

# THE MICROPHILOX PROJECT

ENERGY RECOVERY FROM LANDFILL'S BIOGAS BY THE USE  
OF **MICROTURBINES** AND BIOLOGICAL REMOVAL OF  
HYDROGEN SULPHIDE AND **SILOXANES**

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CESPA R&D Department Responsible

- ❑ **CESPA overview**
- ❑ **Landfill management**
- ❑ **Biogas treatment**
- ❑ **Biogas energy recovery**
  - Advantages
  - Technologies
  - Biogas energy recovery in CESPA
  - Technical drawback
  - Microturbines
  - Biogas upgrading
  - Siloxanes capture and detection
- ❑ **The MICROPHILOX project**
  - Main data
  - Objectives
  - Planning
  - Conclusions
  - Acknowledgment

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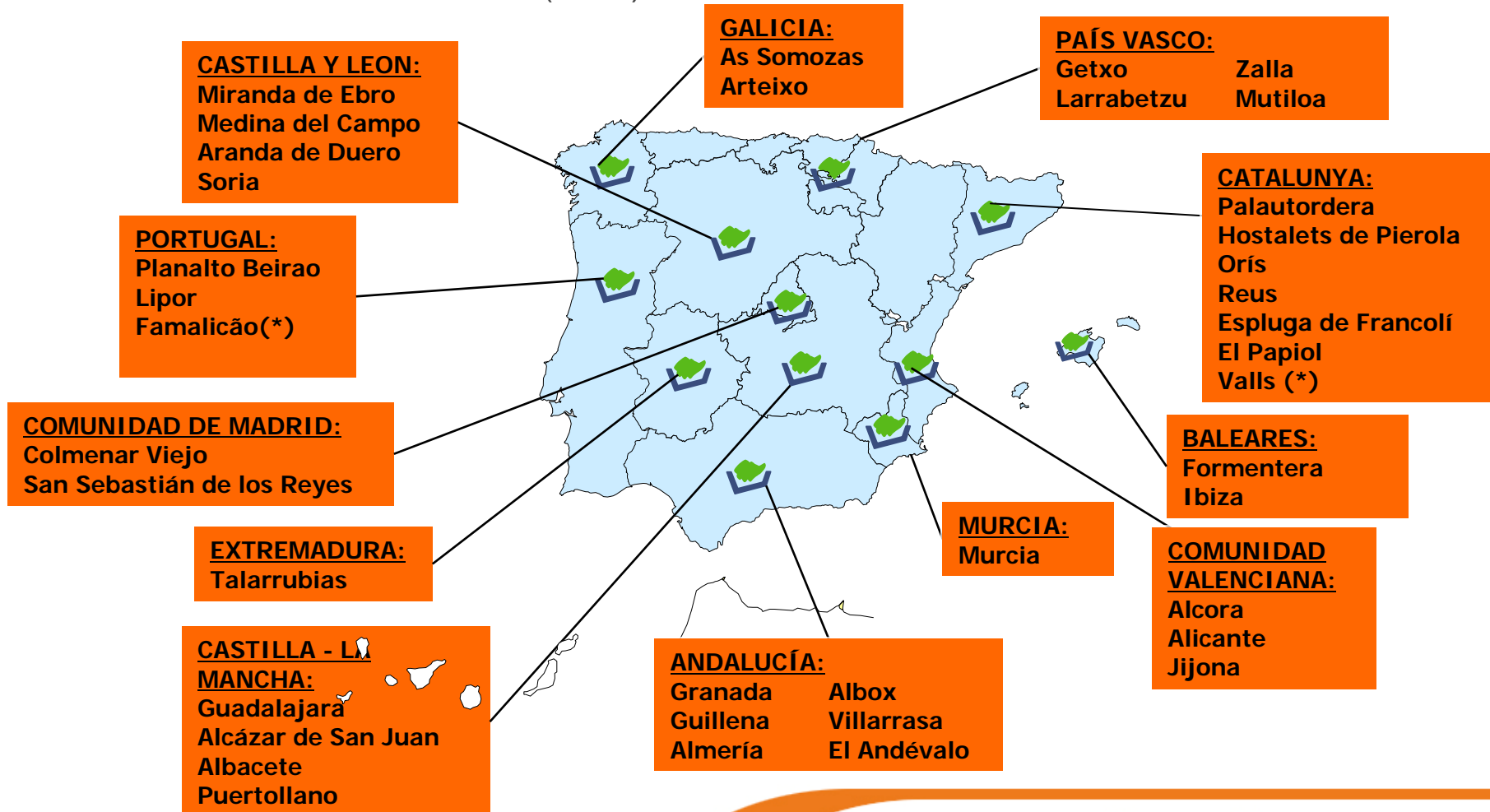
- ❑ **CESPA is part of Ferrovial Servicios and has provided Urban services as well as Industrial services for over 35 years.**
  
- ❑ **Urban services are mostly provided to Local Authorities and include:**
  - Street cleansing
  - Gardening
  - Maintenance of sewage networks
  - Municipal waste collection
  
- ❑ **Industrial services are provided to both public and private clients and include waste management, from collection to final disposal:**
  - Collection of industrial and hazardous waste
  - Treatment and disposal of municipal, industrial and hazardous waste through the operation of transfer, MBT and composting plants, as well as of landfills
  - Environmental consulting and audit services
  - Industrial cleansing

- ❑ **Market leader for Waste management and Gardening services in Spain**
- ❑ **Top 5 player in all other major areas of activity**
- ❑ **829 local authorities served (most through several contracts and services)**
- ❑ **Over 9,000 commercial and industrial clients, including producers of hazardous waste (hospitals, chemical plants, nuclear plants)**
- ❑ **107 treatment plants and landfills in operation**
- ❑ **16.173 employees**
- ❑ **R&D Department since 1999**

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### CESPA is leader in Spain in landfill management and construction:

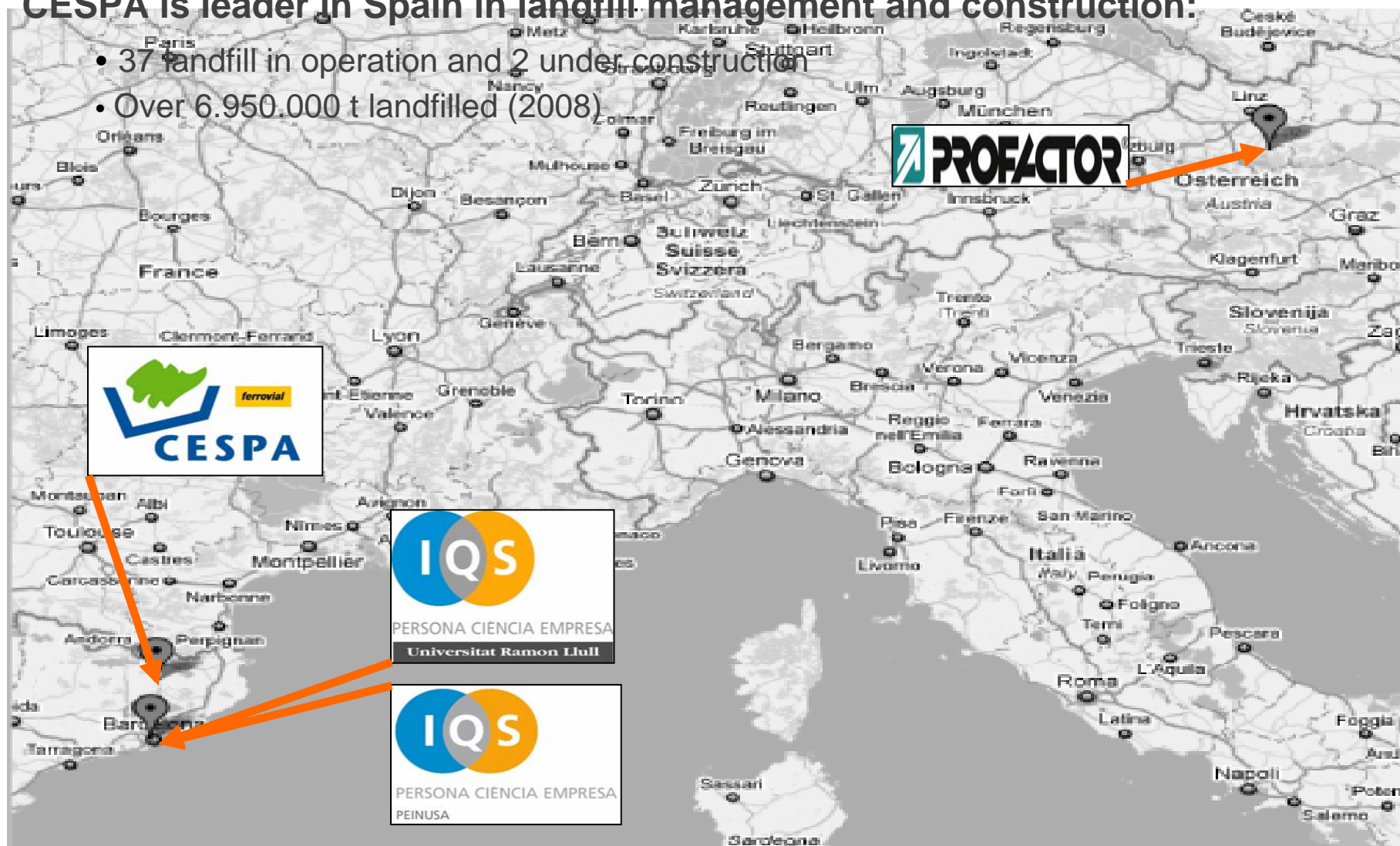
- 37 landfill in operation and 2 under construction
- Over 6.950.000 t landfilled (2008)



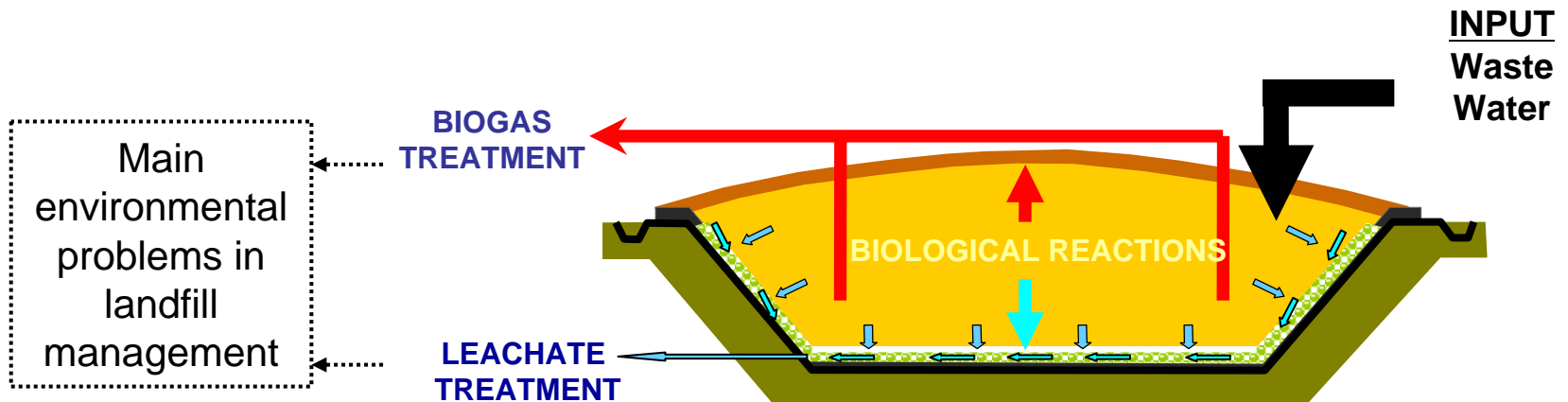
## CESPA

**CESPA is leader in Spain in landfill management and construction:**

- 37 landfill in operation and 2 under construction
- Over 6.950.000 t landfilled (2008)



**Biogas:** Water-saturated gas produced due to the decomposition of organic material under anaerobic conditions mainly consisting of methane ( $\text{CH}_4$ ) and carbon dioxide ( $\text{CO}_2$ ) with traces of contaminant compounds.



