

## **TwinRec Gasification and Ash Melting Technology – Now also established for Municipal Waste**

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### **ABSTRACT**

EBARA's TwinRec is fluidised bed gasification with ash vitrification, designed for material recycling, energy recovery and detoxification of wastes in an integrated, economical process.

TwinRec treats a variety of waste materials, like shredder residues, waste plastics, but also electronics waste and other industrial residues, municipal waste and sewage sludge.

The gasifier features internal bed circulation combined with external metals separation. It is operated at around 550 °C at atmospheric pressure conditions. The metal in the waste is recycled in excellent quality, as it is neither burned nor molten or sintered in the process. The fine ash, char and combustible gas is transferred to the second stage, the cyclonic combustion chamber. Here, air addition releases the energy necessary to vitrify the ash, which is recycled as stable glass granulate.

This way, TwinRec turns waste materials into recyclable metals, construction materials and energy – valorising up to 95% of the waste.

EBARA's TwinRec process is in commercial operation since 2000. Since our presentation in 2001, additional 10 process lines have started operation, and several more are currently under commissioning. We will report from plants which treat shredder residues, municipal waste and various other materials and how they achieve excellent recycling results.

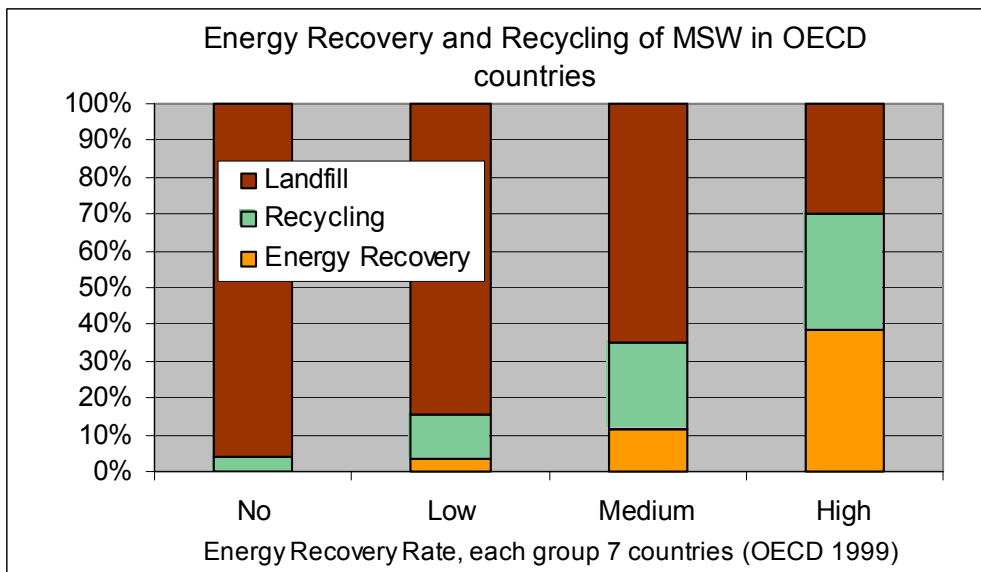
With the recent decision of Kuala Lumpur for a TwinRec plant to treat 62 t/h of municipal waste, the technology is now likely to be the globally most successful waste gasification technology.

**Waste materials – valuable resource or environmental threat?**

In fact, a sustainable waste treatment process has to address both aspects of a waste: recovery of the resources, but also destruction or transformation of the toxic potential. After instalment of waste management strategies based on a reduce-reuse-recycle-recover hierarchy in most developed countries, recycling and recovery has often displaced detoxification as the main driver for waste management.

Landfill bans for combustible waste or at least drastically rising landfill taxes are installed in a growing number of countries, i.e. Switzerland, Austria, Germany, UK and the Netherlands. Furthermore, several EU Directives have set recycling and recovery targets which will divert the addressed waste materials from landfill. Finally, the EU Directive “landfill of wastes” requires diversion of 65% of biodegradable waste from landfill by – the latest – 2020.

Generally, it can be observed that countries which have adopted energy recovery from waste as part of an integrated waste management strategy have also the more advanced waste recycling schemes. So, in advanced integrated waste management schemes, recycling and energy recovery grow in parallel. Figure 1 compares recycling quotas and energy recovery (incineration) quotas for 28 OECD countries. The trend is obvious: The more recycling – the more energy recovery (and vice versa).



