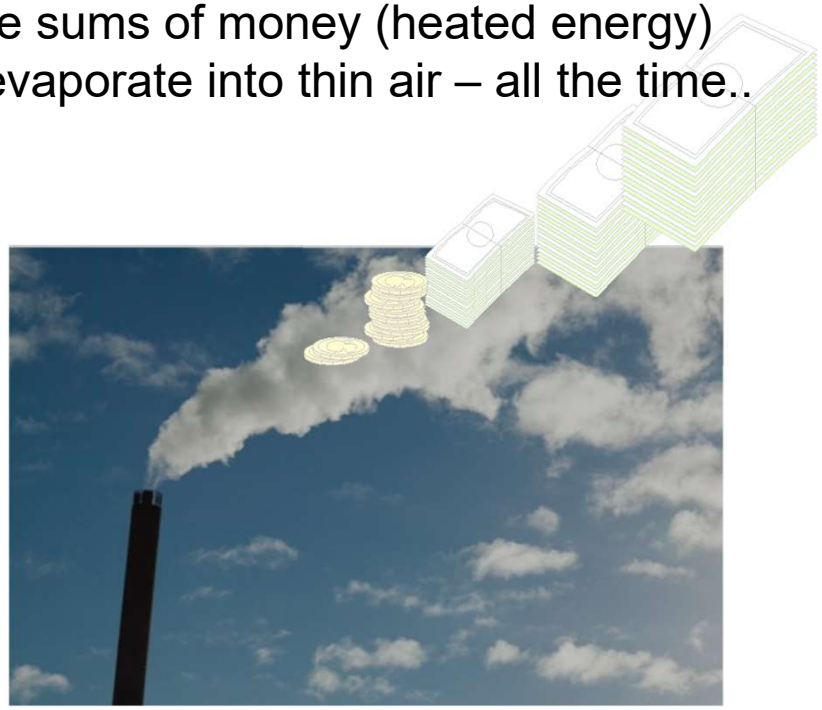
Boiler efficiency improvement

by

MoCo DP™

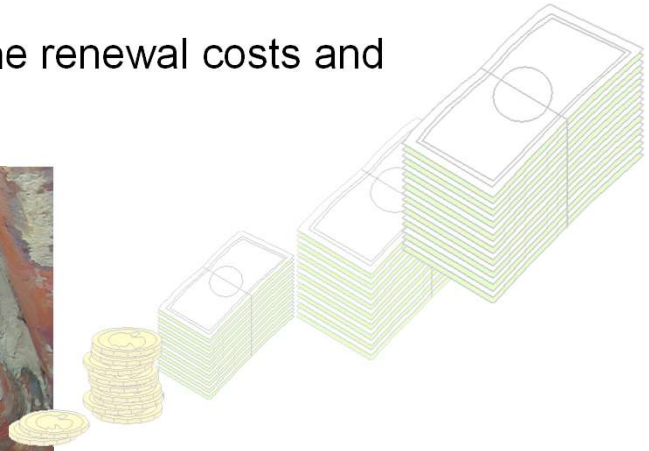
Monitoring **C**orrosion
Dew Point Monitoring System

Large sums of money (heated energy)
will evaporate into thin air – all the time..



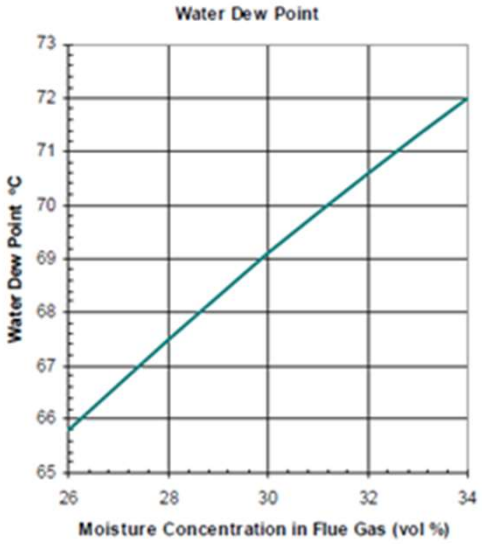
Boiler cold end process temperature is kept in a corrosion safe area
which means the loss of energy production.