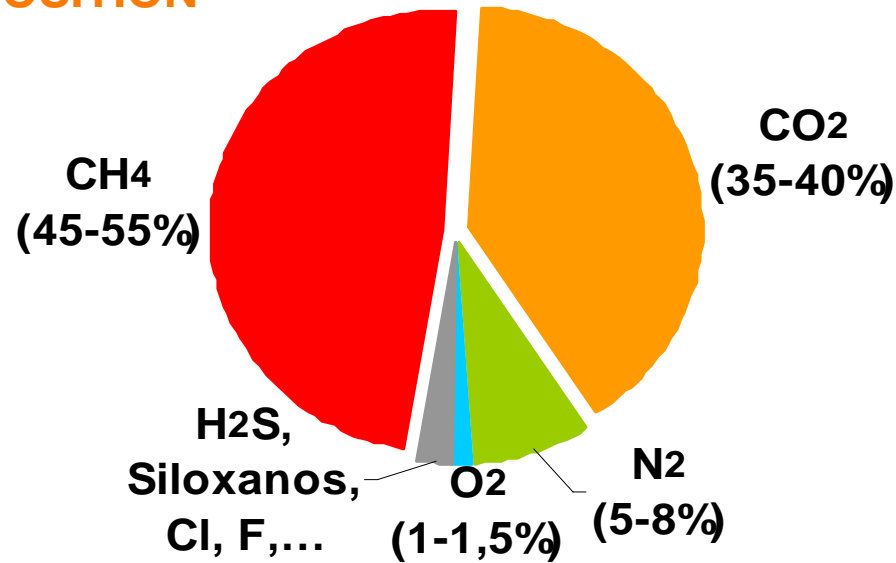
## DIRECTIVE 1999/31/EC

*'Landfill gas shall be collected from all landfill receiving biodegradable waste and the landfill gas must be treated and used. If the gas collected cannot be used to produce energy, it must be flared.'*

**Proper Technologies must be applied**

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## BIOGAS COMPOSITION



Biogas with 50% CH<sub>4</sub> contents

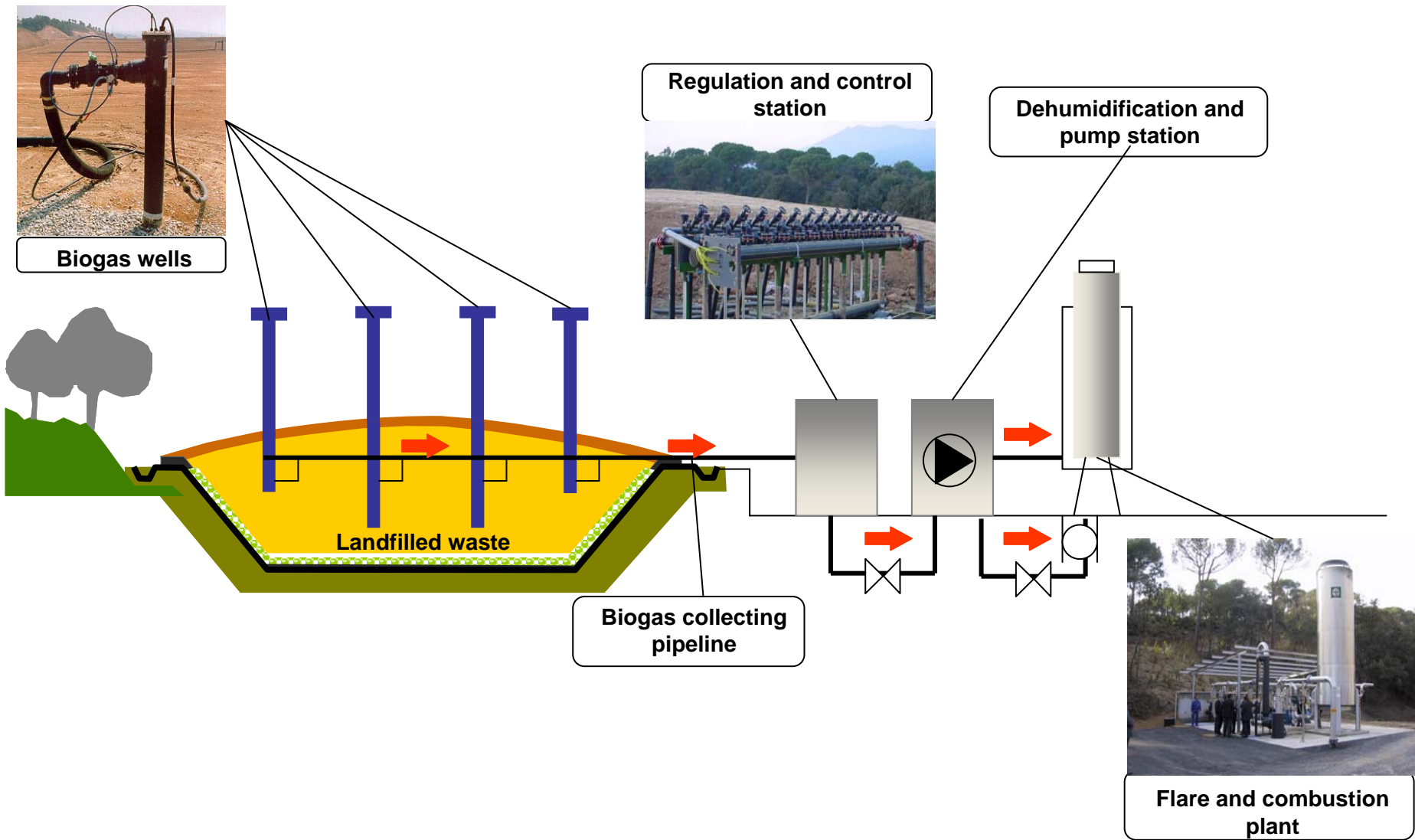
Lower Heating Value  
4.256 kcal/Nm<sup>3</sup>



