



# Energy losses in boiler plant operation

*And top tips to save money*

# Agenda

*Save energy, save money*

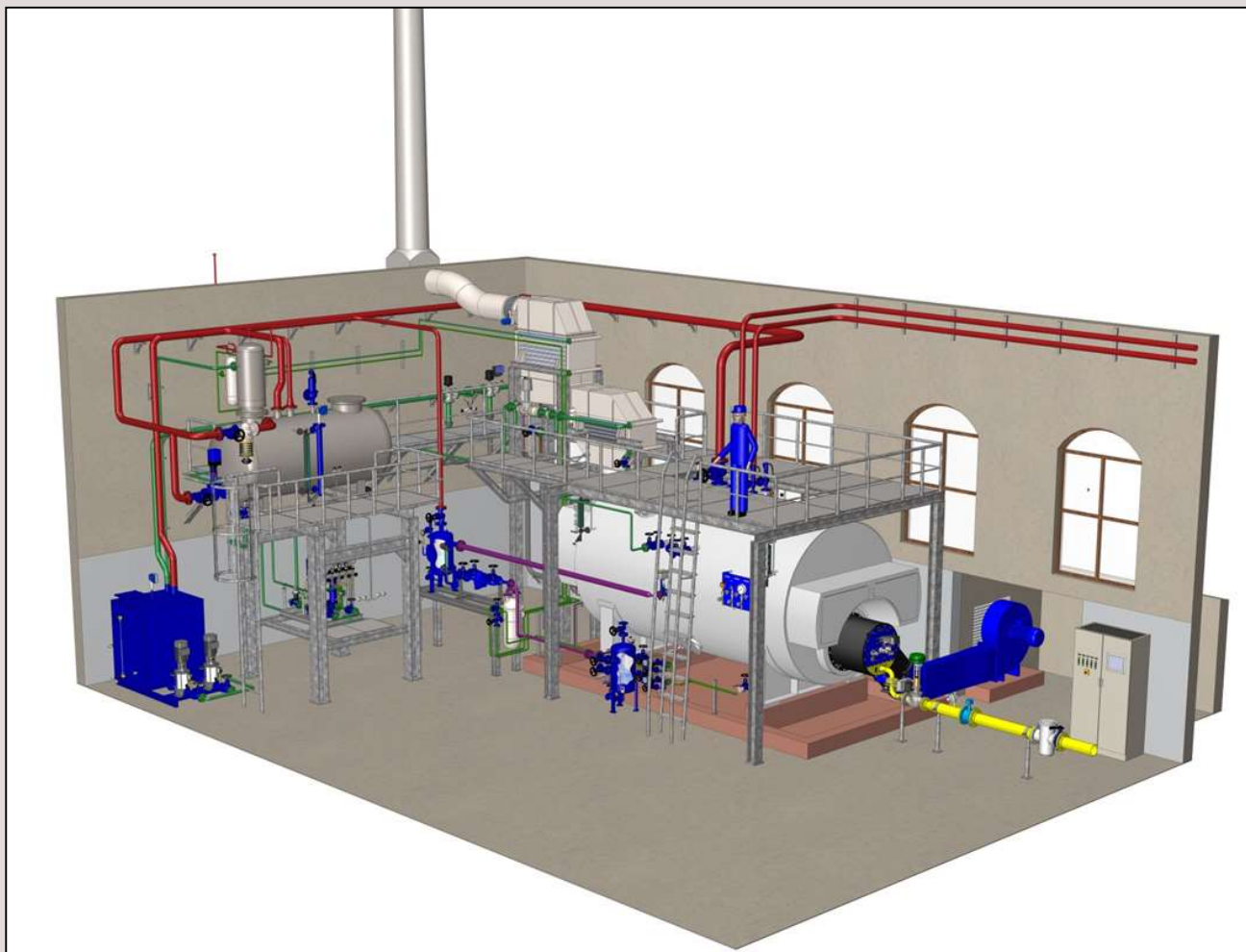


1. *Energy losses*
2. *Energy monitoring*
3. *Burner optimisation*
4. *Optimising plant operation*
5. *Heat recovery*
6. *Practical examples*



# Energy losses

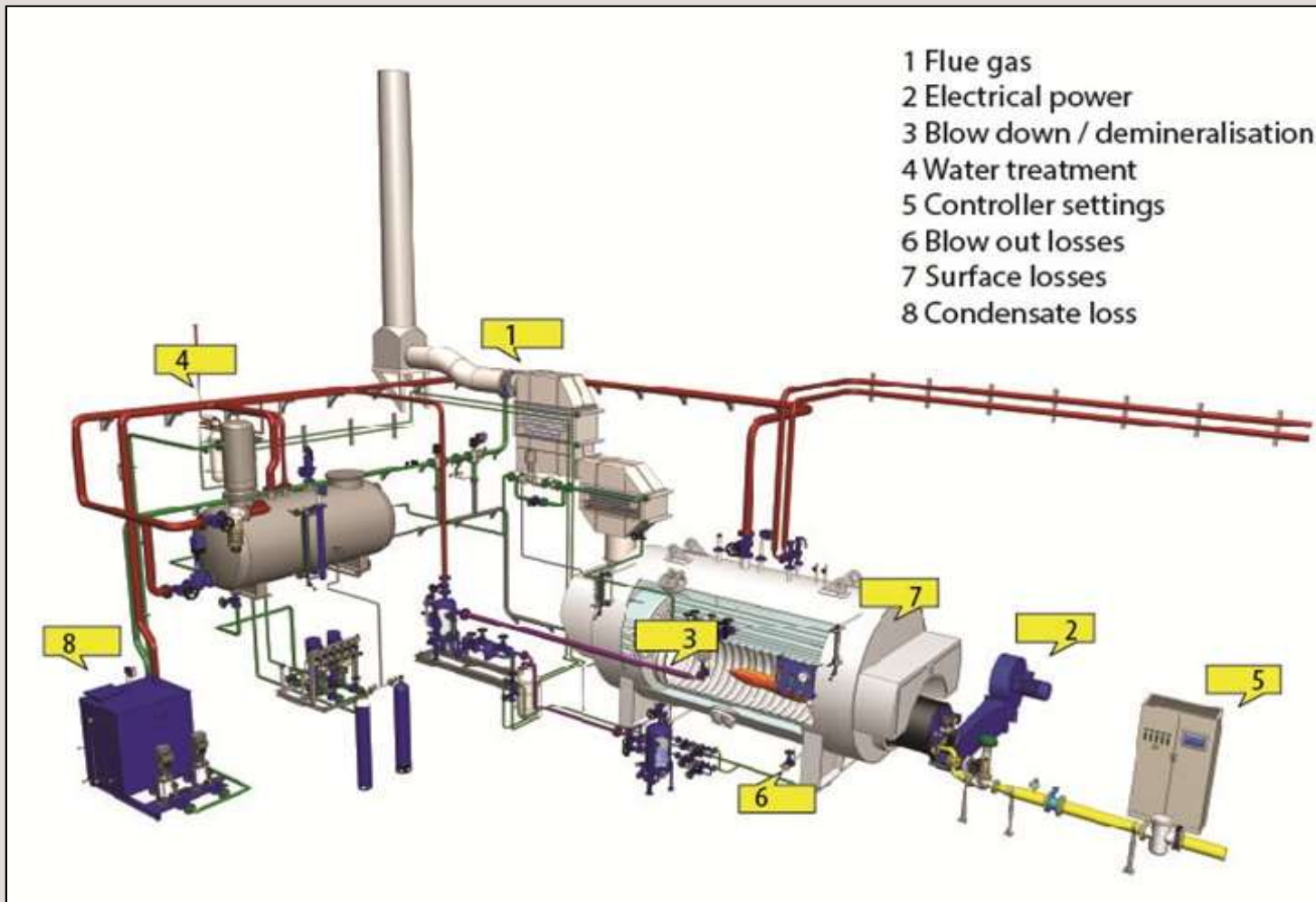
## *Typical boiler plant*





# Energy losses

## *Typical boiler plant*

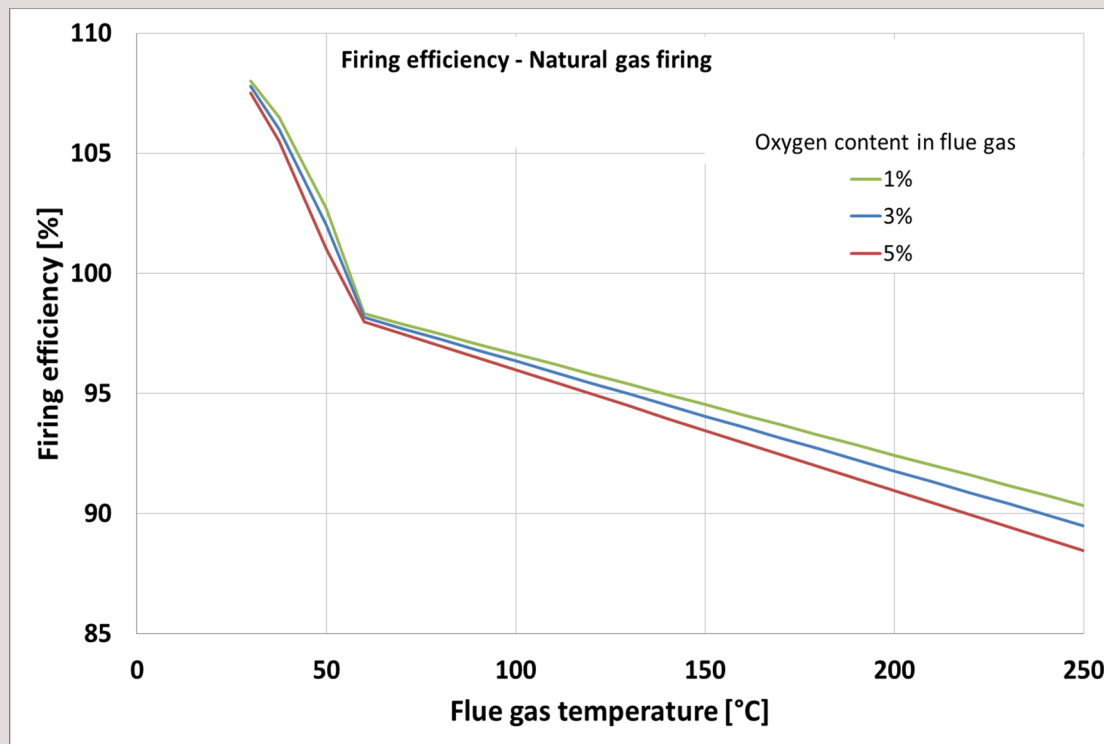


# Flue gas losses

## *Exhaust gas temperature*



Lowering flue gas temperature by 100 K saves 4-5 % of fuel.