On the other hand,
large sums of money are lost for the renewal costs and maintenance of structures

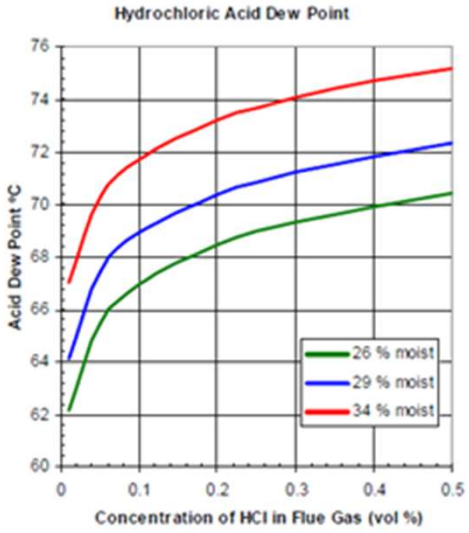


If the process temperature is reduced to too low, whereby the temperature of the coldest regions goes below the acid dew point,
structures begin **to corrode very quickly.**

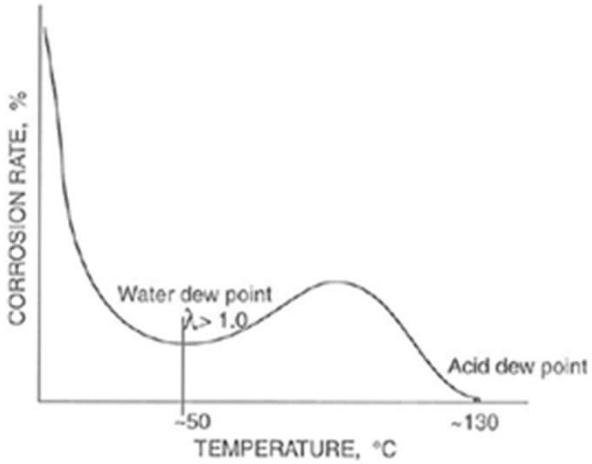
Fuel mixtures, humidity, SO_2 level, etc. affecting the value of all the time the dew point temperature. Without any measurement signal it is considerably safer to stay in the "safe temperature region" and thus, energy is lost from the stack to the sky.



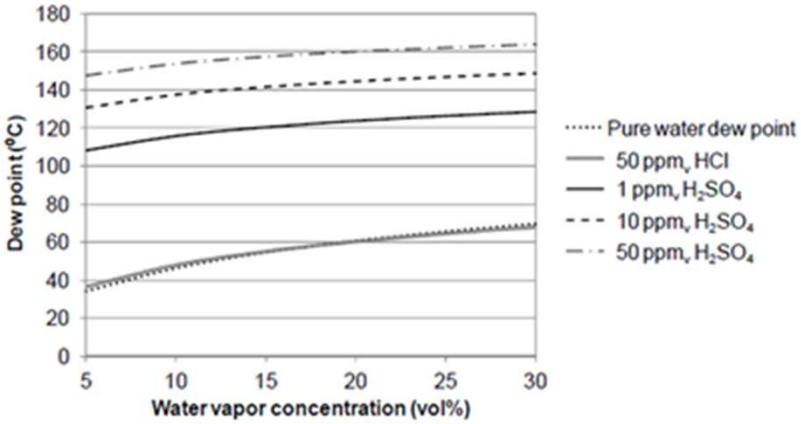
Water dew point as a function of moisture in flue gas.



Hydrochloric Acid Dew Point as a function of the concentration of HCl and moisture in Flue Gas.



Effect of flue gas temperature on the acid corrosion of heat dekivery surfaces.



Pure water and sulfuric acid dew point temperature as a function of water vapor concentration in a flue gas with 1, 10, and 50 ppm H_2SO_4(g), calculated with the correlation by Verhoff and Banchero [14]. The HCl dew point is calculated with the correlation by Kiang [16].

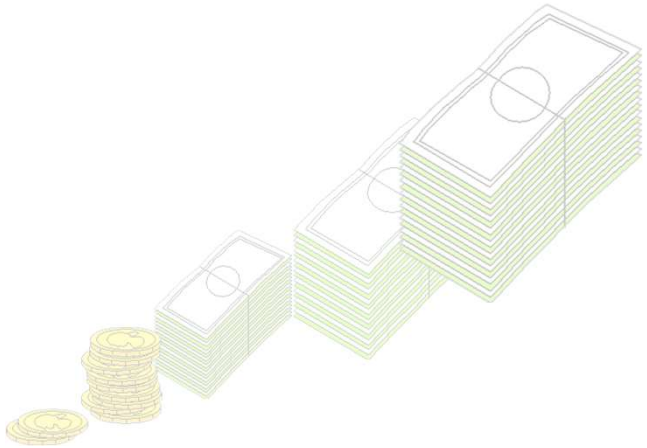
Whenever tube wall surfaces in boiler air heater or economizer fall below acid dew point temperatures of vapours such as **hydrochloric acid, nitric acid, sulfuric acid or even water vapour**, condensation of these vapours can occur on these surfaces, leading to corrosion and tube failures.

