Modern technologies for low-calorific waste gas combustion and energy recovery – key elements in improving industrial process efficiency and emission reduction

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Selected facts about ICS

Foundation year 2007, Poznań

Company size: 20 people (mainly engineers, including 3 with a PhD degree). ICS revenues in recent years have been at the level of several to over a dozen million PLN.

Number of projects: 74 industrial projects completed in various forms: from concept designs, through execution projects with deliveries (technology package), to „turnkey" projects.

Main products: industrial fuel combustion systems, including low-calorific gas combustion, optimization of combustion systems including NOx reduction, based on volumetric combustion technology, Heliex electrical energy generators, Multienergy boiler houses, Zero-emission Process Steam Generators.

Patents: 9 granted national patents, 4 European patents (an additional 2 Polish patents and 1 European are in the patenting process).

Selected clients:

Industrial combustion systems

Depending on the quality of the fuels being burned, including waste gases, we apply one of the following technologies:

1. volumetric combustion technology in semi-adiabatic chambers using jet HTB burners for fuels, including low-calorific waste gases (0.75 MJ/Nm³ ÷ 3.0 MJ/Nm³), without catalysts and auxiliary fuel,
2. volumetric combustion technology based on swirl burners for fuels, including waste gases of medium and higher calorific value,
3. volumetric combustion technology in furnace and boiler chambers using jet burners for fuels, including medium and high-calorific gases.

ICS-based systems are characterized by:

1. low emissions of toxic compounds (e.g. NOx), also for multi-fuel systems,
2. minimal or no requirement for high-calorific support fuel to sustain combustion,
3. ability to burn fuels with dynamically changing parameters (calorific value, pressure, temperature, flow),systems that adapt during operation to changing calorific values of fuels,
4. high energy efficiency due to oxidant preheating at high temperature and low excess air,
5. ability to burn/utilize raw fuels, including contaminated and moistened waste gases, without the need for preparation systems (cleaning, pressurizing).

Waste gas combustion systems – ICS experience

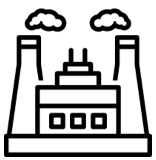
Over the course of its operations, ICS has delivered and commissioned dozens of industrial fuel combustion and combustion process optimization systems, particularly for the utilization of low-calorific waste gases in installations ranging from several to several dozen megawatts. These systems were aimed at recovering energy from waste fuels, reducing emissions of toxic compounds, and improving the energy efficiency of industrial plants.

ICS solutions have been applied, among others, in the following areas:

Distillery industries

Metallurgic industries

Energy industries



Chemical industries

Other industries.

Selected examples of implementation are presented on the following slides

Combustion/Utilization Systems of Waste Gas – KGHM

A project aimed at the management of waste gas – a by-product of copper production, which before implementation was utilized with the use of coal.

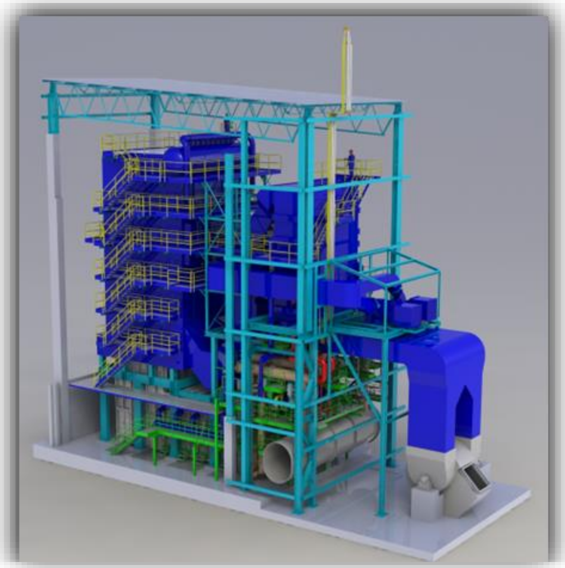


Fig. Waste gas combustion system visualisation

User:	Energetyka, KGHM Polska Miedź S.A. Capital Group
Project status:	completed, 2 boilers, 2009 – 2015
Calorific value:	**1,5 – 2,4 MJ/Nm^3**
Waste gas flow:	up to 65.000,0 Nm^3/h
Boiler capacity:	**up to 50 t/h**
Combustion system power:	up to 50,0 MW
Co-firing capability:	yes, natural gas
Plant:	Głogów Copper Smelter, Poland
Challanges:	Waste gas is a by-product, highly contaminated (especially with sulfur compounds and compounds with strongly corrosive properties), low-calorific, with variable composition and calorific value over time.
Benefits of implementation:	Complete elimination of the need to use coal and minimization of natural gas use as an auxiliary fuel in gas utilization (up to 3%), improvement of the plant's energy efficiency – an increase in steam production efficiency from 64% to approx. 82%, utilization of energy from waste gas for steam and electricity production.

