



Waste-to-energy technologies

DOOSAN Lentjes

Circular economy: Using waste as a resource

Doosan Lentjes is a pioneer in converting waste to energy. Our success is based on decades of experience in planning and building advanced energy from waste plants. To date, we have contracted almost 80 units around the globe. These facilities make a vital contribution to a sustainable waste management system that uses the potential of waste as a resource in the sense of a circular economy. At the same time, all the solutions we offer are in line with the requirements of the revised European WI BREF documents (Waste Incineration Best Available Techniques Reference).

According to the European waste hierarchy, residual waste that is not ready for recycling should be incinerated in modern waste-to-energy plants. This prevents the waste from being dumped in landfills, which are responsible for releasing harmful greenhouse gas (GHG) emissions with adverse effects on both the environment and public health. The thermal treatment of the waste is thus the final step of a sustainable waste management system.

This approach considers waste as an important resource and promotes the maximum exploitation of its potential in terms of a circular economy: Residual waste contains valuable energy from which 50% is sustainable as it comes from fuel of biogenic origins. Harnessing this energy through recovery from incineration enables it to be used for electricity generation, heating, cooling or industrial applications, thus achieving high conversion efficiencies. This supports efforts to reduce the dependence on fossil fuels, such as, coal or petroleum.

At the same time, processing the bottom ash left over from the incineration allows the recovery of secondary raw materials, such as, ferrous and non-ferrous metals,

aluminium or brass. These metals can be used, for example, in road our house construction, which means that fewer primary raw materials have to be exploited.

While maximising resource efficiency, waste-to-energy plants produce minimum emissions that fully comply with the legally required values according to the revised WI BREF documents of the European Union. The revised guidelines are binding on plant operators with immediate effect and must be implemented within four years.

The bottom line: Waste-to-Energy is an important part of the European waste hierarchy by avoiding landfilling, extracting valuable energy from the waste and recovering secondary materials. Thus, the fully WI BREF-compliant technology makes a significant contribution to the reduction of harmful CO₂ emissions.

Reduce



Reuse



Recycle



Recover



Landfill



Your trusted partner

Doosan Lentjes offers you the right solution to make your waste-to-energy project a success. In fact, we have helped customers around the world discover the dependable, cost-effective and ecological benefits of converting their waste into heat and power for municipal and industrial applications. Our plants incorporate our years of experience and reflect our determination to always be ahead when it comes to technology. This means that our customers benefit from thoroughly engineered solutions that combine tried and tested technologies with innovative processes and best-in-class project management.

Capability and exercise

Doosan Lentjes is an expert in waste-to-energy technologies. We deliver proprietary grate technologies, combustion systems and air quality control systems that provide cost-effective and efficient solutions for all your waste incineration needs. From subsystems to turnkey plants, we design and deliver solutions for maximised energy recovery, providing you with environmentally-sound and cost-effective operations backed by a guarantee of maximum safety and high efficiency. What's more, our commitment to improving the value and performance of our products through ongoing investment in new technologies will ensure that we continue to be at the forefront of developments for waste incineration, shaping the future of the industry.

Chute-to-stack solutions

As part of the global Doosan group, our wide range of products and services makes us your one-stop partner for all your waste-to-energy needs. Our leading technologies in incineration, flue gas cleaning and steam generation are complemented by the latest in steam turbine design from Doosan Skoda Power.

People-powered

Because Doosan understands that sustainable business success depends on people performance, it defined its global 2G strategy meaning that growth of people leads to growth of business and vice versa. We, at Doosan Lentjes, strongly believe in this approach which is why we put extensive efforts into recruiting, training and developing the very best talents of tomorrow. Together with our highly committed staff, we aspire to engineer safe and reliable energy generation solutions that shape a sustainable tomorrow for generations to come.

