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Sizing of a power plant at the landfill site

Jury

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ملخص

بعد نجاح الدول الأوروبية في استكمال العديد من محطات تحويل النفايات إلى طاقة, وانتقال هذه العدوى الايجابية إلى كل من اليابان والصين وكوريا الجنوبية, والمعروفة بالتعداد السكاني الهائل والذي يزداد مع مرور الوقت, وبالتالي فإن كمية النفايات هي الأزمة الحقيقية لهذه البلدان.والآن انتقلت هذه التكنولوجيا إلى إفريقيا عبر بوابة إثيوبيا, والمعروفة بكمية النفايات التي تغطي العاصمة الإثيوبية أديس أبابا, بكتلة تبلغ حوالي 3 هكتارات من النفايات.واستثمرت إثيوبيا ب 95 مليون دولار لإنشاء هذه المحطة ولقد درست إمكانية إنشاء محطة لتحويل النفايات إلى طاقة في ولاية بسكرة وذلك لعدم وجود محطات تحويل النفايات إلى طاقة في جميع أنحاء البلاد, والتي يجب أن تساعدنا في التخلص من 13 مليون طن من النفايات(في الجزائر في سنة 2016) و حرقها .

الكلمات المفتاحية:تحويل النفايات إلى طاقة, عدد السكان, النفايات, ولاية بسكرة, محطة توليد الكهرباء, الحرق

Abstract

After the success of the European countries in the completion of many and many waste-to-energy transfer stations and passed this positive infection to Japan, China, and South Korea, known as the huge population which is increasing over time, and thus the amount of waste is a real crisis for these countries. The technology has now moved to Africa from the Ethiopia gate, known as the waste dump that covers the capital, **Addis Ababa**, with a mass of about **3 hectares** of waste. The country has invested **$ 95 million** to complete a waste-to-energy plant.
I have studied the possibility of establishing a waste-to-energy conversion plant in the state of Biskra because there are no waste-to-energy plants throughout the country, which have to help us eliminated and combustion of 13 million tons(in 2016 in Algeria) of waste.

Keywords: waste-to-energy, population, waste, Biskra city, power plant, combustion

Résumé

Après le succès des pays européens dans l'achèvement de nombreuses stations de transfert de déchets à l'énergie et a transmis cette infection positive au Japon, la Chine et la Corée du Sud, connu comme l'énorme population augmente avec le temps, la quantité de déchets est une véritable crise pour ces pays. La technologie s'est maintenant déplacée vers l'Afrique à partir de la Porte de l'Éthiopie, connue sous le nom de décharge qui couvre la capitale **Addis-Abeba**, avec une masse d'environ 3 hectares de déchets. Le pays a investi **95 millions de dollars** pour achever l'usine de conversion des déchets en énergie. J'ai étudié la possibilité d'établir une usine de conversion des déchets en énergie dans l'État de Biskra parce qu'il n'y a pas d'usine de transformation des déchets en énergie dans tout le pays, qui doit nous aider à éliminer et à brûler **13 millions de tonnes** (en 2016 en Algérie) de déchets.

Mots-clés : valorisation énergétique des déchets, population, déchets, ville de Biskra, centrale électrique, combustion

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List of Abbreviations

List of Abbreviations

PYREG: Are a systems manufacturer and solution provider for environmentally friendly technology systems.

WtE: waste to energy.

EfW: Energy from waste.

B&W: The year 2017 marked the 150th anniversary of **Babcock & Wilcox**, the company that began in 1867 with one patent, two friends and an unwavering commitment to reliable and effective innovation. When Stephen Wilcox first avowed that “there must be a better way” to safely generate power, he and George Babcock responded with the design for the first inherently safe water-tube boiler, and the company was born. This challenge to continuously improve endures today.

Termogamma: is an international group of companies whose can be traced back to Lombardy, Northen Italy, where **Giovanni Cavalieri** founded the first company of the group in 1985.

APS: Algeria Press Service is a news agency based in Algeria. Its first hand-typed news with the national flag's colors was then taken up by all the foreign media of the time.

MARTIN GmbH: For almost 90 years, MARTIN GmbH has been successfully active - as general contractor, consortium partner, and supplier of components or engineering partner - in the field of combusting problematic fuels such as low-grade coal and waste. The core component of these plants, the combustion grate, is designed and constructed in detail by MARTIN.

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General Introduction

General Introduction

The poor management of municipal solid waste and the lack of environmental awareness of the citizen make the Algerian cities and the city of Biskra suffering and getting to problems and the solution we need. Not only is the waste problem not easy. Do you realize that the amount of waste is increasing?

The larger the population, the greater the quantity, and the more complex the problems will become, and the obstacle is difficult to get rid of. The waste will flood the surface of Algerian cities after saturation of filling stations, which fill 73 of the 90 landfill centers. Waste dumpers are the problem we are trying to avoid for the emission of methane and other greenhouse gases. These centers will be a pollutant for human health and the health of the environment in general.

Many European and Asian countries, such as Germany, Sweden, Japan, China, etc., have undertaken research to find effective solutions that enable us to use the modern and sophisticated technology that God has blessed us with, Rather than throwing it away or waiting for it to be flooded with emergency sirens for urgent intervention.

In fact, these countries have succeeded in finding successful solutions that have translated these long researches into converting these wastes into electrical energy that could cover the needs of millions of people in exchange for these wastes. The completion of waste-to-power plants was not like other stations, this technique to become a global success and to enter the area and the limits of Africa from the gate of Ethiopia as the first station in Africa by burning 1400 tons of waste a day. How will Algeria be number two or wait to complete the count?

Combustion technology has the following advantages:

- Approximately 100% of the energy in the burned waste is recovered.
- More than 99% of combustion gases are purified and condensate of water vapor is intensified.
- Modern waste-to-power plants can:
  Firstly: Reduce 15% of greenhouse gases by avoiding waste burial.
  Second: Reduce 16% of greenhouse gases by replacing fossil fuels.
- This represents more than 30% of the total reduction of greenhouse gases set out in the EU plan for implementation by 2020. **[SHA 16]**

Facts and conclusions:

- Sweden today buys waste at low cost and uses it for electric power.
- Japan currently leads the world in the proportion of waste that it converts to energy from the total waste generated by its cities

There are many countries in the third world do not deal with the waste of cultural interest, they are not disposed of in a controlled manner, and do not care about the negative effects on the environment and human.

The ideal solution for such a complex dilemma is to immediately start building plants to convert waste into electrical energy, an easy, cheap technology. **[SHA 16]**

From this, I have done a study in the second chapter on the amount of waste in the state of Biskra on the day, month and year in a way that determines this amount with an estimated value after all the authorities refused to collect and manage the waste from giving me the daily statistical information and statistics.

After calculating the amount of waste in the second quarter and getting the total amount of daily waste in the state of Biskra, I compared and embodied this amount in a plant to convert these waste into energy and took the Ethiopian station in the capital **Addis Ababa** to convert the waste into energy as a reference because it's new, started in the beginning of 2018, it followed the latest technologies to burn waste using combustion technology one of them is the important: '**The MARTIN reverse-acting grate SITY2000'**.

Introduction

Biomass is a Greek word where bio means life and maza means mass. **[JAW 17]**

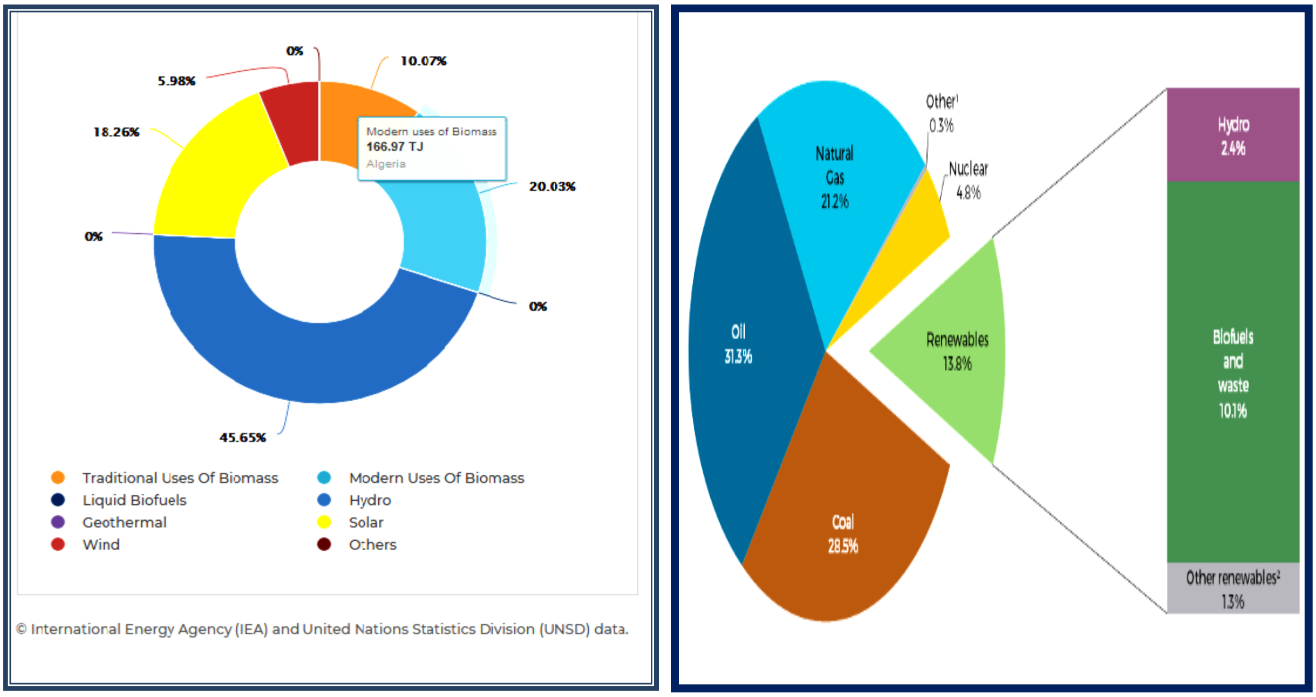


Figure 01: **A**/ Renewable energy consumption by source (2015). **B**/ Statistics of renewable energy in the world (2015)

Biomass contributes as the world's fourth-largest energy source today up to 14% of the world's primary energy demand. In developing countries, it can be as high as 35% of the primary energy supply. Biomass is a versatile source of energy in that it can be readily stored and transformed into electricity and heat.

It has also the potential that it is used as a raw material for the production of fuel and chemical feedstock. Production units range from small scale up to multi-megawatt sizes.

Development of biomass use contributes to both energy and other non-energy policies. **[VER 05]**

1: the principle of electricity production:

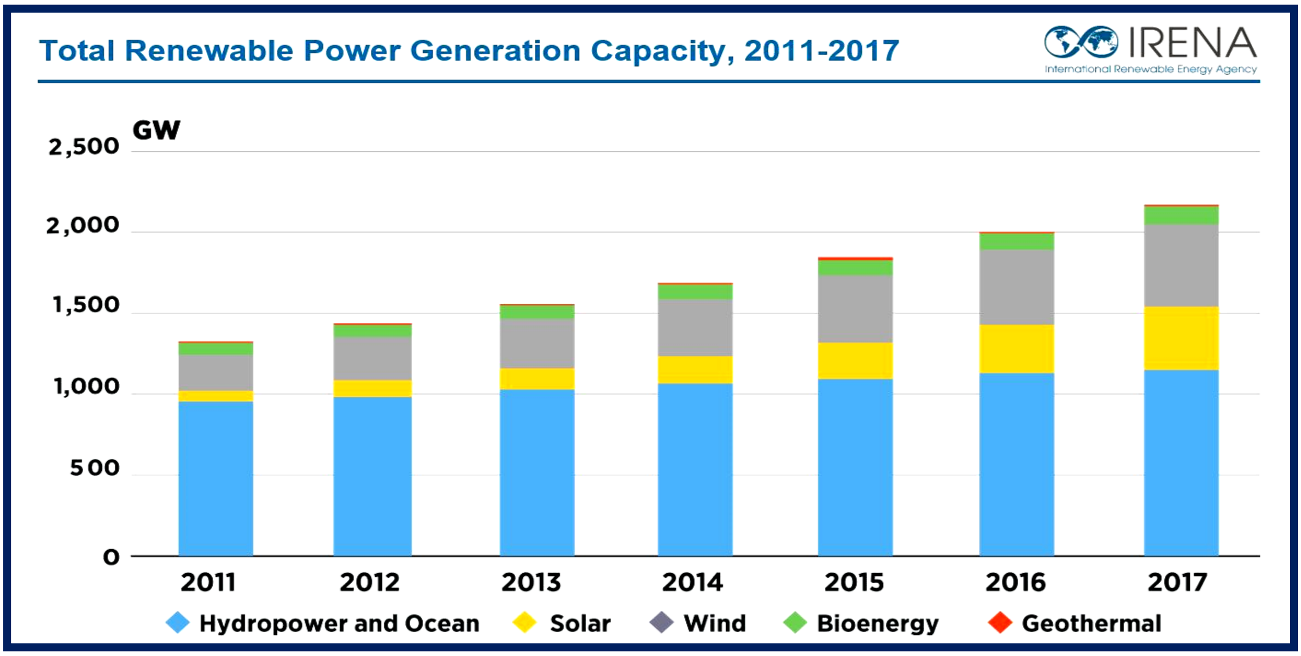
1.1: Organic wastes to produce biogas:

The main sources of biogas from human activities are domestic garbage landfills, fermentation of manure and raw sewage. The advantage of processing these waste products anaerobically, comparing to the aerobically, is the larger decrease in the volume of wastes. For this reason, the industry nowadays prefers anaerobic fermentation to process waste streams. Biogas mainly consists of combustible methane (CH_4) and non-combustible carbon dioxide (CO_2). Besides CH_4 and CO_2, biogas also contains small amounts of Hydrogen Sulphide (H_2S) and some other pollutants. The composition of biogas strongly depends on its source. Table (I) shows the composition of biogas from various sources. **[MOL 10] [AUB 10]**

Table I: Biogas composition from various sources.

BIOGAS SOURCES	CH4 (%)	CO2 (%)	H2S (%)	Si (mg/Nm3)
Garbage	55 to 60	40 to 45	0 to 0.5	0 to 50
Urban sewage sludge	60 to 65	35 to 40	0 to 1	0 to 20
Industrial effluents	55 to 75	25 to 45	0 to 1	0
Agro-food wastes	60 to 70	30 to 40	0 to 0.5	0
Agricultural waste	50 to 55	45 to 50	0 to 1	0
Landfills gas	40 to 50	25 to 40	0 to 0.5	0 to 50

We can observe that biogas from a garbage landfill contains some nitrogen (N_2). CH_4 combusts very cleanly with hardly any soot particles or other pollutants, making it clean fuel. But CO_2, the non-combustible part of the biogas, lowers the calorific value of the biogas. Biogas containing 55% CH_4 has a calorific value of 21.5 MJ/Nm3 while pure CH_4 has a calorific value of 35.8 MJ/Nm3 this is the reason to remove CO_2 from raw biogas,**[MUR 04] [VER 10]**



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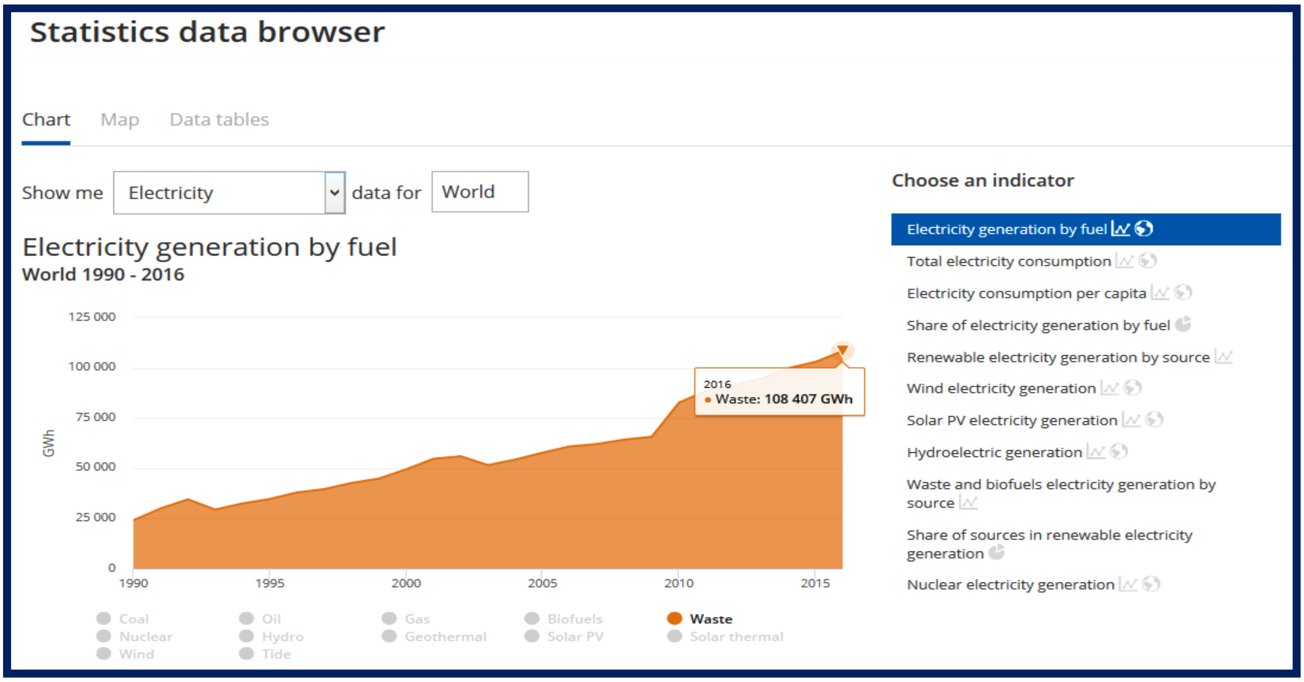


Figure 02-B: Statistics of electricity generation by fuel, 2016

2: Types of biomass:

2.1: Wood and agricultural products:

Most biomass used today is homegrown energy. Wood logs, chips, bark, and sawdust accounts for about 44 percent of biomass energy. But any organic matter can produce biomass energy. Wood and wood waste are used to generate electricity.

2.2: Solid waste:

Burning trash turns waste into a usable form of energy. One ton (2,000 pounds) of garbage contains about as much heat energy as 500 pounds of coal. Garbage is not all biomass; perhaps half of its energy content comes from plastics, which are made from petroleum and natural gas. Power plants that burn garbage for energy are called waste-to-energy plants. These plants generate electricity much as coal red plants do, except that combustible garbage, not coal is the fuel used to re their boilers.

2.3: Landfill gas and biogas:

Bacteria and fungi are not picky eaters. They eat dead plants and animals, causing them to rot or decay. Although this process is slowed in a landfill, a substance called methane gas is still produced as the waste decays. New regulations require landfills to collect methane gas for safety and environmental reasons. Methane gas is colorless and odorless, but it is not harmless.