- Economiser
- Air preheater
- Condensing technology



3 – 15%



# Flue gas losses

*Minimise excess air*



**Lowering oxygen content by 2% saves 0.5 – 1.0% of fuel**

# Surface losses

## *Efficient insulation*



Heat losses depend on the quality of insulation and should not be more than 0.5% of boiler capacity.



- Well thought out insulation
- Lower operating pressure
- Combustion air taken from highest part inside the building



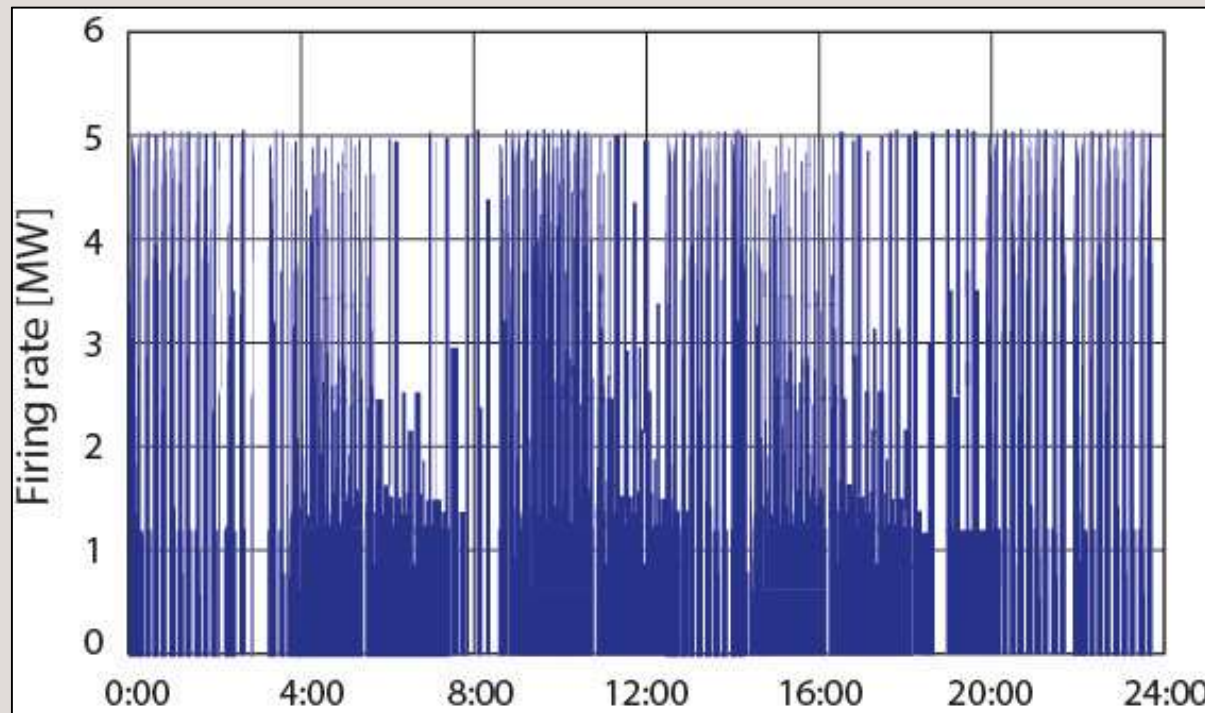
0.3 – 1%





# Purging losses

## *Wasted energy*



**Purging loss of a  
10 ton boiler**

Per start:  
**30 kWh/start**

25 starts per day:  
**750 kWh/day**

200 days per year:  
**150 MWh/year**

→ **ca. 5.000 £/a**

### **Heating the great outdoors!**

The duration of the purging program is predetermined. Purging a burner rated at 5MW for 120 seconds, we're talking about 180m<sup>3</sup> of air, equivalent to the volume of a small house.

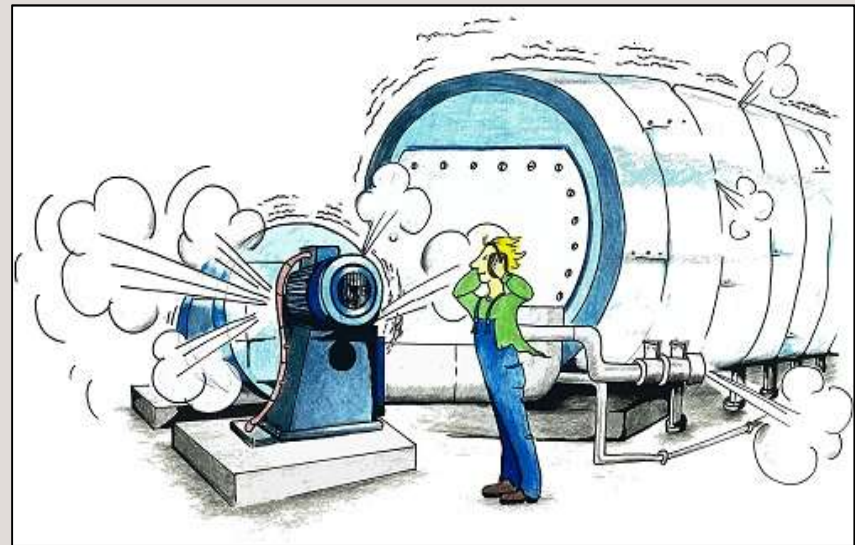
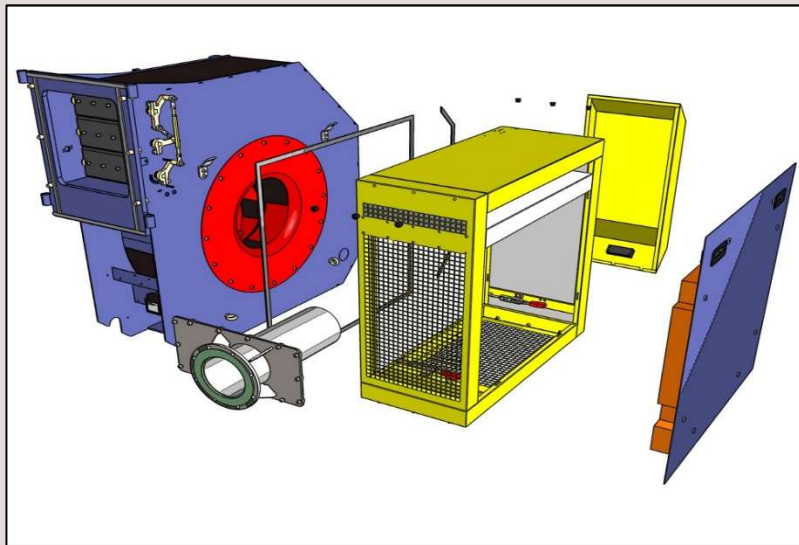


# Electrical losses

## *Fit inverters to fans and pumps*



- A typical motor for a fan on an 8 MW burner needs 22 kW in maximum load;
- Roughly the same at 50 % load; air dampers deflect most of the excess fan energy;
- With Variable Speed Drive (VSD): 1/2 speed = 1/8 electrical power with typical payback within 12 months.
- If a fan on average only runs at half speed, you save 80% on electricity consumption.



# Electric motors

*Tap into higher efficiency*



Replace old design 3-phase electric motors with latest IEC Class motors to comply with Eco Design Directive 2009/125/EC:

| OLD Definition           | NEW Definition               |
|--------------------------|------------------------------|
| EFF3 Low Efficiency      | -                            |
| EFF2 Standard Efficiency | IE1 Standard Efficiency      |
| EFF1 High Efficiency     | IE2 High Efficiency          |
| -                        | IE3 Premium Efficiency       |
| -                        | IE4 Super Premium Efficiency |

**Example:** 30kW 4-pole motor efficiency class

IE1 = 91% efficiency (Standard Efficiency),

IE2 = **92.3%** efficiency (High Efficiency),

IE3 = **93.6%** efficiency (Premium Efficiency)

# Electrical losses

## *IE3 motor with VSD*



### Eco Design Directive 2009/125/EC:

From **01/01/2015** IE3 standard applies to motors in range 7.5kW to 375kW, alternatively an IE2 motor can be used with a frequency converter;

Special motors including ATEX 94/9/EC Explosion protection motors are excluded;

From **01/01/2017** IE3 standard applies to motors in range 0.75kW to 375kW;

Note: IE4 – ‘Super Premium Efficiency’ – some manufacturers are already marketing these, with claims circa 15%+ lower losses than IE3, even though a design standard has not yet been ratified;

IE3 motor with VSD recommended.



# Blowdown losses

*Automatic system = efficient + reliable*



| Blow-down rate | Amount per hour | Amount per year | Losses (tons HEL) |
|----------------|-----------------|-----------------|-------------------|
| 5 %            | 0,5 t           | 3.000 t         | 53                |
| 10 %           | 1 t             | 6.000 t         | 106               |

Over the years, a blowdown valve set in a slapdash manner to discharge copious amounts of water is flushing money down the drain - the only benefit is that the local sewers never freeze.

- Continuously regulated blowdown
- Blowdown heat exchanger
- Correctly adjusted blowdown valve



0.5 – 5%



## Let it flow!

This valve despatches boiling water down the drain, whether boiler is running or not.



# Agenda

*Save energy, save money*



1. *Energy losses*
2. ***Energy monitoring***
3. *Burner optimisation*
4. *Optimising plant operation*
5. *Heat recovery*
6. *Practical examples*



# Doctors' orders!

*Analyse with an energy survey*



Analysis and energy balance form basis for optimisation

Who balances what?