Let's look at the background ..

- H_2O dew point
  - Depends on flue gas moisture
  - Typically 55-75 ºC with biomass fuels
- H_2SO_4 dew point
  - Depends on flue gas SO_3 content
  - Typically > 120 ºC
- HCl dew point
  - Depends on flue gas HCl content
  - Typically 55-75 ºC
- $CaCl_2$ deposit
  - Hygroscopic deposit
  - Typically 95 -120 ºC

Let's look at the background ..

- Low temperature corrosion is experienced in an operating boiler when metal temperatures drop below the water or acid dew point (ADP) of the flue gas.
- $H2SO_4$ and HCl are the acids which contribute most aggressively to corrosion.
- The $H2SO_4$ ADP is largely dependent on the sulphur content of the fuel which mostly oxidises to SO_2 during the combustion process and on the proportion of SO_2 that converts to SO_3. SO_3 in turn converts to H_2SO_4 as the gas cools from about 400°C down to about 175°C.
- Chlorine in the fuel converts to HCl during the combustion process. The dew point of HCl is lower than that of H_2SO_4. However, even small quantities of chlorine can be aggressive at higher temperatures if zinc and calcium are present with high water vapour contents.
- The H_2SO_4 and HCl ADPs are dependent on the partial pressures of the water vapour, SO_3 and HCl in the flue gas.
- A simple solution is to ensure that the lowest tube wall or surface temperature is above the dew point. However, then boiler efficiency drops.
- Still, there is **risk of corrosion without continuous measuring and alarm system**.



Continuous **MoCo DP**™ system for acid- and water dew point temperature detection offers the unique solution to operate safety with maximum efficiency of pre-heaters.

That **increase the efficiency of a boiler**,

which means that **boiler produce more money and less CO_2 emissions!**

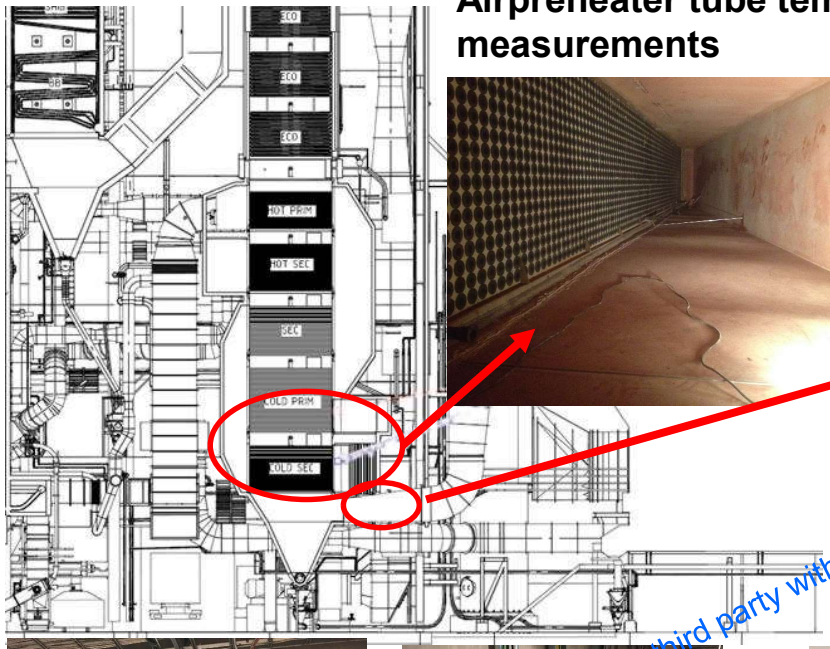
System include;