High energy contents: Contribution to energy diversification

# Biogas treatment

General concepts

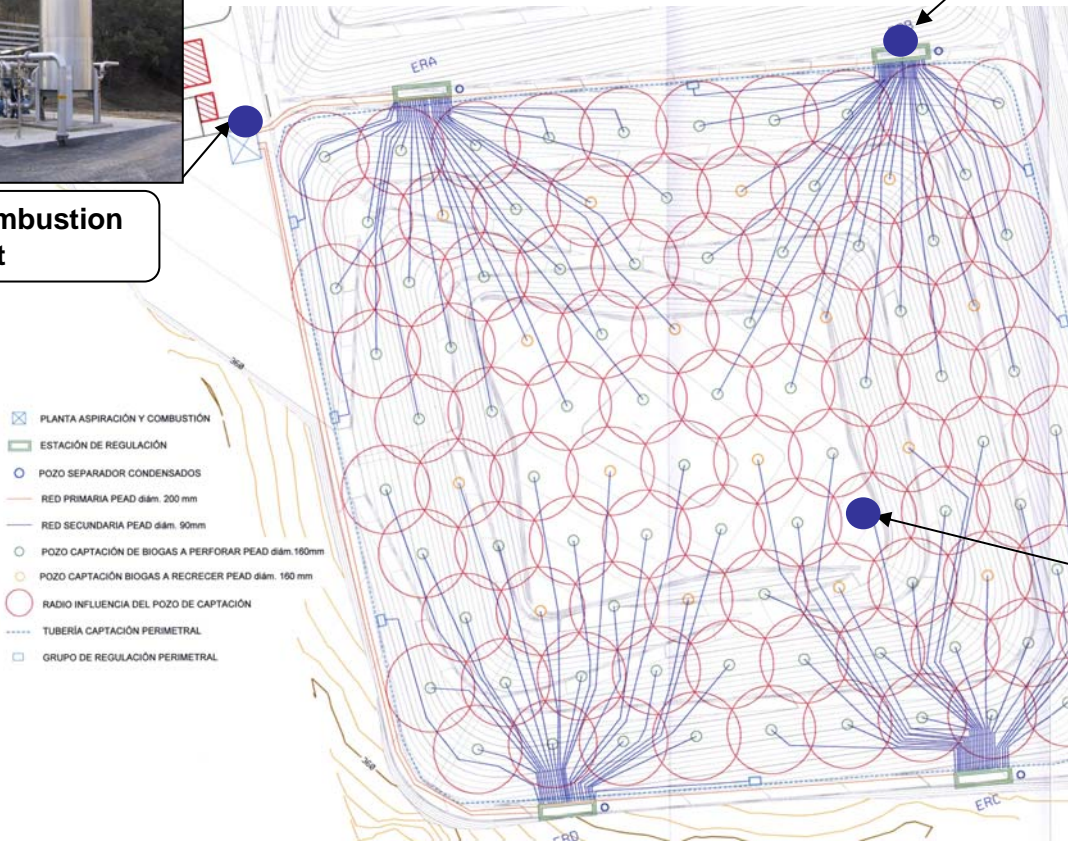




**Flare and combustion plant**



**Regulation and control station**



**Biogas wells**

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## ENVIRONMENTAL

- ❑ Biogas recovery allows minimising environmental risks caused by inadequate operation.
- ❑ High energy content: contribution to energy diversification

## SOCIAL

- ❑ Interesting savings according to present sustainable development policies, since they allow waste valorisation. One tone of urban waste generates 100-150 Nm<sup>3</sup> of biogas in the course of its life.

## ECONOMICAL

- ❑ Energy sales cost fixed by law.

## GENERAL INTRODUCED TECHNOLOGIES:

- ❑ Direct use as fuel: burners, kilns
- ❑ Power generation: CHP Units, Turbines

## INNOVATIVE TECHNOLOGIES:

- ❑ Use in automotive applications
- ❑ Natural gas grid injection
- ❑ Microturbines

## POWER GENERATION

- ❑ **CHP units are the most applied biogas energy recovery technology**

### CESPA BIOGAS CHP ENERGY RECOVERY PLANTS

LANDFILL LOCATION	CHP UNITS	INSTALLED POWER
Els Hostalets de Pierola (Barcelona)	1	1.048 kW
Sta. M <sup>a</sup> de Palautordera (Barcelona)	2	2.303 kW
Alicante (Alicante)	1	1.064 kW
Mula (Murcia)	3	3.474 kW
Granada (Granada)	1	624 kW
Colmenar Viejo (Madrid)	3	3 x 1.420 kW
Valdemingómez (Madrid)	8	8 x 2.100 kW
Alcázar de San Juan (Ciudad Real)	1	1.048 kW
Toledo (Toledo)	1	1.064 kW