*Fig. 1 Municipal solid waste recycling and energy recovery in 28 OECD countries (OECD environmental compendium 1999)*

Consequently, an ideal waste treatment process would combine all three goals in one process:

- complete destruction of the toxic potential of the waste
- maximised recycling of metals and construction materials
- efficient energy recovery.

## TwinRec – thermal treatment, metal recycling and energy recovery

### Process description

Since year 2000, EBARA's TwinRec process is in operation in large commercial installations. It is based on fluidised bed gasification in combination with ash melting. The following description is focused on the core components of the TwinRec system: the fluidised bed gasifier and the cyclonic ash melting chamber.

Any type of waste can be fed to the gasifier. Only bulky wastes need to be cut to pieces smaller 300 mm. Car shredder residues, for example, are fed to the gasifier without any additional preparation, just as delivered from the shredder plant. The gasifier is a proprietary internally circulating fluidised bed of compact dimensions, operated at temperatures between 500 - 600°C. Together with the resulting fuel gas, fine particles are entrained into the gas flow leaving the gasifier. The low gasification temperature in the fluidised bed leads to easily controllable process conditions.

The main function of the gasifier is separation of the combustible portion and the dust from the inert and metallic particles of the waste. Metals contained in the waste, like aluminium, copper and iron, can be recycled as valuable products from the bottom off-stream of the gasifier as they are neither oxidised nor sintered with other ash components. Together with these metals, larger inert particles are removed. Smaller inerts are returned to the gasifier where they serve as bed material. The fine inerts are blown out of the gasifier to enter the next stage.

Figure 2 shows schematically the gasifier and the ash melting furnace.

Fuel gas and carbonaceous particles, both produced in the gasifier, are burnt together in the cyclonic ash melting chamber at temperatures between 1'350-1'450 °C by addition of secondary air. Here, the fine particles are collected on the walls, where they are vitrified and proceed slowly through the furnace.

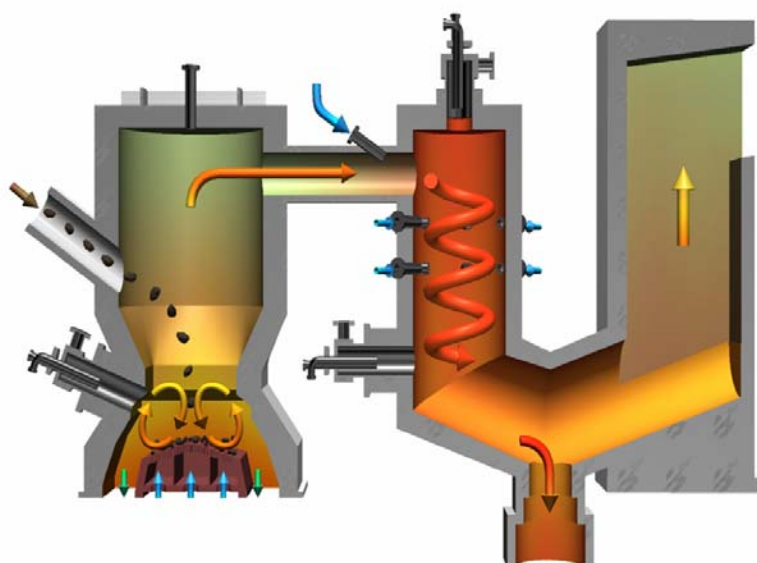


Fig. 2 TwinRec core components – Gasifier and ash melting furnace

The molten slag is quenched into a water bath to form a granulate with excellent leaching resistance, meeting safely all common regulations for recycling in construction.

The high combustion temperature ensures that the most stringent dioxin emission regulations down to 0.1 ng TE/Nm<sup>3</sup> are met with minimal air pollution control measures.

Gasifier and ash melting furnace operate at atmospheric conditions, without consumption of fossil fuels (except for start-up) and oxygen. Due to the low excess air ratio, only a compact sized steam generator and air pollution control unit are required. The energy content of the waste is converted into electricity and/or district heat with high net efficiency.

