Pirelli Ambiente S.p.A.

Existing plants, waste-to-energy and CO2 reduction: a sustainable equation

WTERT 2005 Fall Meeting at Columbia University
New York - October 20-21th, 2005

Pirelli Ambiente's Mission

Pirelli Ambiente operates in the renewable energy sector by recovering energy from Municipal Solid Waste (MSW) with the production of high-grade Refused Derived Fuel (RDF), via:

Existing industrial plants (no need to build **new chimneys)**, resulting in

a significant **improvement in air emissions quality** and

a **reduced waste disposal costs for the community** compared to incineration plants

The Fuel Produced from MSW
high-grade RDF by Pirelli Ambiente

HIGH-GRADE RDF
(see Annex 3)

Derived from
- dry fraction from MSW
- chlorine-free plastic waste and end of life tyres

- high qualitative stability
- calorific value close to coal levels

The **only** RDF that is

- **protected by patents** on its methods of production and use

- **certified by leading industrial boilermakers** (ANSALDO and ABB) and by
  the **Italian Agency for Energy and Environment (*ENEA*),** for its environment-friendly and chemical-physical properties

Potential Users

UTILISATION OF HIGH-GRADE RDF

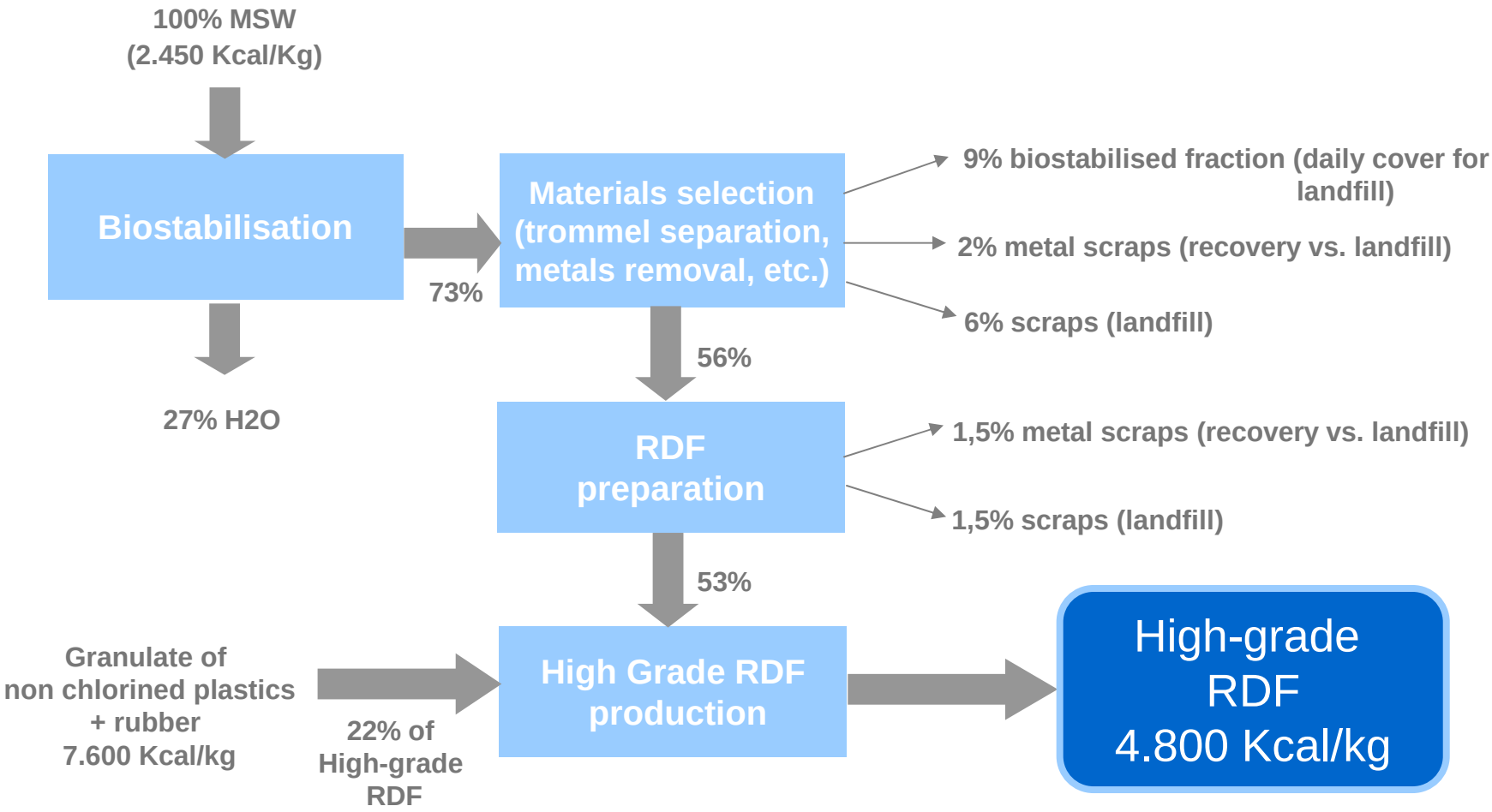
DIRECT USE → **COAL PETCOKE**

Co-firing as fluff in:
- Coal-fueled power plants **(10%)**
- Cement kilns **(40%)**

GASIFICATION → **COAL GAS ORIMULSION**

Co-firing as syn-gas in power plants **(10%)**

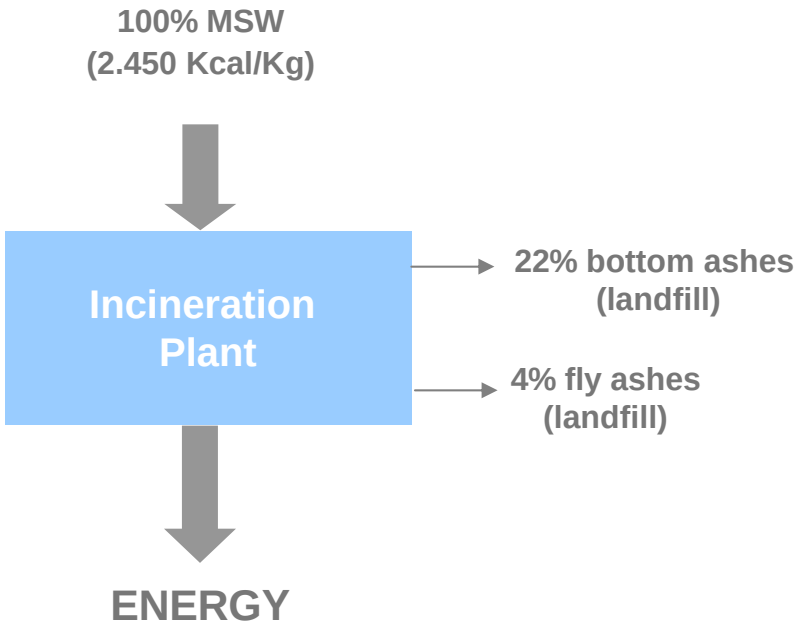
High-grade RDF production
Simplified materials flow chart



Landfill usage: 11%

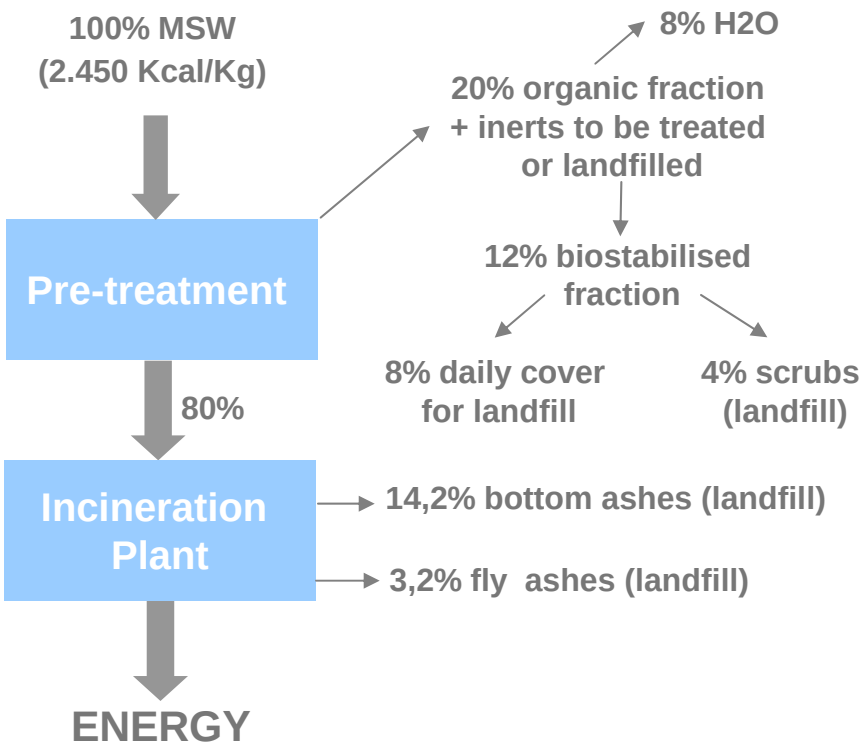
Incineration
Simplified materials flow chart