2.4: Ethanol:

Ethanol is an alcohol fuel (ethyl alcohol) made by fermenting the sugars and starches found in plants and then distilling them. Any organic material containing cellulose, starch, or sugar can be made into ethanol **[1]**

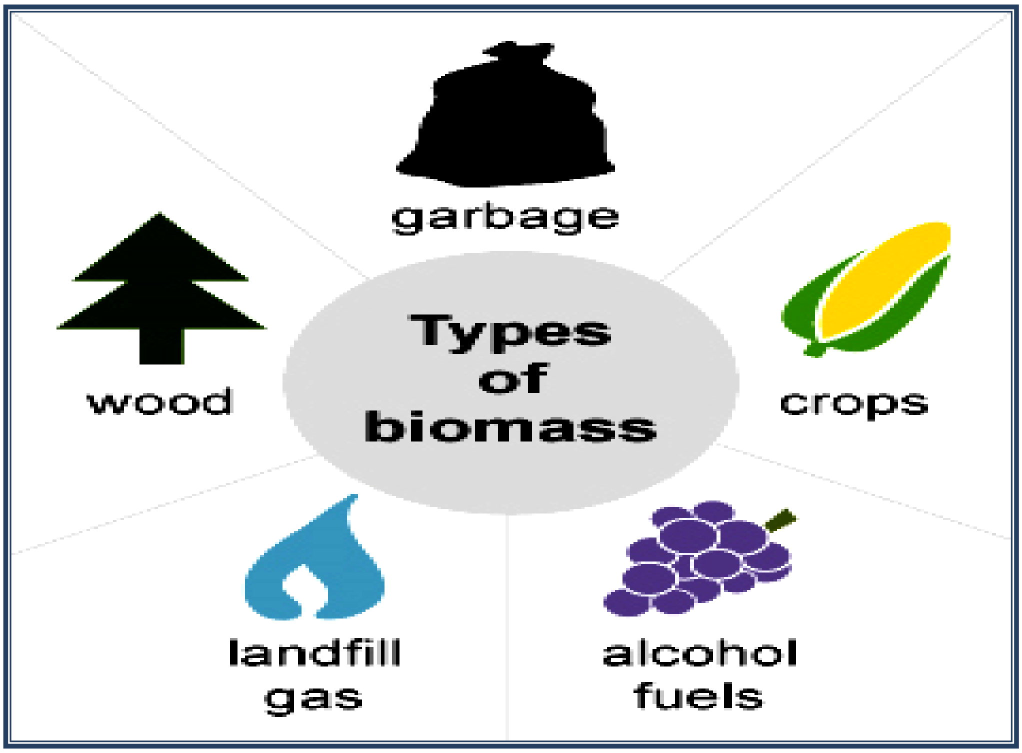


Figure 03: types of biomass energy. Source: **[1]**

3: Organic materials:

The different types of biomass are classified into two families: dry biomass and wet biomass.

3.1: Wood (dry biomass)

Since humanity has controlled fire, it has used wood for heating and cooking. Today, the technology has evolved but the principle remains the same: dry biomass is burned in boilers. We are talking about wood energy. In some countries, such as Tanzania and Nepal, it covers 80% of heating needs.

Figure 04: **A**: dry chopped firewood logs ready for winter **B**: precision-dry-woodchips

C: non-brands-Biomass-briquettes. Source: **[3] [2].**

Fire, or combustion of biomass, is arguably the oldest known and most widely used controllable energy source on earth. In recent years, rising costs of fossil fuels and the development of advanced equipment have made biomass combustion an economical, efficient, and practical energy source. **[4]**

3.2: Manure (wet biomass)

Animal excrement mixed with litter is also a form of biomass. Just like the sludge from our toilets! The fermentation gases from these materials are used for heating or electricity generation. We're talking about biogas.

3.3: Plants (wet biomass)

The vegetable waste that forms compost, such as kitchen peels or garden waste, can also be used to produce biogas. It is even possible to produce energy from most of our biodegradable waste: kitchen (compost) and garden peels, sanitary sludge (toilets, showers), agricultural waste or waste from the food industry...

Some plants can be transformed into fuel to run the vehicle engine, used instead of (or mixed with) gasoline. For example, sugar beet or cane, sunflower seeds or peanuts, produce biofuels. **[6]**

Figure 05: Combustion of biomass used to heat greenhouses. Source: **[5]**

4: Biomass Cogeneration technologies:

- **Combustion**, in which the residual waste is burned at 850 C and the energy recovered as electricity or heat
- **Pyrolysis** and **gasification**, where the fuel is heated with little or no oxygen to produce "Syngas" which can be used to generate energy or as a feedstock for producing methane, chemicals, biofuels, or hydrogen
- **Anaerobic digestion**, which uses microorganisms to convert organic waste into methane-rich biogas that can be combusted to generate electricity and heat or converted to bio-methane. This technology is most suitable for wet organic wastes or food waste. The other output is bio-fertilizer.

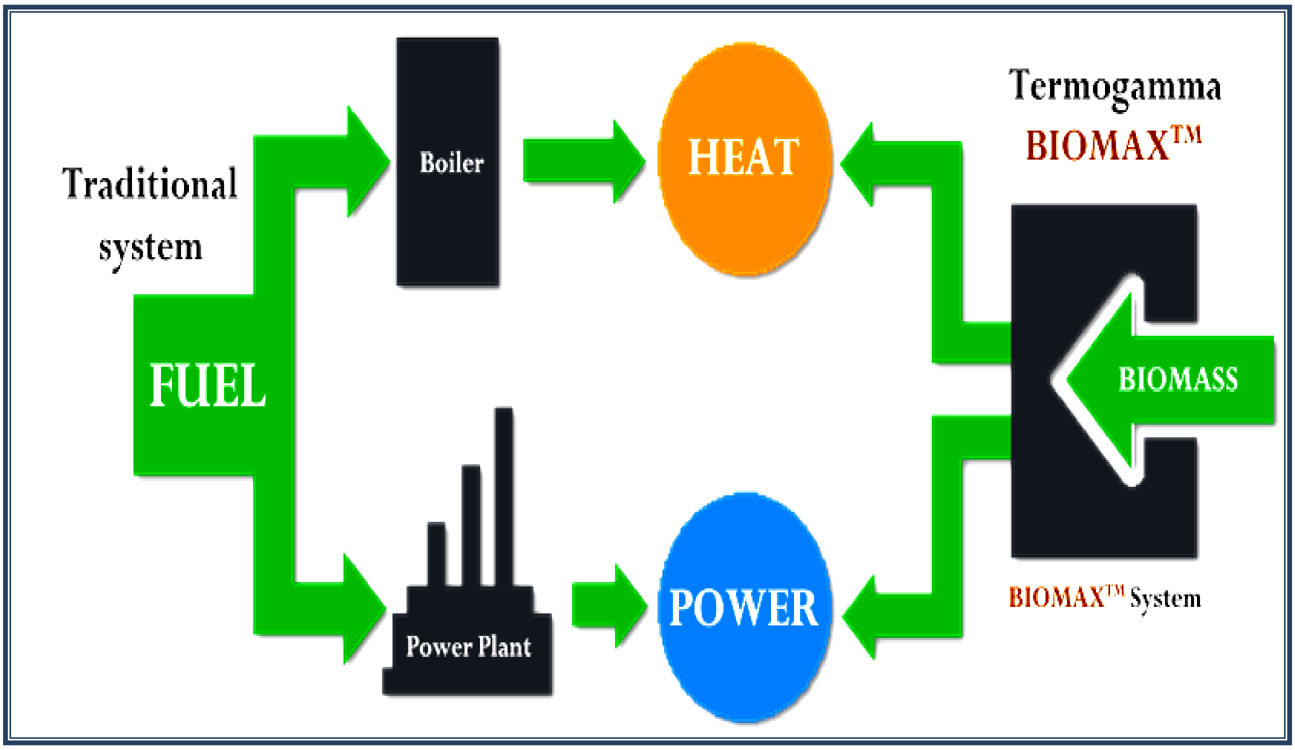


Figure 06: Biomass Cogeneration Schema.

4.1: these technologies have very different characteristics and it is important to:

4.1.1: Combustion

Combustion plants are often referred simply as **EfW** plants. They have a boiler to capture and convert the released heat into electricity and steam, and extensive air pollution control systems that clean the combustion gases to comply with regulatory emission limits before they are released to the atmosphere through a chimney. These plant typically use between 50 – 300 thousand tonnes per year of fuel.

Typical fuels

- Municipal Solid Waste (MSW)
- Commercial & Industrial Waste (C&I)
- Refuse-derived fuel (RDF) or Solid Recovered Fuel (SRF)

Outputs

- **Electricity or Heat** – or both together if a Combined Heat and Power Plant (CHP)
- **Bottom ash** - This is what is left after combustion and it can be used as an aggregate or roadbed material. If metal was not removed pre-combustion, it is recycled at this point.
- **Fly ash** - This is the material collected by the pollution control equipment.

4.1.2: Gasification & Pyrolysis

Sometimes referred to as **ATTs** (Advanced Thermal Treatments) gasification and Pyrolysis plants thermally treat fuels without allowing enough oxygen for complete combustion. They are typically smaller and more flexible than combustion plants and typically consume between 25 and 150 thousand tonnes of waste per year, although some variations can consume up to 350 thousand tonnes per year.

Typical fuels

- Municipal Solid Waste (**MSW**)
- Commercial & Industrial Waste (**C&I**)
- Refuse-derived fuel (**RDF**) or Solid Recovered Fuel (**SRF**)
- (non-waste fuels, e.g. wood / other forms of biomass)

Outputs

- **Electricity or Heat** – or both together if a Combined Heat and Power Plant (**CHP**)
- **Syngas,** which can be purified to produce "biomethane", biofuels, chemicals, or hydrogen
- **Pyrolysis oils** – these can be used to fuel engines or turned into diesel substitute
- **Feedstocks** for the chemical industry – allowing biomass to substitute for oil in the production of plastics for example
- **Bottom ash, Char, or Slag** – by-products which can be used for beneficial purposes such as aggregates or roadbed material.
- (**Fly ash** produced by some but not all plants)

4.1.3: Anaerobic Digestion (AD) / Biogas

Biogas/**AD** plants operate at low temperature, allowing microorganisms to work on the feedstock, turning it into biogas, which is a mixture of carbon dioxide and methane. They are typically much smaller than the combustion or gasification plants. A biogas plant is most appropriate for wet organic wastes, such as food waste, sewage sludge, agricultural residues or energy crops.

Typical fuels

- Food wastes
- some forms of industrial and commercial waste, e.g. abattoir waste
- Agricultural materials and sewage sludge.

Outputs

- **Biogas,** which can be used to generate electricity and heat – CHP is the norm for such plants
- **Bio-methane for the gas grid,** with the appropriate gas scrubbing and injection technologies
- **Digestive** - a material which can be used as a useful fertilizer/soil conditioner on agricultural land in lieu of chemical fertilizers **[REA 11]**

Figure 07: A biogas digester.

5: Biomass in Africa

5.1: Côte d'Ivoire to build the first biomass power plant:

ABIDJAN (Reuters) - The world's top cocoa producer Ivory Coast plans to build a 60 to 70 megawatt (MW) capacity biomass power generation plant running on waste from cocoa pods, part of its aim of developing 424 MW of biomass power generation capacity by 2030.**[FEL 18]**

Figure 08: The first biomass power station will be built in Côte d'Ivoire.

5.2: First power plant in Ethiopia opened in 2018:

The plant is expected to handle more than 1,400 tons of waste per day and produces an estimated power of 25 MW.

The project was jointly established with the Cambridge Industries Limited (CIL) and its partner, the China National Electrical Engineering Company (CNEEC), with a cost of 95 million dollars in the US. **[KHA 18]**

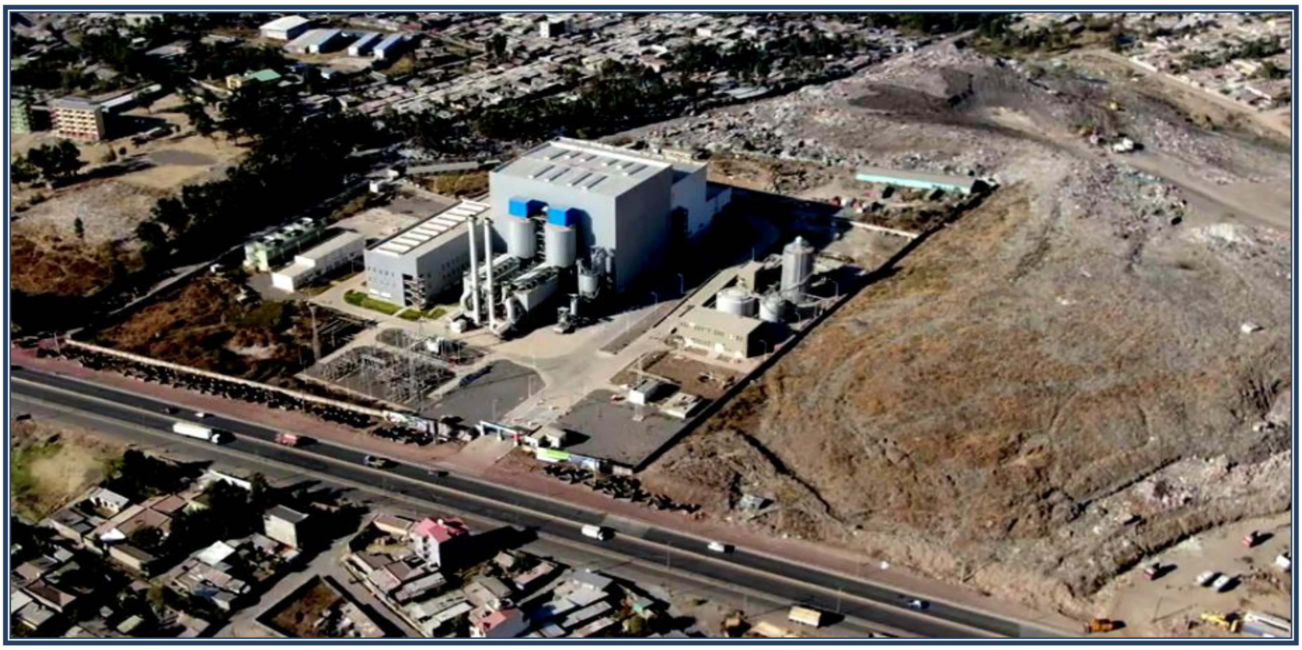


Figure 09: first Biomass power plant beginning produced in 2018

6: Advantages of Biomass Energy

Biomass has been in existence before people started talking about renewable energy sources and energy efficiency. This long term use would not be possible if biomass didn't have any benefit. Here are the advantages that make biomass energy a perfect alternative to fossil fuels.

- **it's a renewable form of energy**

Biomass energy is considered a renewable form of energy because the organic materials used to produce it are never-ending.

- **it's carbon neutral**

We all know that the release of vast amounts of carbon contributes greatly to climate change. Biomass energy takes care of this since it is a natural part of the carbon cycle as opposed to fossil-based sources of fuel such as oil, natural gas, and coal.

- **widely available**

Just like sun and wind energy, biomass energy sources are bountiful in supply. You can find them virtually in every nook and cranny of the world.

- **it's cheaper compared to fossil fuels**

The low cost resulting from the production of biomass fuel is passed on to customers. This means that customer's energy bills will not depend on aspects such as availability and knee jack decisions of energy production and supply firms. Low biomass cost makes this form of energy attractive to manufacturers and producers since they are able to generate higher profits from the extremely low output.

- **Minimizes overdependence on traditional electricity**

Virtually anyone can produce biomass energy because the raw materials are available everywhere.

- **Reduces the amount of waste in landfills**

Most waste produced in homes is either plant matter or biodegradable. This kind of waste can be channeled to more profitable use. Biomass energy generation utilizes any waste that would have otherwise found a way into landfills. This minimizes the impacts of waste in landfills on the environment.

- **Can be used to create different products**

Biomass energy is also versatile, as different forms of organic matter can be used to create different products. Ethanol and similar fuels can be made from corn and other crops. **[7]**

7: Disadvantages of Biomass Energy

While the upsides to biomass energy are plenty, it's not exactly a perfect source of energy. Here are the downsides to biomass energy:

- **Not entirely clean**

Using animal and human waste to power engines may save on carbon dioxide emissions, but it increases methane gases, which are also harmful to the Earth's ozone layer.

- **Risk of deforestation**

Biomass energy sources are renewable, but they have to be utilized sustainably. Uncontrolled biomass production can result in deforestation. Governments feel replanting efforts may not match the rate of cutting down of trees.

- **Requires a great deal of water**

This is the most invisible disadvantage of biomass fuel. All plant matter need a sufficient amount of water to get by, meaning water sources must be abundant.

- **Inefficient as compared to fossil fuels**

Despite the fact that biomass energy is natural in many ways, it doesn't get close to fossil fuels in regards to efficiency. **[8]**

Conclusion

Biomass is used to produce electricity, heat or biofuels through the combustion and fermentation of plant material. At a time when the use of fossil and nuclear energy is being questioned, biomass appears to be a sustainable and positive solution, at least on some points. Research is ongoing and it is undeniable that some processes such as biogas or biofuels are real solutions, On the other hand, it is equally important to realize that in biomass energy, some processes such as overexploitation of wood represents a significant step forward. Major environmental hazard to which an alternative must also be found **[9]**

Introduction

Biskra is a state of the Republic of Algeria in the south-east of the country, nicknamed "The Bride of the Ziban" or the gate of the Sahara, divided administratively into 33 municipalities, the largest state in the south of the country in terms of population, with a population of approximately 633.234 inhabitants. **[ALG 18]**

Due to the continuous increase in population in the state of Biskra and at the level of the country, as indicated by the Minister of Environment and Renewable Energies **Fatima Zahra Zerouati** during a press conference on the occasion of the International Salon for the recovery of waste "The results of this ongoing study will allow us to obtain a data bank on the existing waste sites in Algeria and a better vision for its management." Currently, "there are 13 million tons of wastes produced, 50 percent of which are an organic waste". **[10]**

In this context, I searched for some data on the amount of waste in the city of Biskra, which the population suffers continuously and study these results if there is the possibility of establishing a plant to generate electricity from these wastes, with taking into consideration the safety of the environment at the lowest possible cost.

According to **B&W**, "The transformation of waste into energy, including municipal solid waste and waste gas, is a valuable source of renewable energy, and waste-to-energy conversion plants have been successfully operated around the world".When the waste is converted to energy (or access to energy from waste) the plant converts solid municipal and industrial waste into electrical energy (and/or heat) for industrial processing and central heating systems. They are environmentally friendly and cost-effective energy recovery solutions. The power plant operates by burning waste at high temperatures and using heat to generate steam. The steam then turns on the turbine, which in turn generates electricity.

