Sofinter

Sofinter had been established on 1979

Headquarters:	**Milano – Italy**
Shareholders:	**Acquario SpA**
	Gammon International BV
	Private Equity Partners SpA **JP Morgan Italian Fund III**
Business:	**Boilers, Plants and Services for:** **Power Generation**
	Components and Service for **Environment Control**
Turnover	**500 Mio.Euro p.a.**
Employes	**1,000**

Who we are

Sofinter

GROUP PRESENTATION

www.sofinter.it

ANSALDO CALDAIE S.p.A.

MACCHI STEAM & POWER GENERATION

COMMISSIONING ITALIA

SWS SALINE WATER SPECIALISTS

itea FLAMELESS TECHNOLOGY

europower

ecopower

eco engineering srl

ISOTHERM PWR®

Flameless Pressurized Oxy-combustion Technology

Energy
with emissions close to zero

Presented by G.Figini
to ProcessCEM Asia 2010

October 2010

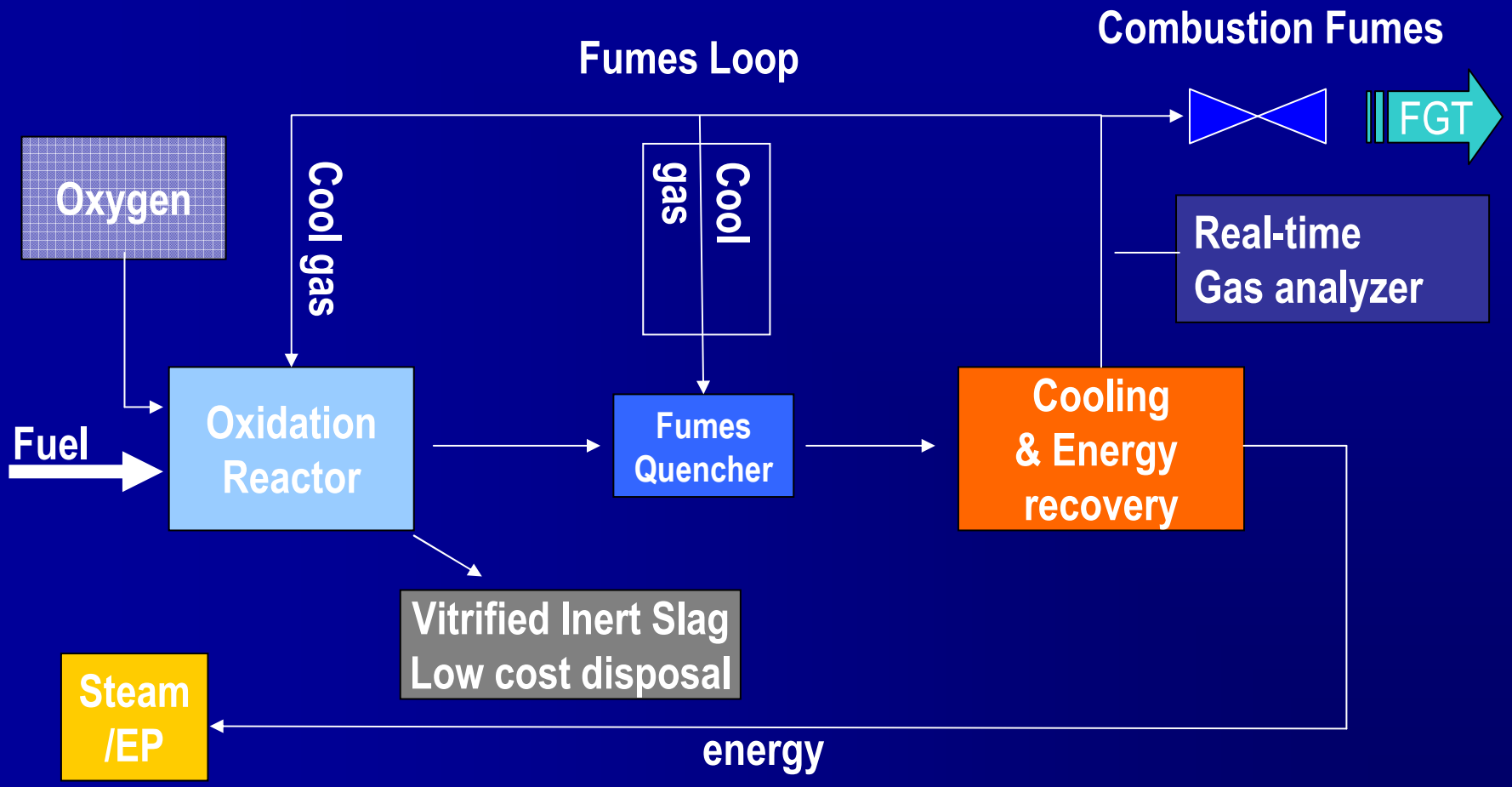
Agenda

1. ITEA – THE ISOTHERM PWR TECHNOLOGY PROCESS
2. ITEA – THE ISOTHERM PWR APPLICATION NICHES
3. CONCLUSIONS

ISOTHERM PWR

FLAMELESS PRESSURIZED OXYDATION TECHNOLOGY/PROCESS WITH HIGH ENERGY RECOVERY FROM TOTAL COMBUSTION OF "BROWN FUELS"