- Combustion efficiency
- Boiler efficiency
- Fuel efficiency

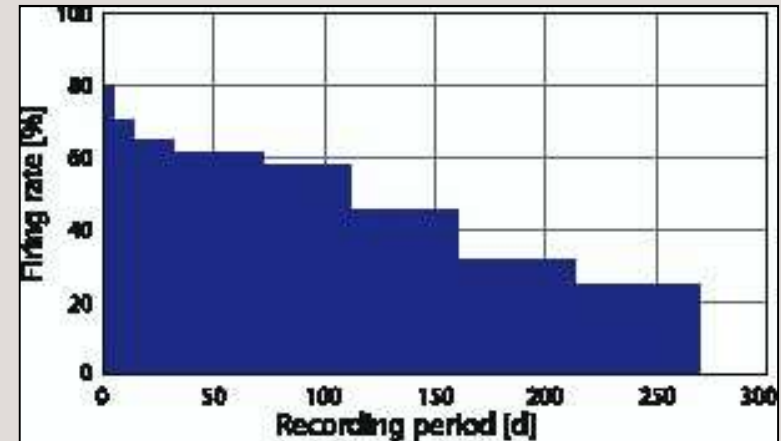


# se@vis efficiency monitor

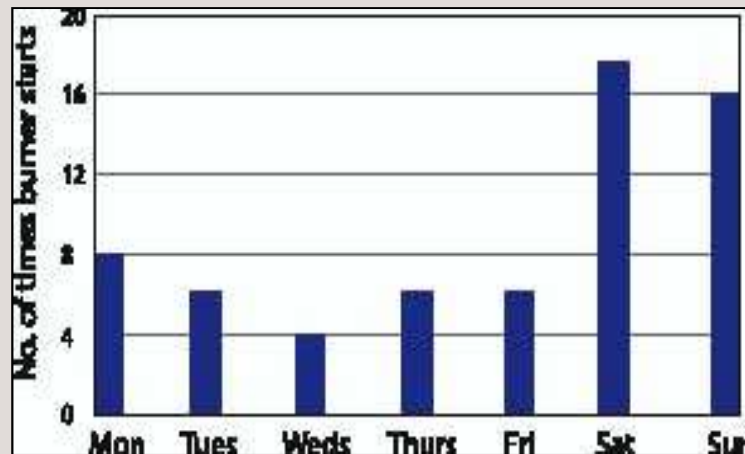
*Establish the facts*



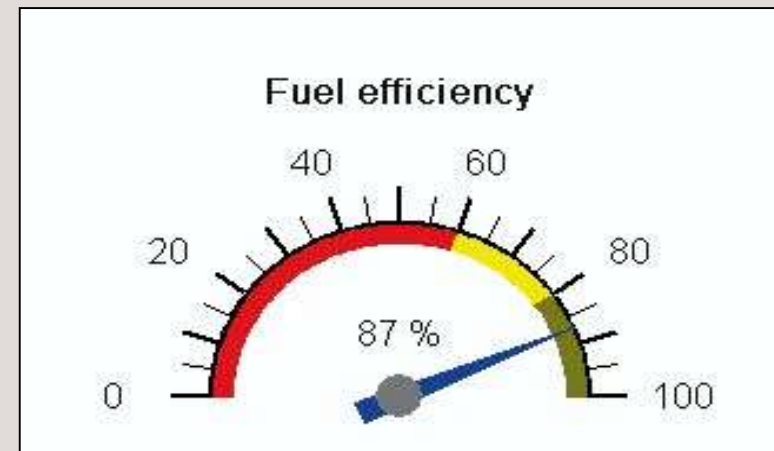
• Recording Trends



• Distribution Graph



• Burner Starts Per Day



• Fuel Efficiency

# se@vis efficiency monitor

## *Data collection*



### **SAACKE energy survey:**

One efficiency monitor can be installed in a day to each boiler and left to record the operation profile of the plant.

After two weeks the data is analysed and a report produced showing what improvement measures can be taken with justification evidence.



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**„Does the burner burn all the fuel/air mixture?“**

Well, sort of.

If we take a more detailed look, intelligent burners operate  
without much excess air and with speed control!

# Burner optimisation



## What are the requirements for an efficient burner?

### Clean and efficient combustion :

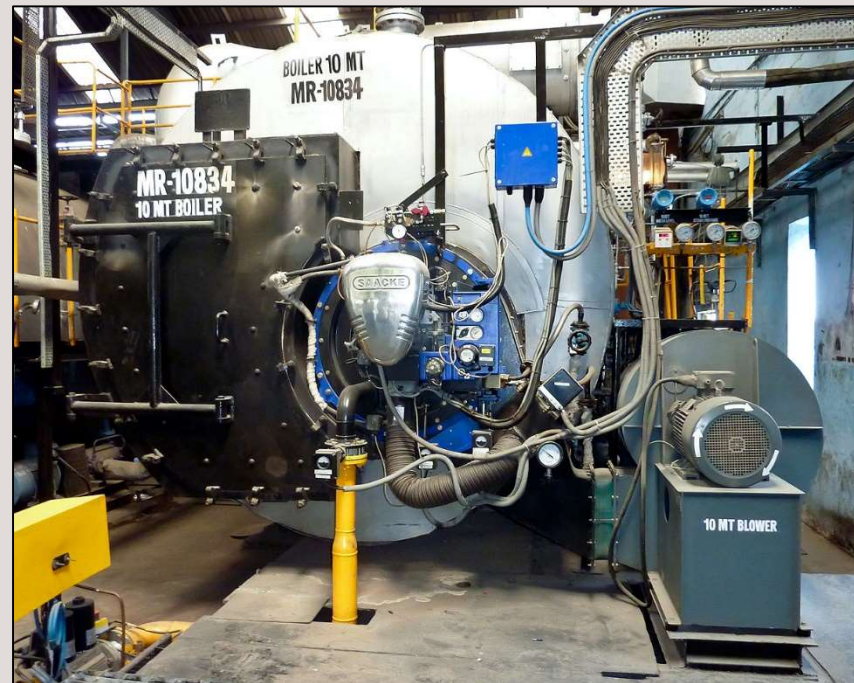
Complete combustion along with low excess air;  
No CO, less O<sub>2</sub>;  
Repeatability, accuracy, reliability.

### Low electrical power consumption:

efficient fans, speed control.

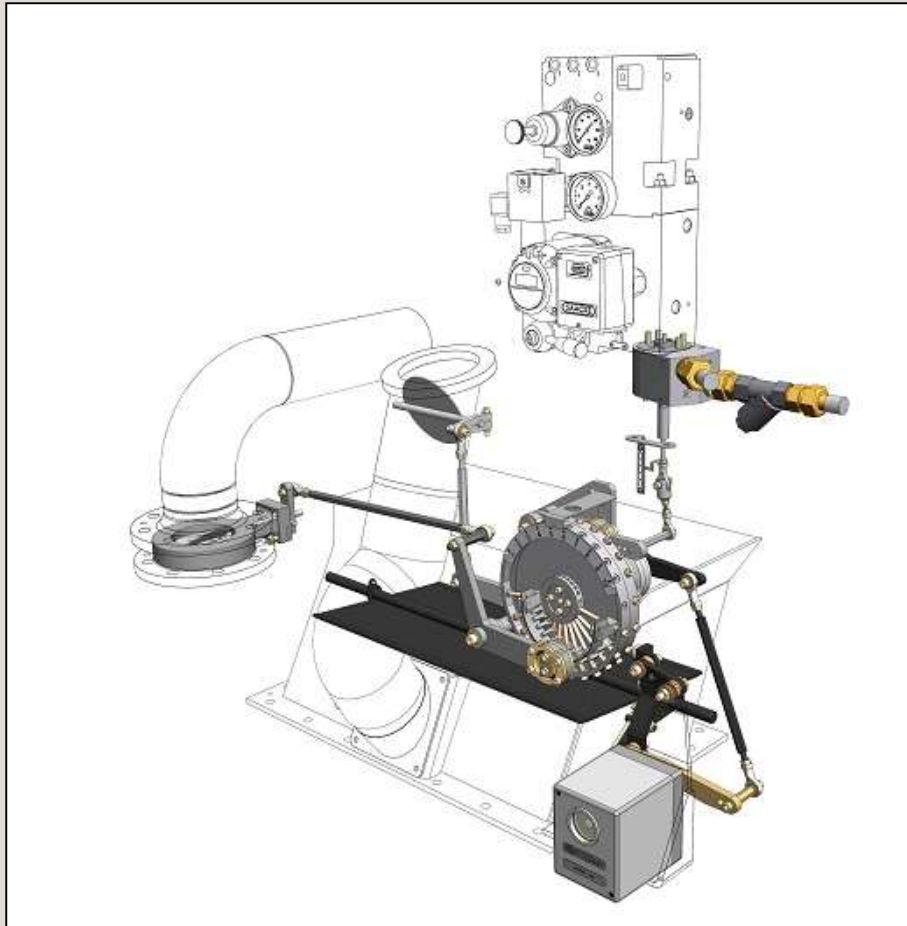
### High turn-down ratio:

optimal power adjustment, no starts and stops.



