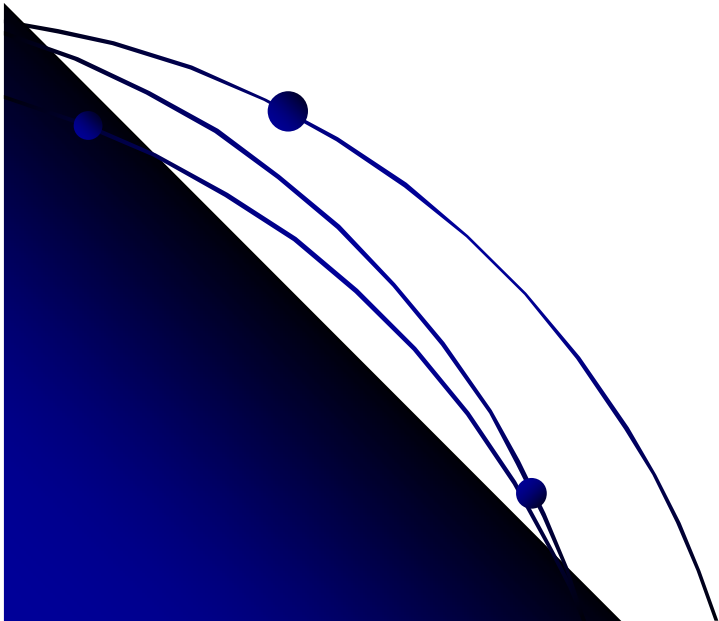


STEPS FORWARD IN ENERGY- UPGRADING OF WASTE TO ENERGY PLANTS (WTE)



**Dubai, May 27th 2009
Middle East Waste Summit**

**Juan I. Unda
RC Consulting
President C.E.O.**

STEPS FORWARD IN ENERGY-UPGRADING OF WASTE TO ENERGY PLANTS (I)

- 1. Actual Developed Societies with waste production uncontrolled and obsolete energy models are causes of climate change.**
- 2. Security of Supply an important issue in many countries.**
- 3. Future models need also to comply with the adequate environmental requirements, low greenhouse gas emissions and with real energy efficiency models.**
- 4. European Waste Directive considers energy valorization (WTE) in a higher step level than landfills, so countries should take advantage of the energy contained in waste before landfill disposals.**
- 5. Waste a Renewable Energy. Waste is not a problem is part of the solution.**
- 6. SENER, considering future society needs has developed and patented, in the waste area, technologies that will have positive effects to fulfill the needs, as SENER-2 and SENER-4 processes.**

STEPS FORWARD IN ENERGY-UPGRADING OF WASTE TO ENERGY PLANTS (II)

SENER-2 System (Patent): Is an adaptation of technology at modern combined-cycle plants to waste upgrading-plants

SENER-2 is a unique and integrated process

Plant: ZABALBARGI

STEPS FORWARD IN ENERGY-UPGRADING OF WASTE TO ENERGY PLANTS (III)

SENER-4 system (patent): Is a high efficiency innovative technology applied to conventional Waste To Energy Plants.

**SENER-4 is a unique upgraded Waste to Energy Technology
Plant: Under development (Robust-Proven Technologies)**

SENER-2 (Zabalgardi Plant)

Location: Bilbao (Basque Country) Spain



SENER-2 (ZABALGARBI PLANT)

TECHNICAL DETAILS

- Operation: 8,000 h/year
- Type of waste: Municipal solid and assimilable waste
- N° Lines: 1 (30 t/h)
2 (under development)
- WTE incineration boiler 110 t/h
steam – 106 bar 328 °C
- Processing capacity: 230,000 –
250,000 t/year