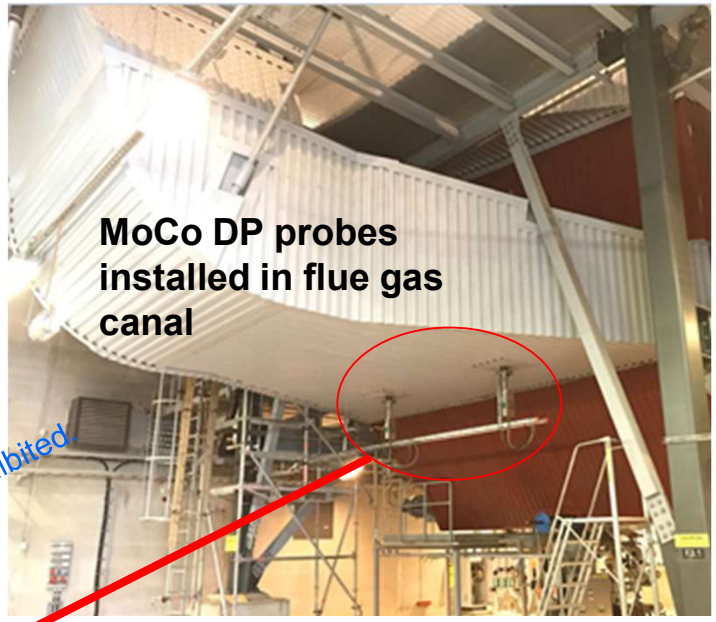
- **MoCo DP_P**™ dew point probes
- **MoCo DP_M**™ dew point detecting measuring unit
- **MoCo DP_Tcontrol** Preheater air tubes surface temperature measurement arrangements
- **MoCo DP_V**™_VICO data collection and data analyze system
- System integration to mill automation (DCS) and/or the other data collection and optimize system.

- **Control signal to automation** - System calculated automatically preheater critical temperature (ADPct) for structure materials and it can be used to control for example steam preheater energy efficient function.

MoCo DP™ system installation

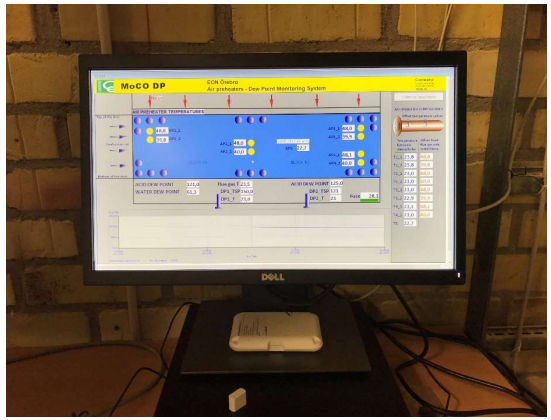
Airpreheater tube temperature measurements





MoCo DP measuring unit

MoCo DP probes



Data collection and analyze system

Measuring of critical dew point temperature (ADPt) based on the sensitive electrochemical corrosion measuring methods. Test coupons and electrode material samples situated in the head of a probe. Test material samples and electrodes are isolated from each others and they have been wired with fibreglass isolated cable to the termination box in the other end of a probe. In measuring of hot corrosion and/or cold end corrosion, temperature plays a major role in the corrosion event of materials. Probe testing material and electrode temperatures is automatically controlled by controlling the cooling air flow thru the probe. Probe test material in flue gas canal corresponds the real structure materials and circumstances (combustion gas flow, scaling, soot blowing, temperature, etc.).

