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UPDATE ON HYBRID COOLING RETROFIT INSTALLATION

ACC Users Group

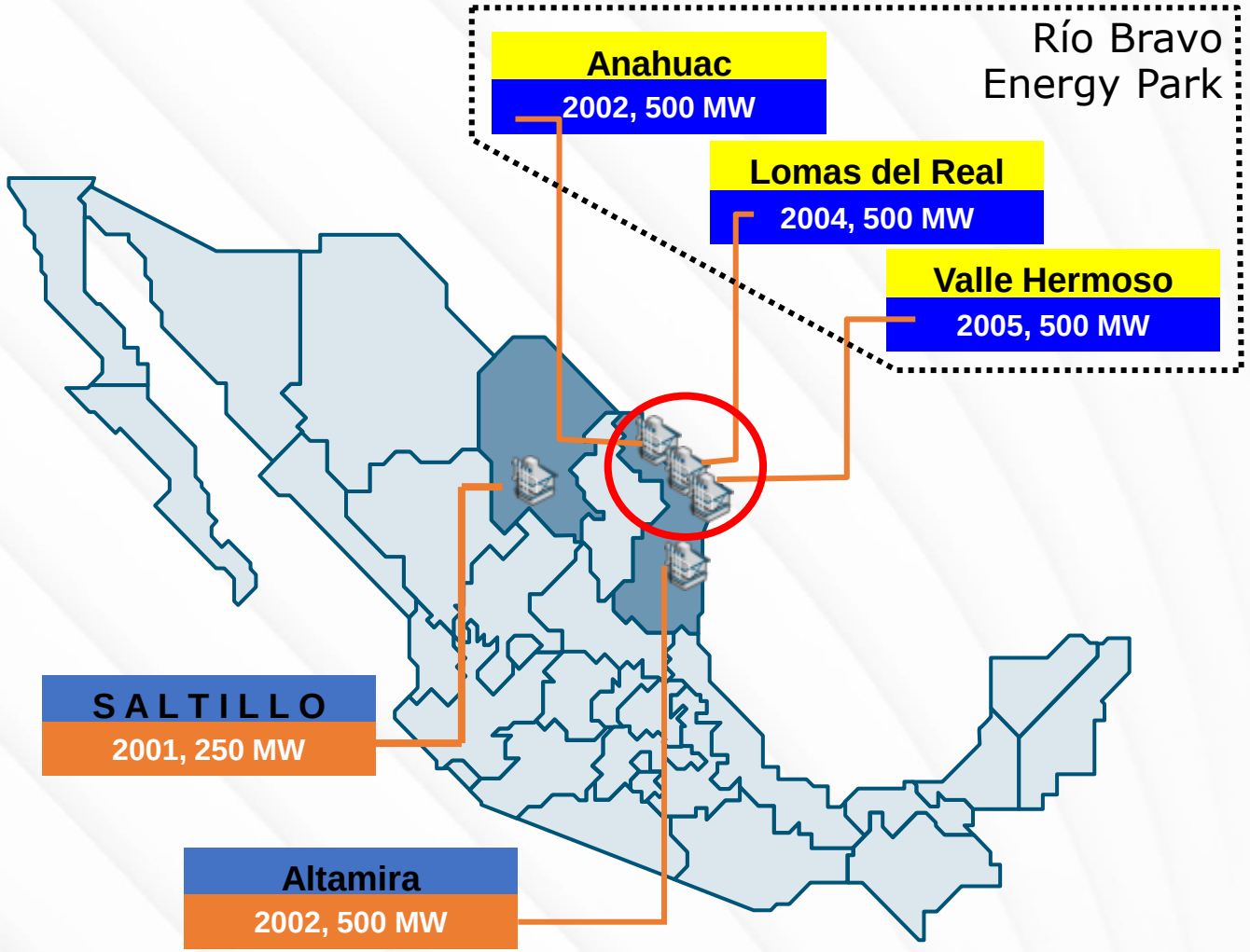
AIR COOLED CONDENSER USERS GROUP

Richmond VA, June 20th, 2023

CONTENT

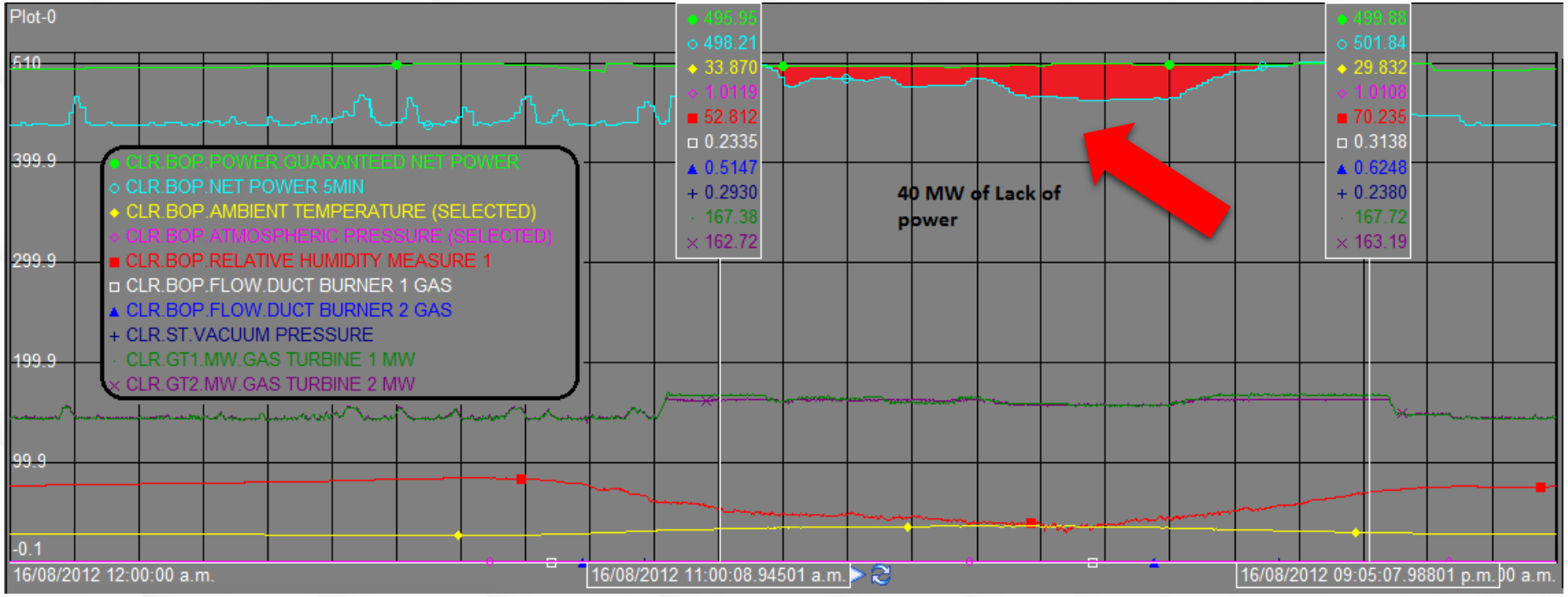
GENERAL INTRODUCTION

All 3 plants at Río Bravo and Central Saltillo use Air Cooled Condensers due to water availability restrictions.



