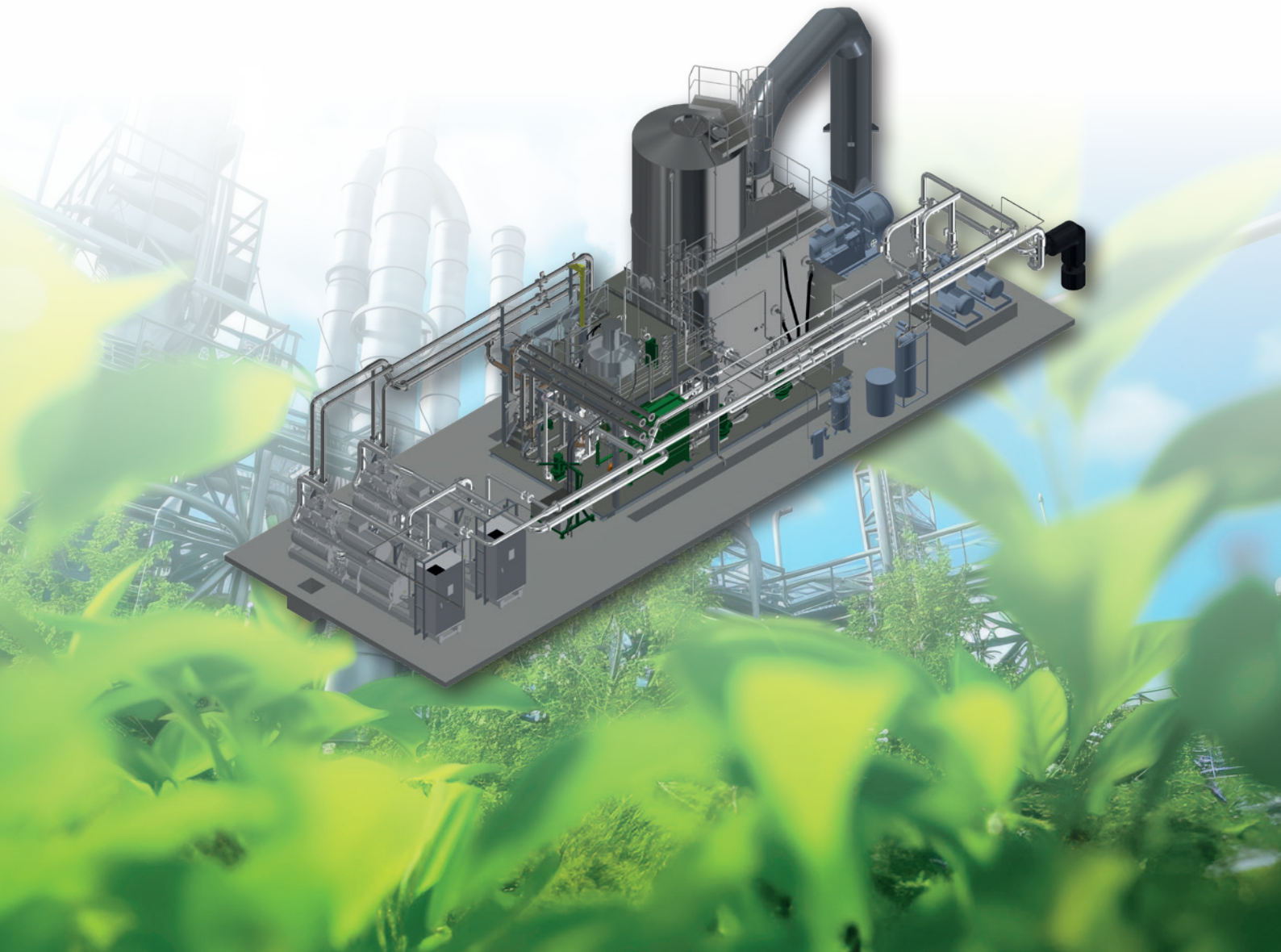




CALIGO FLUE GAS SCRUBBERS





A REVOLUTION IN HEAT RECOVERY

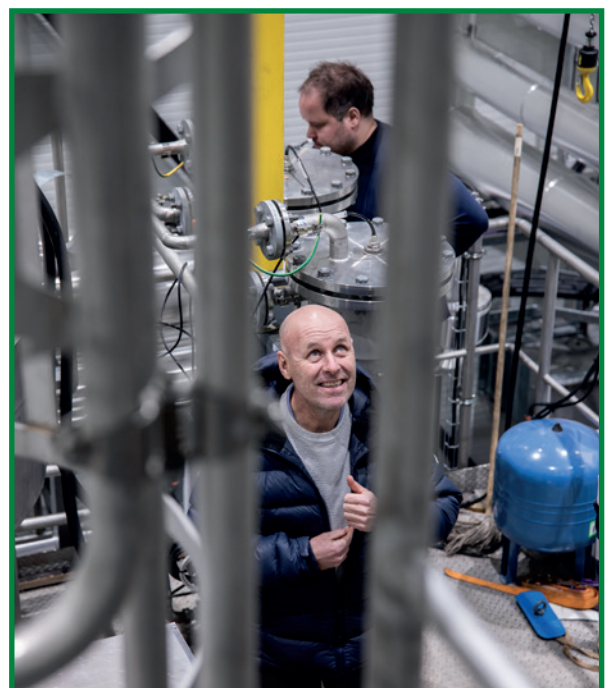
Caligo flue gas scrubber

Despite modern and efficient plant technologies a remarkable amount of heat is still being lost into the atmosphere at bioenergy plants. The heat recovery methods used by traditional scrubbers are fully dependent on the cooling impact of the district heating return flow. If the return flow temperature is relatively high, the scrubbers' condensing capabilities decrease dramatically as a result of the too narrow or non-existent condensing temperature window between the dew point and the cooling flow. In order to attain good heat recovery in a wet scrubber, the cooling temperature window needs to be wide enough. Our innovative solutions combine a heat pump with a wet scrubber in completely new ways. The achieved annual savings are significant when compared with traditional methods.