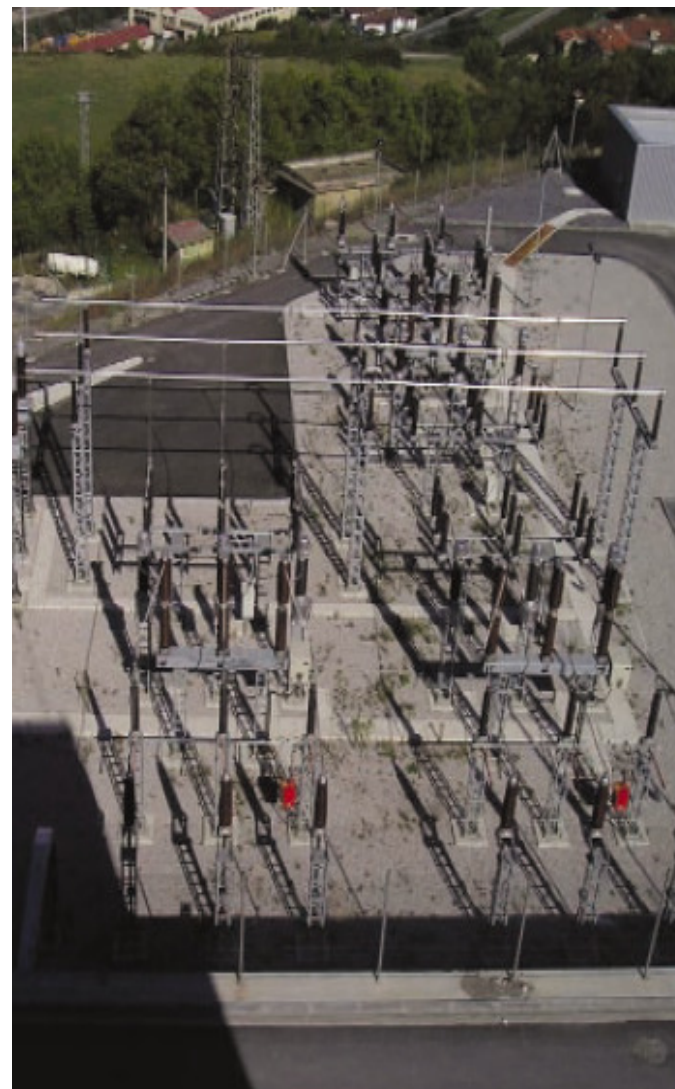
SENER-2 (Zabalgarbi Plant)



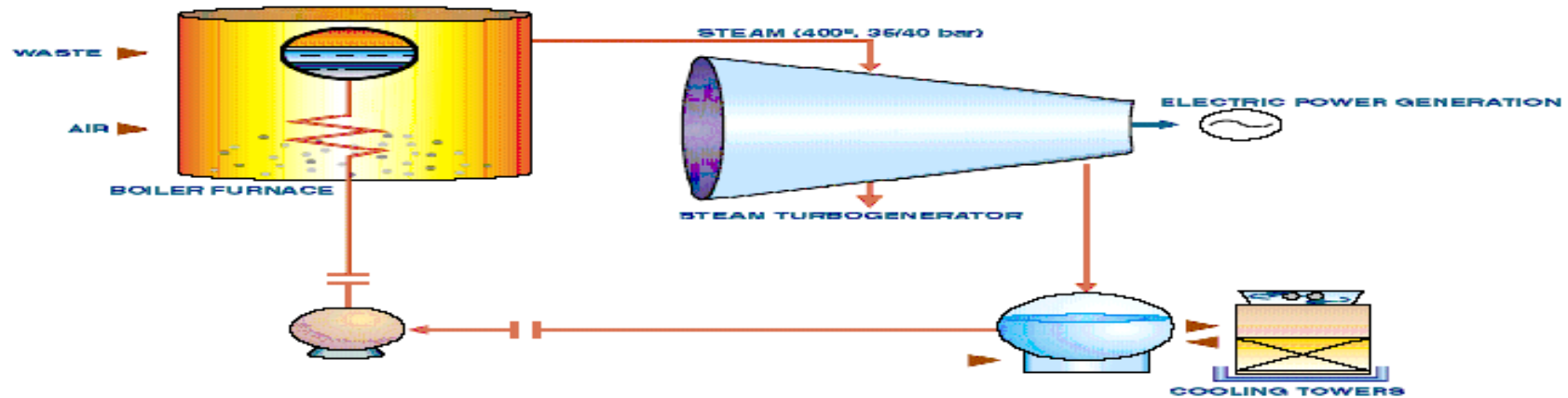
SENER-2 (ZABALGARBI PLANT)

Rated power installed: 99.5 MW

- Steam turbine: 56.5 MW of average gross capacity, condensing, reheat, 96/20 bar, 539/539° C
- Gas turbine: 43 MW of average gross capacity. Fuel: natural gas with intake air cooling (chiller)
- Production of electricity: 730 - 760 GWh / year, net