Incineration of MSW "as received"



Landfill usage: 26%

Incineration of MSW with pre-treatment



Landfill usage: 21,4%

Power production costs from renewable energy sources

Technology	Production costs (€/MWh)	Notes
Co-firing of high grade RDF in coal fired power plants	30*	RDF price = cost of avoided coal
Hydro (small plants)	66	Small capacity
Wind	63	Limited load factor (2000 h/y)
Biomass incineration	121	Limited biomass availability/calorific value
MSW incineration	228*	Consensus problems (NIMBY syndrome)
Photovoltaic	280	Limited load factor and limited availability

Sources: IEFE (Institute of Economy and Politics of Energy and Environment) – Bocconi University, 2005

* Not considering any gate fee for MSW

Co-firing of high-grade RDF saving of CO2 and improvement of air emission quality

Evaluating approach based on Life Cycle Assessment (LCA)

Green House Effect → **1 ton RDF = - 1,42 ton CO2 ***
(High-grade RDF contains a significant renewable fraction - biomass> 50%)

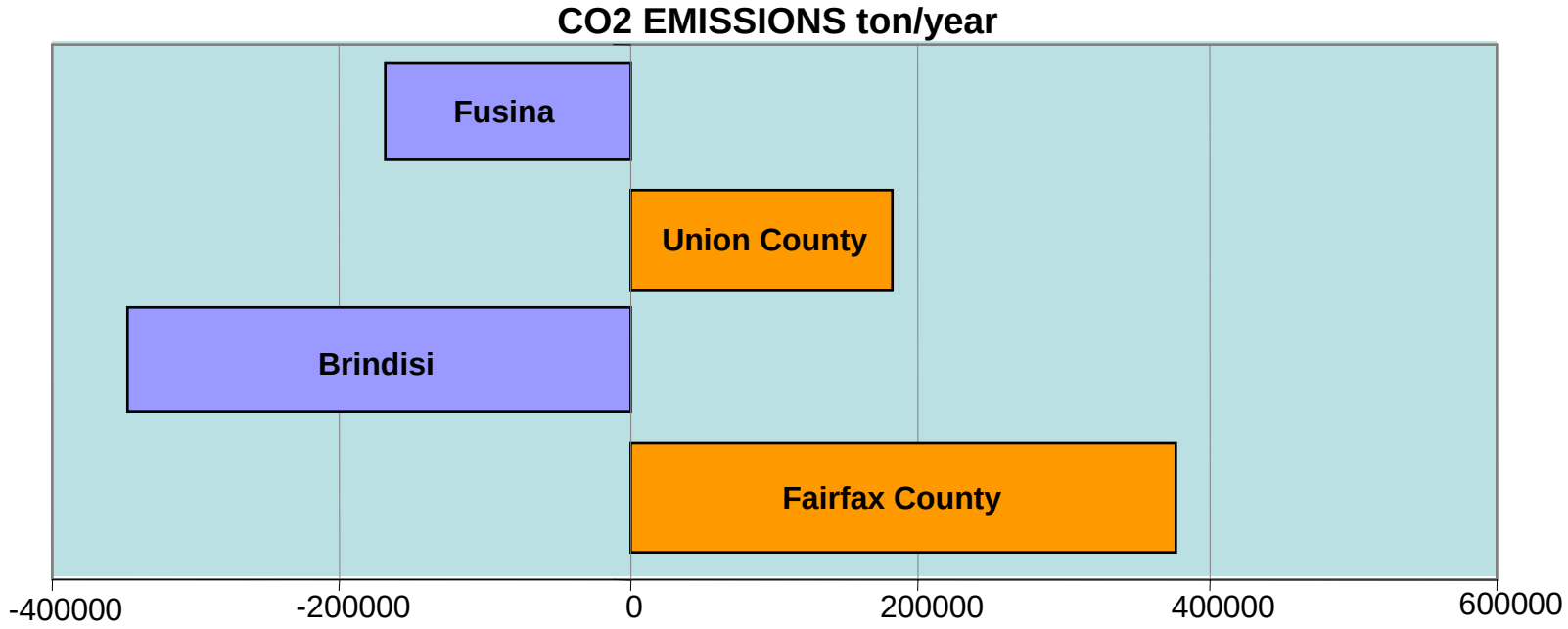
Human Toxicity → **Reduction of all parameters**
(i.e. NOX, Dioxins, heavy metals, dusts)