Manufacturing capabilities

Doosan Lentjes benefits from the Doosan group's international sourcing and manufacturing capabilities. High quality workshops under the full control of Doosan in Changwon/ Korea and Vina/Vietnam provide best practice procurement of goods and services while maintaining and ensuring compliance with laws, regulatory guidelines and internal control procedures. Procurement hubs in Beijing and Shanghai/China supplement Doosan Lentjes' efforts for cost optimised solutions.



Proven technologies from chute...

Trust us to deliver your waste-to-energy requirements using advanced and reliable technologies, such as, grate combustion. Depending on your requirements, we can provide chute-to-stack solutions or full turnkey programmes, relying on expertise that encompasses the full waste-to-energy cycle.

Grate combustion

Grate combustion is a proven thermal waste treatment technology, successfully deployed to hundreds of plants worldwide. Over time, the grate systems have been continuously optimised, perfected and adjusted to adapt to changing baseline conditions and stricter requirements. Today, grate combustion is still the most advanced technology in terms of environmental friendliness, operating reliability, flexibility, and cost-effectiveness.

With close to 80 units to our credit, Doosan Lentjes is one of the world's leading specialists in grate combustion. Our commitment to

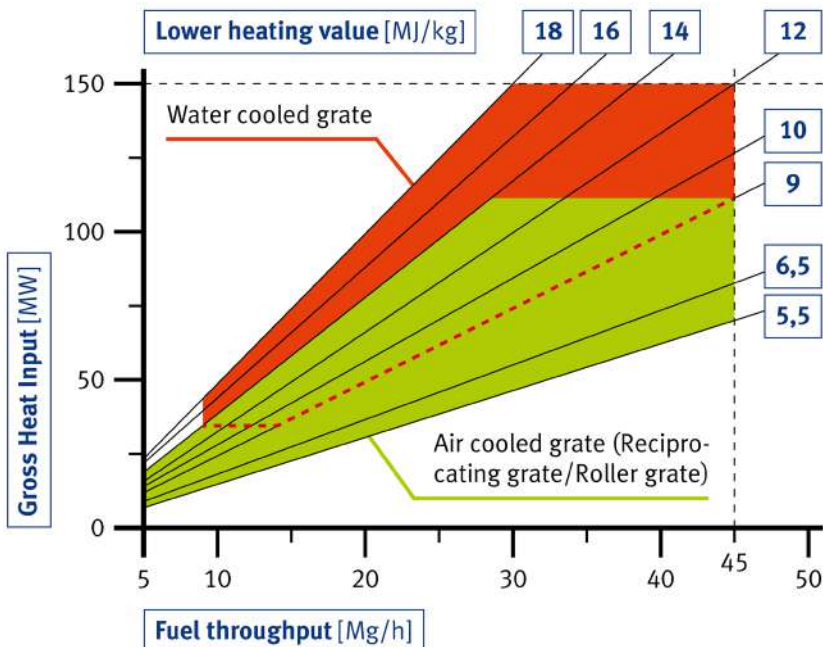
ongoing research and development has contributed significantly to the advanced state of today's technologies. Our modern grate combustion offers unbeatable flexibility when it comes to fuels. Available in various configurations for the reliable burnout of waste across the entire calorific value range from 6.0 to 18 MJ/kg, our rugged construction allows domestic and commercial waste to be burnt without pre-treatment.

Our reciprocating grate features adjustable grate bars that move back and forth between fixed bars. Three sections are installed and

the width of the grate is tailored to suit the moisture content, calorific value and composition of the waste. With low wear and tear and a high thermal load-bearing capacity of roughly 1MW/m², our water-cooled grate is suitable for the incineration of high-calorific waste, such as, solid recovered fuel. The roller grate consists of six graded cylindrical rolls switched in a row, the revolutions of which may be regulated to adapt to different waste incineration behaviour. The roller surfaces are cooled continuously by the primary air, which also enables higher calorific waste to be fed in.

Range of application

Doosan Lentjes' grate firing technologies are designed to handle up to 45 tons of waste per hour in a single unit. Higher total plant throughputs can be achieved by building several units. Depending on the waste composition and the corresponding calorific value, we help you select the grate type best suited. With tailor-made combustion chamber design and optimised steam generator parameters our air or water-cooled proprietary grate systems provide the highest performance and reliability.