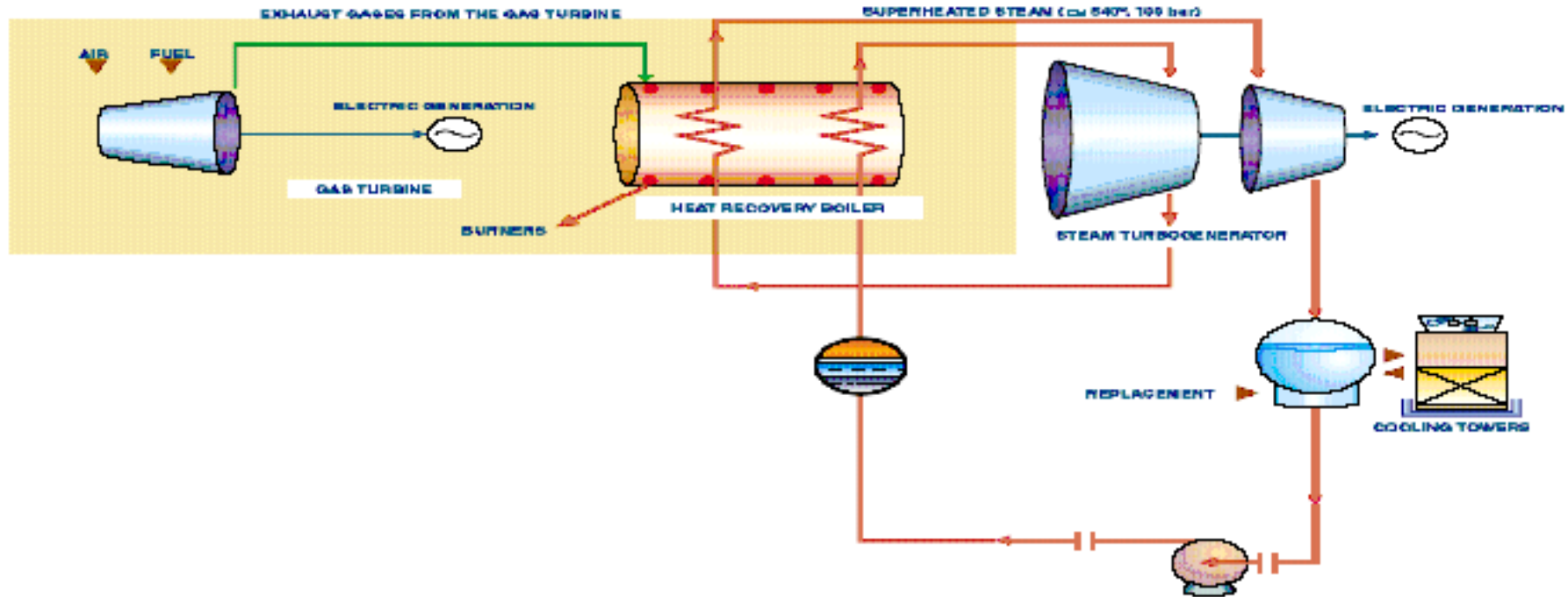
WTE conventional plants



Generating steam to power a turbo-generation unit.

- Restrictions on steam conditions:
 - Temperature: 400°C
 - Pressure: 35 - 40 bar
- Low energy output.
 - 30 t/h of municipal waste >>> 12 MW

Combined cycle gas plants



Restrictions on steam conditions:

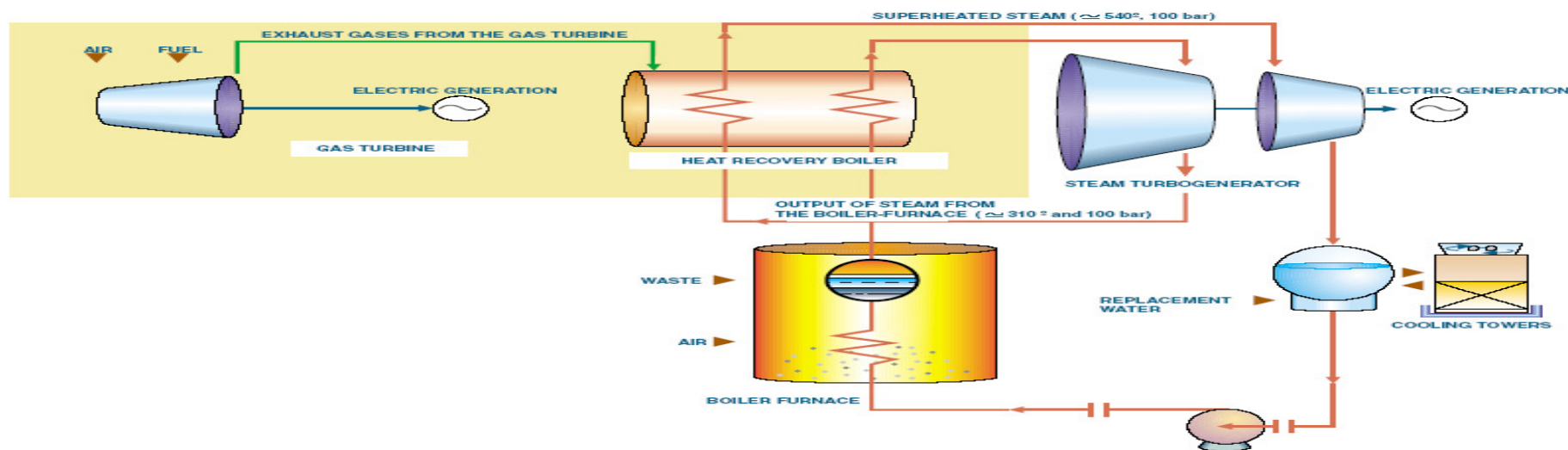
- Temperature: 540°C - Pressure: 100 bar

Energy output.

- 125,000 toe LHV/h >>> obtain a net output of around 72.5 MW

Comparison energy outputs WTE upgrading process.

30 t/h of municipal waste > 12 MW + 125.000 toe LHV/h > obtain a net output of around 72,5 MW = 84,5 MW



- Zabalgardi: 30 t/h of municipal waste + 125,000 toe LHV/h > 95 MW

The new SENER-2 patented process obtains an extra 10.5 MW

Waste upgrading system: it is a unique process

SENER-2

◆ Advantages of the SENER-2 Process.

- Overall net plant efficiency around 47%.
- The process has an electric efficiency of 60% in its normal operation mode which provides an efficiency superior to conventional MSW energy-upgrading systems.
- In other words, the extra power output represents an increase of 87.5% of the energy produced by a conventional MSW plant with the same capacity.
- Improved output with respect to other MSW upgrading plants has likewise been acknowledged by the European Union: the D.G. XVII of the European Commission granted the maximum distinction for this type of project on the Thermie programme (efficiency and savings programme) for Zabalgardi plant. (SENER-2).

SENER-2 (ZABALGARBI PLANT)

◆ Other general characteristics

- Reducing emissions of CO₂ per kWh generated. Avoided CO₂ 275,000 tn/year.
- Improvements in operating conditions – reduced corrosion in furnace by reducing temperature.
- The size of a plant such as Zabalgarbi combines a MSW processing capacity of around 230,000 - 250,000 t/year, and a net installed electricity -generation capacity of about 95 MW. Net production of electricity will be around 730/760 million kWh per year.