Access to energy from waste is a way to recover valuable resources and not just a way to get rid of the garbage. It is a means of recovering valuable resources. Turning waste into energy is a vital part of a series of sustainable waste management and completely complementary to the process of recycling.

Today, 90% of the metals in the bottom ash can are reused. The residual combustion residue in the paving materials can be reused. **[B&W]**

1: How does biomass get to the grid?

There are many ways in which biomass is converted into electricity :

- Biomass is converted into heat which creates steam; the steam turns a turbine to create electricity.
- Biomass is converted into gasses (such as CO+H2 or methane) by a process known as Pyrolysis; this gas can be used to make power. **[11]**

2: Waste in Algeria

According to **APS**, 13 million tons of household wastes are produced annually by Algeria.

- 50% of which organic matter can be referred to as energy or fertilizer
- 32% of packaging materials
- 13% plastics

As the director of studies and development at **Extra-Nat**, **Mr. Karim Buthljeh** said:

“About 30 percent can be recycled materials, including (plastics, aluminum, cardboard,)

If the bag contained 10 kg of waste we can recover 3 kg, but the remaining 7 kg remains as organic matter in general, which we can even recover as fertilizer later. What it means is that the waste bag we cannot get anything from. "

As the agency said, the recycling and valuation of waste could generate Algeria 38 billion dinars annually”.

Figure10: Picture showing the recycling process. Source: **APS**

Figure 11: Some of the recycled materials (cardboard, plastic...etc). Source: **APS**

Figure 12: Recovered medicines and their waste source **APS**.

Figure 13: Recovered bread waste and water bottle caps. Source: **APS**.

3: Stages of urban solid waste management in Biskra city

The operation of urban waste is carried out according to known technical stages:

- **Combine and transport phase**: This stage is essential to affect economic cost and efficiency.

Figure 14: Waste collection containers in Biskra city.

Figure 15: Waste truck for the town of Biskra.

Figure 16: Random burning waste in El Cursse area.

- **Tribal Processing Stage:** stages that are after the collection phase and the process of sorting the collected waste and transfer it to the technical reclamation center and to benefit from it as much as possible.

Figure 17: A truck for two workers who collect plastic bottles from the waste and sell them to the recycling plant located in the area of **Teleghma** "state of **Mila**" 15 DA for one kilogram, according to say the cost of this truck is 3000 DA.

- **The final stage of the waste:** At this stage, the final treatment of the waste is done by burying the waste in the trench, whether treated or untreated.

Figure 18: The trench shows the place where the waste is buried “**landfill site**”.

Figure 19: The trench shows the place where the waste is buried "**landfill site**".

- **System of collection and transport of solid urban waste**

Definition of collection: is the collection of waste from the points produced by an integrated device consisting of private trucks, workers and drivers during specific periods that lift waste from the containers allocated at the production sites and unloading in trucks either manually or mechanically and then transferred to the technical dump sites 'landfill site' and unloading load Trucks part of collection. **[BAL 17]**

- **Financial instruments to cover the costs of waste collection service:**

Table II: Financial instruments to cover the costs of waste collection service. **[BAL 17]**

The amount of tax in dinars	The amount of tax in dinars	Population in the municipality
On the store	To the entire population	/
700 DA	350 DA	Up to 50,000 residents
700 DA	500 DA	More than 50,000 inhabitants

Source: Finance Act 2000

4: The amount of waste according to the population of biskra city:

After searching for references or information about the latest statistics for the amount of waste in Biskra city, I found nothing and I did not want to disclose this information, I did not know the reason for this. After searching at length I devised another method that enables me to calculate the approximate amount of the number as a number to study the possibility of the working station to convert Waste to energy.

According to the National Agency for Waste, in 2017 it recorded an increase in the amount of waste collected in Algeria by 3 percent compared to 2016, after reaching 13 million tons, equivalent to **850 grams per citizen per day**. **[NAO 18]**

4.1: Population estimates as of 31/12/2015

The population estimates as of 31/12/2015 gave the following final results:

- The annual growth rate of 2.30%.

- Population density 40 inhabitants / km².

- The total number of population reached **869215 people**, including:

- 443291 males by 51%.
- 425924 females by 49%.

- Distribution of the population of the state by dispersion:

- The number of municipal councils was 670410, or 77.13%.
- 71050 secondary localities (8.18%).
- Distributed areas: 117,289, or 13.49%.
- The nomadic population is 10,466, or 1.20%.

- Population distribution between urban and rural areas:

- 531525 urban residents or 61.15%.
- 337690 are concentrated in rural areas or 38.85%. **[NBS 15]**

Accordingly: The amount of waste in 2016

0.85 kg / in one day * the population of Biskra 869215 people equals = **727.2 tons.**

Table Ⅲ: Calculation of the amount of waste at the level of each municipality for the year 2016 for Biskra city**.**

N°	Municipality	Distribution		Total	Quantity of waste / ton One day
		Males	Females		
1	**Biskra**	124 834	119 939	244 773	205
2	**El Hadjeb**	6 149	5 907	12 056	10.1
3	**Lotaya**	6 782	6 515	13 297	11.1
4	**Jamoura**	7 634	7 334	14 968	12.5
5	**Branis**	2 678	2 573	5 251	4.4
6	**The Qantara**	6 931	6 658	13 589	11.4
7	**Ain Zaout**	2 290	2 201	4 491	3.8
8	**Sidi Okba**	20 345	19 547	39 892	33.4
9	**El Haouch**	3 226	3 100	6 326	5.3
10	**Chetma**	8 347	8 019	16 366	13.7
11	**Ain Nagga**	7 307	7 017	14324	12
12	**Zrebt El Ouad**	13 326	12 815	26 141	21.9
13	**Mzeraa**	4 619	4 438	9057	7.6
14	**El Faidh**	7 742	7 438	15 180	12.7
15	**E. Sidi Nadji**	1 846	1 774	3 620	3
16	**Amshonesh**	6 142	5 891	12 033	10.1
17	**Tolga**	33 904	32 575	66 479	55.6
18	**Boshkron**	7 968	7 656	15 624	13.1
19	**Ben Azzouz Tower**	7 712	7 410	15 122	12.7
20	**Lichana**	5 987	5 753	11 740	9.8
21	**Fogala**	7 576	7 291	14 867	12.5
22	**El Groos**	9 959	9 574	19 533	16.3
23	**Oulad Galal**	38 394	36 888	75 282	63
24	**Dossen**	16 176	15 541	31 717	26.5
25	**Shuaiba**	8 107	7 789	15 896	13.3
26	**Sidi Khaled**	26 299	25 268	51 567	43.2
27	**Bassbas**	6 533	6 277	12 810	10.7
28	**Ras Al- Miyad**	13 332	12 809	26 141	21.9
29	**Orlal**	4 521	4 342	8 863	7.4
30	**Emlily**	3 944	3 790	7 734	6.5
31	**Mkhadma**	3 320	3 188	6 508	5.4
32	**Oumach**	6 361	6 111	12 472	10.4
33	**Liwa**	13 002	12 494	25 496	21.3
33	**Total State**	**443 29 1**	**425 92 4**	**869 215**	**727.6 tons**

The number of population from Source: **National Bureau of Statistics**.

[http://wilayabiskra.dz/?page_id=1673]

As we see, the amounts of waste for the year 2016 amounted to 727.6 tons per day for all departments of the state of Biskra, after you have followed the previous method and fill this table.

These values are merely rounded values may be more or less, but not something in excess of the limit.

Table Ⅳ: The development of waste from 2016 to 2050 with approximate values.

Year	Population	Waste in one day (tons)	Waste in one month (tons)	Waste in one year (tons)	C=kg/1day
2016	869215	727.6	21828	261936	0.85
2017	889207	744	22320	267840	0.85
2018	909200	760.6	22818	273816	0.85
2019	929192	777.4	23322	279864	0.85
2020	949184	803.4	24102	289224	0.86
2030	1149103	995.2	29856	358272	0.88
2040	1349023	1195	35850	430200	0.90
2050	1548942	1417.8	42534	510408	0.93

In this table, I calculated the evolution of the amount of waste for the next 30 years according to the method of approximating the number of quantities per day, month and year. Taking the value of the quantity of waste produced by the individual in Algeria for 2016, which is 850 g, For the next 30 years because it is difficult to determine the amount of consumption per capita, we do not know what the years of surprises, but I have taken into account in the last ten years the development of the amount of waste produced by one individual from Algeria.

As we note, the amount of waste per day in Biskra province after 30 years in 2050 will be about 1417.8 tons per day, while the annual value of the state is about half a million tons of waste "510408" tons in 2050.

5: The proposed solution is to set up a waste-to-energy plant for over 30 years:

According to the previous study found that the amount of waste produced in the state of Biskra in 2016 was estimated at 727.6 tons per day and in the current year 2019 may be about 777.4 tons per day. The station took **Rippe** Ethiopia as a reference because it is new and because it's from the same area of the team and therefore:

This plant converts 1400 tons of waste per day to obtain an estimated capacity of 25 megawatts over 24 hours, which 1 MW per 56 tons.

And from it:

"If we waste treatment and recycling will be retained value is **30 percent** of the total amount of waste".

30% from (777.4 tons) =544.18tons with recycling: 1MW ____ 56 tons

X MW___777.4 tons (Without waste treatment and recycling) = (1*777.4)/56 =**13.88 MW**

X MW___544.18 tons (With waste treatment and recycling) = (1*544.18)/56=**9.72 MW**

If we take this result, about 10 megawatts, we need to install a turbine (SST-150*) which operates on a range of (5 MW to 20 MW) and we have completed the station on this basis must bear in mind that the number of waste increases by about 25 tons per day Next year.

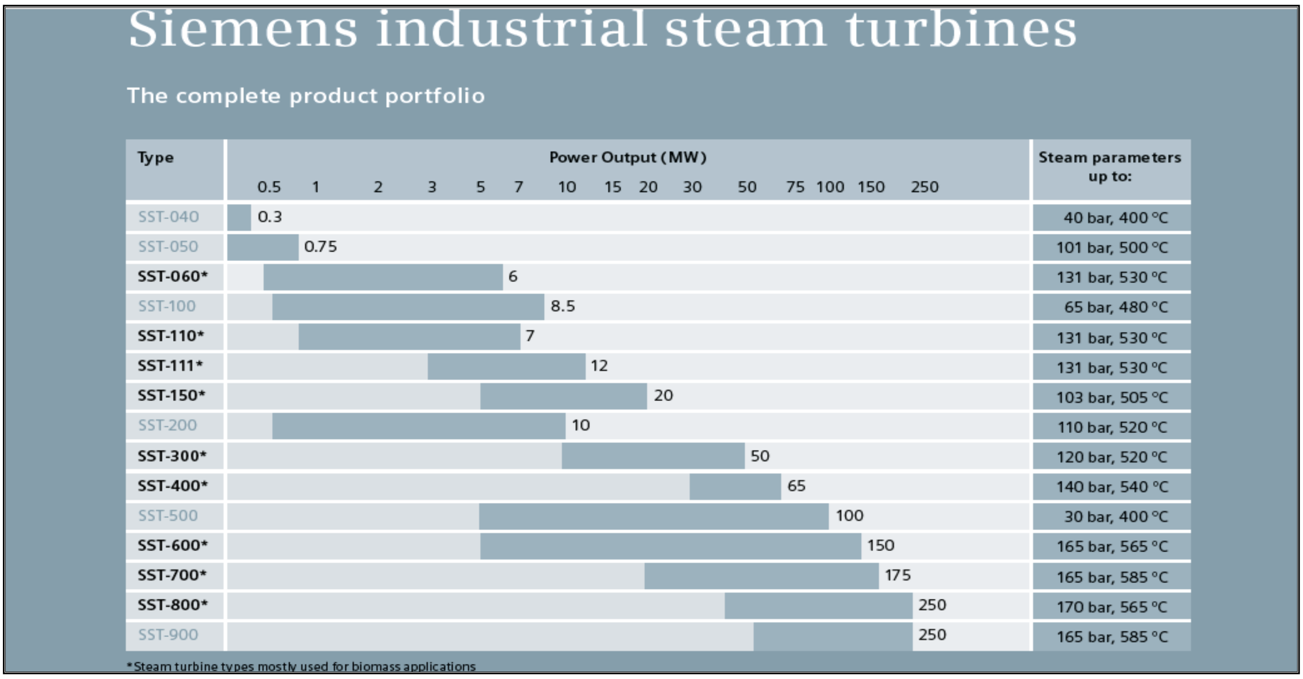


Figure 20: Siemens industrial steam turbines. Source: **[SIE 17]**

Figure 21: map of Biskra city. Source: Google map 2019.

The value of 10 MW is close to acceptance to the selected type of turbine (SST 150*) which works on 20 MW as a power outlet according to the waste growing for the 30 years coming, if we need to make our power plant to work for 20 MW we need more wastes from near towns like (Ariss, Barika, Ain Touta…Ect) in Batna city.

Conclusion

In summary of this chapter, I would like to point out that the results obtained are approximate but not far from reality: I would have preferred to get the amount of waste collected on the territory of the competent authorities for collection and statistics purposes, but they have been silent about these statistics and have refused to give me that information, As they did to the other students they needed in previous years.

In the final part of the second chapter, after knowing the amount of waste produced in the state of Biskra in one day or in the coming years, we now move to the third chapter to scale the power plant at the level of landfill site, which is filled more than 50 percent, What is the ideal way, equipment and technologies that should be used to create a waste-to-energy terminal?

We conclude by saying that the most important benefit behind the construction of the waste power plant is the elimination of the amount of garbage in the country as well as the reduction of the burden on waste management in Algeria and Biskra city.

Introduction

When the waste is converted to energy (or access to energy from waste) the plant converts solid municipal and industrial waste into electrical energy (and/or heat) for industrial processing and central heating systems. They are environmentally friendly and cost-effective energy recovery solutions. The power plant operates by burning waste at high temperatures and using heat to generate steam. The steam then turns on the turbine, which in turn generates electricity. **[B&W]**

I have proposed a solution, which is the burning of waste and the use of gas to obtain energy, according to the director of the integrated waste management agency **Parsa Fatima Zahra**: “The 73 waste landfills centers out of 91 suffer from saturation" and this is the biggest reason to propose a solution **burning of waste**”.

She added:

“The percentage of saturation of the rest of the landfill centers has reached 50 percent, through an increase in the amount of waste collected by 3 percent in 2017, which amounted to 13 million tons compared to 2016, were estimated at 850 grams per citizen”. Today’s scientific and technological development enables us to find solutions to our previously difficult and serious problems. They may be a little costly but not cost-effective because of the great benefits they offer.

The first example of this is the first African country to set up the first waste-to-energy power station in Africa it’s **Ethiopia**, known as the weakest African country in terms of its material and development weaknesses, has turned the curse into a blessing by removing the mountains from waste and turning it into energy and covering 30 percent of the needs Ethiopian capital of electricity.

As is well known, there are five types of biomass conversion processes. I have chosen the type that is used frequently in modern waste-to-energy conversion plants, which is "**Combustion**".

The combustion system, consisting of the Grate system and the furnace, is the technological core of a waste-to-energy plant. We differentiate between a conventional combustion system, the combustion system combined with flue gas recirculation and the SYNCOM-process. **[MAR 13]**

1: The amazing facts about waste incineration in the facilities dedicated to it:

1.1: Goodbye to the mountains of waste

If you do not realize the magnitude of the problems that waste may cause, you should read about the deaths of more than 8,000 Germans in the German city of Hamburg in the late 19th century due to cholera and waste piles

It has a channel **CNN** recently showed pictures of a river of waste in Lebanon reveal the magnitude of the disaster there; this is not the newspaper "**The Week** ", which made the title **"Will sink Lebanon?"** Lebanon is going to sink under the piles of garbage.

Figure 22: is Lebanon sinking? Source: **the week.**

There is no doubt that landfill is not a solution. Every landfill has an unbearable capacity. Whatever landfill is sustainable in the long run, it needs large areas, so waste must be recycled through Recycling Or even the burning of waste or the so-called language of environmental engineers "heat treatment of waste", which contribute to reduce the size and weight and benefit from the resulting materials and energy, yes energy.

1.2: Waste is better than brown coal:

With the development of science and the urgent need for energy, the man reached coal in the ground and reached the so-called brown coal Lignite, Which is not the quality of solid coal but is better than peat, but why are we talking about brown coal? Because there is a better alternative than "waste "He said

In a country like Germany, which is the first to extract brown coal Lignite The percentage of electricity produced by brown coal is 27%. However, scientists in the same country confirm that if the waste is properly treated, its thermal value can reach 13,000 KJ / 1kg while the thermal value of brown coal is about 8600 KJ / 1kg.

1.3: What can "win" of combustion?

You may answer: "Energy." This is true, but in fact, we can benefit from waste more than energy, thanks to the advanced techniques that science has reached. No wonder scientific studies in the field of waste utilization until the moment you read this report.

As an example only, the burning of one ton of waste can earn 25 kg of "scrap" iron, 4 kg of nonferrous metals Non- ferrous metal Such as aluminium and copper, and gypsum, as well as12 kg of hydrochloric acid, which **Jabir Bin Hayyan** called "salt spirit" and widely used in the world of industry, and this, of course, is not 1900 kW of heat and 215 kW of electricity.

More recently, a waste incinerator in the German city of Hamburg published 8,000 tons of scrap iron from waste incinerated in 2014, 2,600 tons of non-ferrous metals, 4,000 tons of salt and 860 tons of gypsum, in just one year, it is waste. **[ASS 16]**

Bilanz Nebenprodukte

Jahr	FE- Schrott Mg	NE- Schrott Mg	Salzsäure Mg	Gips Mg
2011	8.578	1.417	4.347	1.171
2012	8.466	1.122	4.199	1.105
2013	7.534	2.545	4.465	1.190
2014	8.144	2.651	4.121	864

Figure 23: balance-products (bilanz nebenprodukte).

2: The benefits and Disadvantages of the burning process

- Reduce the volume of waste to 90%
- Reduction of waste weight to 60%
- Elimination of all pathogens and carriers of diseases under the influence of high temperature, which plays the role of the sterilizer.
- Energy extraction: thermal energy can be used to supply residential areas, and generate electricity.
- Slag and ash: used for paving roads, filling low places. **[BOU 09]**

Disadvantages:

- Slag and leaking ash are formed where the burning of 1 ton of waste produces 300 tons of ash.
- **Production of gases**: The burning of 1 ton of solid waste consists of 4000-5000m3 of gases, consisting mainly of CO2, H 2O, in addition to some harmful gases, for hydrogen chloride, sulfur dioxide, nitrogen oxide ... **[BOU 09]**

3: Biomass Power Plant VS Other Power Plants:

Figure 24: Oman JV unveils Asia's largest biomass power plant. Source: **[13]**

Biomass Power Plant

- Abundant Resource: wide range of biomass resources from agricultural waste, forestry, etc.
- Convenient: the only renewable energy that can be stored and transported; easy to process and use.
- Low Emission: biomass combustion is carbon neutral, nearly zero CO2 emission and low SO2 emission.
- Cost-Effective: biomass fuel is abundant and plants like sugar mill, the paper plant can use the by-product biomass waste as fuel; governments supply subsidies for biomass power plants.