### Recycling and recovery results

Looking at the wide range of components in all the wastes suitable for TwinRec, the process generates product streams which fit to their characteristics and enable the best use of them:

- Pure metals and alloys are recovered in superior quality from the gasifier and are recycled
- Inert mineral material is cleaned from dust and organic matter to make it suitable for recycling
- Mineral dust and metal oxide powder is vitrified into the glass granulate and recycled afterwards
- Any harmful organic substances are completely destroyed and the total organic content is transformed into energy
- Volatile metal salts are concentrated into the secondary fly ash and available for zinc, lead and copper recycling in the zinc industry
- The amount of final residues for landfill is can be reduced as desired from ecological and economical targets, down to values not yet known to the industry

The energy efficiency of TwinRec is better than in thermal waste treatment processes which require oxygen and consume therefore a good part of the energy internally. Also, the ash melting furnace is integrated into the water steam cycle, making use of the highest temperature level for steam production.

### Recycling of the glass granulate

The glass granulate is the largest fraction for recycling. For a successful application in the construction industry, it must satisfy technical criteria and pass the respective environmental certification.

Technically, the granulate qualifies for various applications, replacing cullet, gravel or sand. It can be applied as loose bulk material, or as filler in combination with inorganic or organic binders. In Japan, the granulate is used as a filler in asphalt.

The main environmental test is usually a leaching procedure, with specific requirements of maximum concentrations in the leachate. The harmonization of these leaching procedures between EU countries or even internationally is still in a very early stage. As a result, different sets of rules are applied in each country.

Fortunately, the TwinRec glass granulate has proven to comply easily with all kinds of leaching tests:

### **Germany**

Besides individual regulation in the German countries, recycling of waste materials in construction is subject to LAGA Z2 compliance, based on the DEV S4 (DIN 38 414-4) leaching process. Leaching of the TwinRec glass granulate (original or after grinding) is a below detection limit for the metals, and for halogenides a few percent of the limit. Of course, no ageing is necessary before recycling.

### **Netherlands**

The Dutch building materials decree prescribes a column leaching test (NEN 7343). Again, most parameters are below detection limits for the TwinRec glass granulate or at a small fraction of the category N2 limits.

### **Japan**

The Japanese leaching test is similar to the German, but the material is ground to 2mm first. All parameters are found below detection limit. As mentioned below, the TwinRec glass granulate is already recycled in large quantities by the construction industry.

### **Switzerland**

In Switzerland, recycling of residues from waste treatment is generally discouraged. Instead, a special (low-cost) category of landfill is announced for high-quality glass granulates. An extensive study was sponsored by the Swiss Agency for the Environment, Forests and Landscape (SAEFL) to investigate the long-term behaviour of such glass materials. TwinRec glass was provided for this study. The result was, that the glass (like others) has excellent properties for a safe, long term storage.

## **TwinRec experience**

### Aomori plant in commercial operation since 2000

The Aomori plant has a thermal capacity of 2 x 40 MW, corresponding to 2 x 60'000 t shredder residue (SR) per year. The SR is delivered from 5 shredder plants (input to shredder: cars and brown/white goods) and by 2 non-ferrous separation plants. All shredder residues are fed to the gasifier without pre-treatment. After the shredder process, the waste size fits perfectly with the waste specification for the TwinRec technology.

In addition the SR, the plant is treating mechanically dewatered sewage sludge, in amounts from 0-30% of the SR amount. Other waste plastic materials are treated at times. Recently, a hospital waste feeding system was installed, which is now feeding sealed boxes of hospital waste directly into the TwinRec gasifier. Other waste recently fed in 1'000 t quantities was bone meal.

Commissioning started in February 2000. Until February 2003, more than 180'000 t of SR and 30'000 t of sewage sludge were treated. The flexibility concerning sewage sludge co-treatment was demonstrated with various amounts of sludge, including SR treatment alone.

Fig. 3 summarises the dual energy and material recycling as it is demonstrated in Aomori: Magnetic metals, after their separation at the TwinRec plant, are delivered to the shredder plant and recycled to the scrap industry. Non-ferrous metals (mainly copper and aluminium, and also stainless steel) as well as the gasifier bottom ash fraction are pre-separated on the plant, then processed to a specialised non-ferrous separation plant. With that scheme, the existing equipment optimised for metals separation can be used. Copper, aluminium and stainless steel of good quality are sold to the respective metal markets.