# Mechanical compound regulator

*Old style*



## Mechanical compound regulator

- Robust design
- Easy to operate
- The more mechanical play in system, the more excess air in furnace
- Two fuels fixed turndown
- No temperature compensation

## The Remedy:

## Electronic compound regulation

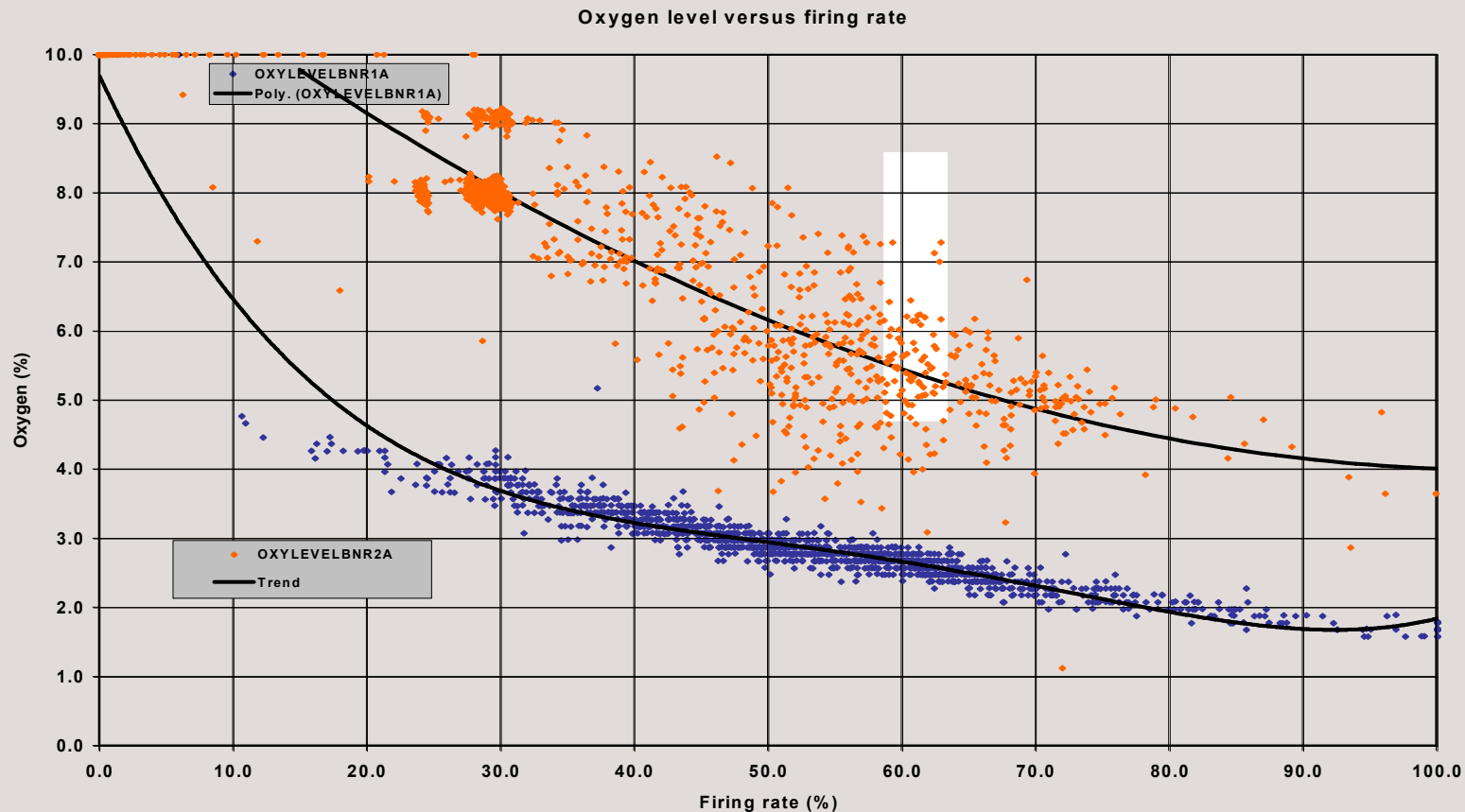


# Flue gas oxygen Comparison

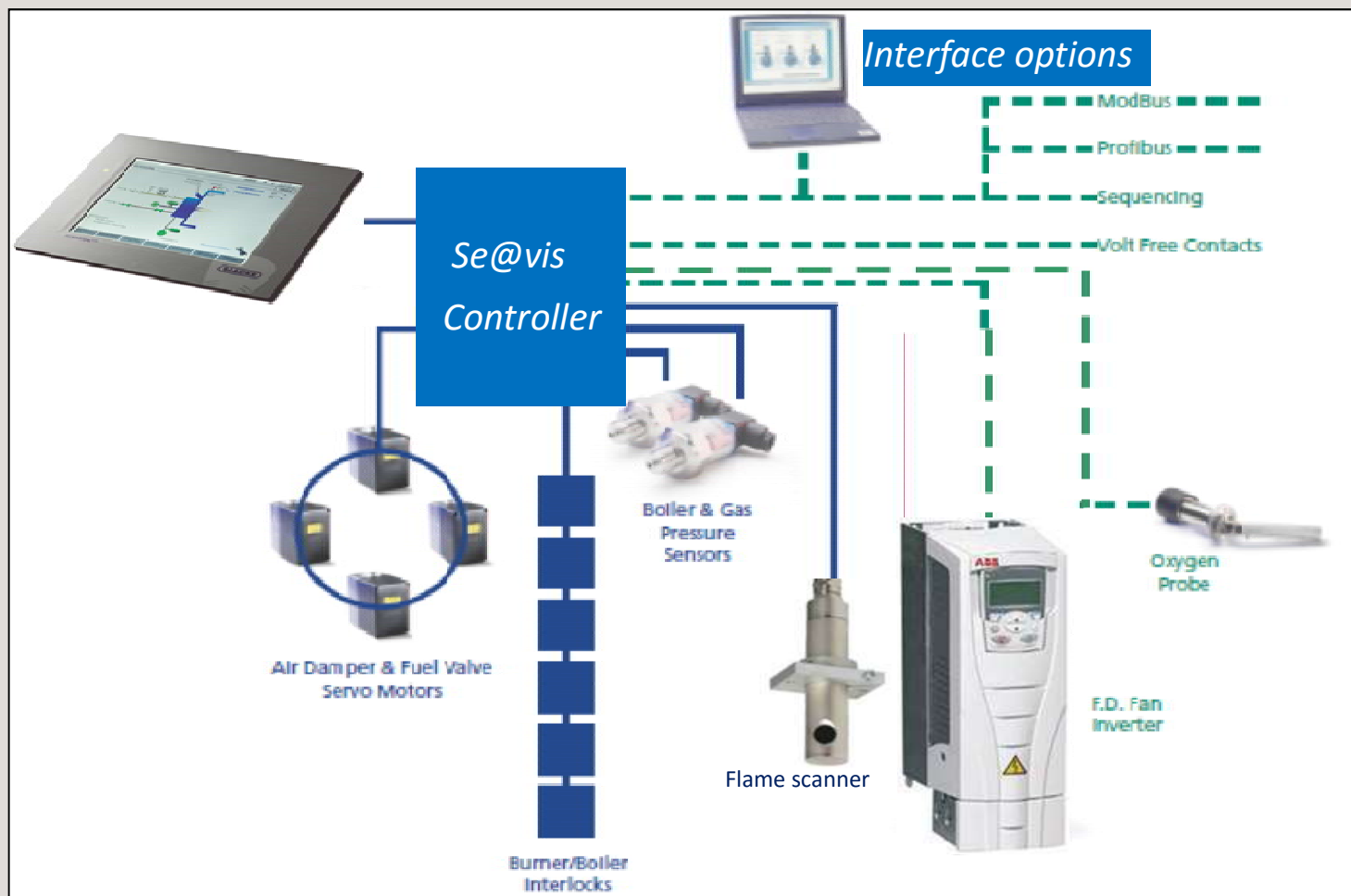
## *Mechanical v Electronic burner regulation*



3 to 4% differential in O<sub>2</sub> level which, as detailed in GPG252 from the Carbon Trust, will give a 4 to 6% fuel saving.



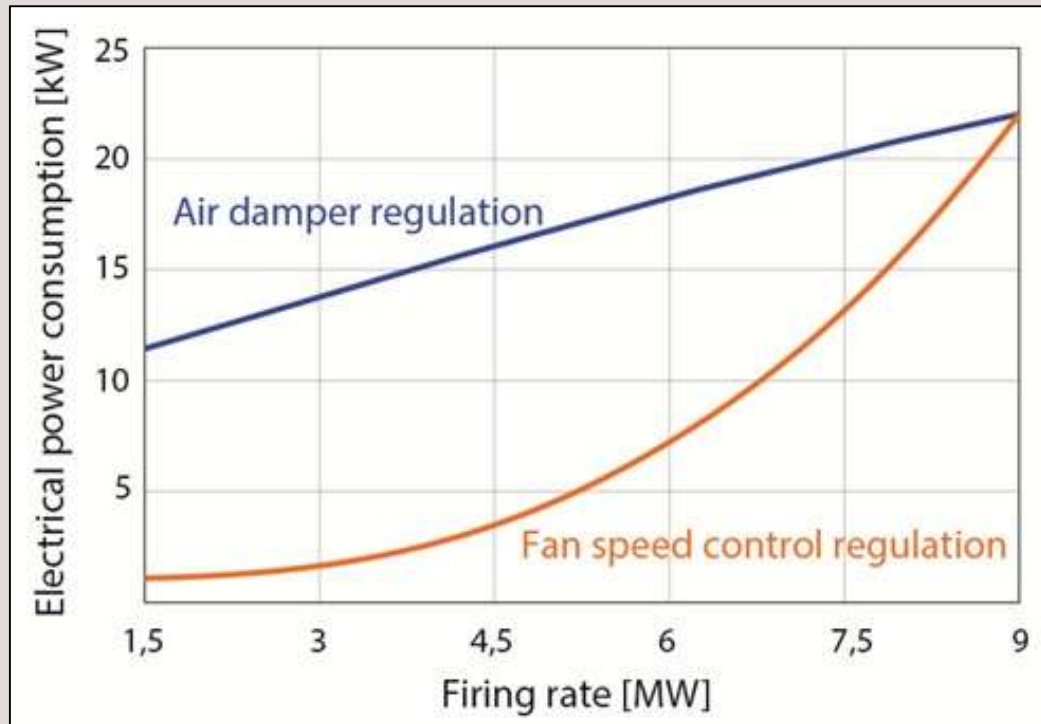
# Electronic compound regulator



# Speed-controlled fan

## Twice the air – eight times the electricity

- Significant savings in electricity
- Considerably less noise
- Increased longevity of mechanical burner and fan components