Combustion/Utilization Systems of Waste Gas – KGHM

A project involving the reconstruction of a waste gas combustion system on a grate boiler, burning coal and waste gas.

User:	Energetyka, KGHM Polska Miedź S.A. Capital Group
Project status:	completed, 1 boiler, **2014**
Calorific value:	**1,5 – 2,4 MJ/Nm^3**
Waste gas flow:	up to 48.300,0 Nm^3/h
Boiler capacity:	**up to 32 t/h**
Combustion system power:	up to 32,0 MW
Co-firing capability:	yes, coal
Plant:	Głogów Copper Smelter, Poland

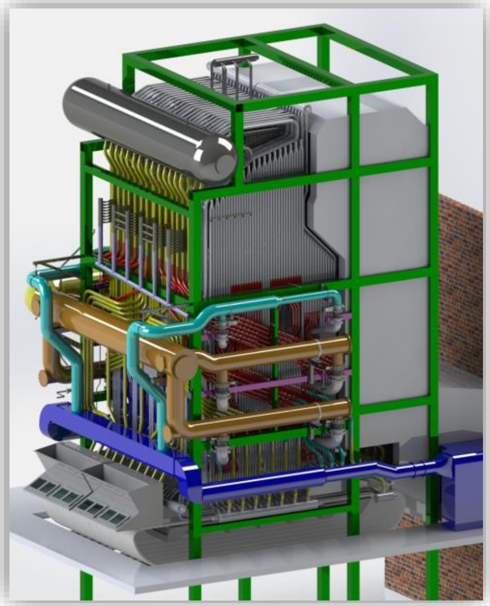


Fig. Waste gas combustion system visualisation

Challanges:	Waste gas is a by-product, highly contaminated (especially with sulfur compounds and compounds with strongly corrosive properties), low-calorific, with variable composition and calorific value over time.
Benefits of implementation:	Reduction of coal consumption by 51%, increase of waste gas utilization capacity by 26% (from 38,300 Nm^3/h to 48,300 Nm^3/h), increase in steam production efficiency from approx. 63% to 69%, improvement of the combustion process quality, payback period estimated at 11.4 months.

Combustion/Utilization Systems of Waste Gas – KGHM

A project aimed at the management of waste gas – a by-product of copper production, which before implementation was utilized with the use of large amounts of natural gas.

Fig. Waste gas combustion system visualisation

User:	Energetyka, KGHM Polska Miedź S.A. Capital Group
Project status:	completed, 3 boilers, **2018 – 2023**
Calorific value:	**1,5 – 2,4 MJ/Nm^3**
Waste gas flow:	up to 45.000,0 Nm^3/h
Boiler capacity:	**up to 35 t/h**
Combustion system power:	up to 35 MW
Co-firing capability:	yes, natural gas
Plant:	Legnica Copper Smelter, Poland
Challanges:	Waste gas is a by-product, highly contaminated, low-calorific, with variable composition and calorific value over time.
Benefits of implementation:	Almost complete elimination of natural gas use as auxiliary fuel in gas utilization (1–2% energetically), improvement of the plant's energy efficiency, utilization of waste gas energy for steam and electricity production.

Combustion/Utilization Systems of Post-Reduction Gas – HCM

A project aimed at the management of post-reduction gas originating from the zinc smelting process in zinc rectification, which before implementation was utilized by flaring.

User:	HCM, Capital Group of Zakłady Górniczo-Hutnicze "Bolesław" S.A.
Project status:	concept design 2024, construction of a full-scale pilot installation on 1 out of 9 columns in 2025
Waste gas flow:	up to 1,700 Nm³/h per column (a total of up to 15,000 Nm³/h for 9 columns)
Calorific value:	**0,76 – 3,6 MJ/Nm³**
Combustion system power:	up to 2.5 MW per column
Co-firing capability:	yes, natural gas
Plant:	Miasteczko Śląskie Zinc Smelter, Poland
Challanges:	Post-reduction gas is a waste gas, low-calorific, with variable composition and calorific value over time, previously utilized by flaring.
Benefits of implementation:	Reduction of natural gas consumption in rectification columns through the use of waste gas, improvement of the plant's energy efficiency, elimination of flaring.

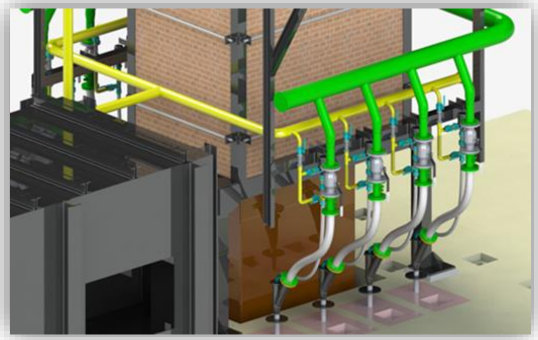


Fig. Visualization after system modifications

Combustion/Utilization Systems of Waste Nitrogen – Orlen

A project aimed at the management of waste nitrogen – a by-product of the natural gas treatment process, containing methane, which is currently released into the atmosphere.