Eco Toxicity → **Reduction of all parameters**
(i.e. NOX, SOX, land use)

* Including avoided CO2 emissions from landfill

CO2 emissions: co-firing of high grade RDF vs. MSW incineration

Potential comparative analysis	energy recovery (ton/year MSW)	basin (inhabitants)°	**CO2 emissions (ton/year) "**
Co-firing in 2 groups of 320 MWh of a coal-fueled power plant, as Fusina * (Italy)	425.000	570.000	**- 170.000**
Incineration in a middle-size plant, as Union County-NJ	430.000	570.000	**180.000**
Co-firing in 2 groups of 660 MWh of a coal-fueled power plant, as Brindisi * (Italy)	870.000	1.170.000	**- 350.000**
Incineration in a large-size plant, as Fairfax County-Virginia	900.000	1.200.000	**375.000**



* Potential substitution: 10%
° Assuming a production of 2 kg. of waste per person per day (EPA, 2003)
" Not Including avoided CO2 emissions from landfill

Example of benefits from co-firing of high-grade RDF in the UK potential market

Co-firing of high-grade RDF in the UK potential market results in:

- energy recovery of a **minimum of 8** to a **maximum* of 17,5 million ton/year of MSW (23% - 50%** of yearly **production in UK)**
- production of a **minimum of 3,9** to a **maximum* of 9,6 TWh from a renewable energy source**
- **avoided CO2 emission**** from a **minimum of 5,7** to a **maximum* of 12,3 million ton/year**

* Assuming that all coal fired power plants will co-firing RDF under European legislation

** Including avoided CO2 emissions from landfill

Business Model

Equity Providers

Local Authorities

Special Purpose Vehicle

Pirelli Ambiente
(minority stake)

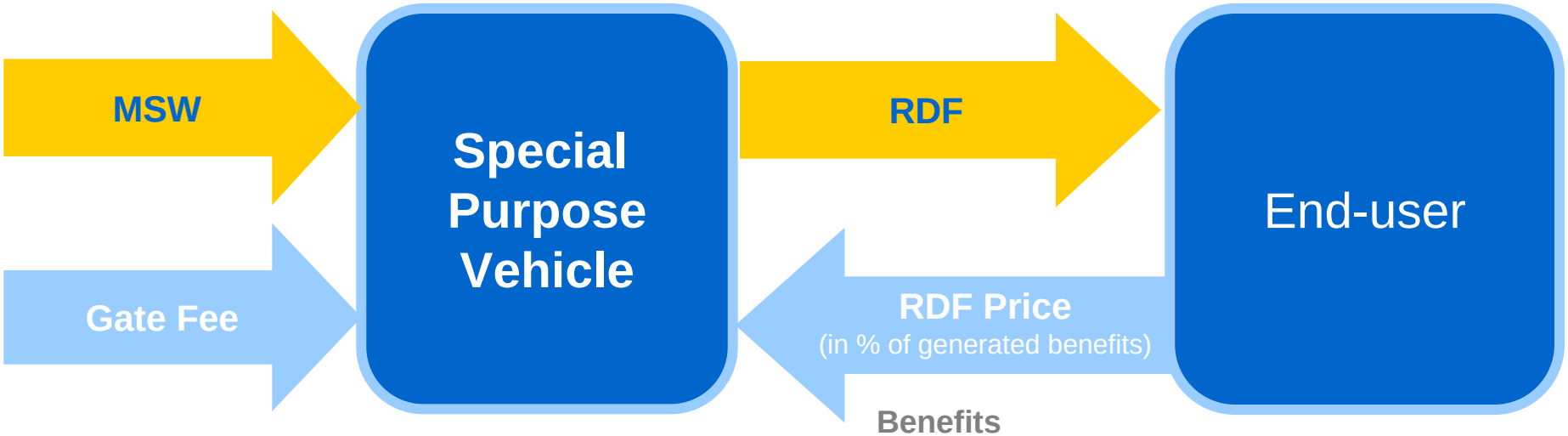
- MSW management and ownership
- Community representative role
- Equity
- PFI - Project Finance Initiative (if available)

