RENEWABLE HEATING & HOT WATER WITH WOOD PELLETS

Webinar 2
Introduction to commercial pellet boiler technology

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www.ecohotwater.co.nz

Combustion process

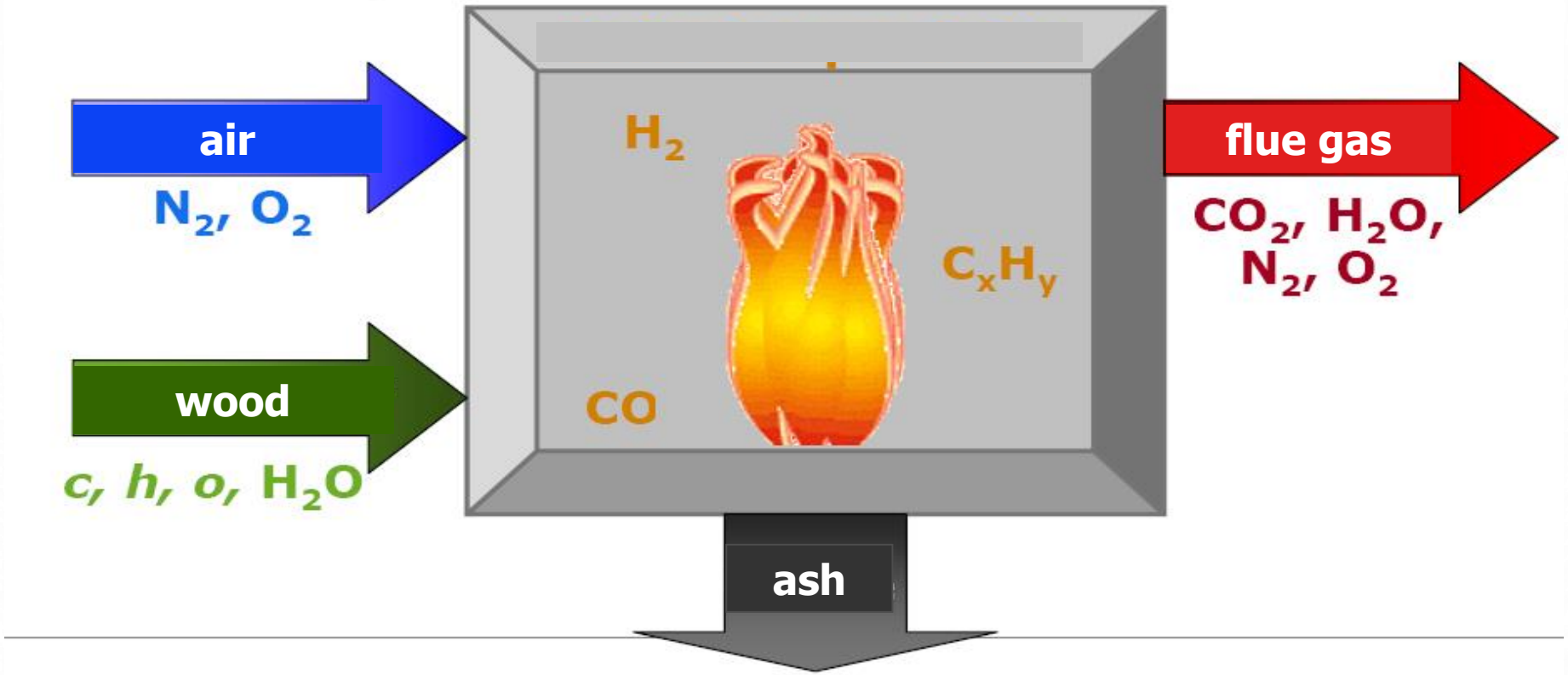
3 phases of combustion:

1. Warming and dewatering

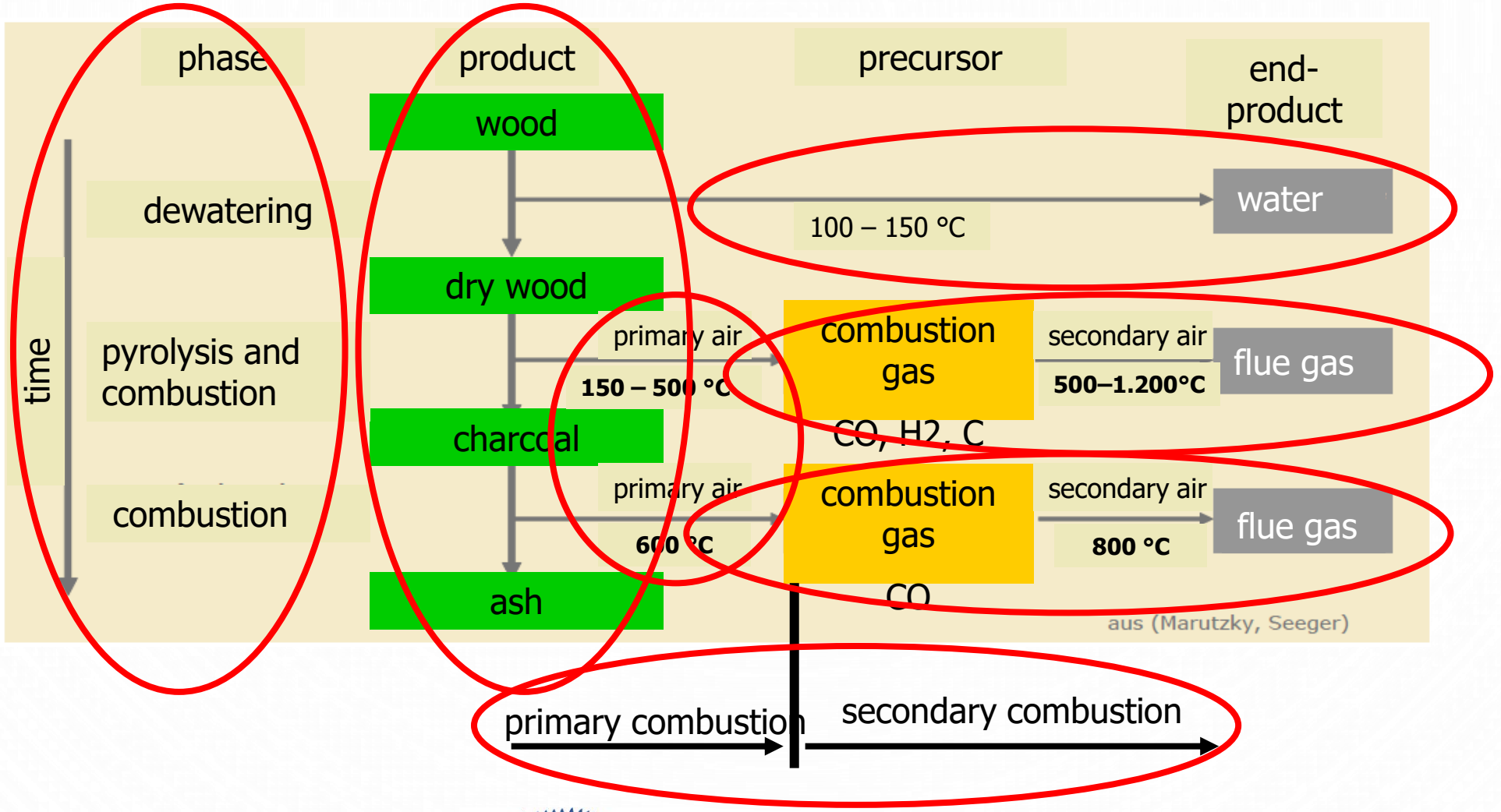
2. Degasification and pyrolysis

3. Combustion of gases
   - primary combustion
   - secondary combustion

Combustion process



Combustion process



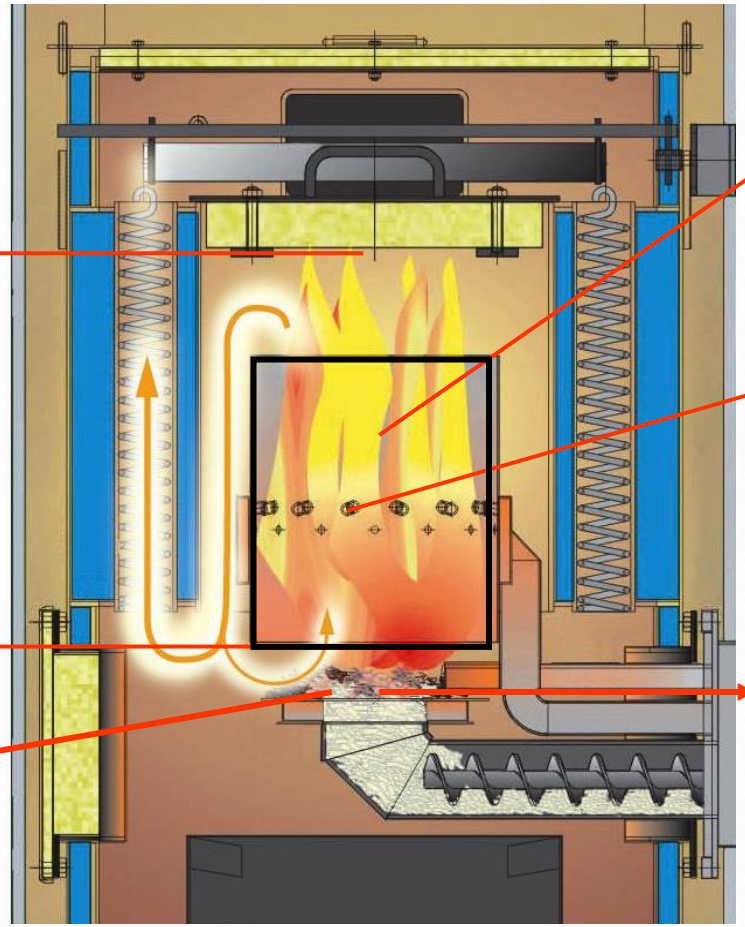
Good combustion

3T - Rule

Requirements of a good combustion:

- high temperature — **Temperature**
- enough residence time — **Time**
- enough oxygen and turbulence — **Turbulence**

