
ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)	87.20	69.50	33.56	80.27	14.07	89.20	72.39	72.50	68.64	67.22	72.39 / ERU w/AC	73.39	74.39	**74.39**	**80.6**
ASHRAE or Local Airport Mean Monthly DB and WB Temperatures															
January	64.94	55.58	23.55	51.13	13.40	66.94	58.36	58.58	56.82	56.08	66.94 / ERU	67.94	68.94	**68.94**	**80.6**
February	71.24	59.54	25.90	56.32	13.58	73.24	62.05	62.54	59.69	58.57	73.24 / ERU	74.24	75.24	**75.24**	**80.6**
March	74.12	60.08	26.45	55.38	13.65	76.12	62.88	63.08	59.66	58.53	76.12 / ERU	77.12	78.12	**78.12**	**80.6**
April	82.94	64.04	29.24	59.41	13.89	84.94	66.85	67.04	62.14	60.29	66.85 / ERU w/AC	67.85	68.85	**68.85**	**80.6**
May	87.98	67.64	32.01	69.20	14.05	89.98	70.48	70.64	65.61	63.84	70.48 / ERU w/AC	71.48	72.48	**72.48**	**80.6**
June	88.70	66.92	31.42	64.35	14.05	90.70	69.73	69.92	64.30	62.27	69.73 / ERU w/AC	70.73	71.73	**71.73**	**80.6**
July	89.24	68.72	32.88	72.82	14.08	91.24	71.56	71.72	66.74	65.03	71.56 / ERU w/AC	72.56	73.56	**73.56**	**80.6**
August	89.24	68.36	32.59	70.92	14.08	91.24	71.20	71.36	66.22	64.43	71.20 / ERU w/AC	72.20	73.20	**73.20**	**80.6**
September	89.78	67.82	32.14	67.24	14.09	91.78	70.64	70.82	64.89	63.13	70.64 / ERU w/AC	71.64	72.64	**72.64**	**80.6**
October	84.74	63.68	28.96	54.82	13.92	86.74	66.46	66.68	60.93	58.55	66.46 / ERU w/AC	67.46	68.46	**68.46**	**80.6**
November	72.68	58.28	25.25	49.91	13.60	74.68	61.05	61.28	57.61	56.09	74.68 / ERU	75.68	76.68	**76.68**	**80.6**
December	64.40	56.12	23.89	54.17	13.40	66.40	58.90	59.12	57.81	57.28	66.40 / ERU	67.40	68.40	**68.40**	**80.6**

****** 1. Year round operation of RTDCCS incorporating MECS and ISECS together (Process Cooling) can provide the required cooling for the IT equipment (server racks). 2. Building HVAC system is serving the entire building and providing required heating, cooling, humidification, dehumidification and pressure control. The column on the right in green does not take into consideration any positive or negative affects of the Building HVAC system. ASHRAE TC 9.9 increased indoor data center White Space temperatures to 18-27°C (64-81°F).***

San Jose International Airport (SJC) http://cms.ashrae.biz/weatherdata/STATIONS/724945_s.pdf Source: 2005 ASHRAE Handbook - Fundamentals (SI)

San Jose CA

Process Cooling, Building Cooling and Natural Gas Turbine Inlet Air Cooling (Turbine Inlet Cooling or TIC) "cold supply air" provided by the Multistage Evaporative Cooling System (MECS) serving Commercial and Industrial facilities and plants

Temp Performance for Cold Supply Air for Commercial & Industrial Applications in San Jose CA

ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)

San Jose International Airport (SJC)

MECS Including ERU, Cooling Towers and Makeup Air Handling Unit (MU AHU) Supplying Cold Fresh Air

- Green: ERU, Cooling Towers (CT-1,CT-2, CT-3) and MU AHU commissioned to provide Cold Supply Air
- Red: ERUs and Cooling Towers that are not necessary to meet Mean Monthly Ambient Air Temps to generate cold makeup air
- Yellow: Selected Cold Water or Air Temps from ERU or Cooling Towers serving the application or the Supplemental Cooling Module (SCM)

Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,857,204)

Continuation in Part US Patent # 20170010029 Adding Supplemental Cooling Module (SCM)