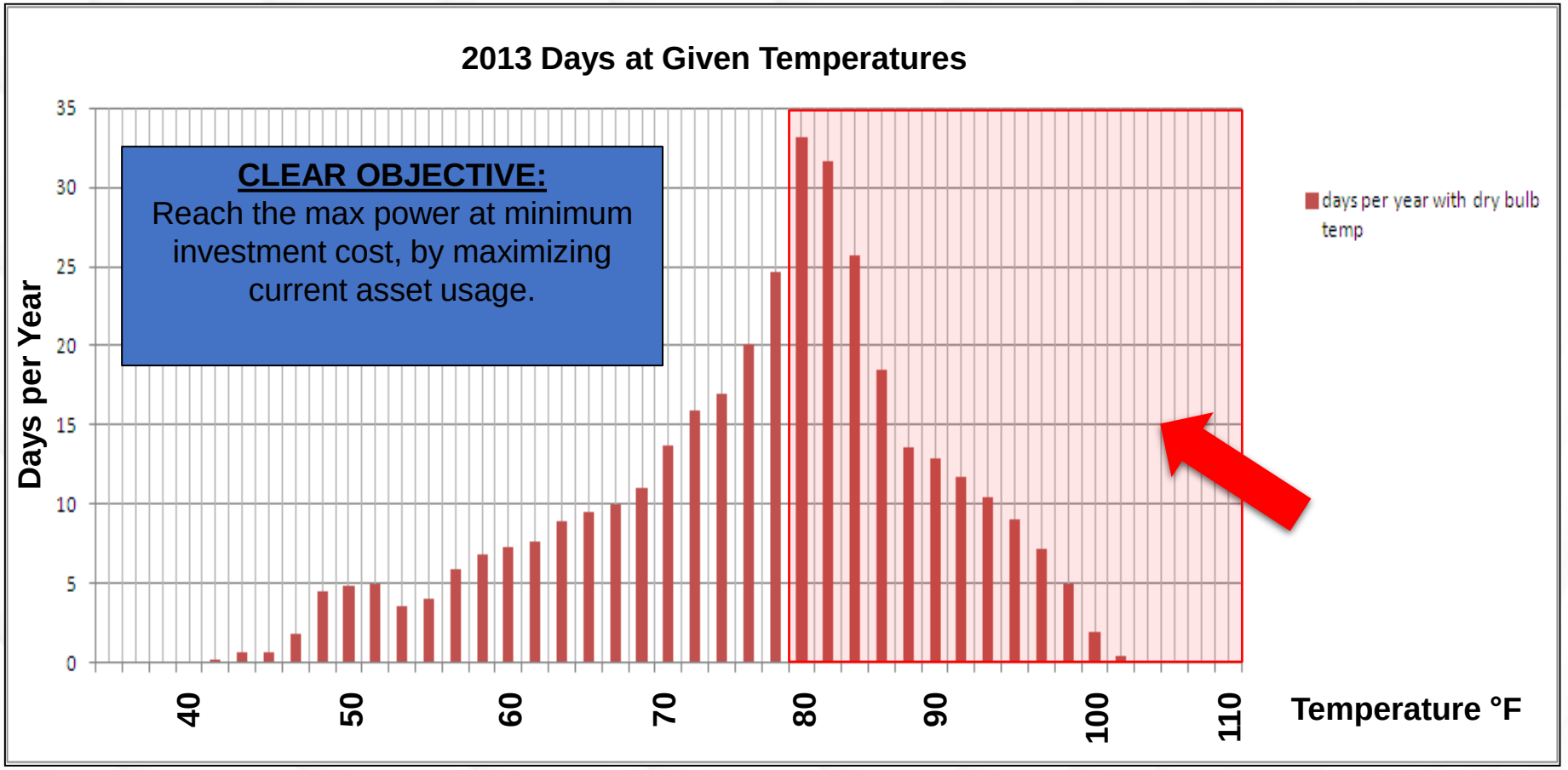
PROBLEM BACKGROUND

- Plants were not able to reach the max power during the summer months due to high steam turbine backpressure from the main condenser, which implied limiting both duct burner (even complete auxiliary firing shutdown), as well as sometimes even reducing combustion turbines output, to avoid a steam turbine trip on high backpressure.