Combustion process in pellet boilers



Secondary combustion chamber

Temperature approx. **800°C – 900°C**

Secondary air-nozzles
Turbulence

Time = residence time more than **one second**

Temperature up to 1,000°C at burner plate

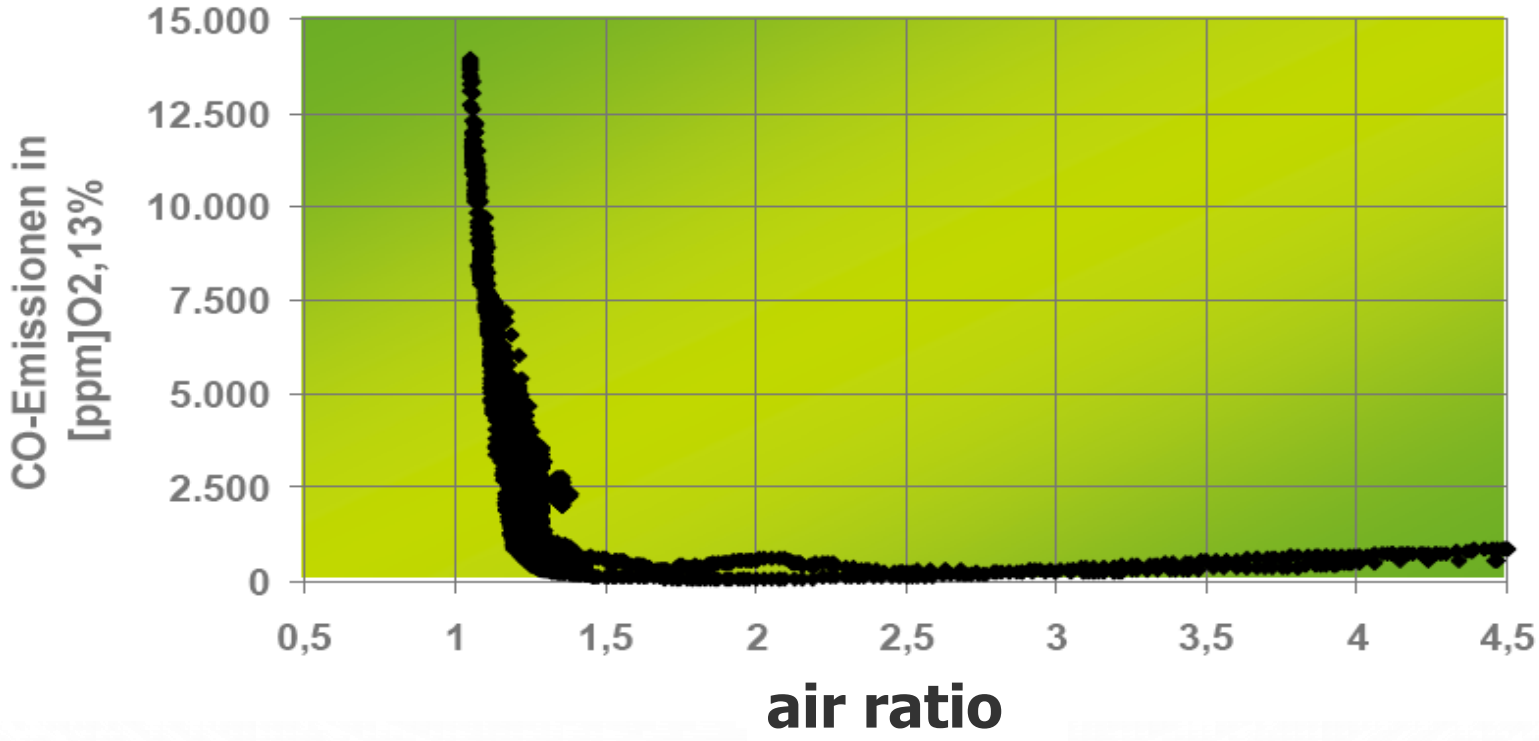
Avoid higher because slag formed at 1,300°C

Primary combustion zone

- underfed grate = no turbulence
- undisturbed gasification
- stable O2 levels & low particulate emissions
- lower CO production

Carbon monoxide / CO

Correlation between CO-emission and air ratio / combustion temperature



ECC Combustion Control in OkoFEN boilers

All critical aspects for efficient combustion monitored constantly

- Combustion chamber temperature in secondary zone
- Negative pressure (draft)
- Fuel available for combustion
- Air supply for combustion

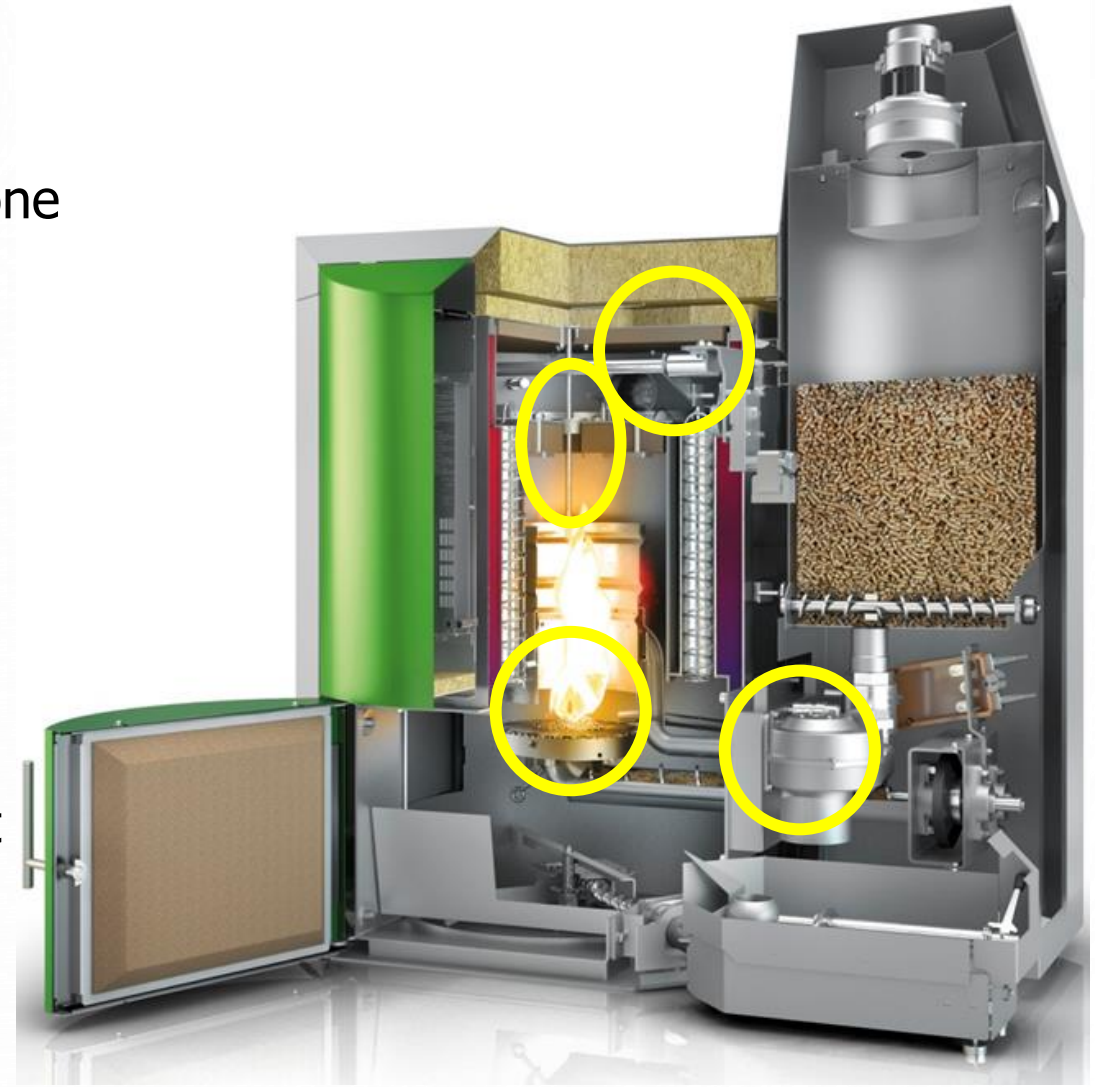
Continuous, automatic calibration with air & fuel mix adjusted in real time

Automatically manages any variation in fuel quality

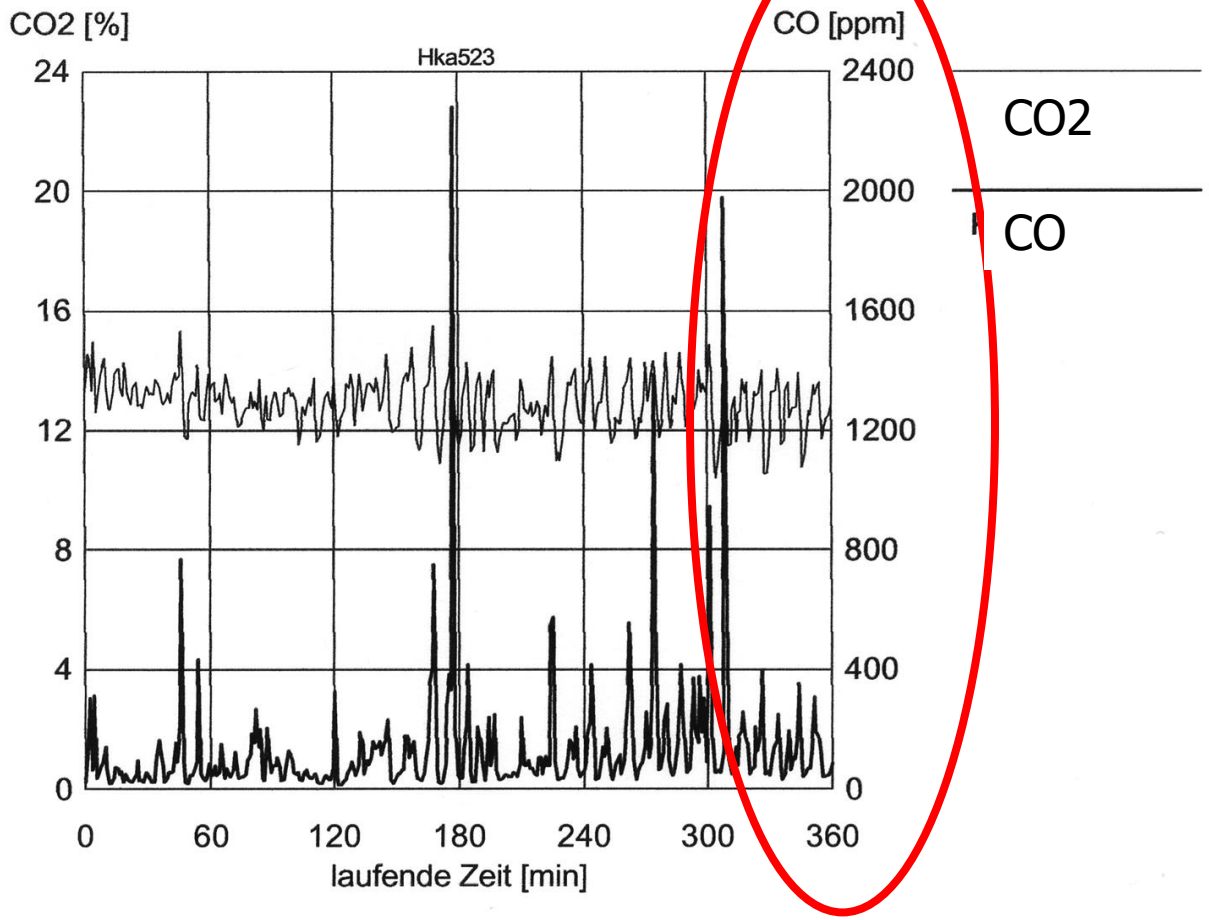
Boiler does not require combustion commissioning at install or after servicing