ISOTHERM BLOCK DIAGRAM



ISOTHERM PWR®

Flameless Pressurized Oxy-combustion

5 MWth Pilot Unit - Aerial View

in operation since 2004

120 ft X 60 ft

Small
Compact
Simple
(few unit operation)

Fully automated
Easy to operate

At Ansaldo CCA Test Rig
Gioia del Colle (BA) Italy

KEY SUCCESS FACTOR OF ISOTHERM PWR

- The lowest emissions rank that known combustion technologies can guarantee.
- The ashes are reduced to totally inert vitrified slugs.
- 96% of introduced heat (LHV) is recovered.
- High rangeability of the combustion process (from 10% to 100% in 1-2 hours)
- High acceptance of water content of the combustible (up to 60-70%)
- Compact relatively small plant
- Competitive capex.

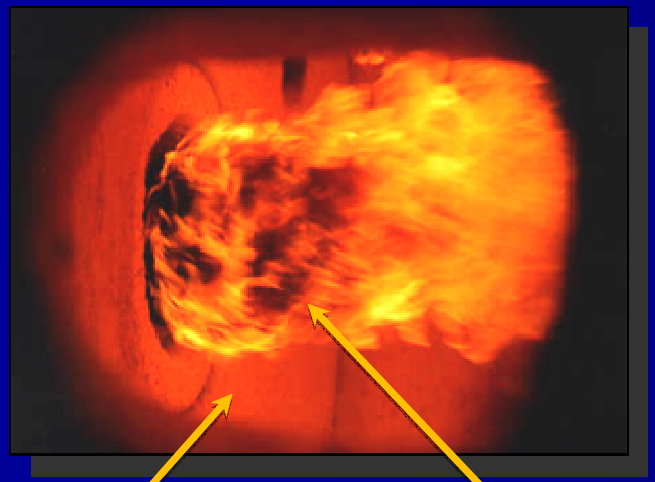
ISOTHERM Innovative Fundamentals

FLAMELESS UNIFORM HIGH TEMPERATURE

Traditional "flame" combustion

"chaotic"

non locally controllable



Cool Zone

Flame Front:
Peak Temperatures

Itea «Flameless combustion »

MILD, flameless, FLOX®, « volume comb.»