The molten glass product fulfils the stringent Japanese soil standard. After grinding, it is sold to the construction industry, where it is currently used as a filler in asphalt. The zinc-rich filter ash is recycled in the zinc industry.

The energy content of the SR is converted to electricity, which is used to operate other plants of the same company; the excess is fed to the grid.

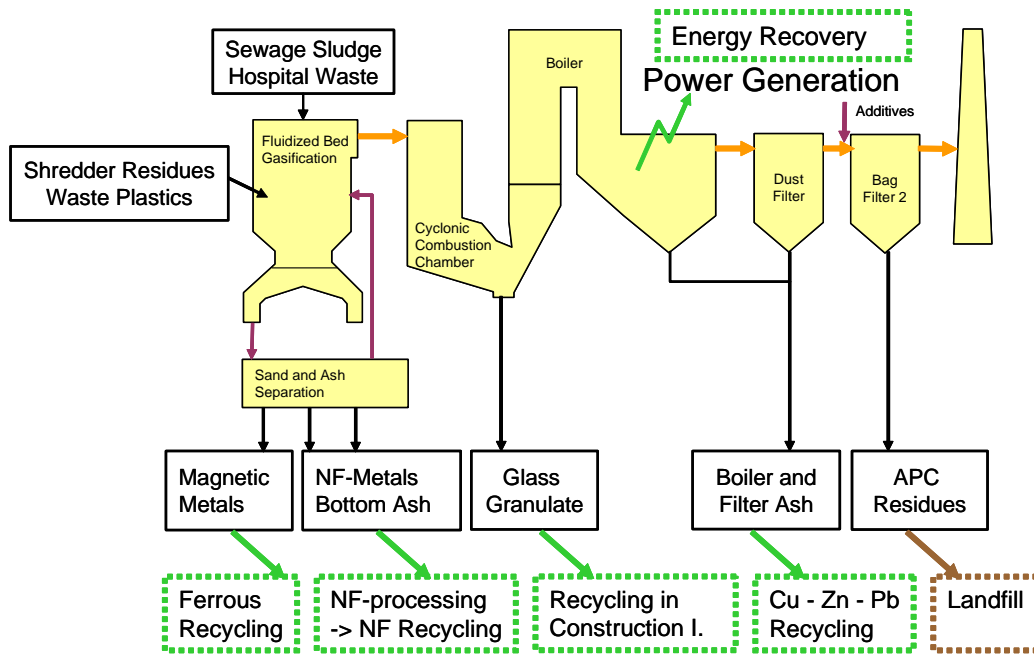


Fig. 3 Combined energy and material recycling at the Aomori plant

Experience from 14 commercial process lines

Since the start-up of the Aomori plant, several more TwinRec plants have been started, resulting in the experience from 20 process lines in operation to date.

A variety of wastes is treated, from waste plastics, SR, sludges, industrial waste, WEEE and slags to municipal solid waste (MSW).

Different as the wastes treated and the capacity of the plants is also the appearance of the plants, as depicted in Fig. 4.

Recently, the Kawaguchi plant was started, treating 18 t/h of municipal solid waste in three process lines (3 x 21 MW).

In addition to vitrification of its own ashes, bottom and fly ash of another incinerator is vitrified in the ash melting furnace. Additionally, some of the secondary fly ash is recirculated and even the inert gasifier bottom ash, after metals separation, is ground and fed back to the ash melting furnace. This way, more than 97% of the waste input are turned into energy, metals and glass granulate for recycling!



*Fig. 4 TwinRec plants in Aomori, Kawaguchi, Kurobe, Sakata and Joetsu*

#### World's largest waste gasification and ash melting plant

On February 7<sup>th</sup> 2003, EBARA announced that it has acquired a major project against serious international competition:

Malaysia's Ministry of Housing and Local Government has decided on EBARA's TwinRec technology for the first thermal waste treatment plant of the country.

The plant, which will be located in Kuala Lumpur, has a total capacity of 1500 t/d (62.5 t/h) MSW in 5 process lines of 300 t/d each. After 38 month of construction, the plant will be world's largest waste gasification and ash melting plant.

#### **Case Study – EU directive's ultimate goals met at minimum cost**

TwinRec is designed to combine material recycling (metals, mineral components, ash) with energy recovery. This concept fits ideally to the goals set by the EU Directive ELV, which requires in its final stage 95% of recycling and recovery of the car.