**21 CHP units**  
**31.7 MW**

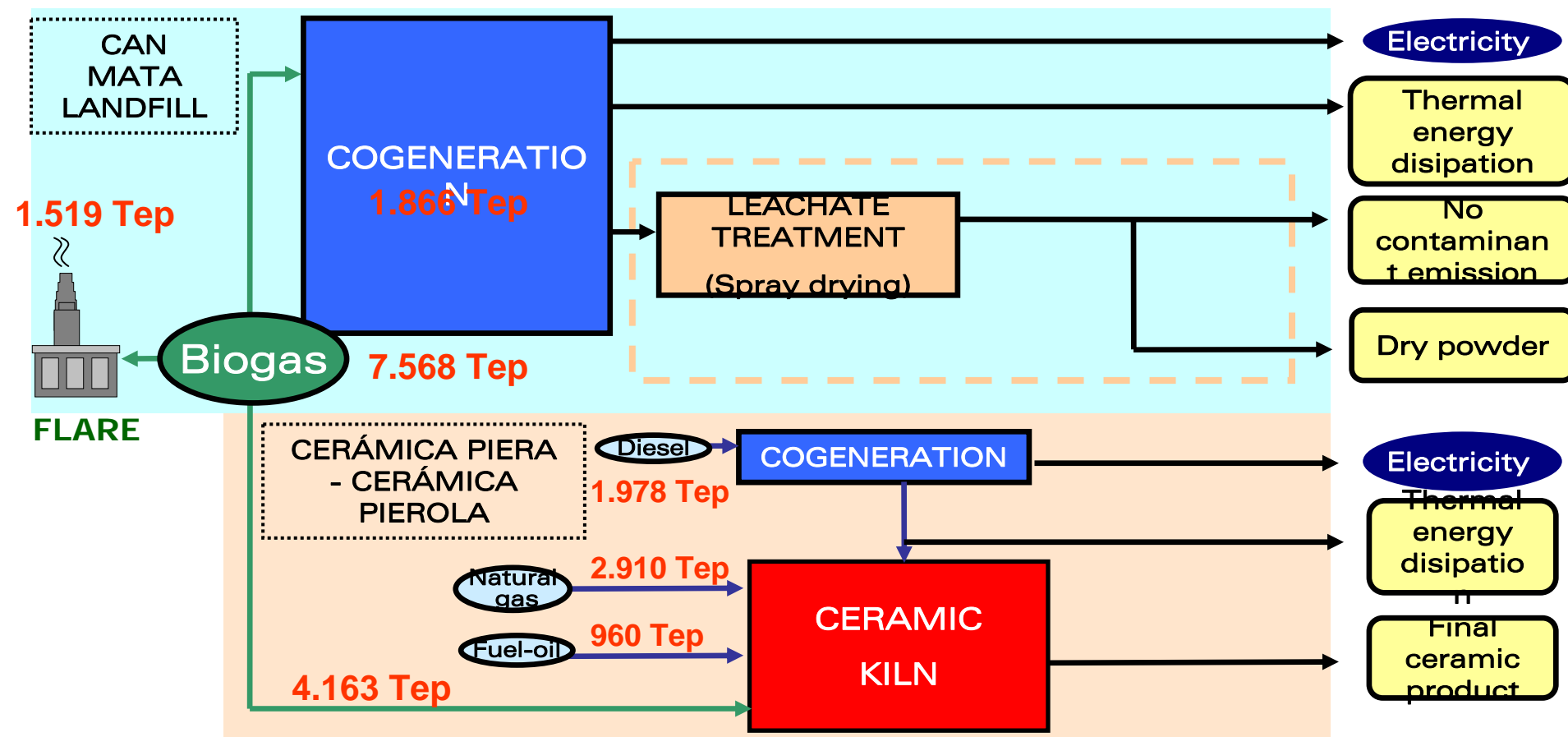
## POWER GENERATION

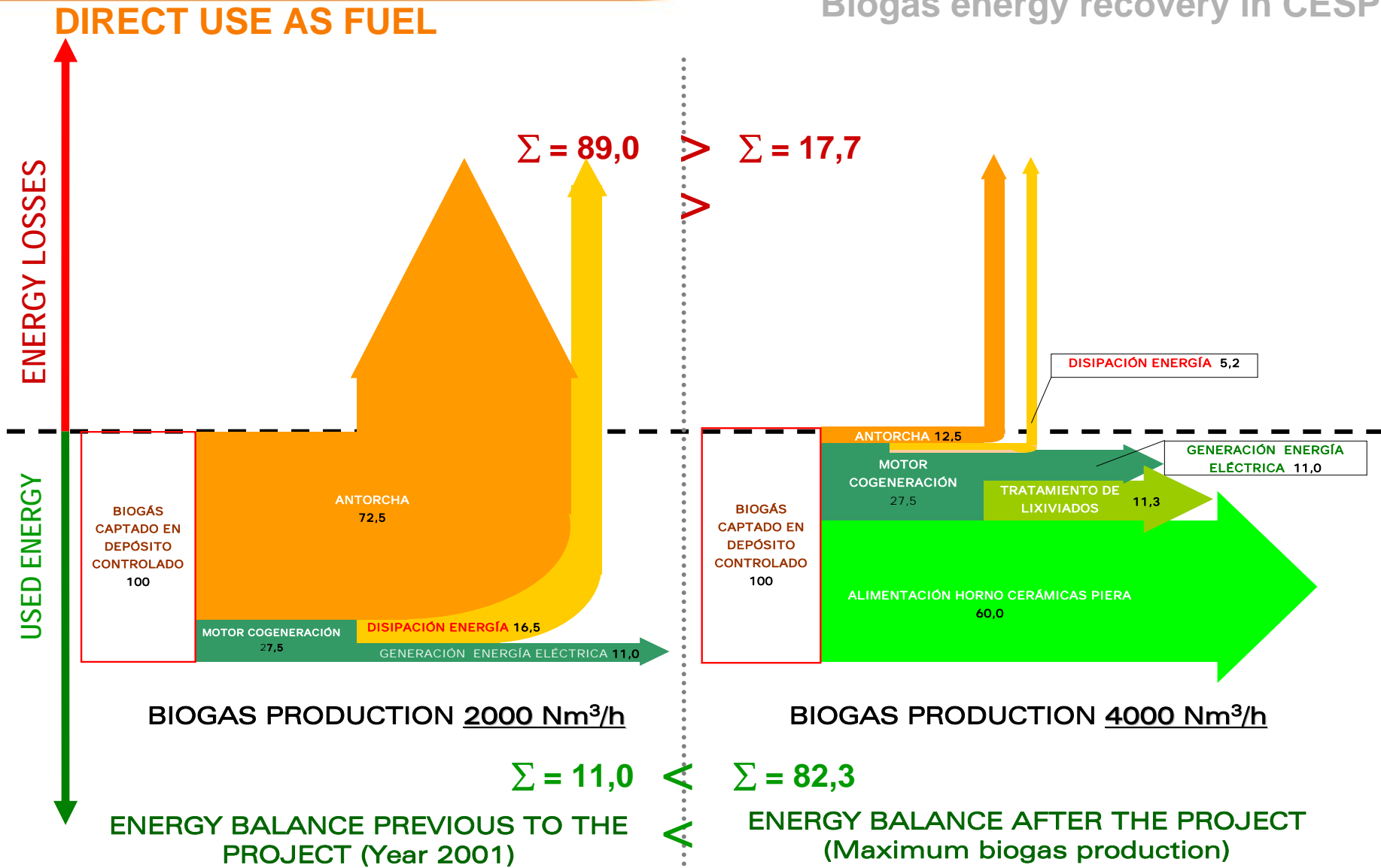
- ❑ CHP units are the most applied biogas energy recovery technology



