WiC

WORKING PRINCIPLES AND PRACTICAL APPLICATIONS

for combustion optimisation in WtE and BtE plants

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CONTENT

TECHNIKGRUPPE

TG is an Austrian engineering company with well trained employees having international experience and worldwide engagement. Due to its long experience in energy-from-waste and biomass TG also acts as an independent consultant for technical and commercial issues.

The development of the WiC (Waste incineration Control) is based on more than 25 years of experience in optimisation on forward moving reciprocating grates. TG has optimised grates of different grate manufacturers and collected extensive experience in the field of combustion technology.

Matthias Lukic

Technical expert, founder, owner and CEO of Technikgruppe, has more than 25 years of experience in combustion of solid fuels on grates.

+43 (0) 676 47 30 213
matthias.lukic@technikgruppe.com

Damir Zibrat

Business Development Manager of Technikgruppe, has more than 25 years of experience in international strategical selling and marketing.

+43 (0) 664 78 36 716 / +43 (0) 676 577 38 44
damir.zibrat@technikgruppe.com

1. INTRODUCTION

Optimisation of combustion processes in waste-to-energy and biomass-to-energy plants can significantly improve plant reliability, availability and profitability. The task of the combustion optimisation system is to stabilise the combustion process and thus stabilise the production of energy and the main process values like flue gas temperature and combustion air flows.

The development of WiC is based on more than 25 years of experience in combustion optimisation on plants from different suppliers.

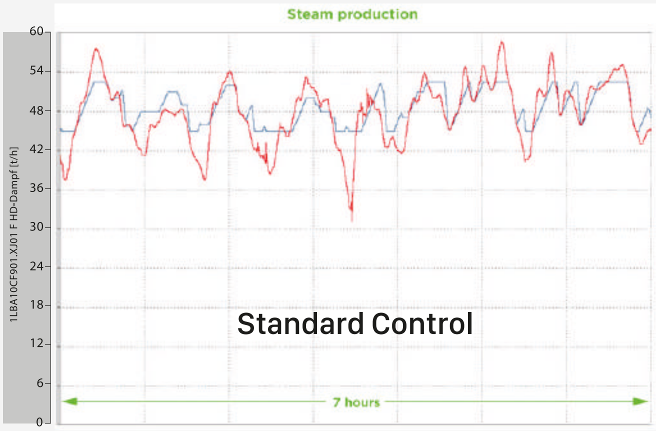


Fig. 1: Steam production controlled by Standard Control

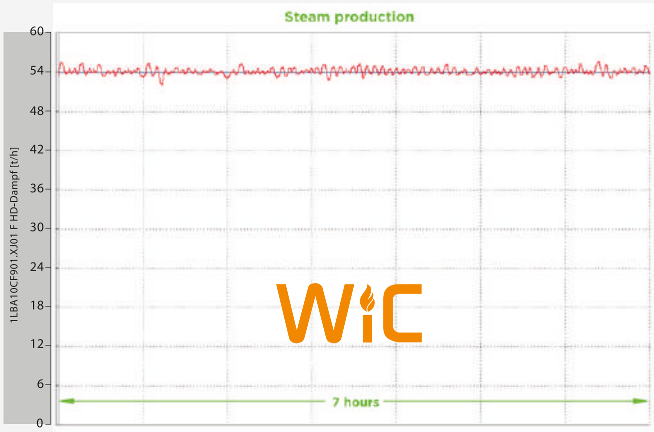


Fig. 2: Steam production controlled by WiC

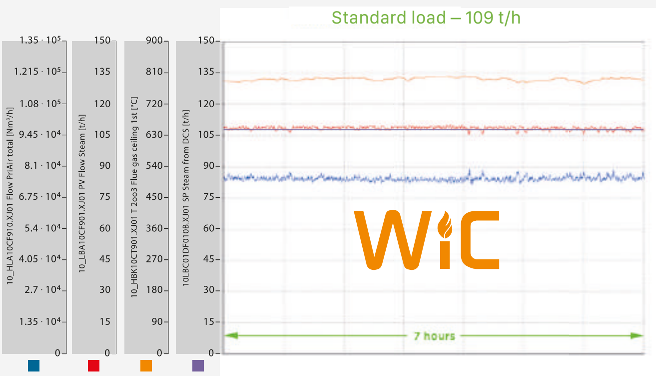


Fig. 3: After stabilising steam production, it was possible to determine the actual capacity of the system

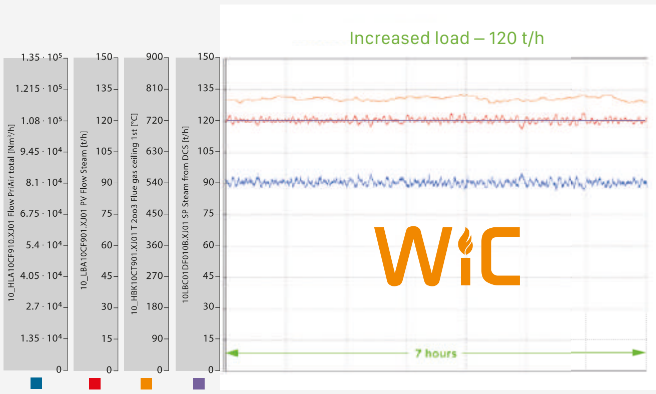


Fig. 4: This led to a 10 % load increase from the original design limit (MCR) without having to make mechanical changes

Based on our experience, we can reliably estimate the benefits of implementing WiC and offer system testing at no cost according to the payment model, 'no cure no pay'.

TG is a supplier of unique combustion technology and, due to extensive experience in waste-to-energy and biomass-to-energy business, TG can serve as an independent consultant. Our technical experts are also open to an academic exchange of experience with universities, research centres, or governmental institutions.

2. PARAMETER DEFINITIONS

The quality of the combustion process significantly influences the characteristics of steam production and other important parameters in Waste-to-Energy and Biomass-to-Energy plants. The combustion process directly affects

- Quantity of steam production
- Stability of steam production
- Quantity of fly ash
- Amount of flue gas cleaning additives
- Stability of flue gas temperature
- Amount of slagging and fouling
- Flue gas temperature
- Corrosion

Steam production in Waste-to-Energy and Biomass-to-Energy plants is determined and limited by

- Boiler design
- Grate design
- Combustion control system

Steam production is usually controlled by automation systems or manually. Automation systems can be semi-automated or fully automated. To better understand the procedures for setting commands for steam production, it is necessary to define values relevant to the process. To avoid possible misunderstandings, it is important to analyse the grate- and boiler-parameters and steam production control commands. The main parameters for setting up steam production and the main parameters for checking the quantity and quality achieved are described in the figure below.

Design limit
recommended maximum steam production - value that must not be exceeded; the design limit is usually defined by the manufacturer of the grate- and boiler-system

Setpoint
desired steam production

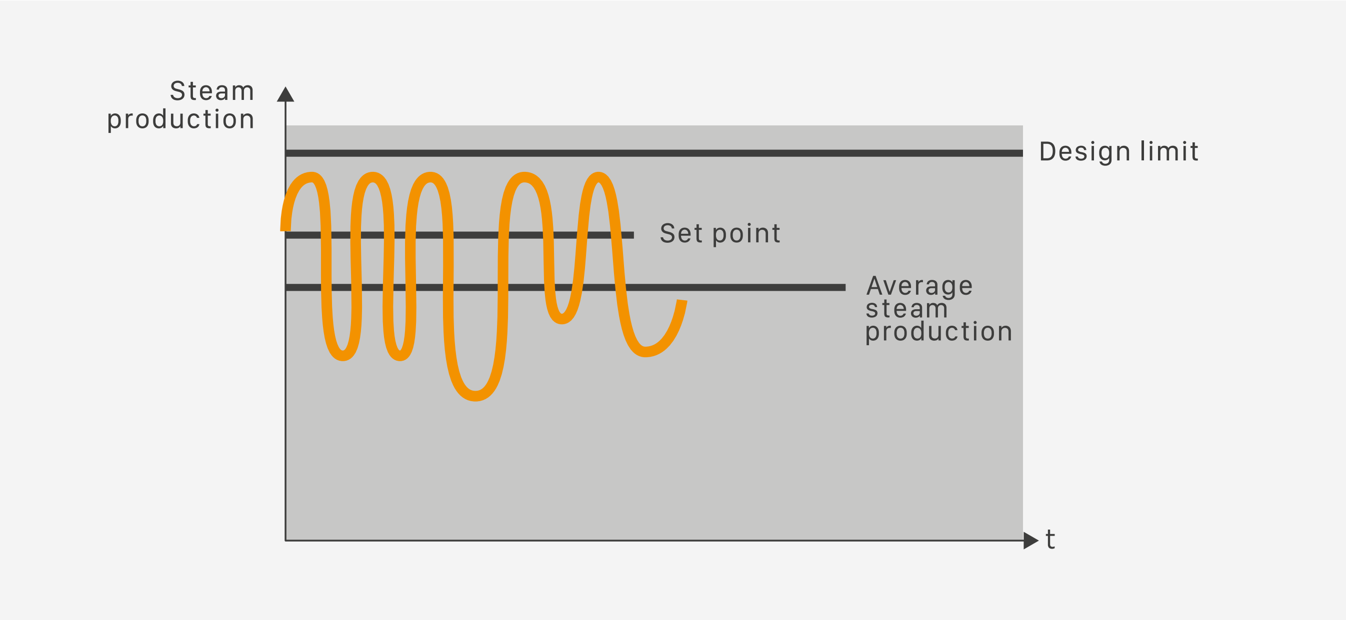


Fig. 5: Oscillations in steam production

Average steam production
deviates from the setpoint in many cases

Due to oscillations in steam production, the set point is in most cases set considerably below the design limit. The simple reason is to avoid exceeding the design limit. This means that there are UNUSED RESERVES in the boiler to produce more steam and burn more waste.