High-grade RDF Production Plant

Existing plants
(power plants or cement kilns)

- Technologies (patents and know-how)
- Financial and project engineering management
- Operations management
- Supply agreement with RDF end-users
- Scientific and communications tools to achieve consensus (LCA)
- Equity

Revenue Stream



Benefits

- Coal substitution
- Incentives for renewable energy sources
- CO2 credits

Conclusions

RDF co-firing in existing plants generates the **following benefits**:

- **Reduces CO2 emission**
- Has the **lowest production costs amongst renewable energy sources**
- **Produces the lowest environmental impact in waste disposal compared to alternatives**
- **Has higher energy efficiency (36%) compared to incineration (25%)**
- **Increases production from renewable energy sources** and gives access to incentives
- Has a **lower waste disposal cost to the community** compared to incineration
- Lowers the **electricity production costs**
- Allows the existing plant to play **a social role in the solution of waste disposal**

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IDEA GRANDA

I.D.E.A. GRANDA, Roccavione (Cuneo), Italy

I.D.E.A. GRANDA (Integrazione dell'Energia nell'Ambiente) is the first industrial application of the technology for energy recovery from municipal solid waste.

It is a company in which A.C.S.R. (a Consortium of **54** Municipalities in the Cuneo area, comprising 154.000 inhabitants) holds 51% and Pirelli Ambiente

The cement kiln **currently substitutes approx. 8% of coal-petcoke consumption by using RDF in its main burners**

Unique and innovative properties

I.D.E.A. GRANDA implements an **innovative and unique process in Europe** based on:

- Valorisation of municipal solid waste and end of life tyres: the **energy recovery** from waste in the Basin increased from **0 to 32%** (higher than the European average level)
- Overall **environmental benefits** assessed at **90 times better than the alternatives** (landfill and incineration plants) according to the **Life Cycle Assessment Study** validated by Milan-Bicocca University
- **A lower cost to the community** compared to alternative solutions
- **No** need to build **new chimneys**
- **Partial substitution** of **fossil fuels** with a renewable source
- **Reduction** of the nitrogen and sulphur oxide **emissions in the cement kiln**
- **Dioxins and furans values are slightly better**
- Shorter **construction and start up time (6 months)**

