



GreenMediaHD

REV 2.0

Chiller

Optimizer

Control

GCOP: Optimization and Energy Saving Controller for Chiller Plants.



Introduction:

By applying artificial intelligence (AI) optimization algorithms in the chiller plants, the electric power energy consumption in the plant is reduced between 15 and a 25 % depending on the operating condition of the chiller compressors, condenser, and evaporator.

The GCOP controller makes an optimal reset of the chiller leaving chilled water temperature set-point, depending on the changes in environmental conditions and cold water demand.

The automatic reset of the set-point allows that in a cooler environmental condition, such as winter days, rainy days, night hours, etc., the leaving chilled water temperature set-point could be set to a slightly higher value than the value set for hotter conditions, causing the chiller compressors to stop quicker with less operation time, without affecting comfort and therefore saving much more power energy.

Another function that the GCOP controller executes to save energy is the chillers sequencing and rotation task. Depending on the cold water demand, the chillers will be started in sequence and when the chiller meets its high efficiency capacity, the next chiller in sequence start running if it is required to comply with the cold water demand. In this way only the necessary chillers will operate to satisfy the cooling demand and also those chillers that are running will be working at the most efficient capacity level.

GCOP_Optimizer is the application used in the GCOP controller for chiller optimization

Installation.

The connection of the GCOP controller is very simple, just connect the power adapter and the Ethernet network plug (RJ45) as shown:



The controller device has several settings, the most commonly used to make the GCOP controller works properly are explained in this document..

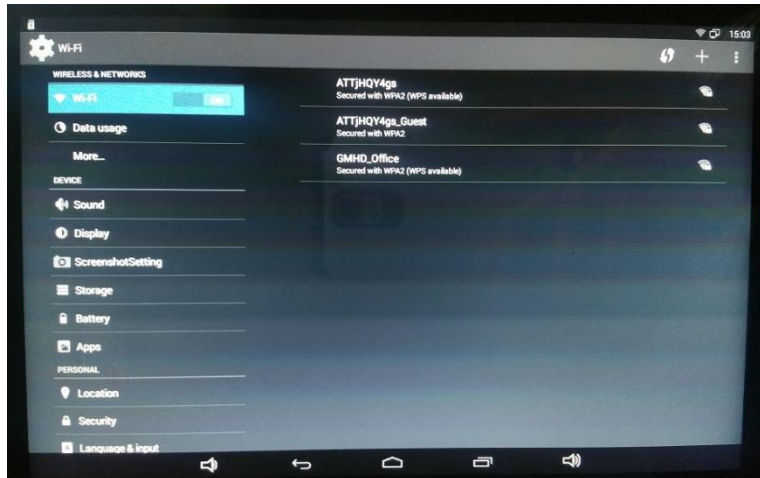
To enter in the device configuration, click (touch) on the following icon:



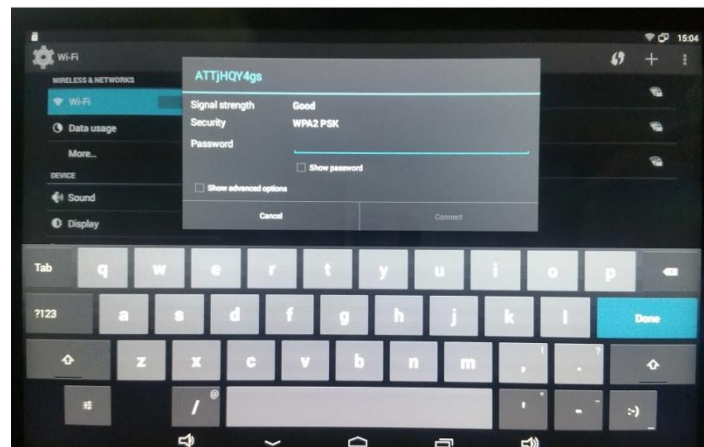
Communication networks settings

1- WIFI network

To enable WiFi communication, the Wi-Fi network is turned ON and the available AP are shown:



Click on the SSID that will be used for the connection, and the following dialog box is shown to enter the password:

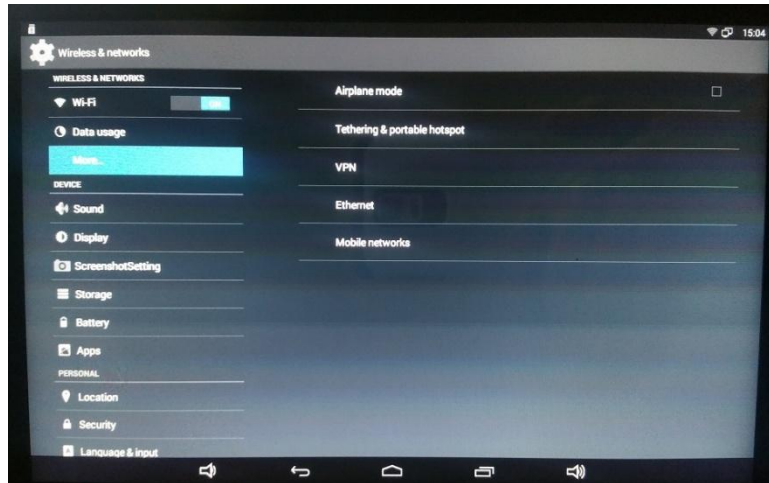


Remember that the AP must be on the same subnet as the chiller control panel or the Bacnet / IP interface.

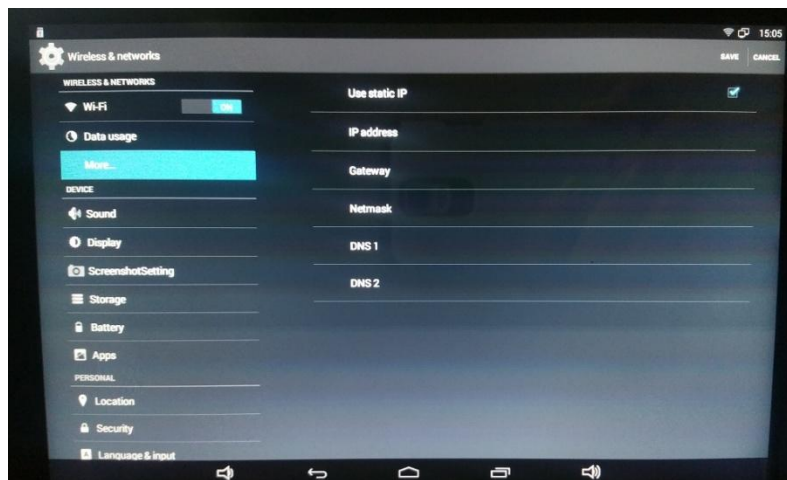
Usually the GCOP controller will be wired connected on the local LAN instead of wireless, because it is faster, safer and more stable.

2- Ethernet network

To setup the parameters of the Ethernet network, go to the option "More ..". and select "Ethernet" as shown:

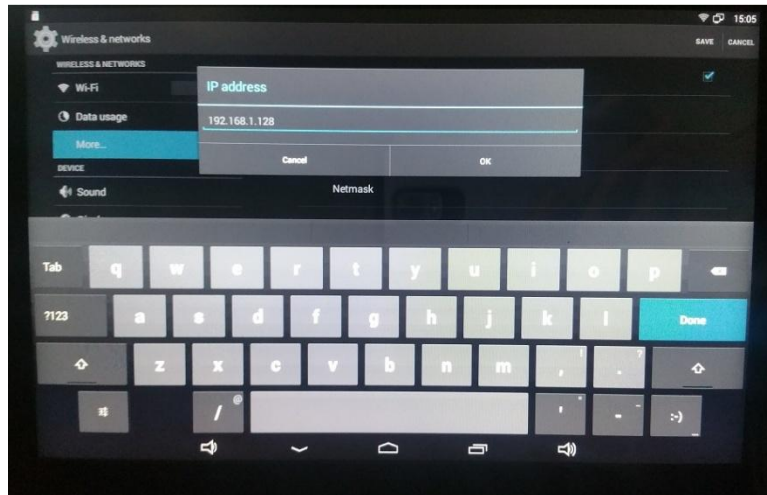


Click on Ethernet network and it shows the following:



The connection to the network can be either DHCP, where the router automatically assigns the IP address to the device, or a static IP, which is the preferable set for the GCOP controller device, although it could work in either settings as long as the controller device is in same subnet of the Bacnet interface that supplies the chillers parameters.

To set a static IP address, check the "Use static IP" option as shown in the image above. Then click on each parameter to configure it, for example, to set the IP address, click on the IP address option and the following dialog box is shown:

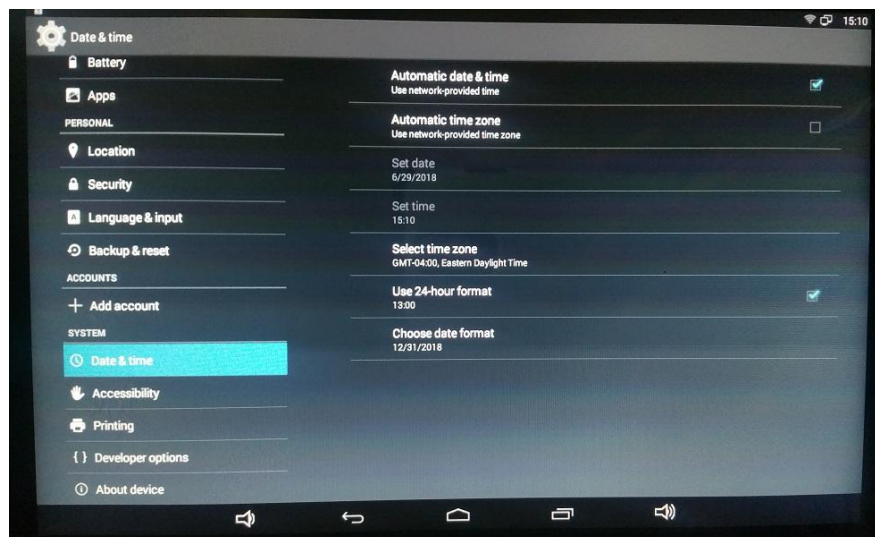


After entering the data of each parameter, such as the Gateway, Netmask, and DNS1 and 2, click on **SAVE** button to save the configuration changes, if this step is forgotten it will be necessary to configure all the data again.

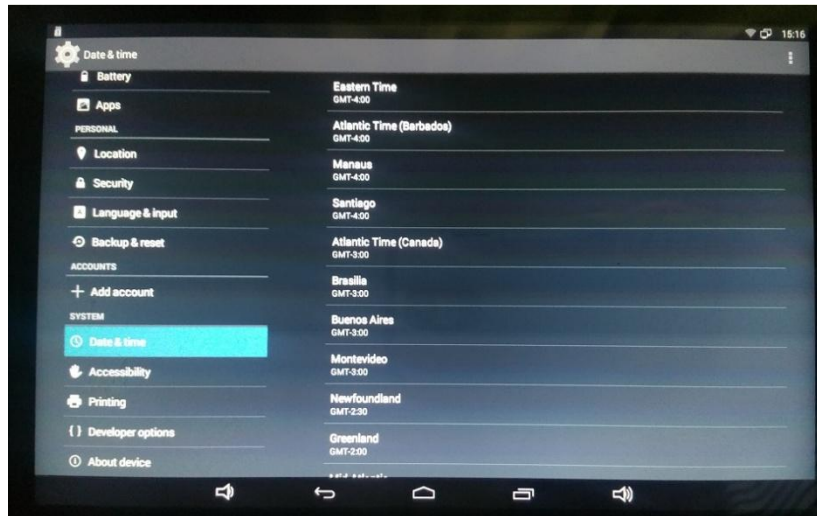
The GCOP controller must be connected to the internet to upload the data to the GCOP Web Server and keep working properly.

Setting the time and date.

The controller device is setup to receive the time and date automatically from the internet network, but if there were some wrong settings, here it is shown how to modify these parameters. To setup the time and date, go to the "Date and Time" option as shown:



Then set the correct time zone. To do that, disable the "Automatic Time Zone" option and select the "Select time zone" option, as shown in the following screen:



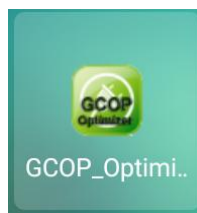
The time and date settings must be automatic, so the "Automatic date & time" option must be selected. If you want to change them manually, first disable the automatic option and then click on the date and time to select the appropriate time.

All these parameters are already set by DLControl & Engineer, so there is no need to change them unless they are not properly set or unset accidentally.

With the GCOP controller connected to the LAN, and all the parameters properly set, you can start the optimization application in the controller device.

Start of the GCOP_Optimizer application.


GCOP_Optimizer will start automatically when the device is powered up. If you quit the application and you want to start manually you must click (or touch in case of touch screen) the following icon:



The following screen will be displayed:



In this presentation screen you have the following options:

The  icon is used to access the main menu options that will be explained in details in this document.

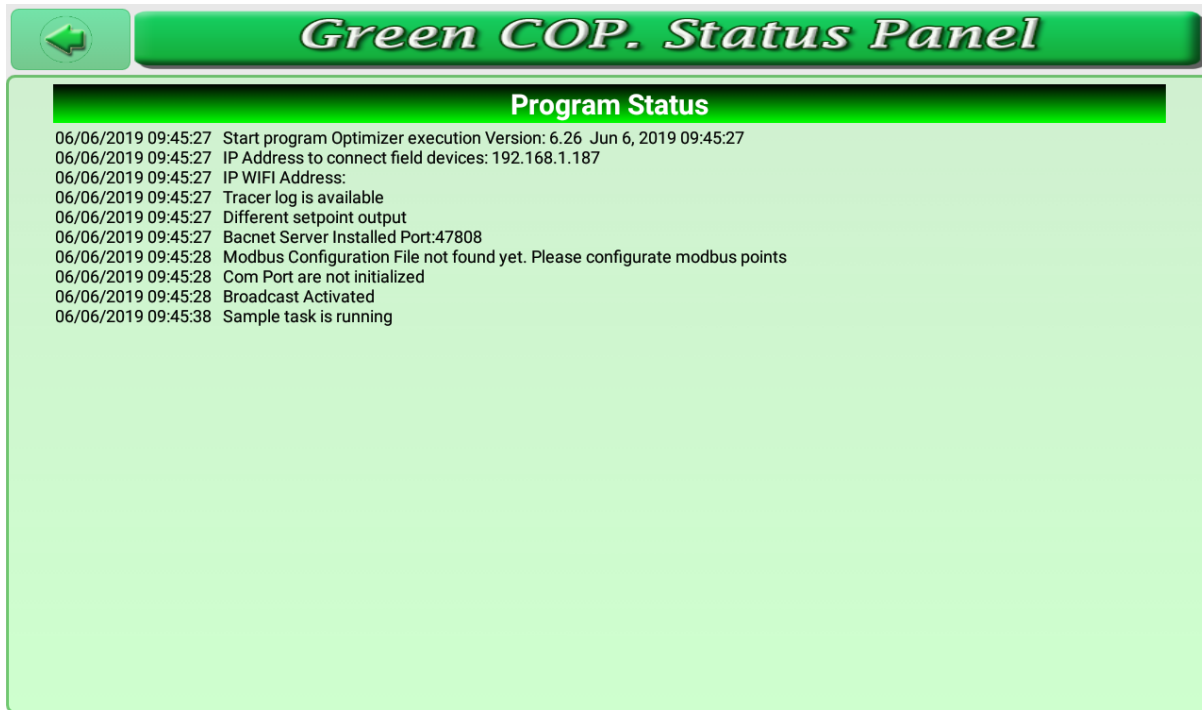
At the right side of the menu icon is located the "Start" button. Click on this button to start the application.

The Start Button is also automatically clicked after a time, so you will notice that after the text Start there is a timer that counts down seconds until it reaches the zero value. When it reaches zero it will automatically start the application unless you click it manually first.

In the upper right corner of the screen is located the "Quit" button used to exit the application.

Finally, on this presentation screen, you have the "Start on reboot only" option. If you check this option, you cannot manually start the application after exiting it. To start the application again you have to turn the power off and then on in the GCOP controller device, so the application can start automatically on reboot.

When the application starts it shows the following screen:



In this screen, the information displayed allows you to visualize the correct operation of the application.

For example, it shows you the starting time of the application, the application version, the IP address of the controller device in the local Ethernet network, and if it were a wireless connection, it would show us the IP address of this wireless connection. More information is also displayed, such as the Bacnet port value assigned to the GCOP controller device. Since the GCOP controller can also read information from electric power meters using the Modbus protocol, it will indicate if the Modbus points file has been created, but if we do not use energy meters with that protocol, the configuration of the Modbus mapping points of energy meters will not be necessary.

As the application continues running over time, new information will be displayed in this panel to check if the application is working fine or if there are some runtime errors.

The button that is in the upper left corner of this screen, which contains a backward arrow, is used to return to the presentation screen in order to access the main menu of the GCOP application

When in the Program Status screen is displayed that the sampling of the chiller parameters task has started, it indicates that the GCOP controller has already made all the necessary initializations and all the optimization algorithms are working. In this moment, the application automatically shows the presentation screen with the list of the main menu options open as follow:



Scroll down this menu to see the rest of the options, as shown below:



From this list of options, if you want to return to the Program Status screen to see what new information is presented and how the application has been running so far, click on "Status Panel" option.

All the main menu options will be explained in details

Configuration of the Variable Set-point Optimization System that resets the leaving chilled water temperature set-point value (Variable Set-point System).

When the chillers are initially installed by the contractors, the value of the leaving chilled water temperature (LCHWT) set-point value is normally fixed at a very low value to guarantee a comfort temperature in the condition of highest cold demand.

Instead of setting a fixed LCHWT set-point value in the chillers for any environmental condition throughout the year, the optimization algorithms of the GCOP controller resets this set-point continuously in real time according to the variations of cold demand and outside temperature.

For lower set-point values, the energy consumption increases, so when cold demand conditions decrease, this set-point could have a higher value for that new conditions and reduce the energy consumption in the chiller. The control algorithm use artificial intelligence functions that make the system learn with time and use the most appropriate set-point variation curve according to the variations of environmental conditions. These environmental conditions are closely related to the year climate seasons, building occupational level and weather changes during the day.

These algorithms also consider changes in the relative humidity in the most critical areas, as well as the monitoring of temperatures in the zones of greater cold demand to avoid the saturation of local temperature control in those zones.

To access the configuration and monitoring screen of the Variable Set-point System, click on the

SP Optimizer

button, and the following screen is shown:

Scroll down this screen to see the rest of the options, as shown below:

Green Cop. LWT SP Optimizer

Enable Control

OFF

Dead Band

1.00

Max. SP Rate/Min

0.10

Winter Average Temp. Limit

75.00

Average OA Temp.

85.90

Description	CHILLER 1	CHILLER 2	CHILLER 3	CHILLER 4
LWT SP Output	44.00	44.00		
Actual Chiller Temp. SP	44.00	44.00		
Manual LWT SP Output	44.00	44.00		
Capacity Limit SP	100.00	100.00		
Active Capacity Limit SP	100.00	100.00		
Manual Cap. Limit SP	100.00	100.00		
Chiller Consumption	0.00	0.00		
Communication State	✓	✓		
Maintenance	OFF	OFF	OFF	OFF

SPV Schedule

Send Data

There are two screens associated to the Variable Set-point System, the first one is shown above and the second will be shown when you click on the upper right button, which is shown as:

Green Cop. LWT SP Optimizer

Temperature Points

Value

Max. Outside Temp.

92.42

Min. Outside Temp.

73.84

Setpoint Points

Value

Min. LWT Setpoint

44.00

Max. LWT Setpoint

53.00

Control Temp Range

ON

Capacity Stability Seconds

0

Capacity Limit Control

Value

Enable Control

OFF

Time Chiller Off (hour)

4

Current Max Temp.

90.00 (8)

Current Min Temp.

73.00 (8)

Capacity for Control

0.00

Control Params

Phase I

Phase II

Time per phase (min)

10

10

Cap. Limit per phase

60.00

80.00

Scroll down this screen to see the rest of the options, as shown below:



Green Cop. LWT SP Optimizer

Control Temp Range: ☐ ON ☐ OFF

Current Max Temp: 90.00 (8) Current Min Temp: 73.00 (8)

Capacity Stability Seconds: 0 Capacity for Control: 0.00

Capacity Limit Control: Value: OFF

Control Params: Time per phase (min): Phase I: 10 Phase II: 10

Time Chiller Off (hour): 4 Cap. Limit per phase: 60.00 80.00

Description	Value	Limit	Dead Band	Enable
Humidity	0.00	70.00	0.10	OFF
Space Temperature	0.00	80.00	0.10	OFF

Space Temperature Control: Max Value Zones Temperature Send Data

To return to the first screen click on the upper right  button.

Each parameter shown in these screens, starting with the first screen, are explained in details.

The value of the outside temperature is shown in the "Outside Temperature" box, in this case 85.00 oF.

In the "Calculated LWT Setpoint" box, the set-point value reset by the GCOP controller, as a result of the optimizations algorithms, is displayed. This value will be sent automatically to each chiller.

The "Capacity Load Offset" box shows a factor that is considered in the final reset of the set-point value. This factor depends on the variations of the chiller capacity. When the chiller capacity is very low, even if the outside temperature is very high, this factor increases, but if the capacity is very high even at a low outside temperature, this factor will be very small, almost zero, so this factor indicates to the optimization algorithm the way to reset the set-point value according to the cold demand. It is also taken in consideration for this factor, how far is the leaving chilled water temperature from the current LCHWT set-point value for the capacity that the chiller is currently handling.







To activate the Variable Set-point System, click on "Enable Control" button to set it in green, with the ON text. The 2 possible states for this button are shown below:

Control enabled: 

Control disabled: 

In the event that high temperatures are detected in some zones of the building where the GCOP controller is installed, and you want to discard that it is due to this controller, simply set the control in the disabled state, and manually reset the LCHWT set-point to fixed desired value. The manual LCHWT set-point reset using the GCOP controller is explained in this document

In the table:

LWT SP Output	44.00	44.00		
Actual Chiller Temp. SP	44.00	44.00		
Manual LWT SP Output	44.00	44.00		
Capacity Limit SP	100.00	100.00		
Active Capacity Limit SP	100.00	100.00		
Manual Cap. Limit SP	100.00	100.00		
Chiller Consumption	0.00	0.00		
Communication State				
Maintenance				

The "LWT SP Output" row shows the LCHWT set-point values sent to each chiller.

The "Actual Chiller Temp. SP" row shows the actual leaving chilled water temperature set-point value. This value should be the same as the value calculated by the GCOP shown in the first row, but if the chiller is in local mode, the chiller does not receive the setpoint remotely. Also consider that a time delay exists before the chiller set the remote setpoint sent by the GCOP.

The "Manual LWT SP Output" row is used to manually reset the LCHWT set-points values and send them to the chillers. If the GCOP Variable Set-point System is enabled, the LCHWT set-points values cannot be entered manually because it is done automatically by the GCOP controller, but if the control is disabled, you can enter the desired set-point values and send them to the chillers when you click on the "Send Data" button that is at the end the table.

The "Capacity Limit SP" row shows the Capacity Limit Setpoint calculated by the GCOP if the Capacity Limit of the chiller is controlled by the GCOP as we explain later.

The "Active Capacity Limit SP" row shows the actual Capacity Limit Setpoint value. This value should be the same as the value calculated by the GCOP shown in the previous row, but if the chiller is in local mode, the chiller does not receive the setpoint remotely. Also consider that a time delay exists before the chiller set the remote setpoint sent by the GCOP.

The "Manual Capacity Limit SP" row is used to manually reset the Capacity Limit Setpoint value and send them to the chillers. If the GCOP Capacity Limit is enabled, the Capacity Limit Setpoint

values cannot be entered manually because it is done automatically by the GCOP controller, but if the control is disabled, you can enter the desired set-point values and send them to the chillers when you click on the "Send Data" button that is at the end the table.

The "Chiller Consumption " row shows the value of kwatts consumed by the chiller. When the mapped of the chillers variables is done, you have two options regarding the calculation of chillers consumption. The first option is to map the load amperes of the chiller, set the input voltage and power factor in the option Variables Setup explained later in this documentation. The second option is to map directly the power consumption of the chillers instead of the load amperes, that depends on the chillers communication options.

The "Communication State" row shows the communication status between the GCOP controller device and each chiller interface. When the green circle appears on the screen the communication is fine, but when it appears in red, it means that there are communication errors and therefore neither the read or sent values by the optimizer will be reliable

Communication OK 

Communication Error 

The "Maintenance" row is used to indicate that the chiller is in maintenance. This enabling button is useful to avoid communication errors with the chiller that is out of service due to maintenance.

If the button is green with the ON text, it means that the chiller is out of service and therefore the GCOP controller neither can read nor send values to the chiller.

In this configuration screen we also can define a dead band used when resetting the LCHWT set-point value.

In order to avoid a continuous change in the LCHWT set-point value every time the optimization algorithm calculates a new value, you must define a dead band zone. Enter this value in the "Dead Band" box and then click on "Send Data" button to save this value.

The dead band operates as follow: If the new calculated set-point is greater than the current set-point plus the dead-band value, the set-point is set to the new calculated value. Similarly, if the new calculated set-point is less than the current set-point minus the dead band value , the set-point is set then to the new calculated value. With the dead band value a hysteresis around the current set-point is created so that the set-point does not change until the calculation of the new value does not exceed more or less the dead band value.

A sudden change in the LCHWT set-point value is also avoided by the GCOP controller. The set-point changing is made smoothly using the value entered in the "Max SP Rate / Minute" box. This value is the maximum variation allowed per minute for the set-point, so the change rate of the set-point value is controlled avoiding sudden changes.

Temperature control in winter conditions:

In winter conditions, depending on the outside temperature (very cold winter), it is possible that the GCOP controller reset the LCHWT set-point value to the highest value and cause the chiller to stop due to the very low cold load. If all the chillers stop for this reason, it may be necessary that some locals, with low temperature requirements, need to be cooled, and you cannot allow that the whole chiller plant stops. To avoid this issue, the GCOP optimizer calculates the outside temperature average during the day, and if this average value is below a pre-set winter limit temperature, the optimizer resets the set-point to a lower value and stops the real-time calculation of a new set-point, meaning that in these conditions, the optimization algorithm is disabled.

The settings for this control are highlighted in the image below:

Winter Average Temp. Limit	75.00
Average OA Temp.	81.55

In the "Winter Average Temperature Limit" box, enter the value for outdoor temperature limit, below which, the GCOP controller sets a low set-point value and the control algorithm is disabled. Once this value is entered, click on "Send Data" button to save this new setting.

The "Average Daily Value" column shows the daily outside temperature average.

Programming schedules for the variable set-point system.

It is possible that some buildings only operate with high cold load during labor hours, i.e., from 7.00am to 6.00pm on weekdays, and the rest of the time, including weekends, the cold load is very low or the chillers plant is completely stopped.

If the cold load is very low after the labor hours, and some cold load must be kept to comply with some temperature and humidity requirements, it is not recommended to have a high LCHWT set-point value, because if the cold load is very low, all the chillers could stop. This issue is very similar to the case of winter temperature we already explained. To avoid this problem, the GCOP controller incorporates the schedule control in the variable set-point algorithms. Note that many building such as: shopping centers, residential homes, etc., the cold demand can be high at any time of the day, then for those cases the schedule control would not be used.

To setup the schedule control, click on **SPV Schedule** button, which is located on the first setting screen of the **SP Optimizer** option. The following screen is shown:



Green Cop. SPV Schedule

Monday to Friday Timer

Time ON	Time OFF	OFF SP	Enabled
06:00	16:00	45.00	ON

Saturday Timer

Time ON	Time OFF	OFF SP	Enabled
06:00	12:00	45.00	ON

Sunday Timer

Time ON	Time OFF	OFF SP	Enabled
00:00	00:00	45.00	ON

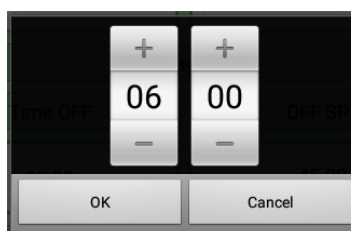
Save Data

You can configure up to three schedules.

The first schedule corresponds to the labor days from Monday to Friday (Monday to Friday Timer)

They are 4 columns in the configuration table above . In the first column, "Timer ON", set the hour and minute of the day to start the variable set-point control algorithm. In the second column, "Timer OFF", set the hour and minute of the day to stop the variable set-point control. In the third column, "OFF SP" box, enter the LCHWT set-point value that will be sent to the chillers when the variable set-point control algorithm is stopped by the schedule. Finally, in the fourth column, "Enabled", click on the button to enable or disable the particular schedule. If the button shows the text ON and a green line, the schedule will be enabled and if it shows the text OFF with a gray line, that schedule will be disabled.

To change the hour and minutes in the schedule, just click on the time value shown in the corresponding column. The following window will pop up:



Time selection pop-up window showing hour (06) and minutes (00) with increment (+) and decrement (-) buttons. OK and Cancel buttons are at the bottom.


Click on the + and - buttons of the hour and minutes to set the desired time, then click on the OK button. The new selected time will be shown in the corresponding column.

In the above example, the variable set-point control algorithm will be performed Monday to Friday from 6:00 am to 4:00 pm each day, and the rest of the time of those days a fixed LCHWT set-point value of 45°F will be sent to the chillers.

If you set the value of zero (00:00) for both "Time ON" and "Time OFF", and the "Enabled" button is ON, it means that during the 24 hours of the day the LCHWT set-point value will equal to the fixed value that is entered in the "OFF SP" column box.