						Energy Recovery Unit (ERU) Stage Cold Water Temp Leaving ERU, °F Without Outside Air (OSA) Humidification and With OSA Humidification		**Cooling Tower Stage** Cold Water Temp Leaving Cooling Towers (CT), °F			**Make Up Air Handling Unit (MU AHU) Stage** Leaving MU AHU, °F					Cold Air Temp	***Conditioned Air Temperatures by Month and ΔT delivered by MECS***		Supplemental Cooling Module (SCM) (uses cold water from any other cold water source to provide trimming of final cold water temps required in cooling applications) provides cooled air as described in the R4 Ventures LLC US Continuation in Part Patent (link above)	
						Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Addt'l Data**	**Addt'l Data**	**Addt'l Data**	**Column 7**	**Column 8**	**Column 9**	**Column 10**	**Column 11**	**Column 12**
	OSA DB °F	WB °F	Calculated Enthalpy (btu/lb)	Calculated Humidity Ratio (grains/lb)	Calculated Specific Volume (cu ft/lb) (ft3//lb) (used to determine mass flow rate in Turbine Inlet Cooling applications)	ERU-1A without OSA Humidification (Cold Water Produced)	ERU-1B with OSA Humidification to 95% RH (Adiabatic Cooling (AC)) (Cold Water Produced)	CT-1 (Cold Water Produced)	CT-2 (Cold Water Produced)	CT-3 (Cold Water Produced)	Temperature of cold water from the selected stage of MECS either ERU, CT-1, CT-2 or CT-3 entering sensible pre-cooling coil of the MU AHU, ˚F / source (Source shown in Red)	DB temperature of OSA leaving sensible pre-cooling coil of the MU AHU, ˚F	Enthalpy of OSA leaving sensible pre-cooling coil of the MU AHU, btu/lb	DB temperature of OSA leaving Adiabatic Cooling stage (AC) of the MU AHU at 95% RH, ˚F	DB temperature of sensible (only) cooled OSA (includes 2.0˚F fan heat) the MU AHU discharges, ˚F	DB temperature of sensibly & adiabatically cooled OSA (including 2.0˚F fan heat) the MU AHU discharges, ˚F	Lowest Achievable Cold Supply Air Temperature	Maximum Air DB temperature reduction (ΔT) provided by MECS vs ambient air DB conditions for the specified month without applying Supplemental Cooling Module (SCM) shown in Columns 11 and 12	Desired Air DB Temperature of Inlet Air Entering the Natural Gas Combustion Turbines (Turbine Inlet Cooling or TIC) (Target Air DB Temp Is 59 °F or lower)	Delta (Δ) showing the amount of trimming of final cold water temperatures to provide the TIC air DB temperature to meet the desired 59 °F. This trimming is provided via Supplemental Cooling Module (SCM)
Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours	87.20	69.50	33.56	80.27	14.07	89.20	72.39	72.50	68.64	67.22	67.22/ CT-3	68.22	28.89	64.37	70.22	66.37	66.37	20.83	59.00	7.37
ASHRAE or Local Airport Mean Monthly DB and WB Temperatures																				
January	64.94	55.58	23.55	51.13	13.40	66.94	58.36	58.58	56.82	56.08	58.36 / ERU w/AC	59.36	22.19	54.08	61.36	56.08	56.08	8.86	59.00	NA
February	71.24	59.54	25.90	56.32	13.58	73.24	62.05	62.54	59.69	58.57	59.69 / CT-2	60.69	23.32	55.98	62.69	57.98	57.98	13.26	59.00	NA
March	74.12	60.08	26.45	55.38	13.65	76.12	62.88	63.08	59.66	58.53	59.66 / CT-2	60.66	23.17	55.73	62.66	57.73	57.73	16.39	59.00	NA
April	82.94	64.04	29.24	59.41	13.89	84.94	66.85	67.04	62.14	60.29	60.29 / CT-3	61.29	23.95	57.04	63.29	59.04	59.04	23.90	59.00	NA
May	87.98	67.64	32.01	69.20	14.05	89.98	70.48	70.64	65.61	63.84	63.84 / CT-3	64.84	26.33	60.70	66.84	62.70	62.70	25.28	59.00	NA
June	88.70	66.92	31.42	64.35	14.05	90.70	69.73	69.92	64.30	62.27	62.27 / CT-3	63.27	25.20	59.00	65.27	61.00	61.00	27.70	59.00	NA
July	89.24	68.72	32.88	72.82	14.08	91.24	71.56	71.72	66.74	65.03	65.03 / CT-3	66.03	27.19	61.96	68.03	63.96	63.96	25.28	59.00	4.96
August	89.24	68.36	32.59	70.92	14.08	91.24	71.20	71.36	66.22	64.43	64.43 / CT-3	65.43	26.75	61.32	67.43	63.32	63.32	25.92	59.00	4.32
September	89.78	67.82	32.14	67.24	14.09	91.78	70.64	70.82	64.89	63.13	63.13 / CT-3	64.13	25.85	59.98	66.13	61.98	61.98	27.80	59.00	2.98
October	84.74	63.68	28.96	54.82	13.92	86.74	66.46	66.68	60.93	58.55	58.55 / CT-3	59.55	22.81	55.14	61.55	57.14	57.14	27.60	59.00	NA
November	72.68	58.28	25.25	49.91	13.60	74.68	61.05	61.28	57.61	56.09	57.61/ CT-2	58.61	21.82	53.45	60.61	55.45	55.45	17.23	59.00	NA
December	64.40	56.12	23.89	54.17	13.40	66.40	58.90	59.12	57.81	57.28	58.90 / ERU w/AC	59.90	22.78	55.08	61.90	57.08	57.08	7.32	59.00	NA

***** NOTE *** If the negative pressure at the turbine compressor inlet allows for the elimination of the fan in the MU AHU, the temperature can be reduced by an additional 2 °F.**

San Jose International Airport (SJC) http://cms.ashrae.biz/weatherdata/STATIONS/724945_s.pdf

Source: 2005 ASHRAE Handbook - Fundamentals (SI)

Washington DC

Real Time Data Center Cooling System (RTDCCS) consisting of the Multistage Evaporative Cooling System (MECS) and Individual Server Enclosure Cooling Systems for each Rack (ISECS)

Cold Water & DC White Space Temp Performance in Washington DC

ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)

Ronald Regan National Airport (DCA)

Energy Recovery Unit and / or Cooling Towers of the MECS Serving the RTDCCS

ERU, Cooling Towers (CT-1,CT-2, CT-3) and MU AHU commissioned to provide Cold Supply Air

ERUs and Cooling Towers that are not necessary to meet Mean Monthly Ambient Air Temps to generate cold makeup air

Selected Cold Water or Air Temps from ERU or Cooling Towers serving the application or the Supplemental Cooling Module (SCM)

Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,899,061)

Real Time Individual Electronic Enclosure Cooling System (also know as Real Time Data Center Cooling System or RTDCCS) (US Patent # 8,857,204)