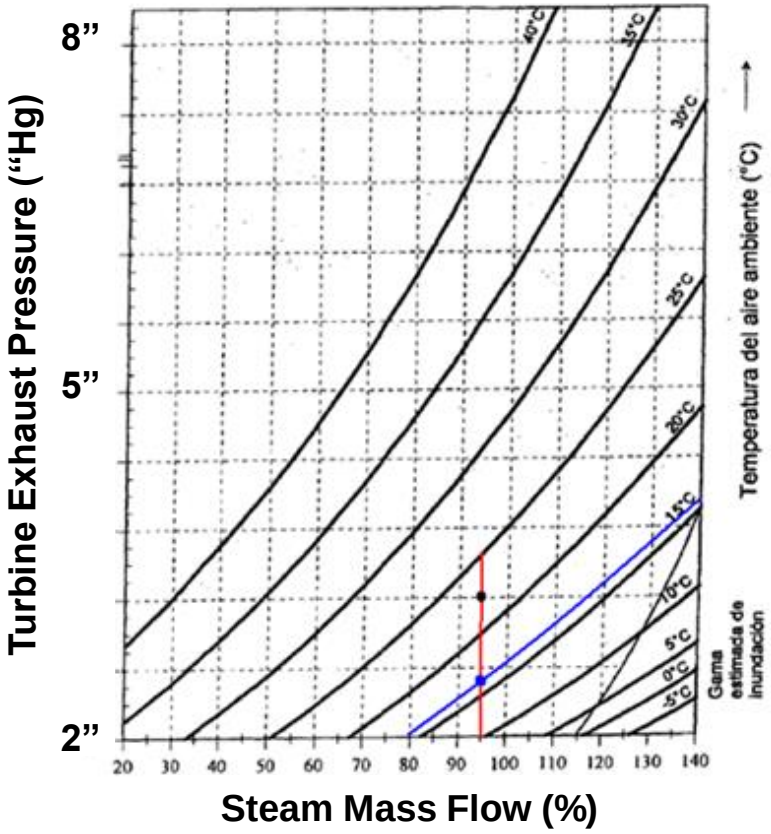
PROBLEM BACKGROUND

- This significant power output reduction due to steam condensing limitations, was due to ACC under-performance in summer and windy conditions.



ROOT CAUSE ANALISYS

- Even though condensers were originally correctly sized, specified and supplied, there has been ACC degradation through the years (severe fouling, tube damage).
- Performance is mostly affected by higher temperatures and winds.



Heat Rate= 335.86 MW =100%

Jan 19th 320 MW= 95.27%
16.673 °C
11 kPa of pressure

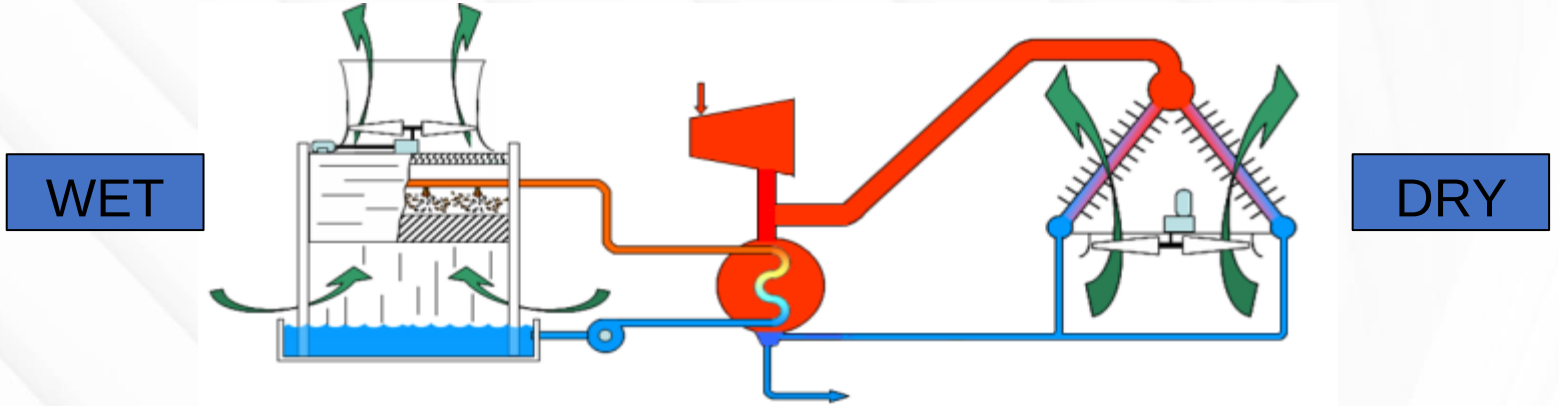
Design Point 95.27%
16.673°C
8.7 kPa

In this example, for 320 MW of condenser load, 16.7°C of ambient temperature, and **without wind,** we **are 0.7 inHg** higher than design point.

DESIGN DATA			
Medium		Exhaust steam	
Flow	kg/s	143	1.13 M # / Hr
Turbine exahust pressure	mbar	126	3.7 “Hg
Steam enthalpy	kJ/kg	2492	
Design Pressure	bar,g	0.5	14.8 “Hg
Design Temperature	°C	120	248 °F
Ambient air temperature	°C	24.7	77 °F
Ambient air pressure	mbar	1011.5	29.9 “Hg
Number of fans		32	
Fan shaft power consumption (per fan)	kW	82	
Motor capacity	HP	150 (112 kW)	

CHOSEN SOLUTION

- Through several years and some expense, many options were evaluated using several common and “unconventional” methods, as well as several suppliers with aftermarket services.
- The chosen solution considered:
  - Río Bravo’s ACCs have a good Fan Power to Area ratio.
  - There are additional water sources near the plants.
  - ACC enlargement was a very expensive option.
- With the help of SPIG USA, a Parallel Condensing System (PCS) was chosen as final solution: A system in which exhaust steam is simultaneously condensed in both a wet evaporative (SSC) and in the existing dry cooling systems (ACC):