The second schedule corresponds to Saturday (Saturday Timer). The explanation here is the same as the case of Monday to Friday schedule. Continuing with the above example, the variable set-point control algorithm will be running on Saturday from 6.00am to 12.00pm and the rest of that day the set-point value is fixed to 45 oF

Finally, the third schedule corresponds to Sunday (Sunday Timer). The explanation here is the same as the case of Monday to Friday schedule. Continuing with the above example, the variable set-point control algorithm will not be executed on Sunday, since both, the ON and OFF timers have a value of 00:00 and the schedule is enabled. In this example, during all Sunday the LCHWT set-point value is fixed to 45 oF.

Once all the schedules are configured, click on  button to save the changes.

CONFIGURATION SCREEN OF THE OPTIMIZER.

As mentioned early if we click on the  button, we enter in the configuration screen

First, you have the following table:

Temperature Points	Value	Setpoint Points	Value
Max. Outside Temp.	89.60	Min. LWT Setpoint	44.00
Min. Outside Temp.	75.20	Max. LWT Setpoint	53.00

In the "Max OutsideTemp." box, enter the outside temperature value above which, the variable set-point algorithm will set the LCHWT set-point to the value entered in the "Min LWT Setpoint" box. It means that in extreme hot weather conditions, the LCHWT set-point will be reset to the minimum value that guarantees the comfort temperature. The variable set-point algorithm, as explained early, will take also in consideration the capacity factor to reset the new set-point value despite of the high outside temperature if the cold demand is very little.

In the "Min Outside Temp." box, enter the outside temperature value below which, the variable set-point algorithm will set the LCHWT set-point to the value entered in the "Max LWT Setpoint" box. In this case, the capacity factor is also taken in consideration, so if the outside temperature is very low but a higher cold demand is required (which rarely happens) the calculated LCHWT set-point value will be lowered.

The calculated LCHWT set-point value also takes in consideration the winter temperature control explained early, and the humidity and the temperature values of critical zones that will be explained ahead in this document

The GCOP controller will reset the LCHWT set-point value between the maximum and minimum values defined by the operator in the above table.

In order for these values to be saved in the GCOP controller, click on the "Send Data" button.

Temperature Range control algorithm.

As mentioned in the previous table, we set a Maximum and Minimum Outside temperature value. These value are fixed until we change them manually. In the real word these value changes with the weather seasons and environmental conditions. If we want that these values update automatically every week, we can set the Control Temperature Range to ON as shown here:

Control Temp Range	<input checked="" type="checkbox"/>	Current Max Temp.	90.00 (8)	Current Min Temp.	73.00 (8)
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In this control we can see the current maximum and minimum outside temperature calculated every week with the GCOP. The number in parenthesis is the number of days taken so far in consideration to calculate these values, in this example 8 days. If we set this control in the ON position by clicking the button in the Control Temp Range means that every Sunday, if more than 6 days are taken in consideration, the values of Current Max Temp and Current Min Temp are set automatically in the Max Outside Temp and Min Outside Temp of the Temperature point table explained previously, and of course, it will change the value of the LCHWT setpoint calculated by the GCOP.

Chiller cooling capacity considerations in the variable LCHWT set-point algorithm.

When the chiller start running, it will increase its cooling capacity to meet the cold demand. The cold demand is essentially the difference between the LCHWT set-point value and the entering cold water temperature in a chiller. The chiller will begin to cool the water until the leaving water temperature in the chiller reaches the LCHWT set-point value. If the difference between the leaving chilled water temperature and its set-point value is very small, the chiller will not see a cold load and will probably stop. For this reason, if we have a very high LCHWT set-point value, especially when the outside temperature is lower and the cold demand is low, it is likely that the chiller will not start or start and stop quickly due to a low cold demand (not cold load). If this is the case where the GCOP controller is installed, the GCOP can be setup to set the lower LCHWT set-point when the chiller starts running and increase its cooling capacity.

In order for the GCOP controller to set the lowest LCHWT set-point value when the chiller starts running and begins to increase cooling capacity, it is necessary to setup some of the parameters located in the second configuration screen of the variable set-point system as shown below:

Capacity Stability Seconds	0	Capacity for Control	0.00
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In the "Capacity Stability Seconds" box, enter a time value in seconds, that will be the time that the GCOP controller will wait after the chiller starts running to apply the variable LCHWT set-point algorithm in that chiller.

When the chiller stops, its cooling capacity is zero, and it is detected by the GCOP controller. The GCOP will then set a fixed LCHWT set-point value equal to the "Min LWT Setpoint" value entered in the table explained early (in the example illustrated above, the minimum set-point is 44 and the maximum is 53). When the elapsed time is equal or greater than the value entered in the "Capacity Stability Seconds" box, the GCOP will then start resetting the LCHWT set-point value according to the variable set-point algorithm result. During that time the chiller starts running with the minimum fixed LCHWT set-point value, and reach a cooling capacity value that allows the GCOP to continue using the variable set-point control. For example, if you entered the value of 600 seconds, it means that the chiller, once it starts running, it begins to increase its cooling capacity using a fixed LCHWT set-point value of 44 oF, and after 10 minutes, the chiller will probably be running with a cooling capacity of 30% and the GCOP starts to reset the LCHWT set-point value.

Sometimes, setting a time for the chiller to increase its cooling capacity when it starts running, in order to reset the LCHWT set-point value after that time has elapsed is not enough. In some cases we must wait until the chiller exceeds a certain cooling capacity value to start applying the variable set-point algorithm.

If you enter a minimum cooling capacity value in the "Capacity for Control" box, the GCOP will only start to reset the LCHWT set-point value when the cooling capacity of the chiller is greater than the entered minimum cooling capacity value, unless the time value entered in the "Capacity Stability Seconds" box has not been elapsed yet. In the same way, if the capacity stability time has been elapsed and the actual cooling capacity value is lower than the capacity for control value, the GCOP will not reset the LCHWT set-point value.

We can enter both parameters, or only one of them, or set both to zero. If we only enter the capacity value for control and set the stability time to zero, the GCOP will set the minimum LCHWT set-point value (i.e. 44 oF) when the chiller starts running, and when the actual cooling capacity of the chiller meets the capacity for control value, the GCOP will start to reset the LCHWT set-point.

If the chiller is already running with a cooling capacity greater than the capacity defined for control, and therefore it is resetting the LCHWT set-point according to the optimization algorithm, if the actual chiller capacity drops below the capacity for the control value (with chiller still running), the LCHWT set-point value will be reset only if the new set-point value calculated by the algorithm is lower than the actual set-point value, and when the actual cooling capacity exceeds again the capacity value for control, the GCOP will continue to reset the set-point according to the optimization algorithm.

If both parameters are set to zero, the initial cooling capacity will not be taken in consideration to calculate the LCHWT set-point when the chiller starts running.

It is possible that the output Bacnet variables mapped in the GCOP controller to send the LCHWT set-point value to each chillers, use the same definition (same type, IP address and instance) for all the chillers, so you only need to write one Bacnet variable to change the value of the LCHWT set-point in all the chillers simultaneously. In this case, you cannot control the LCHWT set-point individually in each chiller, so the initial cooling capacity will be considered only when one chiller is operating in the chiller plant. When more than one chiller is running, if the initial cooling capacity were considered, it would interfere with the application of optimization algorithms in the running chillers when one of the chillers stops and then starts because the same LCHWT set-point value calculated for one chiller (the chiller that stops) would be sent to the rest of the chillers in the plant.

It is recommended to map individually each output Bacnet variable to send the LCHWT set-point value to each chiller if we want to consider the initial cooling capacity in the optimization algorithm. We will discuss the way to map variables later in this document.

Capacity Limit Setpoint Control:

The GCOP can control the initial Capacity Limit Setpoint of the chiller. It is very useful when we have a chiller stopped for a number of hours and when the chiller is started again it has to overcome the initial thermal load which result a high demand of energy consumption. To avoid this demand, we can, for example, set the initial Capacity Limit of the chiller in 60% during 20 minutes. In this time the chiller overcome the thermal load and could stabilize a Cooling Capacity value of 45%, after that time we can set the Capacity Limit to 80% for another 20 minutes and after that time we set this limit to 100%.

To accomplish this control we use the following table:

Capacity Limit Control	Value	Control Params	Phase I	Phase II
Enable Control	<input type="button" value="OFF"/>	Time per phase (min)	10	10
Time Chiller Off (hour)	4	Cap. Limit per phase	60.00	80.00

To enable the Capacity Limit Control, click on the Enable Control button setting the ON position.

In the Time Chiller Off (hour) edit box, set the minimum number of hours that the chiller must stay stopped in order to apply the control. In this example, if the chiller was stopped for four or more hours, the Capacity Limit will be changed when the chiller starts.

In the Time per phase (min) edit box corresponding to Phase I, set the time in minutes that the chiller will be with the first capacity limit, and in the Cap. Limit per phase edit box of the same phase, set the initial capacity limit value that the chiller will have when it starts.

In the Time per phase (min) edit box corresponding to Phase II, set the time in minutes that the chiller will be with the second capacity limit, and in the Cap. Limit per phase edit box of the same phase, set the second capacity limit value that the chiller will have after the time of the phase I will be elapsed.

In the above example, if the chiller was stopped for more than 4 hours, when it starts, the GCOP set the Capacity Limit Setpoint to 60% during 10 minutes, after that time, the GCOP set the Capacity Limit Setpoint to 80% during the next 10 minutes and after 20 minutes the GCOP set the Capacity Limit Setpoint to 100%

Humidity control:

Changes in temperature affect humidity. As the variable set-point optimization system makes small changes in the leaving chilled water temperature, humidity can be monitored in order to take the necessary actions to avoid affecting it. Normally the humidity is affected when the local temperature control in the zone is saturated and it cannot control the cold load in that zone, which is very unlikely if we have a well-balanced air conditioning system. For example, if we have a LCHWT set-point value of 46 oF in the chiller and the valve of the air handler unit (AHU) of a local room is at 60% open, when the LCHWT set-point value is raised to 48 oF this valve could continues managing the cold load being now at 80% open, in this case the humidity is practically unaffected. But if the valve reaches 100% and cannot control the cold load, it is very likely that humidity will be affected.

To avoid that the humidity could be affected, you can configure the maximum limit of relative humidity allowed in the most critical room. That room must have an humidity sensor installed. This limit value is entered in the box corresponding to the "Limit" column of the following table in the configuration page:

Description	Value	Limit	Dead Band	Enable
Humidity	0.00	70.00	0.10	OFF

When the GCOP controller calculates a new LCHWT set-point value, and because of this action, the relative humidity monitored in this local exceeds the value of this limit, the GCOP then adjusts again the LCHWT set-point value in order to lower the relative humidity in that local. A dead band parameter is entered to avoid continuous variations in the set-point value when the humidity is oscillating around the limit. The dead band value is entered in the box corresponding to the "Dead Band" column.

Finally to use this control, you have to click on the button in the "Enable" column to activate the control. If the control is enabled, the button shows a green line, with the ON text, and if it is disabled it shows the OFF text and the line turns gray.

Space Temperature Control.

Changes in LCHWT set-point value in chiller plant might affect the space temperature of the room in various zones, if the local temperature control in that zones becomes saturated and cannot control the local cold load, which is unlikely if the air conditioning system is properly balanced as commented above in the case of humidity control.

The GCOP controls the space temperatures affectations by comparing either the average temperature value of all the zones or the maximum temperature value in all the zones, with a pre-defined limit. If this limit is overtaken, the GCOP resets the LCHWT set-point to a lower value to decrease the zones temperature.

The following screen shows the parameters related to the zones temperature control:

Space Temperature	0.00	80.00	0.10	OFF
Space Temperature Control: Max Value				
Zones Temperature		Send Data		

The "Space Temperature Control" box allows us to select one of two possible options: " Max Value" or "Average", as shown below:

Max Value	<input checked="" type="radio"/>
Average	<input type="radio"/>

If "Max Value" option is selected, the maximum temperature value of all the zones is compared with the limit entered in the "Limit" column of the "Space Temperature" row in the previous table. If "Average" option is selected, then entered limit is compared with the average temperature of all the zones.

In the box located in the "Source Temperature Control" row and "Value" column of one of the tables in this screen, the result value of the selected option for the control of up to 8 temperature zones (average or maximum value) is displayed.

In the "Space Temperature" row and "Limit" column box, enter a comparative limit value used by the GCOP controller to resets the LCHWT set-point value when the Space Temperature Control is enabled. As the case of humidity control, in the "Dead Band" column box, enter a dead band value to avoid continuous variations in the set-point value when the result of the zone temperatures calculation is oscillating around the limit.

Finally the button in "Enable" column box is used to enable or disable the Space Temperature Control, very similar to the case of humidity control already explained.

Click on "See Zones Temperatures" button, to display the temperature value of up to eight zones as shown:

Green Cop. Zones Temperature

Description	Value
Temp. Zone 1	0.00
Temp. Zone 2	0.00
Temp. Zone 3	0.00
Temp. Zone 4	0.00
Temp. Zone 5	0.00
Temp. Zone 6	0.00
Temp. Zone 7	0.00
Temp. Zone 8	0.00

To return to the previous screen, click on button with an arrow in the upper left corner

Configuration of the Sequence Optimization System.

The sequencing algorithm basically consists of keeping running the minimum number of chillers needed, with the highest efficiency, to meet the cold demand in every moment. A typical chiller plant usually consist of two or more chillers. In the optimization algorithm the first chiller is defined as master and the rest are slaves. The master chiller is the first chiller that start running and when it reaches the most efficient cooling capacity percent, and the required cold demand has not been met yet, the GCOP optimizer orders to start running the next chiller in the sequence. While the first or master chiller meets the cold demand, the next chiller in sequence does not start. If with each chiller that is running, the cold demand is not met, the next chiller in the sequence will start running until all the chillers are running.


On the other hand, when the cold demand drops, the last chiller that started running will stop and while the cold demand continues dropping and the chillers are leaving the most efficiency cooling capacity percent, they will stop until only the minimum number of chillers needed to meet the cold demand are running, each one at its most efficient cooling capacity percent.

To avoid a higher mechanical wearing on the master chiller, the GCOP optimizer carries out a rotation of the master chiller in the sequence, which guarantees an even average of operation hours in each chiller.

The optimization algorithm use artificial intelligence to learn at any time what chiller is more efficient, and adjusts the rotation times of the chillers so that, with the minimal number of the most efficient chillers running, the cold demand is satisfied..

Cold demand is usually calculated as follows:


Demand = (Entering Temp - Leaving Temp. SP) +/- Dead Band. Besides, it is also taken in consideration the cooling capacity percent of the chiller and how far is the leaving chilled water temperature from the set-point value for that temperature. In this equation "Entering Temp" is the entering chilled water temperature, "Leaving Temp. SP" is the leaving chilled water temperature set-point, and "Dead Band" is a parameter used to avoid continuous variations in the result of comparing the calculated cold demand value with pre-defined references used to decide where to start running the next chiller in the sequence.

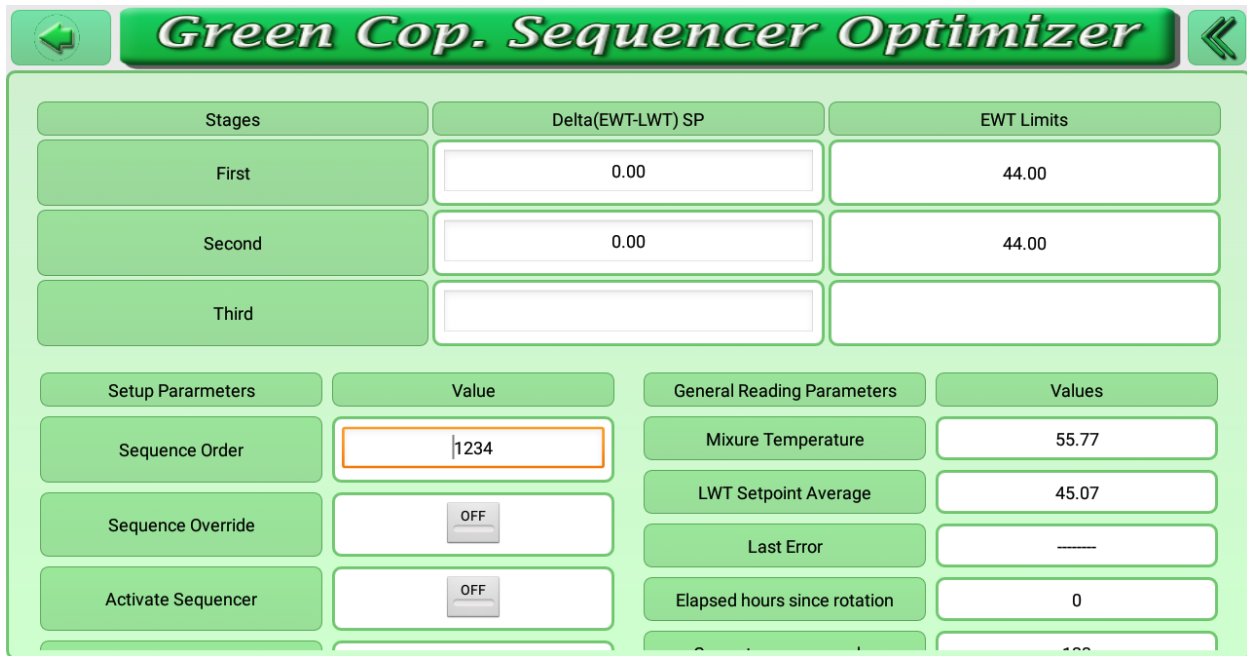
To go to the sequence optimization configuration screen, click on  option in the main menu, and the following screen is shown:

Green Cop. Sequencer Optimizer				
Description	CHILLER 1	CHILLER 2	CHILLER 3	CHILLER 4
Maximum Capacity	100	100	100	
Computed Capacity	97.00	97.00	91.00	
Real Capacity	95.00	92.00	74.55	
Alarm Status				
Chiller ON/OFF				
Chiller Status				
Enable EWT Average				
Enable to Sequence				
Entered CHW Temp.	55.80	55.40	56.10	

Scrolling down on this screen we show the rest of the parameters:

Green Cop. Sequencer Optimizer				
Enable to Sequence				
Entered CHW Temp.	55.80	55.40	56.10	
Leaving CHW Temp.	44.40	44.20	48.80	
Actual Chiller Temp. SP	44.00	44.00	47.20	
Entering CW Temp.	0.00	0.00	0.00	
Leaving CW Temp.	0.00	0.00	0.00	
CHW Pump Status				
CW Pump Status				
Communication State				
Manual Order ON/OFF				

If we click on the upper right  button, we second configuration screen of the sequence optimization is shown:

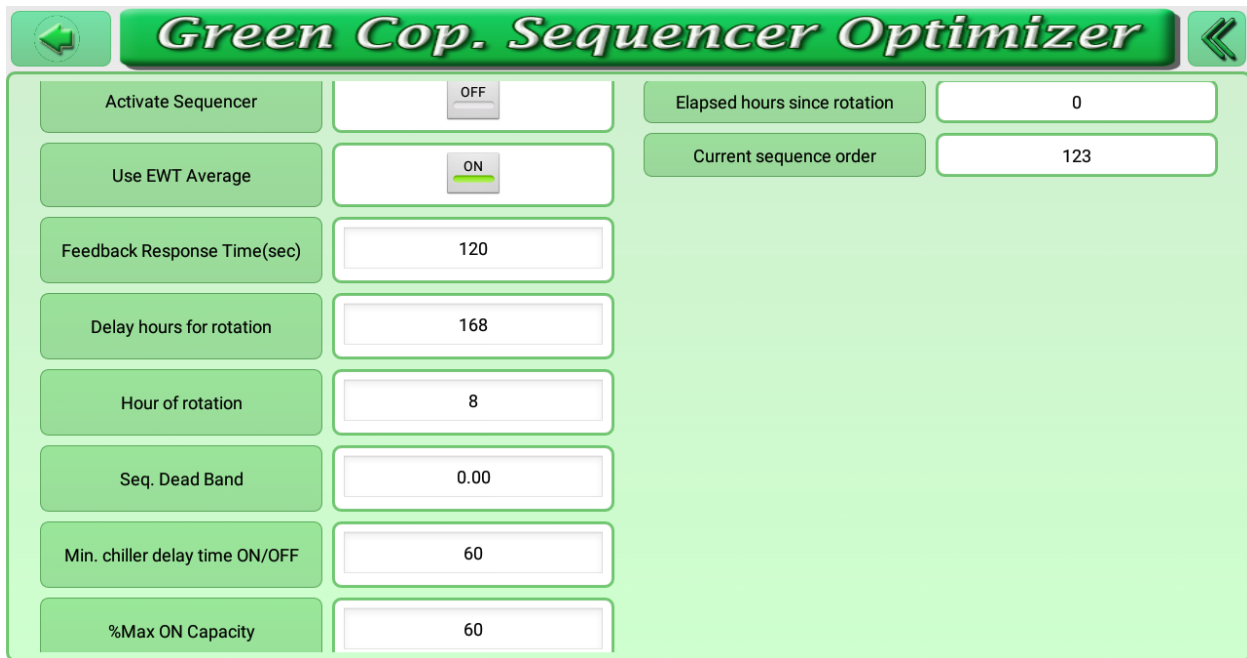


Green Cop. Sequencer Optimizer

Stages	Delta(EWT-LWT) SP	EWT Limits
First	0.00	44.00
Second	0.00	44.00
Third		

Setup Parameters	Value	General Reading Parameters	Values
Sequence Order	1234	Mixture Temperature	55.77
Sequence Override	OFF	LWT Setpoint Average	45.07
Activate Sequencer	OFF	Last Error	-----
		Elapsed hours since rotation	0

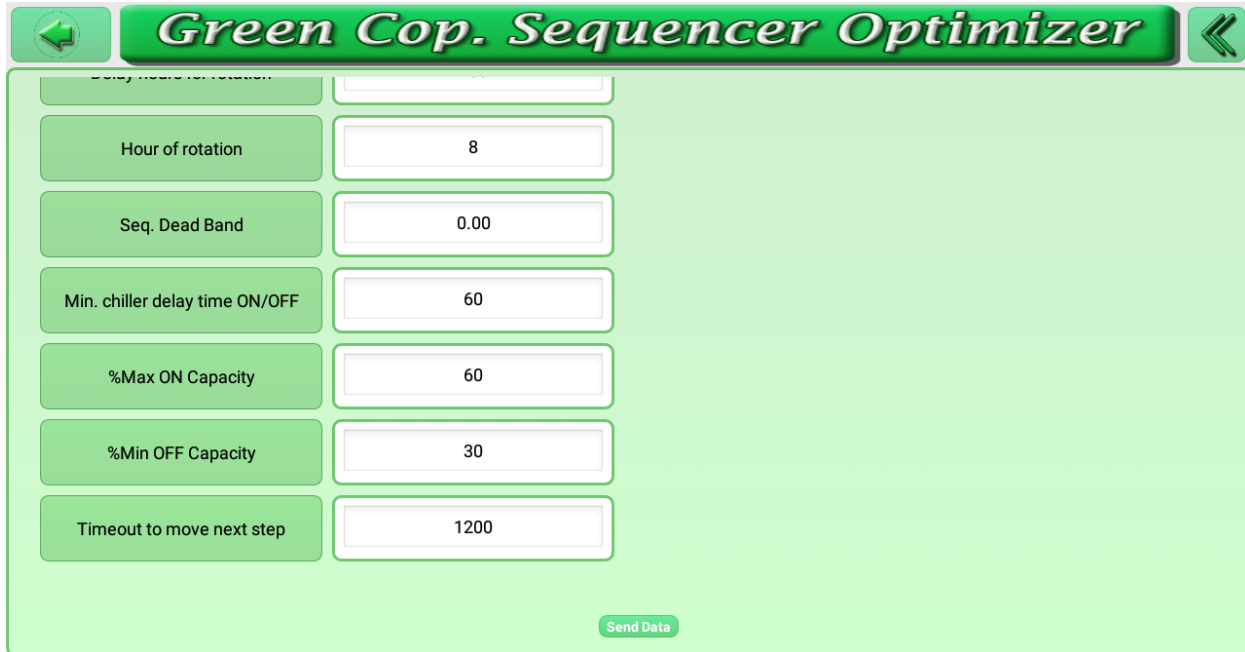
Scrolling down on this screen we show others parameters:



Green Cop. Sequencer Optimizer

Activate Sequencer	OFF	Elapsed hours since rotation	0
Use EWT Average	ON	Current sequence order	123
Feedback Response Time(sec)	120		
Delay hours for rotation	168		
Hour of rotation	8		
Seq. Dead Band	0.00		
Min. chiller delay time ON/OFF	60		
%Max ON Capacity	60		


And making a last scroll down we show the rest of the parameters:



The interface is titled "Green Cop. Sequencer Optimizer" in a green header bar. It features a left arrow button and a double-left arrow button. Below the header, there are seven input fields with green labels and white text boxes. The fields are: "Hour of rotation" (8), "Seq. Dead Band" (0.00), "Min. chiller delay time ON/OFF" (60), "%Max ON Capacity" (60), "%Min OFF Capacity" (30), and "Timeout to move next step" (1200). A "Send Data" button is located at the bottom right of the form.

Hour of rotation	8
Seq. Dead Band	0.00
Min. chiller delay time ON/OFF	60
%Max ON Capacity	60
%Min OFF Capacity	30
Timeout to move next step	1200

Send Data

To return to the first configuration screen we click on  button:

The first configuration parameters of the sequencing algorithm are found in the "Stages" table as shown below:

Stages	Delta(EWT-LWT) SP	EWT Limits
First	0.00	44.00
Second	0.00	44.00
Third		

The first value to enter is the "Delta (EWT-LWT) SP", located in the "First" row box. This value is the maximum difference between the entering chilled water temperature and the average leaving chilled water temperature set-point to start running the second chiller in the sequence. The algorithm assumes that master chiller (# 1 in the sequence) is always running. This difference is proportional to the actual cold demand, so this parameter is a first cold demand set-point. Later we explain how other parameters, such as the actual cooling capacity percent of the running chiller is taken in consideration before starting the next chiller in the sequence.

If there are more than two chillers in the chiller plant, a second "Delta (EWT-LWT) SP" must be entered in the "Second" row box. This value is the maximum difference between the entering chilled water temperature and the average leaving chilled water temperature set-point to start running the third chiller in the sequence, assuming that the chillers 1 and 2 are already running.

If there are more than three chillers in the cooling plant, a third "Delta (EWT-LWT) SP" is entered in the "Third" row box: This value is the maximum difference between the entering chilled water

temperature and the average leaving chilled water temperature set-point to start running the third chiller in the sequence assuming that the chillers 1, 2 and 3 are already running.

Note that the "Delta (EWT-LWT) SP" must be increased in each stage. If this maximum difference increases, it is because the cold demand increases and more chillers are needed to be running.

As the difference between the entering chilled water temperature and the average leaving chilled water temperature set-point value is higher, the cold demand increases.

Up to 3 stages are defined to decide, as the cold demand grows, when to start running the next chiller in the sequence.

If there are 2 chillers in the chiller plant, we only define one stage or delta value to start running chiller 2, assuming that the chiller 1 is always running.

If there are 3 chillers in the chiller plant, we only define two stages or delta value to start running chiller 3, assuming that the chiller 1 and 2 are running.

If there are 4 chillers in the chiller plant, we define all the three stages or delta value to start running chiller 4, assuming that the chiller 1, 2 and 3 are running.

The above table also have the "EWT Limits" column. When the "Delta (EWT-LWT) SP" is defined, the "EWT Limits" value is the maximum value for the entering chilled water temperature to start running the next chiller in the sequence. This value is the result of adding the delta value to the average leaving chilled water temperature set-point.

The average leaving chilled water temperature set-point is shown in the lower left table of the configuration screen in the "LWT Setpoint Average" row, as shown:

LWT Setpoint Average	45.07
----------------------	-------

In the example above that value is equal to 45.07.

There are 2 ways to measure the entering chilled water temperature. One is to get this value from a sensor located the common water entrance to all the chillers known as the mixed entering temperature, and the other way is calculating the average entering water temperature using each entering chilled water temperature value for each chiller, taking only in consideration those chillers that are running.

To select the average entering chilled water temperature instead of mixed entering water temperature, is necessary to enable the button of the "Use EWT Average" row, as shown:

Use EWT Average	<input checked="" type="checkbox"/>
-----------------	-------------------------------------

Parameter Configuration Table:

This table is headed by:

Setup Pararmeters	Value
-------------------	-------

The parameters entered in this table are:

In the "Sequence Order" row box, enter a value corresponding to the order in which each chiller will start running in the sequence control algorithm. Normally chillers are numbered from 1 to 4, although these values can be changed.

By default, 1234 is assumed, meaning that chiller number 1 is the master in the sequence and the first chiller to start running. The chiller number 2 is the second chiller in the sequence, therefore the second to start running. The chiller number 3 is the third chiller in the sequence, therefore the third to start running. Finally, the chiller number 4 is the forth chiller in the sequence, therefore the forth to start running. If you only have 3 chillers, you can enter the value 123. To change this order, enter a new order, for example, you can enter the 2134 value.

To save any changes made in this configuration screen, click on "Send Data" button.

Although the GCOP optimizer receives this sequence order, it still does not change the current sequence order to avoid malfunctioning.

To force the sequence to be changed by the GCOP optimizer, it is necessary to send an override to the current sequence. To do that just click on "Sequence override" row button, and select the ON option as shown:



With this action, the GCOP optimizer changes the current sequence order and resets the sequence override value to OFF again, so you will see that the "Sequence Override" button turns OFF automatically (this is not an error).

The sequencing algorithm control is disabled by default, and before enabling it, be sure that all the parameters configured are correct. Enabling the sequencing control should be the last step.