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						Multistage Evaporative Cooling System (MECS) - Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,899,061)					Real Time Individual Electronic Enclosure Cooling System (also know as Real Time Data Center Cooling System or RTDCCS) (US Patent # 8,857,204)				
						Energy Recovery Unit (ERU) Cold Water Temp Leaving ERU, °F Without Outside Air (OSA) Humidification and With OSA Humidification		Multistage Evaporative Cooling System Cold Water Temp Leaving Cooling Towers (CT), °F			Real Time Data Center Cooling System				
						Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7	Column 8	Column 9	Column 10
	DB °F	WB °F	Calculated Enthalpy (btu/lb)	Calculated Humidity Ratio (grains/lb)	Calculated Specific Volume (cu ft/lb) (ft3//lb) (used to determine mass flow rate in Turbine Inlet Cooling applications)	ERU without OSA Humidification	ERU with OSA Humidification to 95% RH (ERU w/H) Adiabatic Cooling(AC))	CT-1	CT-2	CT-3	Water Temp from ERU, ERU w/AC or CT-1, CT-2 or CT-3 (Source shown in RED) entering the Plate and Frame Heat Exchangers HX-1 and HX-2 (only HX-1 is needed in Wasgtonton DC)	Estimated Cold Water Temp Leaving Plate & Frame HX Served by Selected Stage of MECS	Estimated Cold Air Temp Leaving Fan Coil Unit with only the PCC (FCC not necessary) serving each rack (ISECS) providing cooled air to the Data Center White Space	Lowest Achievable Data Center White Space Temperature (Temp can be set to ±78 °F in cooler months to save significant energy costs through proper configuration of the Monitoring and Control hardware and software)	Optimal Data Center White Space Temperature 80.6 °F DB saving significant energy costs through proper configuration of the Monitoring and Control hardware and software
ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)	89.10	78.60	42.16	132.06	14.30	91.10	85.39	81.60	80.22	79.87	79.87 / CT-3	80.87	81.87	81.87	80.6
ASHRAE or Local Airport Mean Monthly DB and WB Temperatures															
January	35.70	32.20	11.84	22.87	12.58	37.70	34.70	35.20	36.08	36.59	37.70/ ERU	38.70	39.70	39.70	80.6
February	38.40	34.80	12.93	24.10	12.65	40.40	37.33	37.80	38.59	39.04	40.40 / ERU	41.40	42.40	42.40	80.6
March	46.20	40.20	15.32	27.39	12.86	48.20	42.80	43.20	43.20	42.67	48.20 / ERU	49.20	50.20	50.20	80.6
April	56.50	49.50	20.01	41.58	13.16	58.50	52.20	52.50	51.60	51.19	58.50 / ERU	59.50	60.50	60.50	80.6
May	65.90	58.90	25.71	63.46	13.48	67.90	61.75	61.90	61.15	60.88	67.90 / ERU	68.90	69.90	69.90	80.6
June	74.70	67.40	31.92	89.47	13.78	76.70	70.36	70.40	69.67	69.44	70.36 / ERU w/AC	71.36	72.36	72.36	80.6
July	79.10	71.20	35.11	102.88	13.93	81.10	74.20	74.20	73.35	73.10	74.20 / ERU w/AC	75.20	76.20	76.20	80.6
August	77.40	70.20	34.25	100.07	13.88	79.40	73.20	73.20	72.55	72.35	73.20 / ERU w/AC	74.20	75.20	75.20	80.6
September	70.70	63.90	29.22	78.49	13.64	72.70	66.82	66.90	66.29	66.08	72.70 / ERU	73.70	74.70	74.70	80.6
October	59.60	53.70	22.43	52.27	13.27	61.60	56.48	56.70	56.33	56.17	61.60 / ERU	62.60	63.60	63.60	80.6
November	49.00	43.70	17.00	33.85	12.95	51.00	46.36	46.70	46.55	46.48	51.00/ ERU	52.00	53.00	53.00	80.6
December	39.30	35.50	13.23	24.64	12.68	41.30	38.06	38.50	39.88	40.64	41.30 / ERU	42.30	43.30	43.30	80.6

****** 1. Year round operation of RTDCCS incorporating MECS and ISECS together (Process Cooling) can provide the required cooling for the IT equipment (server racks). 2. Building HVAC system is serving the entire building and providing required heating, cooling, humidification, dehumidification and pressure control. The column on the right in green does not take into consideration any positive or negative affects of the Building HVAC system. ASHRAE TC 9.9 increased indoor data center White Space temperatures to 18-27°C (64-81°F).***

Ronald Regan National Airport (DCA)

http://www.weatherexplained.com/Vol-2/2001-Washington-D-C-Ronald-Regan-National-Airport-DCA.html#ixzz56SMoaq1X

Washington DC

Process Cooling, Building Cooling and Natural Gas Turbine Inlet Air Cooling (Turbine Inlet Cooling or TIC) "cold supply air" provided by the Multistage Evaporative Cooling System (MECS) serving Commercial and Industrial facilities and plants

Temp Performance for Cold Supply Air for Commercial & Industrial Applications in Washington DC

ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)

Ronald Regan National Airport (DCA)

MECS Including ERU, Cooling Towers and Makeup Air Handling Unit (MU AHU) Supplying Cold Fresh Air

- ERU, Cooling Towers (CT-1,CT-2, CT-3) and MU AHU commissioned to provide Cold Supply Air
- ERUs and Cooling Towers that are not necessary to meet Mean Monthly Ambient Air Temps to generate cold makeup air
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Advanced Multi-Purpose Multi-Stage Evaporative Cold Water/Cold Air Generating and Supply System (MECS) (US Patent # 8,857,204)