Boiler concepts

Our leading in-house boiler designs can achieve maximum efficiencies through optimum steam parameters and minimum heat losses. What's more, our boiler engineering features greatest flexibility in respect of individual space requirements: Adapting our designs to certain local site conditions allows us to deliver a boiler concept fully integrated into required structures.

Combustion control

Our smart in-house combustion control solutions assure highest plant availabilities, as well as, a reliable facility operation. So you harness the maximum performance potential of your incinerated waste even when featuring changing combustion properties.

Turbo-powered

Our steam turbines from Doosan Skoda Power are designed to meet the challenge of substantial variation in heating rates from the waste incineration process. We work closely with you to ensure our precision turbines are tailored to the specific steam parameters of your chosen incineration technology, ensuring that the steam produced is harnessed in the most efficient way possible.

Heat

Steam or hot water as district heating for households and businesses or as process heat for industrial use.

Electric Power

From steam-driven turbo generators, for households, businesses and industry.

Secondary Materials

Recovery from bottom ash, for construction and house building purposes.

Energy recovery

Recovery of the energy content of waste is a key aspect of thermal waste treatment and at Doosan Lentjes, our focus is always on achieving the highest efficiency. Of the energy initially contained in the waste, we help you to recover more than 65 percent for use by households and industry. Whether you choose to supply electric power and/or heat to a city or opt to meet the energy requirements of an industrial plant, waste-to-energy is environmentally-safe, reliable and economical.

Air quality control

Choose from our different flue gas cleaning technologies, including dry or wet scrubbing, selective catalytic or non-catalytic reduction, absorption and adsorption processes, to achieve reliable compliance with all applicable international emission regulations.

... to-stack and beyond

Flue gas cleaning

Our advanced flue gas cleaning (FGC) systems are designed to reliably remove all critical pollutants from the flue gas while securing maximum cost-efficiency. Depending on your individual requirements, you can select from a number of FGC technologies to be applied to your process. Apart from sophisticated, multi-stage scrubber systems, we offer two main cost-efficient processes also fully complying with European emission limits as per the WI BREF (Waste Incineration Best Available Techniques Reference) directives: Our semi-dry Circoclean® and a straightforward, dry process called FER-DI® (Flexible Economic Reagent Direct Injection).

In the Circoclean® system, the flue gas flows, bottom-up, through a reactor where the chemical reactions between pollutants and absorbents, as well as, the physical adsorption take place. Hydrated lime and activated carbon are used for adsorbing acid gases, such as SO_x, HCl, HF, as well as adsorbing hydrocarbons, such as dioxins and furans and heavy metals like mercury. After the cleaning process in the reactor, the solid particles are separated in a downstream bag filter.

A large amount of the separated particles is fed back into the Circoclean® reactor which improves the consumption efficiency of the utilized reagents. This allows coping with highest loads of pollutants and sudden changes in their concentration whilst complying with emission limits. The recirculation of the clean gas secures stable flow conditions and balances different boiler loads. Injecting water directly into the reactor

allows optimizing the reaction conditions for the absorption process in terms of temperature control and local humidity. The cleaned gas is released into the atmosphere through the ID fan and stack.

The straightforward FER-DI® process is especially suitable for moderate concentrations of harmful substances including acid gases, such as, SO_x, HCl, HF, as well as hydrocarbons, such as, dioxins and furans and heavy metals like mercury. The removal agent which can either be sodium bicarbonate or hydrated lime (in combination with activated carbon, if required) is directly injected into the hot flue gas passing through the ducting area downstream of the boiler. After this cleaning process step, solid particles are removed from the flue gas. And because only a relatively small amount of solid particles is fed back, a recirculation of the clean gas is not required. This allows the plant to feature a compact design with a reduced footprint and, thus, lowering the investment costs.