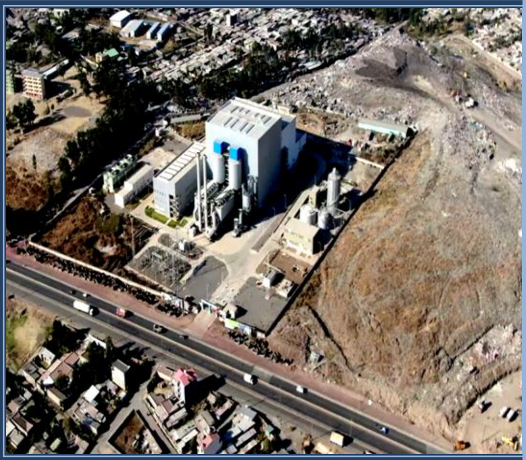
Figure 25: Other Power Plants**.** Source: **[14]**

Other Power Plants

- Thermal Power: Coal based thermal power is the most conventional source of electric power.
- Hydro Power: large investment cost, has a higher requirement of the geographical environment, and the water source cannot be guaranteed.
- Nuclear Power: Nuclear leakage may cause nuclear radiation, and the equipment costs and other costs are much higher than the thermal power
- Wind Power: occupy a larger land area, wind speed is instability, wind energy conversion efficiency is low, high cost, equipment is immaturity, etc.
- Natural Gas Power: higher cost and natural gas shortage.**[15]**

3.1: Some waste-to-energy conversion plants use 'Combustion'

Table Ⅴ: types of biomass power plants.

ETHIOPIA POWER PLANT	SOUTH KOREA POWER PLANT	
		FIGURE
China National Electrical Engineering Company (CNEEC) **the Cambridge Industries Limited (CIL)**	**A consortium of Oman Oil Company (OOC) (30%)** **GS Holdings (70%)**	COMPANIES
China-British	**Omani-Korean**	PARTNERSHIP
cost of $95 million dollar	**cost of $280 million dollar**	THE COST
1400 tons	**6000 tons**	WASTE USES
25 MW	**105 MW**	POWER-GEN

4: The equipment, technologies used in the Ethiopian waste-to-energy plant [CAM 17]

Table Ⅵ: general project profile

General Project Profile	
Owner	Ethiopian Electric Power (EEP) *(www.eep.gov.et)*
	Waste Disposal Partner Municipality: Addis Ababa City Administration (AACA)
Owner's Engineer	Ramboll Group *(www.ramboll.com)*
Total Investment	USD 95,880,000 + ETB 434,530,557
Commencement Date	September 24, 2014
EPC Contractor	A consortium of China National Electric Engineering Co. Ltd. (CNEEC) and Cambridge Industries Ltd (CIL)
Scope of EPC Contractor	Turnkey Engineering, Procurement and Construction
Lead Design Firm	China Urban Construction Design and Research Institute Co,

	LTD.
Project Development	Part of the development program for 7 African cities WtE Facilities

Source: [CAM 17]

Plant Design

The Consortium is led by both China National Electric Engineering Co., Ltd., a company with a long track record of executing thermal projects all over the world, and Cambridge Industries Ltd (formerly a subsidiary of DP Cleantech Ltd, a supplier of Biomass Boilers).

Table Ⅶ: combustion system components.

Combustion System	
Type	Air-cooled Step Grate
Grate Design	SITY2000 - MARTIN GmbH Licensed
Grate Manufacturer	Sanfang-Covanta
Max Grate Capacity Per Line	678tpd
Grate Size Per Line	9.7m x 10.6m

Source: [CAM 17]

Plant Process:

Table Ⅷ: Waste Heat Boiler

Type	Single drum natural circulation boiler, four vertical gas ducts plus one horizontal gas duct
Steam Quantity	2 x 54.1ton/h
Steam Temperature	420°C
Steam Pressure	60bar
Boiler Evaporation Capacity	54.1 t/h
Boiler thermal efficiency	80.94%
Boiler Design & Manufacturer	Hangzhou Boiler Group

Source: [CAM 17]

Table Ⅸ: Steam Turbine and Generator

Steam Turbine and Generator	
Turbine Size	**2 x 25MWe Condensing Turbine Generator**
Generation Capacity	**185GWh per year**
Boiler Manufacturer	**HBG, Hangzhou Boiler Group**

Source: [CAM 17]

Tables a, b, c (Ⅹ): Environmentally-friendly Flue Gas Treatment

Incineration plants have been around for more than 100 years, but modern incineration plants are very different from their forebears. The Reppie Facility has adopted modern back-end flue gas treatment technology which ensures that almost all of the nitrogen oxides (NOx), sulfur dioxide (SO2), heavy metals and dioxins produced by the plant are drastically reduced, thus ensuring the plant operates safely within the strict Emission limits of the European Union. Any residues leftover from the flue gas treatment is recycled or safely disposed of whilst the scrubbed and cleaned flue gas is released into the atmosphere through the Plant's twin 50 high stacks. **[CAM 17]**

Table a

Flue Gas Cleaning	
Design	**Non-catalytic reduction (SNCR) + semi wet + dry + powder activated carbon** **(PAC) injection + Baghouse Filter**
Emission Standard	**EU 2000/76/EC Directive**
Emission Monitoring	**Both on-site and online flue gas emission monitoring**

Source: [CAM 17]

Table b

Leachate Treatment	
Design	**Anaerobic System with membrane bio-reactor (MBR)**
Supplier	**Ever bright**
Daily Processing Capacity	**220m3 per day**

Source: [CAM 17]

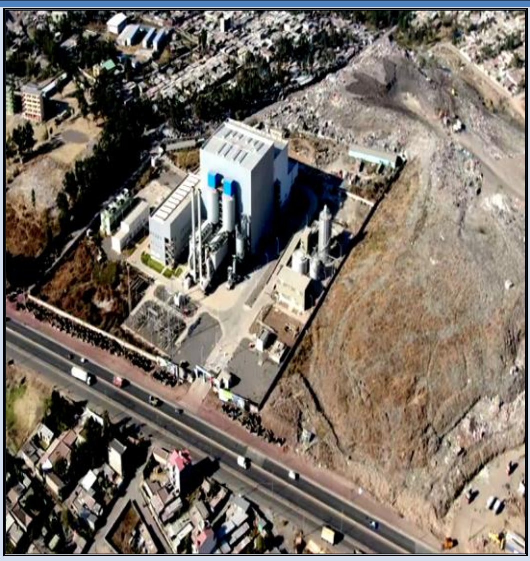
Table c

Residues	
Bottom Ash	100,400 tpa
Fly ash	15,210 tpa

Source: [CAM 17]

5: Comparison between ‘the natural gas’ and biomass ‘Syngas ‘stations derived from:

Table ＸＩ: comparison between “natural gas” against biomass “Syngas”.

ETHIOPIA POWER PLANT	**CHEGA POWER PLANT**	
		**FIGURE**
SYNGAS	**NATURAL GAS**	**TYPE**
1400 TONS OF WASTE	/	**CONTENT**
95 Million dollar	**450 Million dollar**	**COST**
25 MW	**456.89 MW**	**Power-Gen**

5.1: Algeria's oil and gas reserves will not exceed the year 2034:

Algeria owns the world's third largest **rock gas** reserves

The economic expert on renewable energies**, Bouzian Mahmah**, said on Monday that ensuring the security of the country is the Bet of Algeria in the coming years, warning that existing reserves of oil will not exceed the time limits of 2034, forcing the government to resort to investment in shale gas.

According to the spokesman, the government should quickly "implement the National Plan for renewable energies and reflect all the ambitions that are being expressed", stressing that in the 2030 horizon the scheme will only meet about 20 percent of our national needs for consumption, which requires serious thinking about how Oil and natural gas are metabolized by going to exploit shale gas. [BOU 17]

Table ⅩⅡ: Natural gas final consumption – Algeria. Source: [16]

	NATURAL GAS UNITS: TJ	/
Natural gas final consumption – Algeria		
Units: TJ		/
Year	**Natural gas**	/
1990	156192	/
1995	200809	/
2000	246945	/
2005	358318	/
2010	423947	/
2015	685338	/
2016	719752	**34414 in 1 year**

Table ⅩⅢ: Natural gas production – Algeria. Source: [16]

WEAR	NATURAL GAS UNITS : TJ	/
Natural gas production – Algeria		
Units: TJ		/
Year	**Natural gas**	/
1990	1807498	/
1995	2170182	/
2000	3249534	/
2005	3517401	/
2010	3348004	/
2015	3322561	/
2016	3747688	**425127 in 1 year**

Table ⅩⅣ: Comparison between consumption and production of natural gas in Algeria.

Natural gas consumption – Algeria		Natural gas production – Algeria	
Year	**Units: TJ**	**Year**	**Units: TJ**
2016	719752	**2016**	3747688
2017	754166	**2017**	4172815
2018	788586	**2018**	4597942
2019	822994	**2019**	5023069
2020	857408	**2020**	5448196
2034	1339204	**2034**	11399974
2050	1889828	**2050**	18202006
PRODUCTION-CONSUMPTION(2016) **3747688-719752=3027936 TJ**			

6: The NextBAT technology

About two-thirds of household wastes are classified as bio-fuels and we can recover two-thirds of the waste volume as neutral carbon dioxide and reduce dependence on fossil fuels.

European waste recycling plants have the lowest emissions of all industrial sectors and are even healthier than the air we breathe in many cities.

The NextBAT technology ensures high efficiency of up to 99%, as well as a significant reduction in emissions between 95% and 99%. A product of scientific research spread over many years to meet the future needs of future generations for the extraction of fuel from waste.

Today, 50 tonnes of waste can be converted into energy, which would provide electricity to 27 million people in Europe.4 tonnes of waste equivalent to 1 tonne of oil and 2 tonnes of waste equivalent to 1 tonne of coal. **[SHA 16]**

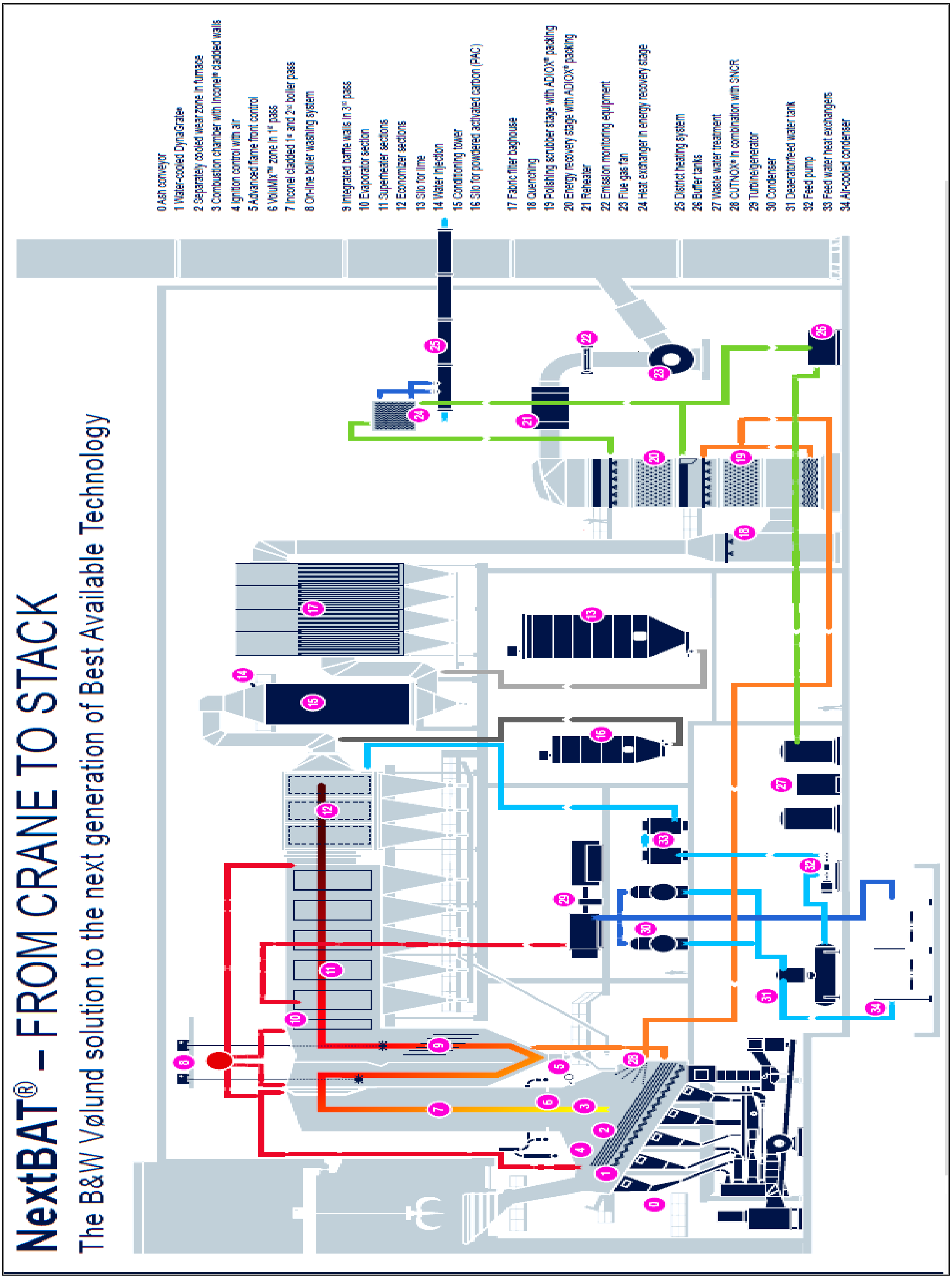


Figure 26: NextBAT-from crane to stack. Source:

[https://www.babcock.com/en/industry/waste-to-energy]

7: Sizing of a power plant at the landfill site:

7.1: The Area:

After I went to the waste disposal area in the municipality of Biskra and measured the area, which is estimated at about 100 thousand square meters (**100000m^2)** and strange in that I found a large amount of waste collected a problem of a small mountain of waste about **100 tons** consisting of household waste and wood and other cartons and this signifies saturation Private Landfill Centre.

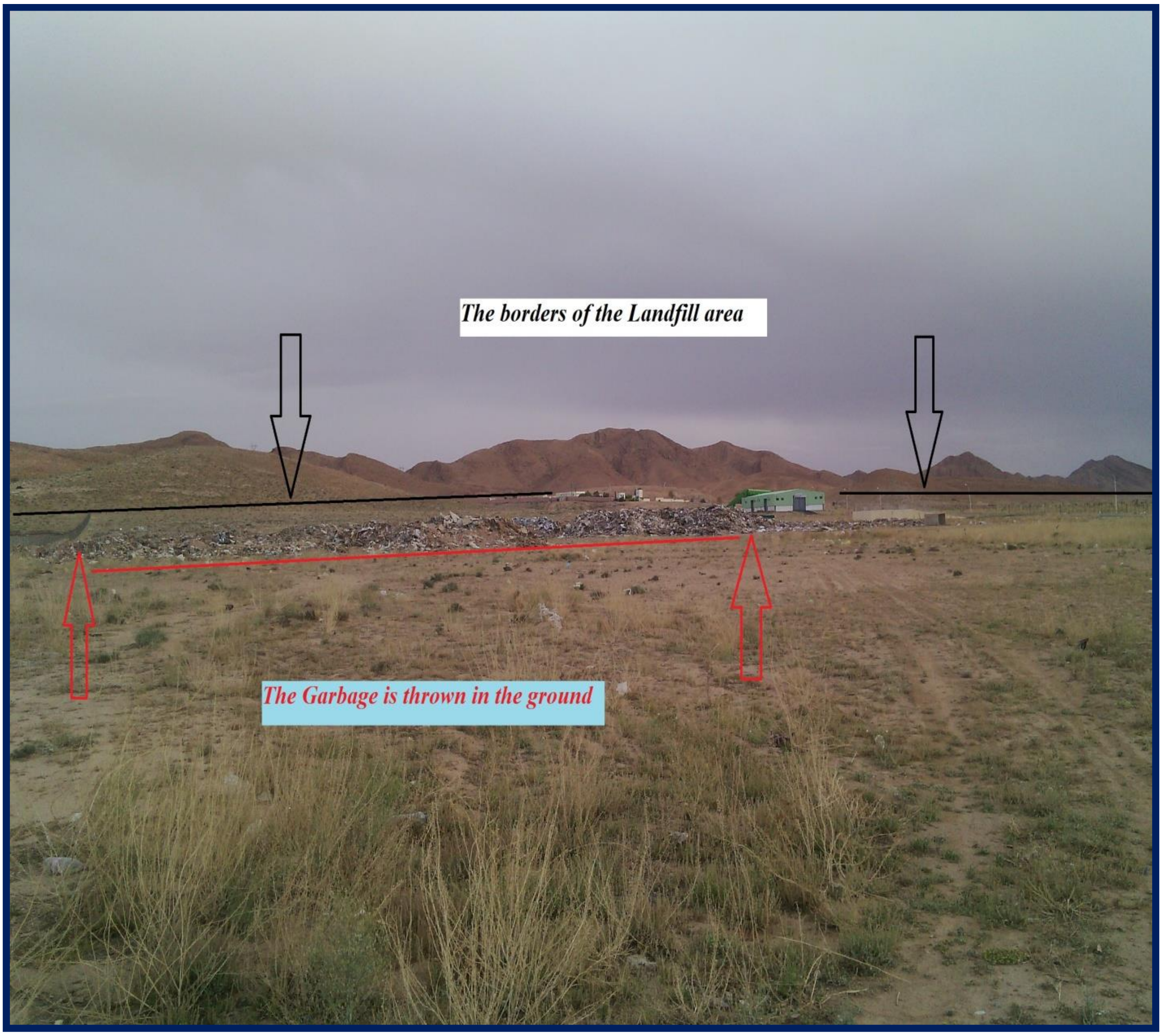


Figure 27: The borders of the Landfill area and the Station construction area **.**

As we can see in the picture, the area is very large and sufficient as a plan to complete a waste-to-energy conversion plant.

Figure 28: This is a Zoom picture of the landfill center in Biskra.

The area is surrounded by many agricultural lands and it is well-equipped with no electricity.

Figure 29: Agriculture area next to the Landfill site.

7.2: Method of waste management before and after entering the station:

We treat the waste of the city and disposed of in an environmentally friendly manner. Like any environmental projects in the world, we will build a plant according to high technical and environmental standards. Because waste is a very valuable resource for energy, derived assessments and laws that are successfully applied to mitigate adverse impacts are used to meet global environmental standards to ensure that waste is treated in a beneficial and environmentally friendly manner using the most up-to-date technologies. This means that the station to be completed in addition to consuming and disposing of the waste of the city to benefit from the generation of electricity and heating, it contributes significantly to the protection of the environment and reduce the percentage of land and air pollution and the meaning of the ozone layer using the technology Next BAT, which guaranteed 99% efficiency of the removal of emissions.