To enable the sequencing control you must click on "Activate Sequencer" row button and select ON option.

In the "FeedBack Response Time (sec)" row box, enter the approximate time that will take to the chiller to respond to the start and stop command sent from the GCOP controller. This time begins when the GCOP optimizer send the order, and ends when the chiller controller actually execute that order. In most of the chiller this action takes a while. This time is used by the GCOP controller to know if there were a failure sending the order to start or stop to the chiller. If a chiller does not

execute the order in that defined time, the GCOP optimizer recognize it as a fault, so the GCOP will try to start the next chiller in the sequence if necessary to guarantee the cold load.

In the " Delay hours for rotation " row box, enter the number of hours that the current sequence order should be used. After this time, there will be a sequence order rotation to the left, meaning that if the sequence order is 1234, it will change to 2341, and in this case the new master will be chiller 2. The rotation guarantees an even operating service of the chillers, otherwise the leader or master chiller would be the chiller with the most running hours and the last chiller in the sequence order would be the one with the least running hours. By default the hours for rotation value is 168, which represents a week of service operation.

In the "Hour of Rotation" row box, enter the time of day at which the rotation action takes place. Since rotation may involve starting and stopping chillers, it is recommended that rotation action takes place at a certain time of day, when the maintenance personnel is present to evaluate that everything goes fine. This value will be the first hour of the day after the delay hours for rotation have elapsed. For example, if you entered 168 hours to delay a rotation and this time is met at 4.00 p.m. of today, and the Hour of Rotation was set to 8.00 a.m., then the rotation will take place tomorrow at 8 a.m.

In "Seq. Dead Band" row box, enter the dead band value for sequencing. This value avoid continuously sending the start and stop command to the chiller when the calculated cold demand is oscillating around the pre-defined delta values used to start the next chiller in the sequence order as explained early.

There are other parameters taken in consideration to start or stop the chiller such as: the cooling capacity percent for starting or stopping the chillers, minimum delay to start or stop the chillers , etc.

In the "Min.Chiller Delay Time ON / OFF" row box, enter the time delay that the GCOP controller must wait to send a new start or stop order after sending the last order. This parameter is useful to avoid increasing the electric power demand in a large value, which may happen if more the one chiller is started or stopped at the same time.

In the "% Max. ON Capacity" row box, enter the cooling capacity percent that a chiller must meet before to start the next chiller in the sequence order, when the cold demand has met the delta value configured. For example, if the chiller 1 is running, and the cold demand exceeds the first delta value, then the GCOP controller waits for the chiller 1 to increase its cooling capacity until it meets this maximum on capacity value. It is possible that when the chiller increase its capacity, the cold demand decreases and there is no need to start the next chiller. If the chiller capacity meets this maximum on capacity, and the cold demand is still above the delta value, this means that the chiller is at its most efficient capacity percent, and the next chiller in the sequence order can be started. Following the example, the chiller 2 starts.

In the "% Min. OFF Capacity" row box, enter the cooling capacity percent that a chiller must meet before to stop the last chiller in the sequence order that is running, when the cold demand is below the delta value configured. For example, if the chiller 2 is running and the cold demand is below

the first delta value, then the GCOP controller waits for the chiller 2 to lower its capacity until it be below of the minimum off capacity value. If the cold demand is below the delta value and the chiller cooling capacity is below of the minimum off capacity value, the chiller is stopped. For this example, the chiller 2 is stopped.

In the "Time out to move next step" row box, enter the time value that the GCOP controller must wait, before starting the next chiller in the sequence order, or stop the last chiller running in the sequence order, if the main algorithm criteria is not met in order to not affect the cold demand.

This value is useful in the following cases:

First case: Suppose the cold demand increases and is above the delta value , for example, the chiller 1 is running and the cold demand exceeds the value set in Delta SP1. To start running the next chiller in the sequence order, the GCOP controller must wait until the chiller 1 reaches the cooling capacity percent defined in "% Max Capacity ON". But due to some internal problem in the chiller (probably a compressor out of order), the chiller cooling capacity cannot meet the maximum value defined to start the next chiller, and the cold demand continues increasing. Then it becomes mandatory to start the next chiller to support the load, and for that reason the GCOP controller waits for the time defined here (the value of this time is enough for a normal operating chiller to exceed the cooling capacity percentage defined for the next chiller to start), and starts the next chiller in the sequence order to satisfy the cold demand, if the cooling capacity requirement is not met.

Second Case: Suppose that the cold demand decreases and is bellow the delta value. The last running chiller in the sequence order does not manage to lower its cooling capacity percent below the value defined in "% Min Capacity OFF". For example, there are 3 chillers running with a cooling capacity of 35% each, and the cold demand is already below the Delta SP2 value. The minimum demand to stop the last chillers in the sequence order was defined with a 30% value, and the chiller is keeping a cooling capacity of 35% so it will not stop. For that reason, the GCOP controller waits for the time defined here and after that time, it calculates that the current total chiller plant cooling capacity, for this example it is 105 % (35 + 35 + 35), and if this capacity fits in N-1 chillers the last chiller is stopped. In the example N-1 chillers can reach a cooling capacity of 200 %(100 +100) which is a greater value than 105, so the GCOP controller stops the last running chiller in the sequence order.

Remember to save all these configured parameters by clicking on "Send Data" button.

General Parameters Reading table:

In the third table on the left, headed by "General Reading Parameters", there are some informative values that are not editable, and are shown below:

General Reading Parameters	Values
Mixture Temperature	55.77
LWT Setpoint Average	45.07
Last Error	-----
Elapsed hours since rotation	0
Current sequence order	123

The "Mixture Temperature" row shows the value of the mixed entering chilled water temperature. This variable is either measured at a common entering chilled water collector to the chillers or is the result of the average of the measured entering chilled water temperature in each chiller.

The "LWT Setpoint Average" row shows the average of the LCHWT set-point value of the chiller plant.

The "Last Error" row shows if there was a failure when the GCOP controller is trying to start or stop a chiller. This information is the result of a timeout when the controller waits for the time defined in the "Feedback response time" after sending the order to start or stop the chiller, and the chiller continuous running or stopped after that time.

The "Elapsed hours since rotation" row shows the number of hours that have already elapsed since the last rotation, and this gives an idea of how close is the next rotation process.

The "Current sequence order" row shows the actual sequence order that is actually operating after the last rotation have been carried out.

Note: The "Current sequence order" value may be different from the "Sequence Order" value that was entered in the configuration as explained early, since "Sequence Order" is used to send a new sequence order by the operator that overwrites the current sequence, and "Current sequence order" value is calculated by the GCOP optimizer once the rotation is done.

Table of chillers parameters:

This table is found in the first configuration screen with the following header:

Description	CHILLER 1	CHILLER 2	CHILLER 3	CHILLER 4
-------------	-----------	-----------	-----------	-----------



Some parameters of this table can be modified.



In the "Maximum Capacity" row box, enter the maximum cooling capacity value that the chiller can reach (if the chiller operates normally this value is 100%). This parameter is used by the GCOP controller to know if a chiller has limitations in its operation at a given time or to scale the capacity.



For example, a chiller has four compressors and one of them is out for maintenance service, so that chiller will never meet a cooling capacity of 100% with the lack of one compressor, and it only could reach a maximum of 75% value. In this case, enter the 75 value in the "Maximum Capacity" row box, which means that when that chiller reaches a cooling capacity of 75%, it has actually reached 100% because it only uses three compressors instead of four. Another use of this parameter is scaling the capacity value. Suppose that instead of measuring the cooling capacity, the amperes consumption is measured, and this variable has the 0-150 range value, meaning that 150 amperes represents 100% of cooling capacity. In this case we enter the 150 value in the "Maximum Capacity" row box and the cooling capacity will vary in the 0-100% range value.

The "Computed Capacity" row shows the calculated cooling capacity value using the real capacity measured, and the maximum capacity value entered in the "Maximum Capacity" row box

The "Real Capacity" row shows the real measured value of cooling capacity. If the maximum capacity entered was 100%, the "Computed Capacity" row value and "Real Capacity" row value are equal.

In the "Alarm Status" row, an image is used to indicate if the chiller is in alarm and it is not possible to be properly controlled by the GCOP optimizer. If there is no alarm the image is blue , but if there is an alarm, the image is green .

In the "Chiller ON / OFF" row, an image is used to indicate the GCOP command order to stop or start a chiller. A blue circle  means stop order and a green circle  means start order.

In the "Chiller status" row, an image is used to indicate if the chiller is stopped or running. A blue circle  means the chiller is stopped and a green circle  means the chiller is running.

In the "Enable EWT Average" row box you have an Enable button to activate or deactivate the use of the entering chilled water temperature value of that particular chiller in the entering chilled water temperature average calculation. This is useful when it is known that the entering chilled water temperature sensor of a particular chiller is damaged, and an erroneous value of this temperature must not be considered in the average calculation. To activate click on the button and the button shows the ON text and a green line. To deactivate click on the button again and the button shows the OFF text and the line turns light gray.

In the "Enable to Sequence" row box you have an Enable button to activate or deactivate the use of a particular chiller in the sequence order. This is useful when you do not want to stop a particular chiller as the result of the sequencing algorithm. For example, a particular chiller is used for heat recovery to supply hot water and it is not recommended to stop that chiller. To activate click on the button and the button shows the ON text and a green line. To deactivate click on the button again and the button shows the OFF text and the line turns light gray.



The "Entering CHW temperature" row shows the entering chilled water temperature value.

The "Leaving CHW temperature" row shows the leaving chilled water temperature value.

The "Actual Chiller Temp. SP" row shows the actual leaving chilled water temperature set-point value.


The "Entering CW temperature" row shows the entering condenser temperature value and is only valid for water cooled chillers.

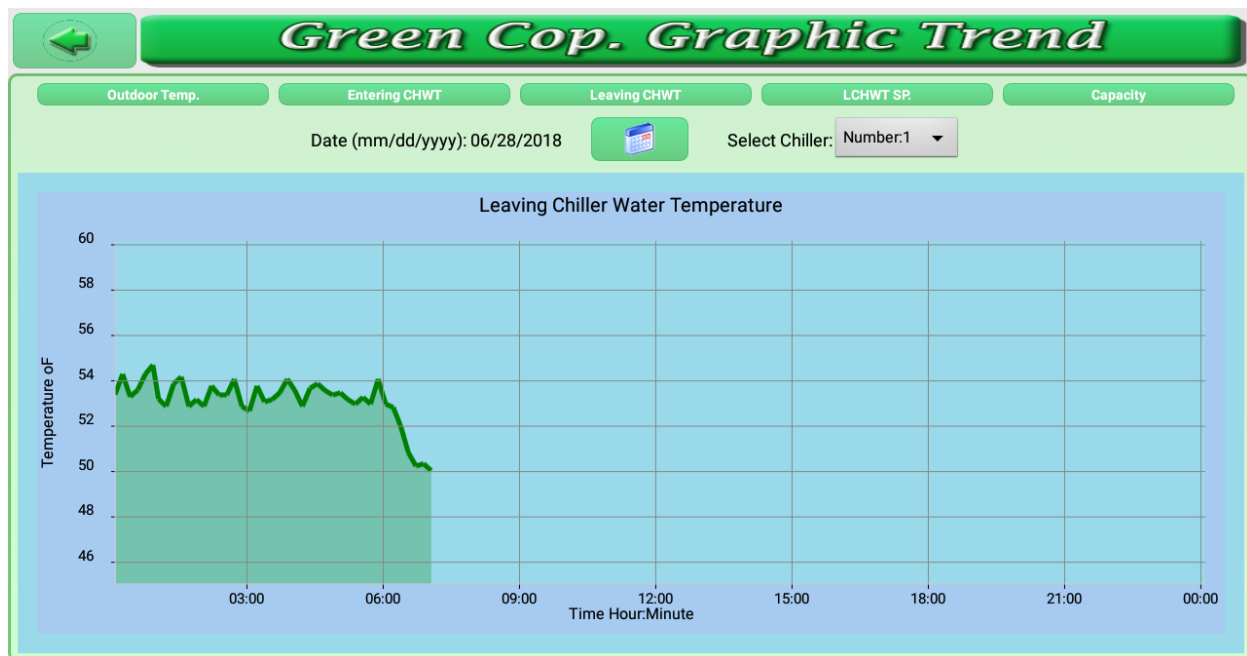
The "Leaving CW temperature" row shows the leaving condenser temperature value and is only valid for water cooled chillers.

In the "CHW Pump Status" row, an image is used to indicate the operating status of the pump that supplies the entering chilled water to the chiller. If the pump is working, an image of a pump appears in green , otherwise if the pump is off, the image appears in red .

In the "CW Pump Status" row, an image is used to indicate the operating status of the pump that supplies the water to the condenser of chillers cooled by water. If the image is green indicates that the pump is on and if it is red, the pump is off.

Trend graphics:


By clicking on  option of the main menu, the following screen is shown:



The GCOP optimizer display a graphic of five important variables that are used in its optimization algorithm, which are:


- Outside Temperature value
- Entering chilled water temperature value
- Leaving chilled water temperature value
- Actual leaving chilled water temperature set-point value
- Chiller cooling capacity.

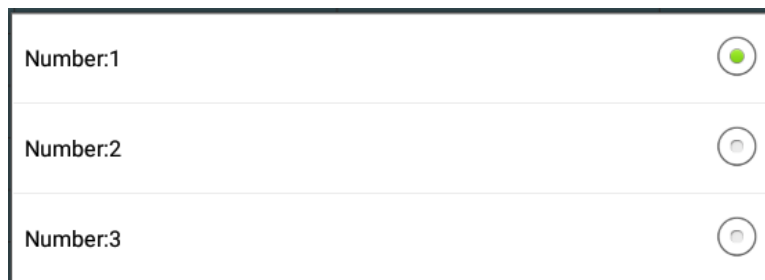
The first graphic in the screen correspond to the leaving chilled water temperature value of one of the chiller in the last 24 hours.

You can select the day you want to display by clicking on the  button to show a setup window , as shown:




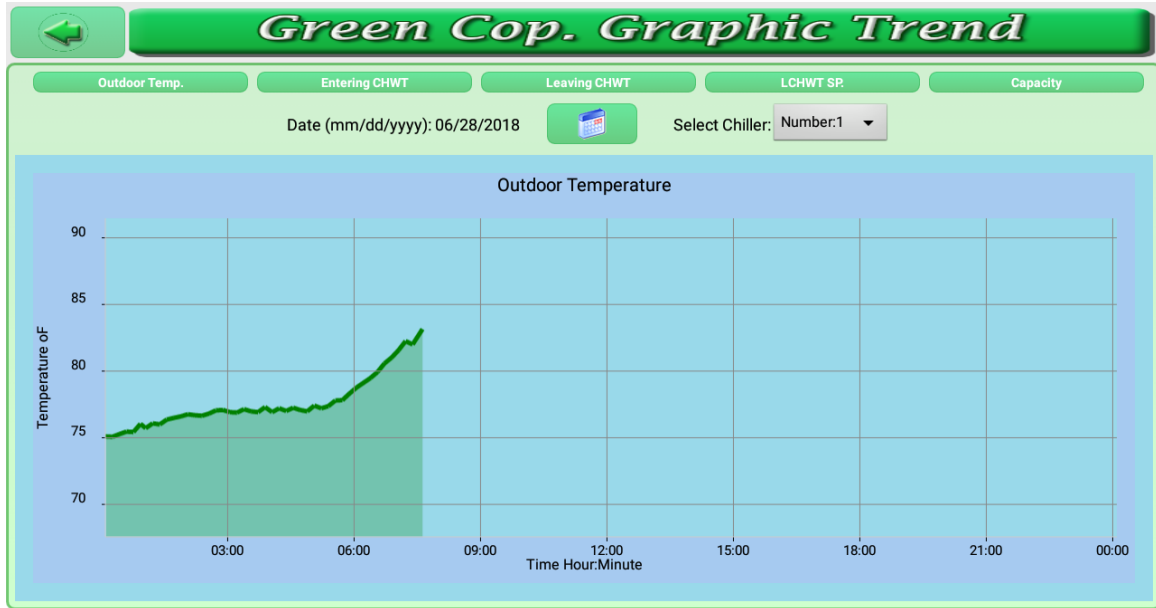
Once the date has been selected using the + and - buttons, click on "OK" button and the graphic corresponding to that day will be loaded in the screen.

To select the chiller that has the parameters to graphic, click on  button, and select the chiller number from a list as shown:



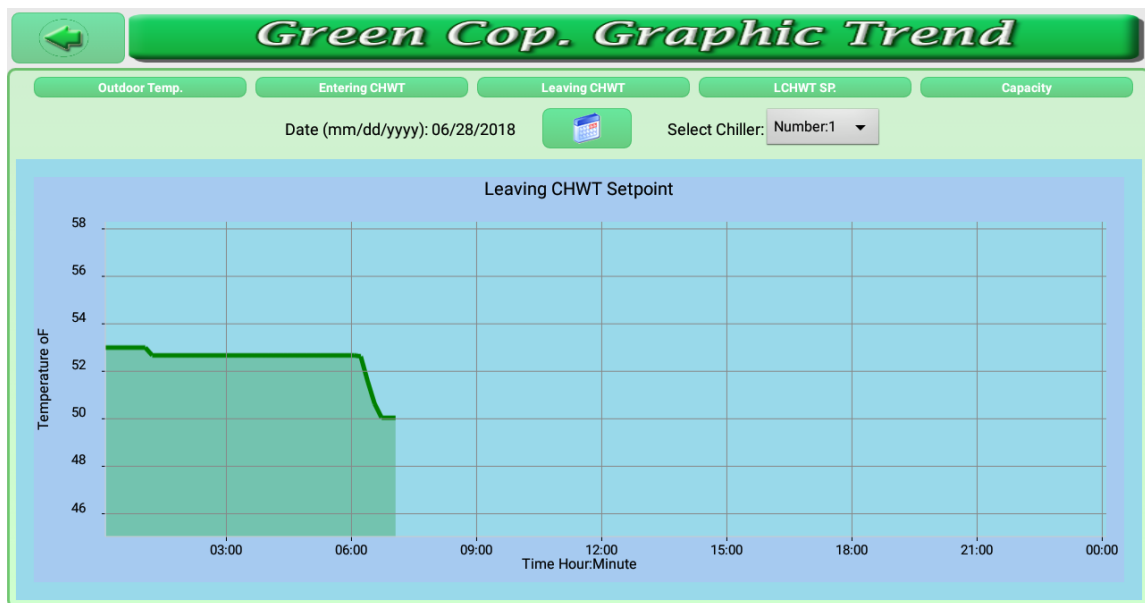
Once the chiller number is selected, the graphic of the selected variable for that chiller is automatically displayed.

To select the outdoor or ambient temperature graphic click on  button, the following graphic is shown:



To select other variables just click on the corresponding button.

As a result of the variable LCHWT set-point value algorithm in the GCOP controller, the actual leaving chilled water temperature set-point graphic may look like this one below:

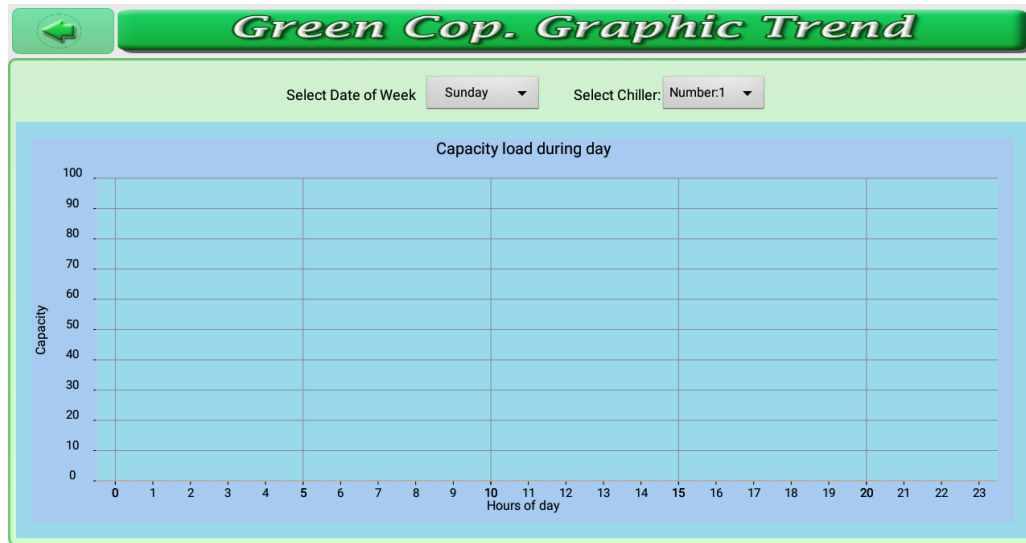


Notice that instead of a fixed LCHWT set-point value, this value varies during time of day.

Chiller cooling capacity behavior graphics.

The **Capacity Load** option in the main shows the chiller cooling capacity behavior every hour each day of the week.

This graphic is displayed as follows:



This bar chart shows, for each day of the week, the chiller cooling capacity per hour.

The capacity values in the graphic were taken when the chiller has the lowest fixed LCHWT set-point value in order to know the magnitude of the cold demand in every hour of day. If the LCHWT set-point value varies, the cold demand could change due to the variations of this set-point (cold demand decrease if the LCHWT set-point value increase), so with a fixed set-point value you get a real variation of the cold demand during the hours of day

The process of taking daily data of the chiller cooling capacity in order to know the behavior of the cold demand is named learning process. This process helps the optimization algorithm to make operational decisions. If there is no data saved in the GCOP controller database, the optimization algorithm uses the average capacity of the chiller during the last hour to make decisions.

Two methods can be used to get the data for the learning process,

The faster method consists of disabling the "Enable Control" button for the variable LCHWT set-point algorithm in the configuration screen for a whole week and also setting a fixed LCHWT set-point value (the lowest possible, i.e. 44oF) in that week. It takes a week for a full learning.

The slowest method is to put the GCOP controller in evaluative mode.

The evaluative mode automatically enabled and disabled the optimization control algorithms every other day. In even days the optimization control algorithms are enable and in odd days the algorithms are disabled and the LCHWT set-point value is automatically fixed in the minimum value that was configured in the configuration screen. The learning process described is carried out only in the odd days, and it will takes a month for a full learning.

In either method, if more days are taken into account, more accurate the results are.

The evaluative mode is used to evaluate the energy savings in chiller plants when using the optimization control algorithms, and the way it is carried out guarantees similar environmental and

occupational conditions for the day with control and the day without control. Later in this document, it is explained how to put the GCOP controller in evaluative mode.

In the graphic, to select the day of the week to observe the cold demand, click on

Select Date of Week

Sunday ▾

 button and a list of the days of the week is shown:

Sunday	<input checked="" type="radio"/>
Monday	<input type="radio"/>
Tuesday	<input type="radio"/>
Wednesday	<input type="radio"/>
Thursday	<input type="radio"/>
Friday	<input type="radio"/>
Saturday	<input type="radio"/>

Once the day of the week is selected, the graphic of that day is displayed.

To select the chiller number of interest, just click on

Select Chiller: Number:1 ▾

button.

Monitoring Mapped Bacnet Points.

To monitor some variables that were mapped in the GCOP controller using Bacnet protocol, click on **Bacnet Values** button of the main menu and the following screen is shown:

←
Green Cop. Bacnet Variables

Address	Variable Name	Value	Address	Variable Name	Value
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—
—	—	—	—	—	—

Using the setup program for the GCOP controller (GCOP_Setup) or the "Variable Setup" option of the main menu in the GCOP controller, it is possible to map some additional variables besides those already used in the optimization algorithms. This is useful to monitor other important parameters in the chillers operation.

In the "Address" column is displayed the last number of the IP address of to the Bacnet device that contains the variable of interest, for example, if the Bacnet device IP address is 192.168.100.12, the 12 value will be displayed in that column. In the "Variable Name" column is displayed the name defined for that variable, and in the "Value" column, the variable value will be displayed.

Monitoring all the mapped GCOP controller variables to detect communication errors

To monitor the variables that are mapped in the GCOP controller, click on button of the main menu and the following screen is shown:


Variables

Green Cop. Devices Variables

06/27/2018 17:07:59	Chiller 1 LWT SP Reading: 44.00
06/27/2018 17:07:59	Chiller 1 LWT SP Output: 44.00
06/27/2018 17:07:59	Chiller 1 ON/OFF: 1.00
06/27/2018 17:07:59	Chiller 2 EW Temperature: 55.50
06/27/2018 17:07:59	Chiller 2 LW Temperature: 45.70
06/27/2018 17:07:59	Chiller 2 Status: 1.00
06/27/2018 17:07:59	Chiller 2 Alarm Status: 0.00
06/27/2018 17:07:59	Chiller 2 Current Capacity: 91.00
06/27/2018 17:07:59	Chiller 2 LWT SP Reading: 44.00
06/27/2018 17:07:59	Chiller 2 LWT SP Output: 44.00
06/27/2018 17:07:59	Chiller 2 ON/OFF: 1.00
06/27/2018 17:07:59	Chiller 3 EW Temperature: 56.40
06/27/2018 17:07:59	Chiller 3 LW Temperature: 44.40
06/27/2018 17:07:59	Chiller 3 Status: 1.00
06/27/2018 17:07:59	Chiller 3 Alarm Status: 0.00
06/27/2018 17:07:59	Chiller 3 Current Capacity: 99.00
06/27/2018 17:07:59	Chiller 3 LWT SP Reading: 44.00
06/27/2018 17:07:59	Chiller 3 LWT SP Output: 44.00
06/27/2018 17:07:59	Chiller 3 ON/OFF: 1.00
06/27/2018 17:07:59	Outdoor Temperature: 84.88
06/27/2018 17:08:28	Write to IP: 192.168.1.225 Name: Chiller 1 ON/OFF Value 1.00
06/27/2018 17:08:28	Write to IP: 192.168.1.225 Name: Chiller 2 ON/OFF Value 1.00
06/27/2018 17:08:28	Write to IP: 192.168.1.225 Name: Chiller 3 ON/OFF Value 1.00
06/27/2018 17:08:29	List of values. Time:17:08:29
06/27/2018 17:08:29	Chiller 1 EW Temperature: 55.50
06/27/2018 17:08:29	Chiller 1 LW Temperature: 44.20
06/27/2018 17:08:29	Chiller 1 Status: 1.00
06/27/2018 17:08:29	Chiller 1 Alarm Status: 0.00
06/27/2018 17:08:29	Chiller 1 Current Capacity: 91.00

With the help of this screen you can see if all the variables are properly read, if there is a communication error this will be displayed.

Initial setup of the operational parameters in the GCOP controller.

Clicking on  button of the main menu the following screen is shown:

Green COP. Setup

Description	Value
New Password	<input type="text"/>
Confirm Password	<input type="text"/>
Admin Password	<input type="text"/>
Confirm Admin Password	<input type="text"/>
GCOP URL	<input type="text" value="http://www.greenmediahd.com/gcop/log"/>
GCOP User Code	<input type="text" value="10"/>
Meter URL	<input type="text" value="http://www.GreenMediaHD.com/meters/"/>
Meter User Code	<input type="text" value="10"/>
	<input type="text"/>

And scrolling down, the rest of the parameters are shown:

Green COP. Setup	
Meter Device Number	1
Web Upload Period	10
Sample Period	10
Bacnet Port	47808
Write Priority	15
Temperature Unit	Fahrenheit
Evaluation Mode	OFF
City Name for temperature	Hialeah, FL
Save Data	

The GCOP controller allows you to define two types of password. The first password will give access to the configuration screens of the variable setpoint and sequencer algorithms, and to quit the application. The second password is for administrative purposes, it give you access to the Setup and Variable Setup screens.

Informative screens, such as the graphic trend screen, do not require a password to get access.

The first password is GMHD by default. To change this password enter the new password in the "New Password" box and re-enter it in the "Confirm Password" box.

The second password is adminGMHD by default. To change this password enter the new password in the "Admin Password" box and re-enter it in the "Confirm Admin Password" box.

The GCOP controller sends data to the GCOP Web Server. In the "GCOP URL" box, the GCOP Web Server url is displayed with the default value: <http://greenmedia.com/gcop/login.php>.

In the "GCOP User Code" box enter the authentication code for the GCOP controller in the GCOP Web Server. This code is supplied by DLControl & Engineer.

If the GCOP controller is also used to measure electric power consumption, then the url of the Meter Web Server must be entered in the "Meter URL" box, the default value of this url is <http://greenmedia.com/meters/login.php>.

In the "Meter User Code" box enter the authentication code for the GCOP controller in the Meter Web Server. This code is supplied by DLControl & Engineer. This parameter is not necessary if the electric power measurement will not be used.

In the "Meter Device Number " box enter the number of the meter associated with this GCOP controller. This number identifies a particular meter in the meters local network when more than one meter is sensed. This parameter is not necessary if the electric power measurement will not be used.

In the "Web Upload Period" box enter the period of time in minutes value to periodically upload the GCOP controller data to the Web Server.

In the "Sample Period" box enter the time interval for reading the different parameters mapped in the GCOP controller from the chiller interface. Note: the writing action from the GCOP controller to the chiller interface are executed immediately.

In the "Bacnet Port" box enter the Bacnet UDP port used in the chiller interface. By default, the UDP port associated with the Bacnet IP communication protocol is 47808 (BAC0 Hex), but this port value can be changed.

In the "Write Priority" box enter the write priority value used to override a value in the Bacnet Interface . The Bacnet communication protocol defines the write priorities to control how two or more client devices have to write a value to a server device at the same time, and only the one with the highest write priority writes the value. A total of 16 (0 ... 15) priorities are defined, the first two are related to "Safety", "Manual Life-Safety" and "Automatic Life-Safety". Usually the lowest priority, i.e., 15, is used, unless you need to define a higher one.