20170010029 Adding Supplemental Cooling Module (SCM)

						Energy Recovery Unit (ERU) Stage Cold Water Temp Leaving ERU, °F Without Outside Air (OSA) Humidification and With OSA Humidification		**Cooling Tower Stage** Cold Water Temp Leaving Cooling Towers (CT), °F			**Make Up Air Handling Unit (MU AHU) Stage** Leaving MU AHU, °F					Cold Air Temp	***Conditioned Air Temperatures by Month and ΔT delivered by MECS***		Supplemental Cooling Module (SCM) (uses cold water from any other cold water source to provide trimming of final cold water temps required in cooling applications) provides cooled air as described in the R4 Ventures LLC US Continuation in Part Patent (link above)	
						Column 1	**Column 2**	**Column 3**	**Column 4**	**Column 5**	**Column 6**	**Addt'l Data**	**Addt'l Data**	**Addt'l Data**	**Column 7**	**Column 8**	**Column 9**	**Column 10**	**Column 11**	**Column 12**
	OSA DB °F	WB °F	Calculated Enthalpy (btu/lb)	Calculated Humidity Ratio (grains/lb)	Calculated Specific Volume (cu ft/lb) (ft3//lb) (used to determine mass flow rate in Turbine Inlet Cooling applications)	ERU-1A without OSA Humidification (Cold Water Produced)	ERU-1B with OSA Humidification to 95% RH (Adiabatic Cooling (AC)) (Cold Water Produced)	CT-1 (Cold Water Produced)	CT-2 (Cold Water Produced)	CT-3 (Cold Water Produced)	Temperature of cold water from the selected stage of MECS either ERU, CT-1, CT-2 or CT-3 entering sensible pre-cooling coil of the MU AHU, ˚F / source (Source shown in Red)	DB temperature of OSA (coil is off) or OSA leaving sensible pre-cooling coil of the MU AHU, ˚F	Enthalpy of OSA leaving sensible pre-cooling coil of the MU AHU, btu/lb	DB temperature of OSA leaving Adiabatic Cooling stage (AC) of the MU AHU at 95% RH, ˚F	DB temperature of sensible (only) cooled OSA (including 2.0˚F fan heat) the MU AHU discharges, ˚F	DB temperature of sensibly & adiabatically cooled OSA (included 2.0˚F fan heat) the MU AHU discharges, ˚F	Lowest Achievable Cold Supply Air Temperature (if coil is off, add 2 ˚F to OSA temperature to account for fan heat)	Maximum Air DB temperature reduction (ΔT) provided by MECS vs ambient air DB conditions for the specified month without applying Supplemental Cooling Module (SCM) shown in Columns 11 and 12	Desired Air DB Temperature of Inlet Air Entering the Natural Gas Combustion Turbines (Turbine Inlet Cooling or TIC) (Target Air DB Temp Is 59 °F or lower)	Delta (Δ) showing the amount of trimming of final cold water temperatures to provide the TIC air DB temperature to meet the desired 59 °F. This trimming is provided via Supplemental Cooling Module (SCM)
Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours	89.10	78.60	42.16	132.06	14.30	91.10	85.39	81.60	80.22	79.87	79.87 / CT-3	80.87	40.12	77.65	82.87	79.65	79.65	9.45	59.00	20.65
ASHRAE or Local Airport Mean Monthly DB and WB Temperatures												Used to determine Air Temps in MU AHU								
January	35.70	32.20	11.84	22.87	12.58	37.70	34.70	35.20	36.08	36.59	37.70 / ERU	35.70 OSA					37.70	NA	59.00	NA
February	38.40	34.80	12.93	24.10	12.65	40.40	37.33	37.80	38.59	39.04	40.40 / ERU	38.40 OSA					42,40	NA	59.00	NA
March	46.20	40.20	15.32	27.39	12.86	48.20	42.80	43.20	43.20	42.67	48.20 / ERU	46.20 OSA					48.20	NA	59.00	NA
April	56.50	49.50	20.01	41.58	13.16	58.50	52.20	52.50	51.60	51.19	58.50 / ERU	56.50 OSA					58.50	NA	59.00	NA
May	65.90	58.90	25.71	63.46	13.48	67.90	61.75	61.90	61.15	60.88	61.75 ERU w/AC	62.75	24.94	58.57	64.75	60.57	60.57	5.33	59.00	1.57
June	74.70	67.40	31.92	89.47	13.78	76.70	70.36	70.40	69.67	69.44	70.40 / CT-1	71.40	31.11	67.32	73.40	69.32	69.32	5.38	59.00	10.32
July	79.10	71.20	35.11	102.88	13.93	81.10	74.20	74.20	73.35	73.10	74.20 / CT-1	75.20	34.14	71.07	77.20	73.07	73.07	6.03	59.00	14.07
August	77.40	70.20	34.25	100.07	13.88	79.40	73.20	73.20	72.55	72.35	73.20 / CT-1	74.20	33.46	70.26	76.20	72.26	72.26	5.14	59.00	13.26
September	70.70	63.90	29.22	78.49	13.64	72.70	66.82	66.90	66.29	66.08	66.90 /CT-1	67.90	28.54	63.87	69.90	65.87	65.87	4.83	59.00	6.87
October	59.60	53.70	22.43	52.27	13.27	61.60	56.48	56.70	56.33	56.17	56.48 / ERU w/AC	57.48	21.91	53.58	59.48	55.58	55.58	4.02	59.00	NA
November	49.00	43.70	17.00	33.85	12.95	51.00	46.36	46.70	46.55	46.48	51.00 / ERU	49.00 OSA					51.00	NA	59.00	NA
December	39.30	35.50	13.23	24.64	12.68	41.30	38.06	38.50	39.88	40.64	41.30 / ERU	39.30 OSA					41.30	NA	59.00	NA

***** NOTE *** If the negative pressure at the turbine compressor inlet allows for the elimination of the fan in the MU AHU, the temperature can be reduced by an additional 2 °F.**

Ronald Regan National Airport (DCA) http://www.weatherexplained.com/Vol-2/2001-Washington-D-C-Ronald-Reagan-National-Airport-DCA.html#ixzz56SMoaq1X

Source: Weather Explained, Weather Almanac, Vol 2, 2001, Washington DC (DCA)