Stepless modulation range

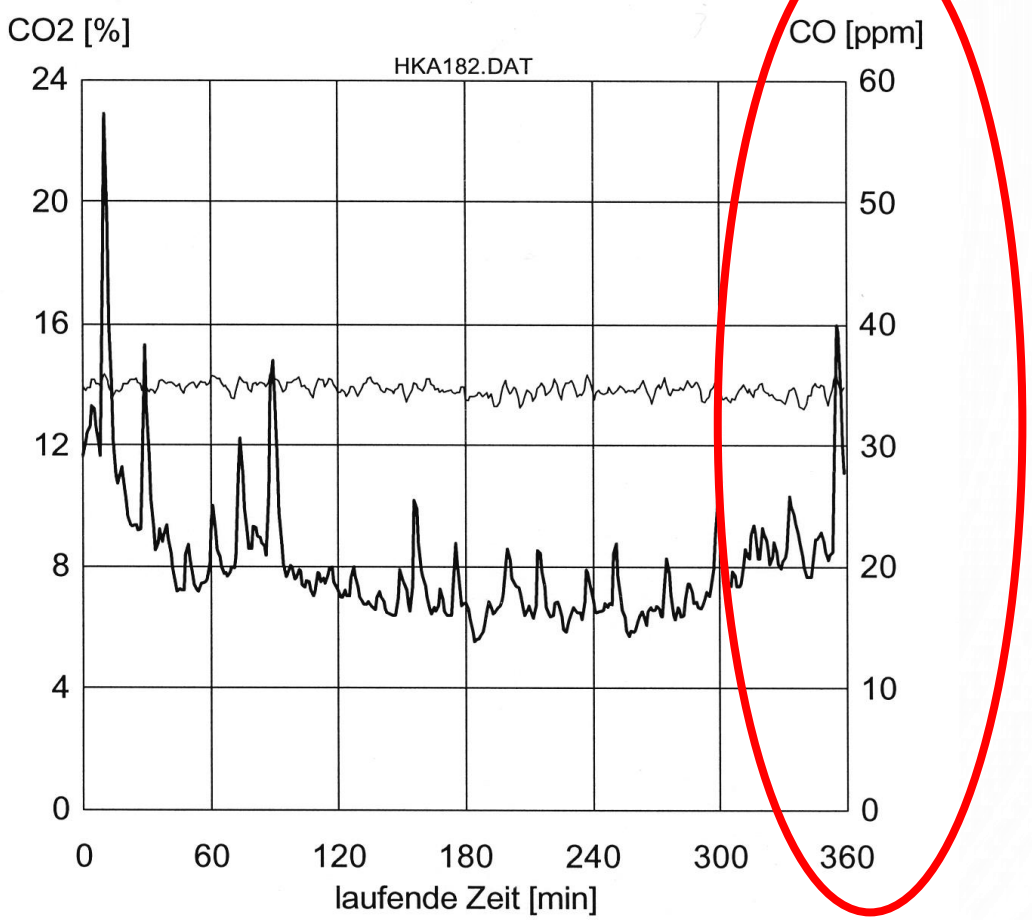
Lower carbon monoxide and particulate emissions



Carbon monoxide & control systems



Lambda sensor controlling combustion



OkoFEN boiler with EPC combustion control

Efficiency & emissions

Apricus® NZ
eco hot water

The target is :

- **high efficiency**

and

- **low emissions**

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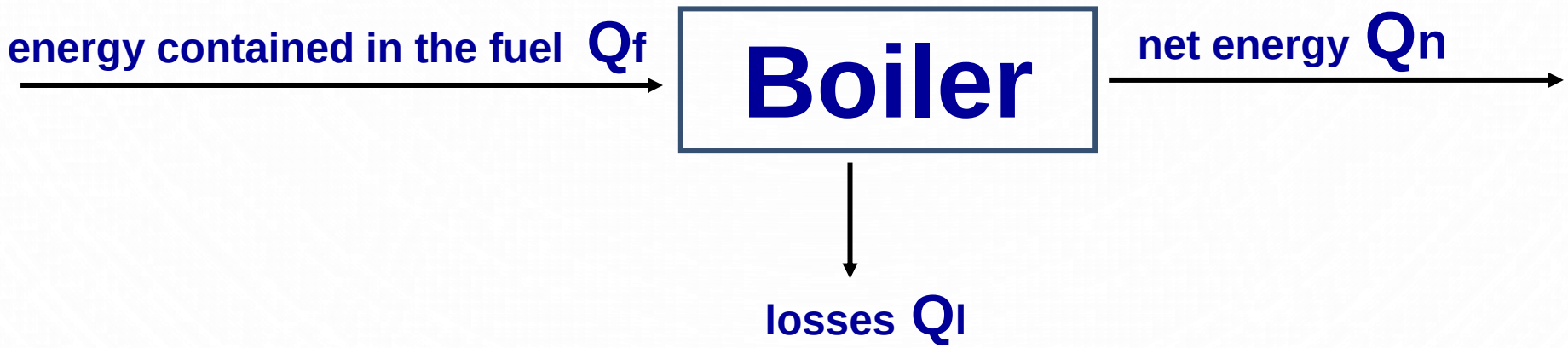
ÖkoFEN

EASYPELL CENTRAL HEATING PELLET BOILER

Efficiency

Efficiency = calorific balance



Losses

Sources of losses

- exhaust gases
- partially burned gas
- partially burned fuel
- radiation loss

The losses of **partial burned gas** and **partial burned fuel** normally are very low – mostly less than 1%

The **radiation loss** depends on the insulation of the boiler - modern boilers have a radiation loss between around 2-3%

The **exhaust gas** loss have a significant impact to the efficiency.

WARNING: if the flue gas temperature is too low – condensation forms and damages the flue outlet

Boiler technology - Froling

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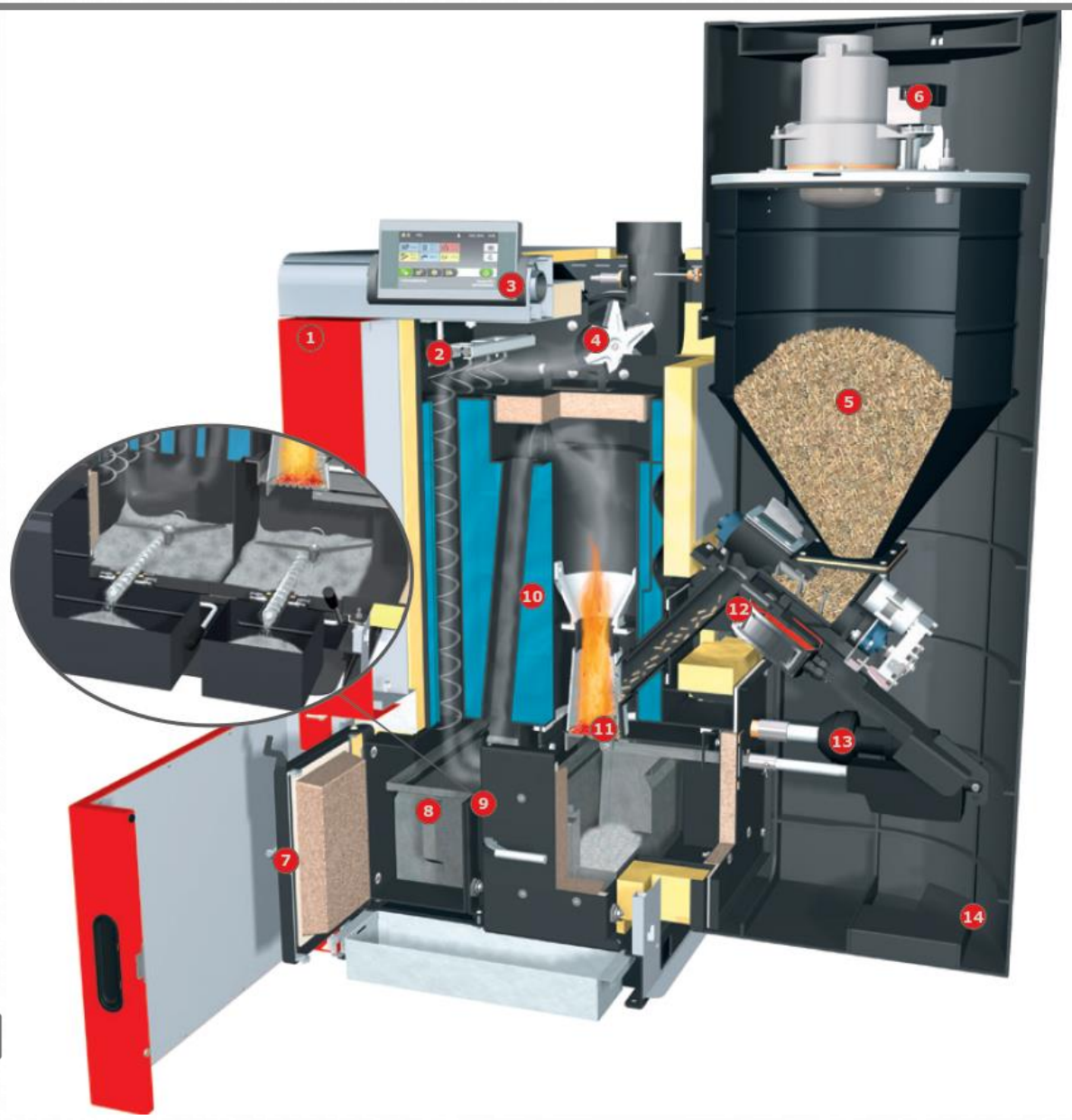

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Boiler technology - ETA

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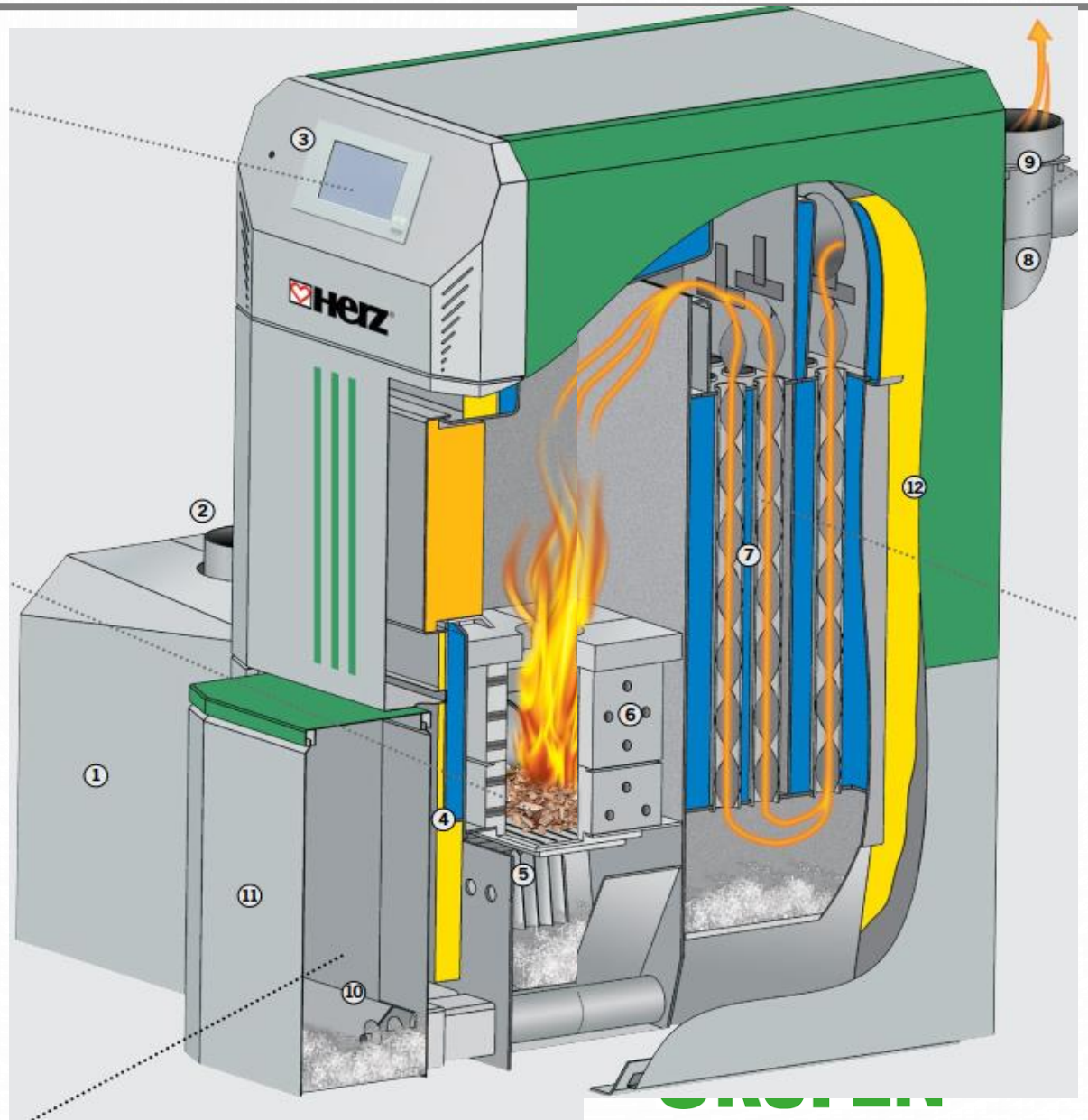
Boiler technology - Herz