The "Evaluation Mode" box is used to enable or disable the evaluative mode in the GCOP controller. As discussed earlier, the GCOP controller can be set into evaluation mode to have a real estimation of energy savings in the chiller plant. In the evaluation mode, optimization algorithms only work on even days, and on odd days the algorithms are disconnected and the LCHWT set-point is set to a fixed value equal to the minimum LCHWT set-point configured in the configuration screen. With the data of both days, the GCOP controller calculate the difference between the chiller cooling capacity on days with control and days without control. The result is plotted on the web server. The chiller cooling capacity is directly proportional to the chiller energy consumption. To set the GCOP controller in evaluation mode, click on the "Evaluation Mode" box button. If the button shows the ON text and a green line, the mode is enabled, but if the button shows the OFF text and a light gray line, the mode is disabled.

In the "City Name" box enter the name of the city and the country, separated by a comma, where the GCOP controller is installed. The GCOP controller uses the outside temperature value as an important parameter in the variable LCHWT set-point algorithm. Normally the outdoor temperature value is available in one or more Bacnet interface in the local network (the chiller interface or any other controller of an BMS system). If there is no field sensor for outside temperature, the GCOP controller takes the temperature value from a Weather Web Server using the location entered in the "City Name" box. For example, in the case of Panama City, enter Panama City, Panama in the editing box.

Discovering and mapping all the Bacnet IP variables used in the GCOP Controller.

So far in this document, with every option of the main menu described in details, the optimization algorithms have been configured and the GCOP controller is ready to optimize and save energy in the chiller plant.

It was assumed that all the chillers parameters are already mapped in the GCOP controller.

The GCOP controller use Bacnet IP or Modbus TCP/IP communication protocol to get all the variables needed from the chillers or any other field controller.

These variables must be correctly mapped in the GCOP controller to use their values in the different optimization algorithms. The mapping of variables will depend on the type and model of each chiller connected in the local network with the GCOP controller.

There are two methods to map the variables in the controller:

1. Use the GCOP_Setup.exe program that is executed on a Windows PC connected in the same GCOP controller local network. With this program, the Bacnet IP or Modbus TCP/IP points are mapped and the configuration file is transferred to the GCOP controller. For more information consult the GCOP_Setup user manual.
2. Map all Bacnet IP variables using the "Variable Setup" option in the main menu of the GCOP controller. With this option there is no need to use any auxiliary program.

The second method to map all the necessary variables in the GCOP controller will be described in detail in this document.

To discover, setup, modify or add the variables used in the optimization algorithms click on

Variable Setup

button of the main menu. The functionality of the GCOP Controller will be temporarily stopped while inside this option to avoid operational errors when defining the variables. The following warning window will be displayed to alert of that action:



Click on Yes button to continue and the following screen is shown:

Green Cop. Device Discovery

Amount: - 2 + Chiller: Number 1 Chiller Plant Additional Variables M & V Config Save Config

Chiller Input Variables			Chiller Output Variables		
Enter CHW Temp	Chiller 1,EW Temperature	...	CHW Temp SP 1	Chiller 1,LWT SP Output	...
Leaving CHW Temp	Chiller 1,LW Temperature	...	CHW Temp SP 2		...
Chiller Status		...	Capacity Limit SP	Chiller 3,LWT SP Output	...
Alarm Status	Chiller 1,Alarm Status	...	Chiller ON[/OFF]		...
Current Capacity	Chiller 1,Current Capacity	...	Chiller OFF		...
Load AMPs		...	CHWP ON/OFF		...
CHW Temp SP	Chiller 1,LWT SP Reading	...			
Active Capacity Limit	Chiller 3,LWT SP Reading	...			
CHW Pump Status		...			

In the left table, scroll down to see the rest of the parameters:

CW Pump Staus		...
Capacity Compresor 1		...
Capacity Compresor 2		...
Capacity Compresor 3		...
Capacity Compresor 4		...

In this screen the variables of each individual chiller are mapped.

The screen shows the name of each variables used in the optimization algorithms that must be mapped.

The first thing to do is to select the number of chillers located in the chiller plant by using the "Amount" option. Click on the +/- buttons to increase or decrease the value.

Then select which of the chillers is going to be mapped using the "Chiller" option as shown:

Number 1	<input checked="" type="radio"/>
Number 2	<input type="radio"/>
Number 3	<input type="radio"/>
Number 4	<input type="radio"/>

You can only select between 1 and the number specified in "Amount" option.

To map the variable, click on  button corresponding to the variable to map and the following screen is shown:



The interface is titled "Green Cop. Device Discovery" in a green header bar. Below the header, there are several input fields and buttons:

- Selected File:** A dropdown menu.
- Type:** A dropdown menu set to "Analog - Input".
- Get Value:** A green button.
- 0:** A text input field containing the number 0.
- Set:** A green button.
- Get Data:** A green button.
- Name:** A text input field.
- Intance:** A text input field containing the number 0.
- IP:** A text input field.
- Clear:** A green button.
- Accept:** A green button.
- Is a Router:** A checkbox.
- Network #:** A text input field.
- Address:** A text input field.
- Device Name:** A label with the text "Chiller Device".
- Variable Mapping Area:** A large empty rectangular box with a green border.

This screen is used to map the variable using Bacnet IP communication protocol.

In Bacnet IP communication, each variable has an instance number, a type, and the IP address of the interface where the variable is located (IP address of the chiller or controller interface).

If a Bacnet IP/Bacnet MSTP Gateway is used, the Network # and Address of the slave are also defined.

In the process of mapping the variables, the GCOP controller will request to the Bacnet IP interface of the chiller, all the variable that are located in that interface. Once received all the information of the variables, this information can be saved in a configuration file, as we explain later in this document. The name of the file uses the IP address of the Bacnet IP interface that has sent the variables for easy identification and if the variables are obtained using the Bacnet Router, this file name also include the number address of the slave Bacnet MSTP device. All the files saved, corresponding to each Bacnet IP interface (of each chiller or field controller) will be used to map the GCOP controller variables as we explain in this document.

If there are configuration files stored in the GCOP controller, select the file that have the information of the variables to map (variables that correspond to the selected chiller) from a list by clicking on "Selected File" option as shown:

192_168_1_128	<input checked="" type="radio"/>
192_168_1_134	<input type="radio"/>
192_168_1_145	<input type="radio"/>
192_168_1_232	<input type="radio"/>

If no file has been saved yet, the "Selected File" option will appear in blank

Selected File:

When starting mapping the GCOP controller variables, no configuration file has been saved yet, so no selection can be made.

The information of each variable can be entered manually if you know the type and instance of the variable, and the IP address of the Bacnet IP interface where the variable is located, but the most probable is that you do not know the variable information and you have to select that information from the group of variables requested to the Bacnet interface. If the variables are obtained using the Bacnet Router, you can also enter manually the Network number and the address of the Bacnet MSTP slave device or get it automatically selecting the variable.

To get all the variables mapped in an specific Bacnet IP interface, click on "Get Data" button, and the following screen is shown:

 **Green Cop. Device Discovery**

IP: Range 1 Range 2 Objects found: 54 APDU:480

☐ Is a Router Network #: Address: Device

Variables found:

In the "IP" box enter the IP address of the Bacnet interface that will be requested to get all the variables located in that interface.

In the Bacnet interface there is an object (or more than one object in the same interface) that has the list of all the variables mapped in that interface. This object is called device object.

Each Bacnet device object has an instance, so if you know the device object instance, enter this value in the "Range 1" box and "Range 2" box is set to zero (0), or if it is known that the instance is in certain range, enter the minimum instance range in "Range 1" box and the maximum in "Range 2" box.

It is recommended for the first time to set both "Range 1" and "Range 2" to 0 value. If both ranges are set to 0, the variables belonging to the first device object (probable the only one) of the Bacnet interface, with the selected IP address, are read by the GCOP controller. It is possible that a Bacnet interface has several device objects configured internally. The list of all the device objects will be displayed along with the rest of the variables mapped in that interface, as you see later in this document, so the instance of that devices will be known and can be entered in the "Range 1" box, to get the variables that belong to those device objects.

If a Bacnet Router is used to get variables from a Bacnet MSTP network, then check the "Is a Router". In this case if you know the Network number, the slave address or the device instance of the device object in the MSTP network, you could enter these values manually to get the list of variables of that device object, but it is recommended in the first discovery to check only the "Is a Router" option and get all the device objects automatically.

Once the IP address of the Bacnet interface, the ranges (optional) and the router option (optional) have been set, click on "Get Device Objects" button, and the following screen is shown:

Green Cop. Device Discovery

IP: 192.168.1.232 Range 1: 0 Range 2: 0 **Get Device Objects** **Save Data** Objects found: 54 APDU:480

☐ Is a Router Network #: Address: Device

Variables found:

Device Objects Searching
searching for Bacnet device objects in the local network...
11% 11/100

In the top right of the screen, the number of variables located in the device object is shown with the text "Objects found:", which in this case is 54. A progress bar window indicating how many variables has been read so far, is shown in the middle of the screen as illustrated above.

Once the 100% of all the variables located in the device object have been read, the following screen will be shown:

Green Cop. Device Discovery

IP: 192.168.1.232 Range 1 0 Range 2 0 Get Device Objects Save Data Objects found: 54 APDU:480

☐ Is a Router Network #: Address: Device

```

00001 ->Type: AI ->Name: Chiller 1,EW Temperature ->Value: 55.40 oF
00002 ->Type: AI ->Name: Chiller 1,LW Temperature ->Value: 45.00 oF
00001 ->Type: BI ->Name: Chiller 1,Status ->Value: 1.00
00002 ->Type: BI ->Name: Chiller 1,Alarm Status ->Value: 0.00
00003 ->Type: AI ->Name: Chiller 1,Current Capacity ->Value: 95.00
00004 ->Type: AI ->Name: Chiller 1,LWT SP Reading ->Value: 44.00 oF
00001 ->Type: AO ->Name: Chiller 1,LWT SP Output ->Value: 44.00 oF
00001 ->Type: BO ->Name: Chiller 1,ON/OFF ->Value: 1.00
00020 ->Type: AI ->Name: Chiller 1,Cond. EW Temp. ->Value: 80.60 oF
00021 ->Type: AI ->Name: Chiller 1,Cond. LW Temp. ->Value: 80.60 oF
00009 ->Type: BI ->Name: Chiller 1,Water Pump Status ->Value: 1.00
00010 ->Type: BI ->Name: Chiller 1,Cond. W Pump Status ->Value: 1.00
00005 ->Type: AI ->Name: Chiller 2,EW Temperature ->Value: 56.50 oF
00006 ->Type: AI ->Name: Chiller 2,LW Temperature ->Value: 45.60 oF
00003 ->Type: BI ->Name: Chiller 2,Status ->Value: 1.00
00004 ->Type: BI ->Name: Chiller 2,Alarm Status ->Value: 0.00
00007 ->Type: AI ->Name: Chiller 2,Current Capacity ->Value: 95.00
00008 ->Type: AI ->Name: Chiller 2,LWT SP Reading ->Value: 44.00 oF
00002 ->Type: AO ->Name: Chiller 2,LWT SP Output ->Value: 44.00 oF
00002 ->Type: BO ->Name: Chiller 2,ON/OFF ->Value: 1.00
00022 ->Type: AI ->Name: Chiller 2,Cond. EW Temp. ->Value: 77.60 oF
00023 ->Type: AI ->Name: Chiller 2,Cond. LW Temp. ->Value: 82.60 oF
00011 ->Type: BI ->Name: Chiller 2,Water Pump Status ->Value: 1.00

```

A list of all the variables located in the device object is shown in the screen. The list has the instance, type and the name of each the variable. Also the value and units of the variable is displayed to easily identify the variable and associate it to the GCOP controller variables.

The meaning of each variable type in Bacnet protocol is the following:

AI: analog-input

AO: analog-output

AV: analog-value

BI: binary-input

BO: binary-output

BV: binary-value

CL: calendar

CM: command

DV: device

EE: event-enrollment

FL: file

GR: group

LP: loop

MI: multi-state-input

MO: multi-state-output

NC: notification-class

PR: program

SC: schedule

AG: averaging

MV: multi-state-value

TL: trend-log


SP: life-safety-point

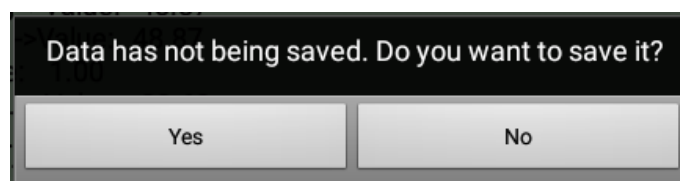
SZ: life-safety-zone

NA: non-available

Once all the variables have been read and listed on the screen, click on "Save Data" button to save all the information in the configuration file, otherwise the information will be lost.

If the "Is a Router" option was checked, the list of variables founds corresponds to the first slave found in the Bacnet MSTB network. Also the network number and the slave address are shown in the top right of the screen, bellow the "Objects found". To continue getting the list of variables of the rest of the slaves in the MSTP network, first save the current list shown for the slave device found and click on the "Get Device Object" button again to get the list of variables of the next Bacnet MSTP slave device. Save this new list and continue clicking the "Get Device Object" button until the message that no more device are found appears on the screen.

If you forget to save the information and return to the previous screen by clicking on  button, the following warning dialog box will be shown in the screen:



Click on Yes button to save the configuration file.

In the chiller variables mapping screen, select the variable to map as shown:

The screenshot shows the 'Green Cop. Device Discovery' interface. At the top, there's a green header with a back arrow icon. Below the header, there's a section with 'Selected File: 192_168_1_232', 'Type: Analog - Input', a 'Get Value' button with a text box containing '0', a 'Set' button, and a 'Get Data' button. Below this, there's a section with 'Name: Chiller 1,EW Temperature', 'Intance: 1', 'IP: 192.168.1.232', a 'Clear' button, and an 'Accept' button. Further down, there's a section with 'Is a Router' (checkbox), 'Network #:', and 'Address:'. Below this, there's a section titled 'Device Name: Chiller Device' containing a table of variables. The first row of the table is highlighted in gray.

Instance	Variable Name
00001	Chiller 1,EW Temperature
00002	Chiller 1,LW Temperature
00003	Chiller 1,Current Capacity
00004	Chiller 1,LWT SP Reading
00020	Chiller 1,Cond. EW Temp.
00021	Chiller 1,Cond. LW Temp.
00005	Chiller 2,EW Temperature
00006	Chiller 2,LW Temperature
00007	Chiller 2,Current Capacity
00008	Chiller 2,LWT SP Reading
00022	Chiller 2 Cond. EW Temp.

To select a variable click on its instance and name from the displayed list. The selected variable is highlighted in gray. The name of the selected variable is copied automatically in the "Name" box, and the variable instance is copied in the "Instance" box.

To get the value of the variable, click on "Get Value" button and, if the communication of the GCOP controller with the Bacnet interface is working fine, the value of the variable will be displayed in the "Get Value" box, otherwise a communication error message will be displayed in the lower part of the screen.

In case you want to write a value to the mapped variable (normally a variable of type "output") in order to transmit this value to the Bacnet interface, enter the value in the box next to the "Get Value" button (the same place of the variable value), and click on "Set" button. This is very useful to test writing variables, such as the LCHWT set-point value, and check if the value actually changed in the chiller interface. If the written value does not change in the chiller interface, it is possible that the selected variable is not for writing or it is mandatory to enable remote LCHWT set-point control in the chiller interface or control panel.

The variable type is selected in the "Type" selector option. The list of variables displayed are only of the type selected in the selector option. If the chiller variable to map is of another type, for example, analog-output instead of analog-input, just click on "Type" selector to select the proper variable type as shown:

Analog - Input	<input checked="" type="radio"/>
Analog - Output	<input type="radio"/>
Analog - Value	<input type="radio"/>
Binary - Input	<input type="radio"/>
Binary - Output	<input type="radio"/>
Binary - Value	<input type="radio"/>
Multi-state Input	<input type="radio"/>
Multi-state Output	<input type="radio"/>
Multi-state Value	<input type="radio"/>

When the variable type is changed, the list of variables displayed to be selected, will change too.

Once selected the variable, click on "Accept" button. If we want to clear the configuration of that variable (leave that variable undefined) click on "Clear" button.

When clicking on either "Clear" or "Accept" button, the chiller variables mapping screen will be shown again, in this case displaying the already mapped variables as shown:

Chiller Input Variables			Chiller Output Variables		
Enter CHW Temp	Chiller 1,EW Temperature	...	CHW Temp SP 1	Chiller 1,LWT SP Output	...
Leaving CHW Temp	Chiller 1,LW Temperature	...	CHW Temp SP 2		...
Chiller Status		...	Capacity Limit SP	Chiller 3,LWT SP Output	...
Alarm Status	Chiller 1,Alarm Status	...	Chiller ON[/OFF]		...
Current Capacity	Chiller 1,Current Capacity	...	Chiller OFF		...
Load AMPs		...	CHWP ON/OFF		...
CHW Temp SP	Chiller 1,LWT SP Reading	...			
Active Capacity Limit	Chiller 3,LWT SP Reading	...			
CHW Pump Status		...			

Not all the variables displayed in the screen above have to be mapped. Some variables are used for the normal functioning of the optimization algorithm and others are for information purposes only.

The variable used in the optimization algorithm calculations are:

- **Enter CHW Temp:** Entering chilled water temperature. This value is used if the average of each entering chiller water temperature option is checked instead of mixed entering water temperature as explained early. With this temperature the cold water demand can be calculated.
- **Leaving CHW Temp:** Leaving chilled water temperature. This value is informative and will not be used in the algorithm, although it is recommended to check the behavior of this temperature while varying the LCHWT set-point value.
- **Chiller Status.** This variable is not essential but allows the GCOP controller to know if the chiller is running or not in order to send the optimization result values to the chiller. If that variable is undefined, the sequencing algorithm check the chiller status by checking the variable used to start or stop the chiller which may be different to the actual chiller status.
- **Alarm Status:** This variable allows the GCOP controller to know if the chiller will respond to the commands sent, especially stop or start command in the sequencing algorithm. For example, If the chiller to start in the sequence order is in alarm condition, probably this chiller cannot respond to the start command, then the controller tries to start the next chiller in the sequence order. In the variable LCHWT set-point algorithm, if this variable is undefined, the new set-point value calculated will be send to the chiller although the chiller is in alarm condition, so the chiller is always assumed in normal state.
- **Current Capacity.** There are chillers that define the total cooling capacity and there are others that define only the cooling capacity per compressor. If the chiller defines the total cooling capacity value, this variable must be mapped but, if only the cooling capacity per compressor is defined in the chiller, the variables Capacity Compressor 1 to Capacity Compressor 4 variable must be mapped, depending on the number of compressors the

chiller has, and the GCOP controller will calculate the Total Capacity of the chiller averaging those variables.

- Active Capacity Limit: Cooling Capacity Limit actual set-point. If this value is not mapped, the GCOP controller assumes that the last set-point value sent to the chiller, which may or may not be equal to the actual set-point, is the actual chiller Capacity Limit set-point.
- CHW Temp SP: Leaving chilled water temperature actual set-point. If this value is not mapped, the GCOP controller assumes that the last set-point value sent to the chiller, which may or may not be equal to the actual chiller set-point, is the actual chiller set-point. To be equal values, the chiller must be enabled to accept remote control of this set-point, and the set-point value have to be accepted by the chiller controller, since there are circumstances where the chiller limits the set-point value that it receives remotely.
- Communication State. This value is mapped only when there is communication interface between the chiller and the GCOP controller, in that case, the interface communication issues with the chiller are located in a variable of that interface, and then must be mapped in the GCOP controller. In case of a direct communication of the GCOP controller with the chiller, this variable is not mapped, since the GCOP automatically generates this value depending if communication issues are detected with the chillers. Depending on the communication status, the GCOP controller decides if it is reliable or not to send the result of the optimization algorithms to the chiller. For example, the GCOP controller may decide to start another chiller in the sequence order if the corresponding one to start has communication errors.
- Capacity Compressor 1, ... Capacity Compressor 4. As explained in the case of Current Capacity early, if the chiller does not has mapped the cooling total capacity then these variables must be mapped.

In the case of the chiller output variables, the following variables must be mapped:

- CHW Temp SP1. Leaving chilled water temperature set-point number 1. This output variable is mapped if variable LCHWT set-point algorithm is used and its definition is essential.
- CHW Temp SP2. Leaving chilled water temperature set-point number 2. Some chiller manufacturers define 2 set-points values and the control algorithm can change the two set-points simultaneously, so the control does not depend on the set-point in use. This output variable is mapped if variable LCHWT set-point algorithm is used and its definition is essential if more than one set-point is supported by the chiller.
- Capacity Limit SP. Cooling Capacity Limit set-point. This output variable is mapped if the control of capacity limit set-point is used and enabled, in that case its definition is essential.
- Chiller ON [/ OFF]. This variable is mapped only if the sequencing algorithm is used and its definition would be essential. In many cases to start and stop the chiller one single variable is needed, where the value of 1 is used to start and the value of 0 to stop, but there are some chillers that may use one variable to start and another to stop, so a variable to stop the chiller must be mapped too, and you need to map the variable Chiller OFF.
- Chiller OFF. This variable is only mapped if the sequencing algorithm is used and if the chiller needs a variable to start and another to stop. A value of 1 in this variable will then stop the chiller.

The rest of variables to map are informative. If "Load AMPs" variable, which value is the amperes consumed by the chiller, is mapped, the chiller electric energy consumption will be calculated by multiplying the Load AMPs value by the voltage and power factor values manually entered in a configuration screen that will be explained later in this document.

The variables for each chiller must be mapped following the already described procedure. If the variables of the second chiller are defined in a Bacnet device(interface) with another IP address, it will be necessary to read all the variables defined in that device. If the variables of all the chillers are defined in the same interface, such as Trane Tracer SC controller, then continue selecting the variables to map for each chiller from the same configuration file saved for that interface.

Once all the necessary variables for each chiller are mapped, click on "Save Config" button and proceed to map the general variables of the chiller plant.

To map the general variables of the chiller plant, click on "Chiller Plant" button, and the following screen is shown:

Green Cop. Device Discovery

Chiller Plant Variables Definition Save Config

Sequence Optimizer Bacnet Variables		Leaving Water Setpoint Control	
Chiller Plant (ON/OFF)	<input type="text"/>	Outdoor Temperature	Outside Temperature <input type="text"/>
Mixed Entering Water Temp	<input type="text"/>	Humidity	<input type="text"/>
Runtime Predefined Values		Space Temp. Zone 1	<input type="text"/>
Temperature Offset	<input type="text" value="0.00"/>	Space Temp. Zone 2	<input type="text"/>
Chiller Running	<input type="text" value="1"/>	Space Temp. Zone 3	<input type="text"/>
Chiller Stopped	<input type="text" value="0"/>	Space Temp. Zone 4	<input type="text"/>
Alarm ON	<input type="text" value="1"/>	Space Temp. Zone 5	<input type="text"/>
		Space Temp. Zone 6	<input type="text"/>

Scroll down in this screen to display the rest of the variables as shown:

Alarm ON	1
Alarm Off	0
Chiller Voltage	430.00
Power Factor	0.90
First Chiller Number	- 1 +
Second Chiller Number	- 2 +
Third Chiller Number	- 3 +
Forth Chiller Number	- 4 +

Variables to map:

- Chiller Plant (ON / OF). This variable is used by the algorithm that controls the start and stop of the chiller plant by schedules. This algorithm can only be configured using the GCOP_Setup.exe program, so usually it is not necessary to map this variable if it is not be used.
- Mixed Entering Water Temp (common mixed entering water temperature to all the chillers). This variable may not exist and it is not needed it if we use the average of the entering chilled water temperature to each chiller instead.
- Outdoor Temperature (ambient temperature) This variable is important for the calculation of the variable LCHWT set-point value algorithm. If this variable is not mapped, the outside temperature value is taken from a Weather Web Server, if the location of the GCOP controller was configured in the Setup option of the main menu as we explained earlier in this document, so it is necessary to define this variable by either way when using the variable LCHWT set-point algorithm.
- Humidity. This variable is the relative humidity value of a location that needs supervision. It is only mapped if the humidity value of a particular location could be affected by the variations in the LCHWT set-point. For more details see the variable LCHWT set-point control in this document.
- Space Temp Zone 1..8. These variables are mapped only if the space temperature of one or more rooms (zones) need to be supervised, if their values are affected when the variable LCHWT set-point algorithm is used. For more details see the variable LCHWT set-point control in this document.


The Chiller Plant variables are mapped using the same procedure of mapping each chiller variables.

In this screen are also configured some variables which values are not located in a Bacnet device, instead those variables values are entered from the user interface (touch screen keyboard). These variables are the following:

- **Temperature Offset.** In this box enter the value used as a correction value for systematic errors in outside temperature. For example, if the outside temperature is checked with a certified meter, and its value is 2 degrees below the value reported by the outside temperature variable value mapped in the GCOP controller, enter the value of 2 in this box. Usually this value is not defined unless more precision is wanted in the outside temperature value compared with a certified meter. In the variable LCHWT set-point algorithm, the absolute outside temperature value is not as important as its tendency.
- **Running Chiller.** In this box enter the value of the actual number read in the "Chiller Status" mapped variable for each chiller, that indicates if the chiller is running. By default this value is 1, which means that if the "Chiller Status" value read is 1, the chiller is running. In some cases, depending on chiller type and model, the Operation Mode of the chiller can contain other values, for example, 0 means stopped, 1 means delayed, and 2 means running, so for this example, enter the value of 2 in this box, which indicates to the GCOP controller that the chiller is running.
- **Chiller Stopped.** In this box enter the value of the actual number read in the "Chiller Status" mapped variable for each chiller, that indicates if the chiller is stopped. By default this value is 0, which indicates that if the "Chiller Status" value read is 0, the chiller is stopped. As explained in the case of chiller running, if when the chiller stops, this value is not 0, then enter in this box the actual value that indicates that the chiller has stopped.
- **Alarm ON.** In this box enter the value of the actual number read in the "Alarm Status" mapped variable for each chiller, that indicates if the chiller is in alarm. By default this value is 1, which indicates that if the "Alarm Status" value read is 1, the chiller is in alarm. As explained in the case of chiller running, if when the chiller is in alarm, this value is not 1, then enter in this box the actual value that indicates that the chiller is in alarm.
- **Alarm Off.** In this box enter the value of the actual number read in the "Alarm Status" mapped variable for each chiller, that indicates if the chiller is in normal operation. By default this value is 0, which indicates that if the "Alarm Status" value read is 0, the chiller is in normal operation. As explained in the case of chiller running, if when the chiller is in normal operation, this value is not 0, then enter in this box the actual value that indicates that the chiller is in normal operation.
- **Chiller Voltage.** In this box enter the value for the line voltage of the chillers if the variable "Load AMPs" has been mapped in each chiller. This value is used in the chiller power consumption calculation. If this value is between 0 and 4, it means that the "Load AMPs" has been mapped directly with the power consumption (demand value) of the chiller instead the load amperes, so no calculation is necessary. If this value is between 5 and 9, it means that the "Load AMPs" has been mapped directly with the power consumption (demand value) of the chiller instead the load amperes and the value is in watts unit, so the value is divided by 1000 to get the consumption value in kwatts. Values above 10 means that the "Load AMPs" has been mapped with the load amperes and power consumption calculation must be done.
- **Power Factor.** In this box enter the value for the power factor of the chillers if the variable "Load AMPs" has been mapped in each chiller. This value is used in the chiller power consumption calculation.


By default the chillers are numbered from 1 to 4, in a consecutive order and the operator can identify easily any chiller with that number, for example, when the GCOP controller indicates that the chiller 2 is in alarm. Sometimes this numbering is not consecutive or the operators are familiarized with another chiller numbering for identification. In this case, to select a different number to identify each chillers, click on the +/- buttons of the following options:

- First Chiller Number: Select the number to identify the first chiller of the sequence in the chiller plant. By default this value is 1.
- Second Chiller Number: Select the number to identify the second chiller of the sequence in the chiller plant. By default this value is 2.
- Third Chiller Number: Select the number to identify the third chiller of the sequence in the chiller plant. By default this value is 3.
- Forth Chiller Number: Select the number to identify the forth chiller of the sequence in the chiller plant. By default this value is 4.

Once all the parameters of this configuration screen have been mapped and defined, click on "Save Config" button and return to the chillers configuration screen clicking on  button.


It is possible to map some other variables available in the Bacnet interface (device) that are not used in the optimization algorithms but may be useful to supervise their values.

To map those additional variables, from the chiller variables configuration screen click on "Additional Variable" button, and the following screen is shown:



The screenshot shows a software interface titled "Green Cop. Device Discovery". Below the title bar is a section labeled "Additional Variables Definition" with a "Save Config" button in the top right corner. The main area contains a table with two columns, each having an "Address" and a "Variable Name" sub-column. There are 10 rows of input fields. To the right of each "Variable Name" field is a small green button with three dots "...".

Address	Variable Name	Address	Variable Name


Click on  button to map each variable using the same procedure explained for the previous configuration screens


Once the variable has been mapped, the last value of the Bacnet device IP address, where the variable is located, will be displayed in the "Address" column. For example, if two variables are mapped, each one on a different Bacnet device, one with 192.168.10.128 IP address and the other with 192.168.10.232 IP address, this mapped variables will be displayed as:

Address	Variable Name	
128	Max. Outside Temp	...
232	Humidity	...