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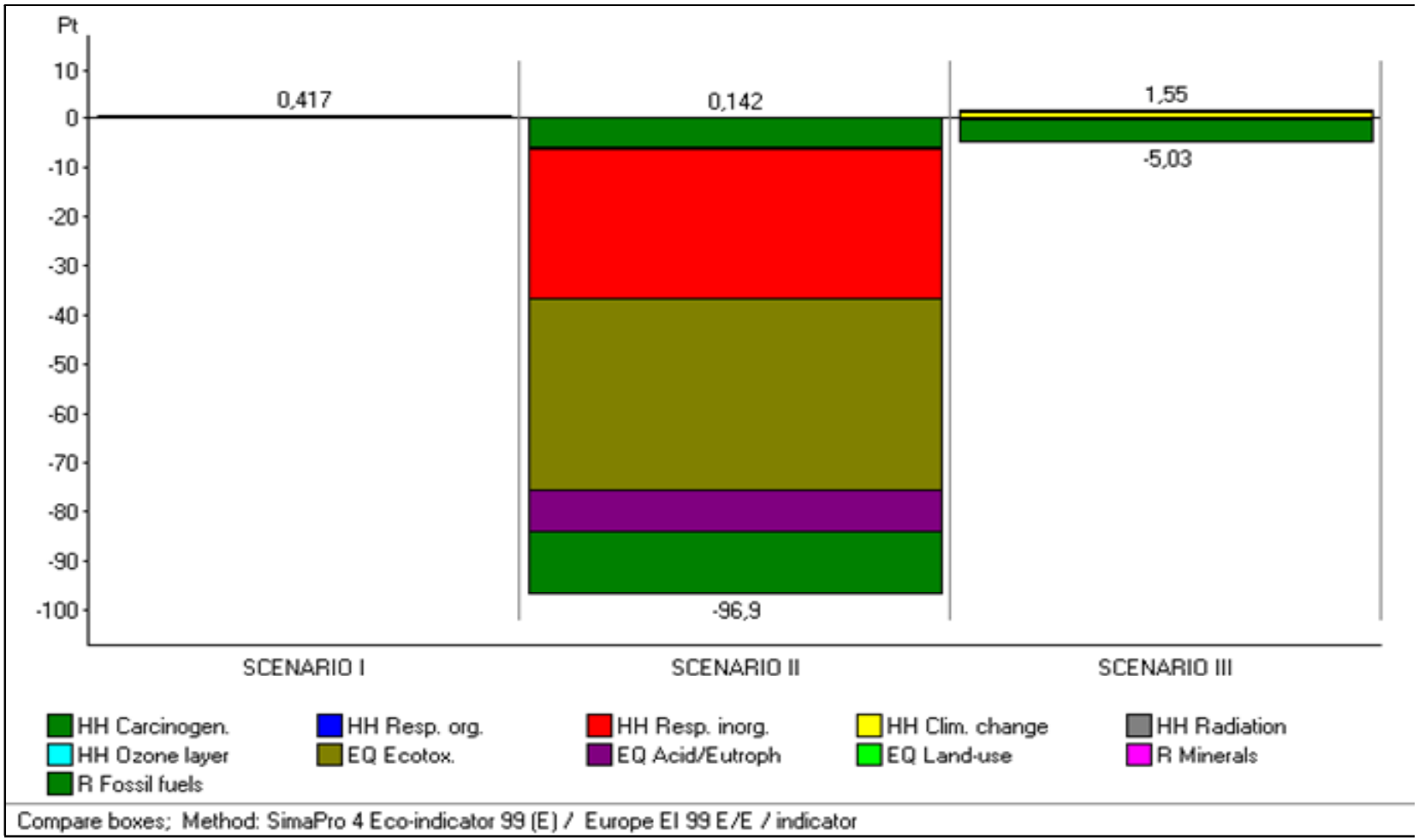
ANNEXES

ANNEX 1
Life Cycle Assesment results for IDEA Granda



ANNEX 2
Technology and Know How:
Pirelli Ambiente's Patents

Pirelli Ambiente filed three relevant patent applications:

Patent **PA 001**
Priority Dec. 97
granted in USA - 2001
granted in UE - 2004

Concerning the **composition of high-grade RDF** and its **chemical-physical characteristics**

Patent **PA 002**
Priority Apr. 98
granted in USA - 2002
Notice of granted
in UE - 2004

Concerning a **combustible composition comprising a fossil fuel and high-grade RDF**, and the **process** and the method for instantaneous combustion

Patent **PA 003**
Priority Mar. 2004

Concerning how to **handle and combine municipal solid waste and the other components to obtain a homogeneous solid fuel of controlled composition**, without using complex mixing devices. The process substantially corresponds to that carried out in the IDEA Granda plant.

ANNEX 3
Technical Specifications of High-Grade RDF

Composition

- MSW dry fraction
- End of life tyres in variable amounts
- Chlorine-free plastic waste

< 30%

Comparison between the chemical-physical properties of the high-grade RDF and the normal grade RDF as per Italian Standards (UNI)

General specifications		High-grade RDF	Normal grade RDF
L.H.V. ar[1]	kJ/Kg Kcal/Kg	> 20.000 > 4.800	> 15.500 > 3.700
Humidity	%ar	< 18	< 25
Ash	%d	< 15	< 20
Chlorine	%ar	< 0,7	< 0,9
Sulphur	%ar	< 0,3	< 0,6

[1] **Lower Heating Value as received**

- A proposed European Norm for the standardization of RDF is expected to be edited soon by CEN (Comité Européen de Normalisation) for a validation program.
- The proposal - that will be published as Technical Specification (TS) is the result of the activity of a specific technical committee (CEN-TC343) appointed by the European Commission for the purpose.
- During the validation time (three years) and until the final approval of the European Norm (EN) each member state can apply its national standard

ANNEX 4
Evaluation of the Pirelli Ambiente RDF Process for Potential Applications in the U.S.