Oscillations
in steam production results in increased wear and tear on the boiler system and additional negative effects on the turbine generator set.

Stabilisation
of the steam production can provide a solid basis for an increase in production without exceeding the design limit. The main idea for these improvements is described in the figure below. If suitable methods are used to stabilise steam production (period B), the amplitude of the steam production will be below the design limit. It is obvious that in this case, the average steam production can be increased without exceeding the design limit.

During period A there are oscillations in steam production. Therefore, Set Point 1 (SP1) is set below the design limit. During period B the steam production is more stable. The amplitudes of the steam production are still BELOW the design limit. There is no increase in steam production in period B because the setpoint is at SP1 level. Due to the stabilisation of the steam production in period B, it is afterwards possible to increase the setpoint from SP1 to SP2. In period C, the set point is increased to SP2. In period C, steam production is bigger than in period A and B and production is still below the design limit.

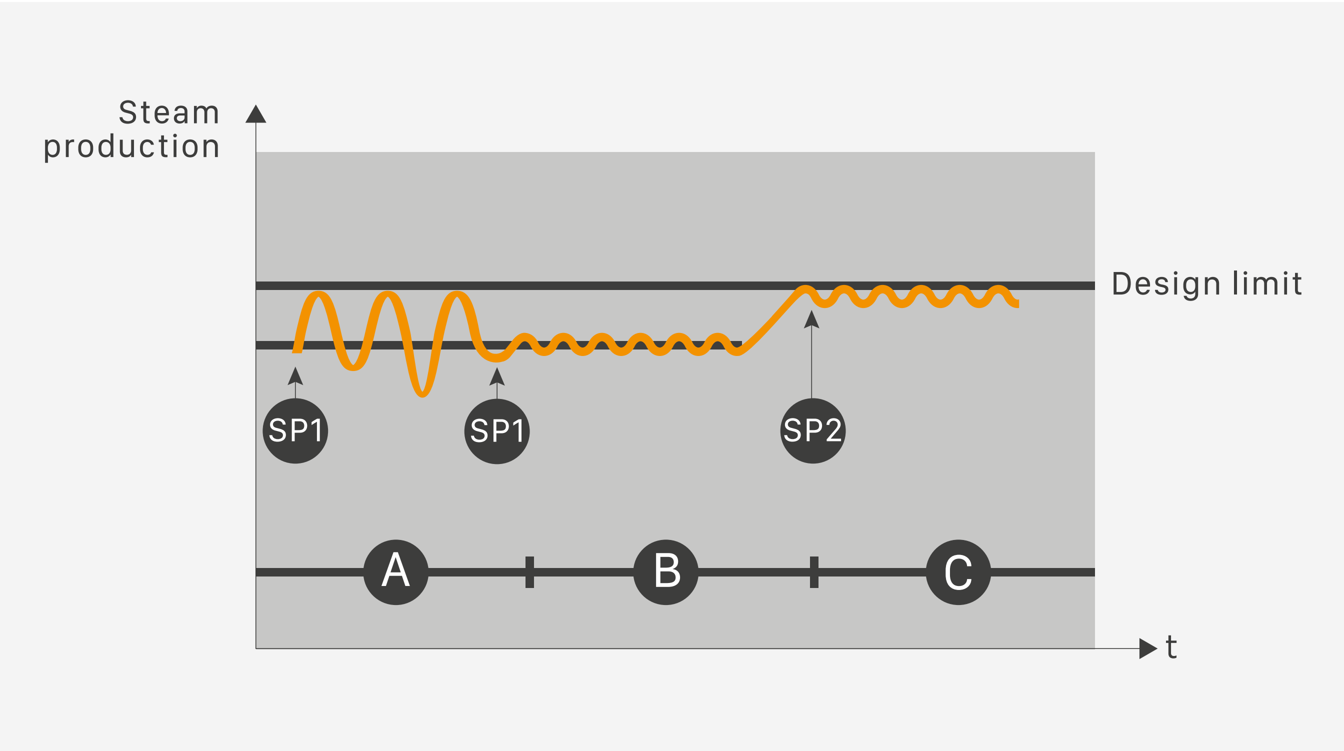


Fig. 6: Basic principle of production increase AFTER stabilisation of steam production.

3. BASIC PRINCIPLES OF COMBUSTION

Fig. 7: Principle grate combustion system

The combustion process in energy-from-waste and biomass plants is very complex, and the demands on control systems in those plants are very sophisticated. There are many theories about the best techniques to recover the energy from waste and there are equally many different approaches to finding suitable solutions.

There are lots of different control algorithms implemented in combustion systems and many approaches how to compare the various methods.

Simplistically, there are 3 main actions which have influence on the combustion process.

- Adding fuel into the combustion chamber
- Adding combustion air (oxygen)
- Mixing the fuel with combustion air

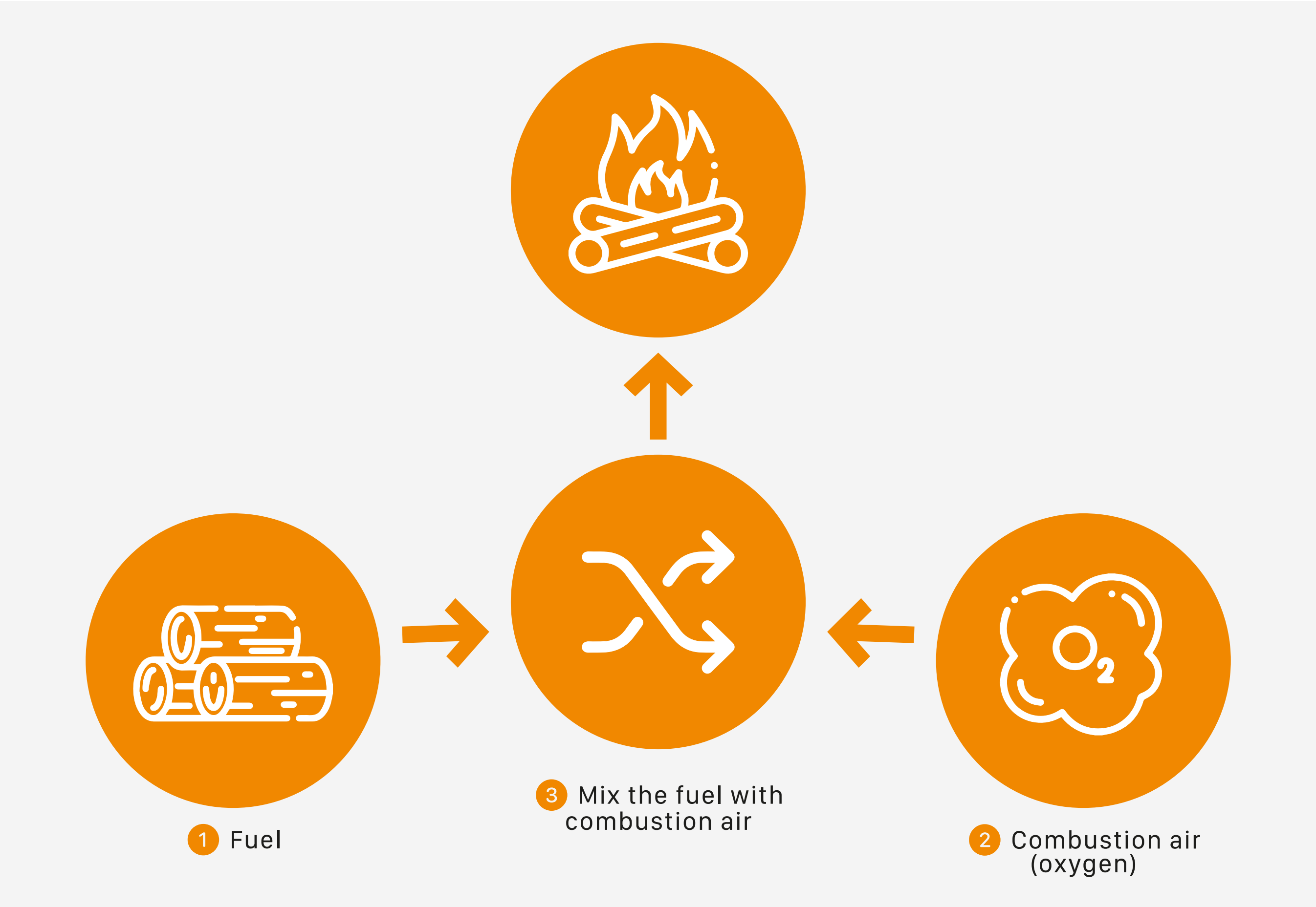


Fig. 8: Three main actions for combustion control

The control of the combustion process is based on 3 main actions:

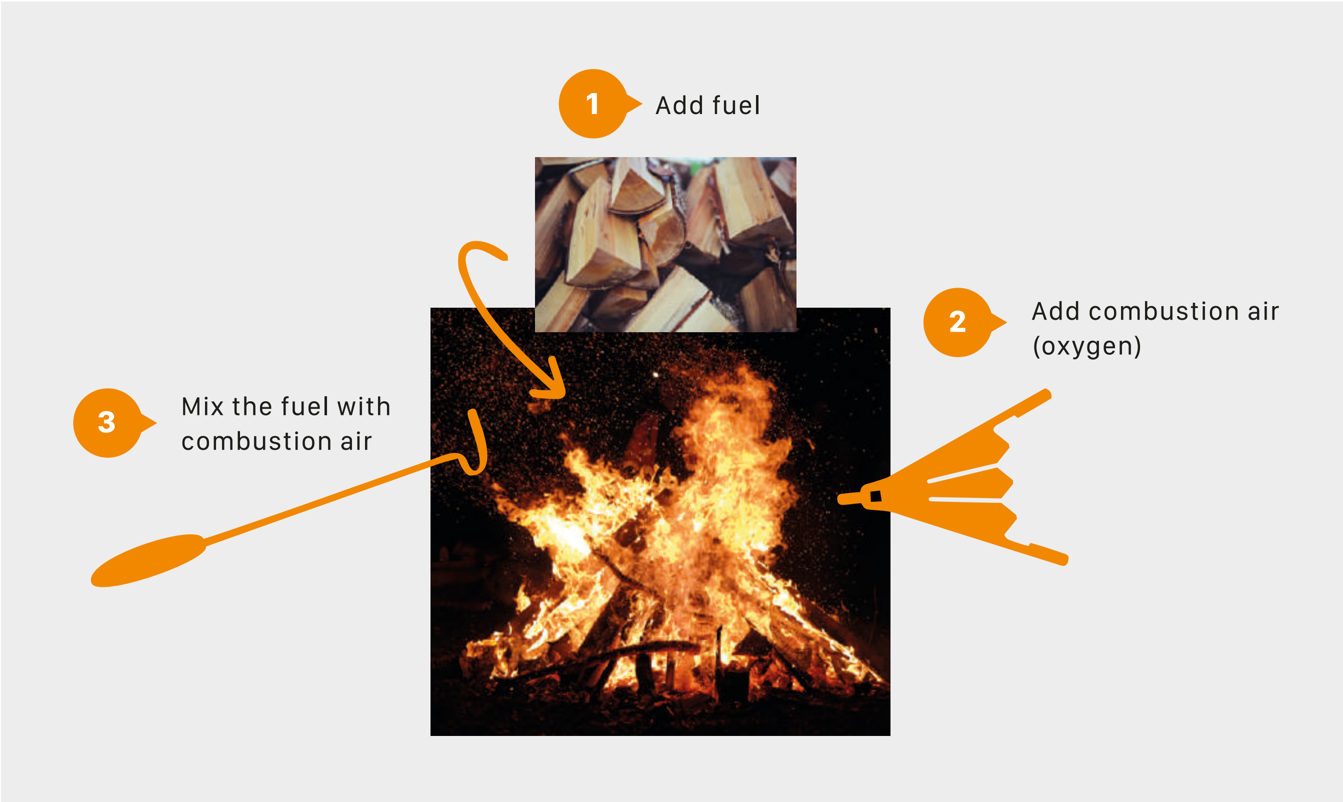


Fig. 9: 3 main actions for combustion

The technical process of combustion described above is best implemented using a forward moving reciprocating grate. On such a grate, the required amount of fuel in the various grate zones can be optimally and very precisely regulated by the WiC Combustion Manager.