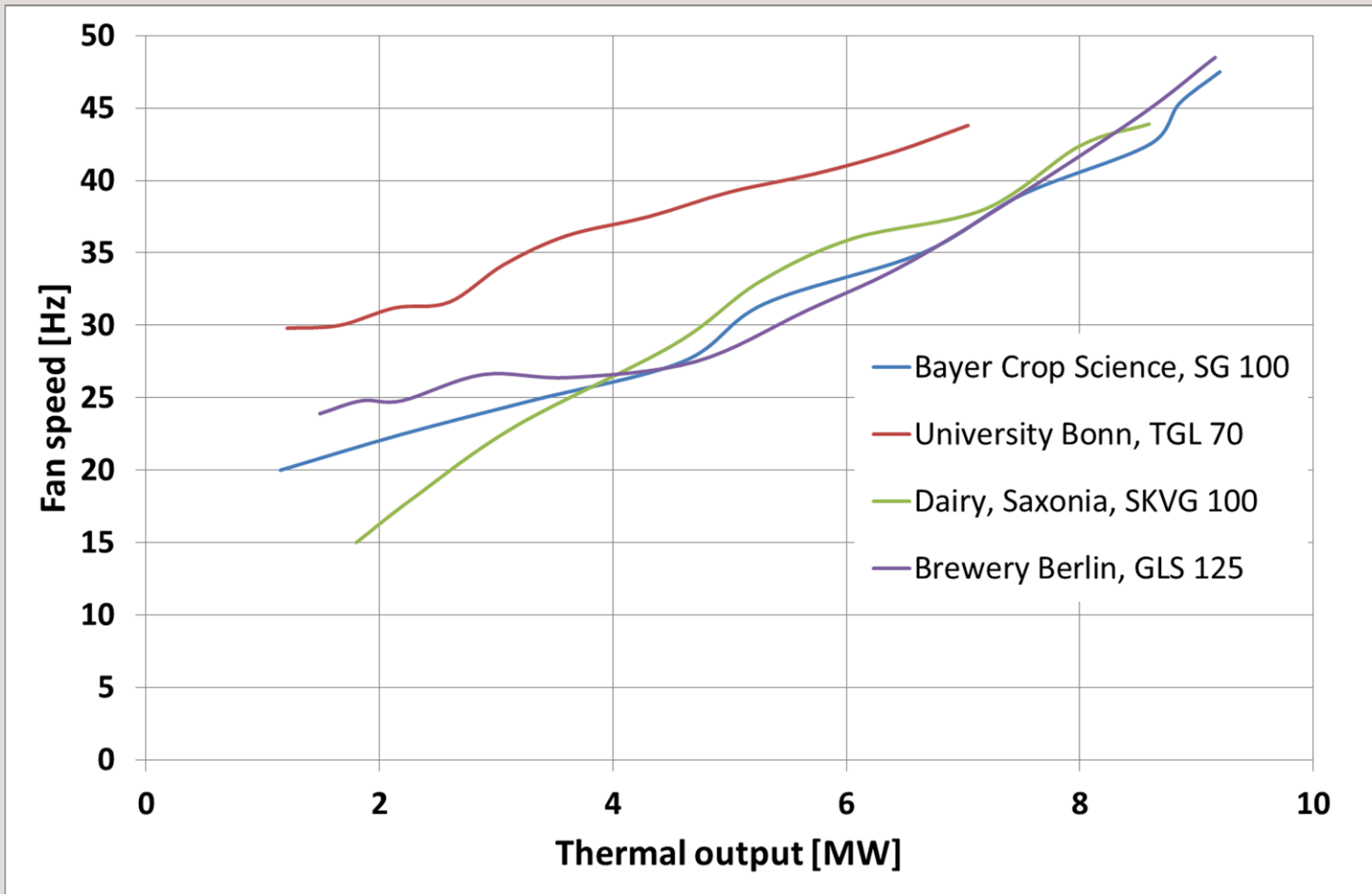


## Simple boxes:

Frequency converter reduces the rpm of the fan and can be fitted (almost) everywhere.

# Speed-controlled fan

*Whose plant is always running in full load?*





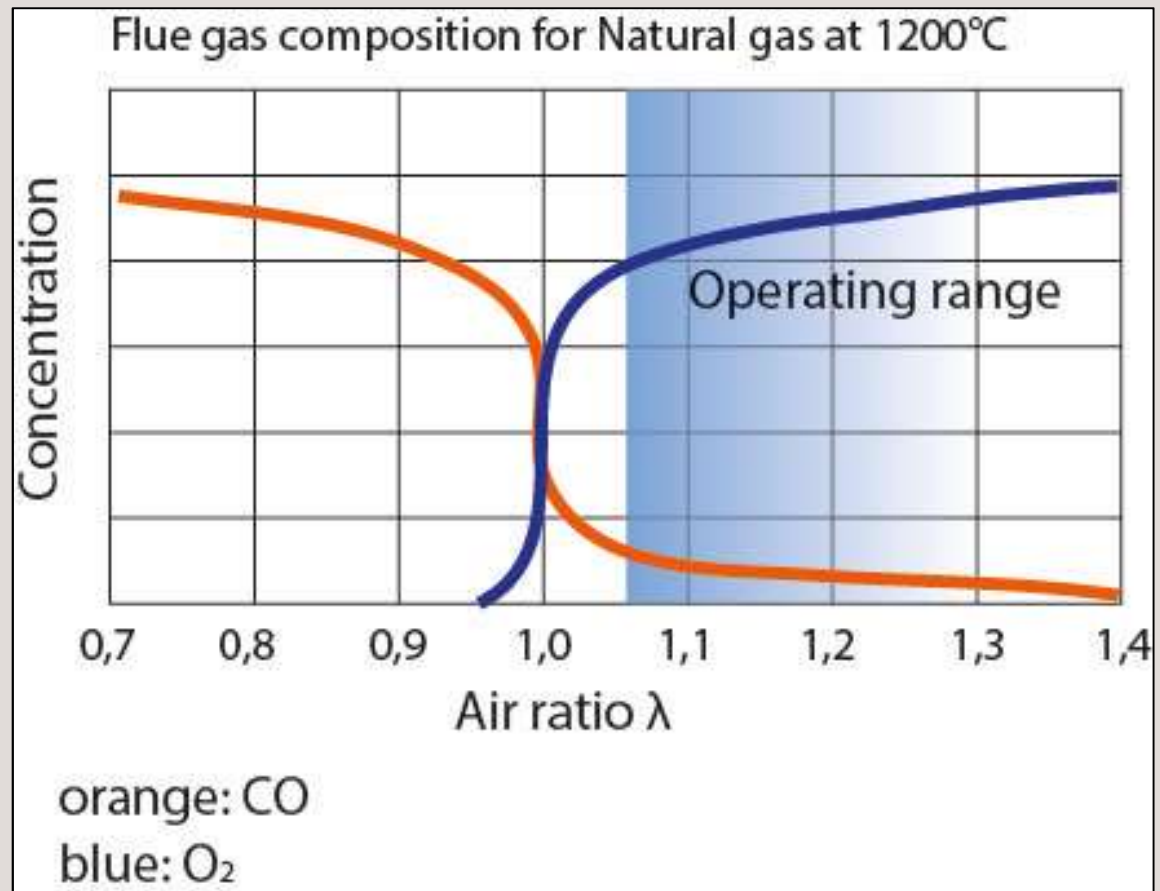
# O<sub>2</sub> and CO control

*What are the reasons for excess air?*



Under laboratory conditions, gas or oil can burn stoichiometrically, i.e. complete and perfect combustion. Remaining oxygen after combustion would in this case be non-existent.

In practice, from the 21 % in the air, some 1.3 to 4.5 % oxygen is left over in the flue gas and does not play a part in the combustion process. It is, however, required depending on burner type and boiler geometry to ensure that every molecule of fuel is completely burned off.



O<sub>2</sub> and CO in the flue gas from  $\lambda = 1$  CO increases

# O<sub>2</sub> and CO control

*What are the reasons for excess air?*



Commissioning for the worst case:



**Safety issue:**

Since air isn't always the same, burners without O<sub>2</sub> correction have to be set to cover the most unfavourable weather conditions. The result is a hefty extra portion of excess O<sub>2</sub> – just to be on the safe side.

# O<sub>2</sub> and CO control

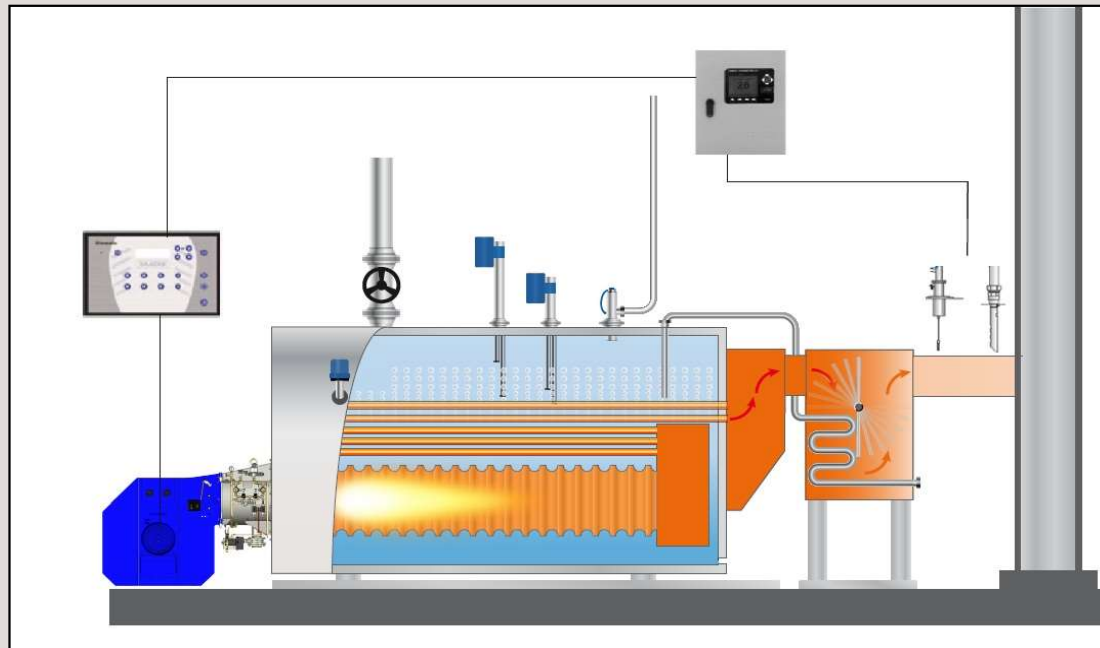
*Minimise excess air and increase efficiency*



Minimise excess air (and heat loss)

Easy to retrofit

**Lower O<sub>2</sub> concentration by 2 % and save 1 % fuel**



Better than in a car...  
Zircon dioxide probe

Flexible Fitting

# O<sub>2</sub> and CO control

*Excess air = fuel and money wasted*



| CHANGE IN VARIABLE                | CHANGE IN O <sub>2</sub> CONCENTRATION |
|-----------------------------------|--|
| Combustion air temperature by 10K | 0.5 – 0.7%                             |
| Atmospheric pressure by 20 mbar   | 0.4%                                   |
| Fuel calorific value by 5%        | 1.4%                                   |

Influential friends!