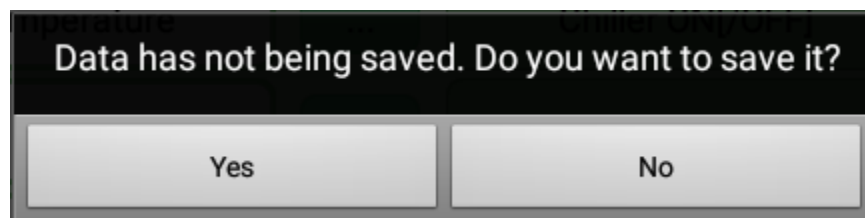
If a Bacnet MSTP router was used to get the variable, the last value of the Bacnet Router IP address and the address of the Bacnet MSTP network slave device is used in the "Address" column. For example if the Bacnet IP of the routes is 192.168.1.23 and the slave address is 4, the Address shown will be 23_R4.

The variable name of the mapped variable is displayed in the "Variable Name" column.

After mapping all the additional variables, click on "Save Config" button and return to the chillers configuration screen clicking on  button.

So far, it has been already configured and mapped all the necessary variables that are used in the optimization algorithms of the GCOP controller. Click on  button of the chillers configuration screen to return to the main screen of the GCOP application and resume the controlling and monitoring operation of the GCOP controller.

If when exiting the chiller configuration screens, after making some modifications, the "Save Config" was not clicked, a warning window alert you to save the changes as shown:



To save, click on "Yes" button. All the configuration is saved and the GCOP controller resumes its control functions.

Monitoring electrical parameters for measuring and verification (M & V) purposes.

With the GCOP controller is also possible to monitor electrical parameters for measuring and verification (M & V) purposes.

The measuring of electrical parameters are made by a power meter that uses the Bacnet IP or Modbus TCP/IP communication protocol.

The mapping of the M & V variables can be done either by using the MV_Setup.exe program, where both communication protocols are supported, or by using the GCOP controller to map variables of Bacnet IP devices..

To map the M & V variables located in a Bacnet IP device, click on **Variable Setup** button in the main menu to show the chiller configuration screen. In this screen click on "M & V Config" button as shown:



The following screen is shown:









The screenshot shows the 'M & V Variables Definition' screen for 'Meter 1'. The screen is divided into two main columns. The left column is titled 'Power Meter Variables' and contains sections for 'Consumption' (with 'Energy Accumulation' and a dropdown), 'Demand' (with 'KW Demand' and a dropdown), 'Max Demand Values' (with 'Max Demand' and a dropdown), 'Reset Day' (with a text input field containing '1'), 'Alarm Limit' (with a text input field containing '0.00'), and 'Demand Period' (with a text input field containing '15'). The right column is titled 'M & V General Settings' and contains 'Consumption Multiplier' (with a text input field containing '1.00'), 'Demand Multiplier' (with a text input field containing '1.00'), and 'Max Consumption per hour' (with a text input field containing '0.00'). A 'Save Config' button is located at the top right of the screen.


Scroll down in the left side and the rest of the parameters are shown:

This close-up screenshot shows the bottom part of the configuration screen. It features two rows of controls. The first row has a green button labeled 'Demand Period' next to a text input field containing the value '15'. The second row has a green button labeled 'Enable Calculation' next to a toggle switch that is currently set to 'ON'.

Up to 8 power meters can be defined. Two variables can be mapped for each meter: Consumption and Demand, and also the values of 3 parameters are defined: Consumption Multiplier, Demand Multiplier and Max Consumption per hour.

To select the power meter to configure, click on "Meter: selector option, as shown:

Meter 1	
Meter 2	
Meter 3	
Meter 4	
Meter 5	
Meter 6	
Meter 7	
Meter 8	

To map the M & V variables follow the same procedure explained early by clicking on  button.


The variables to map are:

- Consumption: The value of this variable is the energy meter counter. This value is increased with time as the electrical energy is consumed. For example, if the value is read at a particular hour of day, when that value is read again one hour later, the difference between this value and the previous one is the kW-h of electrical energy consumed in that hour.
- Demand. The value of this variable is the instantaneous power demand value (kW).

The values to configure in each electric power meter are the followings:



- Consumption Multiplier. In this box enter the value that scales the value read in the "Consumption" mapped variable. If scaling is not required this value is 1.
- Demand Multiplier. In this box enter the value that scales the value read in the "Demand" mapped variable. If scaling is not required this value is 1.
- Max Consumption per hour. In this box enter a value used to filter the energy meter counter ("Consumption") that is read periodically. This value represents the maximum power energy that can be consumed in one hour. It is probable that when starting reading the power meter values, the value for this variable is unknown and it is recommended to enter the value of 0 to not perform any filtering and, after some days of observation, when there is a certain knowledge of the magnitude of this value, enter then the proper value in this box to filter possible reading errors.


Calculation of the Maximum Demand.


Some energy meters can be setup to calculate the maximum energy demand to be monitored and avoid paying penalties. If this is the case, map the variable that has the maximum demand using the "Max Demand" box clicking on  button.

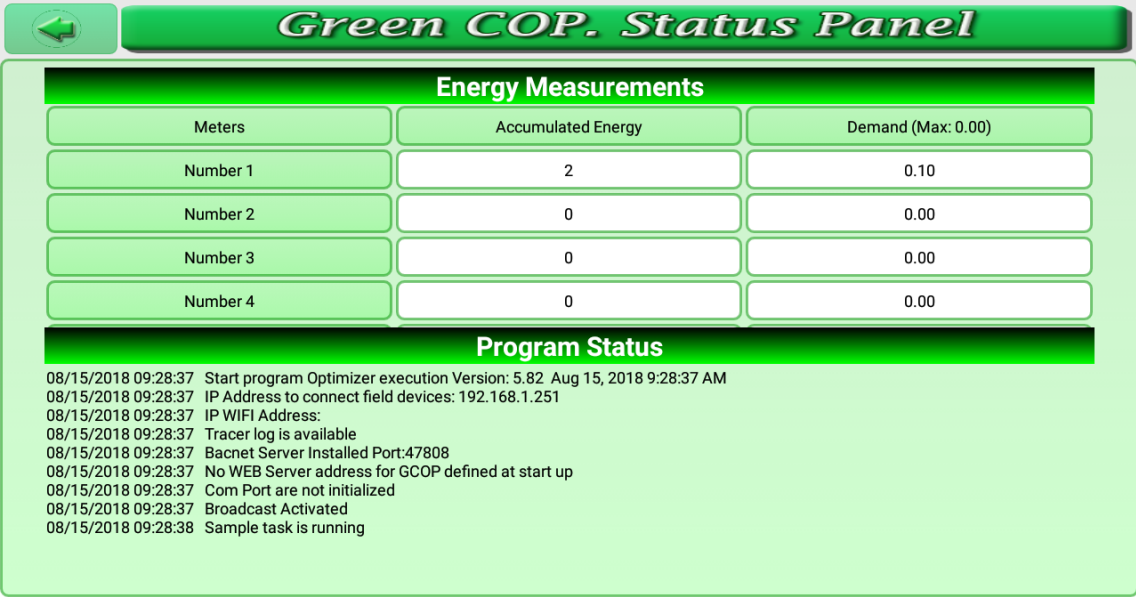
If the maximum demand cannot be calculated inside the power meter, the GCOP controller is able to calculate it, and to do that configure the following parameters:

- Reset Day. In this box enter the value of the day of the month when the maximum demand value is cleared and the new calculation cycle in the month starts again.
- Alarm Limit. In this box enter the value of an alarm limit used to warn that the maximum demand is close to a value that can be penalized.
- Demand Period. In this box enter the value of the time period in minutes to execute the maximum demand calculation (default value is 15 minutes)
- Enable calculation. Click on this button to enable maximum demand calculation. If the button is set to ON, the GCOP controller will calculate the maximum demand, but if the button is set to OFF, this calculation will not be executed.

Once configured all the M & V variables for each electric power meter, click on "Save Config" button and then  button to return to the chiller variables configuration screen. Then click on  button in this screen to return to the main screen of the GCOP application.

If the M & V variables configuration were not saved, a warning window will alert you when you click on  button in the M & V variables configuration screen.

When the M & V variable are configured and you click on  button of the main menu button, the "Status Program" screen will display new information related to the M & V variables as shown:



Energy Measurements		
Meters	Accumulated Energy	Demand (Max: 0.00)
Number 1	2	0.10
Number 2	0	0.00
Number 3	0	0.00
Number 4	0	0.00

Program Status

08/15/2018 09:28:37 Start program Optimizer execution Version: 5.82 Aug 15, 2018 9:28:37 AM
08/15/2018 09:28:37 IP Address to connect field devices: 192.168.1.251
08/15/2018 09:28:37 IP WIFI Address:
08/15/2018 09:28:37 Tracer log is available
08/15/2018 09:28:37 Bacnet Server Installed Port:47808
08/15/2018 09:28:37 No WEB Server address for GCOP defined at start up
08/15/2018 09:28:37 Com Port are not initialized
08/15/2018 09:28:37 Broadcast Activated
08/15/2018 09:28:38 Sample task is running

At the top is displayed a table that shows the energy consumption counter and demand values for each electric power meter. The Maximum Demand value is also displayed.

Variables

From the main menu click on  button to check if the M & V variables are been read as shown:

```
08/15/2018 09:36:29 Chiller 2 Status: 1.00
08/15/2018 09:36:29 Chiller 2 Actual Capacity: 66.55
08/15/2018 09:36:29 Chiller 2 LW Setpoint: 48.67
08/15/2018 09:36:29 Chiller 2 LWT SP Output: 48.52
08/15/2018 09:36:29 Chiller 2 Start/Stop: 1.00
08/15/2018 09:36:29 ===Additional variables available=====
08/15/2018 09:36:29 IP: 192.168.1.128--Max. Outside Temp: 89.60
08/15/2018 09:36:29 IP: 192.168.1.232--Humidity: 50.00
08/15/2018 09:36:29 =====
08/15/2018 09:36:29 Outside Temperature: 83.15
08/15/2018 09:36:29 List of values of meter number: 1
08/15/2018 09:36:29 Consumption: 1.53
08/15/2018 09:36:29 Demand: 0.10
```

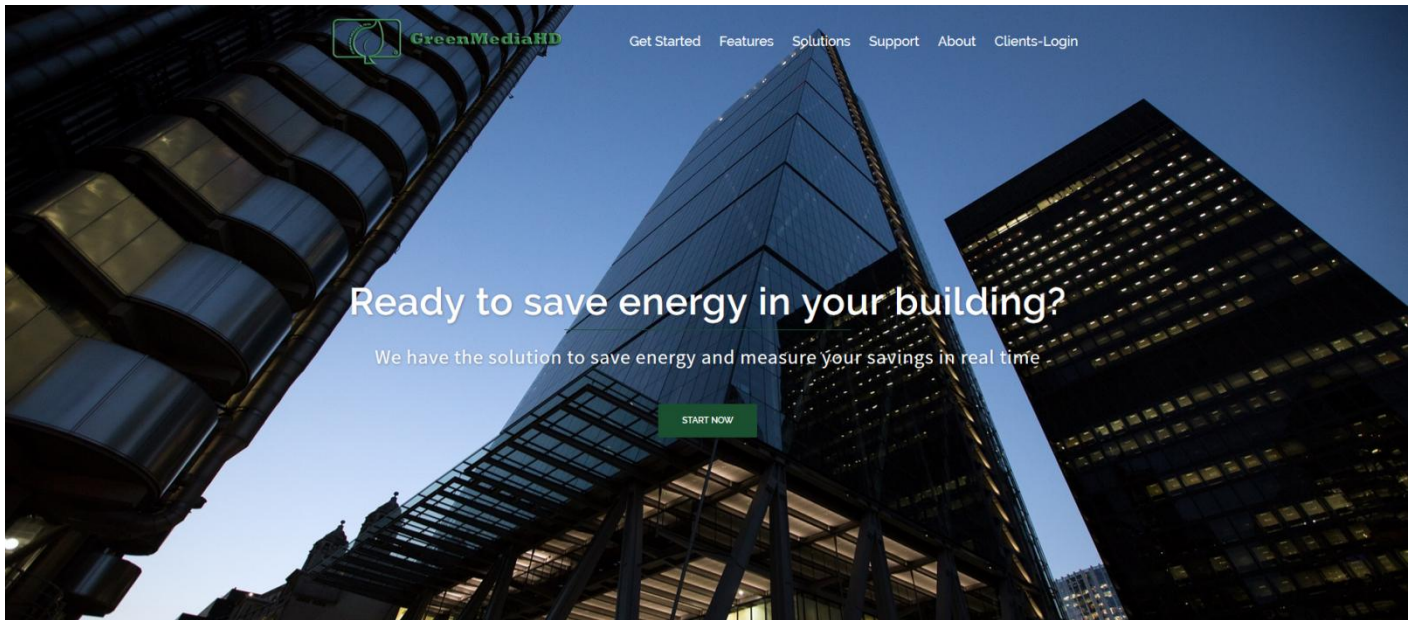
These energy values are uploaded to a database located in the GreenmediaHD Cloud Server, which can be accessed by visiting the page: <http://www.greenmediahd.com>, then enter in the Clients-Login menu option, and select M & V Web Site; or visiting directly the M & V Web Site: <http://www.grennmediahd.com/meters/login.php>

Contact GreenmediaHD support team to obtain credentials to the M & V Web Site.

GCOP Website for the Chillers Optimization Supervising System.

There are two option to visit the GCOP Website

First option, enter the link: <http://www.greenmediahd.com> in your internet browser and the following page is presented:

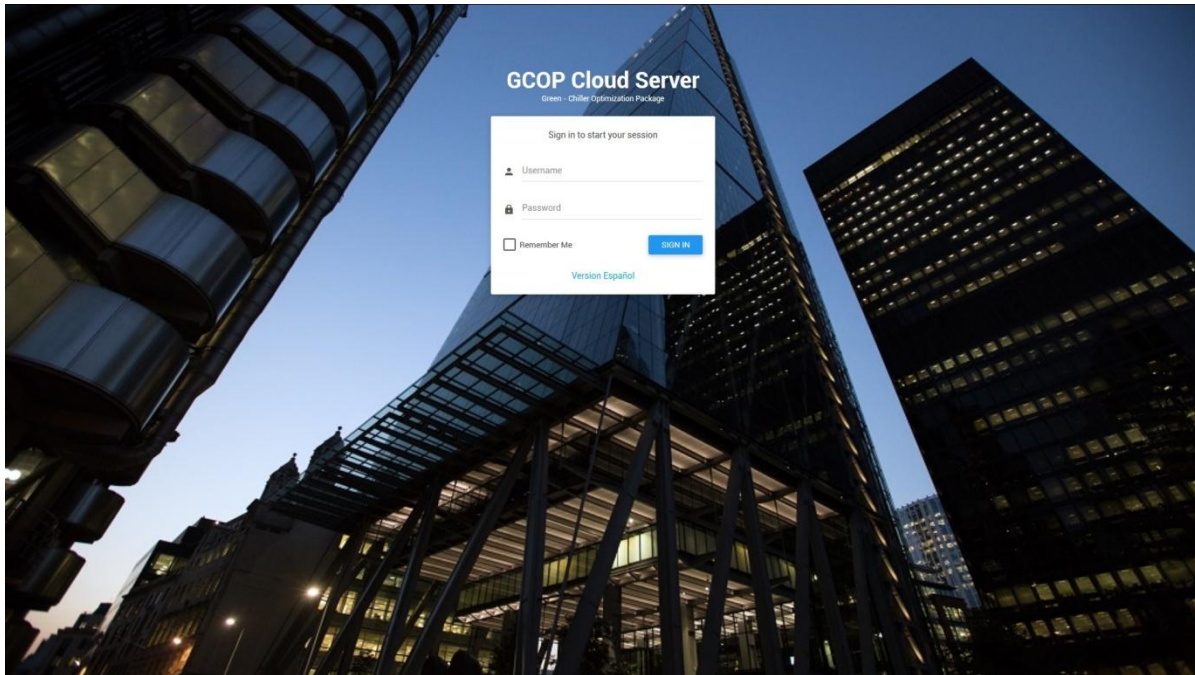


Click on Clients-Login option, and in the page presented, select the GCOP Web-Site site, as shown:



Second option, enter the link <http://www.grennmediahd.com/gcop/login.php> directly in your internet browser.

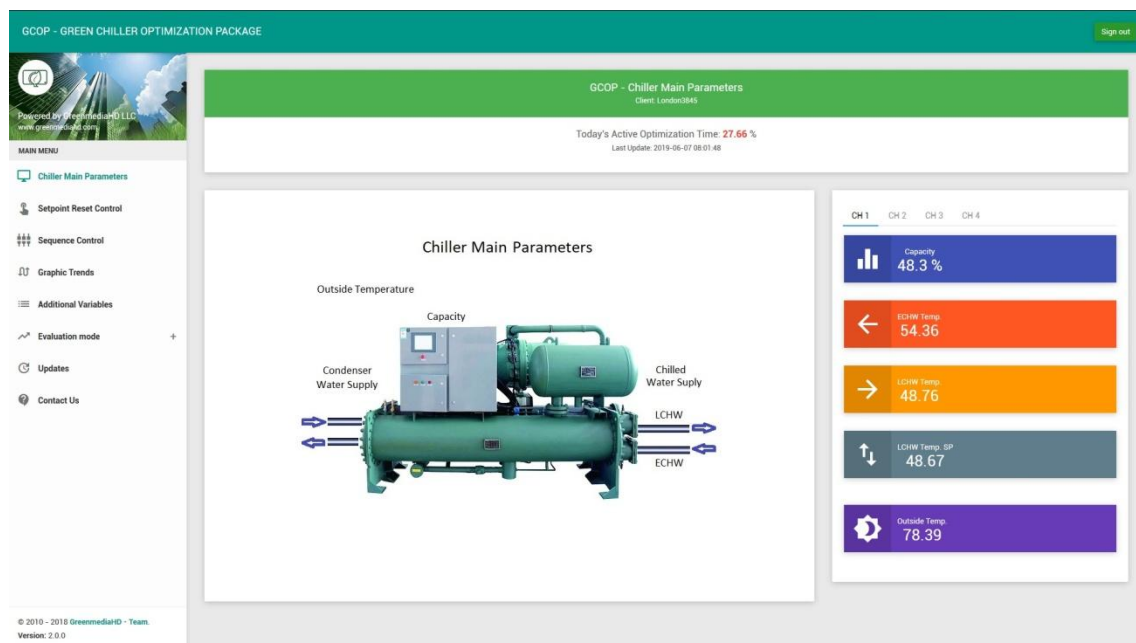
In either case, the following page is shown:



Enter the username and password credentials provided by DLControl support team to the users of the GCOP Controller, and click on Login button. You can use the Spanish version also if your native language is Spanish.

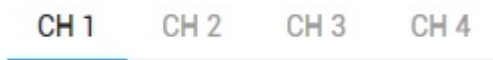
Informative page of Chiller main parameters.

Once the user is authenticated, the following page is shown:



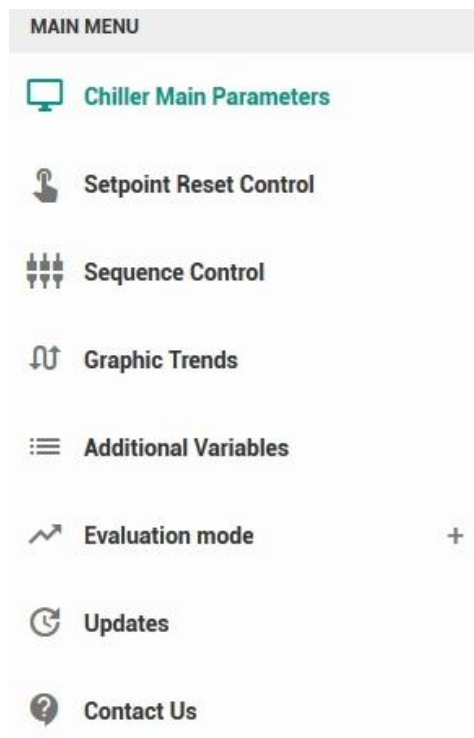
This page shows the main parameter of each chiller as: Cooling Capacity, Entering Chiller Water Temperature (ECHW Temp.), Leaving Chiller Water Temperature (LCHW Temp) , Leaving Chiller Water Temperature Set-point (LCHW Temp SP), and Outside Temperature.

This screen first shows the parameters of chiller 1, in order to see the parameters of the other chillers just click on the corresponding chiller tab as shown:

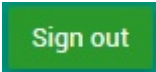


The term "Today's Active Optimization Time" shows the percent of time in the current day that the LCHWT Set-point have been above the minimum value when the chiller is running. This value is an indicator of the percent of the energy saving in the current day, more higher value more savings.

In the left side of the screen we have the different menu options:



We will explain in detail each option.

If you want to Log OFF, just click on the button .

Let's explain now each option of the main menu.

Informative page of Setpoint Reset Control.

When you click on this option, the following page is shown:

GCOP - GREEN CHILLER OPTIMIZATION PACKAGE Sign out

Variable Leaving Chilled Water Temperature Set-point
Client: London3045

Today's Active Optimization Time: **27.66 %**
Last Update: 2019-06-07 08:01:48

OUTSIDE TEMPERATURE: 78.39
CALCULATED LCHWT SETPOINT: 48.67
CAPACITY LOAD OFFSET: 0

Leaving Chilled Water Temperature Setpoint Main Control

GCOP Commands

Control Info Control Settings Schedule

Control ENABLED	Chiller 1	Chiller 2	Chiller 3	Chiller 4
LWT Setpoint Output	48.67	48.67	48.67	44
Actual LWT Setpoint	48.67	48.67	48.67	0
Capacity Limit Setpoint	100	100	100	100
Actual Capacity Limit SP	0	0	0	0
Chiller Consumption	0	0	0	0
Communication State				
Maintenance				

Leaving Chilled Water Temperature Setpoint Auxiliary Control

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Version: 2.0.0

and scrolling the page:

GCOP - GREEN CHILLER OPTIMIZATION PACKAGE Sign out

Variable Leaving Chilled Water Temperature Set-point
Client: London3045

Today's Active Optimization Time: **27.66 %**
Last Update: 2019-06-07 08:01:48

OUTSIDE TEMPERATURE: 78.39
CALCULATED LCHWT SETPOINT: 48.67
CAPACITY LOAD OFFSET: 0

Leaving Chilled Water Temperature Setpoint Main Control

GCOP Commands

Control Info Control Settings Schedule

Control ENABLED	Chiller 1	Chiller 2	Chiller 3	Chiller 4
LWT Setpoint Output	48.67	48.67	48.67	44
Actual LWT Setpoint	48.67	48.67	48.67	0
Capacity Limit Setpoint	100	100	100	100
Actual Capacity Limit SP	0	0	0	0
Chiller Consumption	0	0	0	0
Communication State				
Maintenance				

Leaving Chilled Water Temperature Setpoint Auxiliary Control

Control Settings Capacity Limit Control Outside Temp Range Control Temperature Zones Edit Zone Name

Parameter	Value	Limit	Dead Band	Enable
Humidity	0	70	0.1	
Space Temp.	0	80	0.1	
Space Temp. Control	MaxValue			
Winter Average Temp.	77.56	75		

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Version: 2.0.0

This page shows the information related to the variable LCHWT set-point optimization system of the GCOP controller..

The parameters shown in this page are the same ones that the GCOP_Optimizer application shows in the GCOP controller, which were already described in details early in this document.

The Outside Temperature, Calculated Setpoint and Capacity Load Offset are general parameters shown in the upper part of the screen in order to visualize how the LCHWT Set-point is moving depending on the outside temperature and the cooling load.

Several informative tables are presented, the first one is the "Control Info Tab" as shown:

Leaving Chilled Water Temperature Setpoint Main Control

GCOP Commands

Control InfoControl SettingsSchedule

Control ENABLED	Chiller 1	Chiller 2	Chiller 3	Chiller 4
LWT Setpoint Output	48.67	48.67	48.67	44
Actual LWT Setpoint	48.67	48.67	48.67	0
Capacity Limit Setpoint	100	100	100	100
Actual Capacity Limit SP	0	0	0	0
Chiller Consumption	0	0	0	0
Communication State				
Maintenance				

The first thing to notice in this table is if the control is enabled or disabled. In the example above the control is enabled: **Control ENABLED**

This table shows the parameters that are changed in the chiller by the GCOP such as LCHWT Setpoint and Capacity Limit Set-point. Also the communication state between the chillers and the GCOP, the chiller consumption and the state of maintenance are shown in this table.

To see the control settings click on "Control Settings" tab and the following table is shown:

Control InfoControl SettingsSchedule

Control Limits

Temperature Limits	Value
Max. Outside Temperature	92
Min. Outside Temperature	75.2
Setpoint Limits	Value
Min. LWT Setpoint	58
Max. LWT Setpoint	62

Parameter Settings

Control Parameter	Value
Enable Control	
Dead Band	5
Max. SP Rate per minute	0.5
Capacity Stability Seconds	0
Capacity for Control	0

On this table the minimum and maximum values for the outside temperature and LCHW Set-point are shown in the lest panel. This values are informative and cannot be changed.

In the right panel we have another configuration parameters such as: dead band for the variable LCHWT SP, the maximum rate per minute allowed for the LCHWT SP, the cooling capacity stability and the cooling capacity for control. For details review the description explained in the GCOP Controller.

To see the schedules for control of the LCHWT SP or starting the chillers, click on the "Schedules tab" and the following table is shown:

Timer (Chiller Setpoint Change)	ON	OFF	SP OFF	Enable
Monday to Friday	00:00	00:00	44	<input checked="" type="checkbox"/>
Saturday	00:00	00:00	44	<input checked="" type="checkbox"/>
Sunday	00:00	00:00	44	<input checked="" type="checkbox"/>

The first thing to notice in this table is if the schedule refers to the LCHWT SP change or if it is used to turn the chillers ON/OFF. In the example above it is used to change the set-point:

Timer (Chiller Setpoint Change), indicated in the left upper corner of the table.

As explained in the GCOP controller, it is possible to set three schedules to apply the variable LCHWT SP control or to turn the chillers ON/OFF using the sequencer control. In case of variable LCHWT SP, you set the SP when the variable SP control is off by schedule, and when the schedule refers to turning ON/OFF the chiller, the chiller is turned ON when the sequencer control is OFF by schedule. Three different schedules may be programmed. First schedule refers to labor days (Monday to Friday). Second schedule refers to Saturday and the third schedule refers to Sunday.

In order to apply the schedules, each schedule must be enabled.

The GCOP auxiliary control information is shown in the following table:

Parameter	Value	Limit	Dead Band	Enable
Humidity	0	70	0.1	<input checked="" type="checkbox"/>
Space Temp.	0	80	0.1	<input checked="" type="checkbox"/>
Space Temp. Control	MaxValue			
Winter Average Temp.	77.56	75		

The first table shows the control of Humidity, Space Temperature and Winter SP Limitation.

More details about these auxiliary controls are fully covered in this document when the GCOP controller is explained.

Click on "Capacity Limit Control" tab to get the information about this control as shown:

Capacity Limit Control	Value	Control Params	Phase I	Phase II
Enable Control	<input checked="" type="checkbox"/>	Time per phase (min)	10	10
Time Chiller Off (hour)	4	Cap. Limit per Phase	60	80

Click on "Outside Temp Range Control" tab to get the information about this control as shown:

Temperature Range Control	Value Set	Control Params	Calculated Value
Enable Control	<input checked="" type="checkbox"/>	Max Temp Range	90
Actual Days Count	0	Min Temp Range	70

Click on "Temperature Zones" to see the temperatures zones defined in the GCOP controller for the Space Temperature Auxiliary Control. The table shown is:

Description	Value	Description	value
Temp. Zone 1	0.00	Temp. Zone 5	0.00
Temp. Zone 2	0.00	Temp. Zone 6	0.00
Temp. Zone 3	0.00	Temp. Zone 7	0.00
Temp. Zone 4	0.00	Temp. Zone 8	0.00

Up to 8 zones can be defined.

To edit the name of each zone, click on the "Edit Zone Name" tab control and the following table is shown:

Temperature Zone	Description	Temperature Zone	Description
Temp. Zone 1	<input type="text" value="Temp. Zone 1"/>	Temp. Zone 5	<input type="text" value="Temp. Zone 5"/>
Temp. Zone 2	<input type="text" value="Temp. Zone 2"/>	Temp. Zone 6	<input type="text" value="Temp. Zone 6"/>
Temp. Zone 3	<input type="text" value="Temp. Zone 3"/>	Temp. Zone 7	<input type="text" value="Temp. Zone 7"/>
Temp. Zone 4	<input type="text" value="Temp. Zone 4"/>	Temp. Zone 8	<input type="text" value="Temp. Zone 8"/>
<input type="button" value="Modify"/>			

Once the name of the zone is edited, click on "Modify" button to save de changes.

Send Commands to GCOP

Some commands are allowed to be sent to the GCOP Controller in campus from the GCOP web site.