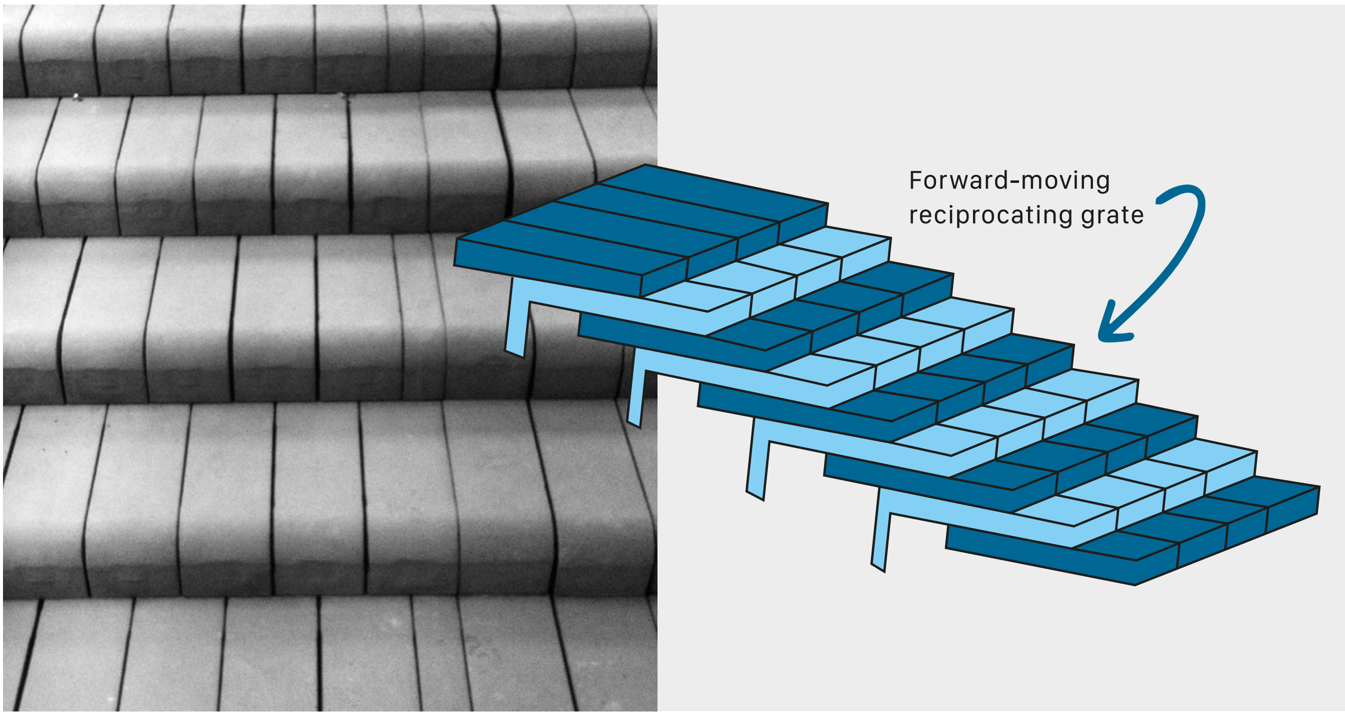


Fig. 10: Forward moving reciprocating grate

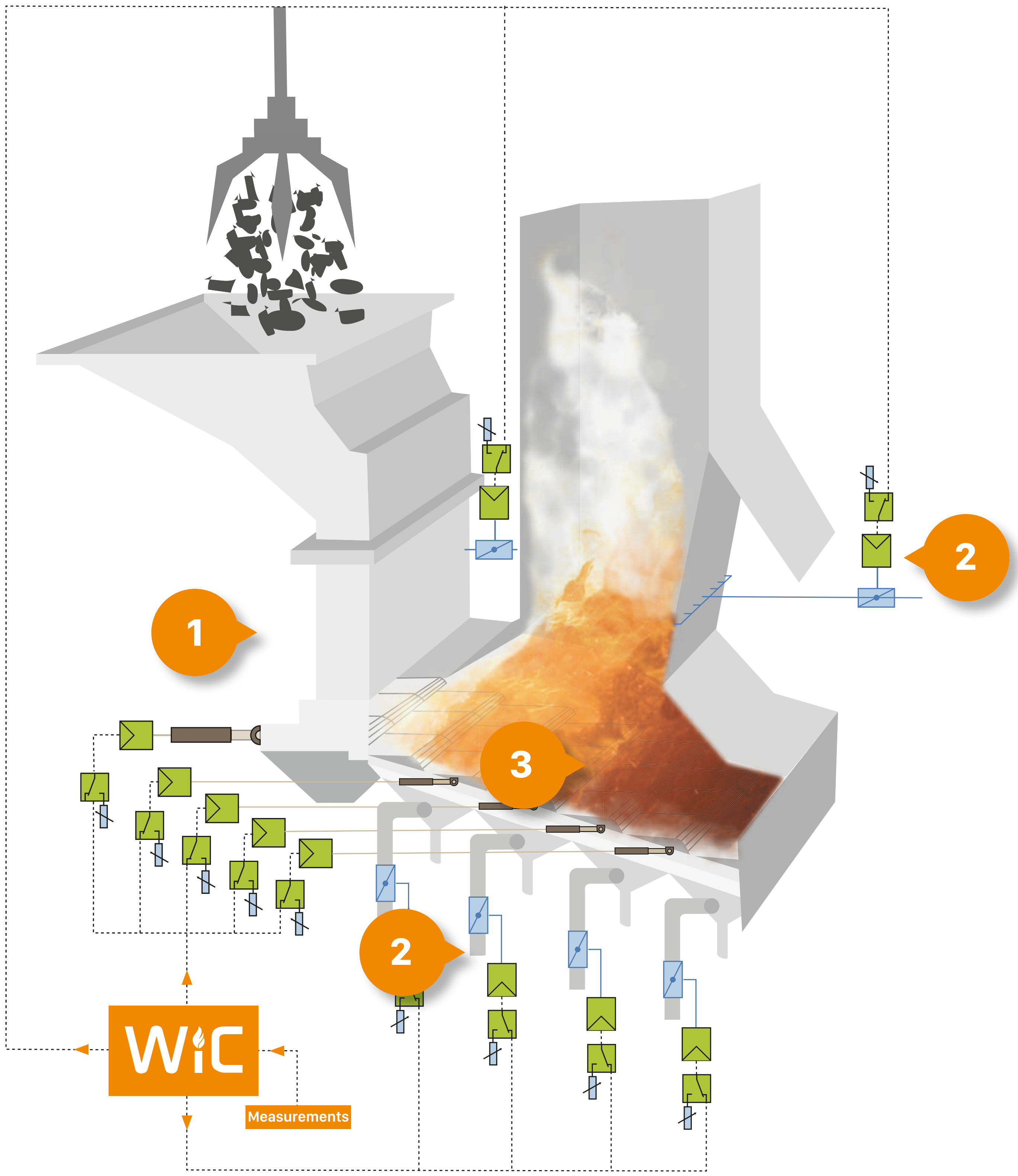


Fig. 11: Principle grate combustion system

Basic principles

After more than 25 years of experience in combustion optimisation, we can say that forward-moving reciprocating grates are ideally suited to the application of the three before mentioned basic principles for combustion.

These three main actions involve around 30 actuators. The actuators offer many possible combinations for fine tuning. If there are 20 actuators and each actuator has 10 possible positions – how many possible combinations do we get?

1	actuator provides	10 combinations	// 0-1-2-3-4-5-6-7-8-9-
2	actuators provide	100 combinations	// 00-01-02-03-04- ……………..96-97-98-99
3	actuators provide	1000 combinations	// 000-001-002-003-004-005-006-007 ………..997-998-999
20	actuators provide	100 000 000 000 000 000 000 possible combinations for fine adjustment.	



Fig. 12: Typical actuators (hydraulics, fan, valve)

The status of the combustion process is changing every few seconds! That means – every few seconds we need to fine adjust the actuators. It is clear that the definition of the appropriate combination every few seconds is a very complex task. Whereas the checking the combustion quality itself is very simple → see diagrams of KPIs from a combustion process.

Fine-tuning a few actuators every few seconds is relatively simple. But we have 100 000 000 000 000 000 000 possible positions for fine adjustment. The requirement of the combustion optimisation system is to define: WHICH actuators should be adjusted and HOW MUCH?
Our approach is as follows: At present, the state of the combustion process on the moving grate can be determined by appropriate analysis of the measurement results of the process parameters. Modern measuring systems in waste-to-energy and biomass-to-energy plants can provide about 100 measurements.

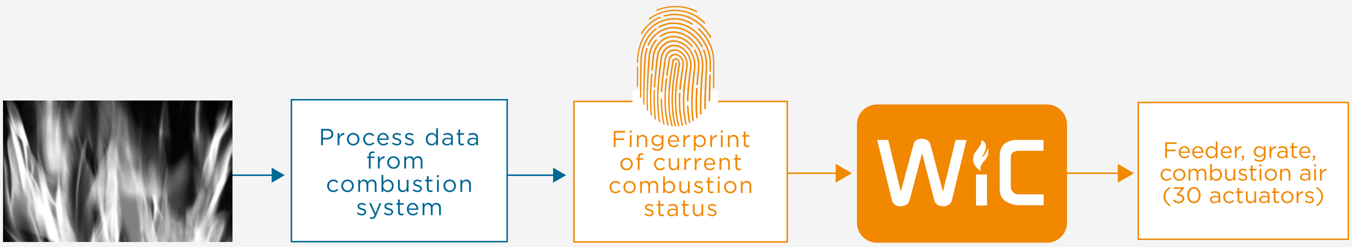


Fig. 13: Modern automation systems provide various signals from the combustion process. These signals are the fingerprint of the current combustion status.

With appropriate algorithms it is possible to calculate the appropriate combination (1 out of billions) and to stabilise the process. Standard industrial process controls cannot be used for this purpose! It is necessary to use particularly powerful controllers.

Fig. 14: ***No thermal camera*** *or pyrometers are needed.*

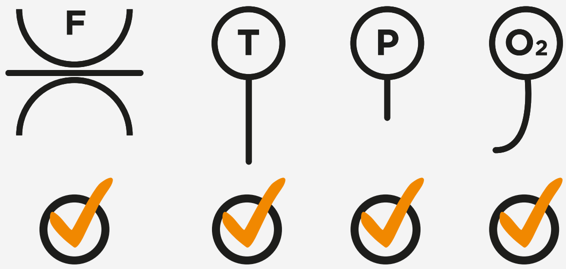


Fig. 15: WiC only needs standard process measurements as data inputs.

4. COMPARISON WITH OTHER SYSTEMS

Some simple combustion optimisation systems can provide stabilisation of steam production by implementing large oscillations in combustion air, especially in primary air. These technologies may be very simple to use, but fluctuations in combustion air flow have significant disadvantages:

- Oscillations in the fan speeds (higher energy consumption - higher mechanical wear)
- Too much movements of the air dampers
- Increased fly ash
- Increased consumption of additives for flue gas cleaning
- Fluctuations in flue gas temperature