The TwinRec gasifier, besides detoxification of the organic material, separates the remaining metals and large inert particles from the combustibles and fine ash, therefore maximizing the total metal recovery from the end-of-life vehicles.

The combustible gas and the fine char are used to vitrify the ashes and fine particles, turning these into a recyclable, inert construction material.

Of course the excess energy is recovered with a steam boiler, available either for direct steam and heat use, or for power generation in a steam turbine.

If desired, the recycling percentage can be further increased by recovering zinc, lead and copper from the secondary fly ash. In total, the amount of SR left for landfill can be reduced to less than 5% of the SR amount, resulting in a total recycling and recovery of the ELV of 99%!

The gate fee of a TwinRec plant for SR will be in the range of 20-50 € per car, which corresponds to the cost of just half a tank filling of gasoline.

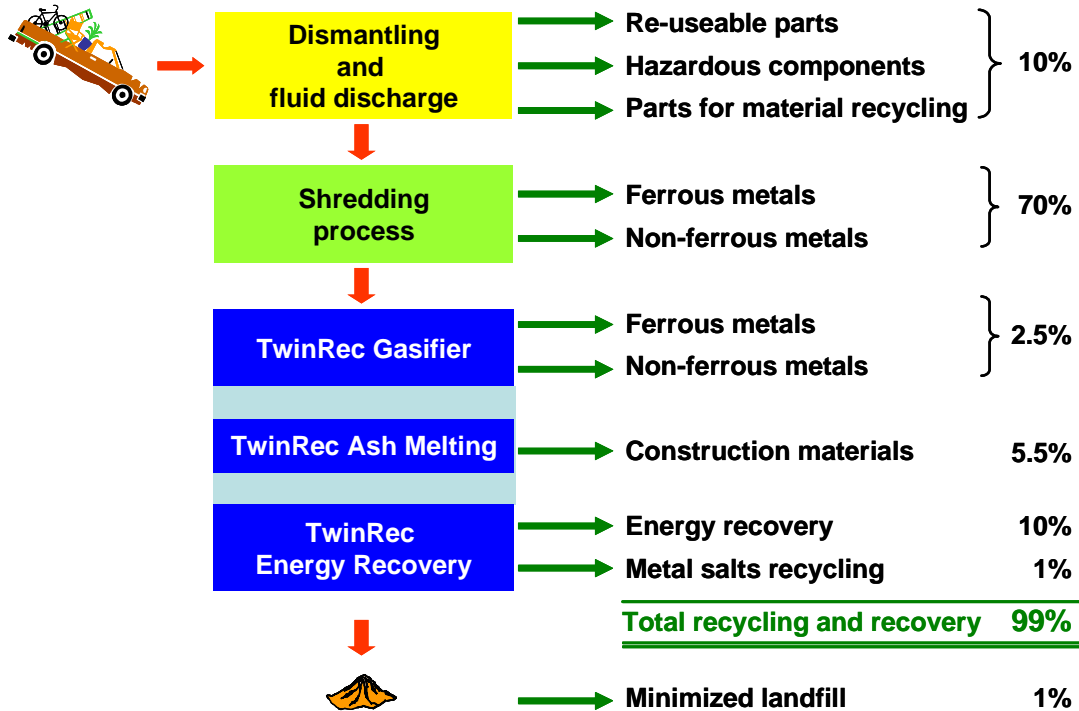


Fig. 5 Stepping up to 99% recycling and recovery with TwinRec

### Outlook: TwinRec for Gasification of Municipal Solid Waste

In direct comparison with the currently more common stoker grate incineration of MSW, TwinRec gasification offers a number of advantages: More and cleaner metals and inert materials can be recycled directly from the bottom ash, while the fines are converted into a vitrified, inert construction material without jeopardizing an efficient energy recovery.

Based on gasification, the process requires low amounts of air, resulting in reduced overall emissions. Most notably, as demonstrated in our reference installation, it is now possible to recycle and recover MSW to a degree not possible before.

Finally, a solid waste gasification process has demonstrated through commercial plants of various sizes, running with multiple kinds of wastes, that it is mature, reliable, efficient and therefore a perfect solution for current and oncoming waste management applications.