volume expanded - controllable

High Uniform Temperature

ISOTHERM Innovative Fundamentals

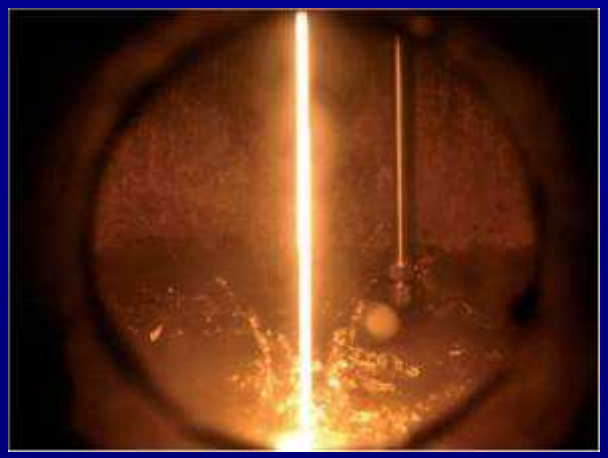
BOTH HEAVY AND FLY ASH MELTING

Ashes quantitative melting and coalescence is unique to Isotherm process.

- **Quantitative Melting**
- **Liquid phase triggers**

Slag coalescence

Molten slag drained at combustor bottom



"Slugging" **process**

Molten slag quenched in a water bath

Vitreous Granular

Zero Residual Carbon
Impervious to Heavy Metal Leaching
Fully inert

ISOTHERM Innovative Fundamentals

BOTH HEAVY AND FLY ASH MELTING

Vitreous Ashes Vs Heavy ashes morphology

Heavy ashes in traditional combustion

Vitreous ashes

Agenda

1 ITEA – THE ISOTHERM PWR TECHNOLOGY PROCESS

2 ITEA – THE ISOTHERM PWR APPLICATION NICHES

3 CONCLUSIONS

ISOTHERM PWR® - Application boundaries
Energy from brown fuels

ITEA flameless process outperforms competitors specifically for:

Treatment of Industrial hazardous waste from

- **Petrochemical, fine chemical**
- **Pharmaceutical**
- **Industrial sludges,**
- **Refinery**

Energy from low ranking fuels:

-biomass
-bitumen
-coal

ISOTHERM® Process Profile:

- ***High Temperature Pressurized OXY-Combustion***
- ***Complete Oxidation (six-nine conversion)***
- ***Vitrified inert slag from ashes***
- ***Flue gas post-treatment: neutralization only***
- ***High yield heat recovery, 100% at high energy level***
- ***Compact hardware per unit power***
- ***Effluents after FGT ~75% CO_2 25%H_2O***

Industrial waste-to-energy applications

ISOTHERM PWR® commercial unit is 15 MWth capacity

KEY FEATURES
vs competing technologies

Far lowest airborn emission (from 10 to 1000 time lower)	no dioxin, furan, HPA, zero soot
Solid residues: No leaching ashes	both heavy and fly ashes transformed into vitrified inert slag
Ease to operate	simple, compact, full automation ample rangeability (10 – 100%) water content up to 70%
Favorable economics	much higher energy yield, lower treatment residues disposal cost.

Industrial waste treatment

Case Overall Figures

CASE: Petrochemical waste from plastic material production

(e.g.: Styrene and Phenol heavies, ketone, bitumen)

Waste calorific value	**KJ/Kg**	**37,509**
Capacity	**(Kg/h)**	**2,000**
Oxygen consumption	**(Kg/h)**	**5,240**
Steam production (t/hr)	**t/h**	**19.81** **400°C - 40 bar**
Power consumption (Oxygen prod. included)	**kW**	**1,800**

Industrial waste treatment: overall emissions

Flue Gas Emissions		
Noxious Gas:	EU 2000/76	Isotherm PWR®
CO	50 mg/m^3, peak value 200	< 1 mg/m^3
NOx	200 mg/m^3, peak value 400	< 100 mg/m^3
SOx	50 mg/m^3, peak value 200	< 30 mg/m^3
TOC	10 mg/m^3, peak value 20	<0.05 mg/m^3
HCl	10 mg/m^3, peak value 60	< 0.1 mg/m^3
PAH	0,1 mg/m^3	<0.0001mg/m^3
Dust (total)	10 mg/m^3, peak value 30	< 1 mg/m^3
PM 2.5	Not yet regulated (Industrial avg. 1.000 – 5.000)	<10 µg/m^3
Dioxin, Furans	0,1 ng/m^3	<0.0001 ng/m^3
Heavy metals	0,5 mg/m^3	< 0.1 mg/m^3
SOOT	Not yet regulated	Zero
CO2 %v (in flue gas)	8	>85