In the city of Biskra dealing with waste in accordance with the principle of reducing the production of waste, it had to be produced if it has to be sorted and reused. Therefore, waste is classified into several categories: paper, glass, metal, plastic, organic wastes and finally other types of waste that cannot be listed according to any of these previous classifications and cannot be reused or recycled.

These non-recyclable wastes are transported on Batna road directly to Biskra station outside the city, where more than 200 truckloads are unloaded during the day. The waste collector is equipped with two cranes that transport the materials that reach the store that feeds the burning lines, with a capacity of about 11 tons. And more than 30 tons of waste burned hourly at a temperature higher than 850 degrees Celsius.

7.3: The Technologies used according to MARTIN GmbH. [MAR 13]

Technical information on bridges Truck weight:

Number of bridges: 02

The remaining non-recyclable wastes and the huge waste within the waste trucks arrive at the station where the trucks are weighed on one of the weight bridges and the truck registration number is taken over a wireless system.

Data are recorded and stored in an integrated system for subsequent processing. In this way, the station ensures that the data on the waste containers and their load is always available in a regulated manner.

Figure 30: bridges Truck weight. Source: **[MAR 13]**

The Feeder:

A crane system lifts the waste from the refuse pit and transports it to the feed chute, which consists of a hopper and chute. The feed rams push the waste from the feed chute onto the combustion grate. Due to the height of the waste column in the chute, Folse air is unable to leak into the combustion system. Microwave level detectors report the height of the waste column in the chute to the crane operator. Bridging and obstructions are prevented by the inclined side walls of the hopper and the flaring of the chute. A shut-off damper located underneath the feed hopper is closed when the plant is not operating.

The feed ram changes the direction of waste flow from vertical to horizontal. The waste, compacted in the feed chute, is loosened during this process and pushed onto the grate in amounts determined by the combustion control system. The transition between the feeder and grate is in most cases designed as a drop-off edge, but can also be built as a slope.

Each feed ram is driven by a hydraulic cylinder. The combustion control system prescribes cycle time, stroke length and stroke speed to achieve uniform combustion on the grate. Feed ram operation is staggered for combustion grates with several grate runs**. [MAR 13]**

Figure 31: Source: **[MAR 13]**

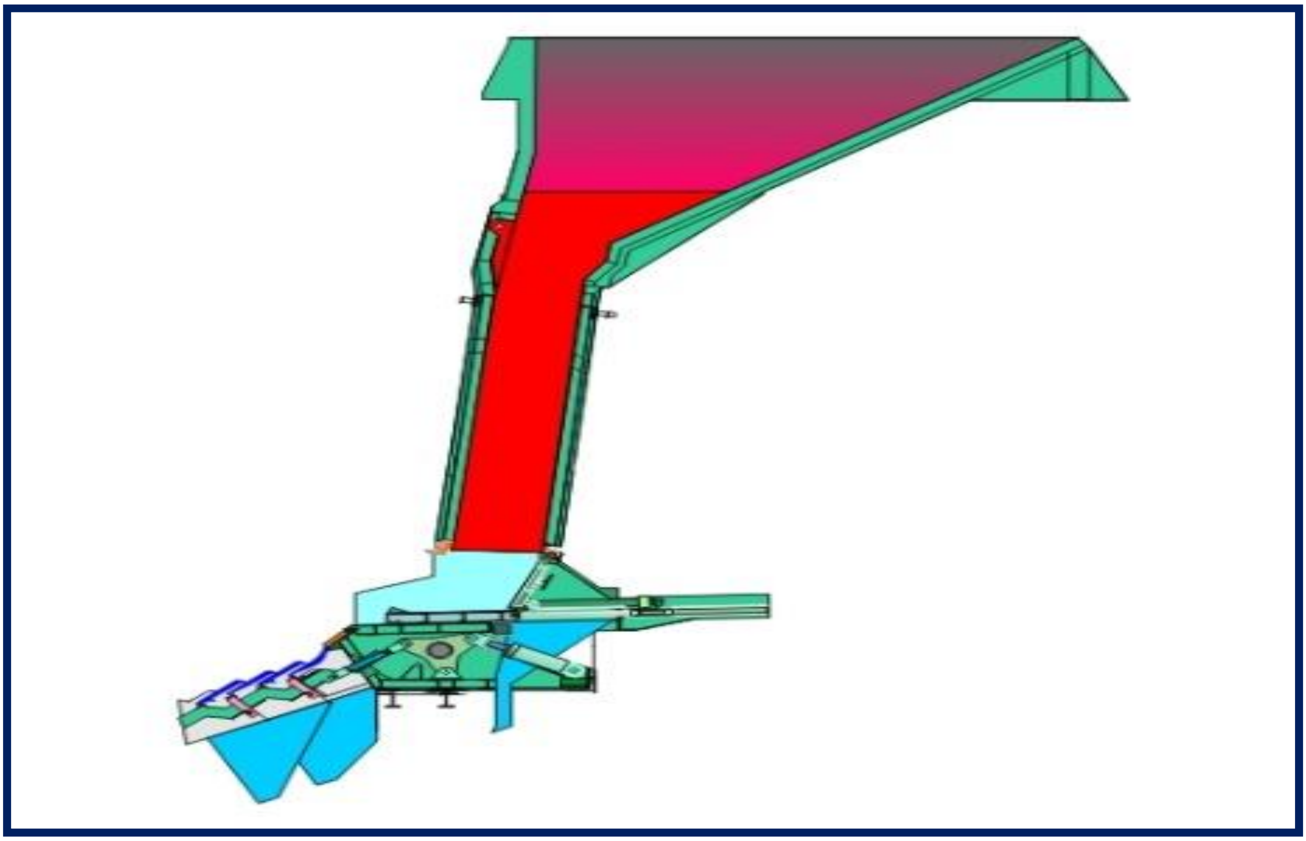


Figure 32: Source: **[MAR 13]**

Combustion system:

These three combustion systems differ in terms of the composition of the combustion air provided:

- Conventional – under-fire and over-fire air is being fed to the combustion process
- Flue gas recirculation - most of the over-fire air is replaced with re-circulated flue gas, after fly ash removal
- SYNCOM - part of the under-fire is enriched with pure oxygen; most of the over-fire air is replaced by the re-circulated flue gas

The grate systems used are the MARTIN reverse-acting grate Vario, the MARTIN horizontal grate and the MARTIN reverse-acting grate SITY2000. **[MAR 13]**

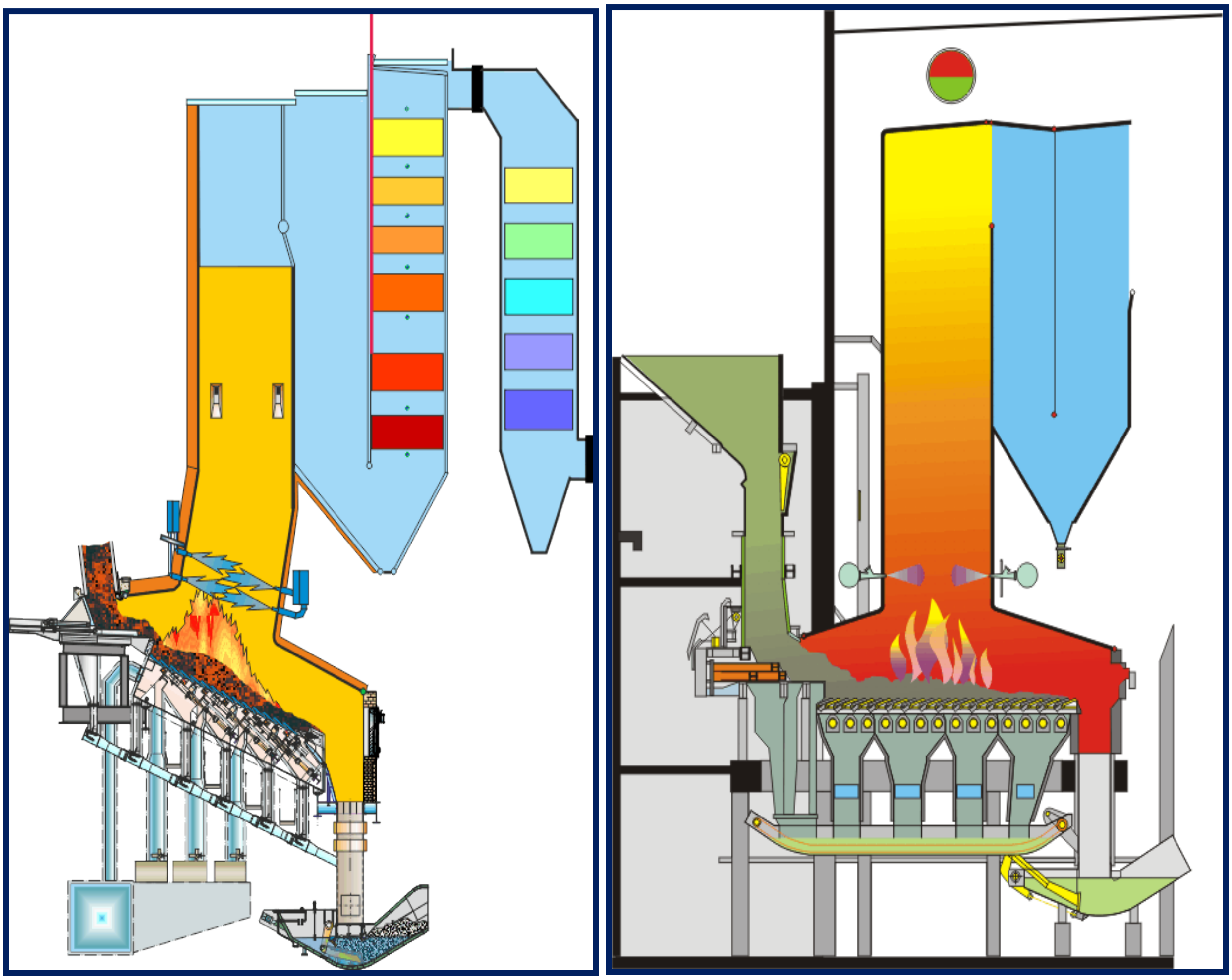


Figure 33: Reverse-acting grate Vario & Horizontal grate.Source: **[MAR 13]**

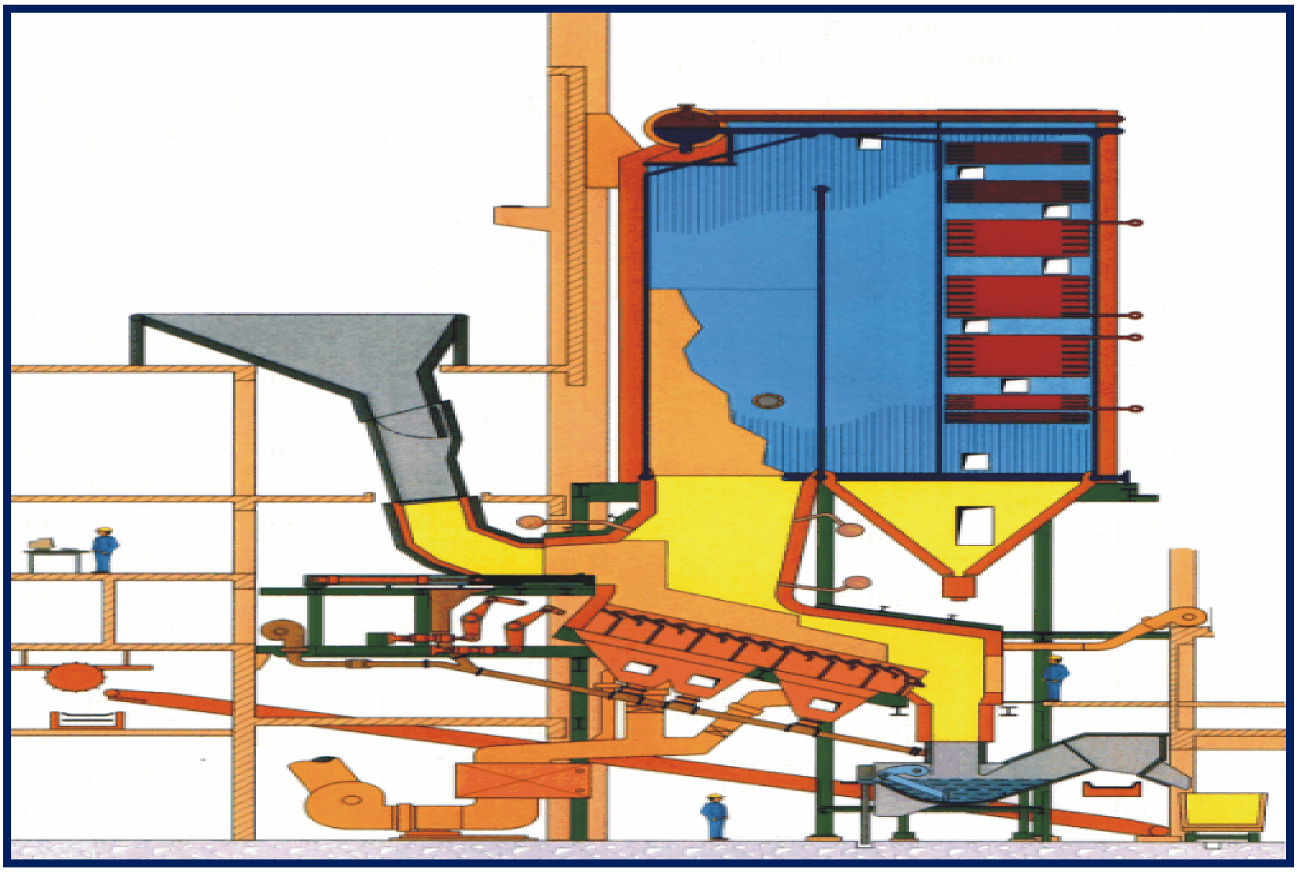


Figure 34: Reverse-acting Grate SITY 2000 Source: **[MAR 13]**

Figure 35: Reverse-acting Grate Vario. **[MAR 13]**

Flue gas recirculation:

Figure 36: Source: **[MAR 13]**

As an alternative to over-fire air systems using only fresh air, we also offer flue gas recirculation. This involves branching off flue gases downstream of the dust removal facility and returning them to the furnace to replace some of the over-fire air. Not only are combustion-related pollutants minimized, but the thermal efficiency of the whole plant is improved and the flue gas burden emitted into the environment is reduced.

The re-circulated flue gases are injected into the furnace via separate nozzles. Any over-fire air still required for secondary combustion is fed in via different nozzles.

The re-circulated gas ducts are insulated in order to prevent corrosive compounds from condensing on the walls and to keep heat loss at a minimum. **[MAR 13]**

Discharge:

For decades, the MARTIN discharger has shown itself to be a compact, reliable and cost-effective device for discharging bottom ash.

A wide range of dischargers is available, the smallest with a discharging capacity of approx. 0.2 m^3/h. Dischargers for coal-based combustion systems have a discharging capacity of approx. 0.4 to 3.0 m^3/h. Discharging capacities for waste combustion plants range between approx. 4.5 and 12.0 m^3/h. **[MAR 13]**

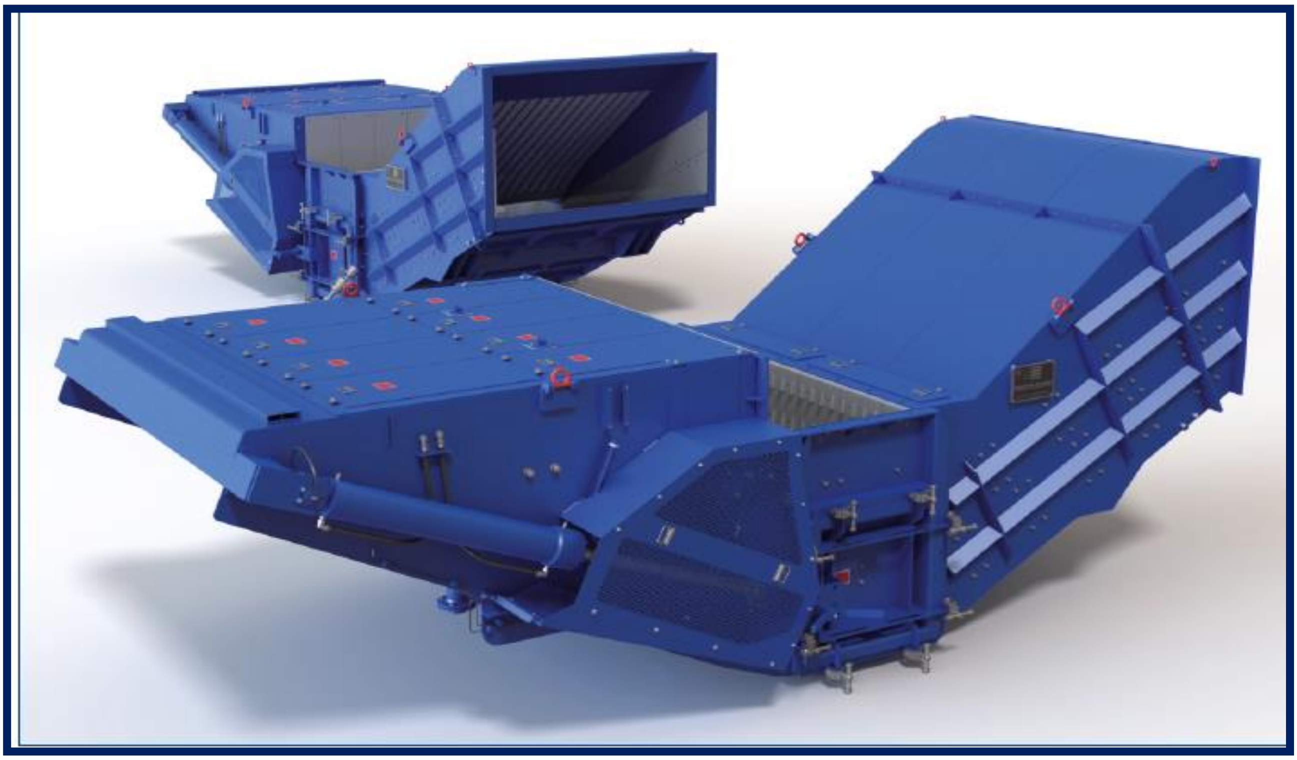


Figure 37: discharge. Source: **[MAR 13]**

The hot, burnt-out bottom ash is transported from the grate end to the discharger's water bath where complete quenching occurs. The water consumption depends exclusively on the temperature of the bottom ash and its capacity to absorb water. Only sufficient water to quench the bottom ash is fed to the discharger. Neither a water overflow nor recirculation is required nor does the area around the discharger remain clean.

The basic design is the same for all dischargers. The discharge is filled with water and a constant amount of bottom ash up to the level of the front air sealing wall. This creates an air seal against the furnace, thus preventing flue gas and thermal pollution in the basement on the one hand and false air ingress into the boiler on the other.