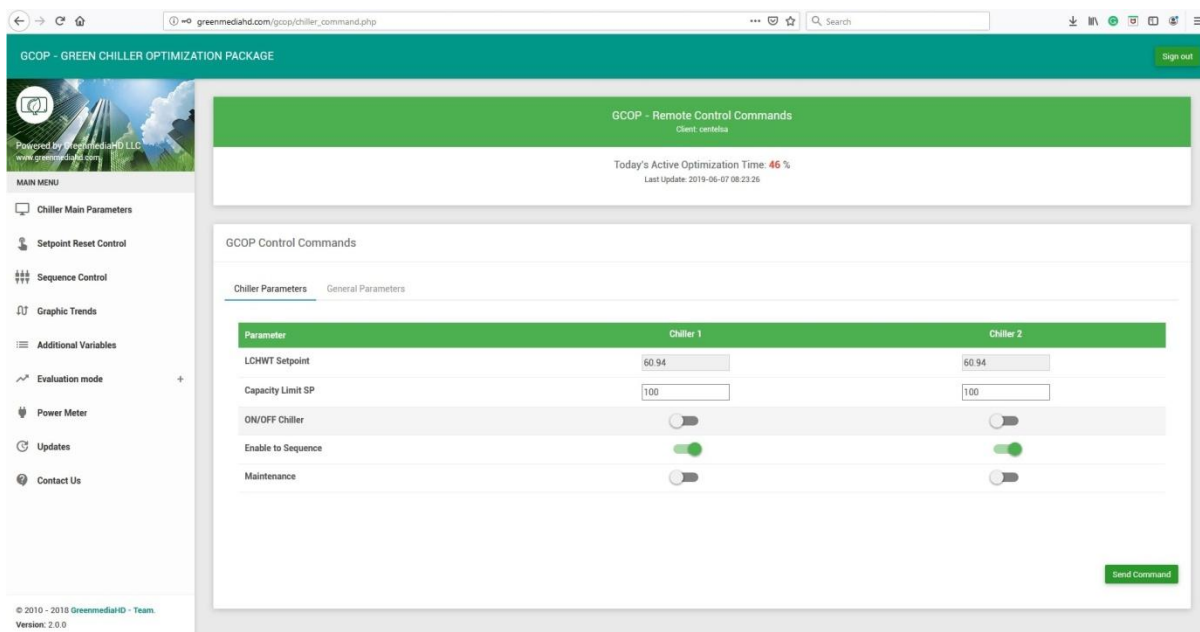
For that purpose you must have a authentication password supplied by DLControl and Engineering.

To sent commands to the GCOP controller click on the **GCOP Commands** button, and enter the correct password in the following windows:



A modal dialog box titled "GCOP Commands". Below the title is the instruction "Enter password to access GCOP Commands". There is a single-line text input field. At the bottom are two buttons: "Cancel" and "OK".

Click on "Ok" button to enter in the sending commands page shown below:



The screenshot shows a web browser at the URL `greenmediahd.com/gcop/chiller_command.php`. The page has a green header with the text "GCOP - GREEN CHILLER OPTIMIZATION PACKAGE" and a "Sign out" button. A sidebar on the left contains a "MAIN MENU" with links: "Chiller Main Parameters", "Setpoint Reset Control", "Sequence Control", "Graphic Trends", "Additional Variables", "Evaluation mode", "Power Meter", "Updates", and "Contact Us". The main content area is titled "GCOP - Remote Control Commands" and "Client: centralia". It displays "Today's Active Optimization Time: 46 %" and "Last Update: 2019-06-07 08:23:26". Below this is a section "GCOP Control Commands" with two tabs: "Chiller Parameters" (selected) and "General Parameters". A table follows with columns for "Parameter", "Chiller 1", and "Chiller 2".

Parameter	Chiller 1	Chiller 2
LCHWT Setpoint	<input type="text" value="50.94"/>	<input type="text" value="50.94"/>
Capacity Limit SP	<input type="text" value="100"/>	<input type="text" value="100"/>
ON/OFF Chiller	<input type="checkbox"/>	<input type="checkbox"/>
Enable to Sequence	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Maintenance	<input type="checkbox"/>	<input type="checkbox"/>


A "Send Command" button is located at the bottom right of the table.

The first table shown allow us to send commands to each chiller.


The parameters that can be commanded are: the LCHWT Set-point, the Capacity Limit Set-point, turn chiller ON/OFF, enable/disable a chiller in the sequencer control, and turn ON/OFF the chiller maintenance option.


To manually modify the LCHWT Set-point, the Reset LCHWT Set-point Control must be OFF, otherwise this setpoint is automatically calculated by the GCOP controller. Enter the new LCHWT Set-point value in the corresponding box for each chiller in the LCHWT Setpoint Row of the table.


To manually modify the Capacity Limit Set-point, the Capacity Limit Set-point Control must be OFF, otherwise this setpoint is automatically calculated by the GCOP controller. Enter the new Capacity Limit Set-point value in the corresponding box for each chiller in the Capacity Limit SP Row of the table.

To manually turn the Chiller ON and OFF, the Sequence Control must be OFF, otherwise this action is automatically done by the GCOP controller. Click on the  selector in the corresponding box for each chiller in the ON/OFF Row of the table.

The selector meaning is:

 Chiller is set to ON


 Chiller is set to OFF.

To enable/disable a chiller in the sequence control, click on the  selector in the corresponding box for each chiller in the Enable to Sequence Row of the table.


The selector meaning is:

 Chiller is enabled to sequence

 Chiller is disabled to sequence


To enable/disable a chiller maintenance, click on the  selector in the corresponding box for each chiller in the Maintenance Row of the table.

The selector meaning is:

 Chiller is in maintenance

 Chiller is not in maintenance

Remember that if a chiller is in maintenance, it will not be considered in any GCOP controlling algorithm and the parameters of that chiller will not be sampled to avoid the communication errors if the chiller is out of service.

Once all the parameters in this table has been modified, click on  button to send the parameters to the GCOP controller in campus.

To modify general GCOP controller parameters click on "General Parameter" tab and the following table is shown:

Chiller Parameters	
General Parameters	
Parameters	Value
Activate Variable LCHWT SP	<input checked="" type="checkbox"/>
Activate Capacity Limit Control	<input type="checkbox"/>
Activate Sequence	<input type="checkbox"/>
Sequence Order	<input type="text" value="21"/>
Override Sequence	<input type="checkbox"/>

Send Command

To enable/disable the LCHWT Setpoint Reset Control click on the ☒ selector in the "Value" box of the Activate Variable LCHWT SP Row of the table. Note that if you want to manually modify the LCHWT Setpoint, you can first disable the LCHWT Setpoint Reset Control in this table, send the command clicking the

Send Command

 button, and then return to the GCOP Command page and use the "Chiller Parameter" tap to modify the LCHWT Setpoint as explained.

The selector meaning is:

☒ LCHWT Setpoint Reset Control is enabled

☐ LCHWT Setpoint Reset Control is disabled

To enable/disable the Capacity Limit Control click on the ☒ selector in the "Value" box of the Activate Capacity Limit Control Row of the table. Note that if you want to manually modify the Capacity Limit Setpoint, you can first disable the Capacity Limit Control in this table, send the command clicking the

Send Command

 button, and then return to the GCOP Command page and use the "Chiller Parameter" tap to modify the Capacity Limit Set-point as explained.

The selector meaning is:

☒ Capacity Limit Control is enabled

☐ Capacity Limit Control is disabled

To enable/disable the Sequencer Control click on the ☒ selector in the "Value" box of the Activate Sequence Row of the table. Note that if you want to manually turn the chillers ON and OFF, you can first disable the Sequencer Control in this table, send the command clicking the

Send Command

button, and then return to the GCOP Command page and use the "Chiller Parameter" tap to turn the chiller ON and OFF as explained.

The selector meaning is:

☒ Sequencer Control is enabled

☐ Sequencer Control is disabled

To change the order of the chillers in the sequence of the Sequencer Control, click the new order in the "Value" box of the Sequence Order Row of the table. To make this change effective you must click also in the ☒ selector in the "Value" box of the Override Sequence Row of the table

The selector meaning is:

☒ Sequence Override is ON

☐ Sequence Override is OFF.

Send Command

Once all the desired parameters of this table is modified, you must click on the button to send the parameters to the GCOP controller in campus.

Informative page of Sequence Control.

When you click on this option, the following page is shown:

GCOP - GREEN CHILLER OPTIMIZATION PACKAGE

Sign out

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MAIN MENU

- Chiller Main Parameters
- Setpoint Reset Control
- Sequence Control
- Graphic Trends
- Additional Variables
- Evaluation mode
- Updates
- Contact Us

GCOP - Sequence and Rotation Optimizer

Client: London3845

Today's Active Optimization Time: 28.93 %

Last Update: 2019-06-07 08:21:43

Sequencing and Rotation Main Control

Chiller Parameters

Control Settings

Control DISABLED	Chiller 1	Chiller 2	Chiller 3	Chiller 4
Maximum Capacity	100	100	100	100
Computed Capacity	49.4	0	0	0
Real Capacity	49.4	0	0	0
Alarm Status				
Chiller ON/OFF				
Chiller Status				
Enable EWT Average				
Enable to Sequence				
Entering CHW Temp.	57.82	54.94	64.98	0
Leaving CHW Temp.	53.96	57.04	69.73	0
Actual CHW Temp. SP	48.55	48.55	48.55	0
Entering CW Temp.	0	0	0	0

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Version: 2.0.0

and scrolling the page:

GCOP - GREEN CHILLER OPTIMIZATION PACKAGE

Sign out

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MAIN MENU

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GCOP - Sequence and Rotation Optimizer

Client: London3845

Today's Active Optimization Time: 28.93 %

Last Update: 2019-06-07 08:21:43

Sequencing and Rotation Main Control

Chiller Parameters

Control Settings

Control DISABLED	Chiller 1	Chiller 2	Chiller 3	Chiller 4
Maximum Capacity	100	100	100	100
Computed Capacity	49.4	0	0	0
Real Capacity	49.4	0	0	0
Alarm Status				
Chiller ON/OFF				
Chiller Status				
Enable EWT Average				
Enable to Sequence				
Entering CHW Temp.	57.82	54.94	64.98	0
Leaving CHW Temp.	53.96	57.04	69.73	0
Actual CHW Temp. SP	48.55	48.55	48.55	0
Entering CW Temp.	0	0	0	0
Leaving CW Temp.	0	0	0	0
CHW Pump Status				
CW Pump Status				
Communication State				

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Version: 2.0.0

This page shows the information related to the Sequence Control optimization system of the GCOP controller..

The parameters shown in this page are the same ones that the GCOP_Optimizer application shows in the GCOP controller, which were already described in details early in this document.

Control DISABLED

To see the control settings of the Sequence Control click on the "Control Settings" tab and the following table is shown:

Chiller Parameters

Control Settings

Control Settings

Setup Parameters	Value
Sequence Order	12
Activate Sequencer	<input type="checkbox"/>
Use Enter Temp. Average	<input checked="" type="checkbox"/>
FeedBack Response Time (sec)	120
Delay hours for Rotation	168
Hour of Rotation	8
Seq. Dead Band	0
Min. Chiller Delay time ON/OFF (sec)	60
% Max. ON Capacity	60
% Max. OFF Capacity	30
Time Out to move next step (sec)	1200

Control Stages

Stages	Delta SP (EWT-LWT)	EWI-LIMITS
First	0	44.00

General Readings

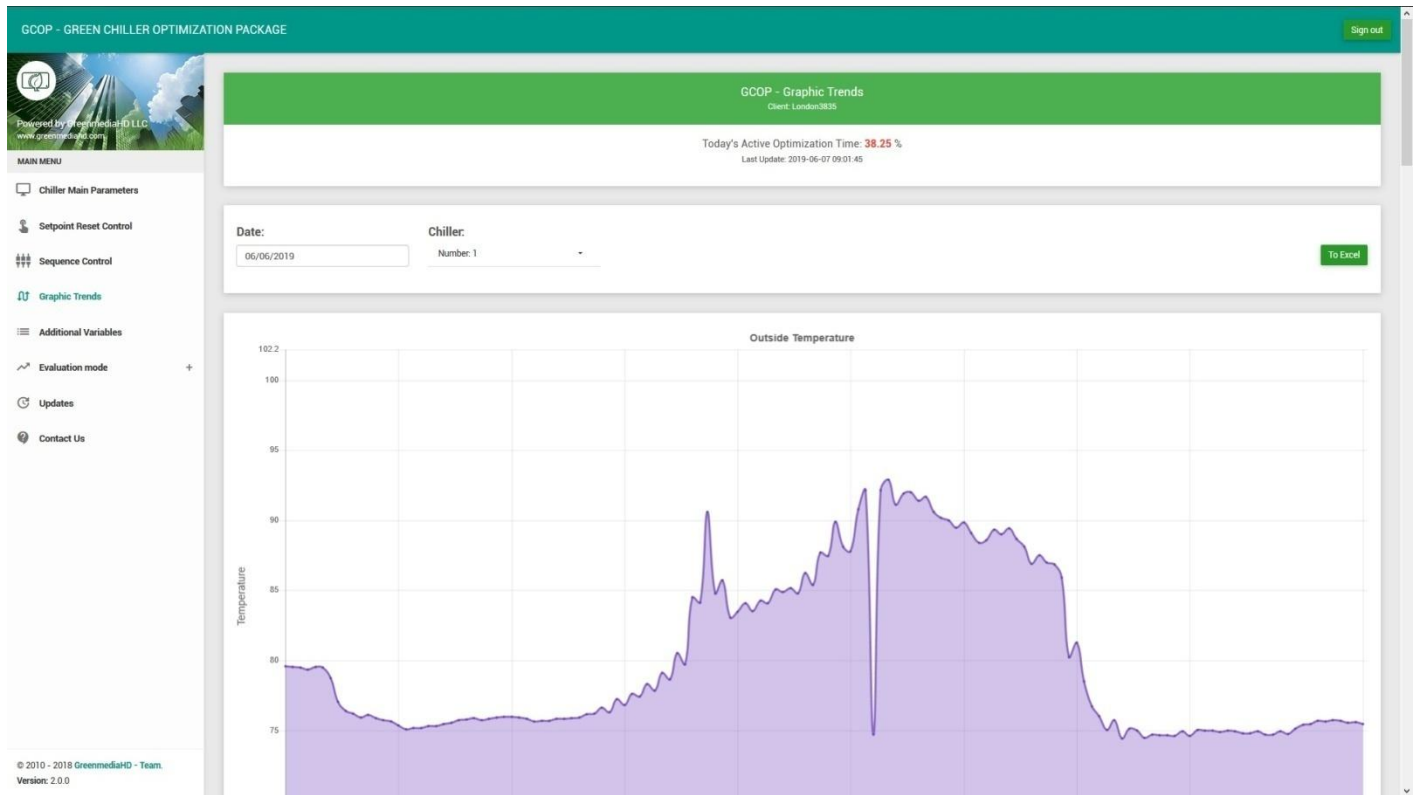
Parameters	Value
Mixture Temperature	55.15
LWT Setpoint Average	44
Last Error	-
Elapsed hours since rotation	0
Current Sequence Order	12

Each parameter was described in details in the GCOP_Optimizer application explained early in this documentation

Send Command

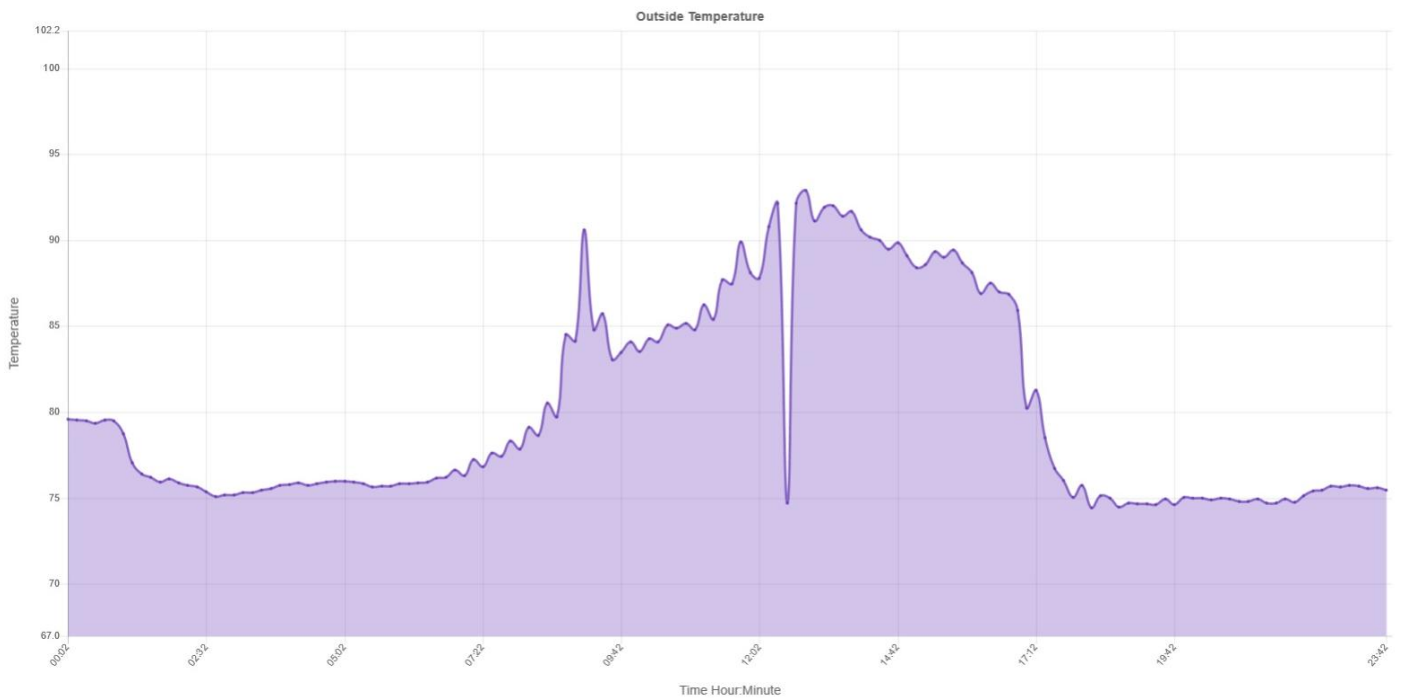
Graphic trends.

When you click on this option, the following page is shown:

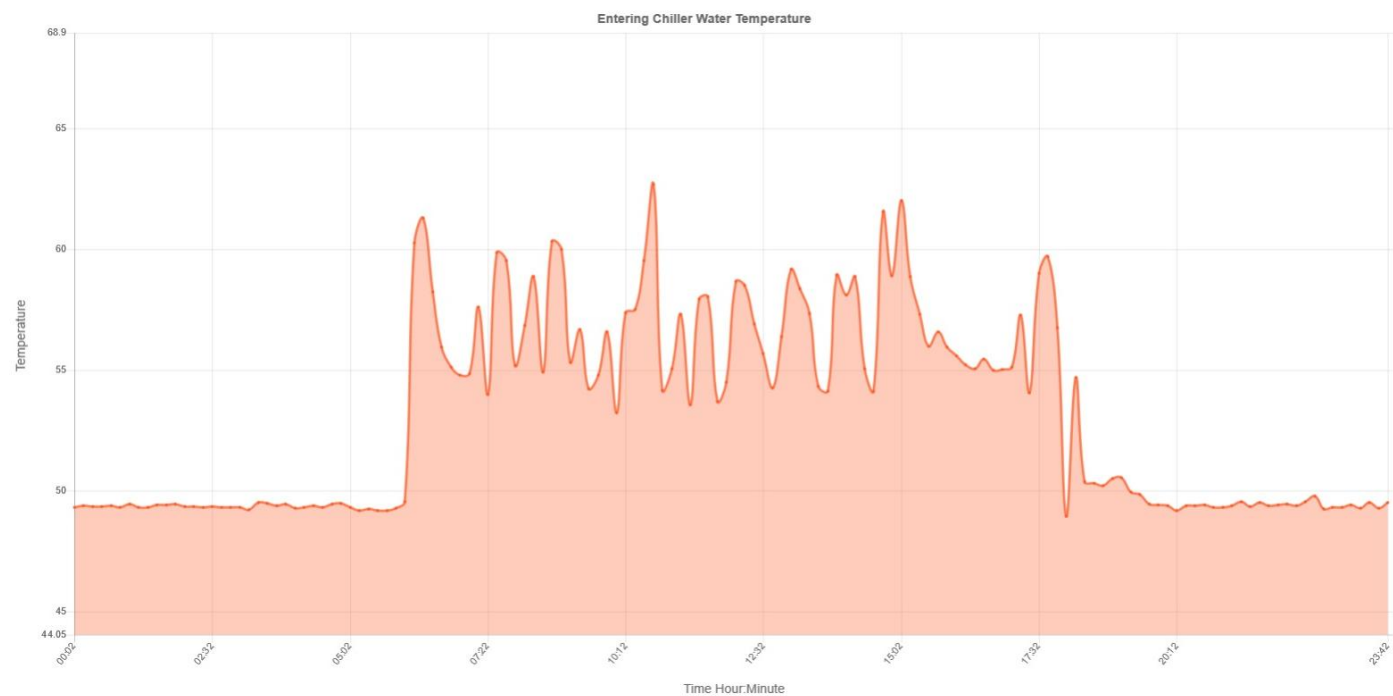


In this page, the trending graphic of the main chiller variables are shown. Scroll on the page to see the different trending as shown:

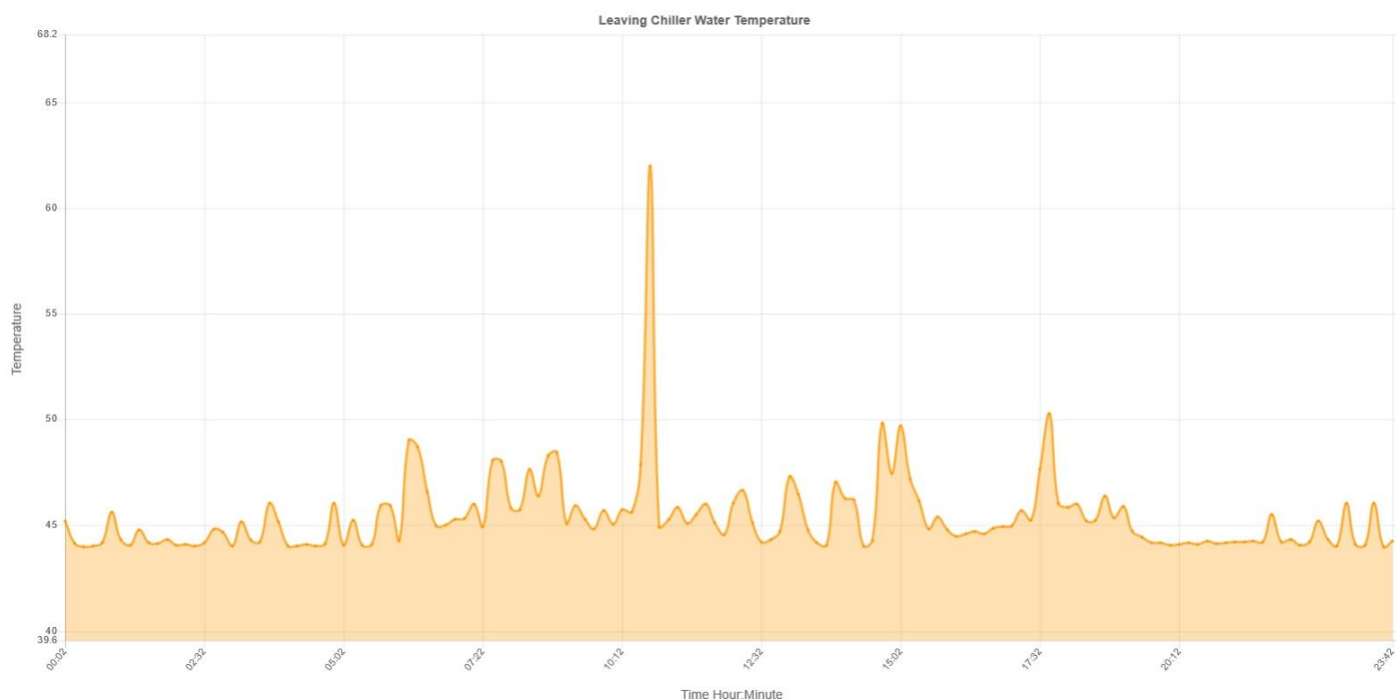
Outside temperature



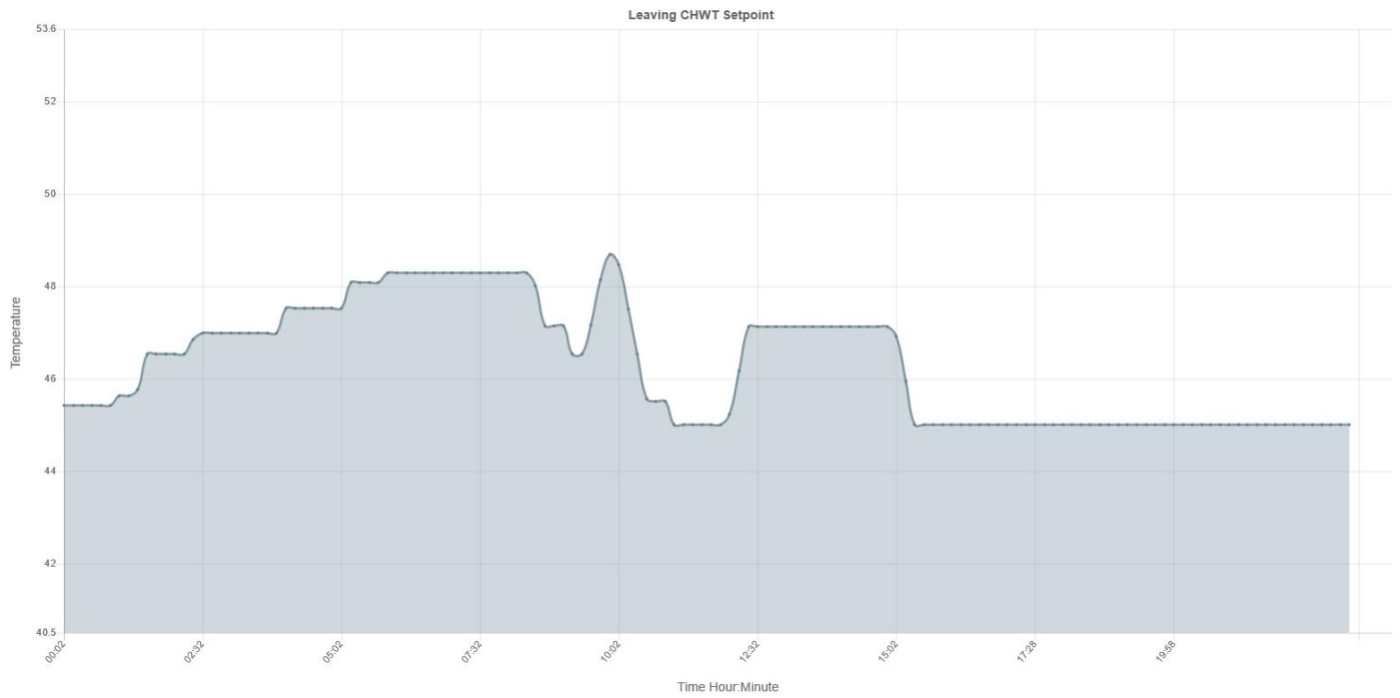
Entering chiller water temperature:



Leaving chiller water temperature:



Leaving chiller water temperature set-point:



Chiller Cooling Capacity:



To select the chiller number for the corresponding trending, click on the chiller option as shown:

Chiller:

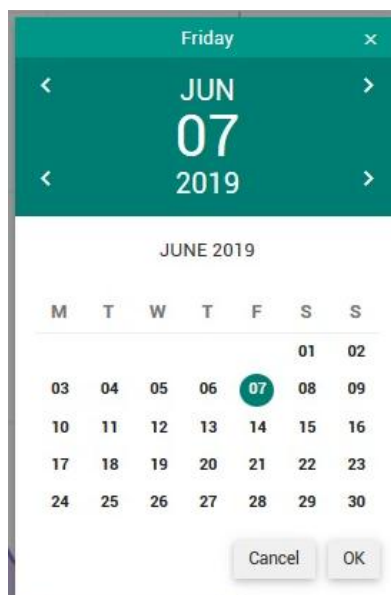


A dropdown menu titled "Chiller:" with four options: "Number: 1", "Number: 2", "Number: 3", and "Number: 4". The "Number: 1" option is selected, indicated by a checkmark icon to its right.

Chiller
Number: 1
Number: 2
Number: 3
Number: 4

Then click on the chiller number to show, and all trending are updated to that date.

To select the day of the trending click on the Date selection option as shown:



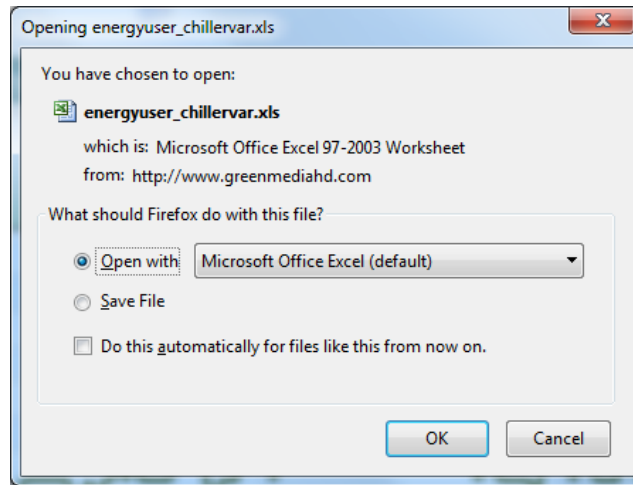
A date selection calendar for June 2019. The top bar shows "Friday" and a close icon. Below it, the month "JUN" and year "2019" are displayed with navigation arrows. The calendar grid shows the days of the month, with the 7th (Friday) highlighted. At the bottom are "Cancel" and "OK" buttons.

JUNE 2019						
M	T	W	T	F	S	S
					01	02
03	04	05	06	07	08	09
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

Then pick the right date, and all trending are updated to that date.

You can have all the data for the selected date exported to an Excel file. Just click on the

To Excel



You can select open or save the Excel file.