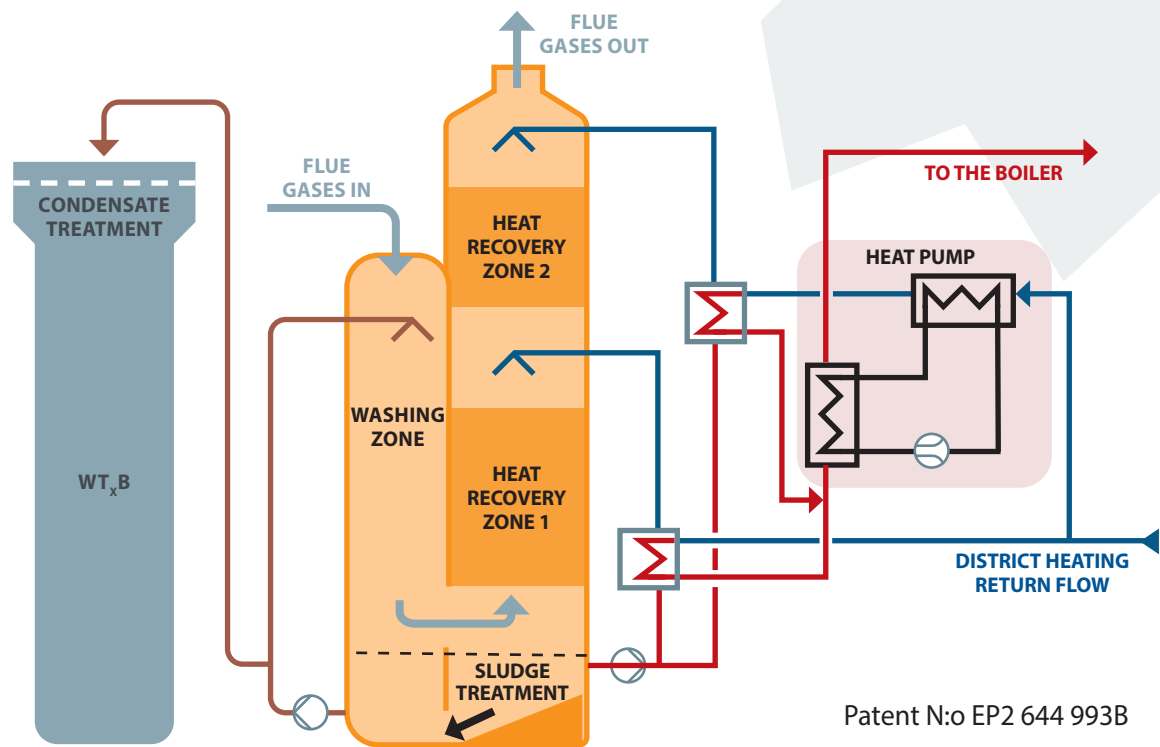
Caligo CSx represents a new generation of heat recovery scrubbers. Its extremely high heat recovery capabilities are based on the dynamic co-operation between the heat pump and two condensing zones in the scrubber. Together they ensure optimal condensing conditions and heat transfer in the process.

Caligo CSx's heat recovery ability is not affected by variations in the district heating return flow temperature. With the heat pump we dynamically adjust the condensing temperature level so that the thermodynamic process conditions remain well below the dew point. The condensing temperature window always remains wide enough and effective condensing takes place continuously.