SENER-2 – Operation modes

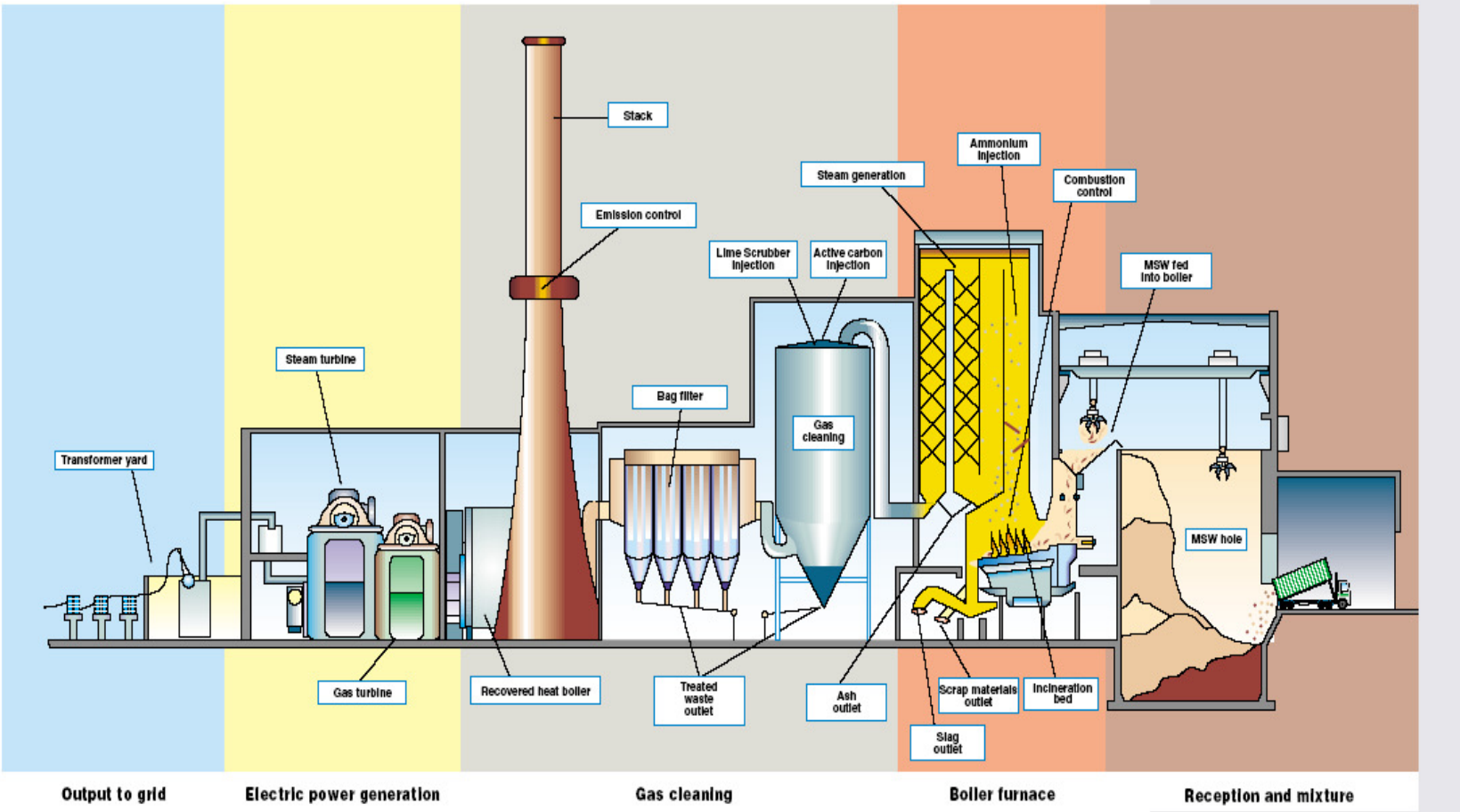
◆ Following operation modes are feasible:

(Flexibility)

- Mode A: Normal Operation
- Mode B: Combined Cycle Operation
- Mode C: Fresh air mode
- Mode D: Incineration and gas turbine through bypass stack
- Mode E: Gas turbine through bypass stack
- Mode F: Incineration only
- Mode G: Shutdown

SENER-2 (ZABALGARBI PLANT)

Boiler and Flue Gas Cleaning System



SENER-2 (Zabalgarbi Plant)

◆ **Flue Gas Cleaning System:**

- **Control of combustion** (850°C, 2 seconds)
- **Reduction of NOx** (ammonia injection and flue gas recirculation)
- **Acid Gases** (SO₂, HF, HCl) scrubbing by spray drier with lime injection
- Elimination of heavy metals, dioxins - furans, and other pollutants by adsorption via **active carbon injection**
- **Bag filter** – for dust removal
- **Monitoring** and control of parameters for emissions into the atmosphere.

ZABALGARBI

Emissions from combustion of the WTE

Emissions₂₀₀₈	ZABALGARBI (mg/N m³)₁	UE emission limits (mg/ Nm³)₂
Dioxins - Furans:	0,0031 (ng TEQ/N m ³)	0.1 (ng TEQ/Nm ³)
NOx	147	200
Particulates	3,33	10
HCl	6,85	10
COT	0,86	10
CO	2,34	50
HF	0,097	1
SO ₂	12,9	50
Pb+Cr+Cu+Mn+ As+Ni+Sb+Co+V	0,0255	0,5
Hg	0,0009	0,05
Cd+Tl	0,0011	0,05

SENER-2 (Zabalgarbi Plant)