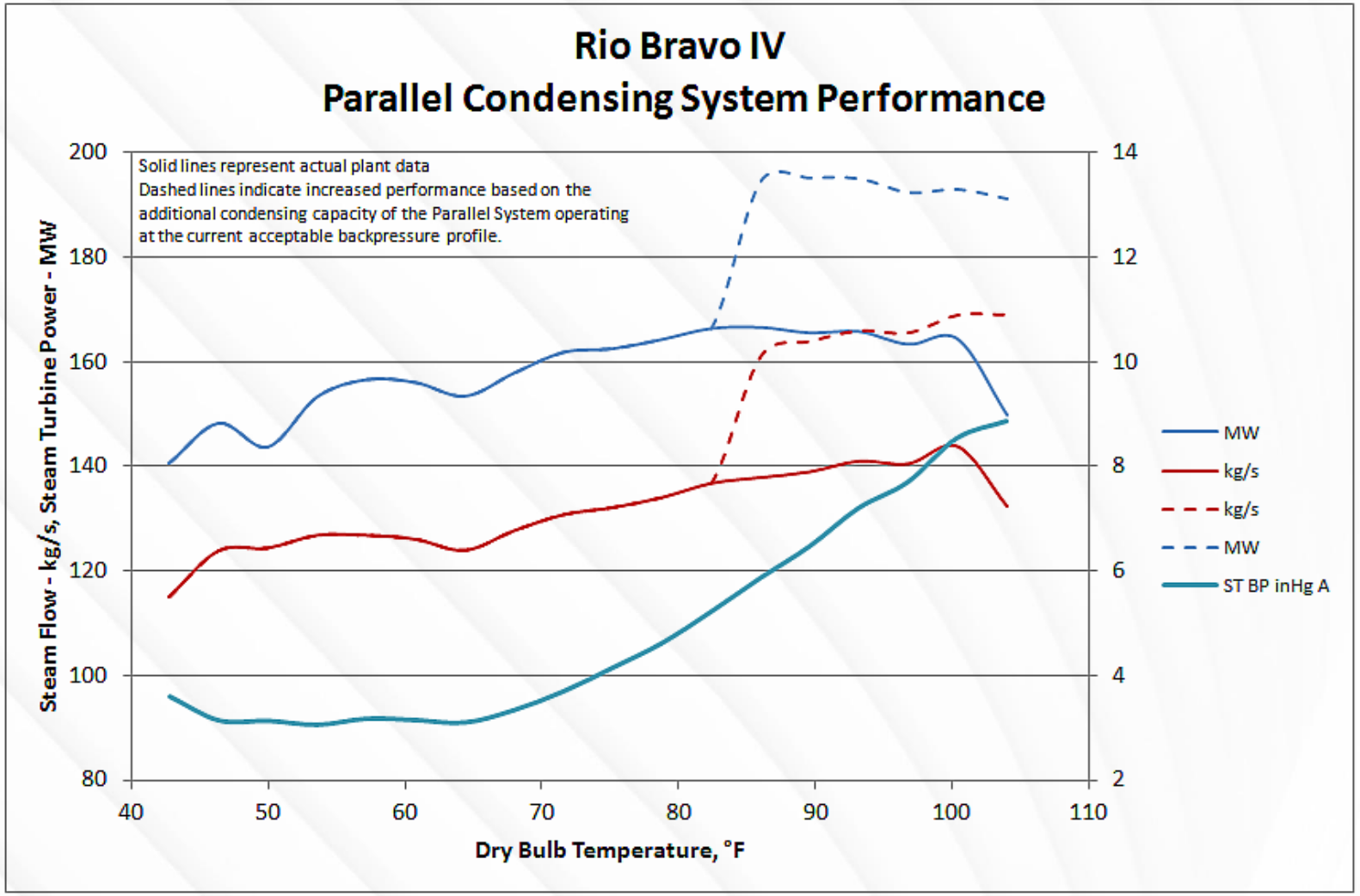


CHOSEN SOLUTION

- Goal: Remove the steam turbine backpressure limitation during all periods with ambient temperature higher than 30° C (86° F, approximately 1,000 hours per year), by adding enough wet cooling capacity to the existing 32 cell ACC.

- Advantages of the Parallel Condensing System:
  - Combines performance of an SSC with water savings of an ACC.
  - Optimize water use to minimize condensing system costs.
  - Sized to augment the performance of the ACC within the available water limitations, while achieving the power generation goals.

CHOSEN SOLUTION



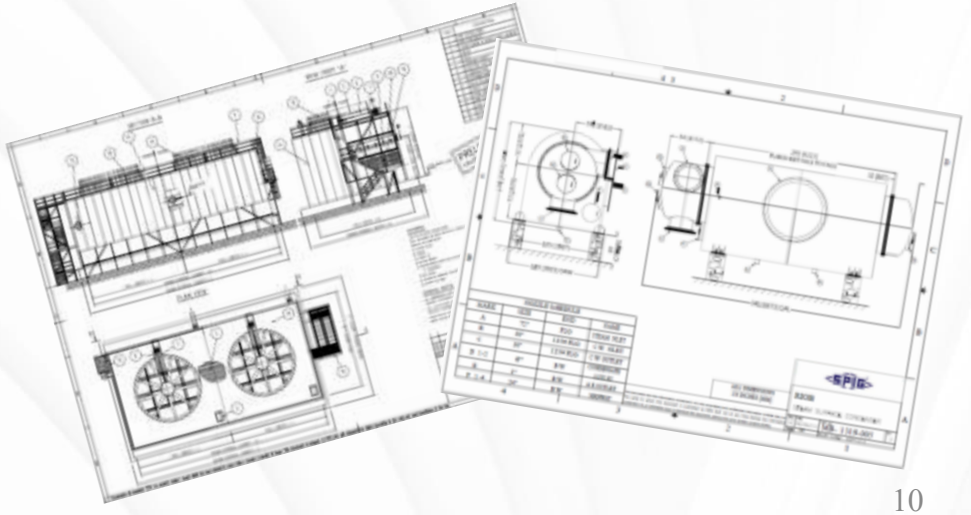
CHOSEN SOLUTION

- After SPIG and Falcon Group evaluation, a PCS was designed to meet the objective at minimum cost and maximum reliability.
- The following tables show the main characteristics of these systems:

MAIN TECHNICAL DATA STEAM SURFACE CONDENSER						
SHELLSIDE				TUBESIDE		
Operating pressure	5.6 "Hg	bar	0.19	CW source		Cooling Tower
Duty		MW	53.38	Circulating Water flow	CMH	3,800
Surface Area	9,380 sqft	m2	871.50	Hot /Cold water temp	°C	46.5/34.5
Steam Flow Rate	180,000 # / Hr	kg/s	22.60	Cleanliness Factor	%	85
LMTD	62 °F	°C	16.50	Number of Passes		2
Material			SA516-70	Material		SA516-70