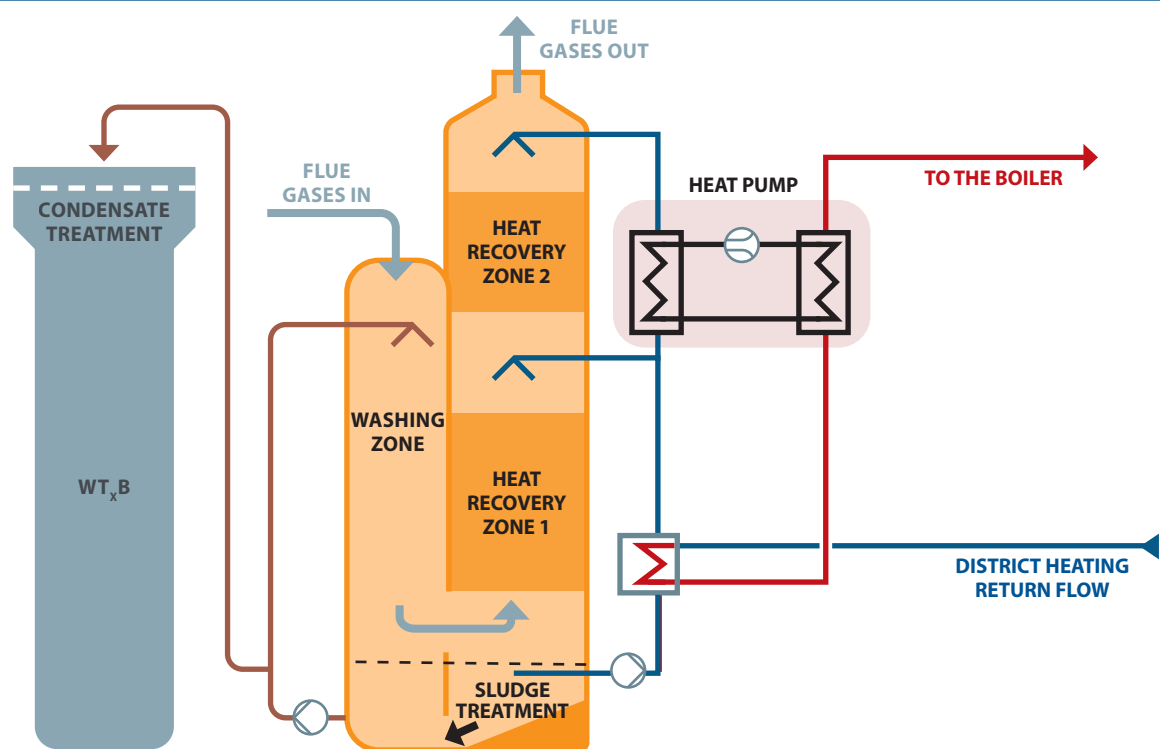
When the district heating return flow temperature rises to 60°C (burning wood chips containing 50% water) the Caligo CSx's heat recovery remains above 20%. Under these conditions the heat recovery of a traditional scrubber decreases to as low as 6%.



Caligo PHP Option – DH return temp up to 65°C



Caligo SHP Option – DH return temp up to 80°C



Heat pumps deliver increased performance

Caligo CSx is equipped with heat pumps that are specifically designed to be optimally used in Caligo condensing applications. The main parts of the heat pump, such as the evaporator, condenser and compressor modules, are designed according to specifications of each Caligo scrubber delivery and client case. The heat pump application is used as an integrated part of Caligo's patented thermodynamic process.

The heat pump adjustment and control is integrated with the scrubber's automation system. Ammonia is primarily used as the thermo fluid due to its excellent operational adjustment capabilities and high thermodynamic efficiency. If you wish, you can also get a heat pump with other thermal material. Typically the COPh values of the heat pump remain between 7–9, when PHP connection mode is applied. For SHP connection mode COPh is typically 5–6.

The heat transfer process inside the heat pump is highly energy efficient. The cooling of the district heating flow does not waste energy. Instead, the heat pump transfers the heat from the return flow past the scrubber to the forward flow of the network. In addition, the friction heat from the electric motor is channeled to the heat pump's internal thermodynamic process where it is recovered and transferred to the district heating network.

Two powerful heat pump connection options

Due to the high variety of field conditions, Caligo has developed two powerful options for connecting the heat pump with the scrubber. Both applications utilize two condensing zones inside the scrubber condensing tower. The lower one is for basic condensing and the upper zone is for boosted condensing based on the heat pump's cooling impact.

A so-called **Parallel Heat Pump connection option (PHP)** is available for network return flow temperatures up to 65 degrees. The lower and upper condensing zones and respective heat exchangers are connected in parallel. The application allows the best heat recovery with the lowest electricity consumption ever experienced on the market. In addition, the connection option enables the use of the optimum size of standard heat pumps, which ensures a short payback period for the total scrubber investment.

A **Serial Heat Pump connection option (SHP)** is available for network return flow temperatures up to even 80 degrees. The upper and lower condensing zones and respective heat exchangers are connected in series. When the network return flow temperature is well below the flue gas dew point, the lower heat exchanger contributes the most to the heat recovery. However, when the network return flow temperature reaches extreme values such as 65–80 degrees, the upper condensing zone together with the heat pump is the only way to recover the waste heat from flue gases. The heat pumps used in the application are specifically designed for higher temperature ranges.

Efficiency from flue gas treatment

The Caligo CSx has been developed for flue gas treatment purposes such as solid particle filtering and sulphur oxide (SO₂) removal. The basic features of the system provide a high filtration level for solid particles above 2 µm in diameter, provided that proper pre-filtering is used in the plant process.

The Caligo CSx system is also available with boosted solid particle filtering capabilities (optional feature). The solid particle load on the scrubber can be increased 3–6 times the standard level, which in some cases allow electrostatic precipitators to be left out of the plant process. Please note, that efficient removal of particle diameters below 2 µm typically requires the use of electrostatic pre-filtering in the plant process.

High solids concentration functionality

The **high solids concentration functionality (HSC)** ensures undisturbed flow inside the scrubber when solid contamination in the condensate is high. The HSC functionality circulates the condensate continuously inside the condensing tower in order to avoid any harmful precipitation and clogging. The HSC functionality is optional.

Complete SO₂ removal

Due to its wet scrubbing and applied technologies the Caligo CSx is capable of removing practically all SO₂ content from the flue gases. The generated acid water is neutralized with lye (NaOH). Neutralization is a basic functionality in the Caligo CSx.