Important Notes to Completing Spreadsheets

<u>Notes Describing MECS Components and their Functionality</u>

1 The basic MECS consists the following Main and Misc. Components:

- Cooling towers CT-1, CT-2 and CT-3
- Energy Recovery Unit (ERU)
- MUAHU
- Misc. components such as pumps, heat exchangers, makeup water treatment system, and blowdown water recovery system.
- System recovering water from the cooling towers exhausts air and returning the recovered water back to the process (Currently it is in a development stage).
- Use the following for sizing the Main Components of MECS and additional assumptions used to creating temperature performance tables
  - 3 °F Cooling Tower approach temperature for estimating temperature performance and sizing and selection of the Cooling Towers
  - Precooling coils for CT-2 and CT-3 2 °F approach temperature for estimating temperature performance and sizing and selection of the cooling coils
  - ERU coil (or heat exchanger) 2 °F approach temperature for estimating temperature performance and sizing and selection of the heat exchangers
  - Precooling coil for the MUAHU 1 °F approach temperature for estimating temperature performance and sizing and selection of the cooling coil
  - Air leaving adiabatic cooling stage of the ERU coil (or heat exchanger) at 95% RH
  - Air leaving adiabatic cooling stage of the MUAHU at 95% RH
  - Fan heat added to air leaving adiabatic cooling stage of MUAHU is 2 °F. If fan is placed upstream, this can be eliminated.

2 The operational MECS Main Components are producing and supplying the cooling sources in the forms of either cold water, or cold air, or both at the same time as follows:

- MECS ERU provide "free cooling" as know in the data center industry by generating cold water to supply the appropriate cold water to MUAHUs, individual fan coil units (Individual Server Enclosure Cooling System or ISECS), group fan coil units, fan walls or in-row cooling systems.
- MECS cooling towers of CT-1, CT-2 and CT-3 generate cold water and cold exhaust air and supply both cold sources (water and/or air) to the appropriate cooling needs. The cooling towers to be sized for the ambient conditions specified by ASHRAE 0.4% "Evaporative" column in the Climate Data Table. The actual seasonal thermal performance of these cooling towers to be determined based on the ASHRAE or Local Airport specified monthly mean ambient conditions presented above.
- Usually the cold exhaust air from the cooling towers is being dumped to the atmosphere, and, therefore, being wasted. In our case the cold exhaust air from the cooling towers CT-1, CT-2 and CT-3 exhaust air is used for either appropriate direct evaporative cooling application or processed by the ERU for the generation of a significant amount of extra cold water which is being used for the appropriate cooling application. At certain ambient air conditions the ERU alone applying the 100% OSA could generate cold water that could be used for some appropriate applications ("free cooling").
- The MUAHU providing just the air cooling consist two cooling stages: sensible cooling stage (pre-cooling coil) and adiabatic evaporative cooling stage. During the year, depending of the ambient air conditions and cooling load requirements the MUAHU may operate either both cooling stages or just one of the them matching the application requirements. In case of necessity the MUAHU could also be equipped with some additional cooling and/or heating means.

3. The all or some appropriate MECS Main Components, depending on application and ambient conditions, could be operating for providing required seasonal or year-round cooling.
4. The MECS could provide required cooling and/or 100% of the makeup air and conditioned air as required, i.e. cooling, humidification, dehumidification, etc. for the wide variety of HVAC and other applications including 100% fresh air exchange in hospitals, sports arenas, convention centers, etc; semiconductor manufacturing facilities; Data Centers; cooling Turbine Generators Inlet air; cooling industrial processes; cooling agriculture buildings and processes; cooling military facilities, etc..
5. For some critical cooling application taking place in the hot and humid regions, trimming the final cold water temperature may be required and the MECS could be equipped with an appropriate Supplemental Cooling Module (SCM) utilizing, at first, the local available natural cooling sources such as geothermal (ground water), water from a stream, river, lake or ocean; or process waste heat to be transformed into a low - temperature adsorption/absorption cooling source.

Guide to completing the Multistage Evaporative Cooling System (MECS) "comfort cooling" and "process cooling" water and air Temperature Performance spreadsheet for a specific geographical location (MECS Temp Performance) tab and the Real Time Data Center Cooling System (RTDCCS) water and air Temperature Performance spreadsheet for a specific geographical location (RTDCCS Temp Performance) tab