Environmental surveillance

Inmission

- **Three air quality Stations: Arraiz (Bilbao), Alonsotegi and Larrazabal**
- **Soil and vegetation sampling.**
- **Surface water sampling.**
- **Continuously updated parameters (air): PM10, O3, NOx, SO₂, COV, HCl, Meteorological tower.**



SENER-2 (Zabalgarbi Plant)

- **Solid by-products (2008)**
- **Bottom ash. Considered to be inert. It accounts for 18,6 % in weight and around 8% involume of incoming WTE.**
- **Ferric scrap material: 2,40 %**



SENER-2 (Zabalgarbi Plant)

- **Fly ash and flue gas cleaning residues represent about 3,7 % in weight and less than 1% in volume of the MSW.**
- **The residues collected undergo an inertisation process in order to stabilise any heavy metals they may contain and to prevent leaching and, finally, are confined in a secure authorized storage facility.**



- **In simple steam cycles in electrical generating plants the gross efficiency 25-30%.**
- **Applying higher pressure measurements in boilers, preheatings (10 stages) and reheatings (1-3), gross efficiency > 40%.**
- **Today's boilers can reach 300 bars and temperatures >600°C. Efficiencies are above 45%.**
- **In WTE plants corrosion limits should be considered in the boiler steam. Temperatures limitations for Boilers normally applied ($\cong 400^{\circ}\text{C}$) to prevent corrosion on tubes (Flue Gas Considering the limitations, applying moderated boiler steam temperatures, reheatings, Side) regenerative water preheatings, efficiencies >32%. Applying additional measurements SENER processes) efficiencies > 36%.**
- **SENER – 4 cycle has the advantages of moderate temperatures, which limits corrosion effects, and the latest technologies applied in reheatings and regenerative preheatings that allows higher efficiencies.**

SENER-4

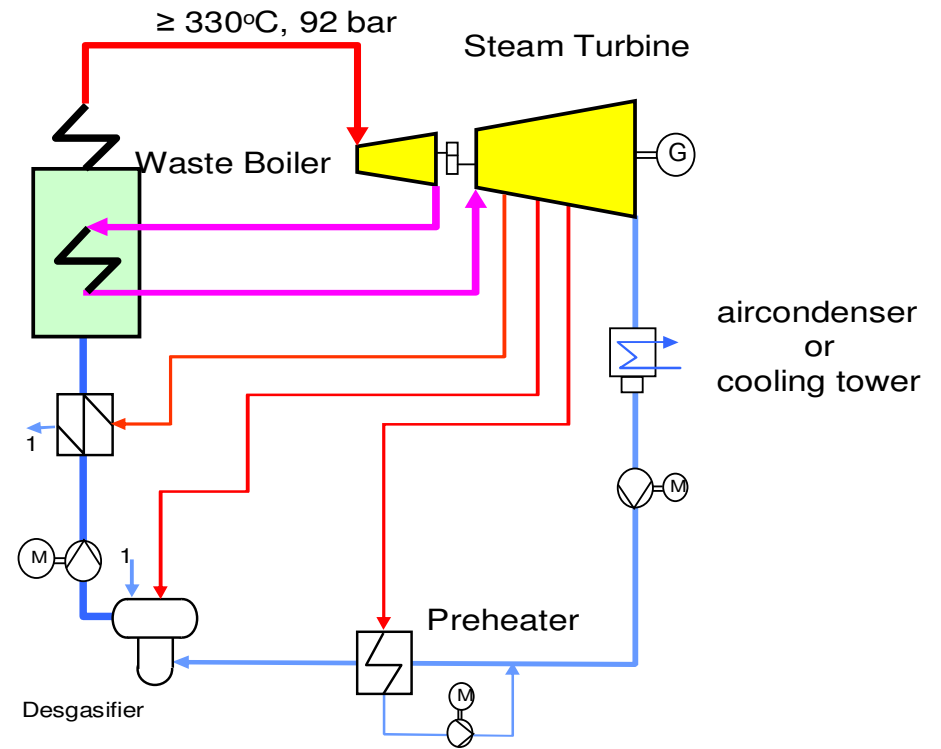
Technical details

- **Operation:** 8,000 h/year (Minimum)
- **Type of waste:** Municipal solid and assimilable waste (9100 kJ/kg)
- **Nº Lines:** 2 x 25 t/h
- **WTE incineration boiler :** 2 x 85 t/h steam
92 bar, > 330 °C
- **Processing capacity:** 400.000 t/year
- **Thermal Gross Power:** 132 MW_t
- **Electric Gross Power:** 46,2 MW_e
- **Avoided CO₂ 279.000 Tn/year**