Residue treatment

An efficient thermal waste treatment generates innocuous residues that, if properly handled, do not emit any pollutants into the environment. These substances include grate bottom ash, as well as, residues from flue gas cleaning. We deploy a number of proven processes to recover reusable resources from the substances, including bottom ash treatment for the recovery of ferrous and non-ferrous metals, waste-water treatment and solidification of residues.

Removal
of multi
pollutants

Compliance
with revised
WI BREF
requirements

Recovery
of valuable
resources

Waste-to-energy as a sustainable energy source

The most common thermal treatment of waste worldwide is incineration, but there is no 'one size fits all' solution. The size and site of the plant will influence the type of technology chosen by Doosan Lentjes.

Waste-to-energy plants consist of a number of differing components – fuel, plant and location being just a few. While the waste will differ from one bag to the next, our experience makes it easy for us to calculate important properties, such as, the energy available in the waste and the renewable content – details which are critical when selecting the best solution. The technology chosen needs to match the waste fuel in terms of both physical properties and environmental impact.

Despite the variants, however, all waste-to-energy plants incorporate the same basic stages:

Illustration below left: Two-track air cooled counter-reciprocating grate
Illustration top right: Roller grate

1. Reception area

In the reception and storage area waste is received and bulky material can be shredded. The bunker storage balances different delivery quantities (eg. over weekends) and allows for mixing in order to improve fuel quality.

2. Thermal treatment

The thermal treatment takes place on the Doosan Lentjes grate system converting the waste into an energy-rich gas. What remains from this step is an environmentally-neutral bottom ash that can be used for construction purposes.