Industrial waste to energy applications

ISOTHERM PWR® unit already commercial: 15 MWth capacity

➢ *CAPEX*	*2000-3500 $/kW* *Oxygen production Unit included (VSA)* *Steam Turbine excluded*
➢ *EFFICIENCY*	*28% Net Electrical Efficiency* *with standard Steam Turbine* *(40 bar, 400°C superheated steam)*
➢ *ENERGY RECOVERY*	*>93% heat recovery* *100% at high energy level*

Industrial waste treatment

ITRO Pte
ROTARY – SOFINTER partnership
pioneers Isotherm waste-to-energy industrial development

Isotherm 15 MWth plant — Jurong, Singapore

Energy from BIOMASS applications

Case overall figures

ISOTHERM PWR® commercial unit is a 15 MWth capacity

➢ *CAPEX*	*1800 – 2800 $/kW* *Oxygen production Unit included (VSA)* *Steam Turbine included*
➢ *EFFICIENCY*	*28% Net Electrical Efficiency*
➢ *Energy recovery*	*>93% heat recovery* *100% at high energy level*

Energy from BIOMASS: performance

Incoming characterization		
• Biomass dry	Kg/hr	4,350
• Biomass moisture (60% !!)	Kg/hr	6,600
• LHV (dry)	KJ/Kg	18,000
• LHV (as such)	KJ/Kg	5,800
Oxygen consumption	(Kg/h)	5,960
Power production	MWhr/y	40,560
net green power production	MWhr/y	35,200
Power consumption	MWhr/y	5,360

Energy from BIOMASS cont'd

AIR EMISSIONS

	ISOTHERM performance	Environment Unique Text, L.152/2006 (italian legislation by EU directives)
TOC (TOTAL ORGANIC CARBON)	1.0 mg/m^3	30mg/Nm^3
Total Dust	3.6 mg/m^3	30mg/Nm^3
CO	10 mg/m^3	250 mg/Nm^3
NO2	100mg/m^3	400 mg/Nm^3
SO2	50 mg/m^3	200 mg/Nm^3

Vitrified slag

SiO2	32,2
P2O5	25,6
Al2O3	12,7
CaO	10,8
Fe2O3	7,7
Cr2O3	7,8
K2O	3,1
TiO2	1,8
ZnO	0,3
MnO	0,1

APPLICATION OF ISOTHERM PWR® TECHNOLOGY FOR BIOMASS

Energy from Coal

Why ITEA Isotherm PWR

- *Emission close to zero;*
- *No more pulverization, but Coal grinding only (fed as coal water slurry);*
- *Itea slugging technology means flue gas almost with near-zero ashes;*
- *Itea slugging technology provides unique advantages firing low rank coal, with high ash content, and low melting T ashes;*
- *Itea Isotherm PWR means high rangeability at constant performance: from 10% of full capacity, both for the combustor and for the USC boiler;*
- *USC boiler unique rangeability, and fast load change response, performance (Ansaldo-Itea);*
- *Ease of further improvements such as turbo-expander;*
- *Ease CCS.*

Near-Zero Emission Power from Coal

ISOTHERM PECULIAR ADVANTAGES

Process Core

- Flexible Fuel Capability (i.e. broad spectrum of low ranking fuels)
- Reduced fuel pre-treatment (grinding only) capital and operating cost
- Global efficiency, CO2 capture included, at least comparable with more popular ZEP technology candidates
- Lower Capex (<75% vs competitor), core unit compactness for retrofit
- No ashes residues
- No air uptake (no CO2 dilution)

Energy Cycle

- ✓ Simplified coal logistic (water slurry)
- ✓ 80 times less volume, 10 times less heat turnaround losses
- ✓ 100% heat recovered at high energy value (605 °C, 240 bar, USC steam)
- ✓ High combustor rangeability (from 10 to 100%)
- ✓ High boiler (Ansaldo-Itea) rangeability (10 to 100%)
- ✓ Promptness in fulfilling rapidly varying power load demand;
- ✓ Ease for further yield improvement (turboexpander)
- ✓ Ease for synergism with advanced (ceramic membrane) Oxygen separation process