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Boiler technology - KWB

Boiler technology – Schmid

Boiler technology – ÖkoFEN

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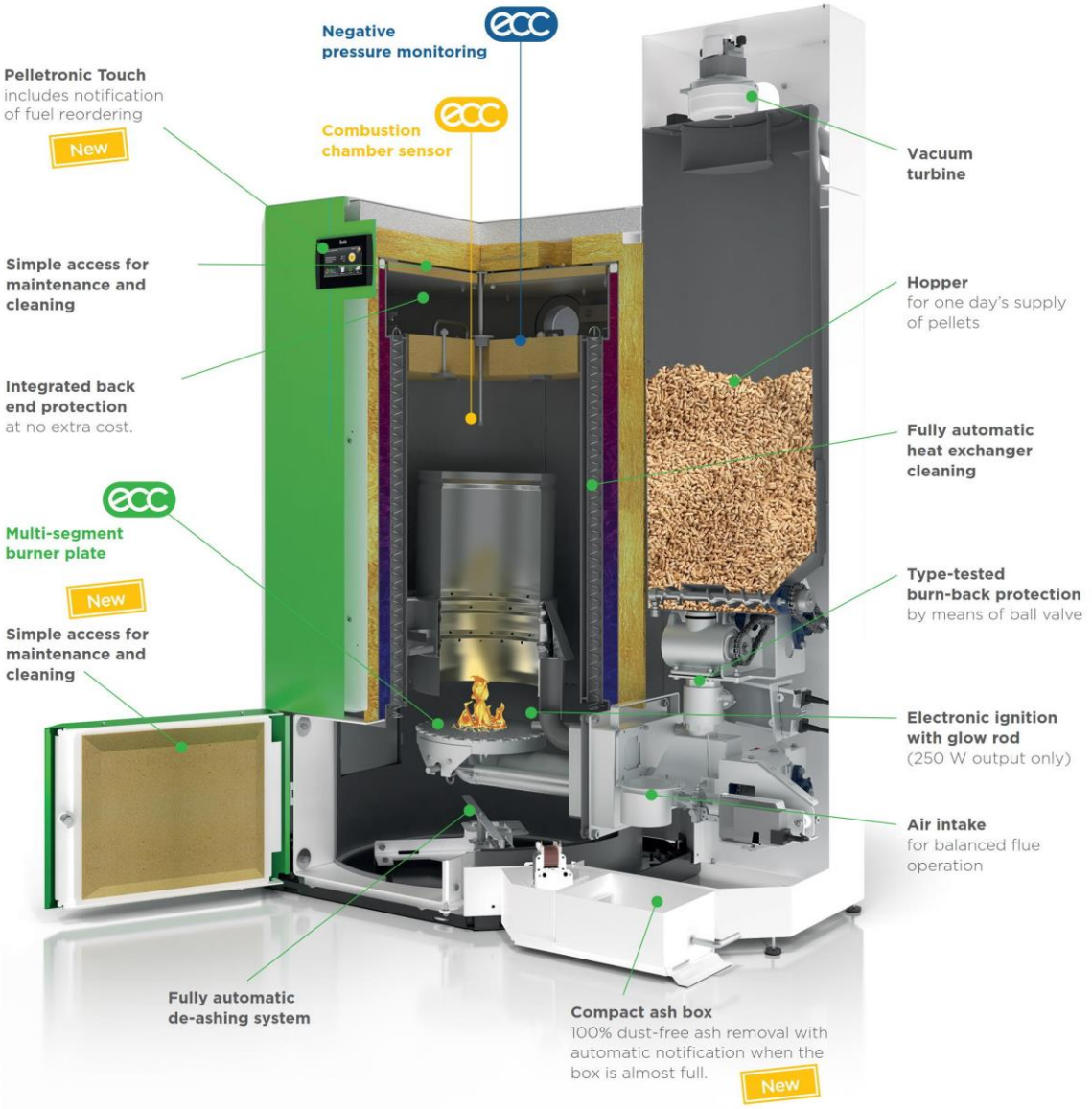

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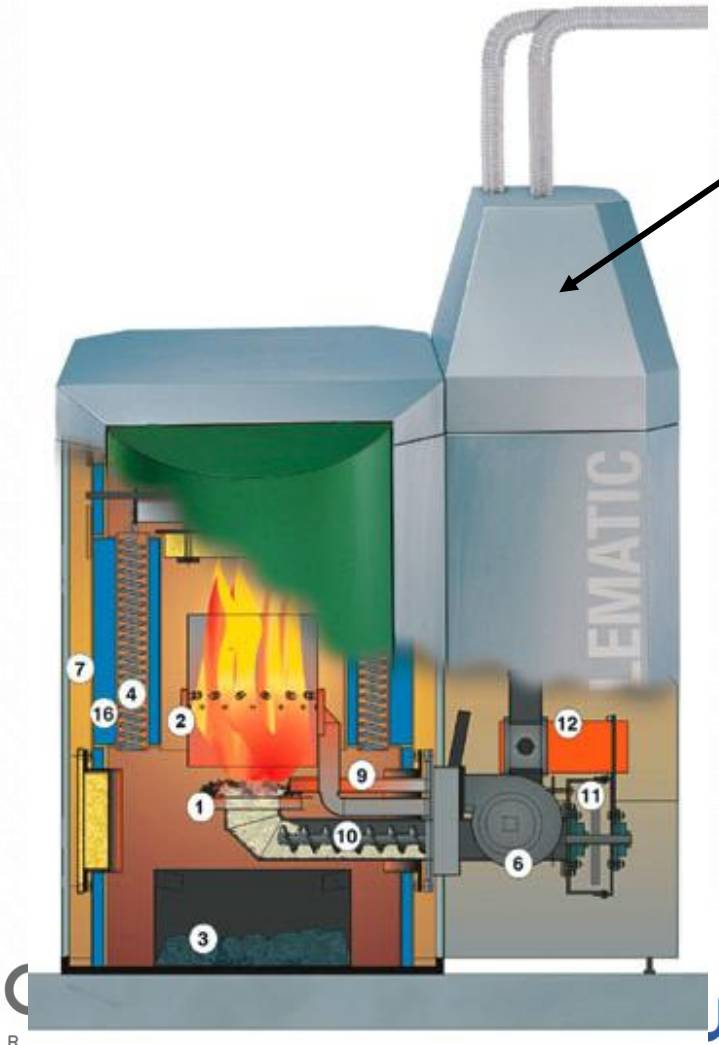
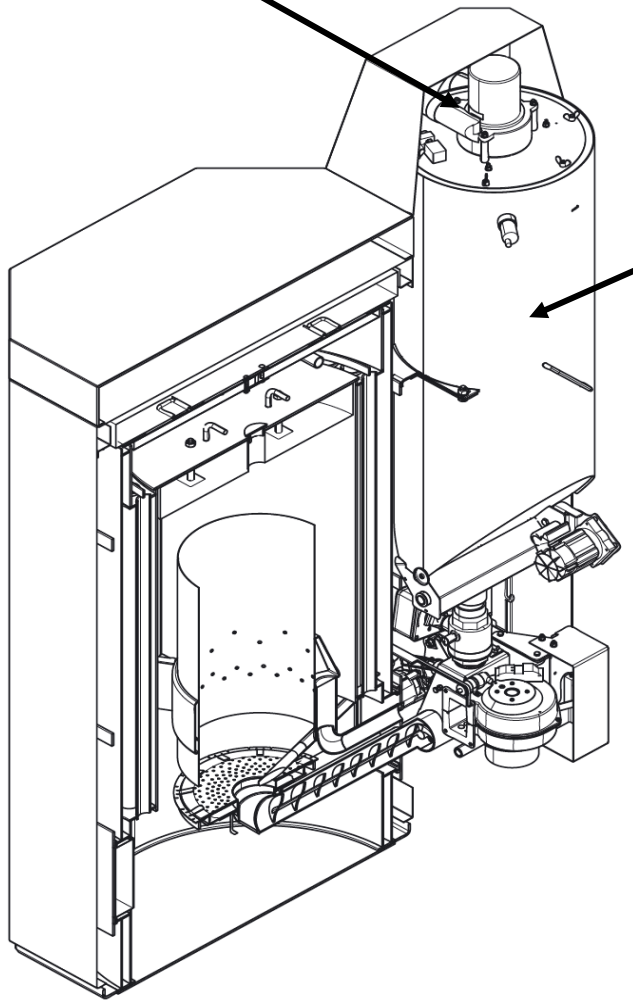
CENTRAL HEATING PELLET BOILER