# Agenda

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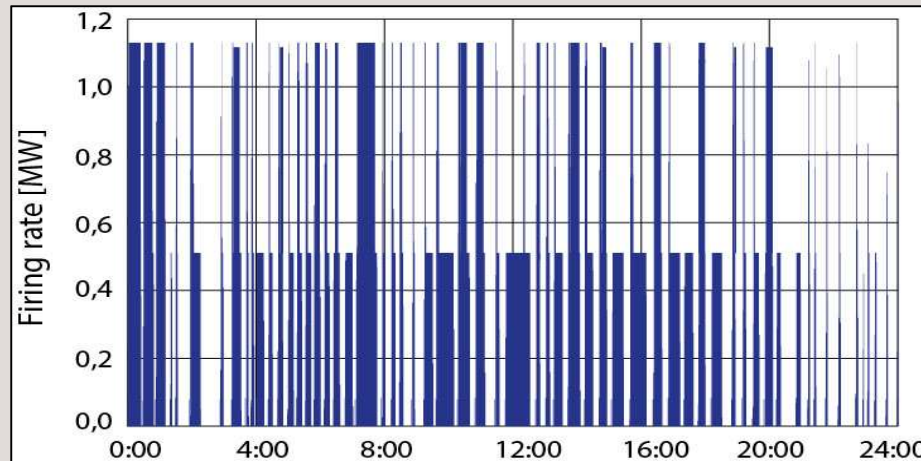
**Can you drive a car if you put your foot on the accelerator and brakes at the same time?**

**Well, sort of – but it's neither fast or economical.**

**Firing a boiler is no different.**

# Optimise controller settings

## *For higher efficiency*

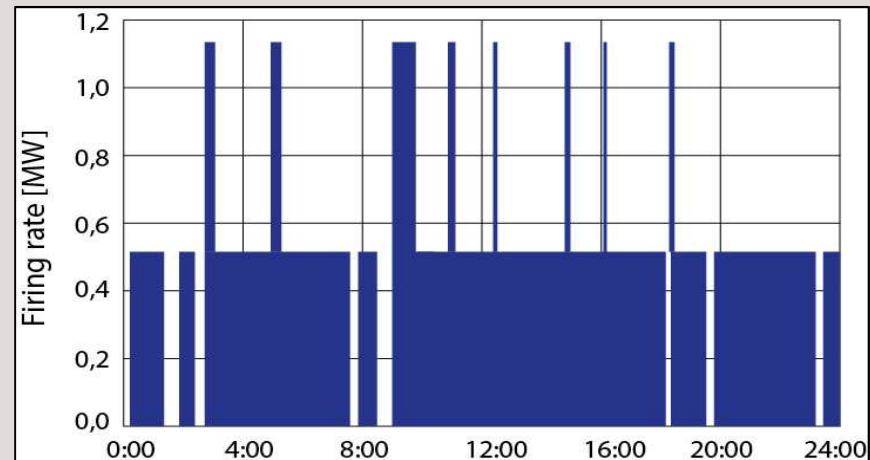


### Before:

- Steam boiler 1.5 t/h with two-stage burner
- 60 starts per day
- Incorrect cut-off limits

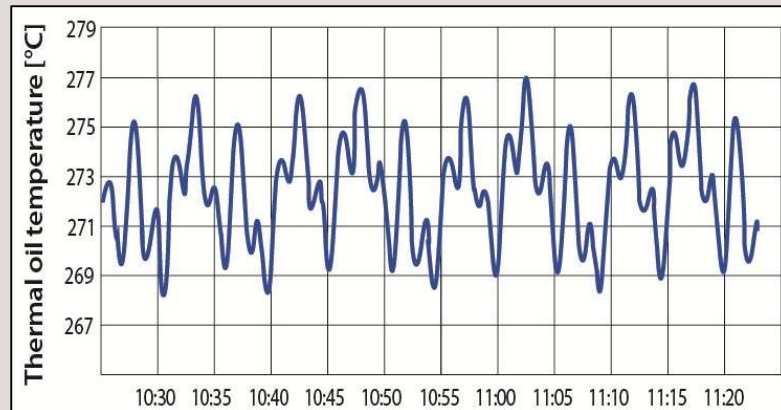
### After:

- Changed controller settings
- 10 starts per day
- Output controller pressure reset to 10.2-12.0 bar instead of 10.9-11.3 bar.
- Savings approx. £2,500 p.a.



# Turndown ratio

*Optimise for higher efficiency*



## Before:

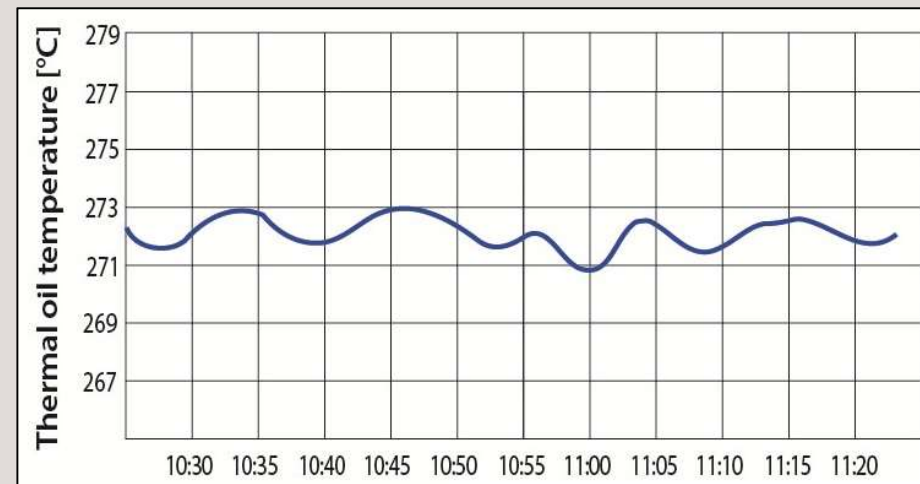
- Fluctuating thermal oil temperatures
- Oversized burner
- 96 burner starts per day

## After:

- Smaller burner
- Carefully adjust controller settings
- 0 burner starts per day

**Savings: £9,100 p.a.**

**More important: better product quality**



# Agenda

*Save energy, save money*

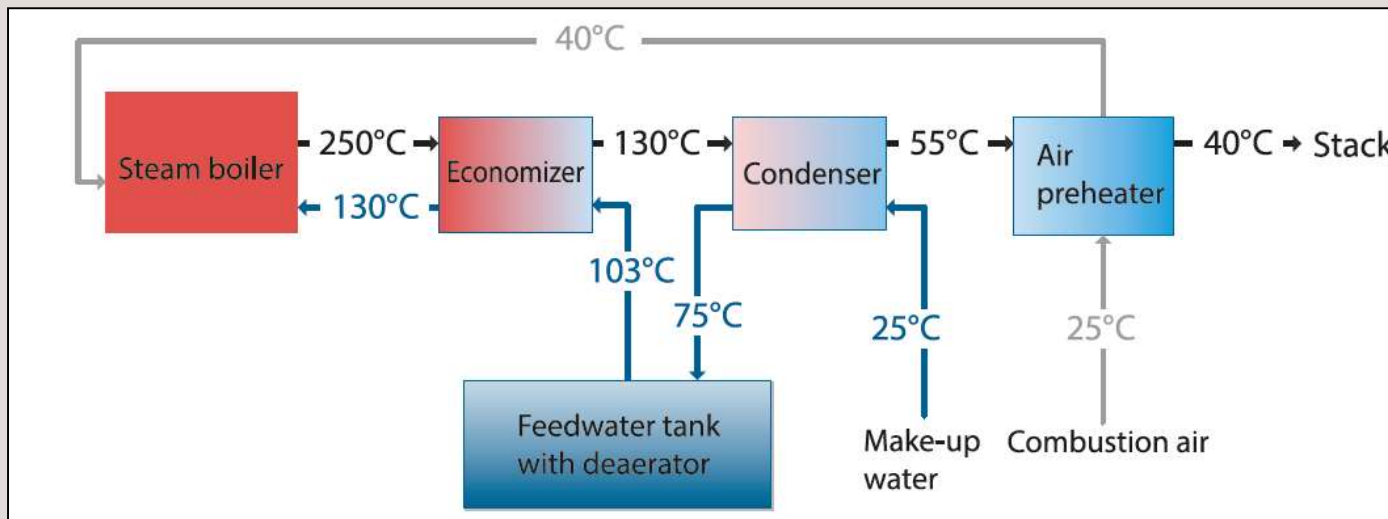


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# Heat recovery from flue gas

*For fuel saving*



| Type          | Function                            | Savings potential                    |
|---------------|-------------------------------------|--------------------------------------|
| Economiser    | Preheating boiler feed water        | 4 – 7%                               |
| Air preheater | Preheating combustion air           | 4 – 10%<br>0.5 – 4% after economiser |
| Condenser     | Preheating treated or service water | 4 – 7%                               |



# Heat recovery from flue gas

*For fuel saving*



## ***A constructive compromise***

*The design of the economiser is always a bit of a balancing act. On the one hand the economiser shouldn't be too big; on the other, flue gas resistance has to be kept to a minimum so that the fan can create enough pressure.*

*An effective length, split and positioning of the finned tubes is of central importance. This is even more the case of "dirty" as opposed to "clean" flue gas.*