The discharging ram pushes the bottom ash under the air sealing wall towards the drop-off edge. As a result, the bottom ash is discharged in a dust-free and odorless manner. There is a drain-off section before the drop-off edge where excess water is extracted by the compressing action of the discharging ram. The bottom ash is therefore moist rather than wet when discharged.

The wear plates, liner plates and wear strips on the discharging ram of the MARTIN discharger are replaceable. The discharge is driven either by a separate or by a central hydraulic unit. **[MAR 13]**

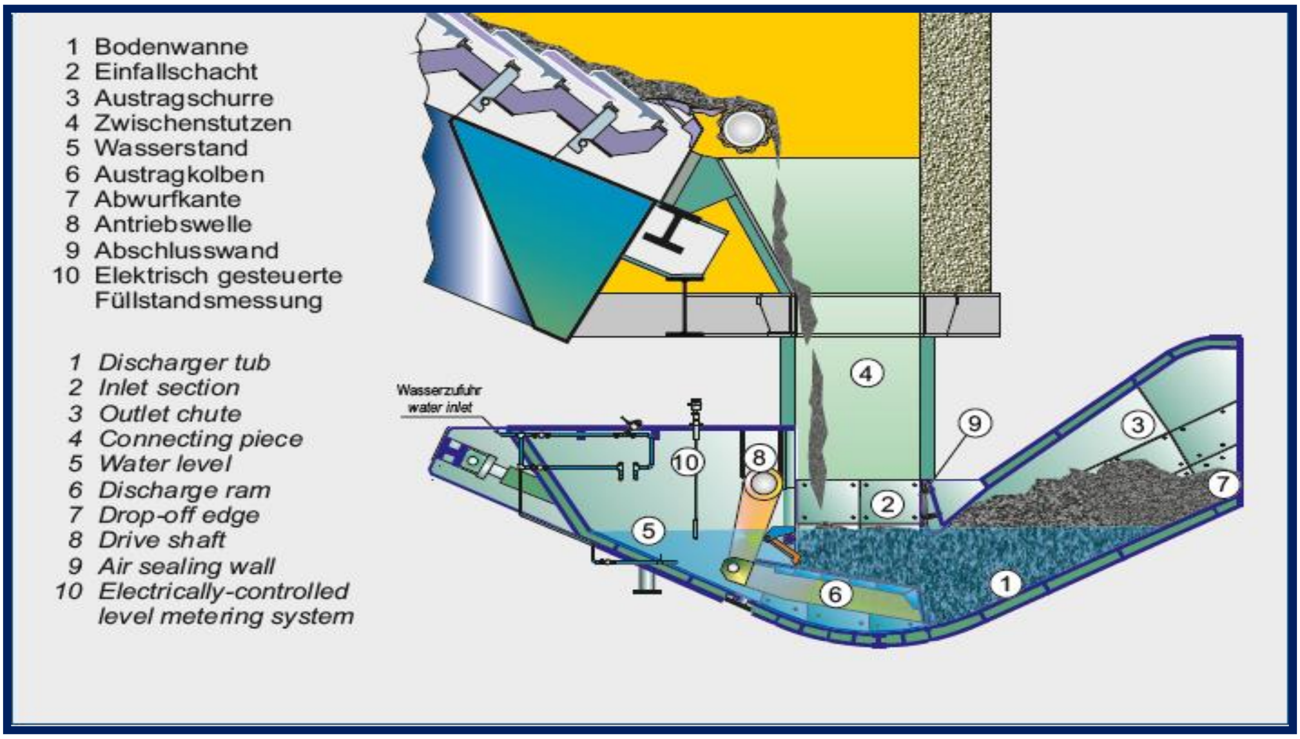


Figure 38: discharge invention. Source: **[MAR 13]**

SNCR process:

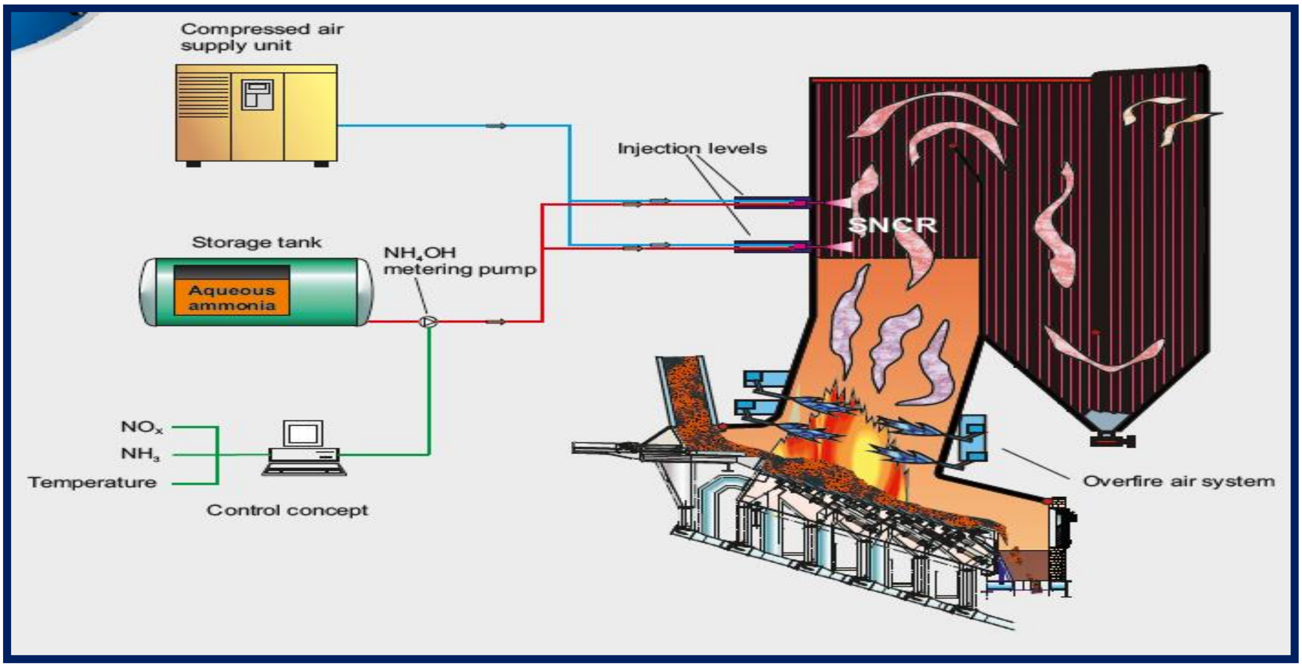


Figure 39: SNCR system Source: **[MAR 13]**

Nitrogen oxides (NO_x) are present in the flue gas due to the nitrogen content of the waste and the high temperatures required to safely destroy organic compounds. They can be reduced by means of flue gas recirculation, catalytic conversion (SCR) or non-catalytic conversion (SNCR).

MARTIN has developed its own process based on SNCR. The nitrogen oxides produced during combustion are reduced to nitrogen (N_2) and water (H_2O) by injection a reducing agent, aqueous ammonia (NH_4OH), into the furnace in the temperature range between approx. 850 to 1'050 °C.

The agent is injected via nozzles in the upper part of the furnace. Depending on the actual flue gas temperature in the furnace, different injection levels can be utilized, thus always staying within the optimal temperature range.

In order to achieve a uniform and fine distribution of the reducing agent, the second mass flow is required. The MARTIN SNCR system preferably uses compressed air for dispersion, softened fresh water can also be used on demand. The two mass flows are mixed in a mixing chamber directly upstream of the nozzle head. This results in low dead times for control of the aqueous ammonia mass flow and a low ammonia slip (NH_3) in the flue gas. Further optimization is possible using an in-situ NH_3 measuring device.

MARTIN has installed an SNCR system in various plants in Europe. **[MAR 13]**

Energy recovery:

Thermal treatment of waste recovers energy that can be usefully employed to generate electricity, heat for district heating purposes or process steam, in almost any number of combinations. The first step is to generate steam in a steam boiler.

Selection of the appropriate boiler type and its dimensions is one of our key services, based on our many years of experience. We determine arrangement, size, and dimensions of the heating surfaces, i.e. of radiation passes, super-heater, evaporator, and economizer. Furthermore, we specify the type and quality of the ceramic lining in addition to the detailed engineering at the interfaces. Our scope of supply includes recommendations regarding the arrangement and type of online cleaning devices for the heating surfaces as well as for measurement and control systems. High availability and long service periods can thus be achieved.

In times of growing concern relating to climate change and a shortage of / rise in costs of primary sources of energy, efficient utilization of energy derived from waste has become more significant. Particularly in Scandinavia, combined use-age of power and heat has been in operation for a long time. Higher efficiency for electricity generation can be reached when combining a waste-to-energy plant with one utilizing fossil fuels. MARTIN's experience and references also cover all these fields.

Manufacturing of the steam boiler is done in close contact and cooperation with carefully selected specialist companies. MARTIN can either subcontract 'packages' or tender and order individual components. In all cases, our design is the basis. **[MAR 13]**

Various boiler designs are shown below by way of examples:

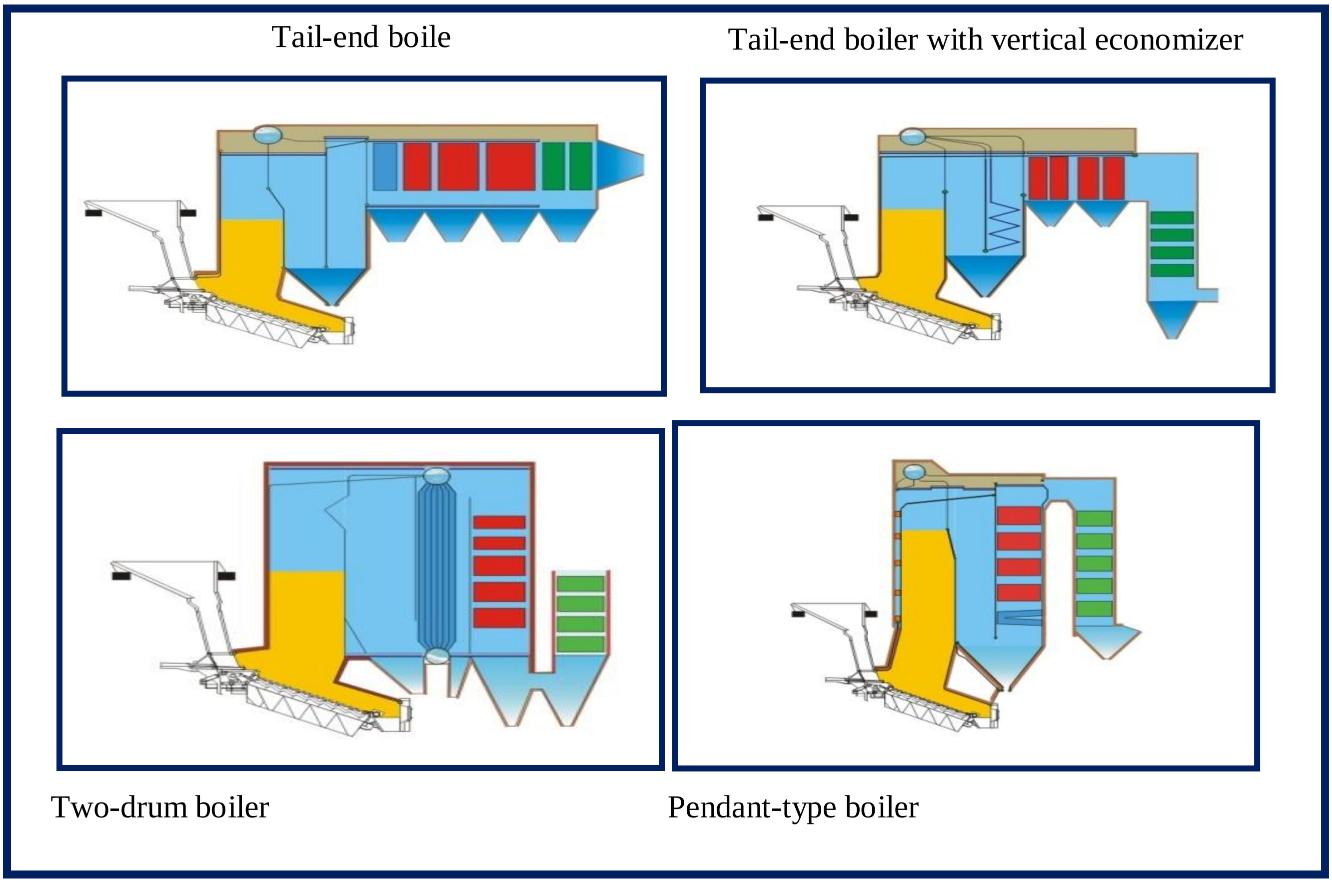


Figure 40: Various boiler designs. Source: **[MAR 13]**

MICC - MARTIN Infrared Combustion Control:

MARTIN achieves these goals by using modern PC hardware and instrumentation and control systems and linking them in an intelligent way. All this is implemented in

The MICC - MARTIN Infrared Combustion Control:

The core component of this combustion control system is an IR camera installed in the roof of the first boiler pass. Using a custom software program, the camera produces a high spatial and temporal resolution image of the temperature and the location of the fire on the grate.

The current image and the trend of the last few minutes are displayed on a monitor in the control room. The information obtained is processed by the combustion control system and influences the combustion system settings.

Signals from thermocouples in the first boiler pass and the IR pyrometer in the second boiler pass as well as steam flow, O2 content in the flue gas at the boiler outlet and under-fire air flow are also processed as controlled variables by the combustion control system. All necessary software tools, e.g. for IR image evaluation, fuzzy-technology-based combustion control, an operating mode concept, and remote data transmission, are integrated into a high-end industry PC (IPC). The IPC is connected to the superordinate distributed control system via a standard bus, irrespective of who supplies the system. All field devices are connected to the superordinate control system. Consequently, the customer has unlimited access to the field devices and can adjust their settings accordingly. **[MAR 13]**

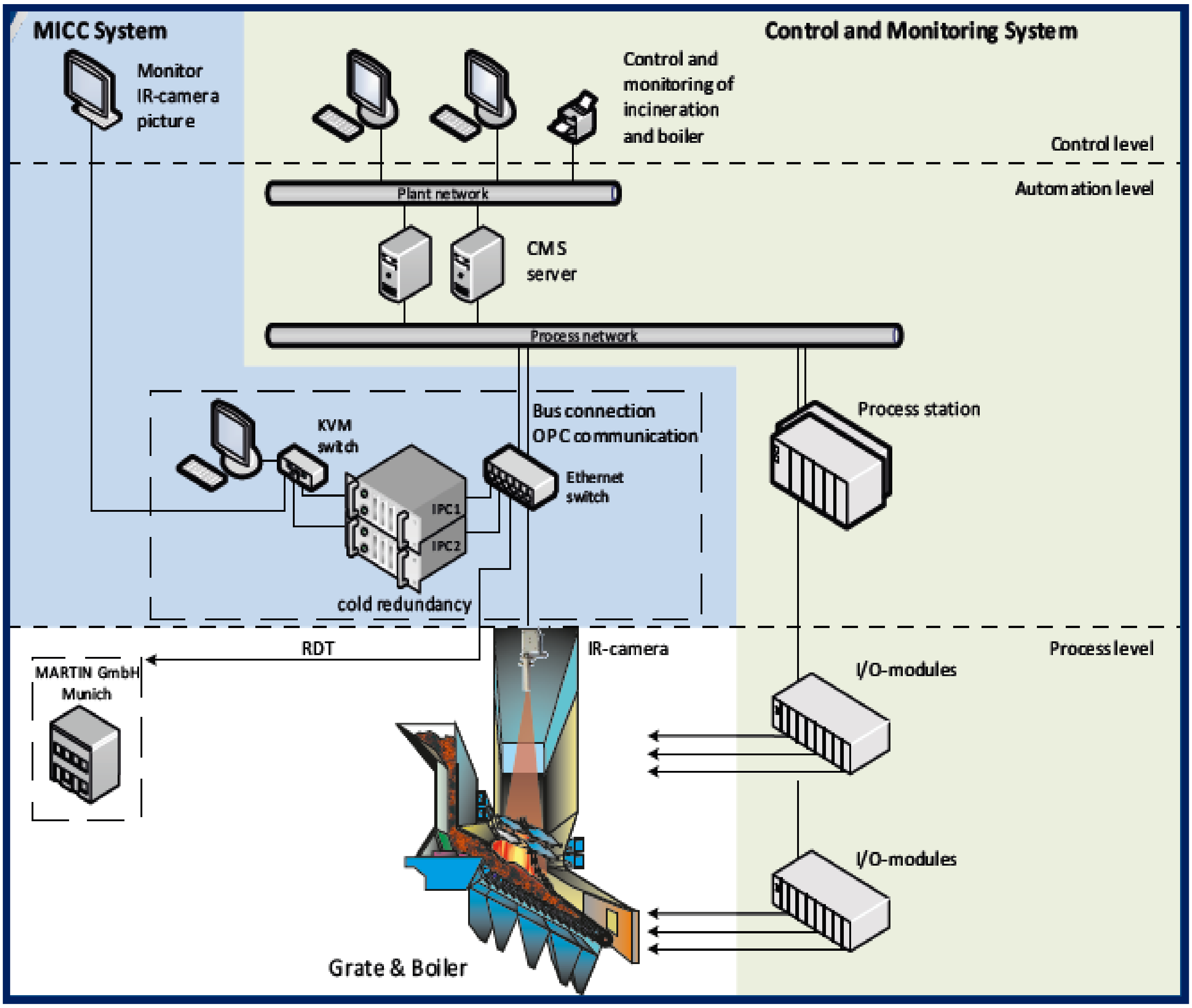


Figure 41: MICC - MARTIN Infrared Combustion Control. Source: **[MAR 13]**

Dry discharge system:

In times of diminishing resources and increased environmental awareness, the bottom ash that remains on the grate after combustion, in particular, the ferrous and non-ferrous metals contained in the bottom ash should be recycled. Dry discharge offers significant advantages in this respect. Not only are the recoverable metals of better quality, but the fine fraction can also be separated from the coarse fraction more effectively and recycled separately.