The content of the file is shown:

energyuser_chillervar-61.xls [Read-Only] [Compatibility Mode] - Microsoft Excel																									
Variables Report																									
1	Variables Report	User:	London3835																						
2	Description:	Chiller number 1																							
3	Date Time	OUTSIDE TMP	ECHWT	LCHWT	LCHWTSP	CAPACITY	Plant Capacity																		
4	2019-06-06 00:02:36	79.56	49.3	45.22	45	30.4	7.6																		
5	2019-06-06 00:12:36	79.54	49.37	44.14	45	33.5	8.375																		
6	2019-06-06 00:22:36	79.47	49.34	43.97	45	33.4	8.35																		
7	2019-06-06 00:32:36	79.36	49.34	44.03	45	33.4	8.35																		
8	2019-06-06 00:42:36	79.51	49.37	44.19	45	34.5	8.625																		
9	2019-06-06 00:52:36	79.49	49.32	45.61	45	30.6	7.65																		
10	2019-06-06 01:02:31	78.71	49.43	44.32	45	33.5	8.375																		
11	2019-06-06 01:12:31	77.06	49.3	44.05	44.95	34.1	8.525																		
12	2019-06-06 01:22:31	76.39	49.3	44.78	45	33.6	8.4																		
13	2019-06-06 01:32:31	76.19	49.41	44.19	45	34	8.5																		
14	2019-06-06 01:42:31	75.92	49.41	44.15	45	33.6	8.4																		
15	2019-06-06 01:52:31	76.09	49.46	44.33	45	33.9	8.475																		
16	2019-06-06 02:02:31	75.87	49.34	44.05	45	33.8	8.45																		
17	2019-06-06 02:12:31	75.74	49.34	44.1	45	33.8	8.45																		
18	2019-06-06 02:22:31	75.62	49.3	44.03	45	33.7	8.425																		
19	2019-06-06 02:32:31	75.37	49.36	44.19	45	33.9	8.475																		
20	2019-06-06 02:42:31	75.08	49.3	44.82	45	30.4	7.6																		
21	2019-06-06 02:52:31	75.17	49.32	44.69	45	31	7.75																		
22	2019-06-06 03:02:31	75.15	49.3	44.01	45	33.5	8.375																		
23	2019-06-06 03:12:31	75.29	49.21	45.18	45	31	7.75																		
24	2019-06-06 03:22:31	75.29	49.52	44.28	45	33.5	8.375																		
25	2019-06-06 03:32:31	75.46	49.48	44.21	45	34.2	8.55																		
26	2019-06-06 03:42:31	75.56	49.39	46.06	45	33.3	8.325																		
27	2019-06-06 03:52:31	75.74	49.46	45.18	45	34.1	8.525																		
28	2019-06-06 04:02:31	75.8	49.28	44.03	45	30.6	7.65																		
29	2019-06-06 04:12:31	75.87	49.3	44.03	45	34.1	8.525																		
30	2019-06-06 04:22:31	75.74	49.37	44.12	45	33.8	8.45																		

Note that the values of the 5 variables for the selected chiller are displayed along with the date and time of each value reading.

Additional Variables.

When you click on this option, the following page is shown:

GCOP - GREEN CHILLER OPTIMIZATION PACKAGE																																																																							
<div>  <div> <p>GCOP - Additional Bacnet Variables</p> <p>Client: London3935</p> <p>Today's Active Optimization Time: 41.08 %</p> <p>Last Update: 2019-06-07 10:01:45</p> </div> </div>																																																																							
<table> <tr> <th>Address</th><th>Variable Name</th><th>Value</th><th>Address</th><th>Variable Name</th><th>Value</th></tr> <tr> <td>10</td><td>Facility Outdoor Air Humidity</td><td>1.47</td><td>10</td><td>Communication Status Ch#4</td><td>3</td></tr> <tr> <td>10</td><td>Temperatura Suministro Agua He</td><td>51.27</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>ambientTempLockout(PAH-EDIF_C-</td><td>82.3</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Diagnostic Shutdown Present Ch</td><td>0</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Diagnostic Shutdown Present Ch</td><td>0</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Diagnostic Shutdown Present Ch</td><td>0</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Diagnostic Shutdown Present Ch</td><td>0</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Communication Status Ch#1</td><td>3</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Communication Status Ch#2</td><td>3</td><td>---</td><td>Not Defined</td><td>----</td></tr> <tr> <td>10</td><td>Communication Status Ch#3</td><td>3</td><td>---</td><td>Not Defined</td><td>----</td></tr> </table>						Address	Variable Name	Value	Address	Variable Name	Value	10	Facility Outdoor Air Humidity	1.47	10	Communication Status Ch#4	3	10	Temperatura Suministro Agua He	51.27	---	Not Defined	----	10	ambientTempLockout(PAH-EDIF_C-	82.3	---	Not Defined	----	10	Diagnostic Shutdown Present Ch	0	---	Not Defined	----	10	Diagnostic Shutdown Present Ch	0	---	Not Defined	----	10	Diagnostic Shutdown Present Ch	0	---	Not Defined	----	10	Diagnostic Shutdown Present Ch	0	---	Not Defined	----	10	Communication Status Ch#1	3	---	Not Defined	----	10	Communication Status Ch#2	3	---	Not Defined	----	10	Communication Status Ch#3	3	---	Not Defined	----
Address	Variable Name	Value	Address	Variable Name	Value																																																																		
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10	Communication Status Ch#2	3	---	Not Defined	----																																																																		
10	Communication Status Ch#3	3	---	Not Defined	----																																																																		



This page shows the values of the additional Bacnet variables that were configured in the GCOP controller. It is useful to monitor variables that could be affected by the reset of the LCHWT set-point like the space temperature of some locals, and the take those locals in consideration setting the auxiliary controls of the Setpoint Reset Control.

Evaluation Mode.

This option contains many options that allow us evaluate the benefits of introducing the GCOP controller to save energy.

Inside this option there are some options that we explain in details.

Just click in the + symbol to expand the options as shown:


Evaluation mode


Average Capacity

Savings Report

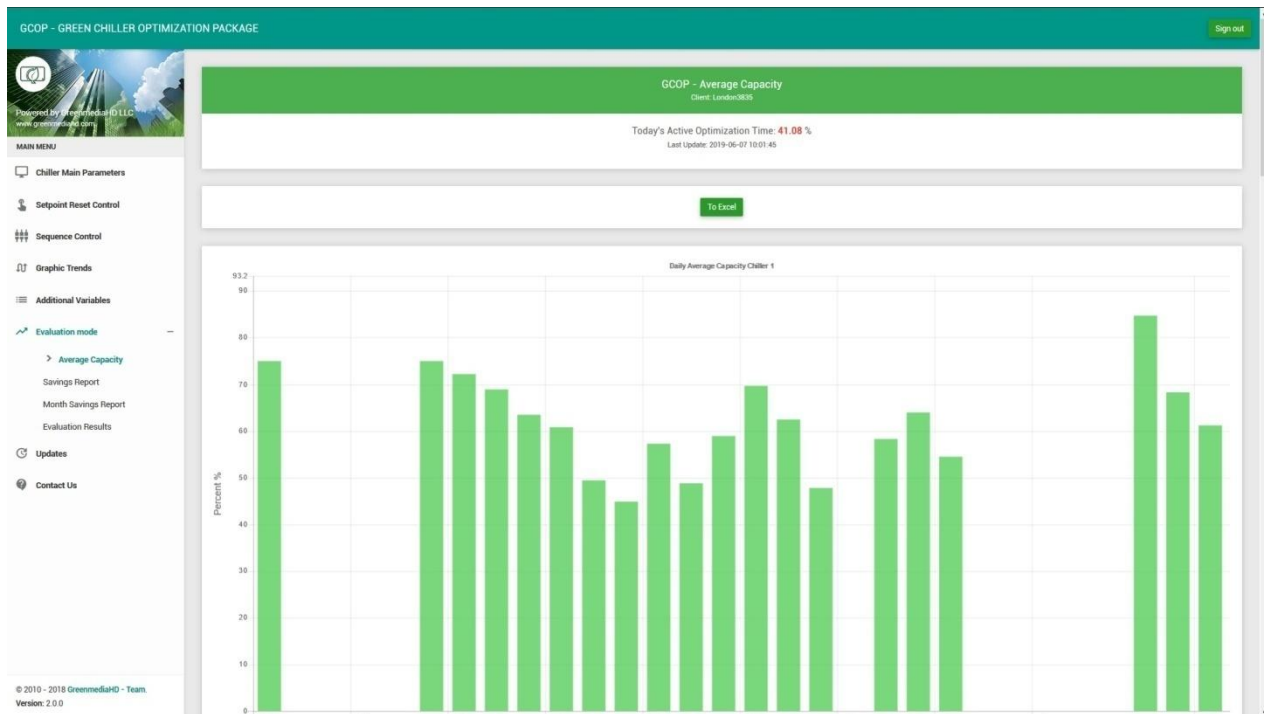
Month Savings Report

Evaluation Results

Total Capacity Setup

Average Capacity.

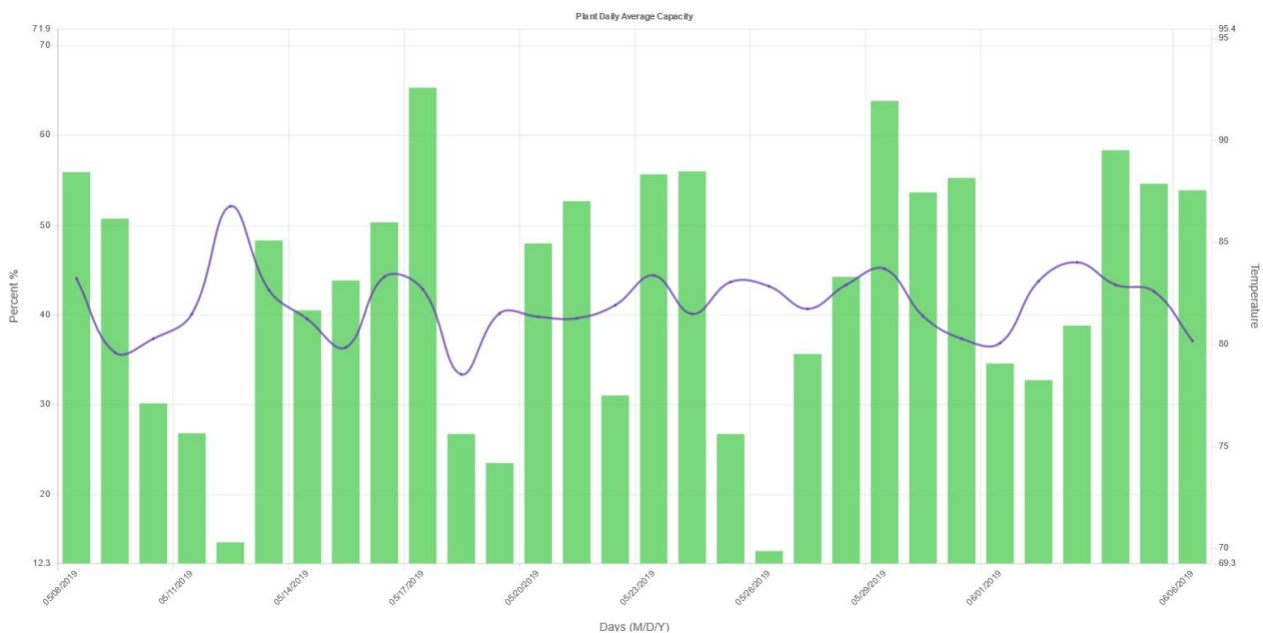
When you click on this option, the following page is shown:



In this page a bar-chart of the daily average capacity for each chiller and chiller plant is shown.

The cooling capacity is proportional to the cooling tons supplied by the chiller plant according to the cool load, and is also proportional to the power energy consumed in the chiller plant.

To see the average cooling capacity scroll on this page, and the last bar-chart correspond to the chiller plant as shown:



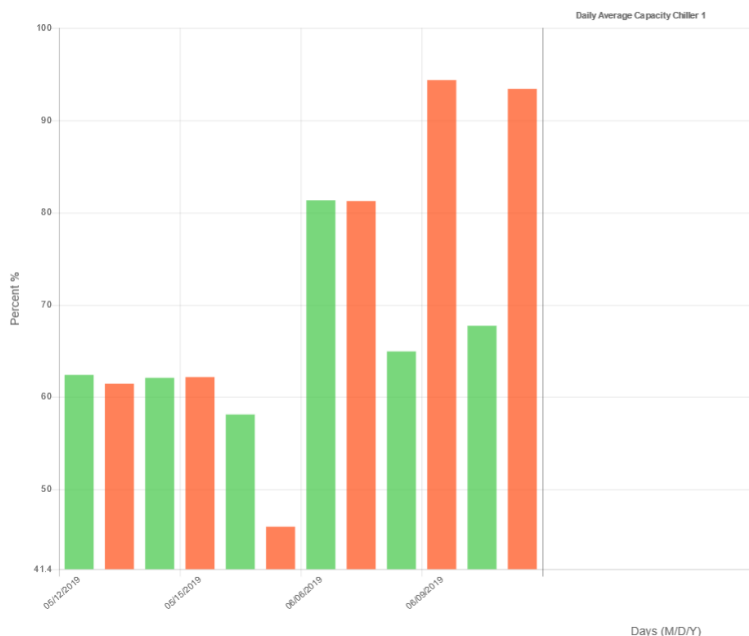
In case of the chiller plant, the outside average temperature is also show in the bar-chart to have a better idea of the current cool load each day.

As mentioned early in this document, the GCOP controller can be configured to operate in Evaluation Mode. In this mode, the optimization algorithms control are enabled only in even days and disabled in odd days, so the GCOP controller only save energy every other day. With this mode of evaluation, one day ON and one day OFF, the cool load is more similar each day and the results of comparing the system behavior when the controls are ON and OFF are more effective.

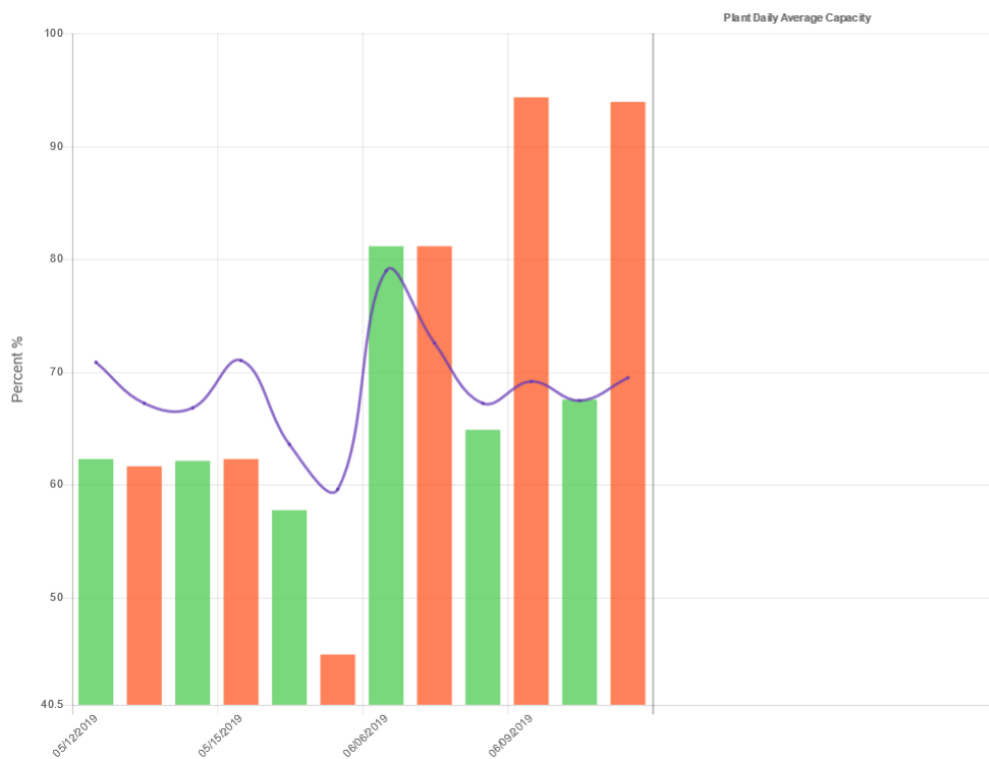
We know when the system is in Evaluation Mode when we see the following text in each page:

SAVING EVALUATION MODE ON

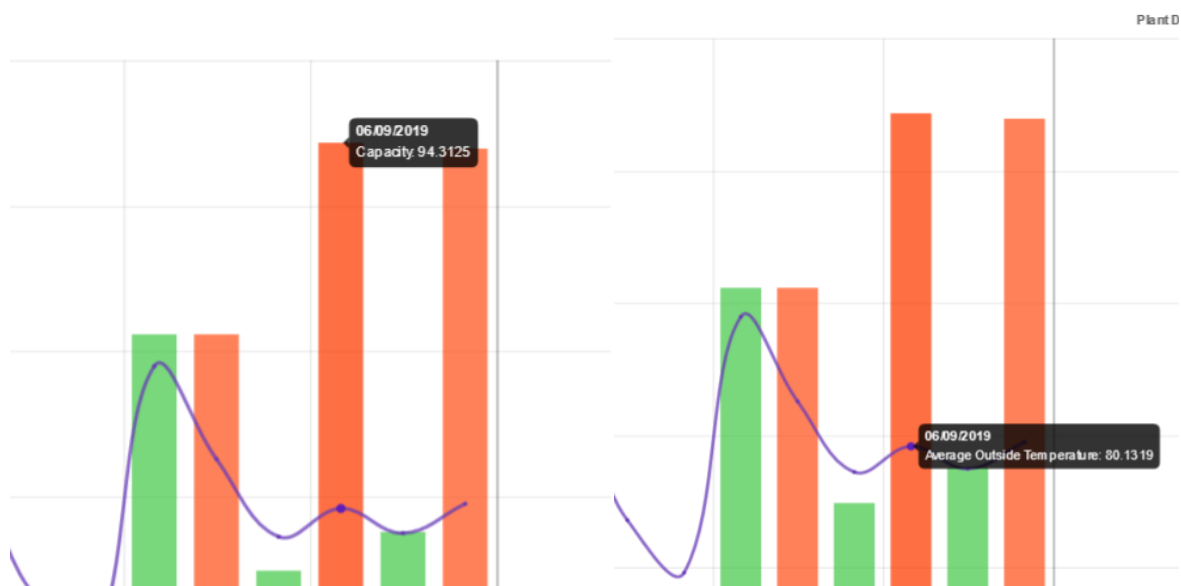
When the system is in evaluation mode, the bar-chart of the average capacity shows a red color for odd day and a green color for even day, this allow us to easily compare the two days as shown:



And for the chiller plant:



You can see the values of each bar and temperature curve if you hover the mouse over the graphic as shown here:



Saving Report.

Before entering in details with this option, let's explain why the GCOP save energy.

The most energy losses in a chiller is excess lift. Lift is determined by subtracting the temperature of the chilled water going out to your building from the temperature of the water that's leaving the condenser to be cooled by a cooling tower or fans. The term *lift* can also be used to describe a chiller's operating pressures in place of its temperatures.

One common practice to reduce lift is to apply a chilled water reset strategy. The leaving chilled water temperature was traditionally fixed, usually somewhere around 44°F. The chilled water reset allows the temperature of the chilled water to be increased during part load conditions. This reduces the amount of work done by the chillers compressor.

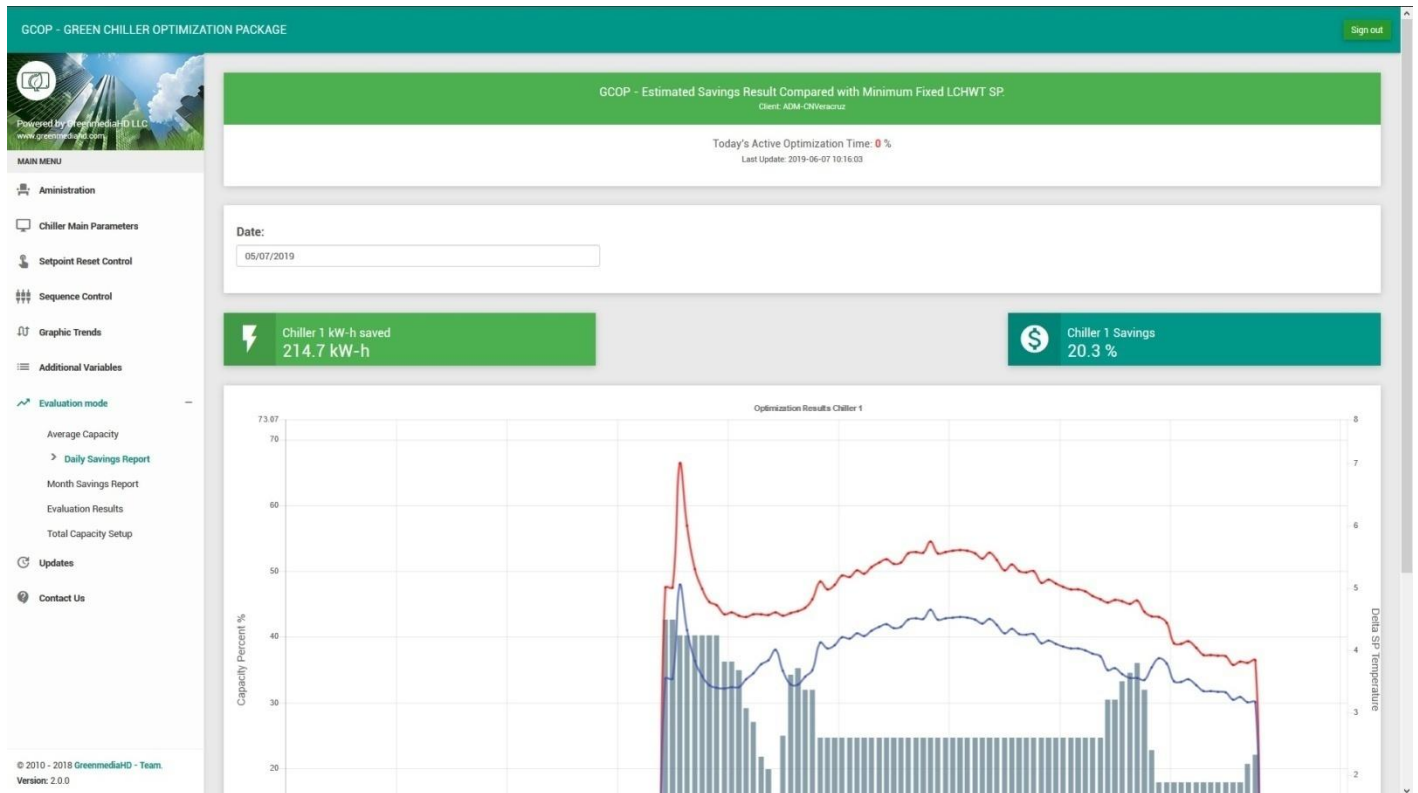
The increase in chilled water temperature results in an increase in evaporator pressure of the refrigerant. The compressor takes the refrigerant at the evaporator pressure then compresses it and increases its pressure to the condensers pressure, so the higher the evaporator pressure the less work the compressor needs to do to increase that pressure.

As a rule of thumb, the chiller efficiency can be increased by 1-5% per degree the chilled water temperature is increased. The chiller efficiency can be expressed in kW/Tons. This increase in efficiency makes possible to save 12-25% of power energy in chiller plant.

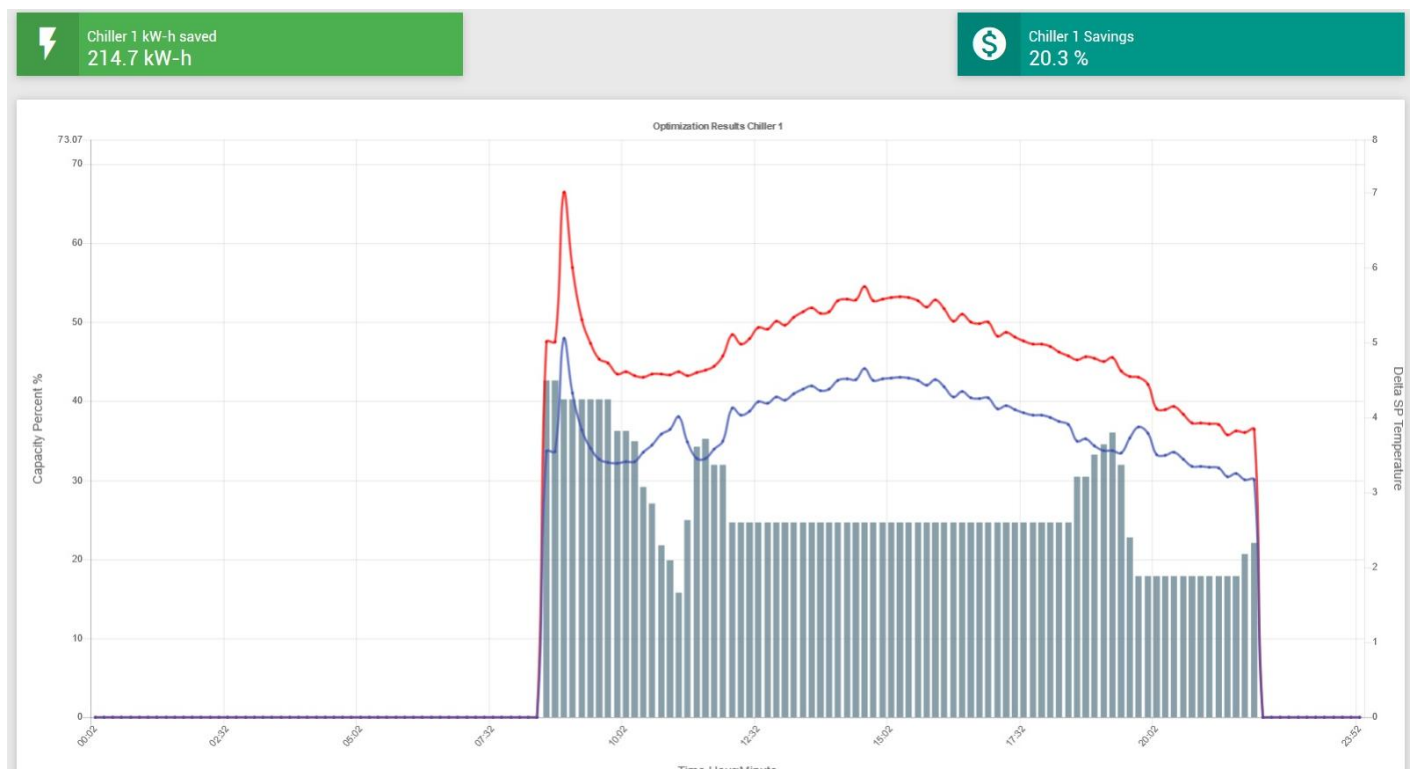
Taken in consideration the chiller model, type, and efficiency given by the chiller manufacturer, and based in the variation of leaving chiller water temperature and cooling capacity for a given cool load, the GCOP calculates a coefficient of chiller efficiency that evaluates how much the cooling capacity of the chillers varies with the variation of the leaving chiller water temperature set-point. Based in the chiller efficiency expressed in kW/tons, the GCOP also evaluates how many kW are reduced compared with a minimum fixed LCHWT Set-point.

The processed data gathered during the evaluation mode make the calculated coefficient of chiller efficiency even more accurate. In order to make a more conservative calculation, it is assumed only a 1.5 % increase in chiller efficiency and 15 % of power energy savings in chiller plant.

When you click on the Saving Report option, the following page is shown:



Let's explain this graphic analyzing the full chart shown here:



This chart describes for every chiller how the resetting of the LCHWT set-point impacts in the current cooling capacity showing what value would have the cooling capacity if the minimal fixed set-point were used instead. Up to 4 charts can appear in this page, that depends on the amount of chillers defined in the GCOP configuration.

The gray bar shows the changes of the LCHWT set-point above the minimum fixed set-point value (Delta SP), that means that if the GCOP Setpoint Reset Control were disabled, all bars would have a zero value, and a fixed minimum LCHWT set-point were used instead of a varying set-point. In the example above, the LCHWT set-point has moved up to 4.3 oF above the minimum fixed set-point value.

The blue line represent the actual chiller cooling capacity with the LCHWT set-point being reset by the GCOP controller.

The red line represent the chiller cooling capacity if the minimum fixed LCHWT set-point were used instead of a varying set-point. This capacity is calculated by the GCOP controller using the estimated coefficient of chiller efficiency, the nominal tons of the current chillers, and the chiller efficiency supplied by the chiller manufacturer based in the type, model and year of the chiller, in function of the variation of the Leaving Chiller Water Temperature values.