# Heat recovery from flue gas

*Economiser savings >5%*

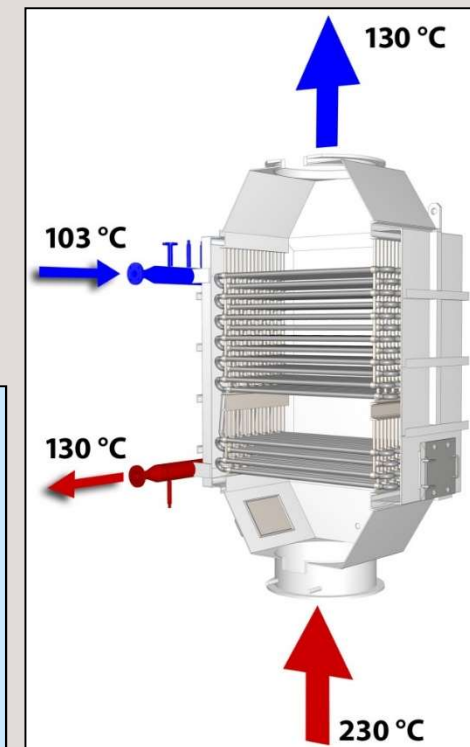


- Preheat feedwater (steam boiler)
- Increase return temperature (hot water boiler)
- Reduce flue gas temperature
- Increase efficiency

## Flue gas energy

10 bar steam boiler, 3 % O<sub>2</sub> in flue gas, flue gas temperature downstream of heat exchanger: 130 °C

| Installed heating capacity | Economiser performance at 100 % burner capacity and 250 °C flue gas temperature | Economiser performance at 60 % burner capacity and 230 °C flue gas temperature | Economiser performance at 30 % burner capacity and 210 °C flue gas temperature |
|----------------------------|---|--|--|
| 4 MW                       | 220 kW  | 105 kW   | 43 kW  |
| 6 MW                       | 330 kW  | 165 kW   | 65 kW  |
| 8 MW                       | 440 kW  | 215 kW   | 85 kW  |
| 10 MW                      | 550 kW  | 275 kW   | 108 kW   |
| 12 MW                      | 660 kW  | 330 kW   | 130 kW   |
| 15 MW                      | 830 kW  | 410 kW   | 165 kW   |
| 20 MW                      | 1.100 kW  | 550 kW   | 220 kW   |



# Heat recovery from flue gas

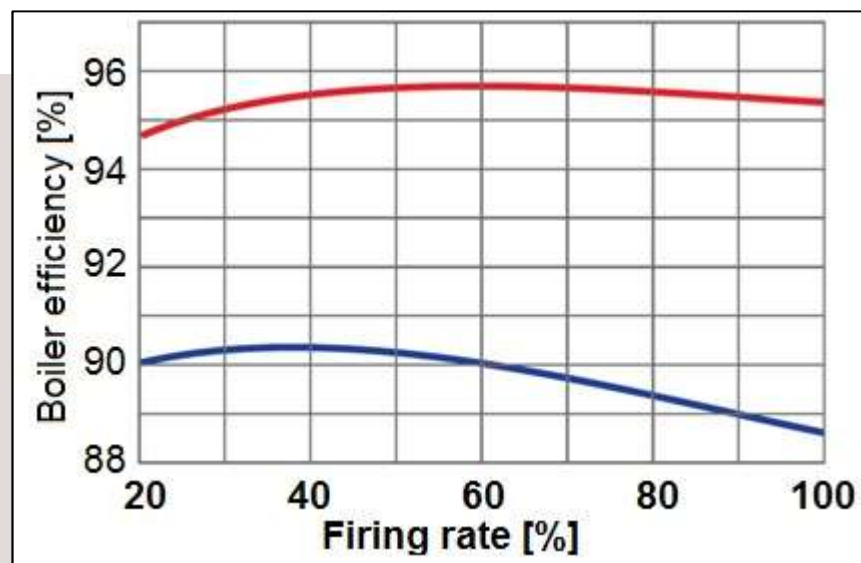
## Economiser



Efficiencies:

Boiler with economiser (red)

without economiser (blue)



| Burner Capacity | O2 in flue gas | Flue gas temperature |                   | Operating hours  | Energy savings per year | Savings per year   |
|-----------------|----------------|----------------------|-------------------|------------------|-------------------------|--------------------|
|                 |                | Before fitting Eco   | After fitting Eco |                  |                         |                    |
| 4 MW            | 2.8 %          | 210°C                | 130°C             | 1,500 h/a        | 217 MWh/a               | £ 8,700 /a         |
| 6 MW            | 2.6 %          | 230°C                | 130°C             | 2,500 h/a        | 673 MWh/a               | £ 26,900 /a        |
| 8 MW            | 2.4 %          | 250°C                | 130°C             | 1,500 h/a        | 640 MWh/a               | £ 25,600 /a        |
| 10 MW           | 2.2 %          | 270°C                | 130°C             | 500 h/a          | 310 MWh/a               | £ 12,400 /a        |
| <b>Total</b>    |                |                      |                   | <b>6,000 h/a</b> | <b>1,840 MWh/a</b>      | <b>£ 73,600 /a</b> |

Example:  
Gas price: 0.04 £/kWh

Investment circa £50K  
ROI < 18 months

# Air preheater

*Reducing flue gas by 100K saves 4% of fuel*



- Preheat combustion air
- Ideal solution if there is no need for economisers
  - high-pressure condensate system
  - Thermal oil heaters

## **Temperatures up to 55°C:**

Standard burners

## **Temperatures up to 100°C:**

Electronics, flame scanner etc must be replaced

## **Temperatures above 100°C:**

New modified burner is needed



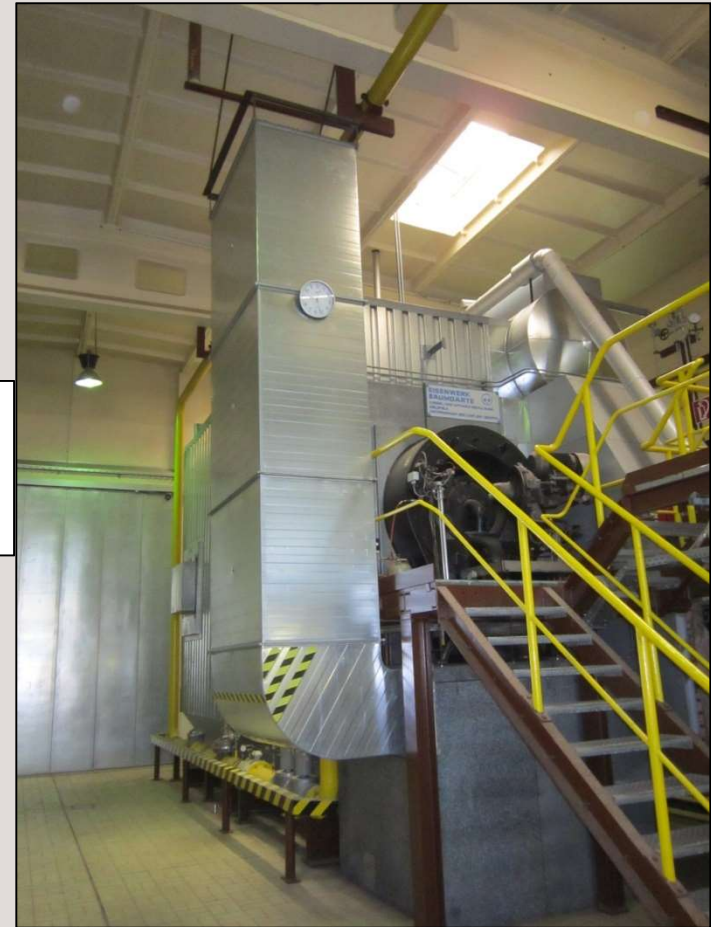


# Super-heated ceilings

*Low cost efficiency gain*



Hot summer 2012:  
37°C at ground level  
60°C on top of boiler





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# Monta – Adhesive tape production

## *Example of efficiency improvement*



### **Problem:**

Inefficient firing of Heavy fuel oil



# Monta – Adhesive tape production

*Efficiency improvement*



## What's new?

- Conversion from HFO to gas
- Economiser
- Condenser
- Blowdown control
- O<sub>2</sub> / CO control
- Speed control
- Lower operating pressure