Caligo CSx – technical data

Materials

- › Washing tower: Super Duplex steel
- › Condensing tower: Super Duplex steel
- › Condensate treatment: WTxB, steel EN1.4404
- › Ladders and railings: steel EN1.4301 (stainless)
- › Working levels: steel EN1.4301 (stainless)
- › Platform: steel S355 (painted)

Automation

- › Logic: Siemens S7 (incl. PC remote and local panel)
- › Automation SW: Caligo SW v.2.03 software
- › I/O's: app. 120 pcs
- › Communication: Profibus

Condensate treatment

- › WTx (see separate brochure)

Heat pump

- › Fully integrated industrial heat pump(s) with Caligo control and regulation package

Connections

- › District heating: Flanges 2 pcs, DN150–DN250
- › Flue gas channels: Flanges 3 pcs, DN500–DN1200
- › Power supply: Scrubber 10–50 kW, Heat pump 50–250 kW
- › Pressured air: Instrument air 6 bar (g)
- › Raw water: Flanges DN32
- › Lye feeding: 8–12 mm pipe connection
- › Condensate out: DN40–DN65
- › Sludge out: DN40–DN50

Caligo CSx – optional

Modules

- › SB – Sludge bagging & drying
- › CC – Condensate cooling
- › ES – Enhanced Scrubbing
- › CEP – Caligo ESP system
- › NaOH source with safety pool

Site Connecting Services

- › Flue gas channels from the plant to the scrubber and from the scrubber to the chimney
- › Connecting of flue gas dampers if Caligo standard positioning is not applied
- › DH ducting from the network to the scrubber and from the scrubber to the boiler
- › Power cabling to the scrubber and heat pump electric cabins (2 pcs)
- › Pressurized air and raw water lines from the plant to the scrubber system
- › Sludge ducting from the scrubber to the plant disposal system
- › Data cabling from the scrubber automation to the plant automation
- › DH ducting between the heat pump and the scrubber
- › Cabling between the scrubber and the heat pump

Infrastructure

- › Building bases
- › Sheltering buildings
- › Building sewer and raw water system
- › Air conditioning and back up heating systems
- › Emergency shower
- › Heat pump container solution
- › AISI 316 Flue installed
- › AISI 316 Chimney and it's installation
- › Fixed internet connection line for remote technical support purposes

The Caligo CSx standard model is always delivered with a Caligo WTxB condensate treatment unit (see our separate brochure). The WTxB module is an integral part of Caligo CSx mechanics and the module is controlled by the Caligo CSx automation system.

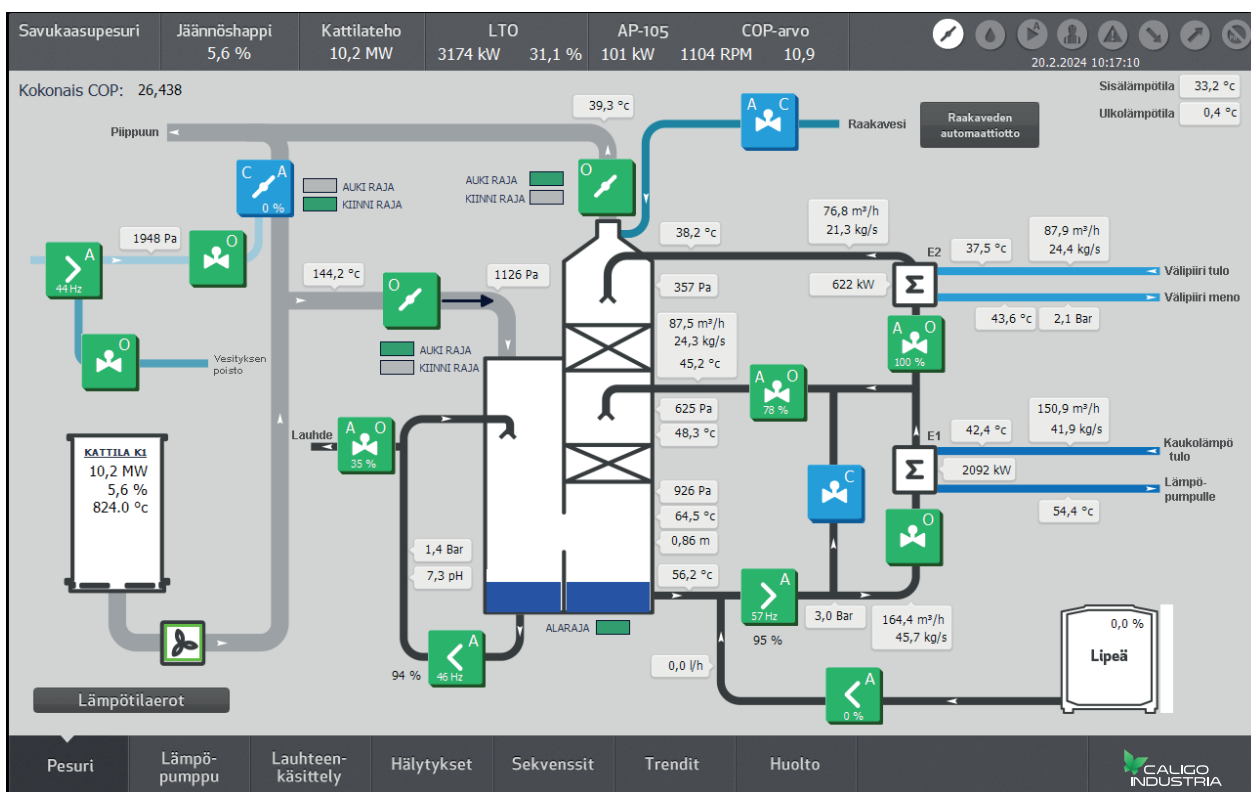
Sludge that forms during Caligo CSx operation is removed automatically either via external sludge treatment or via the Caligo sludge treatment and storing unit. The unit consists of a filtering bag (1 m³) and a filtering pool. The treatment increases the sludge solid concentration above 40%, which simplifies the further handling and transportation of the solids. The sludge treatment unit is optional.