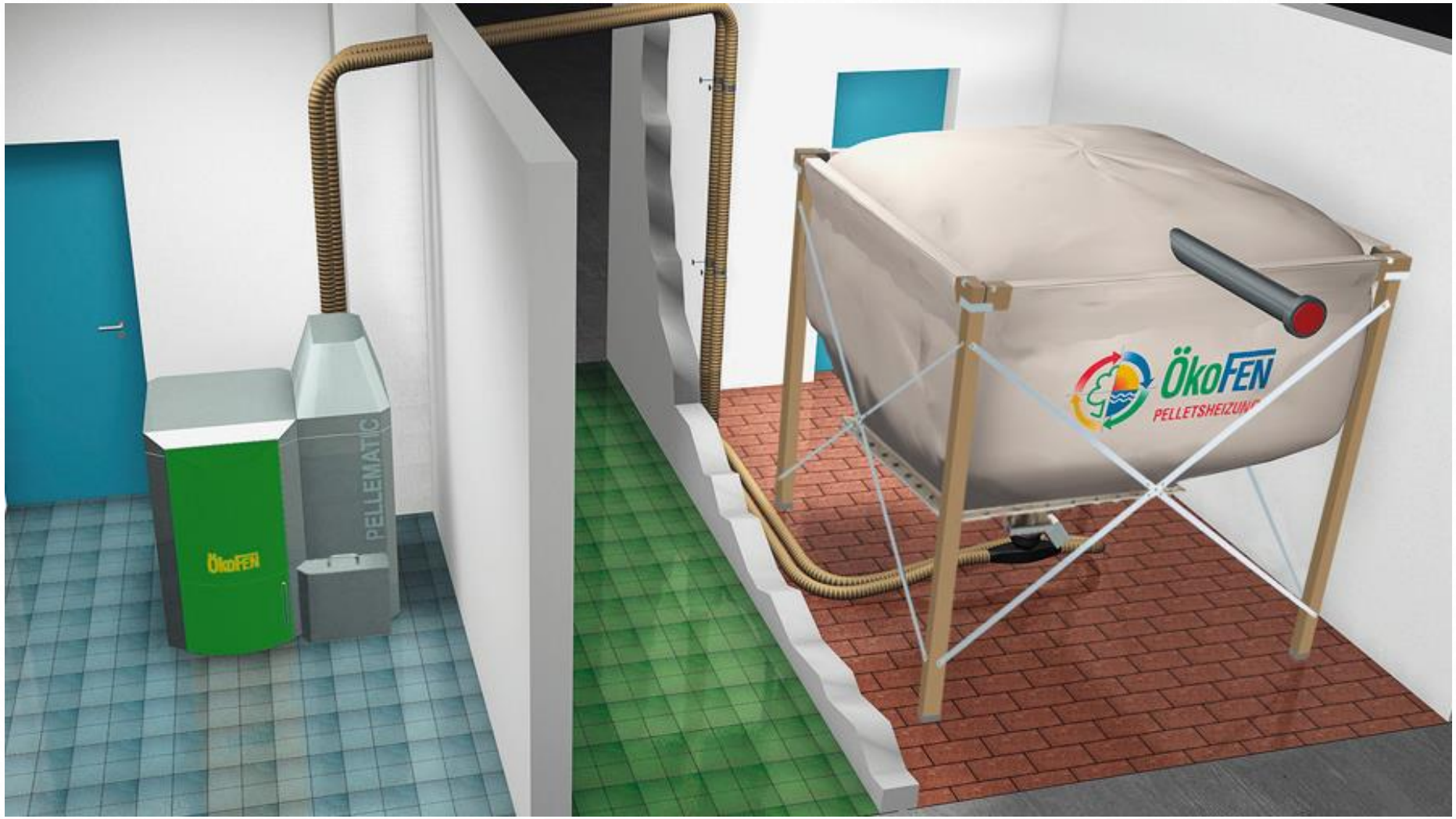
Boiler technology

Pellet transport system = **vacuum suction turbine**

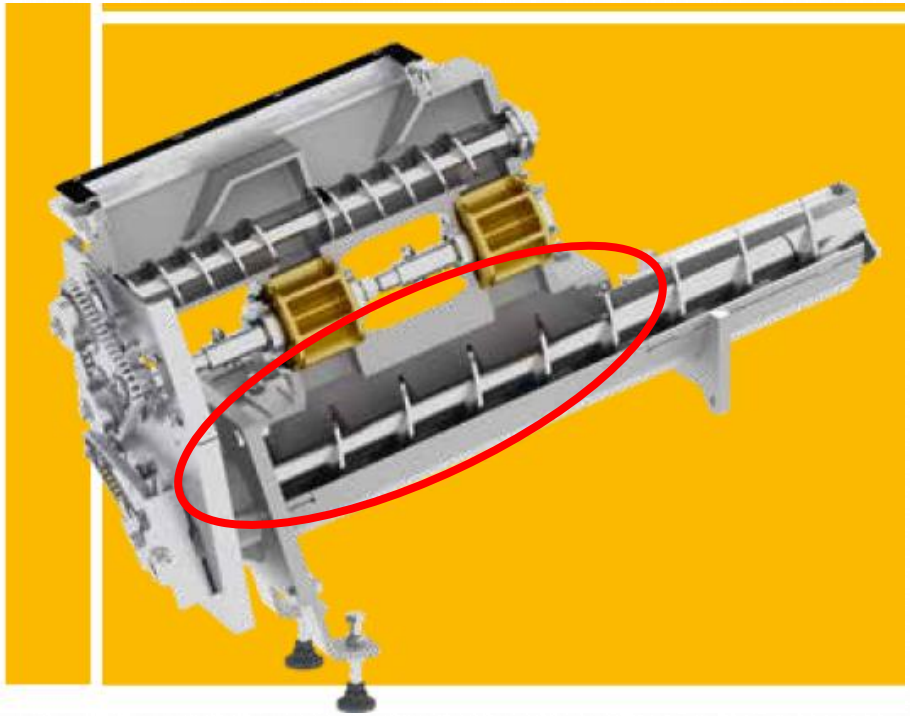




Textile tank with vacuum suction system



Burn back protection systems



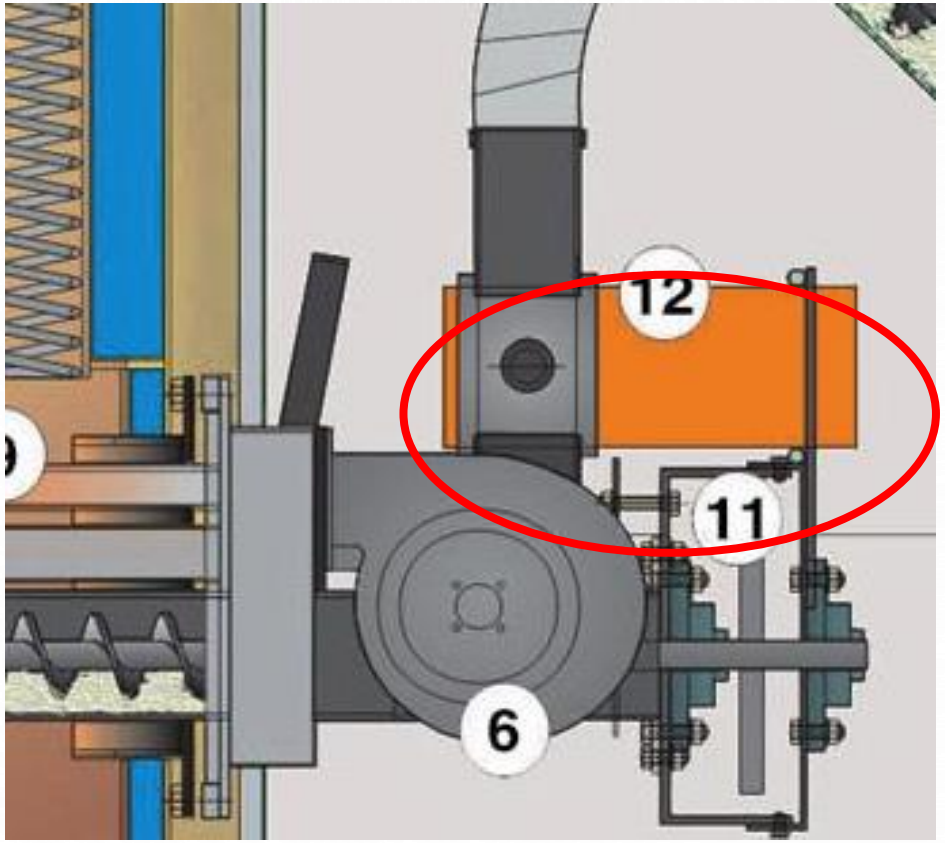
Rotary valve

Gate valves

Physically separates pellet store from combustion chamber
Monitored during operation and should default to closed

Burn back protection

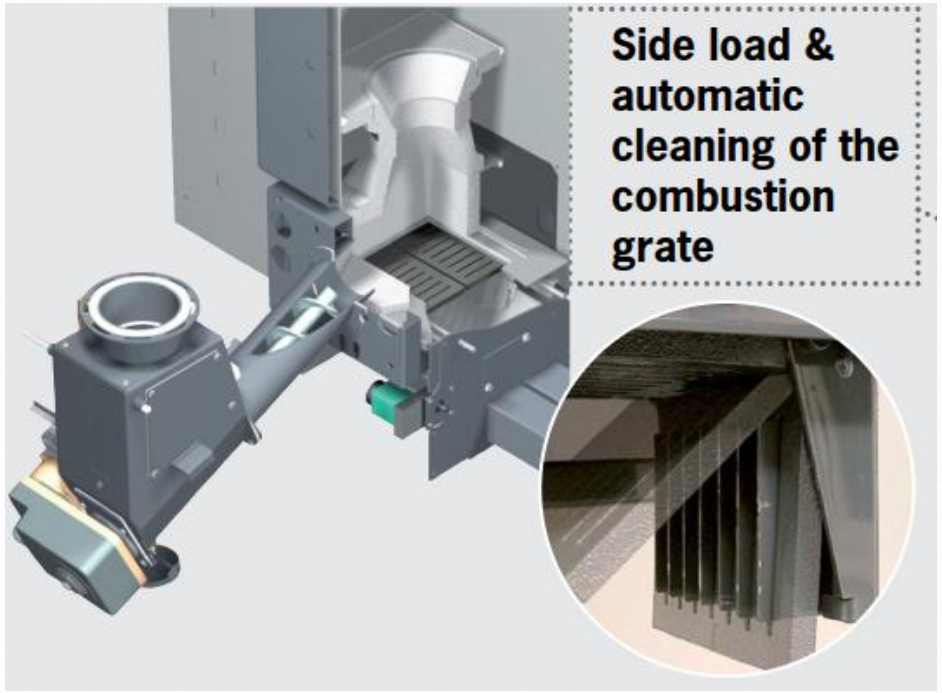
Ball valve – "Belimo valve"



Ball valve provides mechanical & air seal

- Burn back mechanically blocked
- Spring loaded, reverts to normally closed position without power
- Combustion air blocked
- No potential damage to pellets with rotary valve