116 / 94 °F

MAIN TECHNICAL DATA WATER COOLING TOWER			
Type			Exhaust steam
No of cells/fans			2
Circulating Water flow		CMH	3,800
Hot (inlet) water temp	116 °F	°C	46.5
Cold (outlet) water temp	94 °F	°C	34.5
Wet bulb temp	74 °F	°C	23.3
Drift Loss		%	≤0.05
Evaporation Loss %		%	1.7
Number of blades			6
Fan speed		RPM	180
Driver rated capacity		kW	55



PROJECT EXECUTION

TOWER

PROJECT EXECUTION

CONDENSER BOX

PROJECT EXECUTION

WATER PIPES & COMMISSIONING

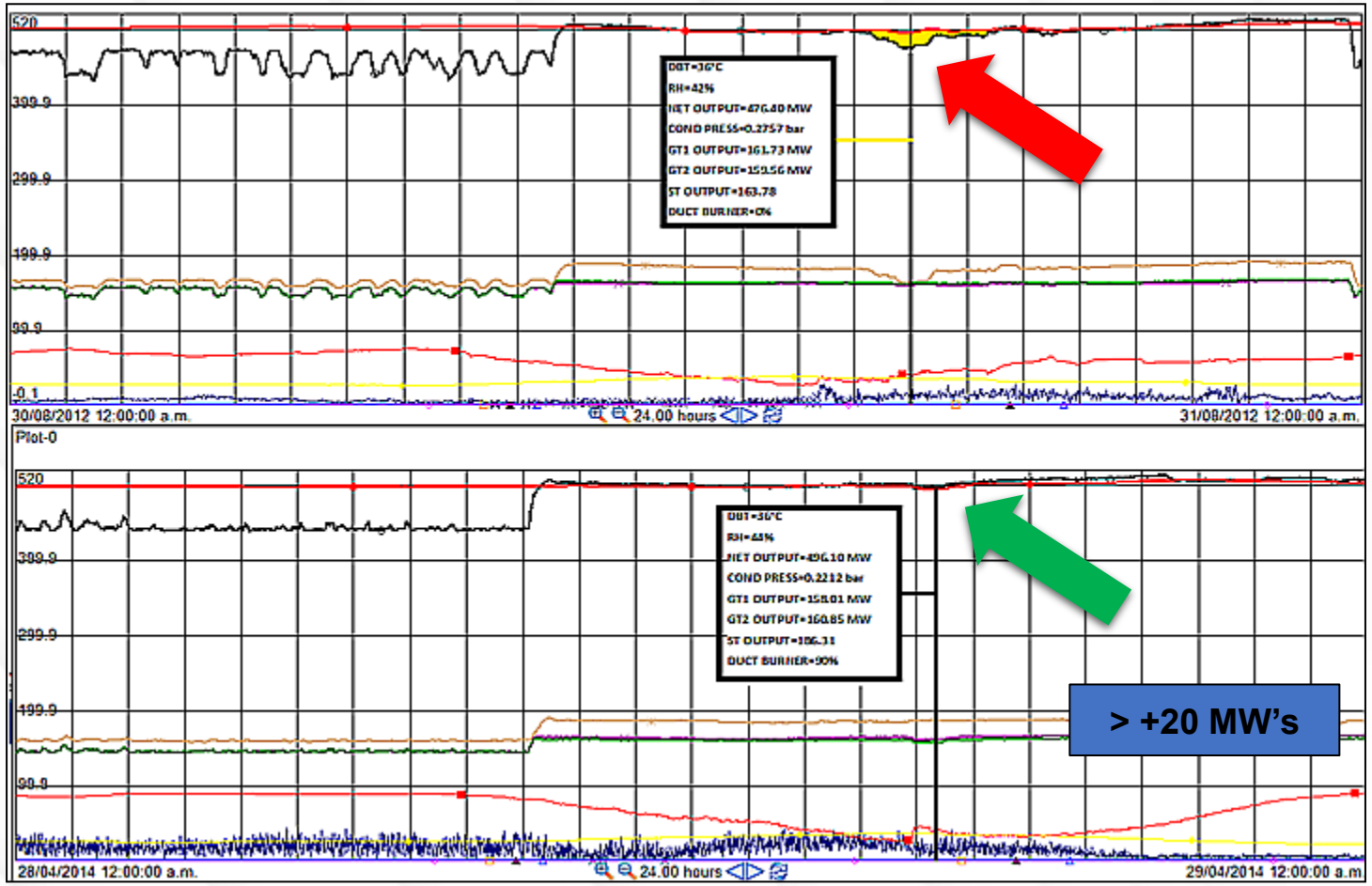
RESULTS AFTER INSTALLATION

The most relevant results after PCS installation in the 3 Río Bravo plants were:

- Auxiliaries consumption increase by about 500 kW's when PCS is in operation due to cooling water pumps, blowdown and make-up pumps, as well as cooling tower fans.
- Complete elimination of the backpressure limitation, with a significant sustained improvement of up to 80 mBar.
- Power output increase in excess of 20 MW's due to condenser pressure reduction and now the possibility of increasing condenser load, thus greater steam flow through the turbine and more power.
- Heat rate improvement due to the lower condenser pressure and thus lower backpressure on the steam turbine (more "free" power).