SCRUBBER MODULE (CSx)	Length (mm)	Width (mm)	Net height (mm)	Net weight (t)
CSx for 4 MW boiler	6000	3000	6000	8,0
CSx for 6 MW boiler	6000	3500	7500	12,0
CSx for 12 MW boiler	9000	4000	8000	20,0
CSx for 20 MW boiler	11000	5000	8500	28,0

Dimensions above are indicative.

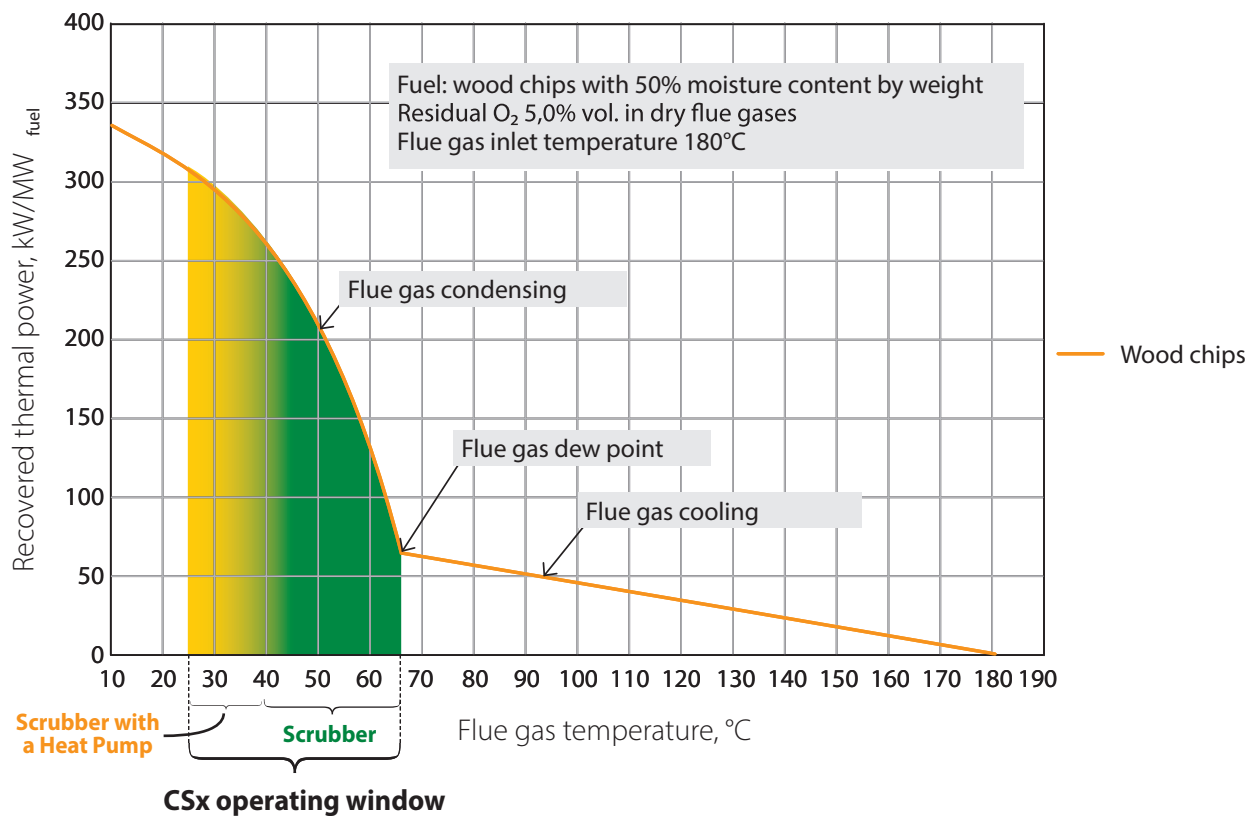
HEAT PUMP MODULE (CSx)	Length (mm)	Width (mm)	Net height (mm)	Net weigh (t)
HeatPac 104	3050	1000	2000	2,6
HeatPac 106	3750	1000	2000	3,3
HeatPac 108	4050	1000	2000	4,0

User interface



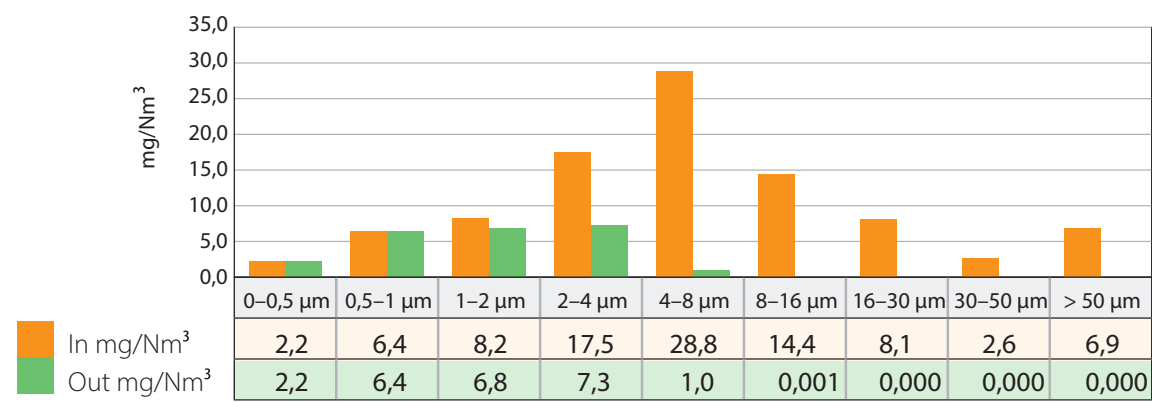
Thermal power released from flue gases

Released thermal power as a function of temperature (kW/MW_{fuel})