Side or top load pellets & moving grates

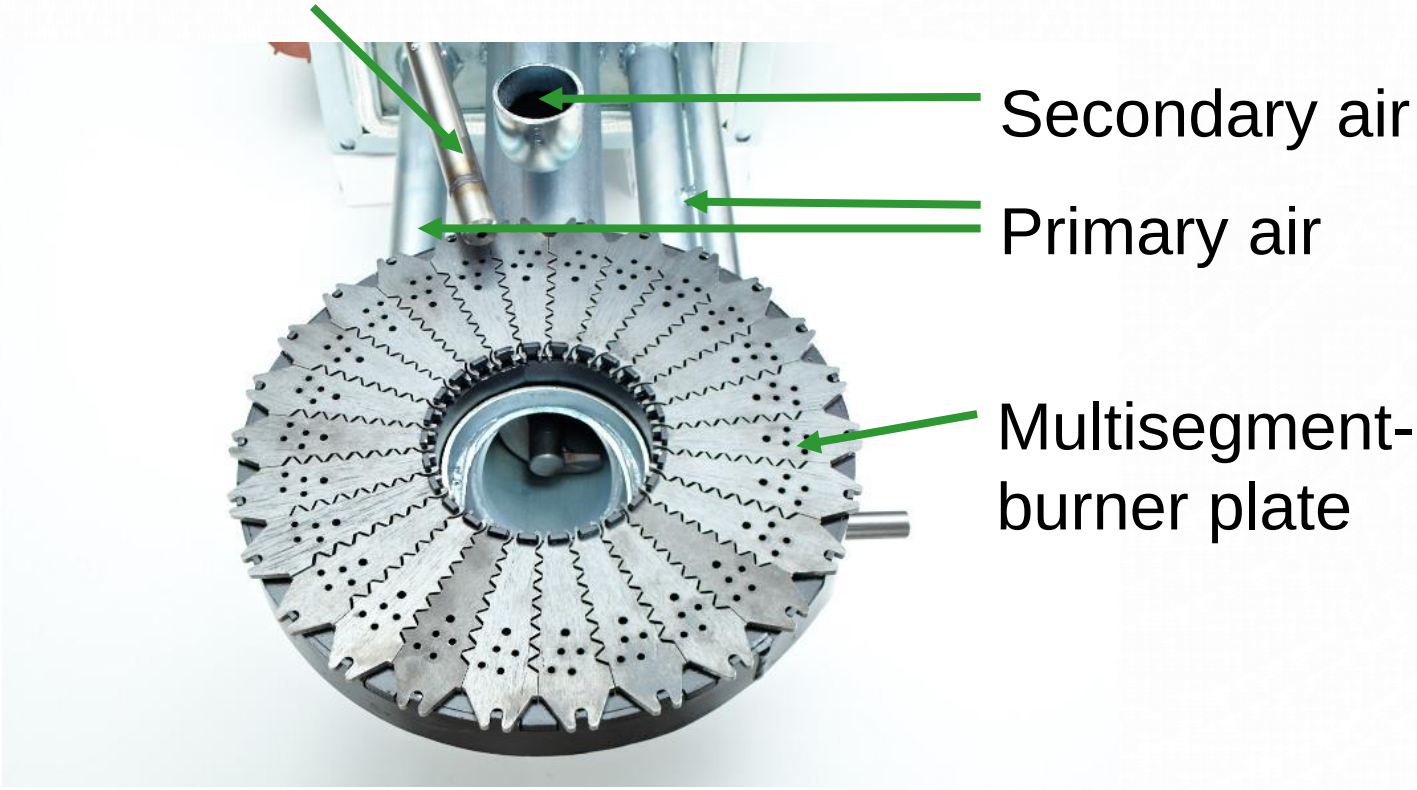


Pellets side loaded on to fire grate

Pellets dropped on to fire grate

Underfed pellets burner plate

Ignition – pipe with a heating cartridge 250W



Underfed pellets burner plate

Pellets fed from centre & below

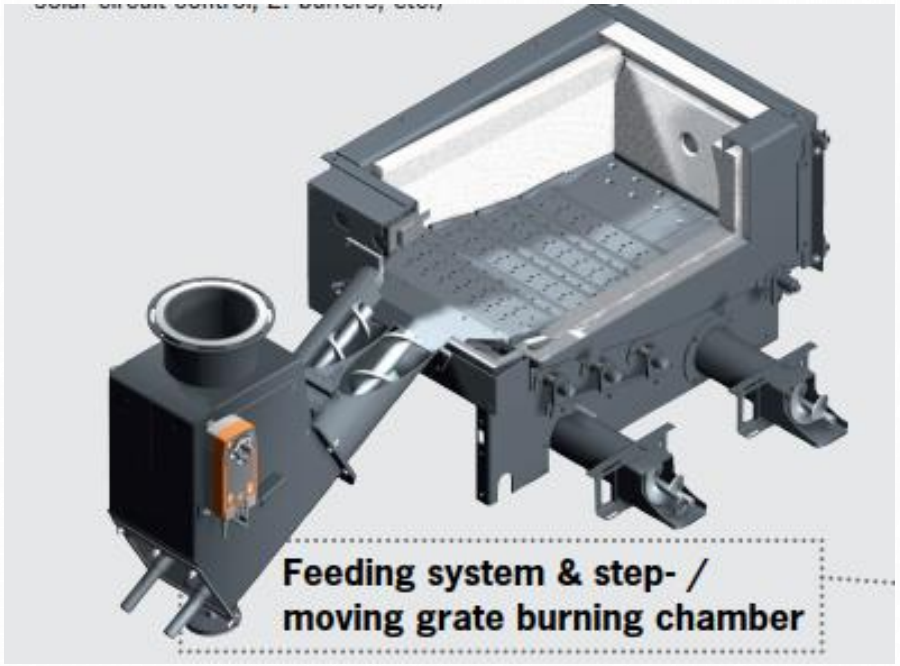
Movement of pellets from middle to outside of burn plate matches 3 phases of combustion:

1. Heating & dewatering
2. Gas release
3. Primary combustion

Fuel feed does not disturb fire bed

Tipping or moving grate

Tipping grate



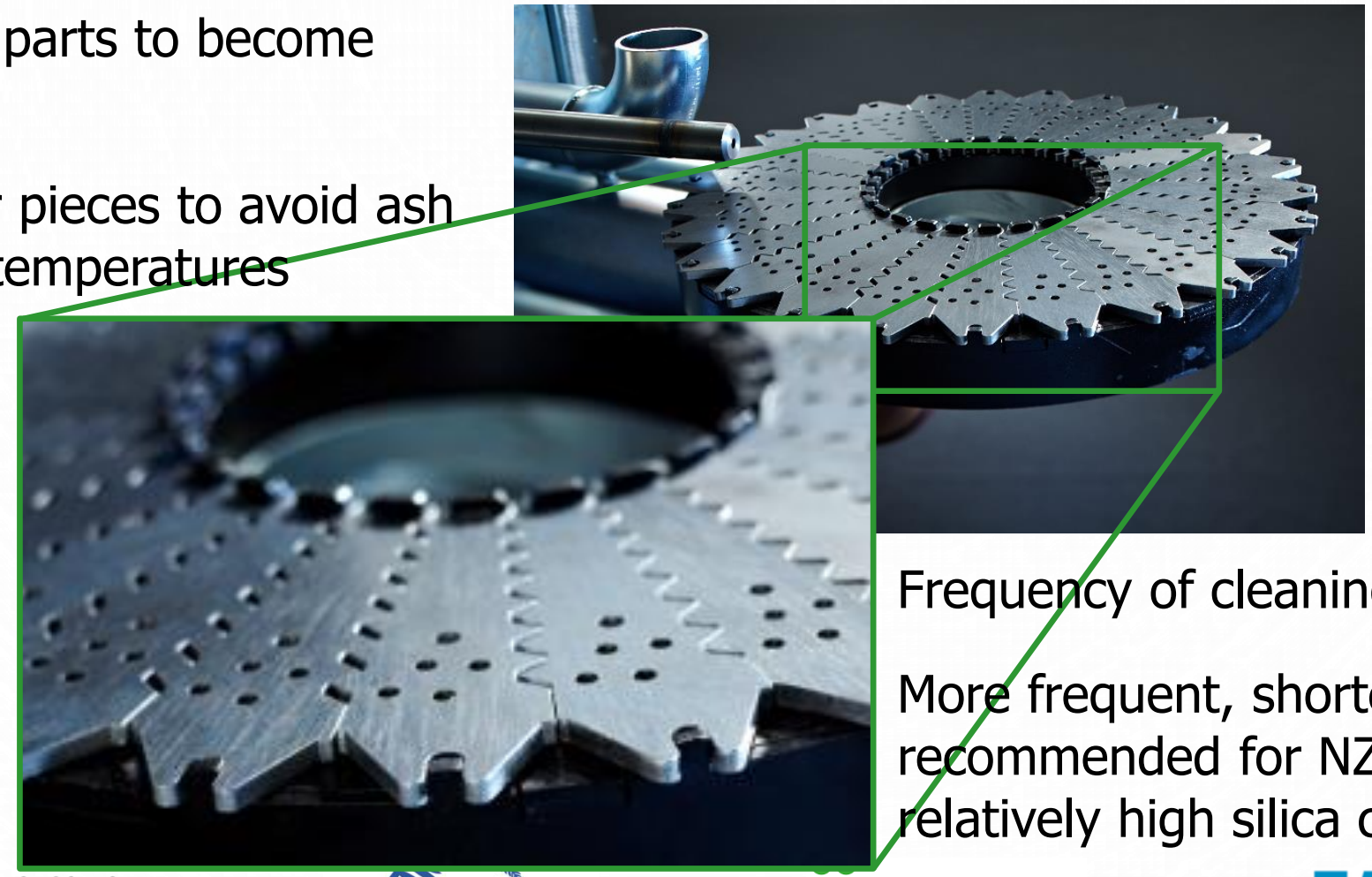
Moving grate

Multi segment burner plate

Automatic removal of residue

No large moving parts to become blocked

Breaks up clinker pieces to avoid ash fusion at higher temperatures



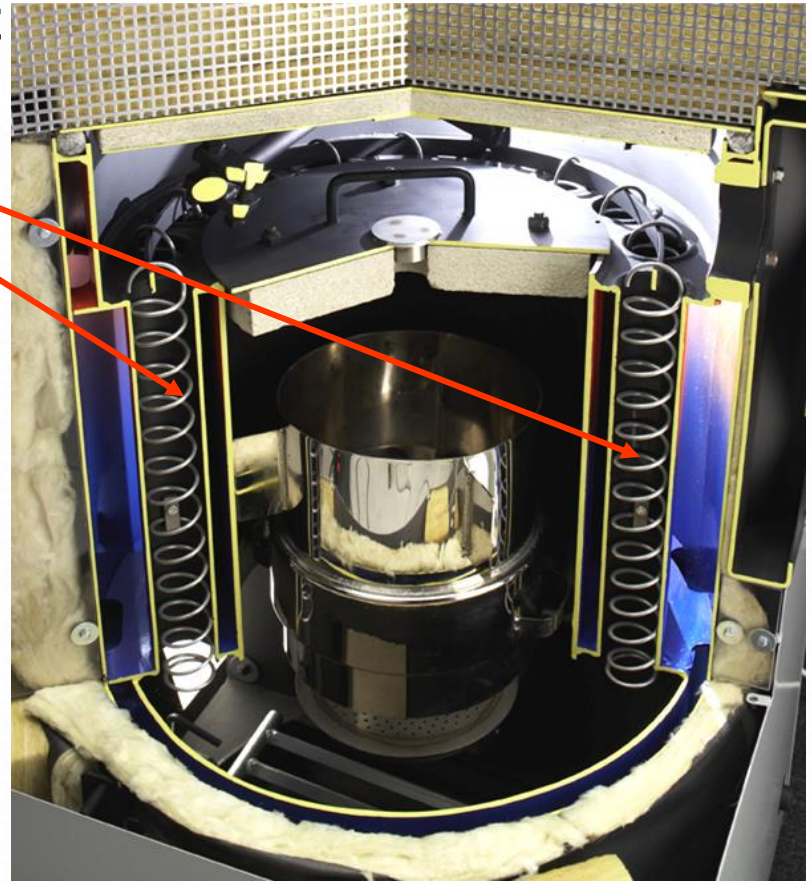
Frequency of cleaning can be adjusted

More frequent, shorter periods recommended for NZ pellets with relatively high silica content