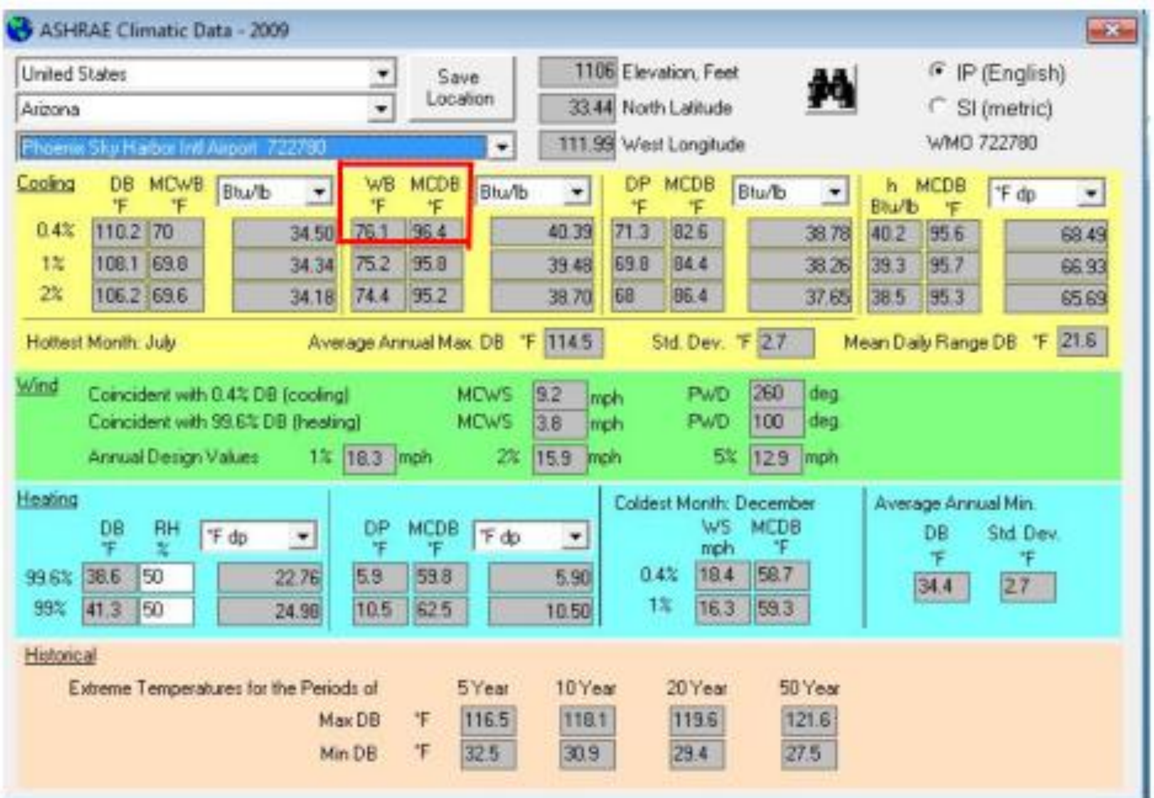
This guide will walk through the process of completing the fields in the temperature performance spreadsheet for any specific geographical location. The step-by-step process will detail all the tools necessary, where to obtain these tools, and how to use them. Please e-mail Darrell Richardson with any questions to darrell@r4ventures.biz. darrell@r4ventures.biz

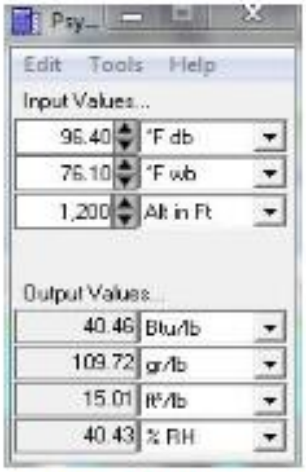
Tools

PsyCalc Tool – please go to the following website and download the basic PsyCalc Tool. For a more comprehensive PsyCalc Tool, go to the software developer's website (Linric Corporation) and select the appropriate PsyCalc tool.
https://www.munters.com/en/knowledgebank/apps/psychroapp/

For a more comprehensive PsyCalc Tool, go to the software developer's website (Linric Corporation) and select the appropriate PsyCalc tool.
http://linric.com/products.asp

Example picture of PsyCalc Tool for the randomly selected geographical location – Phoenix, Arizona, USA:





Median Monthly Dry Bulb (DB) and Wet Bulb (WB) Temperatures

The median monthly dry bulb and coincident wet bulb temperatures can be located at, for example, for the Phoenix AZ location. http://www.weatherexplained.com/Vol-2/2001-Phoenix-Arizona-PHX.html#ixzz2XMUi3ldJ Scroll down to the mean dry bulb and wet bulb temperature rows which are by month. Copy and paste the appropriate mean DB and WB temperatures in degrees Fahrenheit into spreadsheet lines 29 – 30 and 33 - 34. If temperatures are shown in Celsius, convert to Fahrenheit. These temperatures will automatically be posted to columns B and C by month.

Completing the spreadsheet starting the Summer Design Conditions row then completing for each month

Step 1 – Open PsyCalc. Open Tools, ASHRAE Climate Data, and All Design Data. Select country, state, and international Airport or city. Click save location. The next columns are for evaporative applications and the selected temperature (WB and MCDB) is outlined in the **Red Box (ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)).** The spreadsheet starts by establishing altitude and the ASHRAE .4% summer design conditions for cooling applications (1st row under Cooling). For example, Phoenix, AZ is at an elevation of 1106 feet, the ambient DB temperature is 96.4 °F and the coincident WB temperature is 76.1 °F (Using 1200 feet as the default elevation for Phoenix, AZ) (Input Values as shown above in graphic). Place these temperatures into the spreadsheet in the appropriate row titled "ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year)" ***(Note: The WB temperature for the Evaporative application is being used for sizing cooling tower(s))*** . With this tool still open. set the 1st drop down menu in Output Values to btu/lb (Enthalpy) and enter the number in the 0.4% row in column D, set the 2nd drop down in Output Values to gr/lb (Humidity Ratio / moisture content) and enter number in column E, set the 3rd drop down in Output Values to ft^3/lb (ambient air Specific Volume) and enter number in column F. This row is complete and ready for calculating temperature performance at these **worst case** summer design conditions.

Inputting monthly gr/lb, btu/lb, and ft^3/lb, open PsyCalc set up from the drop down menus input values °F db, °F wb, and altitude in feet (Use 1200 feet for Phoenix, AZ). The output value drop down menus are then set enthalpy (btu/lb), humidity ratio (gr/lb), relative humidity (% RH); and air specific volume (cu ft/lb) (ft^3/lb). To begin, input dry bulb and wet bulb temperatures in Inputs in PsyCalc Tool for January in the Input numbers and read the calculated output numbers. Insert these numbers in columns D (Value 1), E (Value 2), and F (Value 3). Follow these steps until enthalpy (btu/lb), humidity ratio (gr/lb) and specific volume (ft3//lb) has been established for all months. All monthly rows are now completed and ready for calculating temperature performance of the MECS cooling stages at mean monthly dry bulb and wet bulb temperatures.