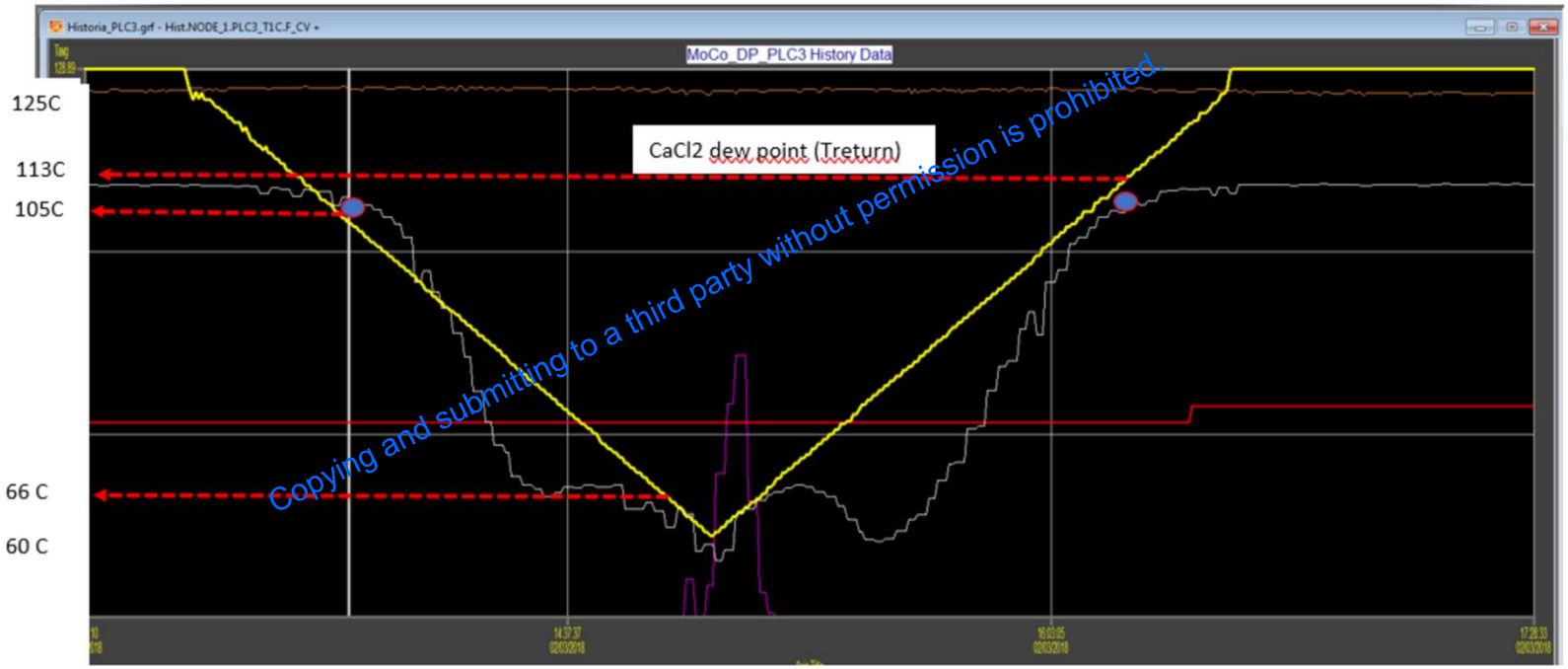
Electrodes and temperature sensors in the head of the probe

The principle of the DP detecting

A changes in the process (burnt fuel, moisture, SO_2, etc.) and temperature have an effect in a probe material corrosion rate. MoCo DP system with sensitive corrosion measuring methods and automatic electrode temperature control makes possible to detect critical dew point temperatures by running automatically dew point tests. In every test electrode temperature (yellow) is lowered until system detect dew point corrosion activation then temperature raised back to the operating temperature and the system registers the recovery temperature.

MoCo DP_DEW POINT DETECTING SYSTEM

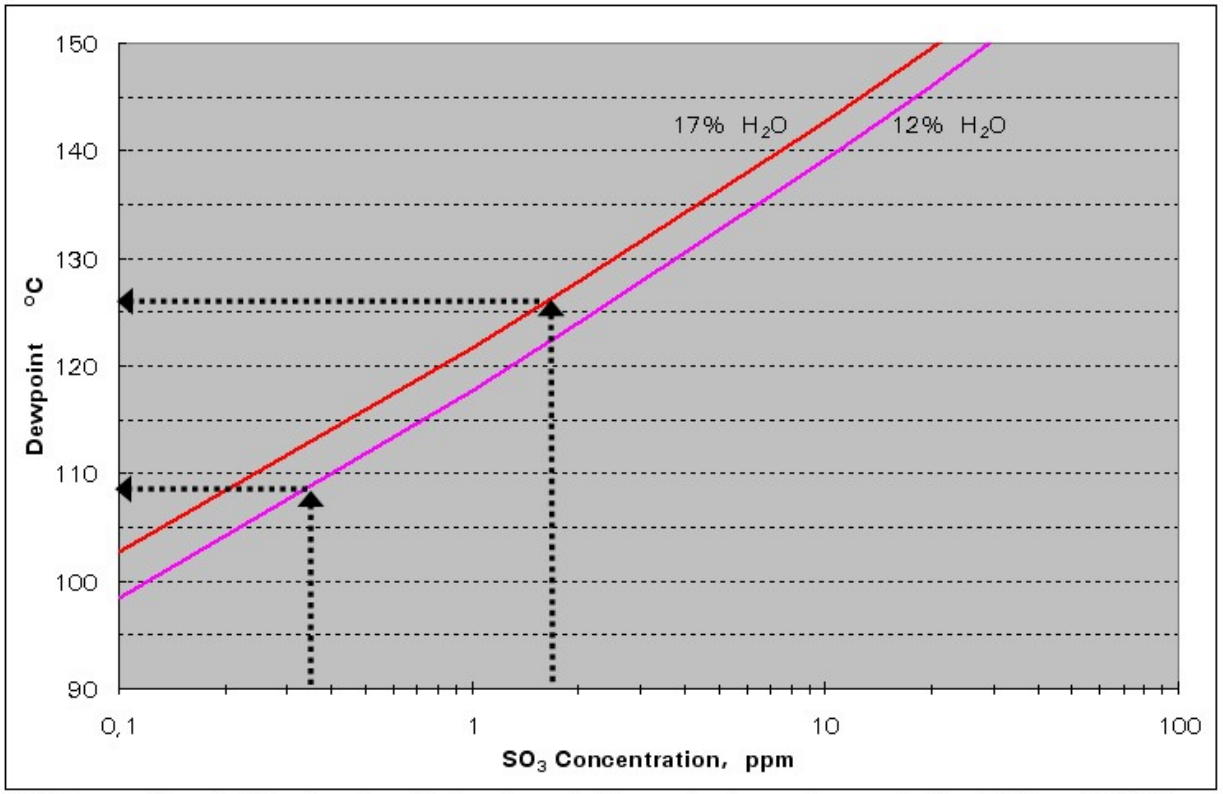
Yellow=electrode temperature, white and magneta=electrochemical measurement results, red=automatic critical dew point detecting temperature