Report by Earth Engineering Center (EEC) of Columbia University

EEC visited I.D.E.A Granda plant together with Buzzi cement kiln in Cuneo, and the ENEL power plant close to Venice, where the co-firing of an RDF, produced by a nearby third company, has been tested satisfactorily in a 320 MW boiler.

Conclusions of Columbia University Report

- The **detailed examination of the RDF process and the RDF** by EEC confirmed their **full feasibility from a technical standpoint**

- There is **no technical risk** in designing and building a facility that will produce RDF of the specified size, moisture and calorific value

ANNEX 5
Co-firing in Power Plants: Experiences in Europe

Italy	In **Fusina (Venice)** power plant, owned by Enel, the experimentation of co-firing of RDF was positively concluded and an industrialization phase is under negotiation with Pirelli Ambiente as the technological partner
Deutschland	In **Janschwalde** coal power plant (3.000 MW) fitted with FGD and owned by **VEAG**, since 2001 RDF is directly co-fired on industrial scale, substituting up to 5% of fossil fuel In **Gerstein Werk** coal power plant, owned by RWE, RDF is co-fired with pulverised coal
Nederlands	In **Maasvlakte** coal power plant (1.000 MWe), owned by E.ON, liquid refuses and other organic wastes are utilised in co-firing
Denmark	In **Fynsvaerket Odense** coal power plant (385 MWe), grinded plastics are utilised in co-firing
Finland	In **Lahti** (150 MWe) coal power plant, a gasification plant is operating with RDF and feeding in combustion chamber a volume of syn-gas equal to 10% of termal input of the power station

ANNEX 6
Co-firing of RDF in Power Plants: USA Experiences

Plant	Fuel	Capacity
- **Ames Municipal Electric System** Ames, Iowa	- Coal/RDF	- 33 MWe 75 MWe
- **Illinois Power Co Baldwin Power Station** Baldwin, Illinois	- Coal/end of life tyres	- 560 MWe
- **Lakeland Electric and Water Mcintosh Plant** Lakeland, Florida	- Coal/RDF	- 350 MWe
- **Otter Tail Power Co** Big Stone City, South Dakota	- brown coal/RDF/ end of life tyres/ biomass	- 440 MWe
- **Tennessee Valley Authority Allen Station** Memphis, Tennessee	- RDF/waste wood and coal/ biomass/ end of life tyres	- 176 MWe

ANNEX 7
Use in a Plant for Instantaneous Combustion: Certifications Available to Pirelli Ambiente

From 1997 to 1999 Pirelli Ambiente has carried out:

Tests at **IFRF Laboratories** (International Flame Research Foundation - Nederland) and at **SCC laboratories** (Stazione Sperimentale Combustibili – Experimental Fuel Station- Milan) for the **determination of combustion kinetics of singular constitutive elements of the mixture**

Tests at **IFRF Laboratories on. on fluid dynamic simulation of co-firing high-grade RDF/ pulverised coal** for **ABB Ricerca S.p.A**

Combustion tests at ENEA (Italian Agency for Energy and Environment) La Casaccia **Experimental Station of Incineration** (Stazione Sperimentale di Termodistruzione) for the characterisation of high-grade RDF in a circulated fluidised bed (c.f.b.) combustor

Tests at **Ansaldo Energia Termosud S.p.A. - Gioia del Colle** for the co-firing with **pulverised coal in a 48 MWt pilot plant equipped with industrial burner in full scale (30 / 40% of substitution)**

ENEA Certification of environmental survey of the above tests carried out at Termosud Plant in Gioia del Colle (Bari)

Characterisation of high-grade RDF: simulation of **loading and unloading phase** of high-grade RDF from a motor vehicle – **handling** of high-grade RDF