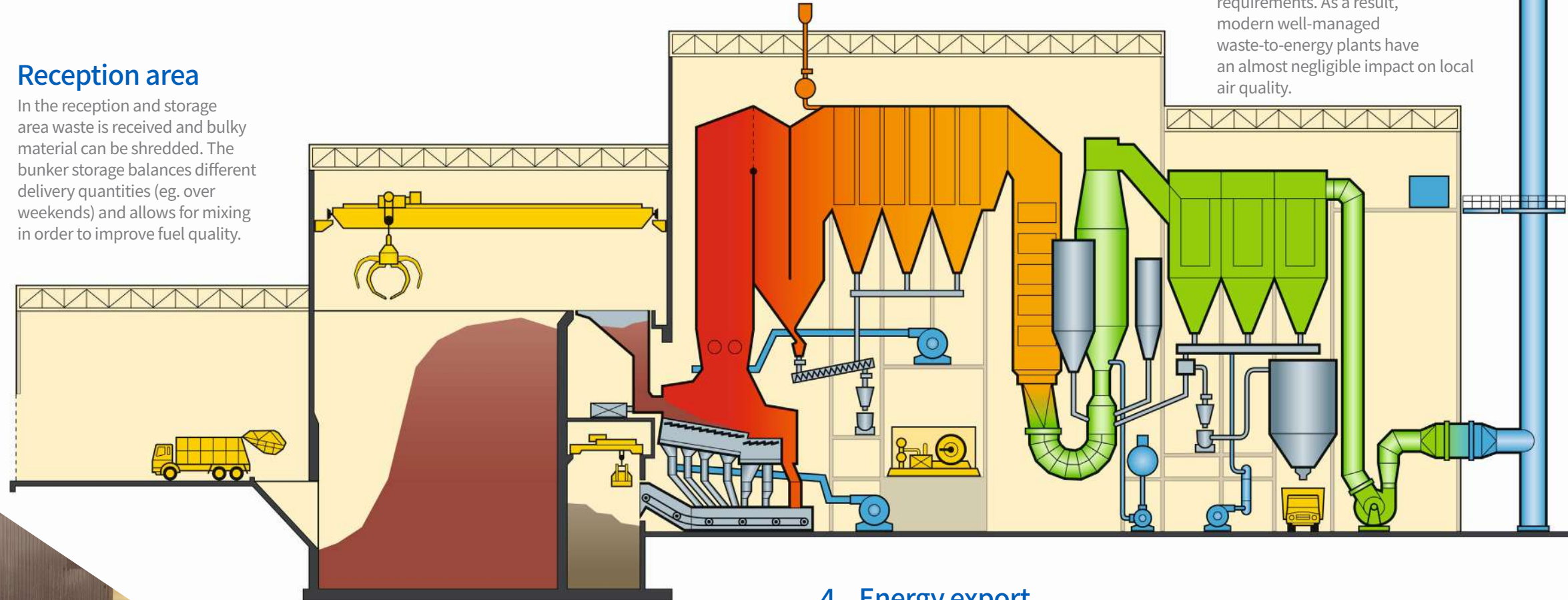
3. Emissions clean-up

The potential health implications of emissions are understandably a focus of concern, which is why our emissions clean-up process ensures that all waste gases emitted from the plant meet stringent regulatory requirements. As a result, modern well-managed waste-to-energy plants have an almost negligible impact on local air quality.

4. Energy export

The steam produced by the hot gases in the boiler is fed into a steam turbine to generate electricity, the main part of which is exported to the grid. In addition, the steam can be directly used for industrial processes or for district heating purposes.

The overall environmental benefits depend not only on the thermal treatment, but also on the energy conversion technology to which it is coupled. It is important to consider overall efficiency, net of any energy required to run the process. Waste-to-energy plants from Doosan Lentjes have a number of potential advantages, including a variety of potential energy output.





Taoyuan, Taiwan

Contract award: 1998

Main fuel: municipal waste

Number of lines: 2

Waste capacity: 450,000 t/a

In 1998, Doosan Lentjes was selected to deliver a new waste-to-energy plant in Taoyuan, Taiwan.

The plant combines our proven roller grate and steam generator technologies to produce electricity and heat. Doosan Lentjes provided the entire plant on a full turnkey basis.

The Taoyuan facility consists of two lines capable of processing up to 450,000 tons of municipal solid waste per year and has a proven, exceptional performance. This ensures a safe waste disposal and 36MW_e energy supply to the national power grid, in addition, to a significant heat supply.

Global references

Today, our advanced waste-to-energy technologies convert millions of tonnes of waste into valuable energy every year, serving as testament to our professionalism and expertise. Customers around the world trust our competence in planning, engineering, manufacturing, constructing, commissioning, and delivering their facilities on schedule and to a high degree of quality.

Krakow, Poland

Contract award: 2012

Main fuels: municipal, bulky and similar pretreated waste

Number of lines: 2

Waste capacity: 220,000 t/a

Doosan Lentjes was subcontracted by POSCO E&C, the main contractor, to provide core grate and boiler components for the new two-line waste-to-energy plant in Krakow, Poland, owned by Krakowski Holding Komunalny.

Designed for optimal energy recovery and compliance with emissions values below the European standards (Industrial Emissions Directive), the plant serves as a role model for new EU member states.



Budapest, Hungary

Contract award: 2002

Main fuels: municipal solid waste

Number of lines: 4

Waste capacity: 480,000 t/a

In 2002, **Doosan Lentjes** was commissioned by FKF RT to carry out an major modernisation and rehabilitation of their waste-to-energy plant located in Budapest, Hungary. This project comprised the replacement of the four existing boilers including the roller grate system and the installation of a new flue gas cleaning system. The work resulted in an increased plant availability and ensured full compliance with the strict emission guidelines.

Harlingen, the Netherlands

Contract award: 2009

Main fuels: municipal, bulky and similar pretreated waste

Number of lines: 1

Waste capacity: 230,000 t/a

Doosan Lentjes was contracted by Dutch waste management specialist Omrin in 2008 to undertake the development, manufacture and installation of the grate, boiler and balance of plant (BoP) for the REC Harlingen waste incineration facility in the Netherlands. Low operating costs and high availability were achieved through a single high-capacity incineration line and an integrated additional gas-fired superheater to avoid high temperature corrosion while maintaining optimum boiler efficiency. The plant delivers overall process efficiency of more than 80 percent.