<u>We're now ready to start calculating the monthly temperature performance for each cooling stage of the Multistage Evaporative Cooling System.</u>

Important Approach Temperatures and Assumptions:

- Assumed 3 °F CT approach temperature for temperature estimating for future sizing / selection of components to meet the specific load
- Precooling coils for CT-2 & CT-3 have assumed a 2 °F approach temperature
- ERU coil (or air-water heat exchanger) with assumed 2 °F approach temperature
- Precooling coil (PCC) and Final Cooling Coil (FCC) for the MUAHU assumes a 1 °F approach temp for temperature
- Relative Humidity of the air leaving adiabatic cooling stage is at 95% RH (assumed) and entering ERU coil (or air-water heat exchanger)
- Relative Humidity of the air leaving adiabatic cooling stage of MU AHU is at 95% RH (assumed)
- Fan heat added to air the is MUAHU is 2 °F (assumed). If fan is placed upstream, this heat can be eliminated.

Column 1 - ERU – 1A (without adiabatic cooling): the water temperature performance of the energy recovery unit (ERU-1A) in Column 1 is the outside air (OSA) DB temperature plus assumed 2° F (coil approach temp). Enter this temperature in Column 1.

Column 2 – ERU-1B (with adiabatic cooling – (ERU/AC)): Use PsyCalc 1st input OSA °F db (for each months and the ASHRAE Coincident Summer Design DB & WB Temps at .4% (Annual) for Evaporative Applications (35 hours per year) and second input value to gr/lb for the corresponding DB Temps. The output enthalpy in Btu/lb is shown in Column D and is used **in solving for °F db of the air at 95% RH (enthalpy now shown in the spreadsheet)**. Change top 2nd input value to 95% RH with altitude always remaining the same. Lower the °F db in the input values until the enthalpy **(btu/lb determined previously) matches the enthalpy of the air entering this stage (spreadsheet column E).** Enter this calculated DB temperature in Column 2. Cold Water temperature leaving Water Coil equals DB air temperature leaving humidifier and entering Water Coil plus 2 °F coil approach temperature.

Flow diagram of the ERU-1B: OSA -----> Humidifier -----> Water Coil ------> Fan ------> Warmed Air Exhaust
(Cooled Water temp)

Column 3 – CT-1: the cold water temperature produced by CT-1 is the outside air (OSA) WB temperature plus 3° F.

Column 4 – CT-2: the cold water temperature produced by CT-2 which has a pre-cooling coil bank on the air inlet of the cooling tower is calculated as follows. The cold water produced by CT-1 is used as supply water to the cooling coil bank of CT-2 and OSA passes through these coils and enters into CT-2 at lowered DB and WB temperatures of the air to be processed by CT-2. Let's establish these air temperatures. First, we calculate the new DB temperature of air leaving the coil by adding 2° F (cooling coil approach temperature) to the cold water temperature supplied from CT-1 to the CT-2 pre-cooling coil. Using PsyCalc, enter this new CT-2 entering DB temperature as an input, input the humidity ratio number previously calculated in column E in the spreadsheet (OSA humidity ratio does not change in any of these stages) and solve for WB temperature. Add 3° F (cooling tower approach temperature) to this WB temperature to arrive at the cold water temperature produced by CT-2 in enter this number in Column 4.

Column 5 – CT-3: the cold water temperature produced by CT-3 which has a pre-cooling coil bank on the air inlet of the cooling tower is calculated as follows. The cold water produced by CT-2 is used as supply water to the cooling coil bank of CT-3 and OSA passes through these coils and enters into CT-3 at lowered DB and WB temperatures of the air to be processed by CT-3. Let's establish these air temperatures. First, we calculate the new DB temperature of air leaving the pre-cooling coil of the CT-3 by adding 2° F (cooling coil approach temperature) to the cold water temperature supplied from CT-2. Using PsyCalc, enter this new CT-3 DB temperature as an input, input the humidity ratio number previously calculated in column E in the spreadsheet (OSA humidity ratio does not change in any of these stages) and solve for WB temperature. Add 3° F (cooling tower approach temperature) to this WB temperature to arrive at the cold water temperature produced by CT-3 in

Column 6 – Select the Cold Water Temperature from the MECS cooling stages that best fits to the cooling application and enter this temperature into Column 6.

MECS Temperature Performance Table

Addt'l Data Columns - Added columns to the excel spreadsheet (Columns M, N and O) to facilitate the temperature calculations shown in Columns 7 and 8.

Column M – DB temperature of OSA leaving sensible pre-cooling coil of the MU AHUF.

Column M is assuming a MU AHU having **one sensible cooling coil** using supply cold water from the selected (yellow) cold water source shown in Column 6 (selected cooling stage of MECS). Numerically the DB air temperature leaving the coil equals selected cold water temperature entering the coil plus the assumed 1 °F coil approach temperature. Column M then becomes the DB temperature of air leaving the sensible cooling coil.

Column N – Enthalpy of OSA leaving sensible pre-cooling coil of the MU AHU, btu/lb.

Using the PsyCalc Tool, enter DB of air leaving the coil (Column M) (Input 1), humidity ratio of OSA (Column E of the spreadsheet) (Input 2), and altitude of the location (Input 3), and solve for enthalpy (btu/lb) of the air leaving sensible cooling coil. Column N then becomes the enthalpy (btu/lb) leaving the sensible cooling coil.

Column O – DB temperature of OSA leaving Adiabatic Cooling stage (AC) of the MU AHU at 95% RH,˚F.

Again using the PsyCalc Tool, enter DB of air leaving the coil (Column M) (Input 1), change Input 2 to Relative Humidity and enter 95%, and altitude of the location (Input 3), and then lower the DB temperature in Input 1 until the enthalpy in the output (btu/lb) equals the enthalpy shown in Column N. Column O then become the humidified air DB temperature leaving the adiabatic cooling stage of the MU AHU.