**DIRECT USE AS FUEL**

**Hostalets de Pierola Landfill: Landfill biogas valorisation as a fuel for the manufacture of high quality ceramic products (Ceramica Piera – Cerámica Pierola)**





## DRAWBAKS FOR GENERAL INTRODUCED TECHNOLOGIES

### ❑ Burners and kilns.

- Needed the location near the landfill of an industrial installation able to use biogas as energy source
- The economical viability is based on a high production of biogas with a high energetic value

### ❑ CHP engines are economic viable when:

- Are economically viable for  $Q_{\text{biogas}} > 550 \text{ Nm}^3/\text{h}$
- It is needed a  $\text{CH}_4$  concentration over 40%
- A good quality of biogas is needed: upgrading process

### DRAWBAKS FOR GENERAL INTRODUCED TECHNOLOGIES

- ❑ Energy recovery technologies are not being applied in small landfills or in landfill at the beginning or end of its useful life

Possible solution proposed by Technical Department of CESPA

**Microturbines for energy recovery of landfill biogas**



CESPA NEEDS TO STUDY TECHNICAL, ECONOMICAL AND ENVIRONMENTAL VIABILITY OF MICROTURBINES

## MAIN CHARACTERISTICS

- ❑ **Modular equipment from 30 kW–200 kW**
- ❑ **Able to operate with biogas up to 35% CH<sub>4</sub> concentration**
- ❑ **Low maintenance costs**
- ❑ **Low emissions**
- ❑ **26% electric efficiency (vs. 38% CHP)**
- ❑ **57% thermal efficiency (vs. 40% CHP)**

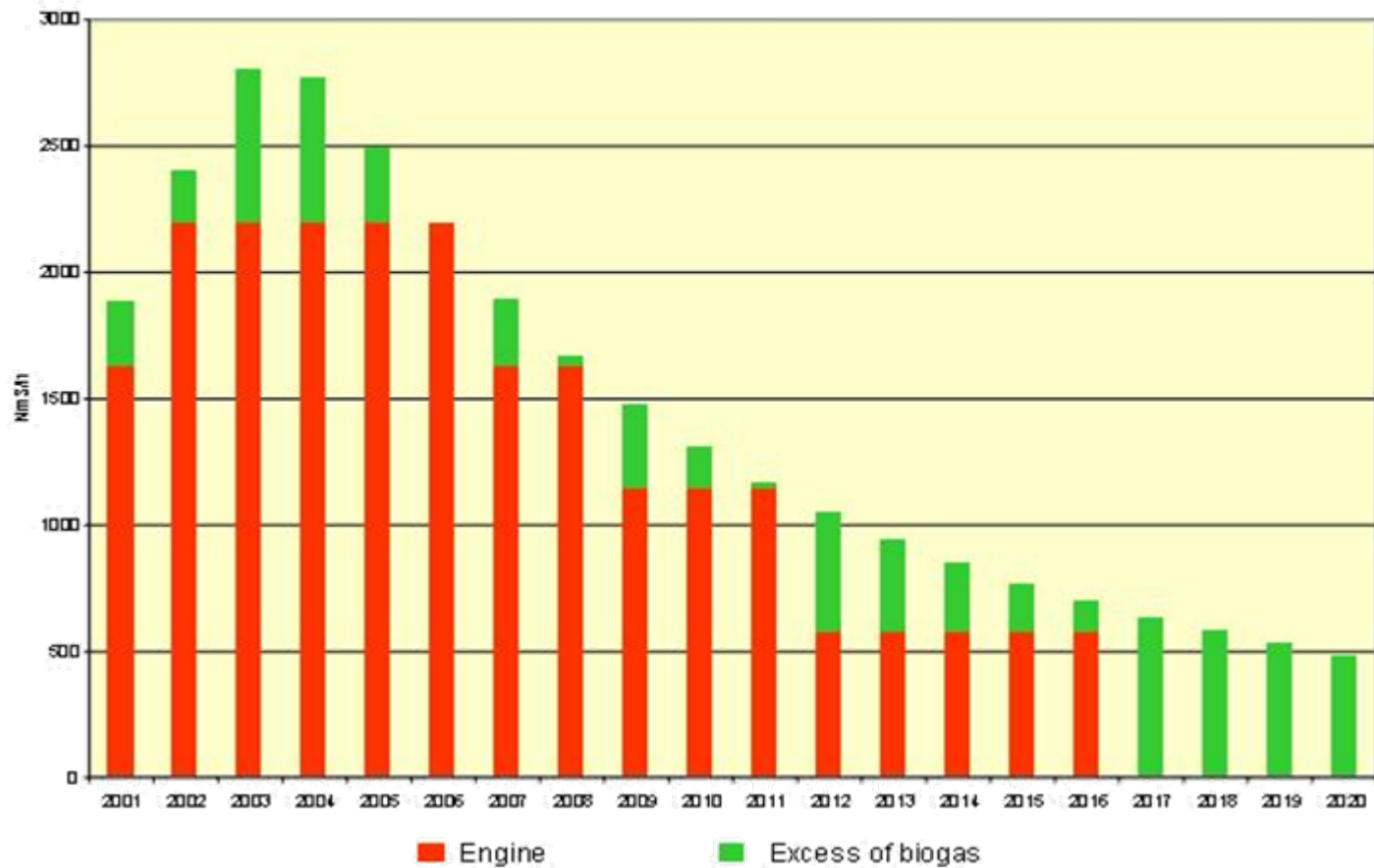


## SUITABLE APPLICATIONS

- ❑ **Landfills with low biogas flow**
- ❑ **Landfills in its initial or final exploitation phase**
- ❑ **Use of biogas excesses in big landfills**

## SUITABLE APPLICATIONS

Available landfill biogas for energetic uses



- ❑ Technical and economical viability of an energy recovery plant can be threatened due to the presence contaminants in biogas.
- ❑ H<sub>2</sub>S and siloxanes in biogas are the most problematic contaminants.