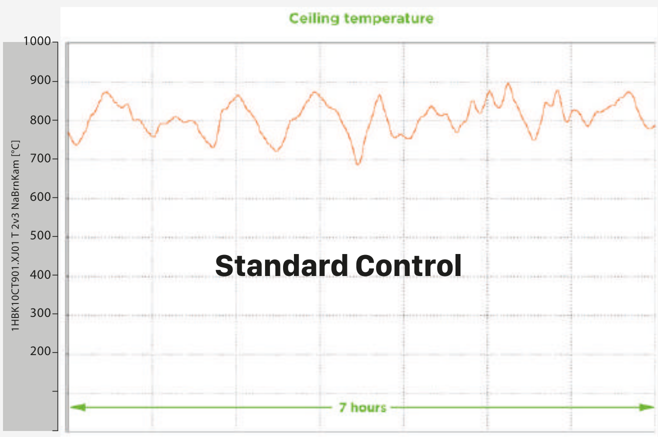


Fig. 16: Ceiling temperature with standard control

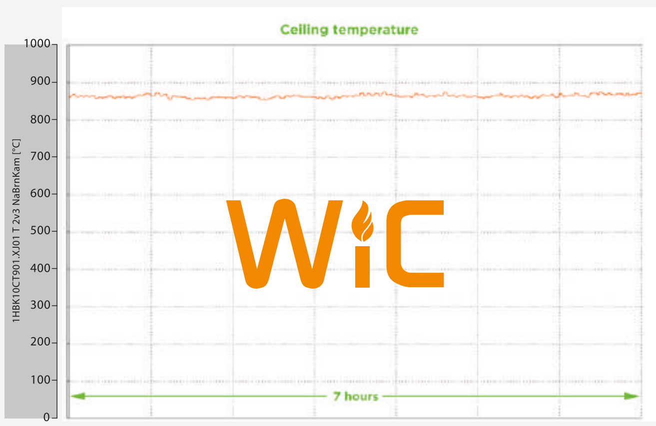


Fig. 17: Ceiling temperature with WiC Combustion Manager

Traditional systems vs. WiC

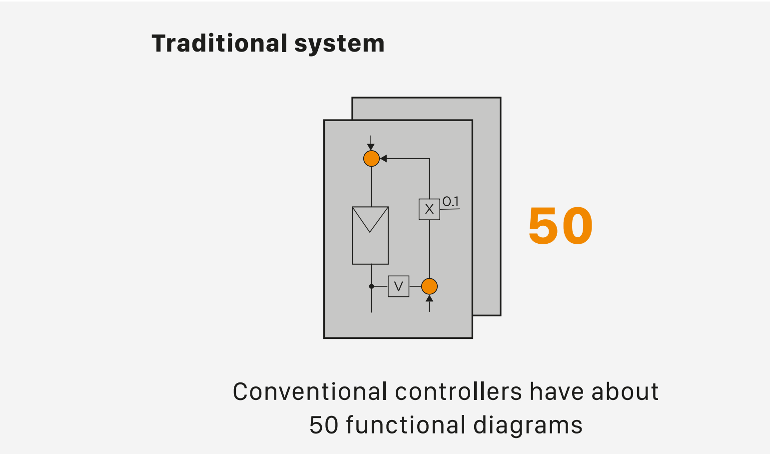


Fig. 18: Traditional system

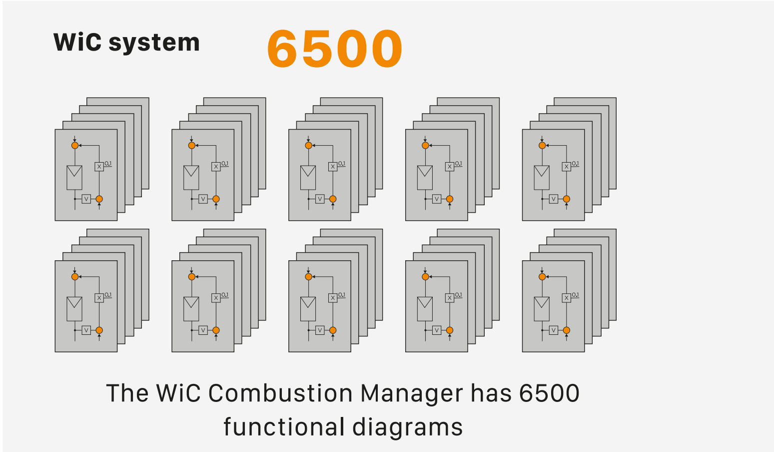


Fig. 19: WiC system

WiC uses real-time data processing, with far more data than traditional systems. WiC processes some 6500 functional diagrams instead of typically 50.

Every plant is unique and for every particular plant the control calculations must be done thoroughly. In the combustion management process, it is necessary to calculate many equations simultaneously in real time.

With its 6500 functional diagrams, WiC provides a quality and accuracy which is not possible to reach with conventional controllers and classic control strategies. In general, after 1-2 hours of switching on the WiC, it is possible to see a stabilisation of the steam production, which can lead to an INCREASE IN INCINERATION CAPACITY! The operator can use a switch to define which system is controlling the combustion: the DCS or WiC. Trained operators are essential for a powerful use of an automated combustion system. Under certain circumstances, operators switch the combustion control to manual. If this happens frequently, the system should be checked by experts to eliminate the „source of interference“.

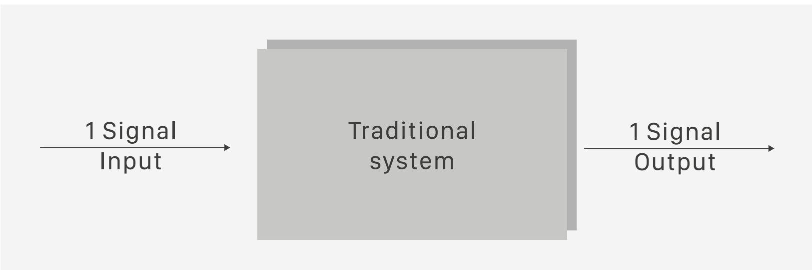


Fig. 20: 50 functional diagrams

Fig. 21: 6500 functional diagrams

WiC simultaneously processes approximately 100 input signals and calculates all needed setpoints (20-30 output signals).

5. IMPLEMENTATION OF WIC

Quick, simple, safe and proven connectivity to automation systems

In most applications, the WiC is a bypass or an „add-on“ system to the existing combustion control system. It may also be integrated from project start up. The WiC usually comes in a cabinet of 600 x 800 x 2000 mm (24 x 31 x 79 inch D x W x H) and is placed in the DCS room.

The basic working principle of the WiC is to “listen” to process signals coming from the DCS, calculate appropriate setpoints for combustion parameters and send them back to the DCS to control the actuators of the combustion system (air dampers, feeder- and grate-hydraulics).

Note:

- WiC does not replace the existing system
- WiC is a bypass/add-on system for exact process set point calculations
- WiC does not interfere with the existing safety system
- with a single switch (software and/or hardware)the operator may define the source of set points, utilizing WiC-set-points or DCS-set-points. This is essential for the operators to gain confidence in a „new combustion philosophy“. The operators can, at any time, switch back to their familiar existing system and they can directly compare with the new WiC Combustion Manager.

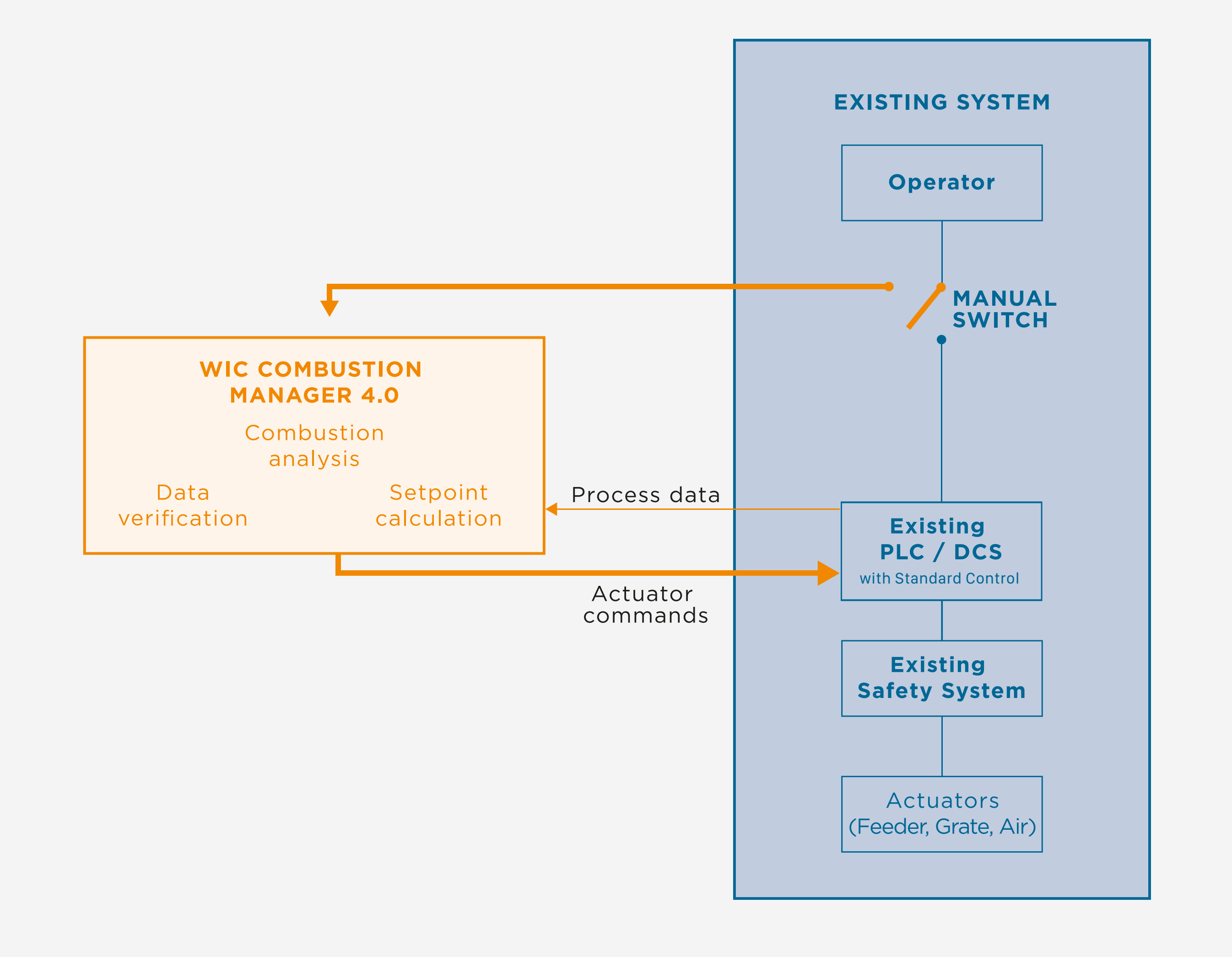
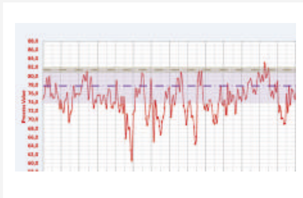


Fig. 22: Connectivity to automation systems

A typical WiC implementation schedule would be as follows:

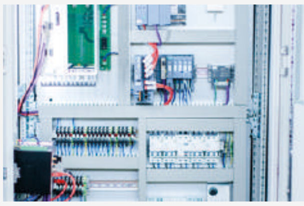
1. Obtain measurement data, drawings …
(may be done remotely/via email)

2. Carry out data analysis and feasibility study



3. Site survey – interview site team engineering/operations/maintenance

4. Install WiC – fine tune combustion



5. Train the operators and staff

6. RESULTS

By implementation of standard control, big overshooting of steam production is possible and this is the main reason why the set point (average steam production) is kept below the design limit.