MoCo DP real-time power plant cold end measurement ADP results compared to the theory (SO_2>SO_3, H_2SO_4)

	50 %	90 %	Load
H_2SO_4 ppm	12 %	17 %	H_2O
0,1	98,3	102,6	
1	117,7	121,7	
2	123,9	127,8	
10	139,2	142,7	
20	146,1	149,5	
50	155,6	158,8	
100	163,1	166,1	

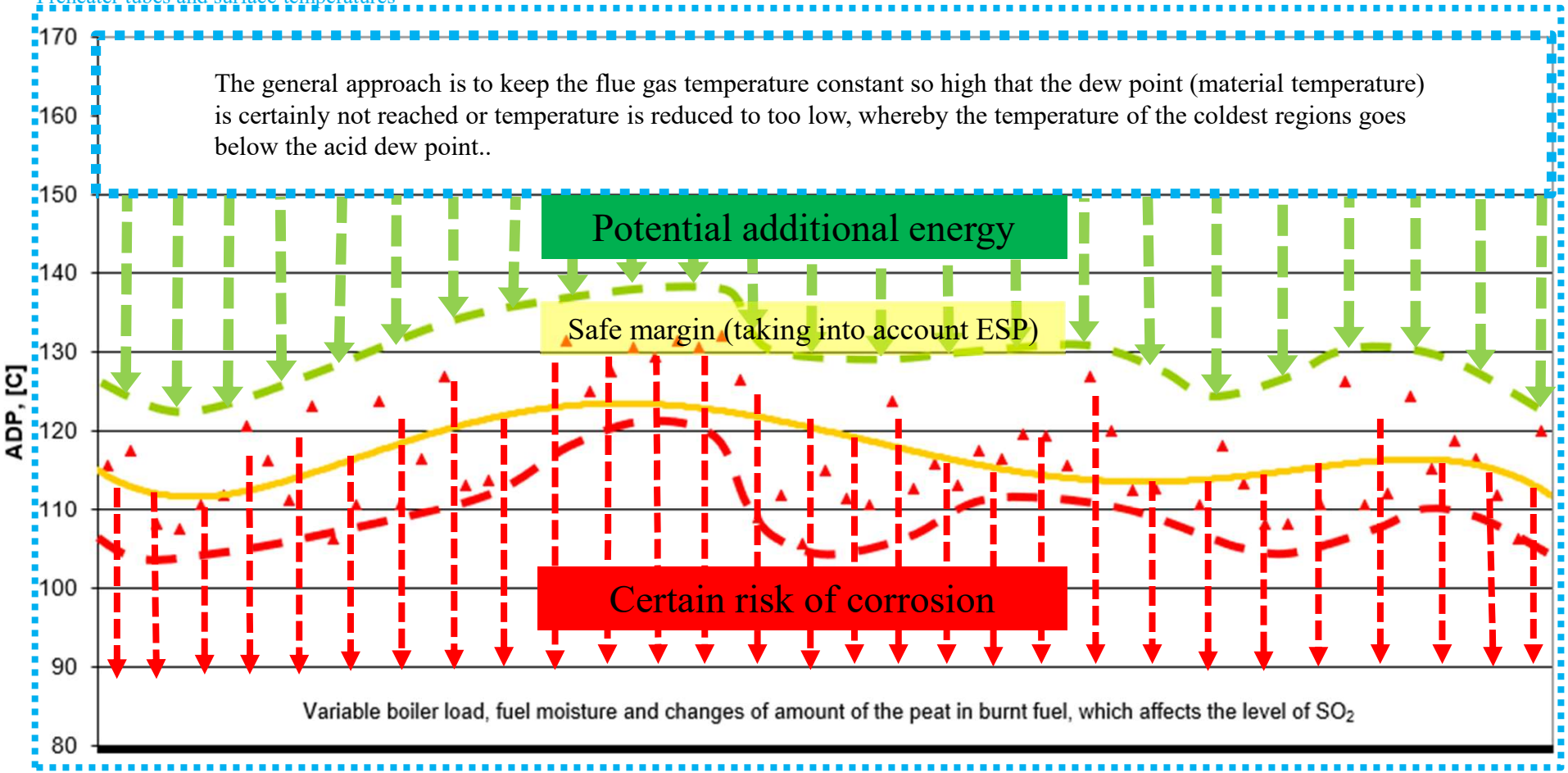
SO_2 to SO_3 conversion (1 - 5%)			4,5	%
Give,	SO_2	8	24	mg/m^3
whereof,	SO_3	0,36	1,08	mg/m^3
MoCo DP acid dew point (ADP) result		108	126	°C