Column 7 – **DB temperature of sensible (only) cooled OSA (including 2.0 ˚F fan heat)** MU AHU providing sensibly cooled Cold Supply Air to the space without OSA Humidification (No Adiabatic Cooling) includes 1 °F coil approach temperature (previously included) and 2 °F for fan heat. Assumes the MU AHU is being used in Turbine Inlet Air Cooling and/or building cooling applications without adiabatic cooling. The MU AHU having **one sensible cooling coil** uses supply cold water from the selected (yellow) cold water source shown in Column 6 (selected cooling stage of MECS). Column M calculates the DB temperature of air leaving the sensible cooling coil and includes the 1 °F coil approach 1 and Column M becomes the DB temperature of the air leaving the sensible cooling coil. Using the PsyCalc Tool, enter DB of air leaving the coil (Column M) (Input 1), humidity ratio of OSA (Column E of the spreadsheet) (Input 2), and altitude of the location (Input 3), and solve for enthalpy (btu/lb) of the air leaving sensible cooling coil which is shown in Column N. Column N then becomes the enthalpy (btu/lb) leaving the sensible cooling coil. This DB temperature and the enthalpy shown in Columns M and N are the air conditions leaving the coil and passing through the non - operating humidifier and entering the fan section of the MU AHU. To determine the air temperature leaving the MU AHU and entering the space, add 2 °F for fan heat to the DB temperature (Column M) of air entering the fan section. This DB air temperature leaving the fan section equals the DB temperature of air entering the turbine or building space depending on the application. Enter this DB temperature in Column 7.

Column 8 – **DB temperature of sensibly & adiabatically cooled OSA (including 2.0 ˚F fan heat) the MU AHU discharges. ˚F**. MU AHU with operating humidifier (adiabatic cooling or "AC"): Using PsyCalc Tool, enter the DB temperature shown in Column M, change second input to 95% RH. Start lowering the DB temperature input value at the top (input values) until the DB temperature reaches a temperature that corresponds to the enthalpy number (btu/lb) **matching the fixed enthalpy (btu/lb) number in Column N (output values)**. This is the humidified air DB temperature leaving the humidifier and entering the fan section of the MU AHU (adiabatic cooling or AC). To determine the air DB temperature of air leaving the MU AHU and entering the turbine or building space, add 2° F to this humidified air DB temperature (new DB temperature shown in input values) entering the fan section. This is the DB air temperature leaving the fan section (MU AHU) and is the air DB temperature entering the turbine or building space depending on the application. Enter this calculated air DB temperature into Column 8 (remember this is at 95% RH).

Column 9 is the lowest achievable cold supply air temperature from the selected MECS stage (selected temperature) to meet the assumed DB set point temperature of the space or application.

Column 10 is the maximum air DB temperature reduction (ΔT) provided by MECS vs ambient air DB conditions for the specified month without applying Supplemental Cooling Module (SCM) shown in Columns 11 and 12.

Supplemental Cooling Module (SCM) - The next two columns support calculations for the Supplemental Cooling Module (SCM) (uses cold water from any other cold water source; i.e. ground water; water from a stream, river, lake or ocean; absorption or adsorption chiller; or any other cold water source; to provide trimming of final cold water temperatures required in cooling applications) providing cooled air as described in the R4 Ventures LLC US Continuation in Part Patent.
(Continuation in Part US Patent # 20170010029 Adding Supplemental Cooling Module (SCM)).

Column 11 is the desired air DB temperature of inlet air entering the Natural Gas Combustion Turbines (Turbine Inlet Cooling or TIC) (Target Air DB Temp Is 59 °F or lower).

Column 12 is the delta (Δ) showing the amount of trimming of final cold water temperatures to provide the TIC air DB temperature to meet the desired 59 °F. This trimming is provided via Supplemental Cooling Module (SCM).

RTDCCS Temperature Performance Table

Column 7 – Estimated water temperature leaving the first Plate and Frame Heat Exchanger (HX-1): Water temperature from the elected cooling stage of MECS plus 1° F (HX approach). Enter this water temperature in Column 7. Note: The fan coil unit (FCU) serving each individual server rack identified in all documents as the Individual Server Enclosure Cooling System or ISECS consists of an with two water cooling coils, a pre cooling coil (PCC) being fed with cold water from HX-1 and a final cooling coil (FCC) being fed with cold water from HX-2 (See System Diagram). The Monitoring and Control System (hardware and software) will select the appropriate stage of MECS (different stages produce cold water at different water temperatures) to feed HX-1 and HX-2 depending on the desired Data Center White Space set point temperature and the flow of the water will be controlled by a flow control valve to maximize energy efficiency.

Column 8 - Estimated Cooled Air DB Temp Leaving the PCC and the Fan Coil Unit serving each server rack (ISECS): Column 8: use water temperature entering the coil plus 1° F (coil approach). Enter this DB air temperature in Column 8. (Note: In Phoenix AZ, the ISECS fan coil unit is only utilizing the PCC as the Final Cooling Coil (FCC) is not necessary to meet the assumed set point temperature of 78 °F. The FCC may be required in other geographical locations of the world in order to meet the desired set point temperature of the data center.)

Column 9 - Lowest Achievable Data Center White Space Temperature: This column shows the lowest achievable Data Center White Space air DB temperature that can be delivered by the combined MECS and RTDCCS using just the pre cooling coil (PCC). Depending on customer requirement and set point temperature, the final cooling coil (FCC) may be required.

Column 10 - Optimal Data Center White Space Temperature is a recommended set point temperature of 80.6 °F DB (or 81 °F DB for charts) saving significant energy costs through proper configuration of the Monitoring and Control hardware and software.