		CHP LIMITS	MICROTURBINES LIMITS	MAX. BIOGAS LANDFILL CONTENTS (CESPA)	ORIS BIOGAS CONTENTS
Siloxanes	mg/Nm <sup>3</sup> CH <sub>4</sub>	10	0,016	280	43
H <sub>2</sub> S	mg/Nm <sup>3</sup> CH <sub>4</sub>	1.750	175.000	10.000	32

### Upgrading process previous to biogas recovery



## TECHNOLOGIES

Upgrading processes can be divided into:

❑ **Physical-Chemical methods:**

Activated carbon filters are the most common used technology

- Demonstrated efficiency (up to 99%)
- High cost operation
- Derived solid waste that must be treated

❑ **Biological methods:**

- Efficiency up to 95% for  $\text{SH}_2$
- Low cost operation
- Not demonstrated for siloxanes removal

Technical innovations proposed by CESPA

**Necessary to optimize the biological treatment for  $\text{SH}_2$  and to develop a biological siloxanes removal process for biogas**



**CESPA NEEDS TO STUDY TECHNICAL, ECONOMICAL AND ENVIRONMENTAL VIABILITY OF BIOLOGICAL UPGRADING OF BIOGAS**

- ❑ **To evaluate upgrading process efficiency we have to be able to know the H<sub>2</sub>S and siloxane concentration in biogas**
- ❑ **Different capture and analysis technologies for siloxane detection resulted in different assessment data: problems with technical guarantee and pre-treatment monitoring**

Possible solution proposed by Technical Department of CESPA

**Development of a reliable methodology for the capture and analyses of siloxanes**



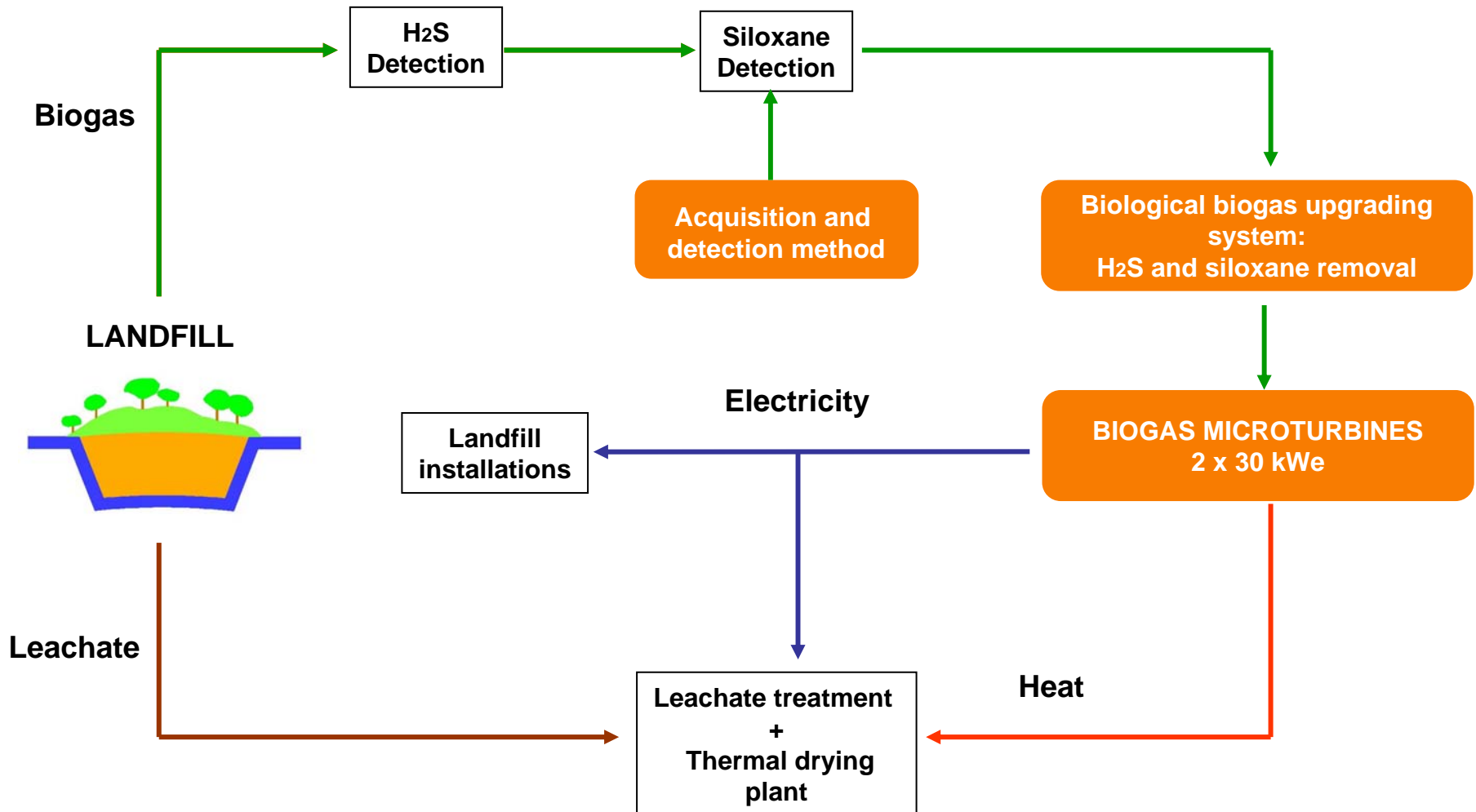
**CESPA NEEDS TO STUDY TECHNICAL VIABILITY OF A NEW METHODOLOGY FOR SILOXANES ANALYSIS**

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## PRESENT SITUATION

- ❑ **Biogas recovery with CHP engines not viable in landfill with low biogas production or with low CH<sub>4</sub> content**
- ❑ **Biogas recovery needs to optimize H<sub>2</sub>S and siloxanes removal technology**
- ❑ **Present sampling and analytical methods for siloxanes have resulted in different assessment data: problems with technical guarantee and pre-treatment monitoring**