HX cleaning & ash removal

Automated cleaning system of heat exchange area of fly ash

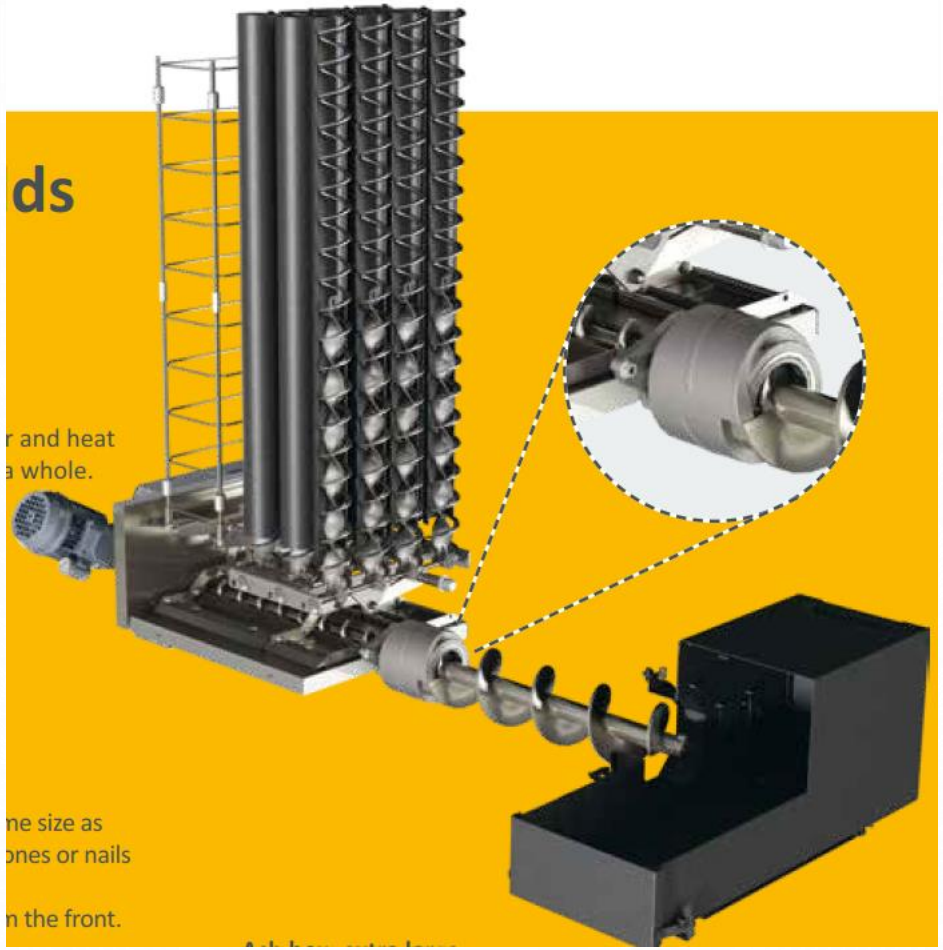
- convenience
- constant performance



Automatic, mechanical ash transfer to external box

HX cleaning & ash removal

Automatic cleaning & ash removal



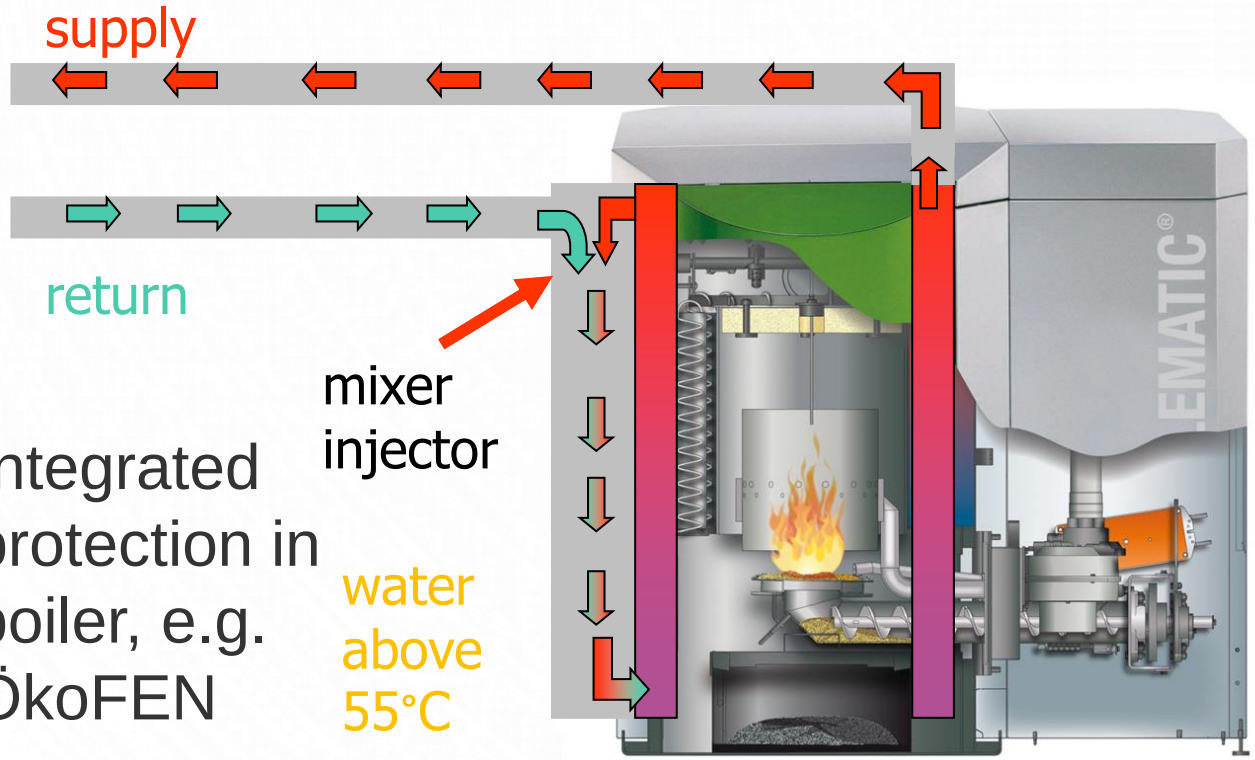
Ash from pellets

- Certified organic fertiliser
- Around 5kg per tonne of pellet fuel
- 5kg ash per 5MWh heat energy

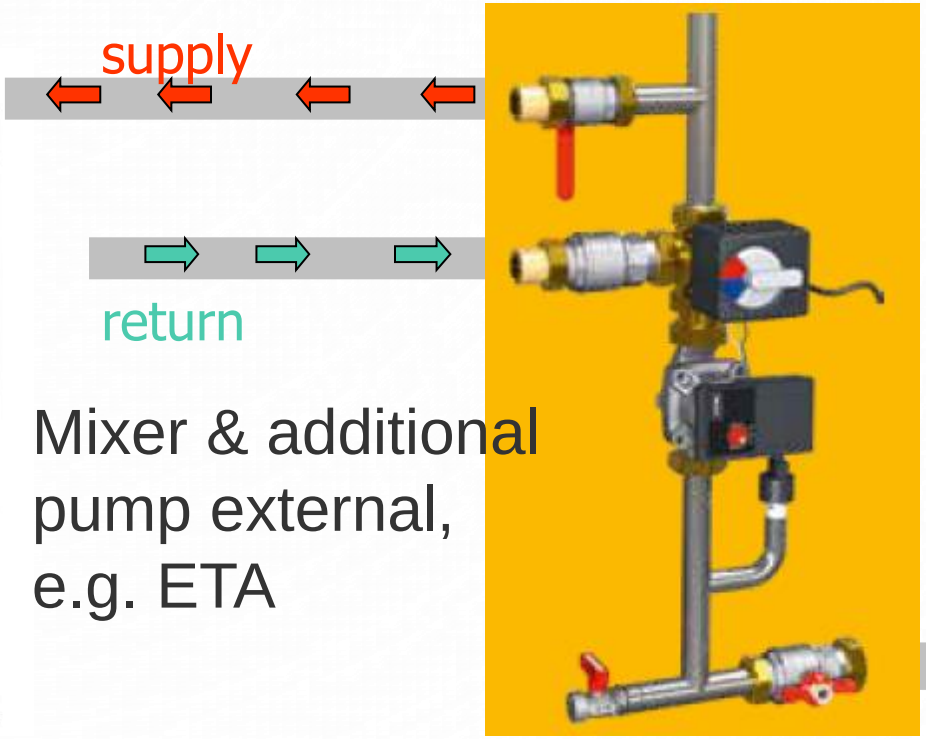
Internal condensate / back end protection

Internal water jacket must be maintained above 55°C because moisture in pellets

Low temperatures = condensation on metal wall = rust or creosote formation



Integrated protection in boiler, e.g. ÖkoFEN



Mixer & additional pump external, e.g. ETA

Safety systems for combustion

Different boiler designs use different strategies to protect against (uncontrolled) temperature rise at end of burning cycle

Fundamental questions:

- How much / how long will fuel continue to burn in combustion chamber?
- How much thermal capacity is available in system to absorb additional thermal energy from continued combustion?
- Is there a mechanism to block combustion?
- What is the ultimate safety device?

Safety systems for combustion

Apricus NZ eco hot water

Buffer tank

- absorbs thermal energy as remaining pellets burned out
- required for many designs of pellet boiler, especially larger models
- not required if boiler can completely stop combustion air; e.g. ÖkoFEN

Thermal capacity in boiler water

- Boiler controls ensure combustion is shut down while thermal capacity remains in boiler water volume to absorb thermal inertia in combustion chamber
- Careful balance that requires good understanding of control logic and boiler operating cycle

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Ultimate safety systems for combustion

Pressure / over temperature relief – <u>all</u> boilers

- Pressure relief valve opens if temperature continues to increase and causes system pressure to increase
- Back-up system if other measures aren‘t sufficient

Water sprayed in to combustion chamber – <u>some</u> boilers

- Ultimate back-up in some boilers with potential for large amounts unburnt pellets in combustion chamber
- To be avoided whenever possible because big clean out job afterwards and can cause damage through thermal shock

Boiler sizes

10 to 32kW

36 to 64kW

128kW

Boiler cascades

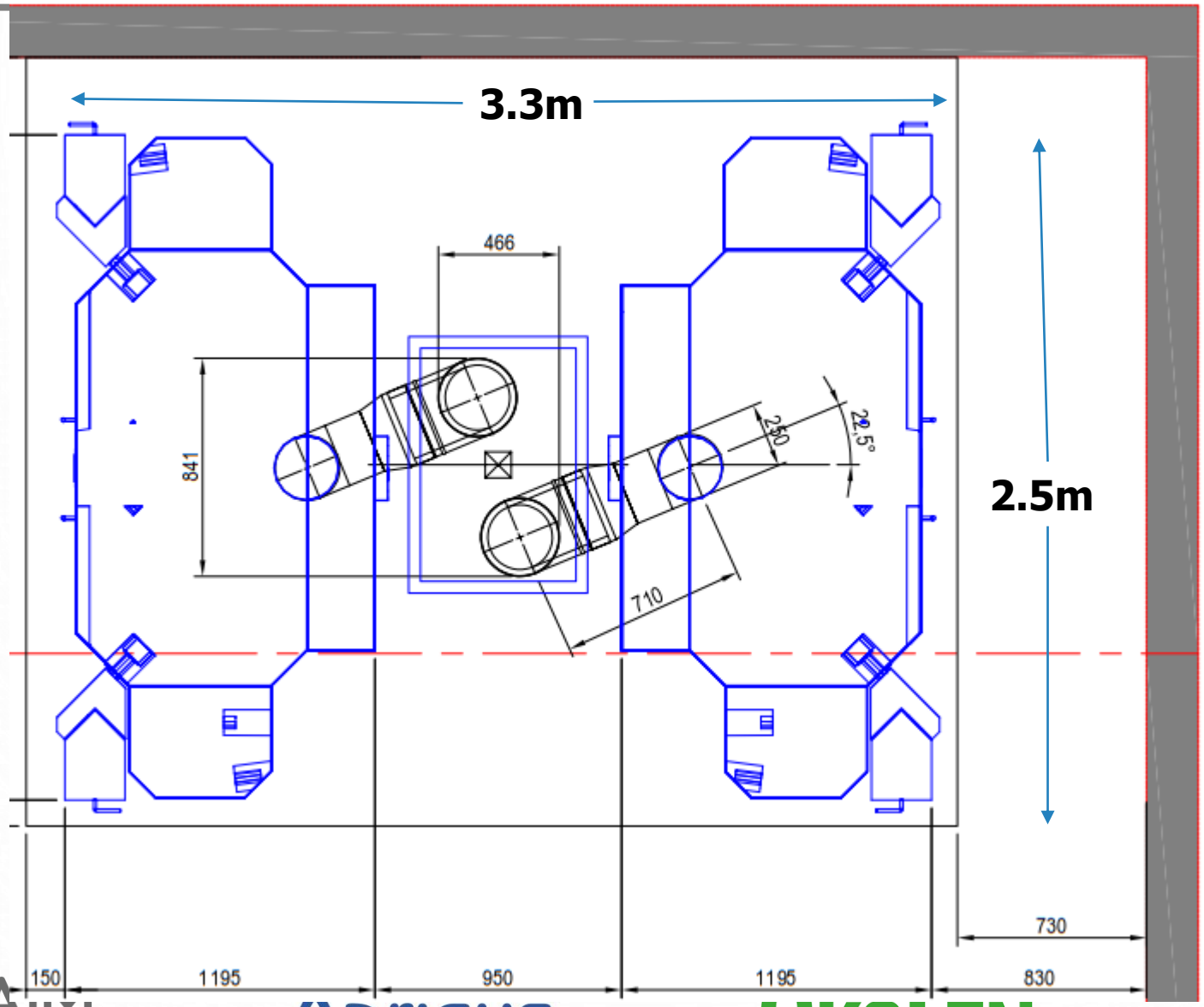
64 to 256kW

128kW to 512kW

- Cascades provide flexible install options
- Particularly suitable for retrofit in existing buildings
- Multiple smaller boilers manoeuvred more easily in to inaccessible & upper storey plant rooms
- Larger systems possible with multiple cascades
- Huge modulation range & redundancy capacity

Boiler cascade - 256kW example

Boiler cascade - 256kW example



Modulation range

Single pellet boilers

- Generally up to 260kW maximum
- 30% to 100% modulation range
- E.g. 64kW = 19kW to 64kW or 260kW = 78kW to 260kW