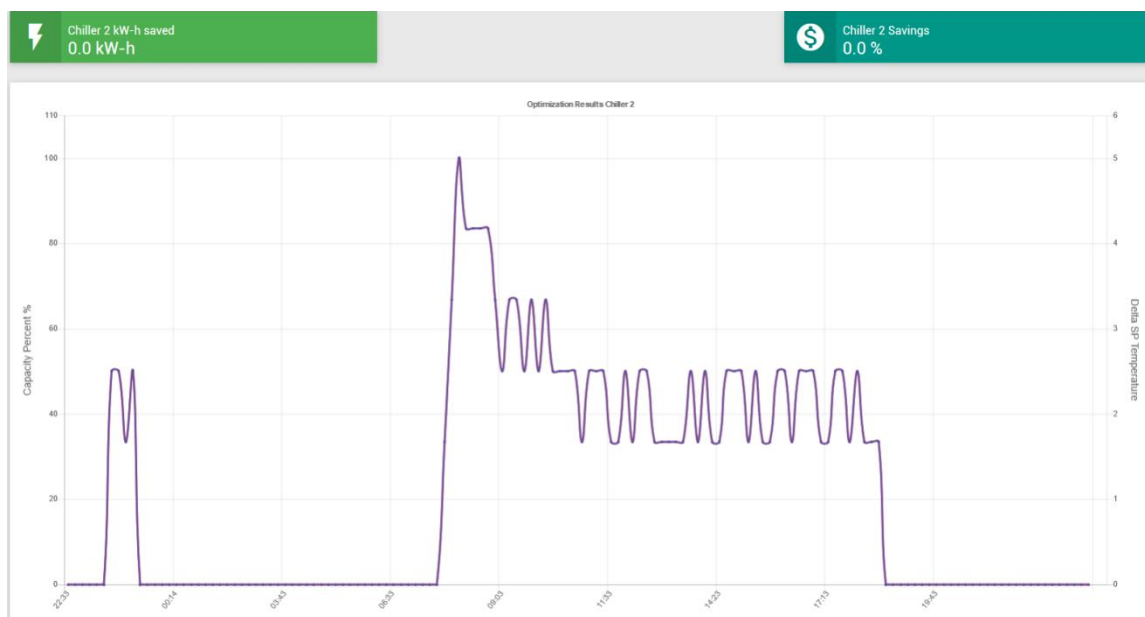
In the left green box above the chart, the estimated kW-h saved for the corresponding chiller are shown. This savings is calculated by the GCOP controller comparing the actual kW/Ton obtained with the set-point reset control and the estimated with a fixed set-point

In the dark green right box above the chart, the estimated saving percent for the corresponding chiller are shown. This savings is calculated by the GCOP controller comparing the actual cooling capacity obtained with the set-point reset control and the estimated with a fixed set-point

Note that when the Delta SP is lower, the gap between the red and blue lines are lower (less savings) and on the other hand, if Delta SP is higher you get more savings.

Note also that the savings estimation is made only when the chiller is running.

When the Setpoint Reset Control is disabled, the chart might look like the following:



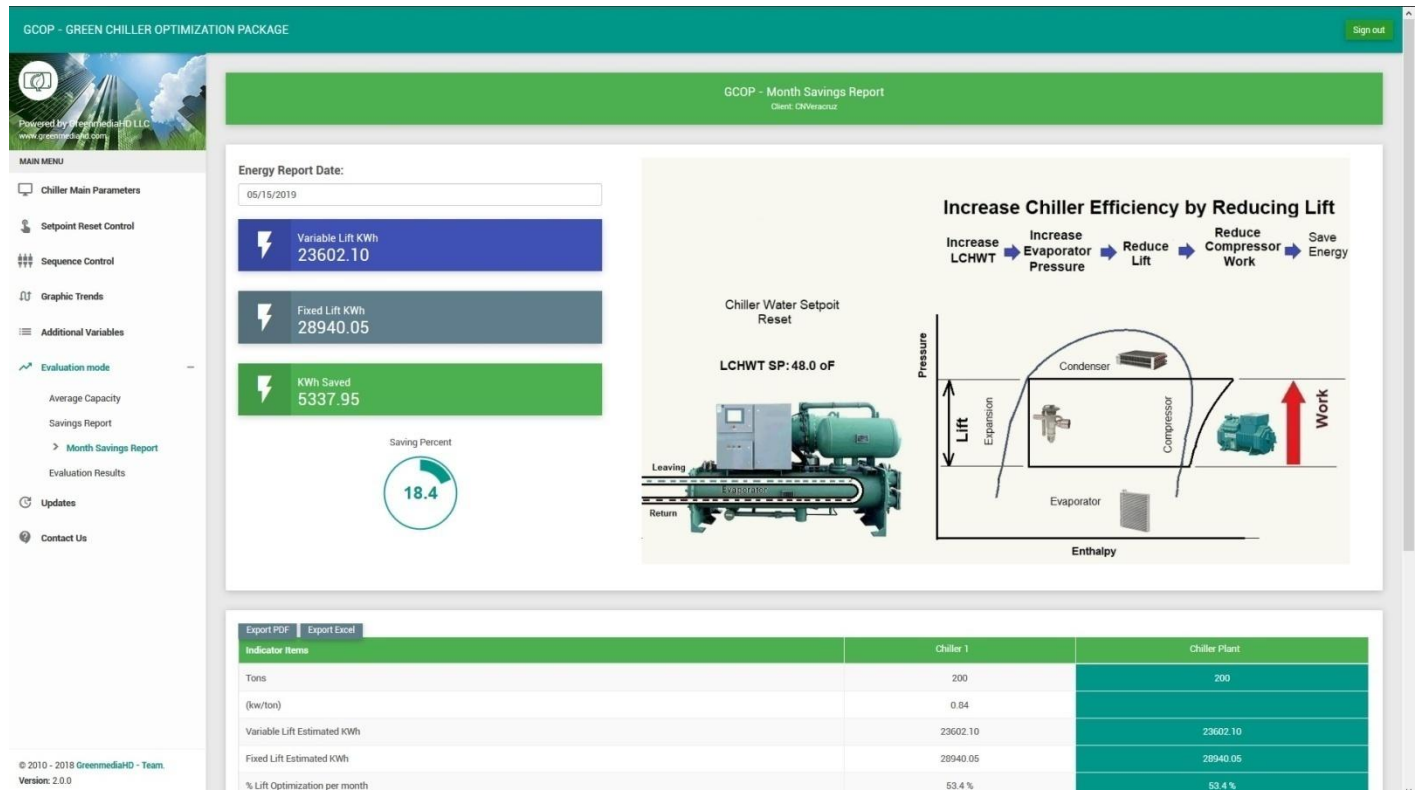
Where no savings are obtained.

As explained in the Graphic Trends option, you can pick any date you want to show the savings by clicking on the Date selection above the graphics charts.

Month Saving Report.

Based in how the GCOP controller calculate the savings by resetting the LCHWT set-point as explained in the Saving Report option, a month report is elaborated considering the saving in the last 30 days from the selected date of the month report.

When you click on the Month Saving Report option, the following page is shown:



In the left panel of the first part of the page, we have the following information:

Energy Report Date:

05/15/2019

**Variable Lift KWh**
23602.10**Fixed Lift KWh**
28940.05**KWh Saved**
5337.95

Saving Percent



In the Energy Report Date, we pick the Date of the saving report. The result of the report consider 30 days before that date, so you will have a month report until that date. In the example before, we have the report from the 04/16/2019 until 05/15/2019 (considering 31 days in May).

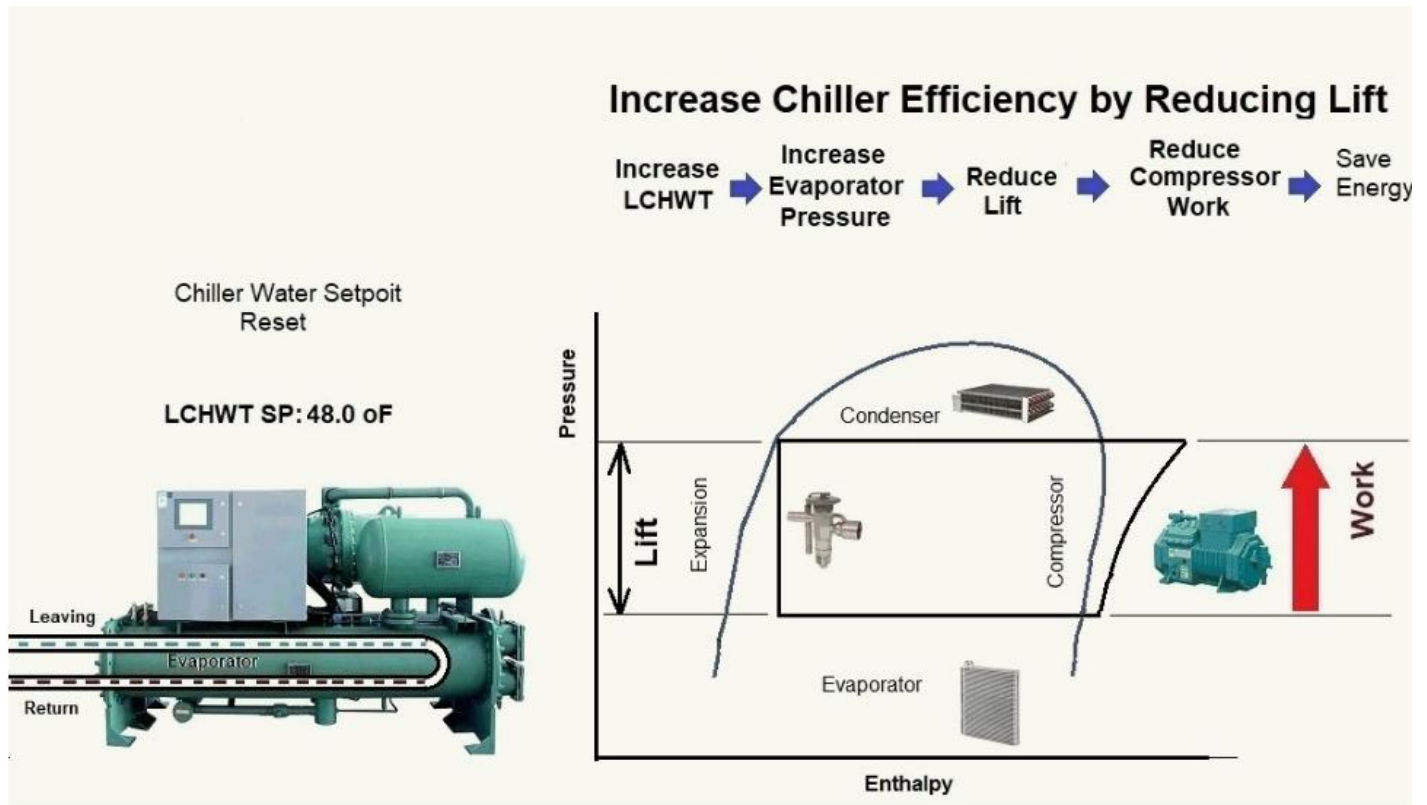
The first blue box is the estimated kWh of chiller plant considering the actual chiller cooling capacity for each chiller. This capacity assumes that LCHWT set-point has been reset by the GCOP controller (the Setpoint Reset Control was enabled) and for that reason the lift of the chiller was varying.

The gray blue box is the estimated kWh of chiller plant considering the calculated chiller cooling capacity for a fixed minimum LCHWT set-point for each chiller. Remember that this calculation is made by the GCOP controller using the estimated coefficient of chiller efficiency, the nominal tons of the current chillers, and the chiller efficiency supplied by the chiller manufacturer based in the type, model and year of the chiller, in function of the variation of the Leaving Chiller Water Temperature values. Because the calculation is done evaluating a fixed LCHWT set-point, it is called Fixed Lift.

The green blue box is the difference between a Fixed and a Variable Lift, represented the kW-h saved in the chiller plant, in example above 5337.95 kWh were saved in the chiller plant in the last 30 days.

The gauge in the bottom indicates the saving percent, for the example above it represents a savings of 18.4 percent in chiller power energy consumption.

The drawing in the right panel in the first part of the page as shown:



It is an animated image that illustrate how the LCHWT set-point reset impact in the chiller compressor work, saving energy.

In the second part of this page a table with the main savings indicators is shown:

Indicator Items	Chiller 1	Chiller Plant
Tons	200	200
(kw/ton)	0.84	
Variable Lift Estimated KWh	23602.10	23602.10
Fixed Lift Estimated KWh	28940.05	28940.05
% Lift Optimization per month	53.4 %	53.4 %
Month Running Hours	436.33	436.33
Month Optimization Hours	409.83	409.83
% Optimization per Running Hours	93.9 %	93.9 %
Maximum Delta SP	6.85	6.85
Delta SP Average	2.69	2.69
Delta SP Standard Deviation	0.73	0.73
KWh Saved	5337.95	5337.95
Electrical Rate (\$/KWh)	\$ 0.18	\$ 0.18
Saving Cost	\$ 960.83	\$ 960.83
Total Saving	18.4 %	18.4 %

Let's explain each indicator item.

There is a column for each chiller and a column for the chiller plant where the corresponding values are set.

Tons: This is the nominal ton of each chiller. The chiller plant has the sum of all the chillers.

(kW/Ton): This is the efficiency of the chiller supplied by the manufacturer.

Variable Lift Estimated kWh: This is the estimated kWh of each chiller and chiller plant considering the actual chiller cooling capacity for each chiller where the LCHWT set-point has been reset by the GCOP controller.

Fixed Lift Estimated kWh: This is the estimated kWh of each chiller and chiller plant considering the calculated chiller cooling capacity for a fixed minimum LCHWT set-point in each chiller.

% Lift Optimization per month: This is the percent of time that the chiller has being optimized in the month, that is, the percent of time in which the LCHWT set-point has been reset with a value above the minimum fixed set-point in a month.

Month Running Hours. This is the number of hour that the chiller has being running in the month.

% Optimization per Running Hour: This is the percent of time that the chiller has been optimized considering only the running hours of the chiller in the month, that is, the percent of time that the LCHWT set-point has been above the minimum fixed set-point due to the GCOP optimization algorithm.

Maximum Delta SP: This is the maximum variation of LCHWT set-point above the minimum set-point value.

Delta SP Average: This is the average variation of LCHWT set-point above the minimum set-point value.

Delta SP Standard Deviation : This is the standard deviation of the variation of LCHWT set-point above the minimum set-point value.

kWh Saved: This is the difference between a Fixed and a Variable Lift Estimated kWh and represents the kW-h saved in each chiller and the chiller plant.

Electrical Rate (\$/kWh): This is the value that represents the electrical energy cost per kWh.

Saving Cost: This is the cost of the kWh saved using the Electrical Rate value.

Total Savings: This is the percent value of the kWh saved in each chiller and the chiller plant.

This report can be exported to PDF or Excel.

To export to PDF click on the **Export PDF** button, and for Excel click on **Export Excel** button.

Example of PDF file:

Chiller Plan Saving Report-12.pdf - Adobe Acrobat Reader DC

File Edit View Window Help

Home Tools Chiller Plan Saving ...

GCOP | Green - Chiller Optimization Package

Indicator Items	Chiller 1	Chiller Plant
Tons	200	200
(kw/ton)	0.84	
Variable Lift Estimated KWh	23342.00	23342.00
Fixed Lift Estimated KWh	28507.47	28507.47
% Lift Optimization per month	51.3 %	51.3 %
Month Running Hours	433.00	433.00
Month Optimization Hours	393.50	393.50
% Optimization per Running Hours	90.9 %	90.9 %
Maximum Delta SP	6.85	6.85
Delta SP Average	2.70	2.70
Delta SP Standard Deviation	0.73	0.73
KWh Saved	5165.47	5165.47
Electrical Rate (\$/KWh)	\$ 0.18	\$ 0.18
Saving Cost	\$ 929.78	\$ 929.78
Total Saving	18.1 %	18.1 %

Example of Excel File:

GCO

Home Insert Page Layout Formulas Data Review View Add-Ins Team

Clipboard Font Alignment

Indicator Items

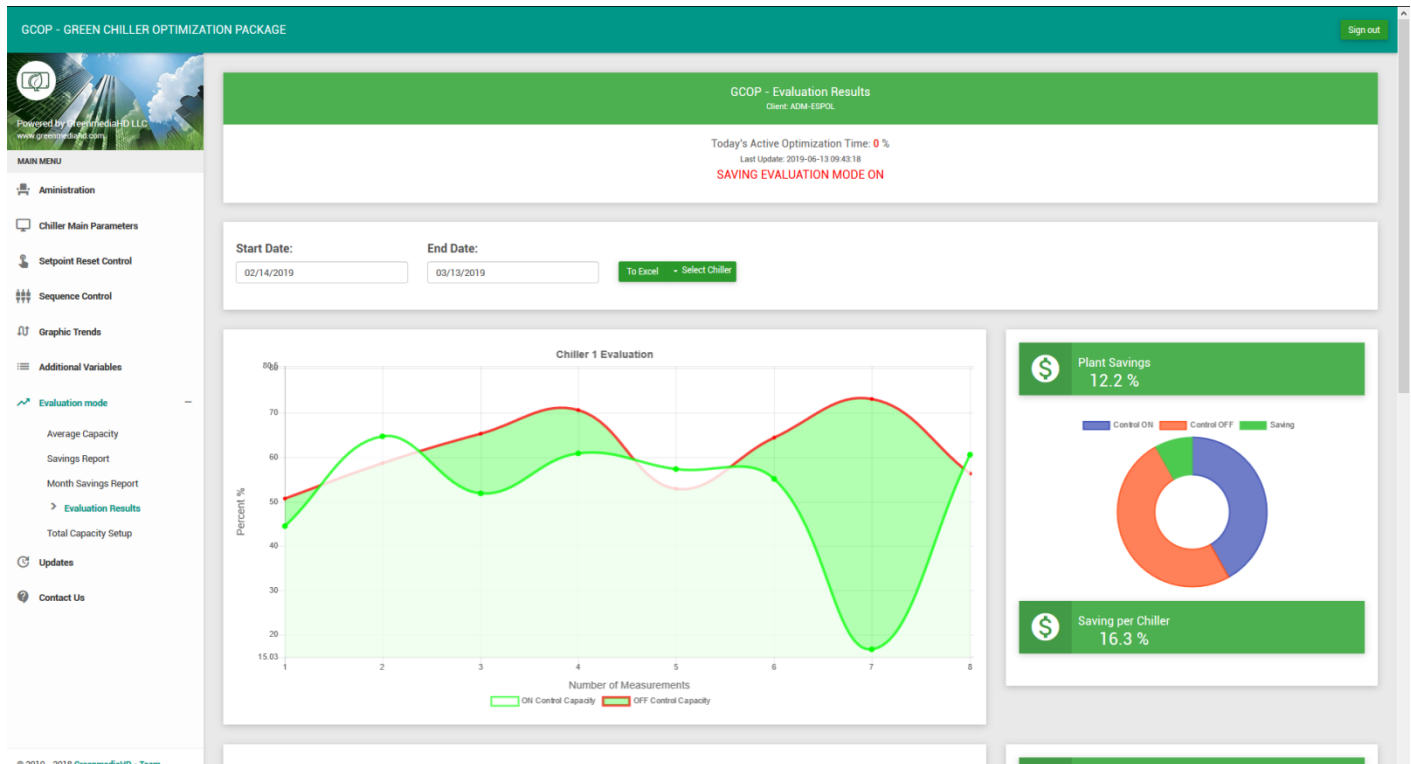
A	B	C	D	E	F
Indicator Items	Chiller 1	Chiller Plant			
1 Tons	200	200			
2 (kw/ton)	0.84				
3 Variable Lift Estimated KWh	23342	23342			
4 Fixed Lift Estimated KWh	28507.47	28507.47			
5 % Lift Optimization per month	51.3 %	51.3 %			
6 Month Running Hours	433	433			
7 Month Optimization Hours	393.5	393.5			
8 % Optimization per Running Hours	90.9 %	90.9 %			
9 Maximum Delta SP	6.85	6.85			
10 Delta SP Average	2.7	2.7			
11 Delta SP Standard Deviation	0.73	0.73			
12 KWh Saved	5165.47	5165.47			
13 Electrical Rate (\$/KWh)	\$ 0.18	\$ 0.18			
14 Saving Cost	\$ 929.78	\$ 929.78			
15 Total Saving	18.1 %	18.1 %			
16					
17					
18					
19					
20					
21					
22					

Evaluation Result.

As mentioned before the GCOP controller can be configured to operate in Evaluation Mode. In this mode, the optimization algorithms control are enabled only in even days and disabled in odd days.

This option is used to display a graphic chart that allows us to compare the cooling capacity behavior when the optimizations algorithms are in use and where they are not in use. This results show us how much energy can be saved using the optimizations algorithms in the GCOP controller.

When you click on this option, the following page is shown:



In the left chart you can pick the date when you want to start and end the analysis of the savings, those days must match the days when the GCOP is in evaluation mode to get more accurate results.

Every point in the X-Axe of the chart correspond to two consecutive odd and even days, so for example, you have 8 points it means 16 days (8 even days and 8 odd day). The two days must be consecutive, if the chiller is running in an even day and stopped in the odd day, that couple of values are not considered.

The page shows also the plant savings, where only the two consecutive days when each chiller is running are taken in consideration.

The red line in the chart is the average chiller cooling capacity in the odd days (GCOP optimization is OFF) and the green line in the chart is the average chiller cooling capacity in the even days (GCOP optimization is ON). The green space between the two lines is proportional to the savings.

The donna chart at the right shows the percent of the cooling capacity in odd and even days, and the percent of savings. The orange color represent the percent of the chiller average cooling capacity in odd days, the purple color represent the percent of the chiller average cooling capacity in even days, and the green color the saving percent.

In this chart is also displayed the savings percent of each chiller and the chiller plant in the selected period of evaluation.

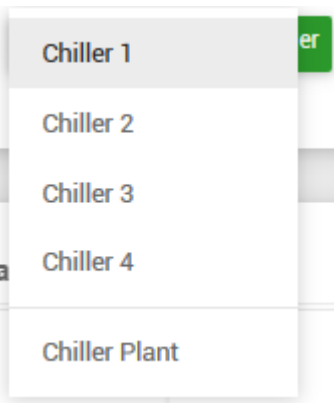
All the information gathered during the evaluation period is very useful to calculate the coefficient of efficiency of each chiller more accurately.

If the GCOP controller is not in evaluation mode when you enter in this page, the following warning appears on the screen:

Warning! The GCOP is NOT in evaluation mode. The results of evaluation may not be reliable.

And of course, there is no comparative difference between odd and even days when the GCOP controller is not in evaluation mode, in both days the optimization algorithms are enabled, but if you remember the evaluation period you can pick up the start and end date and review the results.

You can export the data to Excel using the To Excel - Select Chiller button. With this button you can select a chiller number or the chiller plant as shown:



Example of the exported Excel file:

energyuser_chillvar-66.xls [Read-Only] [Compatibility Mode] - Microsoft Excel

Evaluation Report								
A	B	C	D	E	F	G	H	I
1	Evaluation Report	User:ESPOL	Control On Ave. Capacity	Control Off Ave. Capacity	Chiller Saving	Chiller Plant Saving		
2	Chiller number 1		51.5 %	61.5 %	16.3 %	12.2 %		
3	Sample No.	Control ON Value	Control OFF Value	Difference				
4	1	44.5333	50.629	6.0957				
5	2	64.7262	58.6891	-6.0371				
6	3	51.9203	65.2369	13.3166				
7	4	60.8754	70.6766	9.8012				
8	5	57.2815	52.9077	-4.3738				
9	6	55.1	64.3491	9.2491				
10	7	16.7	73.18	56.48				
11	8	60.525	56.2446	-4.2804				
12								
13								
14								
15								
16								

Updates.

When you click on this option, the following page is shown:


www.greenmediahd.com/gcop/updates.php

GCOP - GREEN CHILLER OPTIMIZATION PACKAGE

GCOP - Last Updates
Client: London/3836


Today's Active Optimization Time: **41.08 %**
Last Update: 2019-06-07 10:01:45

Last Software Update



Download

Last Documentation Update



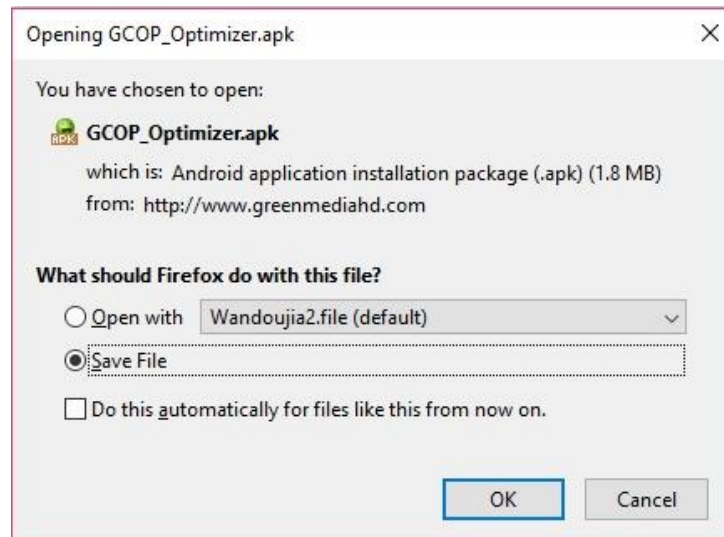
Download

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Version: 2.0.0

To update the GCOP_Optimizer App just click on the Down load button of this image:



The following windows appears:

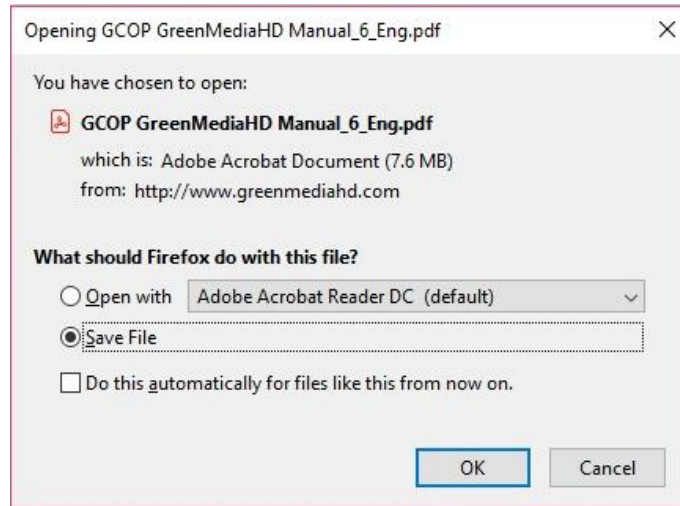


It is very useful to download the software update in the GCOP controller and install the new update directly in the controller, you can do it if you are using the Internet Explorer browser in the GCOP controller directly, otherwise you can download the updated application in the computer, copy it to a flash memory and install it in the GCOP controller using the File Explorer of the GCOP controller.

To download this documentation click on the Download button of the following image:

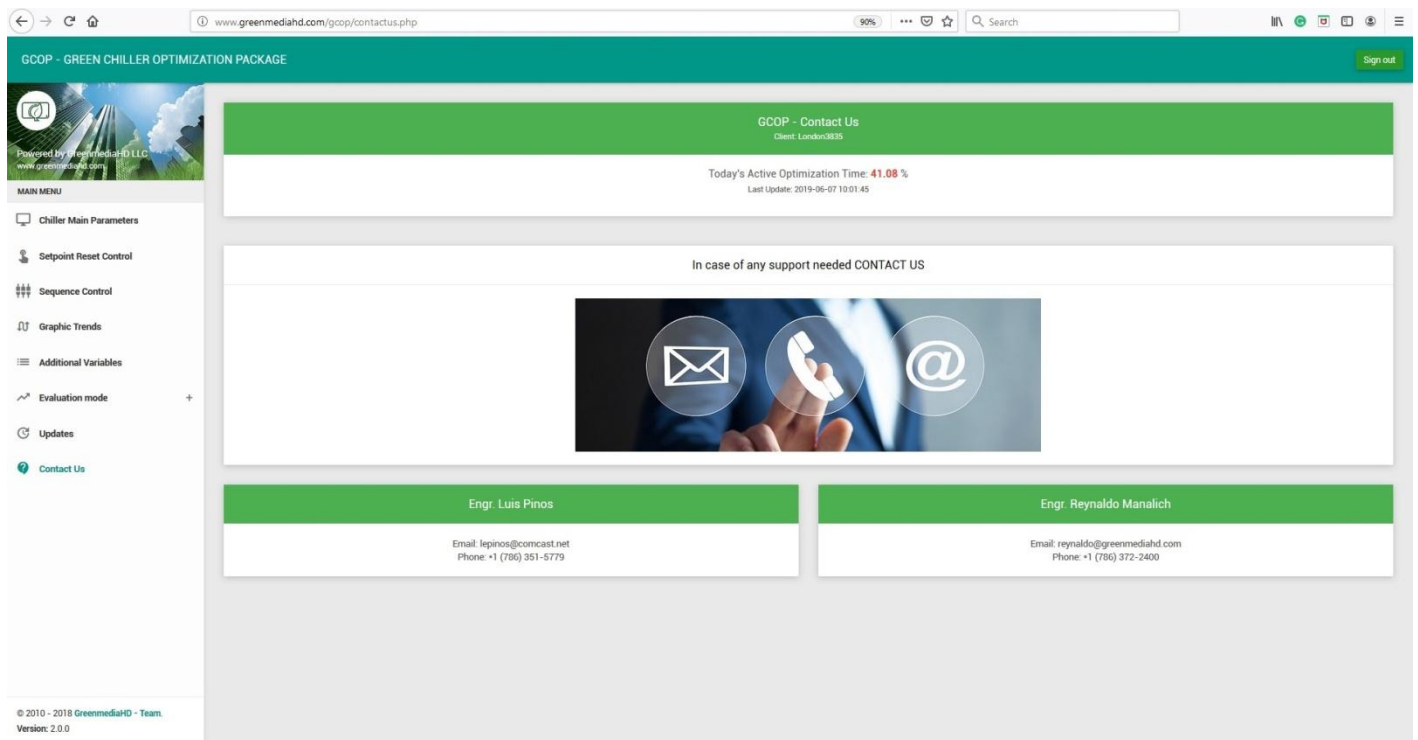


The following windows is shown:



Contact us.

When you click on this option, the following page is shown:



In case of any support call the phones that appear on this page or write e-mail to these contacts.