The MARTIN dry discharge system consists of the following components:

- MARTIN ram-type discharger
- Air separator enclosed in a housing
- Dust removal system
- Air system **[MAR 13]**

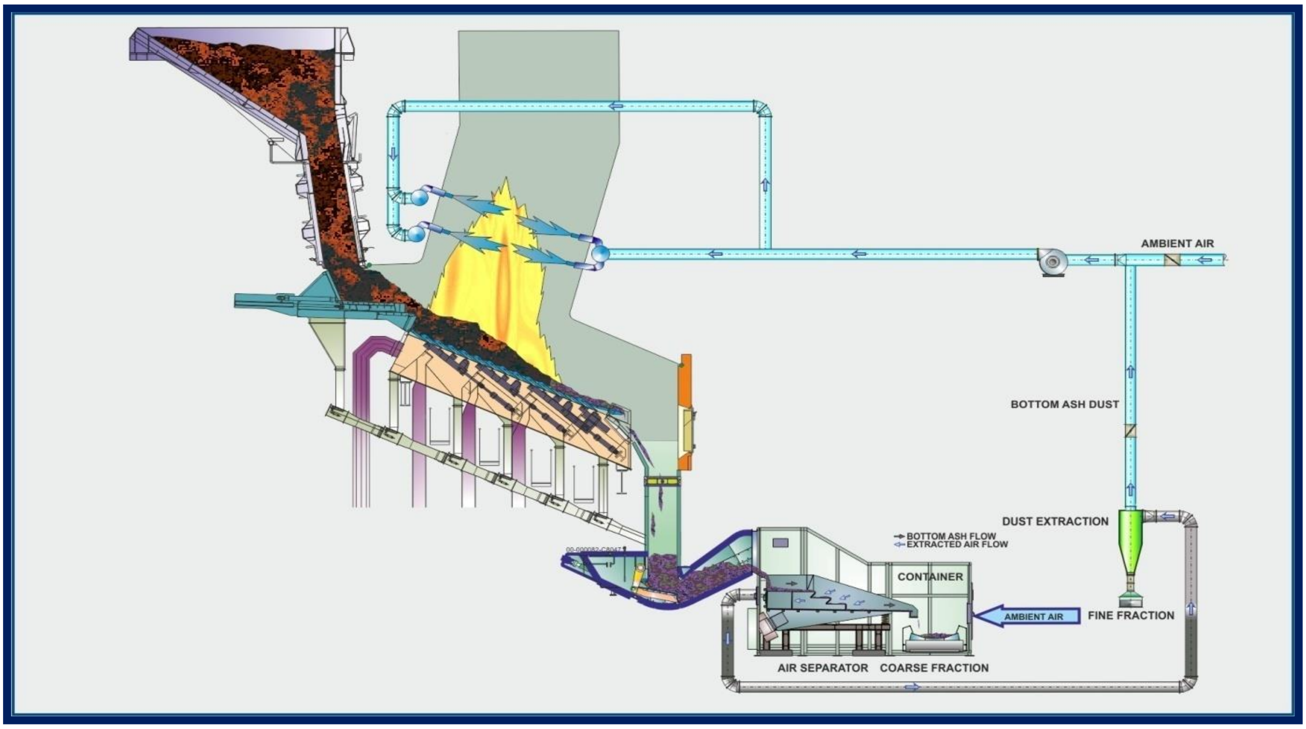


Figure 42: Dry discharge system. Source: **[MAR 13]**

The MARTIN dry discharge system offers the following advantages:

- There is no water consumption (saving water and transport costs)
- The metals obtained are of better quality
- Most of the bottom ash is recycled
- The coarse fraction has a reduced dust content and can be transported
- Improved metal quality

Figure 43: Metals recovered. Source: **[MAR 13]**

7.4: The used turbine is (SSt150):

A steam turbine with an efficient and compact arrangement

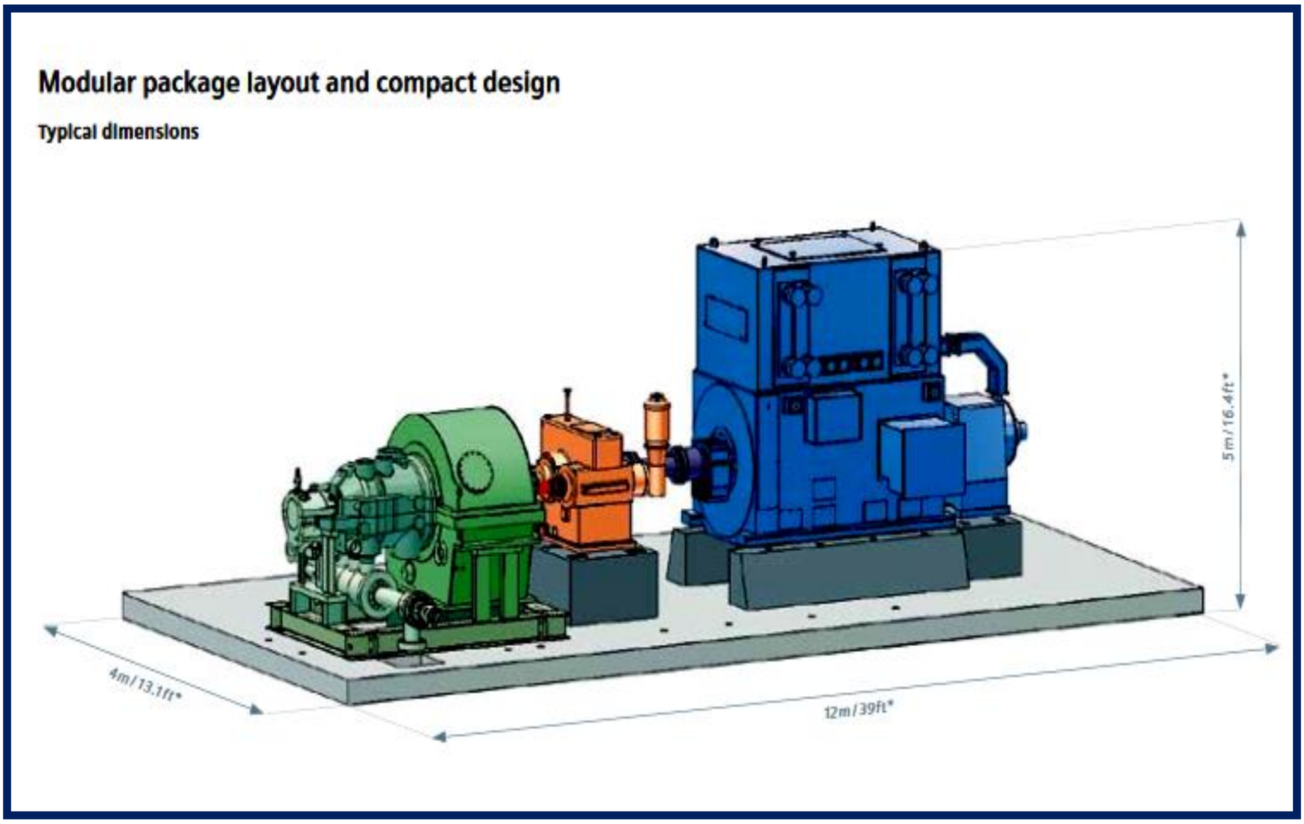


Figure 44: Modular package and compact design Source: **[MAR 13]**

The SST-150 is a single-casing steam turbine, providing the geared drive to a 1,500 or 1,800 rpm generator. The turbine is packaged in a skid-mounted design (can also be with separate oil system). This is a very compact arrangement which provides high efficiency in power generation and mechanical drive applications. The pre-engineered turbo set enables early planning of the turbine building layout, saving time for the customer.

The SST-150 is a steam turbine with impulse blading, developed to meet the most demanding customer requirements for cost-efficient power generation and mechanical drive applications. The turbine is used for both backpressure and condensing applications with internally controlled extraction and scope for several bleeds. Both back pressure and condensing turbines are available with the upward or downward exhaust. The exhaust flange can be equipped with top or bottom exhaust. **[SIE 17]**

The steam example application:

Roi ET, Bangkok, Thailand

The 9.9 MW electrical capacity power plant is based on mostly rice husk and a smaller fraction of wood chips (up to 10 %) as fuel. The power plant was erected by Bua sommai Electricity Generating Co., Ltd. (Bua sommai) located in Roi ET, Thailand. Out of the gross generation capacity of 9.9 MW, a total of 8 MW is fed into the national electricity grid.

Steam turbine: [SST-150] Power **output:** [9.9 MW] with: Generator Drive

Figure 45: Roi ET, Thailand: Turboset for the Bua Sommai Electricity biomass power plant.

Source: **[SIE 17]**

I chose the **SSt150 turbine** because we would burn 544.18 tons of waste per day, equivalent to 42.7MW of power.

7.5: Technical features of the turbine (SSt150):

- **Power output** **up to 20 MW**
- **Speed** **up to 13,000 rpm**

Live steam parameters

- **Inlet pressure** **up to 103 bar / 1,495 psi**
- **Inlet temperature** **up to 505° C / 940° F**

Exhaust steam parameters

- **Back-pressure** **up to 10 bar / 145 psi**
- **Condensing** **up to 0.25 bar / 3.6 psi**

Steam extraction

- **Controlled (up to 4)** **16 bar / 230 psi /**

  350° C / 560° F

- **Uncontrolled** **25 bars / 365 psi**

Source: **[MAR 13]**

8: The cost of production of this plant:

Biomass – Overnight capital costs for biomass technologies (Figure 11) are between approximately $2,000/kW and $4,000/kW. The MiniCAM costs are at the low end of the range, and the MERGE costs are at the high end over the entire time horizon. AEO and EPA costs start at the high end, but then fall, with AEO having costs below $2,500/kW by 2030. NREL-SEAC overnight capital costs are constant at slightly under $3,000/kW over the modeling horizon. The GPRA data set does not include biomass. **[TID 10]**

TABLE 5.5: ESTIMATED EQUIPMENT COSTS FOR BIOMASS POWER GENERATION TECHNOLOGIES BY STUDY

	O'Connor, 2011	Mott MacDonald, 2011	EPA, 2007 and EIA, 2010	Obernberger, 2008
		(2010 USD/kW)		
Stoker boiler	2 600 - 3 000	1 980 - 2 590	1 390 - 1 600	2 080
Stoker CHP	2 500 - 4 000		3 320 - 5 080*	3 019
CFB	2 600 - 3 000	1 440	1 750 - 1 960	
CFB CHP			4 260 - 15 500	
BFB		2 540	3 860	
Co-firing	100 - 600			
100% biomass repowering	900 - 1 500			
MSW	5 000 - 6 000			
Fixed bed gasifier ICE		4 150	1 730	4 321 - 5 074
Fixed bed gasifier GT	3 000 -3 500			
Fluidised gasifier GT			2 470-4 610	
BIGCC	3 500 - 4 300		2 200-7 894	
Digester ICE	1 650 - 1 850	2 840 - 3 665		
Digester GT	1 850 - 2 300			
Landfill gas ICE	1 350 - 1 500		1 804	

Note:
* = CHP back pressure steam turbine. ICE = internal combustion engine.
GT = gas turbine. MSW = municipal solid waste.

Figure 46: estimated equipment costs for biomass power generation technologies by the study.

Source: International Renewable Energy Agency :(IRENA)

Economics

The major capital cost items for a biomass power system include the fuel storage and fuel handling equipment, the combustor, boiler, prime mover (e.g. turbine or engine), generator, controls, stack, and emissions control equipment.

System cost intensity tends to decrease as the system size increases. For a power-only (not combined heat and power) steam system in the 5 to 25 MW range, costs generally range between $3,000 and $5,000 per kilowatt of electricity. Levelized cost of energy for this system would be $0.08 to $0.15 per kWh, but this could increase significantly with fuel costs. Large systems require significant amounts of material, which leads to increasing haul distances and material costs. Small systems have higher O&M costs per unit of energy generated and lower efficiencies than large systems. Therefore, determining the optimal system size for a particular application is an iterative process. **[FEMP 16]**

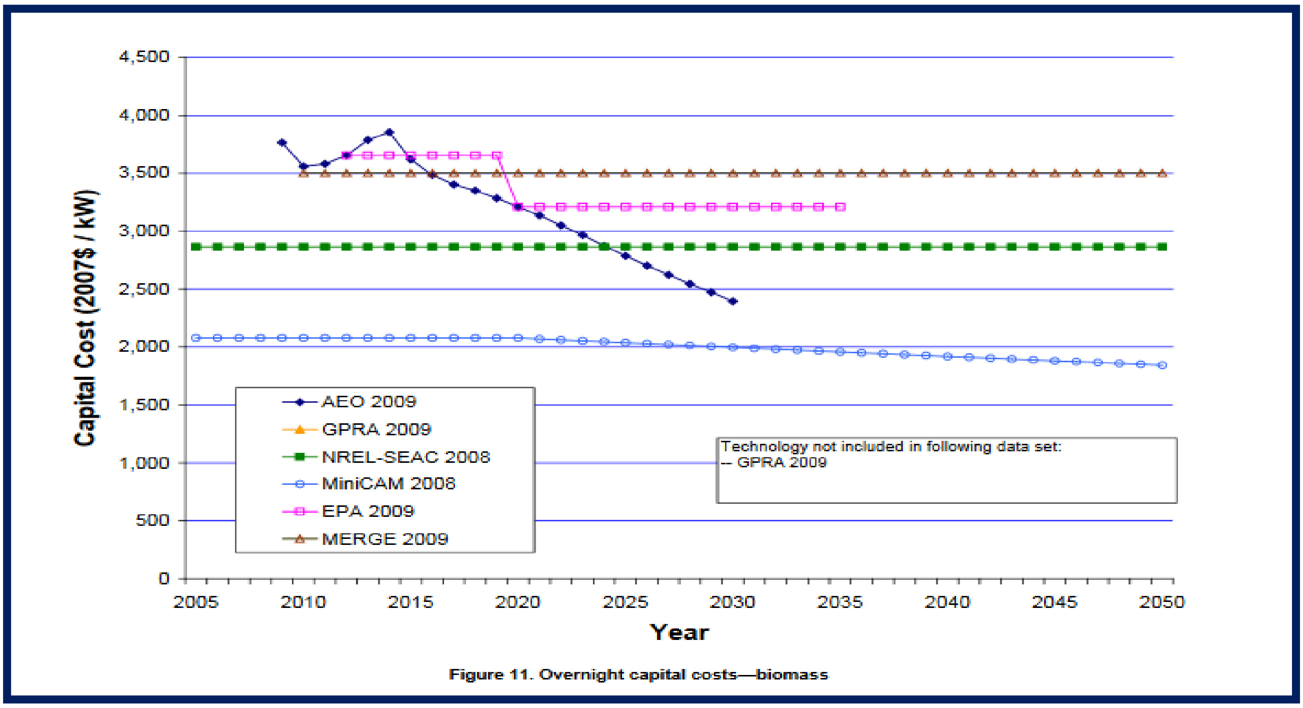


Figure 47: overnight capital costs. **Source: NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.**

9: The final cost of the power plant in biskra city:

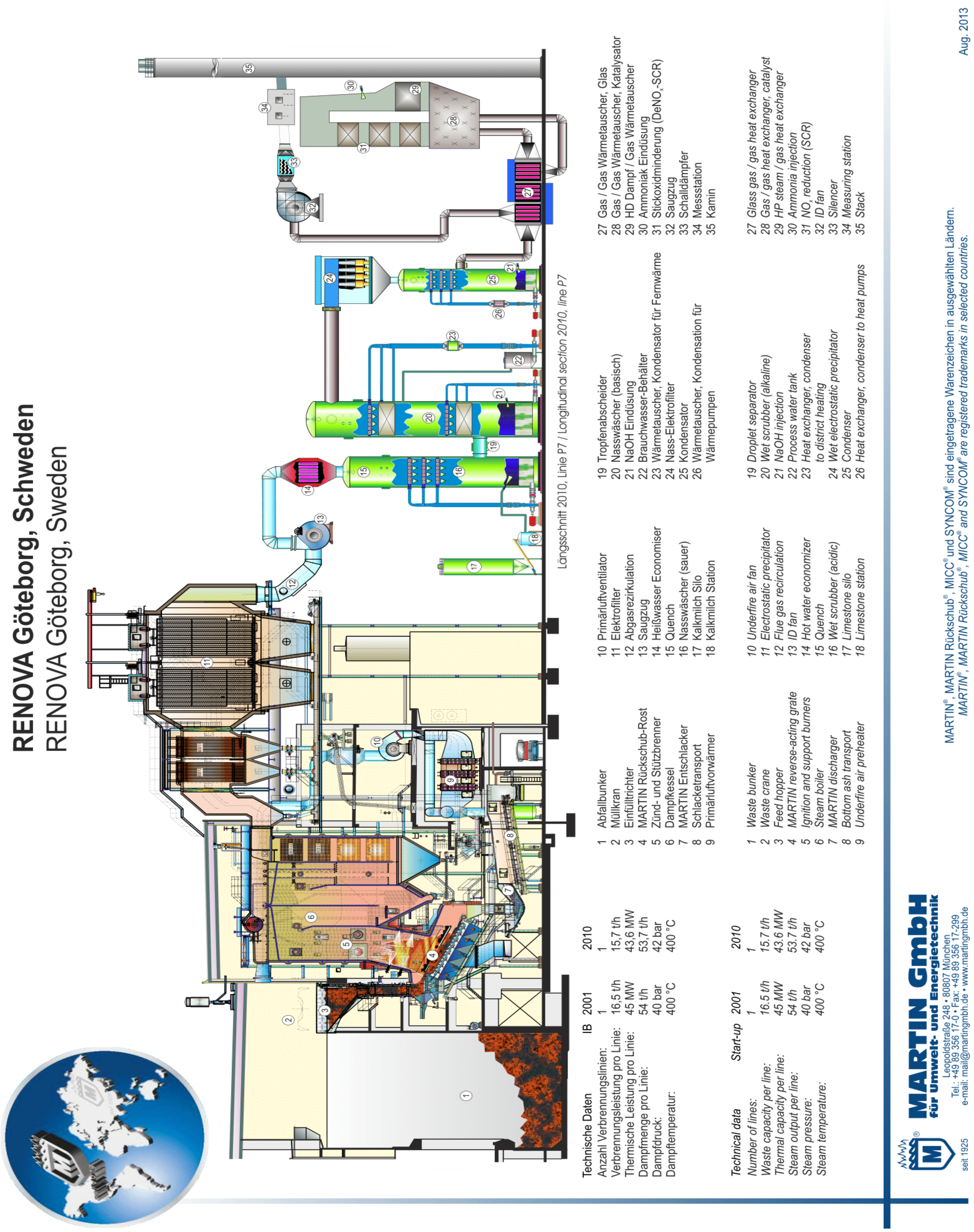
The cost of this plant will be very low for the Ethiopian station because it is different in terms of the quality of waste because it rises above the level of the sea of 2300 meters and therefore the area will enjoy high humidity and therefore waste will need special attention, which costs more than estimated 95 million dollars for 1.85 GW A **$ 3800** for 1 kW Courier.

For the Biskra state station and according to the **Federal Energy Management Program,** if the station you want to manufacture produces between 5 and 25 MW, the costs are between 3000 dollars and $ 5000 per kilowatt. If the station Biskra and according to calculations: So for the state of Biskra costs will be between $ 3,000 and $ 3400 for two cases:

Table XV: cases of Biskra power plant costs.