Cascades of boilers

- Lowest output of single boiler in cascade
- Can be as low as 7.5%
- E.g. 4 x 128kW (512kW) = 38kW minimum = 7.5% minimum output / 92.5% modulation
- No upper limit on output but very large heat loads (over 1.5MW) most likely use larger individual boilers with much smaller modulation range

Flue gas condensing modules

Stainless steel heat exchanger added to flue gas outlet of boiler

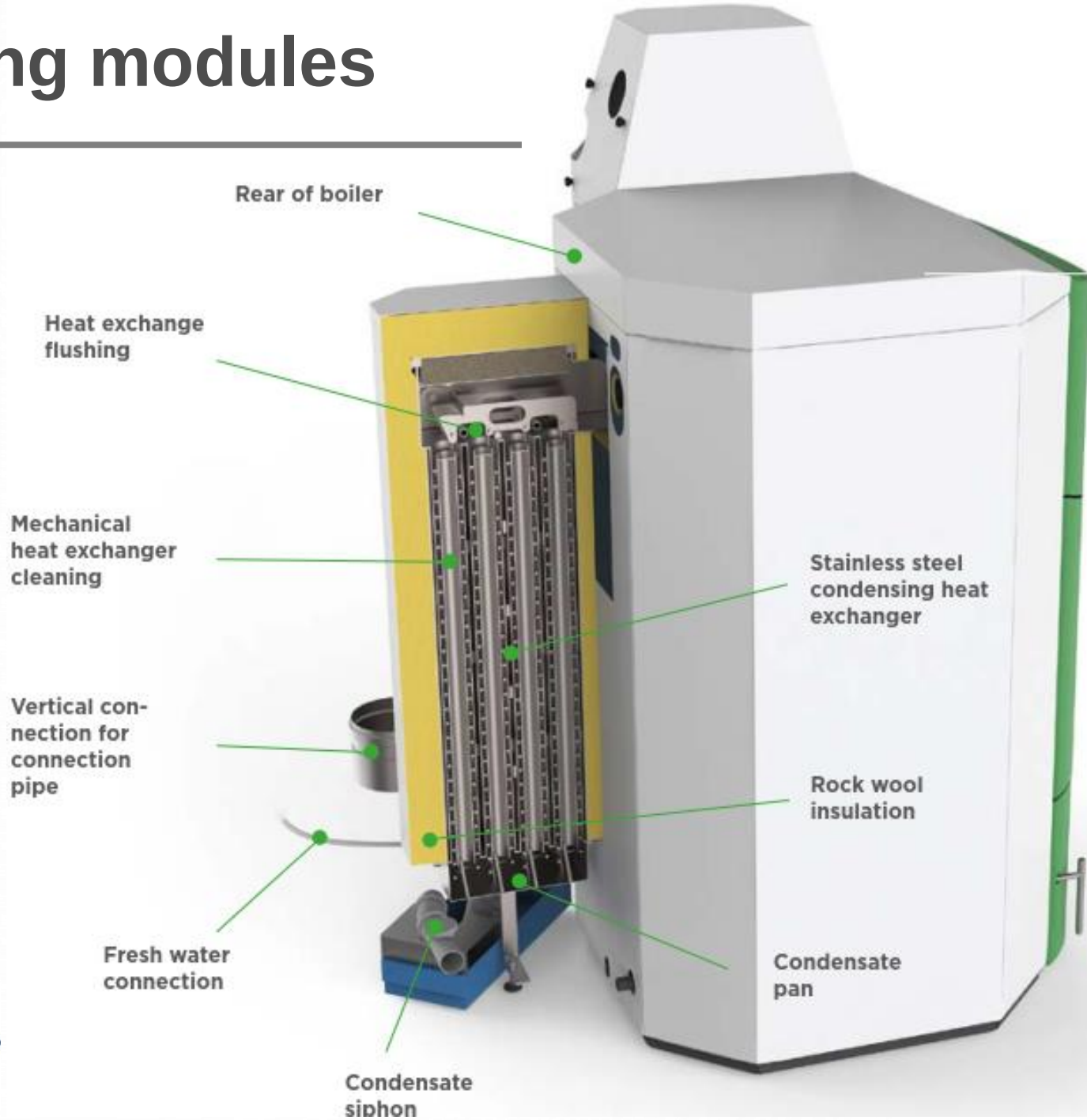
Recovers latent heat energy of water vapour in flue gases

Requires low temperature returning water - under 55°C

Ideal for underfloor heating systems or large buffers for DHW

Reduces particulate emissions & increases fuel efficiency by >15%

Self cleaning with water flushing



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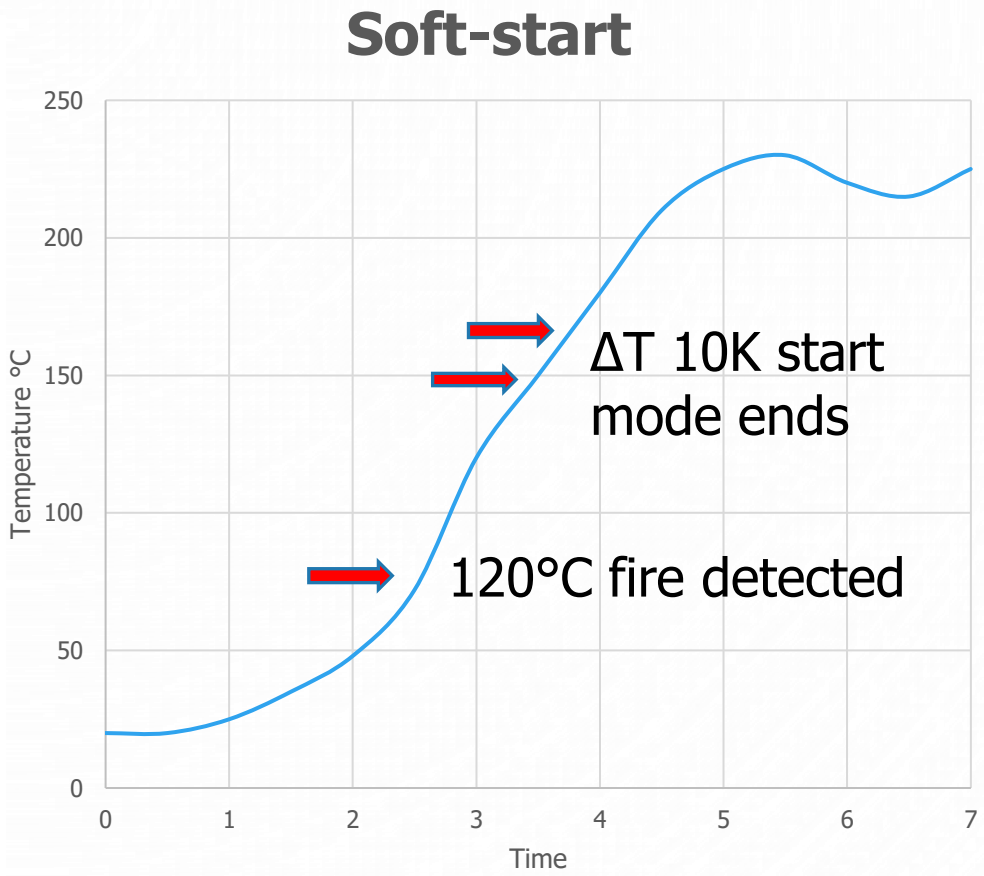
Boiler combustion phases - Softstart

Boiler start mode - Soft-start

- Electric heater turns on
- Screw feeds pellets
- Combustion chamber rises to 120°C = fire
- Pellet valve closes, pellet feeding screw stops
- Stable temperature and drop of 10K
- Pellet valve opens, screw feeds pellets again
- Shift to power mode



High control of ignition and temperatures

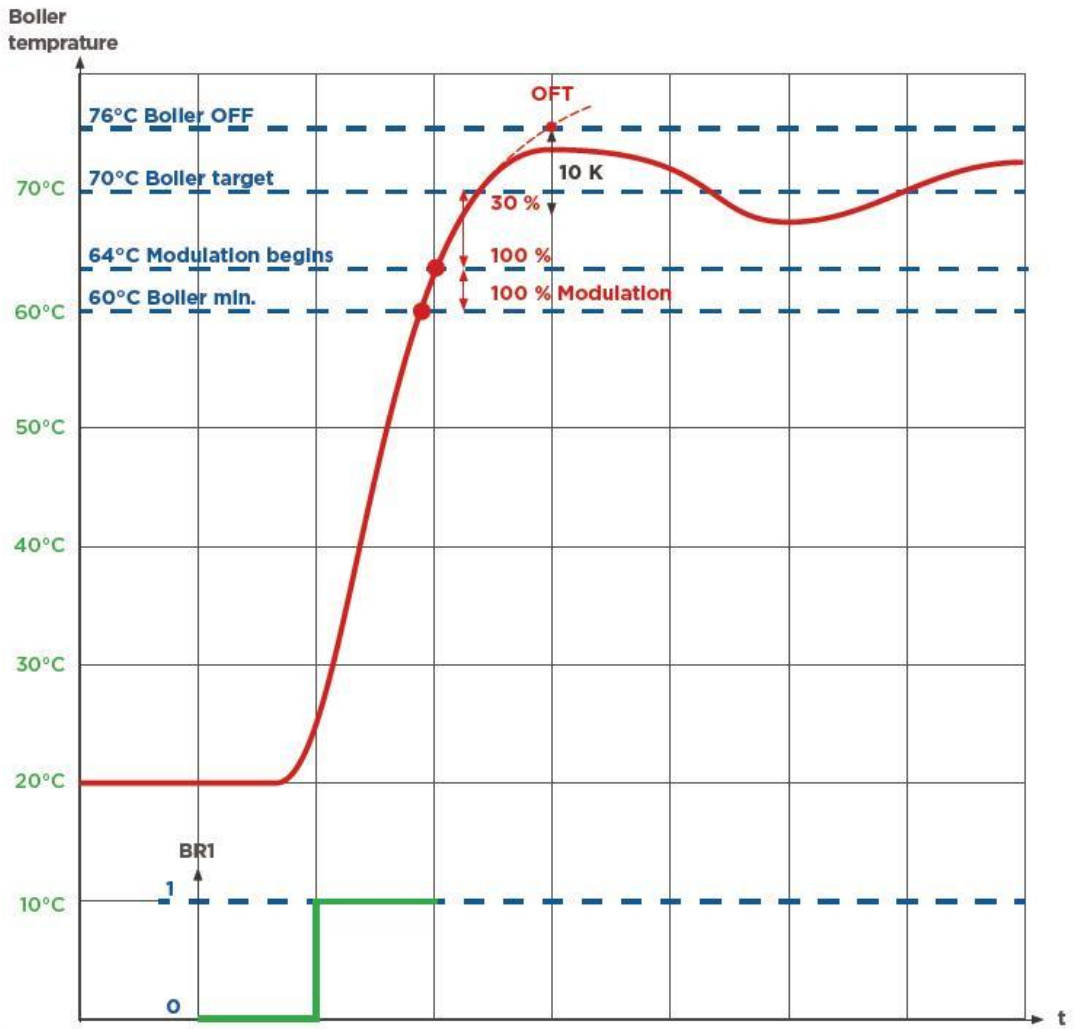
Long lifetime of elements with smooth operation

Avoid loss of unburned pellets

Boiler combustion phases - Powermode

Operating in Powermode with set parameters

- <60°C boiler temperature pump inactive = internal condensate protection
- 60°C internal water temperature = circulating pump starts
- Boiler 100% power & pump minimum speed
- 64°C modulation starts – boiler power decreases & pump speed increases
- 70°C optimum operating temperature, boiler power & pump speed set according to heat load
- 76°C boiler turns off, can be increased if required



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