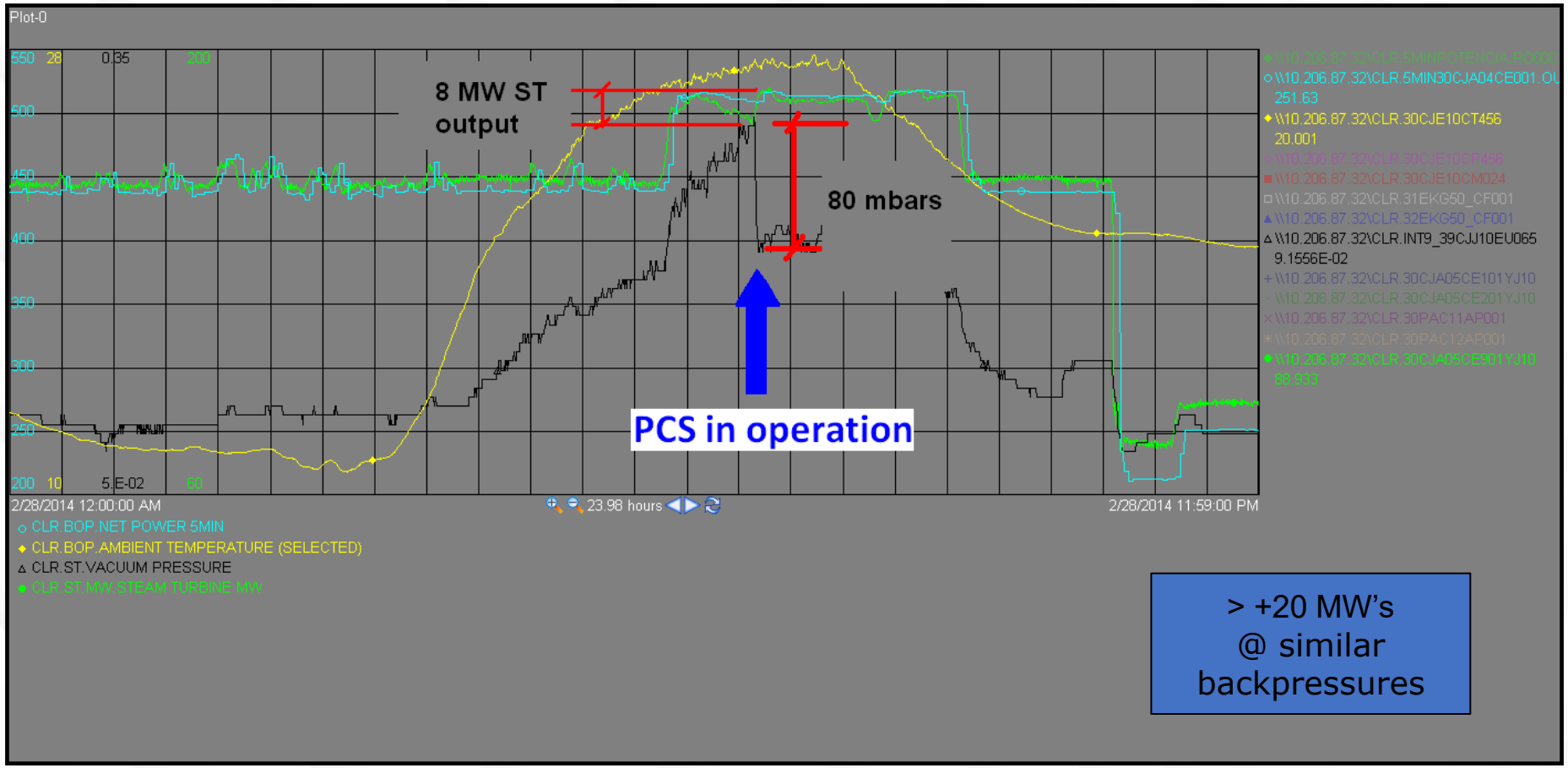
RESULTS AFTER INSTALLATION

No more power output limitations, no more plant de-rating…



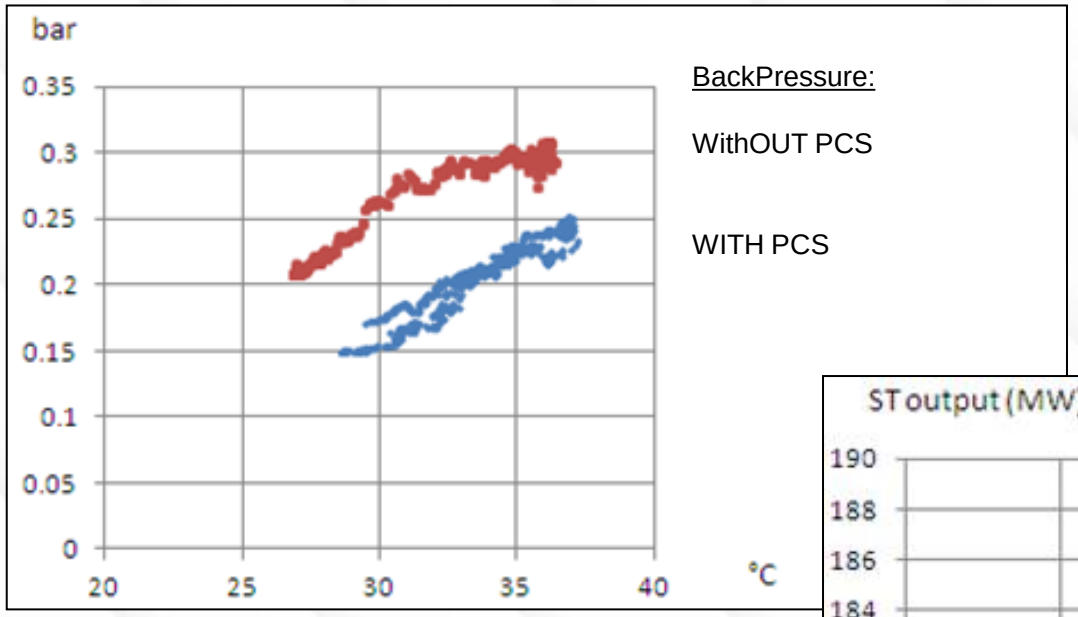
RESULTS AFTER INSTALLATION

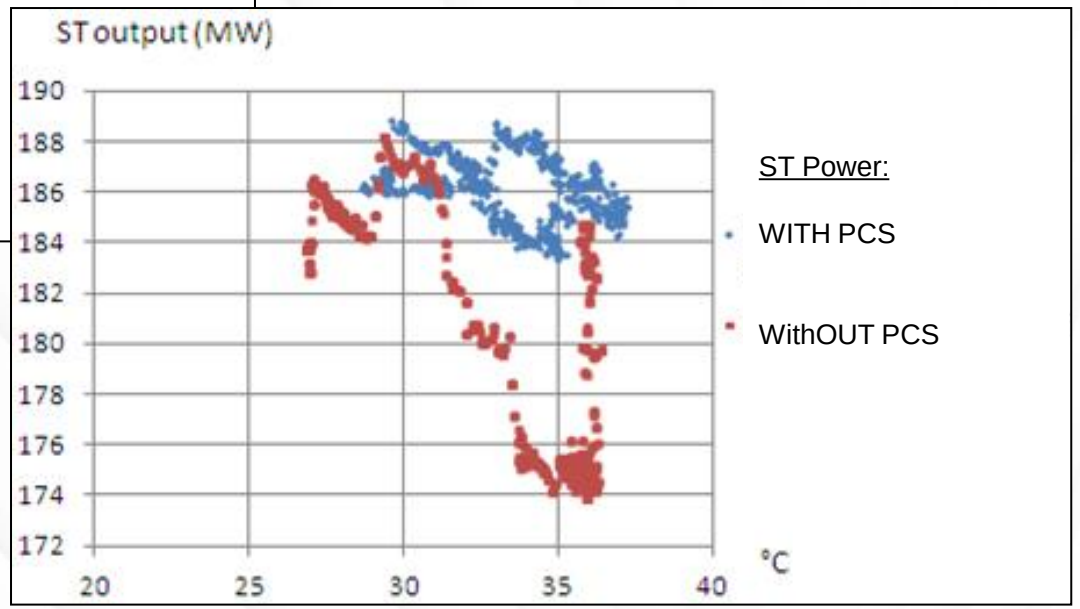
As soon as the wet cooling "booster" kicks-in, the Plant meets max power, gains +8 MW's and simultaneously backpressure drops by 80 mBars (2.36 inHg).



RESULTS AFTER INSTALLATION

The PCS results in consistent and repeatable operational reliability under adverse summer conditions.