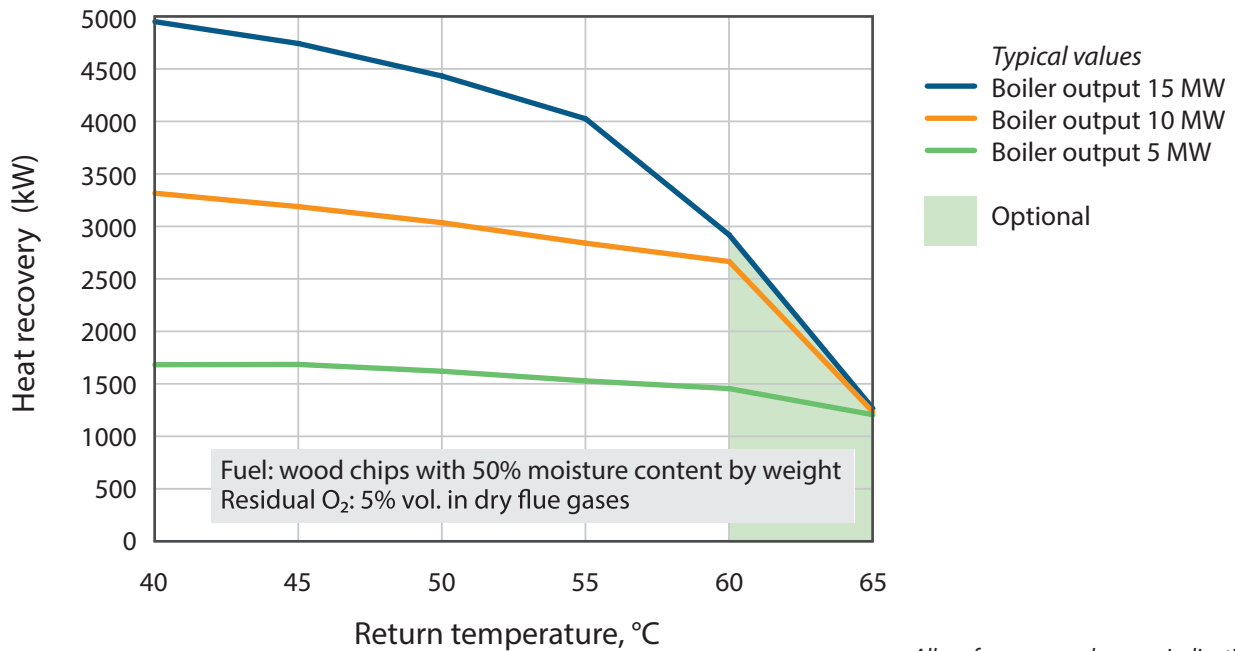


Flue gas particle contamination

Incoming and outgoing particle contaminations per diameter category

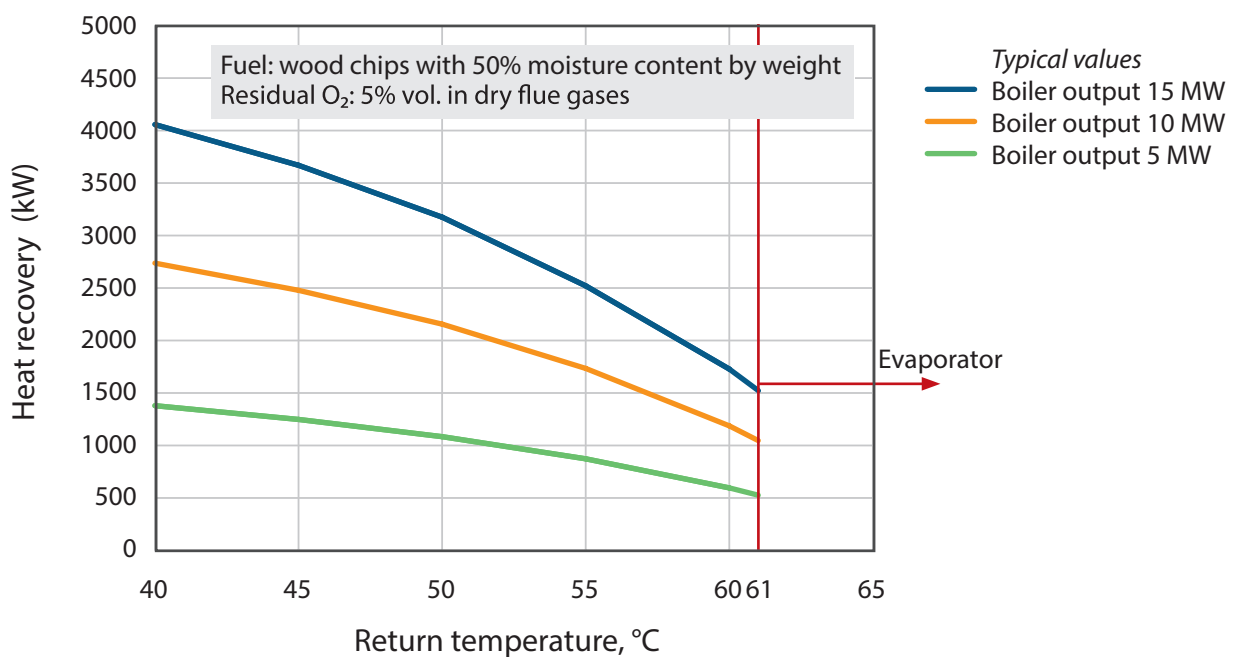


PHP Model Heat Recovery



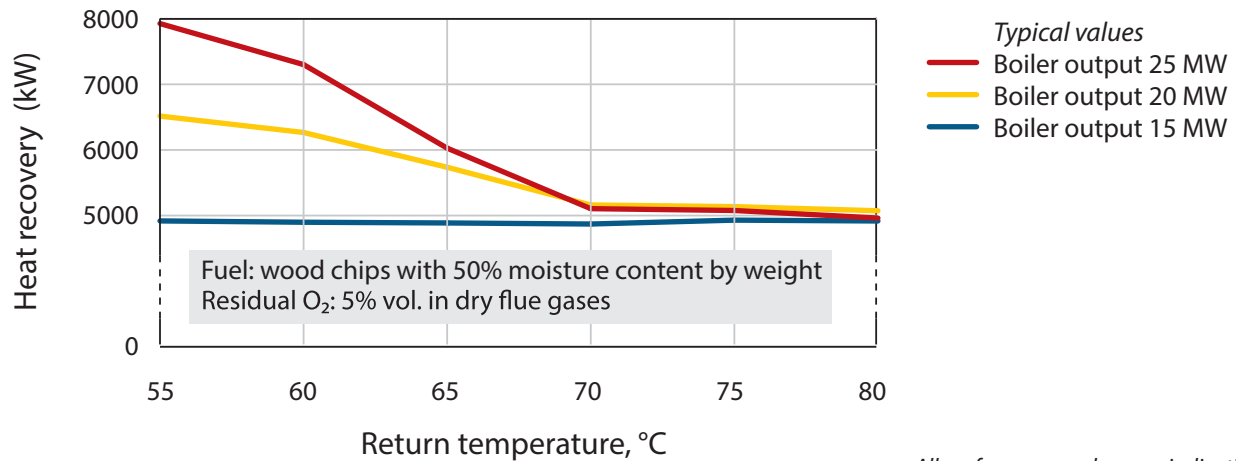
All performance values are indicative.

Basic Scrubber Heat Recovery



All performance values are indicative.

SHP Model Heat Recovery



All performance values are indicative.

Electricity consumption with heat pump connection

BOILER OUTPUT	DH return temp	Typical usage
Caligo model SHP 15 MW	low	650 kW
	high	1150 kW
Caligo model SHP 20 MW	low	700 kW
	high	1150 kW
Caligo model SHP 25 MW	low	750 kW
	high	1150 kW

BOILER OUTPUT	DH return temp	Typical usage
Caligo model PHP 10 MW	low	140 kW
	high	240 kW
Caligo model PHP 15 MW	low	180 kW
	high	240 kW

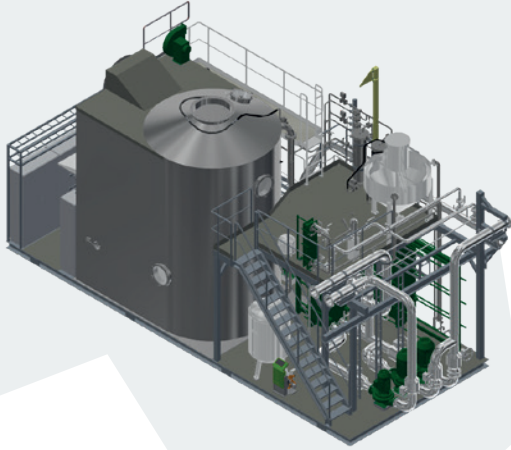