R.R.Pierce; Chemical Engineering;"Estimating acid dewpoints in stack gases", Apr.1977 pp.278-281.
max. error 7°C

Flue gas temperature before AP ~200 .. °C

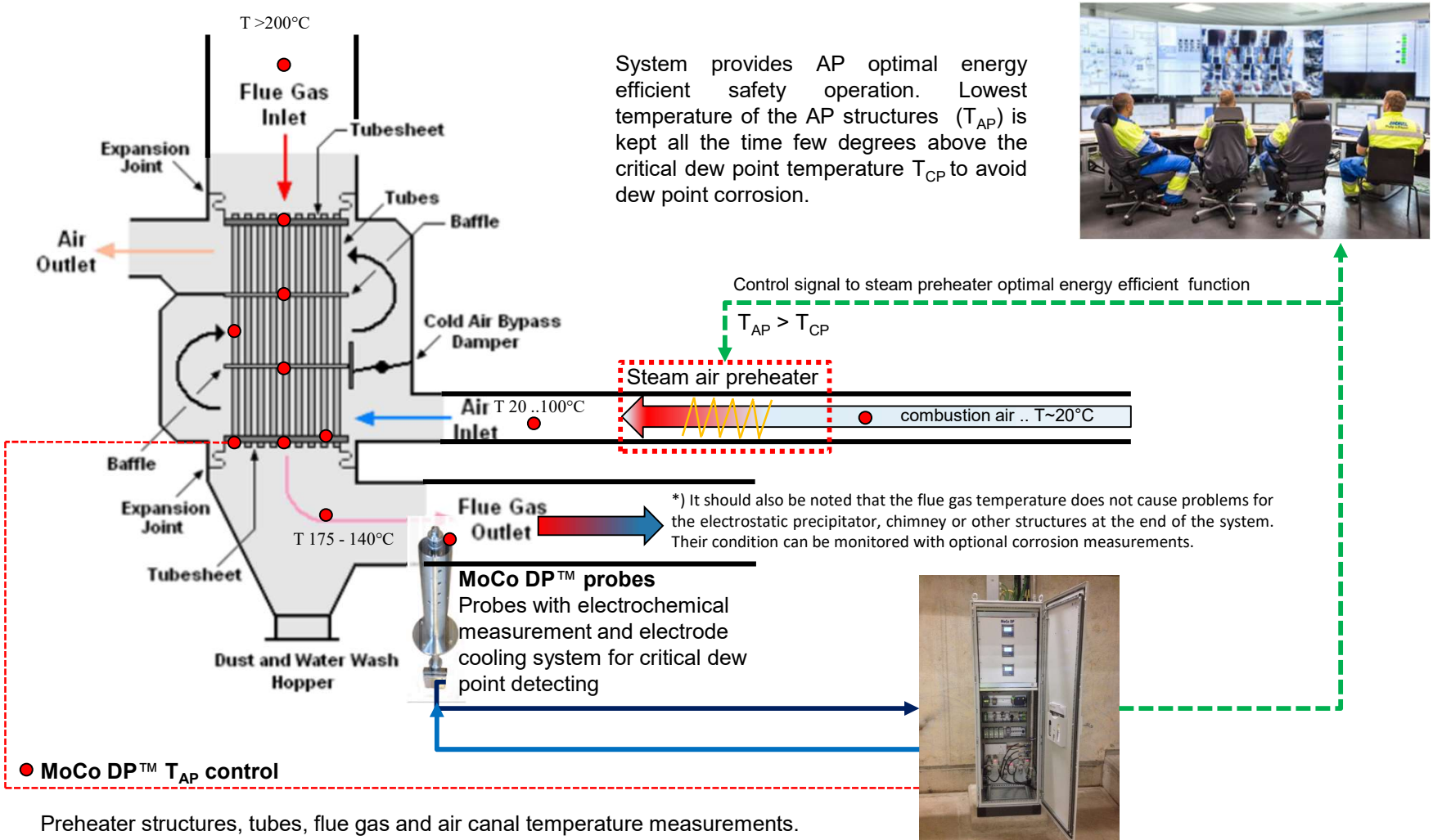
Preheater tubes and surface temperatures