Handling growing amounts of waste

Doosan Lentjes is your experienced partner when it comes to future waste management challenges. As a reliable provider of state-of-the-art waste-to-energy solutions, we help you to flexibly handle the growing amounts of municipal solid waste produced while reducing the negative environmental impact of waste disposal.

Worldwide mega trend

The world is facing a continuous increase in population which is equivalent to a growing urbanisation that has evolved into a global mega trend: Until 2030, more than 5 billion people are expected to live in cities, two billion more than today. This development leads to growing amounts of municipal solid waste being generated: In so-called mega cities, the annual volume of waste is assumed to increase by up to 2.2 billion tonnes until 2025. Given this background, the application of advanced technologies for thermal waste treatment is the solution of choice: Increasing amounts of waste are reliably reduced while the need for landfill sites decreases.

Large-scale solutions

We, at Doosan Lentjes, understand the certain requirements imposed towards thermal waste treatment technologies in the context of global urbanisation trends: Our modern waste-to-energy solutions designed to handle increasing volumes of waste, feature efficient, multi-line incineration systems with large single units. What's more, with respect to securing long-term flexibility, these units are capable of processing waste with continuously changing qualities and compositions.

Drawing back on decades of experience in large-scale waste-to-energy applications, we have the know-how to enable you to meet even the most demanding waste management challenges resulting from increasing quantities to be treated. Our grate-based incineration solutions have proven their efficiencies in plants built around the globe: Close to 80 units contracted to date, thermally treat millions of tonnes of solid waste. Thanks to our flexible, single units with capacities of up to 300,000 tonnes per year, our clients are in a position to reliably handle even the largest amounts of waste with changing incineration behaviour. In combination with highest plant availability and maximum cost-efficiency, our solutions help our customers to secure a safe, long-term, waste disposal while keeping operating costs at a minimum – both are critical success factors to secure a successful business performance, now and in the future.

The bottom line: Large-scale WtE solutions are the response to handling growing amounts of residual waste produced in the context of global urbanisation trends.

Profile: Metropolitan area of Bangkok, Thailand

Citizens: Roughly 16.9 million

MSW generation: 10 million t/a



Madeira, Portugal

Integrated waste treatment centre

Fuel:
Municipal solid waste

Contract award: 1998
Number of lines: 2
Waste capacity: 128,000 t/a

In 1998, **Doosan Lentjes** was awarded the turnkey contract by the Autonomic Region of Madeira to deliver an integrated waste treatment centre in Madeira, Portugal.

The plant comprised both waste-to-energy plant inclusive of a clinic and slaughter waste incineration unit and bio-composting facilities along with a landfill for slag and residues.

Following the requirements of the European waste hierarchy, the government separates as much as possible into the fraction of bio waste for composting and residual waste for incineration, to minimize the waste which has to be landfilled.

With Doosan Lentjes as the sole EPC provider, the client benefited from receiving an integrated waste treatment solution from one single source.



Considering individual waste properties

With decades of experience in global waste-to-energy projects, Doosan Lentjes offers you the right solution for your individual type of waste. Our advanced waste treatment plant designs are tailored to the requirements of fuel compositions and properties to secure a maximum combustion efficiency.

Global variations

The economic development of a country measured by the level of income has a significant impact on its waste composition and properties. So, in low-income countries, the share of low caloric-valued organic matter in the total waste volume can be more than 60% compared to less than 30% in high-income countries. However, in low-income countries, high calorific-valued paper waste accounts for only 5% whereas for more than 30% in high-income countries.

Apart from the economic situation, also other factors have the potential to influence the properties of the waste generated: These include climate conditions in the form of precipitation frequencies, as well as, geographical locations determining the utilisation of certain materials, such as, wood for e.g. building purposes.