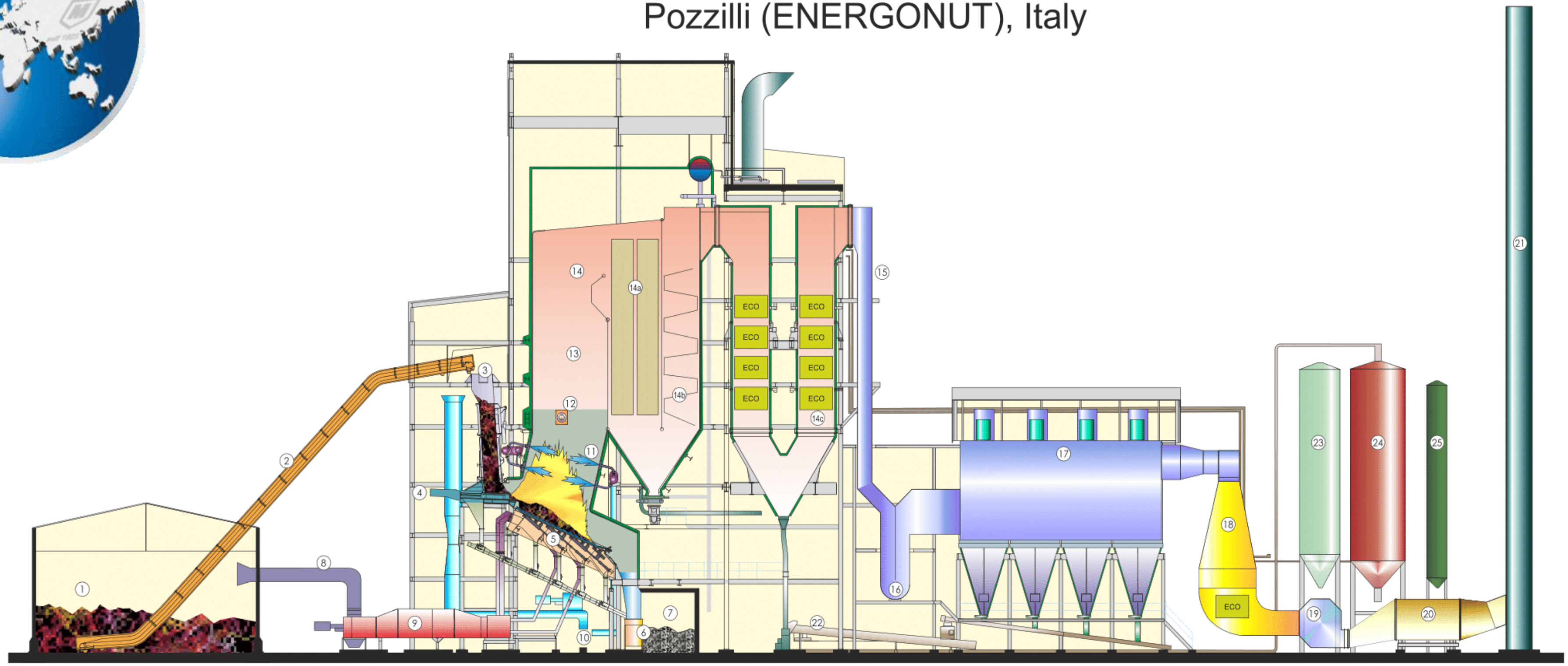
Cases	*Costs incurred in 3000$*	*Costs incurred in 3200$*	*Costs incurred in 3400$*
Case 01(10 MW)	**30 BILLION $**	**32 BILLION $**	**34 BILLION $**
Case 02(20MW)	**60 BILLION $**	**64 BILLION $**	**68 BILLION $**

10: comparison between the new technologies used in Pozzili (ENERGONUT) Italien and RENOVA Gӧteberg, Sweden:



Pozzilli (ENERGONUT), Italien

Pozzilli (ENERGONUT), Italy



Technische Daten	
Anzahl Verbrennungslinien:	1
Verbrennungsleistung pro Linie:	13,4 t/h
Thermische Leistung pro Linie:	49,9 MW
Dampfmenge pro Linie:	61,2 t/h
Dampfdruck:	56 bar
Dampftemperatur:	400 °C

1 Entlade-/Lagerhalle
2 Abfall-Transportsystem
3 Einfülltrichter
4 Beschickung
5 MARTIN Rückschub-Rost Vario
6 Entschlacker
7 Schlackebunker
8 Primärluftabsaugung
9 Primärluftsystem mit Luvo
10 Sekundärluftventilator
11 Sekundärluft-Eindüsung
12 Zünd- und Stützbrenner
13 Feuerraum
14 Dampfkessel mit
14a Überhitzer
14b Verdampfer
14c Economiser
15 Bicarbonat-Aktivkohle Eindüsung
16 Umlenk-Flugstromreaktor
17 Gewebefilter
18 Externer Economiser
19 Saugzug
20 Schalldämpfer
21 Kamin
22 Flugaschetransport
23 Bicarbonatsilo
24 Reststoffsilo
25 Aktivkohlesilo

Technical data	
Number of lines:	*1*
Waste capacity per line:	*13.4 t/h*
Thermal capacity per line:	*49.9 MW*
Steam output per line:	*61.2 t/h*
Steam pressure:	*56 bar*
Steam temperature:	*400 °C*

1 Tipping/storage hall
2 Waste transport system
3 Feed hopper
4 Feeder
5 MARTIN reverse-acting grate Vario
6 Discharger
7 Bottom ash bunker
8 Underfire air intake
9 Underfire air system with air preheater
10 Overfire air fan
11 Overfire air injection
12 Ignition and support burners
13 Furnace
14 Steam boiler with
14a Superheater
14b Evaporator
14c Economizer
15 Bicar-activated carbon injection
16 Deflector entrained-flow reactor
17 Fabric filter
18 External economizer
19 ID fan
20 Silencer
21 Stack
22 Fly ash transport
23 Bicar silo
24 Residue silo
25 Activated carbon silo

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Aug. 2013

Figure 48: figures a, b are they representing two power plants of waste-to-energy with combustion technologies.

Comparison between two waste-to-energy transfer plants in terms of technology used, we note that there are ten additional technologies used only within 5 years, that is, a station of interest and research experts and engineers to ensure the development of this field.

Conclusion

In the last chapter, we have identified the most prominent technologies and technologies that have characterized biomass stations over the years and are looking to find the best value for this renewable energy. As noted, these technologies, such as NEXT BAT, Polluted to the environment and the atmosphere by 99 percent so that it is cleaner than the air we breathe, and other technology Martin GmbH, known internationally and at the level of Europe in a large extent in the burning through the use of the Grate systems: the MARTIN reverse-acting grape Vario, the MARTIN horizontal grate and the MARTIN reverse-acting grate SITY2000

If we set up a waste-to-energy plant in Biskra state, the cost would be between $ 60 million and $ 70 million in approximation in 20 MW, and $30 to $35 million in 10 MW. Yes, it may be a little expensive, but it will be the only solution to get rid of these wastes in the right way.

General Conclusion

In the face of the increase in the amount of waste in Algeria and its 48 states per year, which have been filled with 85% of the total of 91 landfill centers in Algeria and the development of waste disposal technologies in developing countries, this research has examined an innovative model of the power plant through the new technology Developed in the field of waste incineration, which is the most effective and efficient solution for the disposal of these wastes instead of filling them.

The purpose of this study is to determine whether this model has the capacity to work as a crane for these wastes from the popular neighborhoods and high-end residential areas and the country's picturesque nature to protect and protect the environment and in turn convert it into energy to reduce some of the burdens on natural gas reserves in Algeria.

First, we explained the solutions we have made so far. The approach of public and private institutions has proved from the top down that it is unable to cope with this problem. To cope with this crisis, the use of 544.18 tons of waste in the state of Biskra after processing and recycling may remove the obstacle of 196 thousand tons per year would be a success that may be the enemy of some large cities.

Finally, these plans were tested for two cases that were studied according to the last used stations. The latest technology used by **NEXT-BAT** and Germany's **MARTIN GmbH** was the reason for the construction of 530 waste-to-power plants around the world. The first is the construction of a 544.18 ton Which will cost about $ 30 to $ 34 million, but this plant will not last for more than 10 years on the basis that the waste is increasing with the population, which makes us enter the second case, which is the operation of the station with 20 MW, which costs from 60 to 64 million dollars to The station is about 30 years with the increasing waste and with the lack of local authorities to ensure that recycles waste and processed.

Has recently proposed to introduce a perfect type of technological excellence developed in European countries since 1928 by the German company, which was registered this year in Munich as a company that started the first waste incineration plant in Sao Paulo, Brazil in 1952, and now we are in 2019, Prior to the years the equipment and equipment used in many stations have evolved to focus on accuracy, quality and reduce the high costs.

We conclude from this research that much work can be done by experimenting with the construction of a waste-to-energy plant in Biskra as a link between the North and the South and not judging the costs that are considered a little expensive but that renewable energy "biomass" will reduce the costs of using it over time Like other renewable energies, solar energy, which was considered a costly effort, became the concept of excellence to provide services of general interest to remote and desert areas on a large scale.

Annex 01

Thermal waste treatment facilities using MARTIN technologies

Anlagen zur thermischen Abfallbehandlung mit MARTIN Technologien

Usines de traitement thermique des déchets urbains avec les technologies MARTIN

Impianti per il trattamento termico di rifiuti urbani con le tecnologie MARTIN

Country *Land* *Pays* *Paese*	Number of plants *Anzahl Anlagen* *Nombre d'usines* *Numero impianti*	Number of lines *Anzahl Linien* *Nombre de lignes* *Numero linea*	Throughput Mg/d *Durchsatz* *Capacité* *Capacità*
Austria	6	10	3188
Azerbaijan	1	2	1584
Belgium	6	11	3878
Brazil	2	4	600
Canada	3	5	1156
China	134	251	134119
Czech Republic	3	7	2359
Denmark	3	3	1560
Estonia	1	1	660
Ethiopia	1	2	1234
France	67	115	29254
Germany	31	48	19849
India	4	7	4050
Italy	13	22	9528
Japan	88	199	34790
Jersey	2	4	654
Korea, Rep. of	10	17	3825

Luxembourg	2	3	720
Macao	3	6	1728
Monaco	2	3	417
Netherlands	14	33	13936
Norway	3	6	1056
Poland	1	1	288
Portugal	1	2	1280
Russian Fed.	3	5	1000
Singapore	4	21	13992
Slovakia	1	2	524
Spain	3	5	1344
Sweden	12	14	5134
Switzerland	37	46	12002
Taiwan	7	18	7400
Thailand	4	5	3250
United Kingdom	26	45	20122
United States	32	72	31592
TOTAL	530	995	368074

Annex 02

Thermal waste treatment facilities using MARTIN technologies

No. *Nr* *N°* *N.*	Country *Land* *Pays* *Paese*	Plant *Anlage* *Usine* *Impianto*		Number of lines *Anzahl Linien* *Nombre de lignes* *Numero linee*	Throughput [Mg/d] *Durchsatz* *Capacité* *Capacità*		Thermal capacity [MW] *Thermische Leistung* *Puissance thermique* *Potenza termica*		Start-up *Inbetriebsetzung* *Mise en service* *Messa in servizio*	Grate technology *Rosttechnologie* *Technologie de grille* *Technologia griglia*
					per stream	*total plant*	*per stream*	*total plant*		
437	CN	Ningbo IV	*	1	600	600	48.61	48.61	2018	S
438	CN	Dongguan Hengli III	*	3	600	1800	48.61	145.83	2018	S
439	CN	Mianyang		2	500	1000	40.51	81.02	2018	S
440	CN	Suzhou		1	600	600	48.61	48.61	2018	S
441	SG	Singapore 6		4	900	3600	120.00	480.00	2019	R
442	CN	Shaoxing		3	750	2250	60.76	182.28	2018	S
443	CN	Chizhou		1	400	400	32.41	32.41	2018	S
444	CN	Dingyuan		1	500	500	40.51	40.51	2018	S
445	CN	Hefei Changfeng		2	500	1000	40.51	81.02	2018	S
446	CN	Laibin		2	500	1000	40.51	81.02	2018	S
447	CN	Lingquan		1	600	600	48.61	48.61	2018	S
448	CN	Meizhou		2	500	1000	40.51	81.02	2018	S

449	CN	Putian III	*	1	600	600	48.61	48.61	2018	S
450	GB	Kemsley		2	979	1958	102.00	204.00	2019	V
451	CN	Dongguan Downtown II	*	2	600	1200	48.61	97.22	2019	S
452	JP	Tomioka		2	250	500	26.00	52.00	2015	R
453	JP	Okuma		1	200	200	15.00	15.00	2018	R
454	CN	Shanghai Laogang II		8	850	6800	82.36	658.88	2019	R
455	CN	Caoxian		1	600	600	48.61	48.61	2019	S
456	CN	Taizhou		1	600	600	48.61	48.61	2019	S
457	CN	Xuyi		2	525	1050	42.53	85.06	2019	S
458	CN	Zhangpu		1	525	525	42.53	42.53	2019	S
459	CN	Chunhui		1	600	600	48.61	48.61	2019	S
460	CN	Rongcheng		1	400	400	32.41	32.41	2019	S
461	TH	Saraburi		2	750	1500	60.76	121.52	2019	S
462	GB	Deeside (North Wales)		1	695	695	68.38	68.38	2019	V
463	CN	Ma'anshan		2	400	800	31.02	62.04	2017	S
464	FR	Thiverval/Grignon/Plaisir	*	1	346	346	33.50	33.50	2019	R

465	CN	Shantou-Lei Dashi		2	600	1200	48.61	97.22	2020		S
466	CN	Jiyuan		2	300	600	24.30	48.60	2020		S
467	CN	Pan Zhihua		2	400	800	32.41	64.82	2020		S
468	CN	Beiliu		2	350	700	28.36	56.72	2020		S
469	CN	Huangshan		2	300	600	24.30	48.60	2020		S
470	CN	Lanxi		1	400	400	32.41	32.41	2020		S
471	CN	Chenzhou II	*	1	550	550	44.56	44.56	2020		S
472	CH	Aarberg		1	248	248	33.00	33.00	2020		V
473	GB	Bristol-Avonmouth		2	574	1148	57.85	115.70	2020		V
474	CZ	Prag		4	336	1344	35.00	140.00	2019-22		R
475	CN	Pingnan		1	600	600	48.61	48.61	2020		S
476	CN	Lufeng		2	400	800	32.41	64.82	2020		S
477	CN	Hetian		2	500	1000	40.51	81.02	2020		S
478	CN	Chenghai II		1	300	300	24.30	24.30	2020		S
479	CN	Xiantao		1	500	500	40.51	40.51	2020		S
480	IN	Guntur		2	600	1200	48.61	97.22	2021		S
481	IN	Tripupati		1	450	450	36.46	36.46	2021		S
482	IN	Visakhapatnam		2	600	1200	48.61	97.22	2021		S
483	CN	Foshan Nanhai III	*	2	750	1500	78.13	156.26	2019		R

484	CN	Zhengzhou		6	700	4200	56.70	340.20	2020		S
485	CN	Hezhou		1	400	400	32.41	32.41	2020		S
486	CN	Xinfeng		2	400	800	32.41	64.82	2020		S
487	CN	Yuncheng II		1	600	600	48.61	48.61	2020		S
488	CN	Qingyang		1	600	600	48.61	48.61	2020		S
489	CN	Shijiazhuang-Jingxing		2	600	1200	48.61	97.22	2020		S
490	CN	Yingshang		1	600	600	48.61	48.61	2020		S
491	CN	Fuzhou III	*	2	600	1200	48.61	97.22	2020		S
492	CN	Huaibei II		2	750	1500	60.76	121.52	2020		S
493	CN	Jintang		2	400	800	32.41	64.82	2020		S
494	CN	Wenling		1	750	750	60.76	60.76	2020		S
495	CN	Anqing		1	600	600	48.61	48.61	2020		S
496	CN	Korla		1	750	750	60.76	60.76	2020		S
497	CN	Xuchang		3	750	2250	60.76	182.28	2020		S
498	CN	Houjie		2	350	700	28.36	56.72	2021		S
499	CN	Beiliu II	*	1	350	350	28.36	28.36	2021		S
500	SE	Stockholm-Högdalen	*	1	492	492	54.10	54.10	2020		V
501	CN	Jingzhou II		1	750	750	60.76	60.76	2021		S
502	CN	Dongying II	*	1	600	600	48.61	48.61	2021		S

503	CN	Kaihua		1	300	300	24.30	24.30	2021	S
504	CN	Nanping		1	300	300	24.30	24.30	2021	S
505	CN	Xianyou		1	600	600	48.61	48.61	2021	S
506	CN	Zhoushan		1	600	600	48.61	48.61	2021	S
507	CN	Zhuji		1	500	500	40.51	40.51	2021	S
508	FR	Troyes		1	252	252	24.42	24.42	2020	V
509	JP	Kawasaki Tachibana		3	200	600	28.00	84.00	2023	R
510	CN	Dali II	*	1	600	600	48.61	48.61	2022	S
511	CN	Pujiang		2	400	800	32.41	64.82	2022	S
512	CN	Luzhou II	*	1	500	500	40.51	40.51	2022	S
513	CN	Chifeng I		2	400	800	32.41	64.82	2022	S
514	CN	Juancheng		1	600	600	48.61	48.61	2022	S
515	CN	Xinyi		2	500	1000	40.51	81.02	2022	S
516	CN	Maoming Dianbai		2	750	1500	60.76	121.52	2022	S
517	CN	Putian III, No.3	*	1	600	600	48.61	48.61	2022	S
518	CN	Yongtai		1	600	600	48.61	48.61	2022	S
519	CN	Taizhou III	*	2	750	1500	60.76	121.52	2022	S
520	CN	Jinan		2	750	1500	60.76	121.52	2022	S

521	TH	Saraburi II	*	1	750	750	60.76	60.76	2022	S
522	GB	Grangemouth (Earls Gate)		1	821	821	75.00	75.00	2021	V
523	CN	Luoqi		4	750	3000	60.76	243.04	2022	S
524	CN	Taixing II	*	1	450	450	34.88	34.88	2022	S
525	CN	Shanwei II	*	2	700	1400	56.72	113.44	2022	S
526	CN	Huimin		2	300	600	24.30	48.60	2022	S
527	CN	Gong'an		1	500	500	40.50	40.50	2022	S
528	TH	Saraburi III	*	1	750	750	60.76	60.76	2022	S
529	CN	Lufeng II	*	1	400	400	31.00	31.00	2022	S
530	DE	Würzburg 1	*	1	240	240	29.20	29.20	2020	R

LEGEND

Legende

Légende

Leggenda

S = SITY 2000

S = SITY 2000

S = SITY 2000

S = SITY 2000

*** Repeat order**

* Folgeauftrag

* Commande réitérée

* Ordinazione successiva

R = Reverse-acting grate

R = Rückschub-Rost

R = Grille à recul

R = Griglia a spinta inversa

V = Reverse-acting grate Vario

V = Rückschub-Rost Vario

V = Grille à recul Vario

V = Griglia a spinta inversa Vario

H = Horizontal grate

H = Horizontal-Rost

H = Grille horizontale

H = Griglia orizzontale

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