“Standard control” is very likely to produce dangerous overshooting above design limit! Therefore, in most cases, the manifacturer sets the design limit (MCR) below the real design limit. That means, that in most cases the boilers are built with reserves to cover the overshooting due to lack of combustion control quality. These reserves may be utilised by implementing a more reliable and stable combustion control system. → WiC

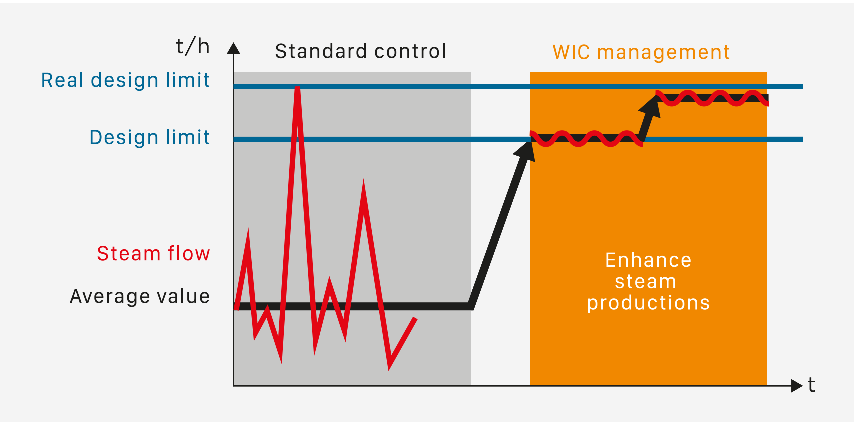
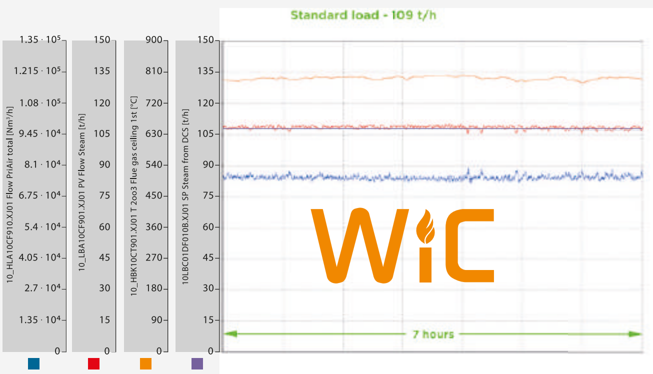
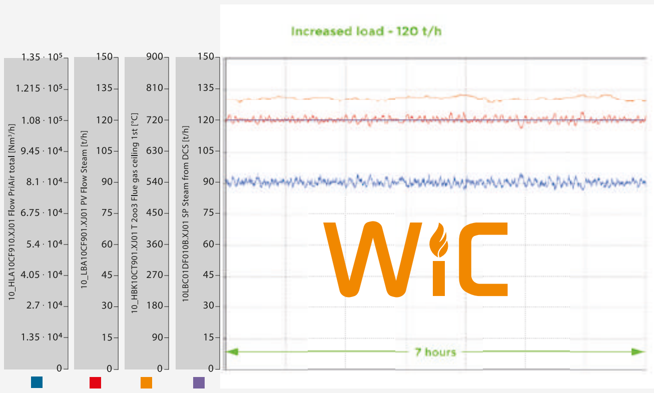


Fig. 23: Enhancement of steam production towards real design limit

Case story 1: Improvement of production + 10%



After stabilisation of steam production, the actual plant capacity can be determined.



This led us to a load increase of 10 % from original MCR (without any mechanical changes). It is important to note that even after increasing steam production from 109 t/h to 120 t/h the steam production is still stable.

Fig. 24: Stabilisation at design limit (MCR)

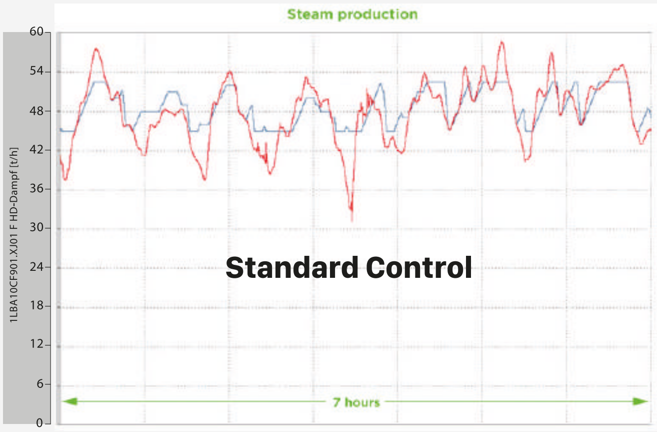
Fig. 25: Stabilisation at real design limit (MCR + 10%)

Because of the large oscillations in steam production (usually caused by poor quality of combustion control or inadequate type of grate) most boilers are oversized to overcome the fluctuations in steam production and to mitigate the risk of poor performance of the steam circuits. This means that real design limit for steam production, in some cases, is much greater than typically expected. Therefore, by reducing the fluctuation in steam production, greater steam output may be achieved. Depending on the individual design and installation of the plant, and after a detailed engineering evaluation and the necessary approvals, it may be possible to enhance steam production and incineration capacity without any hardware changes. This means that good control of the combustion process can improve the output of the existing boiler.

After implementing WiC and removing the large fluctuations in steam production, Technikgruppe experts monitored steam production over a long period of time to prove the process was indeed extremely stable. Technikgruppe then carried out a detailed design evaluation on the boiler and steam circuit and with approval from the approval body we were able to increase steam production and thus increased the combustion throughput by approximately 10%. This was all accomplished by using WiC to reduce steam fluctuations, thus creating a very stable process without any mechanical changes. Of course, this result (10%) cannot be guaranteed for all plants, but the design study will quickly show what is possible.

Below are some graphs of the combustion improvements that have an impact on profitability, reliability and availability. The integration of the WiC leads to significant additional earnings through:

Stabilisation and enhancement of steam production



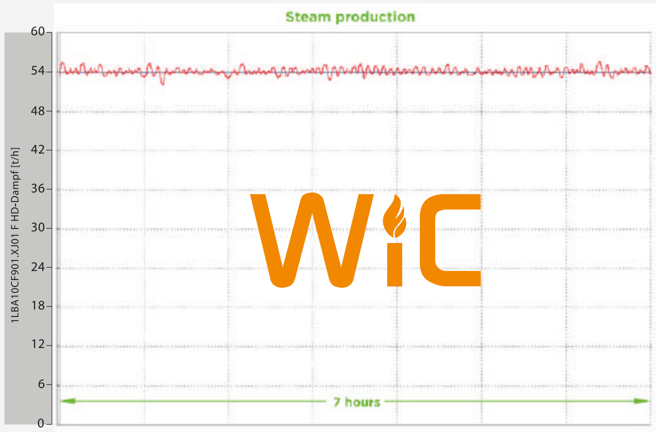
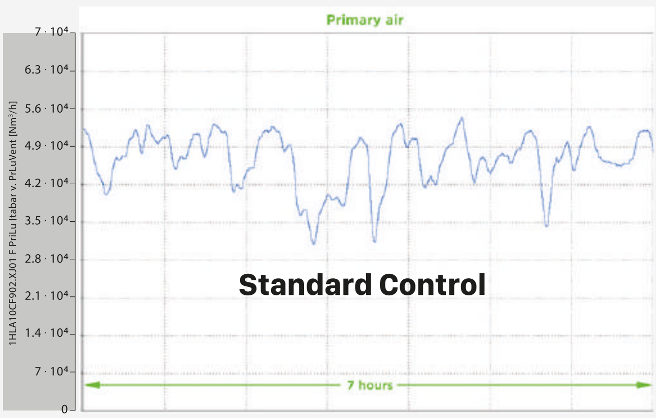


Fig. 26: Steam production controlled by Standard Control

Fig. 27: Steam production controlled by WiC (+ 10%)