Energy from Coal
CCS applications

DEVELOPMENT PATH ENEL ITEA

- ✓5 MWth Unit in operation since 2007
- ✓15 MWth Unit
- ✓48 MWth pilot unit : detailed engineering completed
- ✓320 Mwel - Feasibility study stage

Energy from Coal

NO FLUE GAS !!!
NO STACK !!!

EFFLUENTS ARE READY FOR SUBSOIL INJECTION AND STORAGE !!!

Chemical analysis of the effluents	Isotherm PWR®
CO	< 1 mg/m^3
NOx	< 100 mg/m^3
SOx	< 30 mg/m^3
TOC	<0.05 mg/m^3
HCl	< 0.1 mg/m^3
PAH	<0,0001mg/m^3
Dust (total)	< 1 mg/m^3
PM 2.5	<10 µg/m^3
Dioxin, Furans	<0,0001 ng/m^3
Heavy metals	< 0,1 mg/m^3
SOOT	Zero
CO2 v (in flue gas)	>93 %

Energy from Coal

Demo Unit overall figures

Thermal and Mass balance for a 320 MW coal fired power generation demo Unit

Coal flow rate	**130000 *kg/h***
Oxygen consumption	**267000 *kg/h***
Net Energy production	**2560000 *MWh/y***
Vitrified slag flow rate up to	**28000 *kg/h***

Energy from Coal

2015 TARGET: 320 MWe COAL FIRED PLANT

CCS competitive positioning

Figures scaled up for 1,000 MWe unit

	Post-combustion Capture (amine scrubbing)	IGCC	Atmospheric Oxy-combustion	ITEA-ENEL Flameless Pressurized Oxy-Combustion
Yield el.	33.5% [2]	34% *	31.5% - Enel 31.5% [1] *	**35.5% –Itea-Enel** **34.9% [1]** *
CAPEX	2867 $/kW [2]	4,500 $/kW [3]	3,600 $/Kw * *	**< 2,300 $/kW** * *
Standby to full-load time	up to 6 hours		up to 6 hours	**30 minutes**
Low rank coal or lignite	N/A	N/A	N/A	**Applicable** **55% [4]**

* Including energy for cryogenic Oxygen and CO2 compression

* * including ASU separation unit and CO2 compression up to 60 barg

Ref.1: **MIT** J. Hong et al. - *Analysis of oxy-fuel combustion power cycle utilizing a pressurized coal Combustor* – Energy **34** (2009) 1332–1340

Ref.2: **DOE, NETL** – *Pulverized Coal Oxy Combustion Power Plant* - (2007)

Ref.3: **DOE, NETL** Futuregen Project : IGCC 150 MWe demonstration unit CAPEX 1.6 B$

Ref. 4 Coal price-equalized equivalent yield

Agenda

1 ITEA – THE ISOTHERM PWR TECHNOLOGY PROCESS

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ISOTHERM PWR ITEA TECHNOLOGY / PROCESS PATH

TRADITIONAL APPROACH TO COMBUSTION

Flame combustion

- Chaotic process/non controllable
- Possible formation of dangerous products during combustion

⇩

- expensive/complex fumes treatment lines
- Dangerous non combusted ashes with sometime problematic disposal
- Plants with limited rangeability
- Low CO_2 concentration in outlet fumes

ITEA APPROACH

Pressurised flameless oxy-combustion

- Combustion controlled to its completion
- Total absence of dangerous products during combustion
  - no dioxine
  - no furanes
  - no soot

⇩

- Simple fumes treatment
- Non combusted ashes reduced to vitrified inert slugs
- High plant rangeability (10 => 100%)
- High CO_2 concentration (95%) in outlet fumes

itea FLAMELESS TECHNOLOGY

THANK YOU !

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