SENER-4 PROCESS

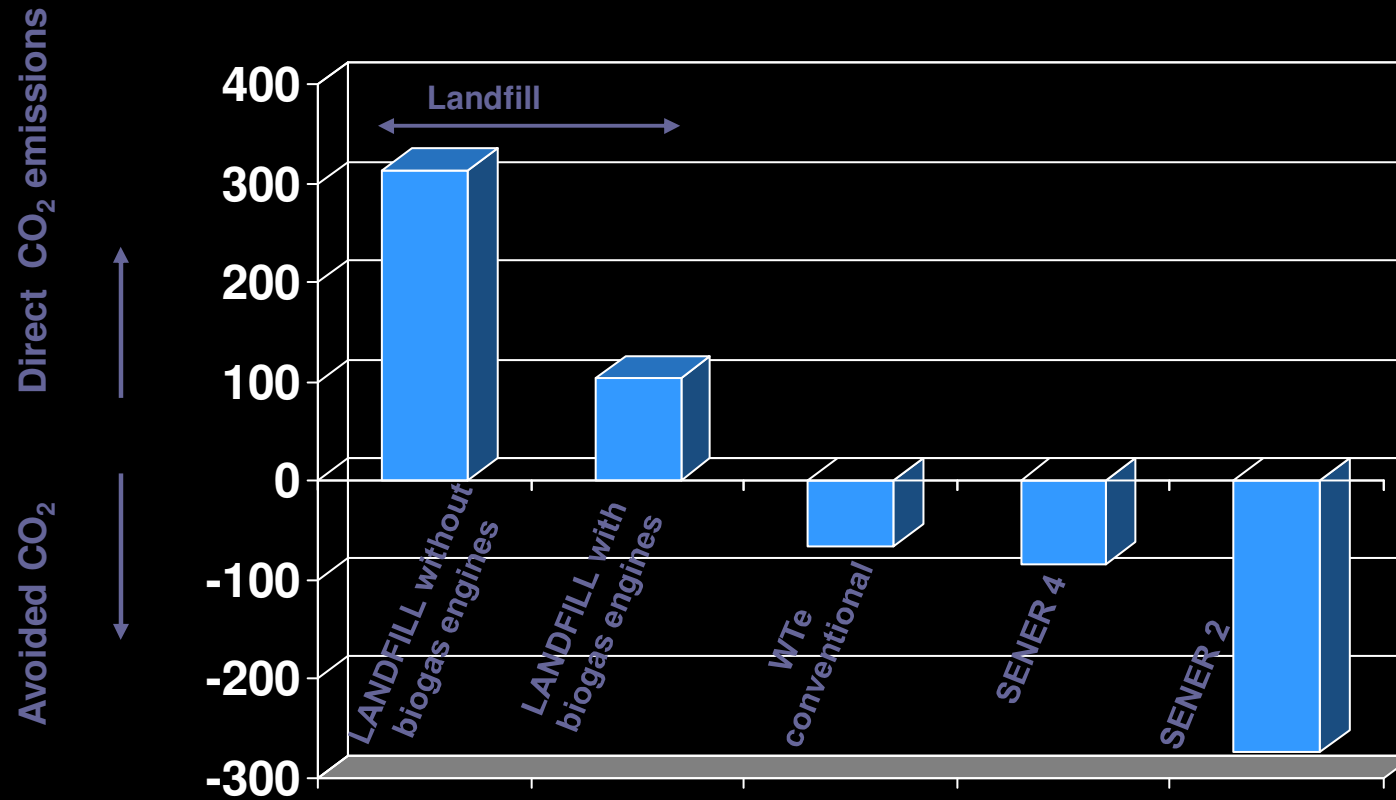
- In this cycle steam is generated in the waste boiler at a high pressure and moderate T^a , that will avoid accelerated corrosion in hottest parts of the boiler tubes.
- The design of the Thermal Cycle allows a higher efficiency ($> 35\%$) and significant higher electric generation.



GREENHOUSE EFFECT

kTon CO₂ / Year

for 240 kTn MSW/Year



- Thank you for your attention

- Juan I. Unda (juan.unda@telefonica.net)