Stabilisation of the combustion air flow



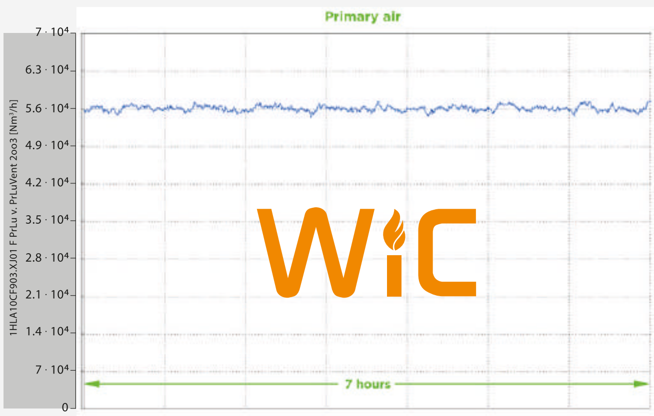


Fig. 28: Primary air flow controlled by Standard Control

Fig. 29: Primary air flow controlled by WiC

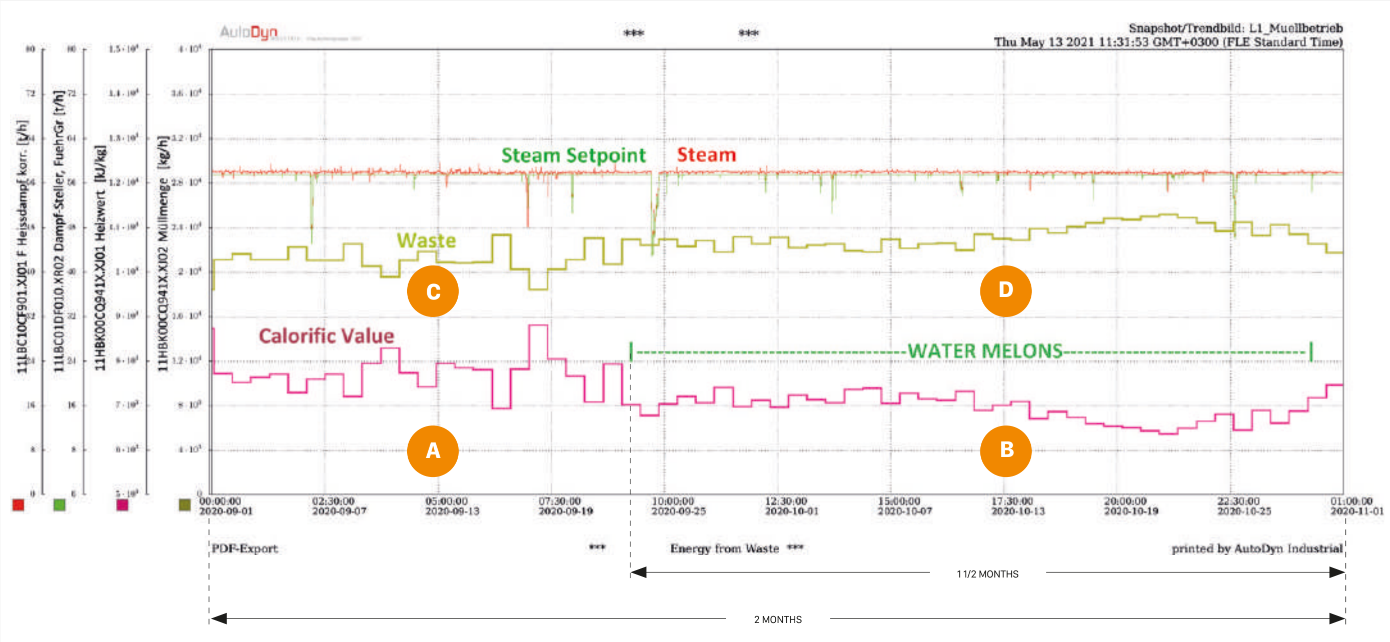
Case story 2: Combustion of low calorific waste, maintaining full load

The incineration of waste with low calorific value is generally a very complex process. Due to the great experience and expertise in the field of combustion technology, very complex calculations and very powerful processors, the WiC-Combustion Manager can optimally incinerate low calorific waste.

The following is an example of trends for an optimised incineration of low calorific waste.

C waste throughput with normal waste average 21 t/h

D waste throughput with watermelons average 24 t/h



A Calorific value normal waste average 7,5 MJ/kg

B Calorific value with watermelons average 6,5 MJ/kg

In this particular case, you can see a very successful incineration of waste with a high water content, which was seasonal due to watermelons in the waste.

During the incineration of waste of normal quality, the calorific value of the waste averaged 7.5 MJ/kg, see A. The waste throughput for the incineration of regular waste averaged 21 t/h, see B. A high content of watermelons in the waste caused the average calorific value to drop to 6.5 MJ/kg, see C.
Nevertheless, the WiC Combustion Manager ensured stable and unchanged steam generation thanks to the appropriate combustion control!
Because of the lower calorific value of the waste, it is necessary to increase the waste throughput to 24 t/h, see D. This means that WiC guarantees stable steam generation even in difficult situations, and with increased waste throughput – which means higher profit (money from the gate fee).
Each combustion line is unique and each line must be analysed in detail. If you have problems with the incineration of low calorific waste, please contact TECHNIKGRUPPE and our experts will analyse your specific case.

7. EVALUATING THE BENEFITS OF WIC

After the installation of the WiC, one important question comes up: "What is the benefit of the WiC Combustion Manager?" For answering this question, the following procedures will work as simple and reliable testing methods.

It is necessary to have approximately the same waste quality and then check the KPIs under WiC- and under DCS combustion control. With one simple switch plant operators can move between the existing system und WiC.

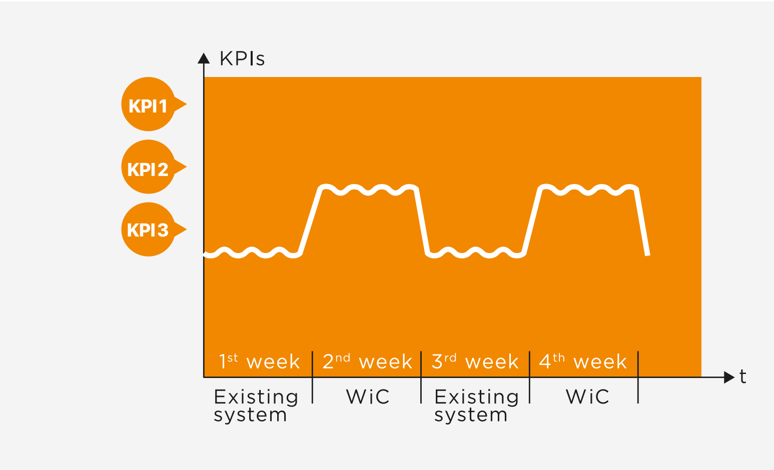


Fig. 30: Comparison WiC/Standard system

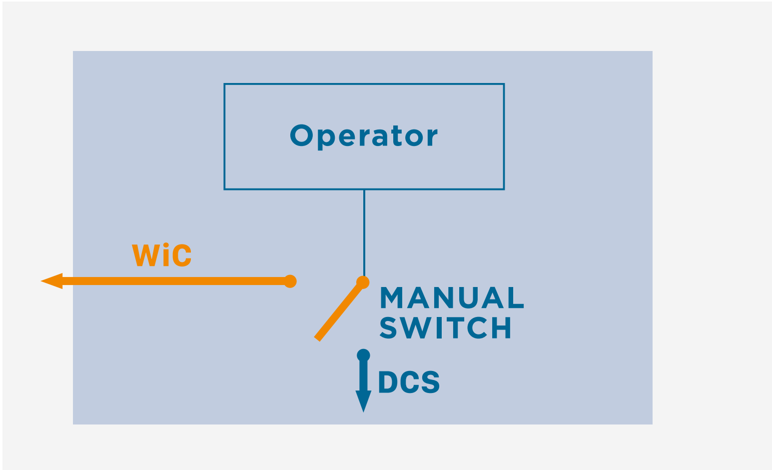


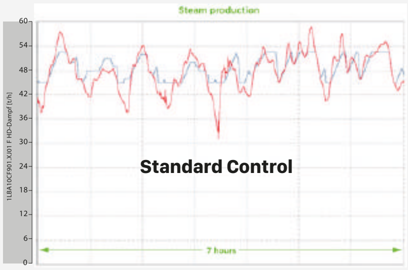
Fig. 31: Switching between WiC/Standard system (DCS)

The periods under comparison shell be selected with similar waste conditions.
The following Key Perfomance Indicators (KPIs) are to be compared between the existing system and the WiC.

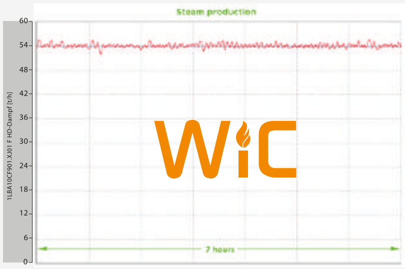
- stability of steam production
- amount of steam production
- waste throughput
- stability of flue gas temperature
- stability of primary and secondary air
- O_2 concentration
- amount of additive consumption
- amount of operator interventions

Some criteria are short term, being relevant for a fast initial assessment of the WiC benefits. Long term benefits can be assessed on the basis of process signals over a period of several months after WiC installation. The WiC is a fully automated system and provides operation without permanent observation (OWPO). Besides that, WiC is also a great help for operators in case of disturbances. Note: For the WiC implementation there is no need for mechanical modifications of the existing combustion system. WiC is an add-on system utilizing the existing equipment.