Basic Caligo model's typical electricity usage <30 kW. With optimized heat recovery performance. All PHP and SHP values with model specific heat pump applications.

Other performance values

PERFORMANCE DESCRIPTION	Option	Guaranteed
Particle contamination after the scrubber (when incoming particle contamination is max. 150 mg/m ³ n)*	CS15/5	Below 50 mg/m ³ n
Particle contamination after the scrubber (when incoming particle contamination is max 300 mg/m ³ n)*	CS30/5	Below 50 mg/m ³ n
SO ₂ precipitation degree	All models	Over 95 %
Condensate pH, out	All models	6...10
Condensate solids contamination, out	All models	Below 10 mg/l
Raw water consumption in operation	All models	0 m ³ /h

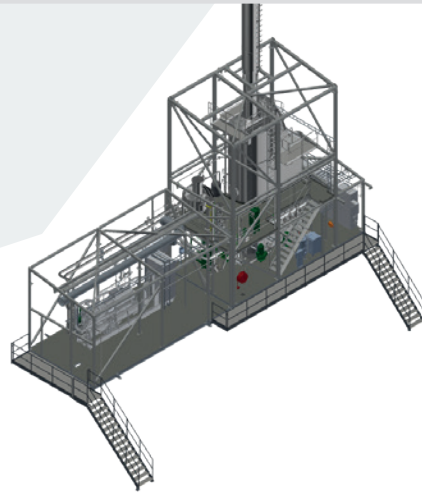
* N.B.! Performance values are valid only when incoming flue gas particles diameter distribution follows the standard SMS 2027 Diagram 4 (for wood chips and peat).