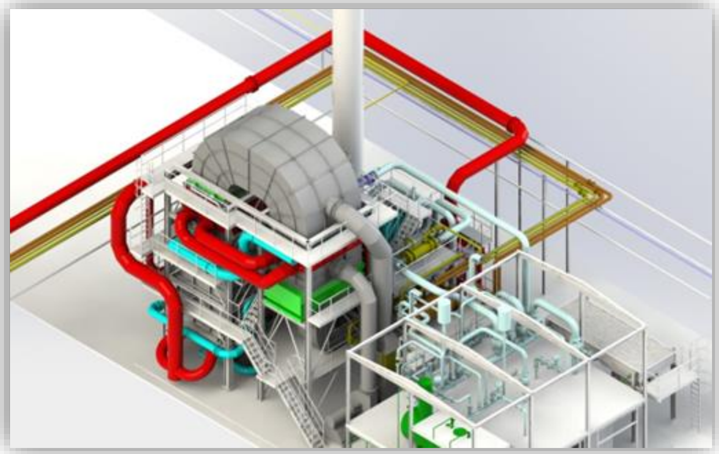


Fig. Visualization of the Waste Nitrogen Combustion System

User:	PGNiG S.A. Zielona Góra, Orlen Group
Project status:	concept design, 2024; contract negotiation, 2025
Calorific value:	**up to 0.72 MJ/Nm³**
Waste gas flow:	several tens of thousands Nm³/h
Combustion system power:	up to 6,5 MW
Co-firing capability:	yes, natural gas
Plant:	Odazotownia Grodzisk Wielkopolski, Polska
Challanges:	Waste nitrogen is a gas generated in the natural gas purification process. It contains a very low methane concentration – up to 2% – and is currently released into the atmosphere.
Benefits of implementation:	Almost complete elimination of natural gas use in technological processes, improvement of the plant's energy efficiency, utilization of waste gas energy for steam and electricity production, combustion without supporting fuel and catalysts.

Combustion/Utilization Systems of Mine Gas – PGNiG

A project aimed at the management of mine gas – a by-product of hard coal mining, containing methane, which was previously flared.

Fig. Front view of the water boiler with built-in burner

User:	PGNiG Termika, Orlen Group
Project status:	completed, 2 boilers, 2025
Calorific value:	**from 10,8 up to 25,2 MJ/Nm^3**
Waste gas flow:	up to 4,000.0 Nm^3/h per boiler
Combustion system power:	15,0 MW per boiler
Co-firing capability:	yes, fuel oil
Plant:	Hard coal mine, Jastrzębie Zdrój, Poland
Challanges:	Mine gas is generated in the process of coal extraction. It is characterized by variable methane content – from 30% to 70% – and before project implementation it was utilized by flaring.
Benefits of implementation:	Improvement of the plant’s energy efficiency, utilization of waste gas energy for hot water production.

Combustion/Utilization of Distillery Syrup – Polmos Żyrardów

A project aimed at the management of distillery syrup – a by-product of alcohol production – through the use of a drying-carbonization chamber installed on a biomass boiler.

User:	Polmos Żyrardów, Moët Hennessy Louis Vuitton Group
Project status:	completed 2023
Calorific value:	**approx. 5,9 MJ/kg**
Waste gas flow:	approx. 85 kg/h
Combustion system power:	140 kW
Plant:	distillery, Żyrardów, Poland

Fig. View of the steam boiler (left) and the HELIEX generator (right)

Challanges:	The issue of managing waste biomass fuels from alcohol production. Distillery syrup is a liquid fuel characterized by low calorific value and high-water content.
Benefits of impementation:	Improvement of the plant's energy efficiency, utilization of energy from waste biomass fuel for steam and electricity production for plant needs, support of a circular economy approach.

Summary

ICS combustion and waste gas utilization systems as well as combustion process optimization systems are:

- Efficient combustion/utilization of waste fuels, enabling the generation of heat or process steam.
- High energy efficiency of processes thanks to energy recovery from combustion and its use for heating substrates, as well as conducting processes with a low oxygen content in flue gases (minimization of stack losses).
- Reduction of CO_2 emissions through minimizing flaring and improving process energy efficiency.
- Short payback period, which under optimal conditions can be less than one year.
- System autonomy, eliminating the need for additional fuels to sustain the combustion process.
- Reduction of production and fuel consumption costs, supporting a circular economy.
- Reduction of NOx, CO, and other toxic compound emissions from combustion processes.

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Thank you for your attention.