Stabilisation and enhancement of steam production



Steam production controlled by Standard Control

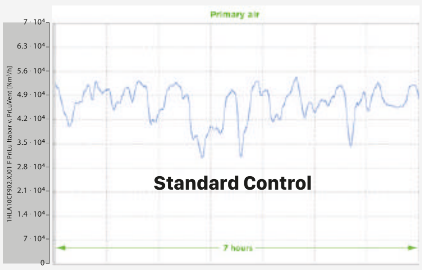


Steam production controlled by WiC

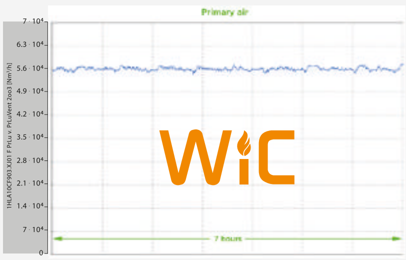
Stabilisation of steam flow brings:

- increased steam production
- increased waste throughput
- increased electricity production
- better burn out quality

Stabilisation of combustion air flow



Primary air controlled by Standard Control

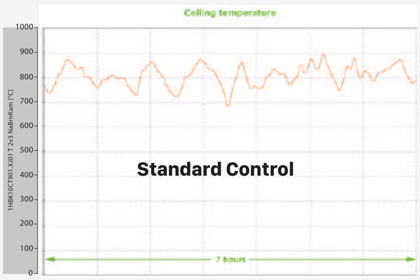


Primary air flow controlled by WiC

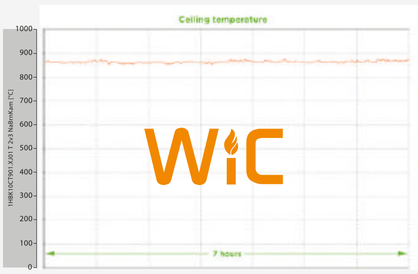
Stabilisation of combustion air leads to:

- less additives in flue gas cleaning
- less energy and mechanical forces on fans
- less slagging and fouling

Stabilisation of flue gas temperature (ceiling temperature)



Ceiling temperature with Standard Control



Ceiling temperature with WiC

Stabilisation of flue gas temperature brings:

- less slagging and fouling
- less wear on refractory
- less corrosion
- less cleaning effort
- lower ceiling temperature
- better heat transfer

8. FINANCING/COMMERCIAL MODEL

Every plant and every incineration line is a unique system. Good results on one line in a particular plant does not automatically mean good results in others. TG's basic purchase model provides a Combustion Management System without any commercial and technical risks. The implementation of the WiC is totally financed by TG. Our tested and proven methods provide simple and reliable comparison between before and after WiC installation. **Finally, only a test run and evaluation will provide a real picture of the system quality.**

After analysing the measurement data and inspecting the plant, TECHNIKGRUPPE will assess the potential benefits of implementing WiC on the specific incineration line. Being convinced that the implementation of WiC will provide significant commercial and technical benefits, TG will offer a free test installation.

During the test period, WiC generates additional profit which remains with the dient. The additional profit is generally always higher than the monthly cost for WiC.

The financing model for WiC:

- **Profits as soon as installation commences – WiC offers more than all other systems on the market, also in terms of financing.**

After TG's feasibility study, TG can assess the potential and benefits offered by WiC for your particular plant. If the outcome of the feasibility study is positive, TG is able to offer installation commissioning and training free of charge:

- **no upfront investment**
- **test installation commissioning and training free of charge**
- **no technical risk, no commercial risk for the customer**

WiC generates additional profits from the beginning of installation

Fig. 32: Financial profits

TG has great experience in reliably assessing the advantages of the WiC system on your particular plant.

After commissioning, the customer can immediately measure the short-term benefits of the WiC (financial benefits). At that point the customer can decide freely, without any obligations, whether to go ahead with a contract for WiC. The entire risk is borne by TG. The customer can terminate the contract month-by-month for any reason, without any further obligations.

If a leasing model with monthly fees is chosen, the fees are less than the profit enhancement. After a certain time, the customer becomes the owner of the WiC and pays only for the software licence and optional maintenance contract.

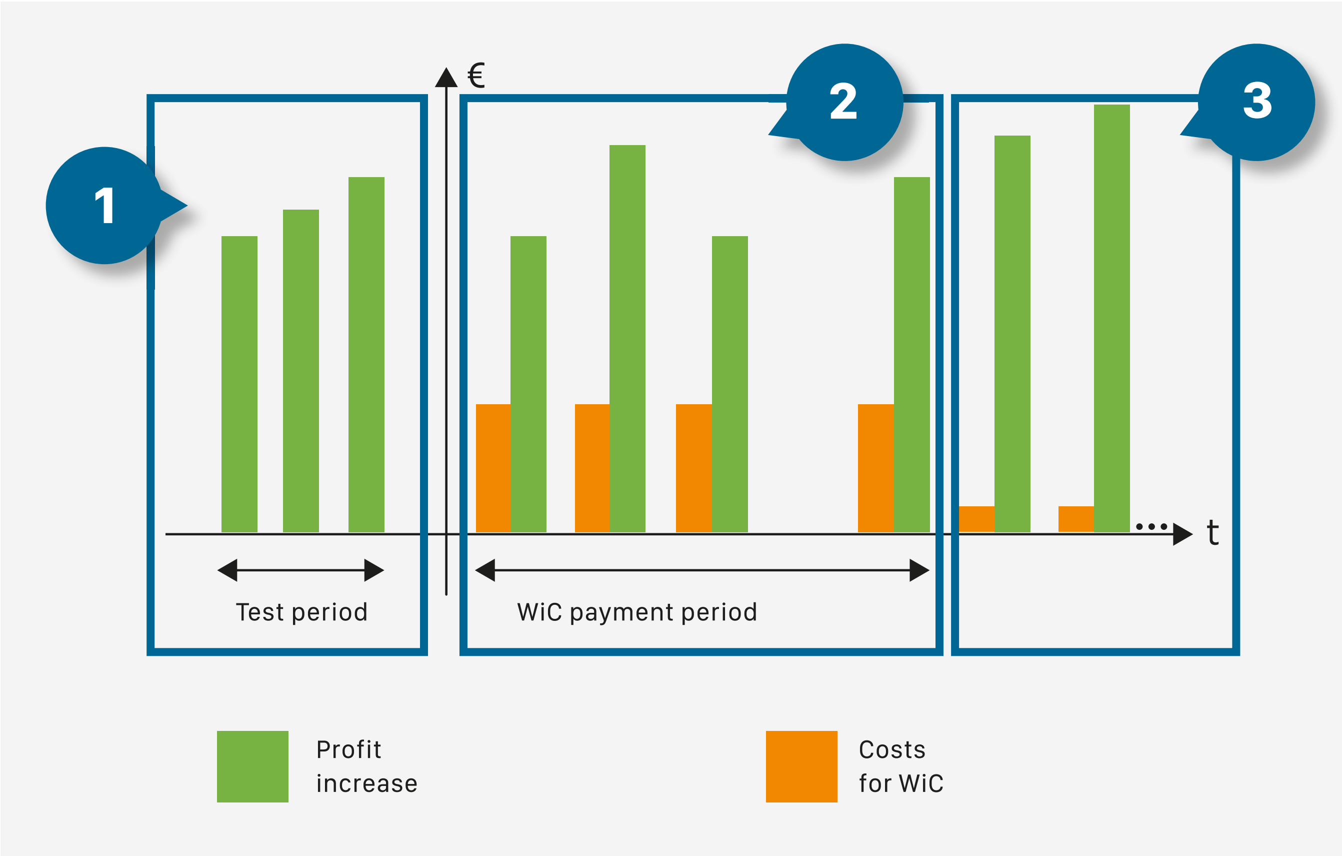


Fig. 33: Financial/Commercial Model

1. During the test phase, the customer does not pay a fee.
   • Even in the test period, it is clear that the profit exceeds the costs of the WiC system. The test period is free for the customer.

2. During the payment period, the customer can cancel at any time and in such a case TG will uninstall the system free of charge.
   • The monthly fee for the WiC system is fixed and is independent of the amount of profit the customer makes with the WiC system. Typically, the payment period is 3 or 5 years.
   • It is also possible to rent the system

3. After the payment period, only software license costs and any optional maintenance contract will be incurred
   • Ownership is transferred to the customer

SERVICES

9. WIC SERVICES

- 24/7 service
- Remote support
- Monitoring and data archiving
- Permanent monitoring of combustion process
- Reporting of inconsistencies
- Disturbance analysis
- Improvement suggestions
- Consultancy during planned shut downs
- WiC-maintenance (1 week/year on site)

TG offers 24/7 support with daily analysis of the combustion process. Our engineers provide reports for your plant and inform you about possible improvements. In case of disturbances, we are able to analyse the data to find the source of problems. The service contract includes full WiC maintenance (including spare parts) and inspection of your plant for one week once a year.

TG Mess-, Steuer- und Regeltechnik GmbH | Austria
Hauptstrasse 229, A-8141 Premstaetten | Wagnerweg 26, A-8054 Seiersberg-Pirka
Phone: +43 (0)316 255536-0 | office@technikgruppe.com | www.technikgruppe.com

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