Generally flue gas temperature after AP ~175 .. 145°C

MoCo DP™

Critical Dew Point Temperature Monitoring and steam preheater Optimal Control System



System provides AP optimal energy efficient safety operation. Lowest temperature of the AP structures (T_{AP}) is kept all the time few degrees above the critical dew point temperature T_{CP} to avoid dew point corrosion.

*) It should also be noted that the flue gas temperature does not cause problems for the electrostatic precipitator, chimney or other structures at the end of the system. Their condition can be monitored with optional corrosion measurements.

MoCo DP™ probes
Probes with electrochemical measurement and electrode cooling system for critical dew point detecting

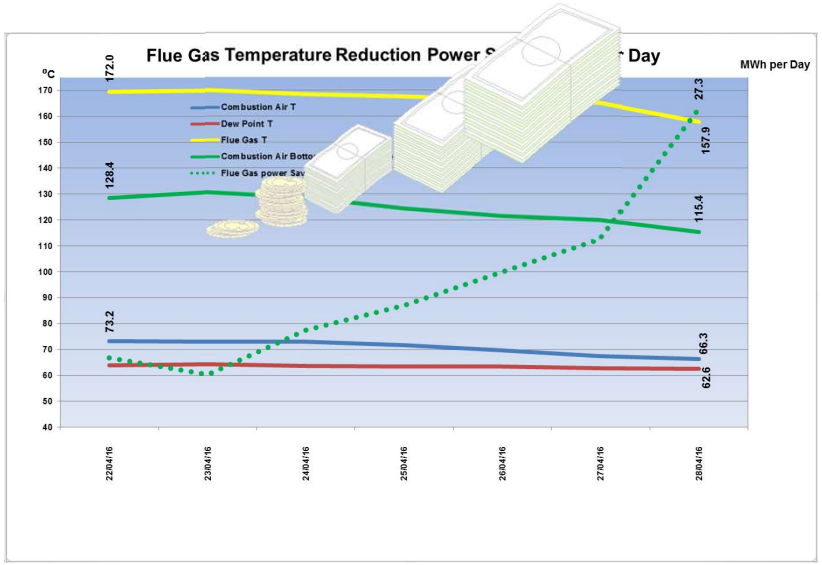
Preheater structures, tubes, flue gas and air canal temperature measurements.
T_{AP} reference value is the lowest measured AP structure value.

MoCo DP™ M
Automatic critical dew point temperature **T_{CP}** scanning and analyze > control signal to automation and steam preheater automatic optimal control

The benefits of the system can be tested by study of current process state.

The current situation can be determined by means of field research, which also allows predicting the potential annual energy savings to be achieved,

or



On the other hand if temperature has been too low, where the structures are corroded. In this case, the savings will come from optimizing the situation and saving in the future for maintenance costs..

CASE:

In the initial situation (before MoCo DP system installation), the flue gas temperature of the plant after air-preheater (AP) has been about 166-170C degrees.

$FGT_{after\ AP}$	% (LHV)	Change %pp	€/a
166	88,9	0	0
160	89,32	0,42	184 103
155	89,69	0,79	344 861
150	90,06	1,16	504 298

- **Automatic steam air preheater control taken into use in the spring of 2018. Since most of time temperature after AP has been 145 – 155C degrees.**
- **Efficiency improvement has been over 1,16%pp most of time.**
- **Savings > 0,5 Meur/a.**
- **Total savings > 1Meur since 2018**

Continuous **MoCo DP increase the efficiency of a boiler**,

which means that **boiler produce more money and less CO_2 emissions!**

Thank you.

We are at your service.

Kari Kärkkäinen, M.Sc. (Tech.)
CEO, Coresto Oy
+358 44 5255999
kari.karkkainen@coresto.fi