Prioritise customisation

We, at Doosan Lentjes, understand that locally different waste compositions and properties require the applied combustion concept to be individually adapted enabling an efficient burn-out of the fuel. With this in mind, we have developed advanced combustion solutions for a number of different applications with calorific values ranging from 5.5 – 16 MJ/ kg and hourly throughputs of 8 – 50 tons per line. Depending on the particular application, we help our customers select the most suitable grate type and combustion chamber concept while customising the designs to individual requirements.

Pre-treatment

To ensure an efficient handling of waste with locally different compositions and properties, an appropriate mechanical biological pre-treatment might be required. Consisting of process steps for separation, digestion or drying, the pre-treatment plant aims at processing waste which is not suitable for recycling or recovery. Apart from recyclables, the pre-treatment process produces green fuels with higher calorific values positively influencing the overall incineration efficiency achieved in the WtE plant.

As an experienced partner for the efficient handling of waste across the calorific value range, we evaluate your waste compositions and properties and are in a position to deliver a fully integrated waste treatment centre. With the entire solution delivered from one source, you benefit from reducing interfaces and receiving an optimally harmonised plant design.

Added value: Long-term focused data evaluation

Modern waste-to-energy plants are complex systems that should run on advanced software monitoring solutions delivering high quality process data from all relevant sources of the facility. Evaluating these data over a longer period secures that your plant runs successfully in the long-term.

Integrated control tools

Integrated control tools (ICT), such as, Symphony Plus Historian (SPH)[®]* help you to reliably collect, store and access data from different sources of the waste-to-energy (WtE) plant with only one single interface. Analysing these data allows identifying potentials for improving the plant performance.

Trends identification

Doosan Lentjes helps you to get more value from your data by enhancing conventional short-term monitoring activities: We analyse, compare and evaluate the collected data in the context

of a longer period of time to identify trends and developments indicating operation conditions that negatively influence your future plant performance: For this purpose, all selected data collected in the WtE facility are transferred online to our local Symphony Plus Historian (SPH)[®]* server enabling an in-depth analysis and evaluation carried out by our dedicated experts. They develop tailor-made solutions for optimising your plant's long-term performance and reducing maintenance efforts. Drawing back on our expertise allows you to avoid expensive plant downtimes affecting your future business success.

* Symphony Plus Historian (SPH)[®]:
Trademark of ABB



Customer-orientation

Global reach

World-class technologies and innovation

Worldwide project execution

Your benefits with us at a glance

- Excellent engineering spirit combined with a wealth of experience in international project management
- Almost 30 years of experience in WtE being equivalent to close to 80 units contracted to date around the globe
- World-class grate-based WtE solutions
- Highly efficient incineration and energy, as well as, material recovery from a wide range of waste compositions and qualities
- Together with the global Doosan group, one-stop partner for all WtE requirements
- Compliance with the most stringent international emissions reduction requirements
- High process flexibility through adaptability to changing fuel compositions and qualities
- Cost-efficient constructability through modular solutions flexibly adaptable to individual requirements
- High plant availability
- Continuous investments in in-house research and development activities to ensure ongoing innovation and improvement
- Tailor-made after-sales services encompassing maintenance and modernisation

Virtual Plant Tour

Waste-to-energy in 360° at Doosan Lentjes

Visit our homepage and take a virtual journey through our WtE facilities around the globe – a great opportunity for you to experience our reference plants in an impressive 360° environment and convince yourself of our capabilities! To start the tours, please type the address below in your internet browser and open the Virtual Doosan World.

www.doosanlentjes.com



Doosan Lentjes

Doosan Lentjes provides proprietary environmental technologies for thermal waste treatment and energy generation. Our areas of expertise include the incineration of renewable fuels such as waste, sewage sludge and biomass, heat recovery systems and flue gas cleaning equipment. We deliver flexible solutions for long-term waste disposal safety and climate-friendly steam and power generation.

As a member of the global Doosan Group, Doosan Lentjes is part of a strong international network of companies providing complementary technologies, skills and value to customers the world over.

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