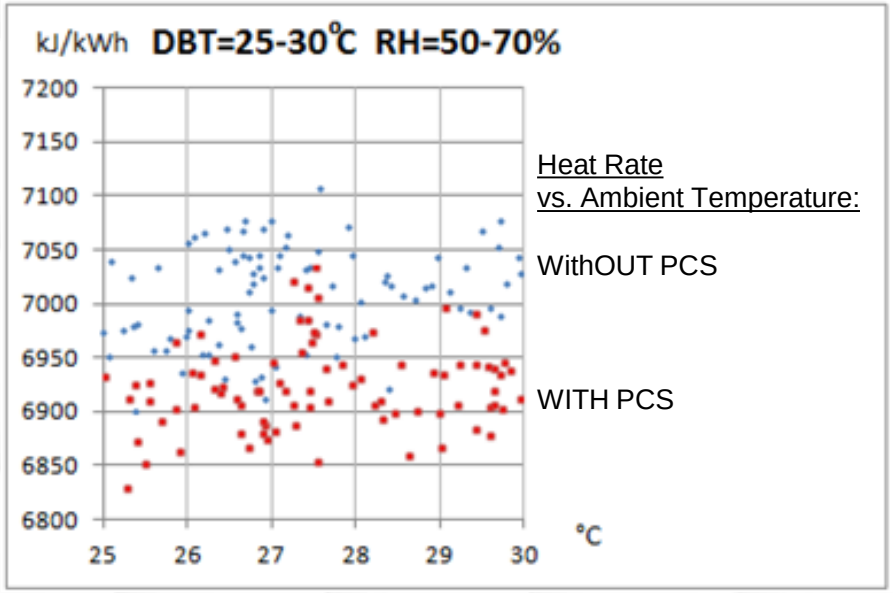


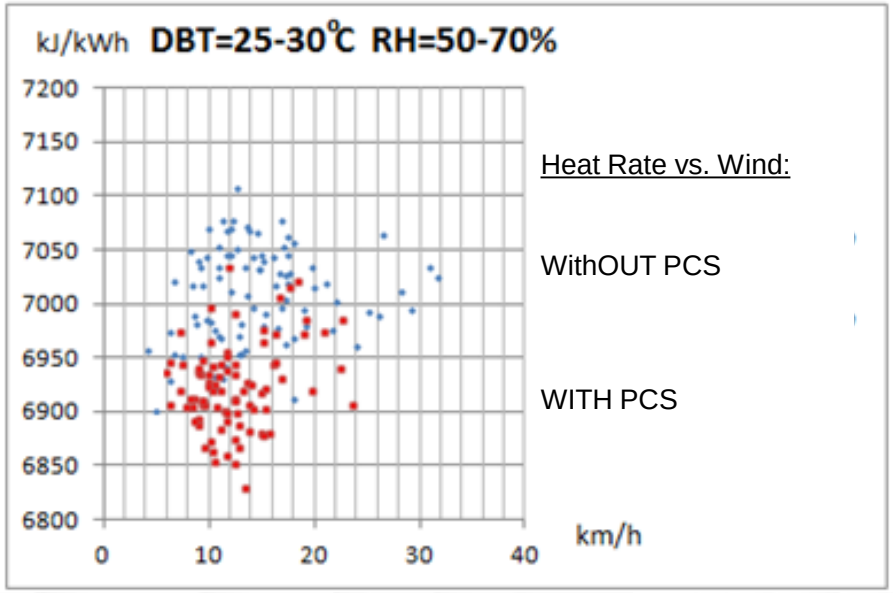
RESULTS AFTER INSTALLATION

After some operational time…

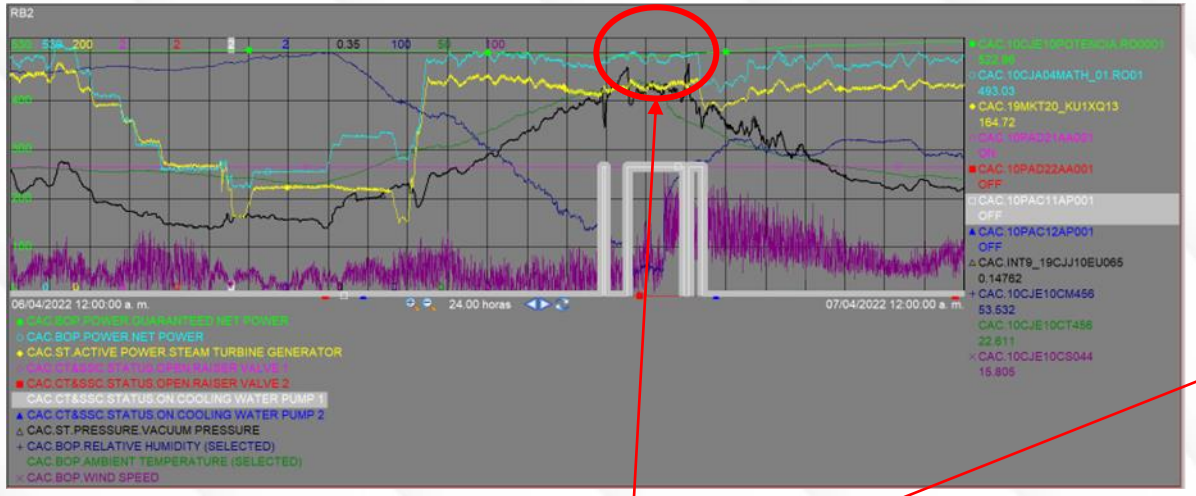
•PCS operation results in a clear improvement of Plant heat rate with temperatures higher than 25° C (77° F) & humidity lower than 70%.

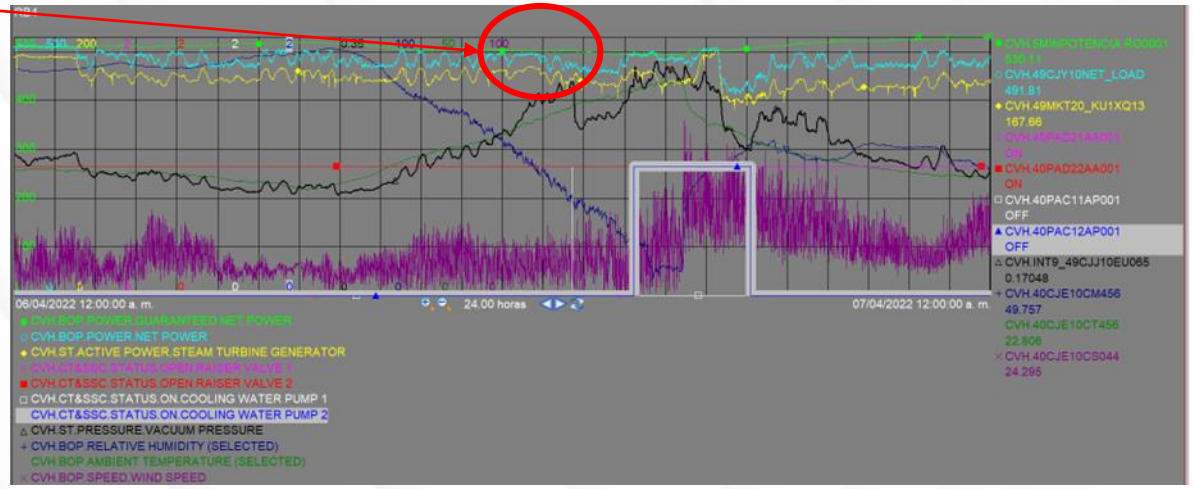
•For lower temperature and higher humidity, the increment in auxiliary consumption is more than the steam turbine power output gain, and there is no heat rate improvement, thus PCS operational limits are consistent with design expectations.





RESULTS – HOTTEST DAY IN 2022





All Plants reached the guaranteed power during the hottest day in 2022.

- 104 ° F on April 6th.

CONCLUSIONS AFTER 9 YEARS OPERATION

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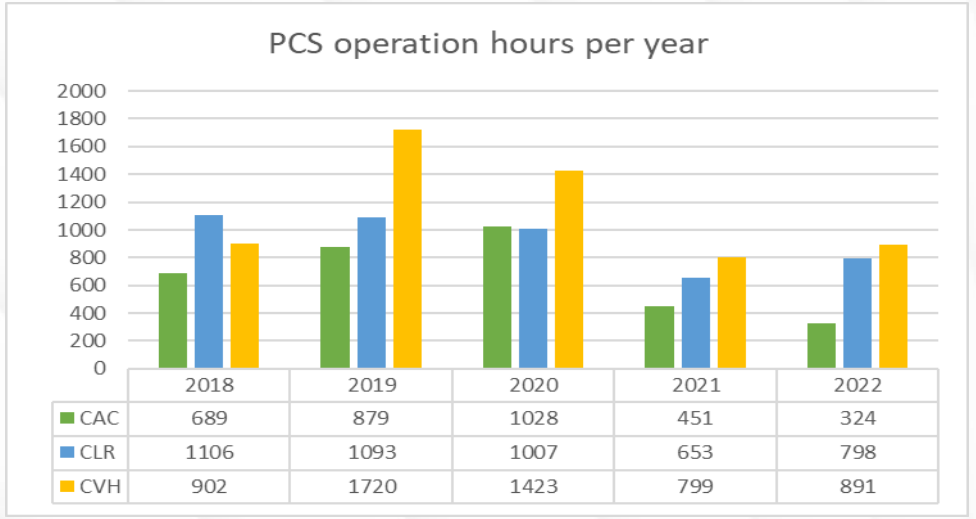
OPERATION

- No more power output limitations, no more plant de-rating. System operated during the hottest days of the years.
- Depending on dispatch and water availability, system operated during periods with ambient temp > 77 ° F and relative humidity < 70%.
- After performance analysis and based on the best results, it was decided to operate the system with only one cooling tower cell aligned and align the second cell during the hottest periods if condenser vacuum is reaching the alarm set.



	2018	2019	2020	2021	2022
CAC	689	879	1028	451	324
CLR	1106	1093	1007	653	798
CVH	902	1720	1423	799	891

CONCLUSIONS AFTER 9 YEARS OPERATION

MAINTENANCE

- No relevant findings during inspections and preventive maintenance performed up to date.
- Maintenance program includes:
  - Condenser. Internal inspection (tubes condition, coating, anode), tubes cleaning depending on condition.
  - Cooling tower. Basin and structure inspection and cleaning.

Thank you