Products



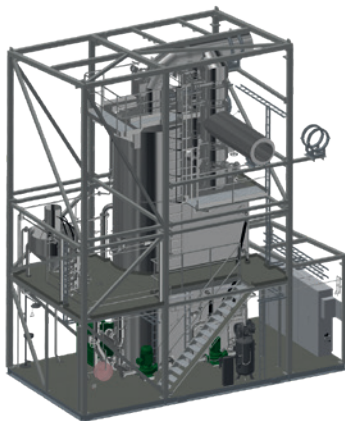
Caligo CSxBWT – Basic flue gas scrubber

This is our basic unit. It includes flue gas particle and SO₂ filtering, one heat recovery area as well as condensate and sludge handling.



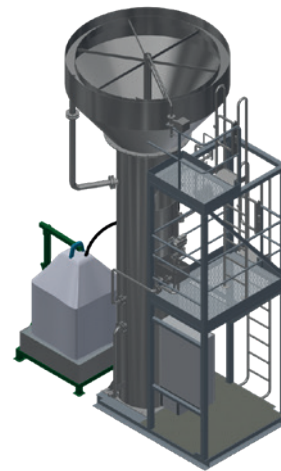
Caligo CSxHPxWT – Flue gas scrubber with heat pump

The Caligo CSxHPxWT model comes with a connected heat pump. The patented heat pump connector ensures maximum heat recovery even when return district heating temperatures are high. In such cases a basic scrubber's heat recovery crashes. This solution can save even over 30% of yearly fuel costs.



Caligo CSxHPxWT – Flue gas scrubber with heat pump connector

This unit is recommended if the basic flue gas scrubber is sufficient for current needs, but the district heating return temperatures may rise in future, e.g. when more industrial customers are added to the network. The scrubber has space reserved for a second heat recovery area and heat pump connector (does not include heat pump).



Caligo WTx – Condensate treatment unit

The condensate treatment unit can also be delivered as a separate unit. It handles condensate treatment, filtering and sludge separation completely independently. The treated condensate can be fed into the wastewater drain.

Selected References

Caligo scrubbers with a heat pump module

VATAJAKOSKEN SÄHKÖ OY, KANKAANPÄÄ 2021

- › Industrial plant
- › Caligo scrubber with two heat pumps
- › Heat recovery 6,0 MW

VALIO OY, LAPINLAHTI 2021

- › 22 MW bioenergy plant
- › Caligo scrubber with two heat pumps
- › Heat recovery <25%

HERRFORS OY, YLIVIESKA 2019

- › 31 MW CHP plant
- › Heat recovery >30% (planned) PHP-connection

DALKIA, JOUÉ-LÈS-TOURS, FRANCE 2018

- › 9,5 MW plant
- › Caligo scrubber with two SHP heat pump modules
- › Heat recovery 20–25%



Caligo basic scrubber with option for heat pump module connection

KAUHAJOEN LÄMPÖHUOLTO OY, KAUHAJOKI 2020

- › 15 MW bioenergy plant
- › Heat recovery >20%

KURIKAN KAUKOLÄMPÖ OY, ILMAJOKI 2020

- › 15 MW bioenergy plant
- › Heat recovery >15%



Caligo basic scrubber, average heat recovery 20–25%

STENVALLS TRÄ AB, SESKARÖ SAWMILL, SWEDEN 2023

- › 9 MW bioboiler at a sawmill

VYNCKE NV, WIELE, POLAND 2021

- › 18 MW bioenergy plant

NEVEL OY, KARKKILA 2021

- › 8 MW bioenergy plant

LANTMÄNNEN CEREALIA OY, KOTKA 2020

- › Food factory

FLO ENERGIE – PIVETEAU BOIS SAW MILL, SAINTE-FLORENCE, FRANCE 2019

- › 15 MW biomass plant

KEITELE ENERGY OY, KEITELE SAW MILL 2019

- › 18 MW biomass plant

KEITELE TIMBER OY, ALAJÄRVI SAW MILL 2019

- › 16 MW biomass plant



Caligo piccolo basic scrubber

PÖYTYÄN LÄMPÖKESKUS OY, RIIHIKOSKI 2017

- › 2,5 MW plant
- › Average heat recovery 15%

CLEAN EFFICIENCY

We develop, market and sell product and system solutions for the purification of flue gases in the energy and processing sectors, for the utilisation of waste heat from processes , and for industrial shut-off and control dampers worldwide.

All our solutions are delivered as factory assembled and tested products. Caligo solutions have been extensively productized. Expensive field installation projects are no longer needed.

Our offices are located in Turku and Jyväskylä, Finland. Please, do not hesitate to contact us to tell us about your specific challenges. Our highly skilled experts will choose the best solution from our product range to meet your demands.

Caligo Industria Oy

sales@caligoindustria.com

Sales

Oskari Salovaara, CEO
Tel. +358 50 452 8208
oskari.salovaara@caligoindustria.com

Mika Nummila, CTO
Tel. +358 50 530 8311
mika.nummila@caligoindustria.com

Turku

Itäinen Rantakatu 72
FI-20810 Turku

Jyväskylä

Ylistönmäentie 33C
FI-40500 Jyväskylä

Tampere (production)

Etu-Hankkionkatu 1 B 2
FI-33700 Tampere

www.caligoindustria.com