## TECHNICAL SOLUTION PROPOSED BY TECHNICAL DEPARTMENT OF CESPA:



**PARTNERS**

**CESPA**

**PROFACTOR**

**IQS**

**PEINUSA**

**PERIOD**

**Start date: 03/10/2005**

**End date: 31/03/2009**

**BUDGET**

**Total budget: 1.303.319 €**

**LIFE-Environment program financial contribution: 581.806 €**

- ❑ **To show viability, effectiveness and environmental interest of microturbines for landfill biogas energy recovery.**
- ❑ **To show viability, effectiveness and environmental interest of biological upgrading systems for hydrogen sulphide and siloxanes removal from landfill biogas.**
- ❑ **To obtain an analytical method for the acquisition and identification of siloxanes .**
- ❑ **To show the environmental, economic and technical viability of the combined system (upgrading, siloxane analysis and microturbine) for landfill biogas energy recovery**

**(1) Electricity and heat production from landfill biogas using microturbines**

**TASK A. Study of microturbine technologies**  
**TASK B. Installation and test of microturbines**

**CESPA**

**(2) Design, manufacturing, implementation and control of a biological removal system for H<sub>2</sub>S and Siloxanes**

**TASK C. Design and application of H<sub>2</sub>S biological removal system**  
**TASK D. Design and application of siloxane biological removal system**

**PROFACTOR**

**(3) Development of an effective method to capture and analyse siloxanes in biogas**

**TASK E. Study of capture and analysis methods for siloxane**  
**TASK F. Application of defined method**

**IQS**  
**PEINUSA**

**(4) Integration of designed systems**

**TASK G. Intregation of the system**

**CESPA,**  
**PROFACTOR, IQS,**  
**PEINUSA**

**(5) Environmental Cost Analysis**

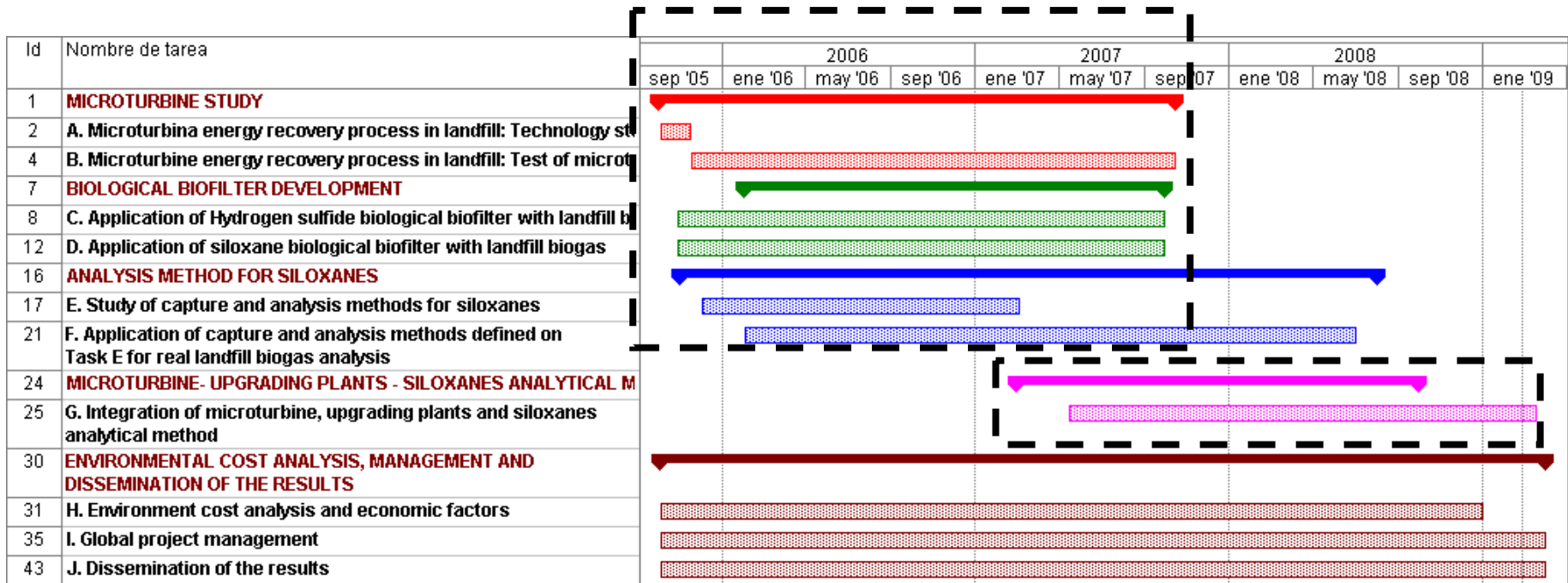
**TASK H. Environmental cost study**

**CESPA**

**(6) Diffusion of results**

**TASK J. Dissemination of results**

**CESPA,**  
**PROFACTOR, IQS,**  
**PEINUSA**



- ❑ Microturbines are suitable for the generation of electricity with landfill biogas and represent the best alternative for small landfills, and the main alternative for landfill at the beginning or end of its useful life.
- ❑ The H<sub>2</sub>S biofilter developed has achieved efficiencies up to 95% optimizing technical and economically the SH<sub>2</sub> removal. The siloxanes biofilter has not achieved the expected results and it is necessary to continue with its development.
- ❑ A reliable methodology for the capture and analysis of siloxanes has been developed and demonstrated.

The MICROPHILOX project has received several awards:

- ❑ **IX Premios Garrigues - Medio Ambiente 2006** in the category of Innovation, Development and application of better technologies organised by Garrigues Medio Ambiente and Expansion.
- ❑ **Globe Energy Award for Spain 2006**
- ❑ **Bioenergía Silver 2008**, awarded by the Asociación Técnica para la Gestión de Esiduos y Medio Ambiente (ATEGRUS).

THANK YOU FOR YOUR ATTENTION