# Monta – Adhesive tape production

## *Efficiency improvement*



New exhaust system of stainless steel

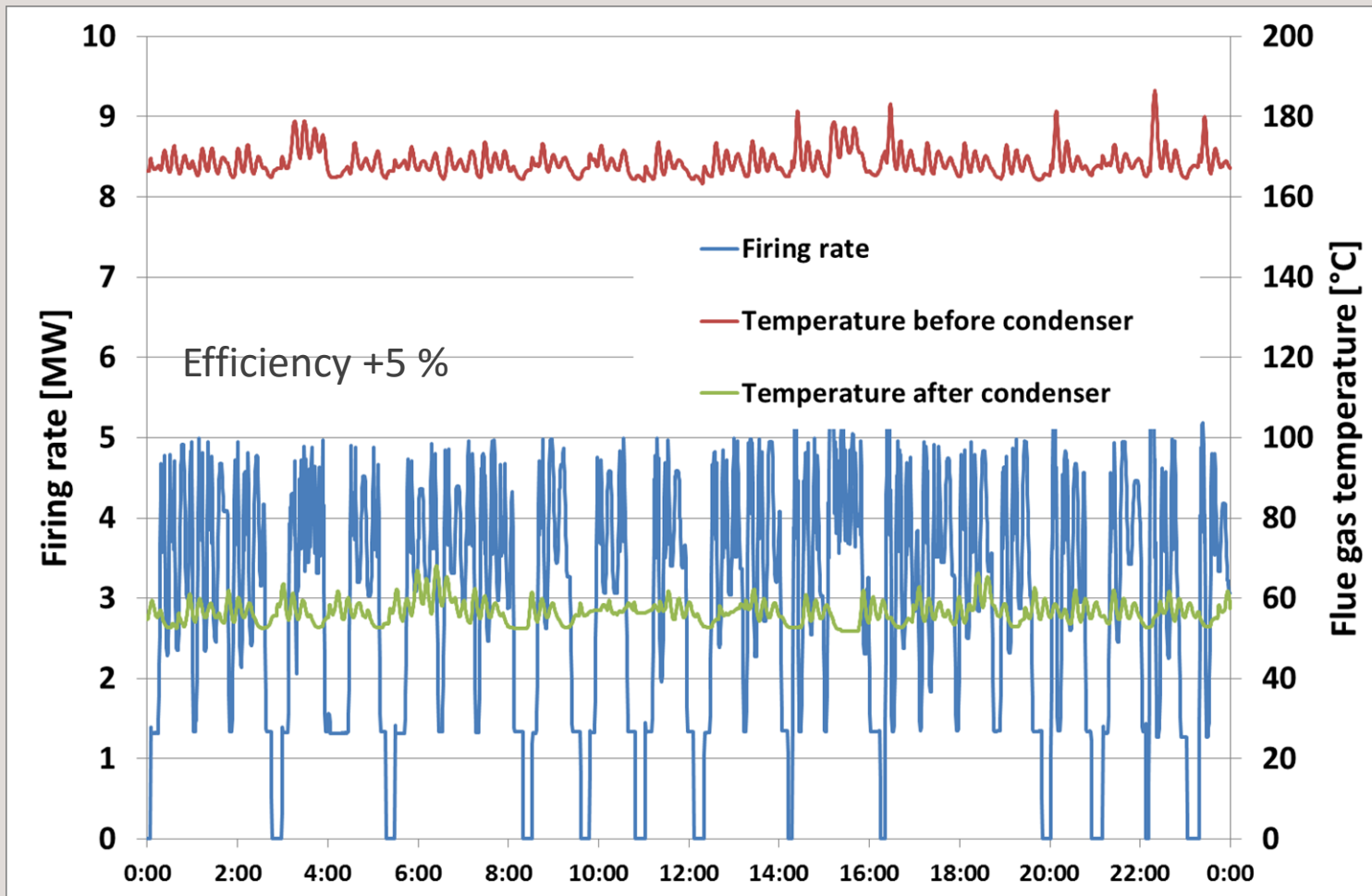
Efficiency: 95 %





# Monta – Adhesive tape production

## *Efficiency improvement*





# Monta – Adhesive tape production

*Major efficiency gain*



## Some more facts:

|                                   |                    |
|-----------------------------------|--------------------|
| <b>Fuel costs for HFO</b>         | <b>812,000 £/a</b> |
| Additional costs for HFO          | 160,000 £/a        |
| O <sub>2</sub> excess in flue gas | 4 %                |
| Flue gas temperature              | 279°C              |
| <b>Combustion efficiency</b>      | <b>87 %</b>        |

**Time for retrofitting 3.5 weeks**  
**Payback period 2 years**

|                                   |                    |
|-----------------------------------|--------------------|
| <b>Fuel costs for natural gas</b> | <b>768,000 £/a</b> |
| O <sub>2</sub> excess in flue gas | 1 %                |
| Av. Flue gas temperature          | 75°C               |
| <b>Combustion efficiency</b>      | <b>97 %</b>        |

# Top Tips to improve efficiency

## *And SAVE MONEY*



1. Repair water, steam and condensate leaks;
2. Check hotwell and steam traps;
3. Check water treatment/TDS blowdown system and optimise;
4. Reinstall lagging and cladding; install on any exposed surfaces;
5. Check calorific value, viscosity and analysis of fuel deliveries (periodically for gas); and optimise liquid fuel atomising temperature/pressure;
6. Check fuel filters on regular basis;
7. Check provision of adequate ventilation;
8. Re-check process load requirement, check number of burner stops and starts - and optimise steam pressure/fluid temperature and turndown settings;

# Top Tips to improve efficiency

## *And SAVE MONEY*



9. Consider night or weekend pressure set-back system;
10. Check operation of boiler sequence control system;
11. Introduce planned maintenance regime and replacement of consumable items;
12. Regular servicing and combustion tests/optimisation;
13. Replace Bowden cable drive and solid linkage drive systems on burners with direct drive electronic burner/boiler management system;
14. Fit inverter variable speed drive control to combustion air fan;
15. Fit oxygen trim control;
16. Fit CO trim control;

# More Tips to improve efficiency

## *And SAVE MONEY*



17. Fit economiser to pre-heat boiler feed water;
18. Consider air intake from boiler-house high level;
19. Consider air pre-heater;
20. Invest in operator training with regular review and refreshment;
21. Fit only genuine spare parts, maintain critical items in stock;
22. Carry out a boiler plant energy efficiency survey using the SAACKE se@vis efficiency monitor;

# More Tips to improve efficiency

*And SAVE MONEY*



- 23. Consider if by-products from your process can be used in your heat generating plant to save transport/landfill or disposal costs and reduce fuel costs;
- 24. Fit a surface blowdown automatic system with flash tank/cooler;
- 25. Fit an automatic TDS / bottom blowdown system;
- 26. Check condensate returns, consider installation of sensors to check for contamination, recycle or re-use heat content;
- 27. Fit an intelligent control system to provide control of boiler feed water level, alarms, blowdowns, TDS measurement, monitor economiser heat recovered performance, facilitate inverter drive for feed water pump motors (continuous run and on/off pumps)



# More Tips to improve efficiency

*And SAVE MORE MONEY*



## 28. Replace old inverter drives with latest design:

If an average 1980's AC motor and VSD are replaced with a high efficiency motor and state-of-the-art VSD, the payback time could be less than 12 months and up to 36 months depending on operating profiles and energy prices.

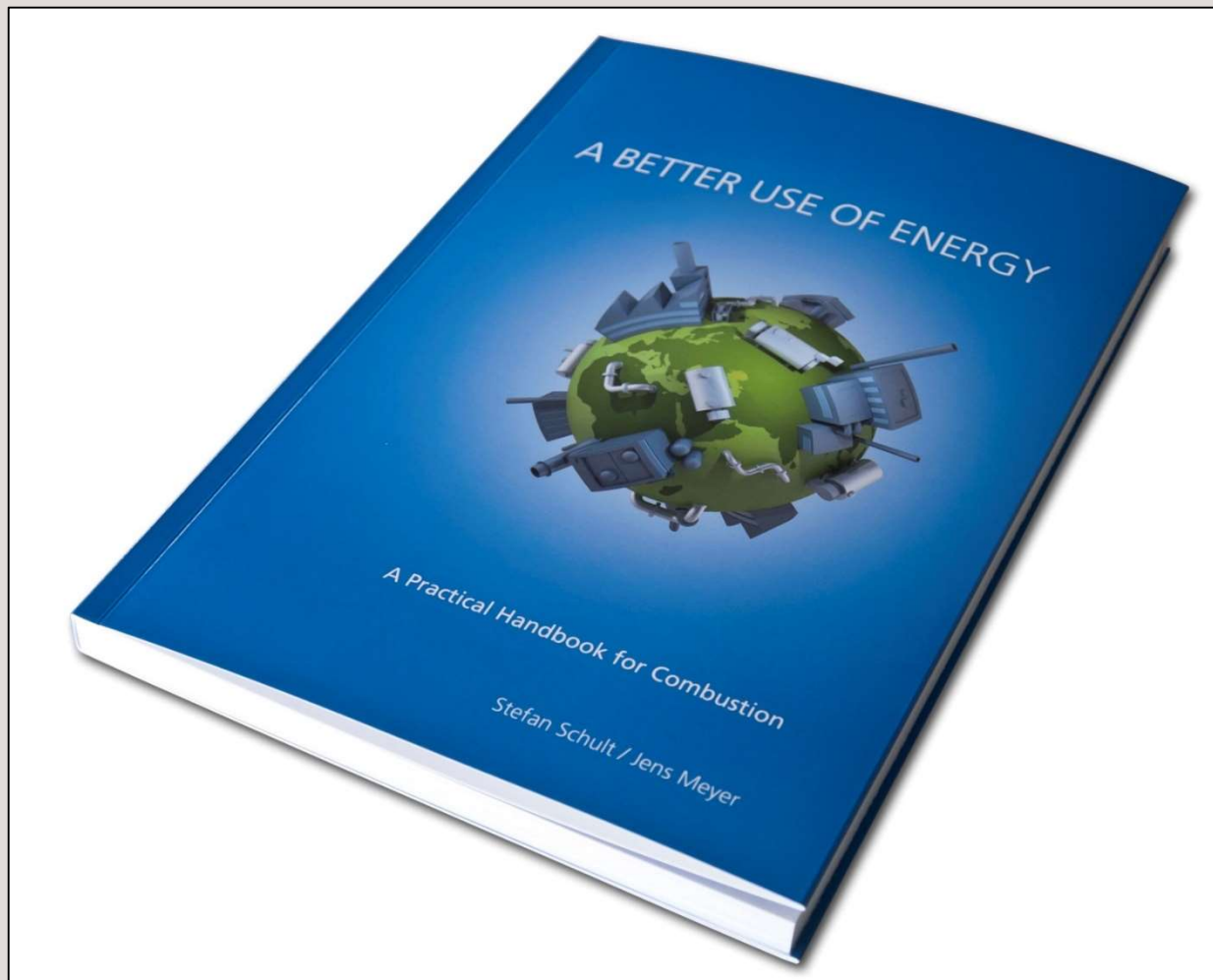
Today's motors are approximately 3% more efficient than their predecessors.

Manufacturers claim today's drives enable higher quality output waveforms which may reduce motor losses by up to 10-15%.

SAACKE demonstration model uses ABB drive with 'flux optimisation mode' for additional saving. It proves electrical energy saving and noise reduction, as well as keeping the balloon in the air!

# Final tip

*Read the book*



## GLOBAL AND LOCAL

With service stations in more than 20 countries around the world, more than 70 international agents and a range of service centers in all of the key ports, we can be found wherever our customers need us.

A white silhouette of a world map is centered on a dark blue background. Numerous small blue dots are placed across the map to indicate service locations, with a high concentration in Europe and scattered dots in North America, South America, Africa, Asia, and Australia. A large, solid olive-green circle is centered over Europe, containing the text "WE ARE AS INTERNATIONAL AS OUR CUSTOMERS". A dashed yellow circle is also centered over Europe, extending slightly beyond the green circle.

WE ARE AS  
*INTERNATIONAL*  
AS OUR  
CUSTOMERS

# Thank You for Your Attention.

