COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK
EARTH ENGINEERING CENTER

FINAL REPORT

September 6, 2004
Report to Pirelli Ambiente, Milano, Italy
Attention: Mr. Nicolo Dubini, Managing Director

Evaluation of the Pirelli Ambiente SRF Process for Potential Applications in the U.S.

Draft of this report was transmitted to Mr. Nicolò Dubini (nicolo.dubini@pirelli.com) on June 1, 2004, This final report has taken into account the comments of Pirelli Ambiente to the June 1 draft, as per July 28 e-mail of Mr. Luca Zucchelli of PA)

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Evaluation of the Pirelli Ambiente SRF Process for Potential Applications in the U.S.

Report of the Earth Engineering Center, Columbia University, New York City

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1. Introduction

Pirelli Ambiente is the owner and developer of the SRF technology, patented in Europe at the European Patent Office (EPO) and in the United States of America (US) at the US Patent Office. This technology consists of separating the non-recyclable and combustible fraction of municipal solid wastes (MSW), shredding it to about –20 mm and mixing it with the appropriate fractions of plastic and rubber residues, also of about –20 mm size, so as to obtain a specified calorific value (e.g., 24 MJ/kg, i.e. same as a mid-range U.S. coal). The SRF fuel is then transported to existing pulverized coal power plants or cement kilns where it is co-fired with coal.

Under an agreement between Pirelli Ambiente (PA) and the Earth Engineering Center of Columbia University (EEC), Prof. N.J. Themelis, Director of EEC and Mr. Nathiel Egosi, EEC Research Associate, traveled to Italy and met with PA representatives in Milan during the week of April 19, 2004. At the April 19 meeting in Milan, PA made presentations on the PA SRF process and current state of development and provided EEC with copies of their E.U. and U.S. patents on the SRF process and SRF fuel. On April 20, in the company of Mr. Luca Zucchelli of PA, the EEC engineers visited the Cuneo (population: 150,000) municipal Materials Recovery Facility (MRF) where the MSW component of the SRF is produced and later the nearby I.D.E.A. Granda (IG) facility built by PA where the MSW component is processed along with plastics and rubber residues to SRF fuel. This plant occupies an area of about 10,000 m^2 (of which the building occupies about 1,700 m^2), cost about 3 million Euros and has a production capacity of 40 tons per hour of SRF (75% MSW, 17-18% plastics, balance rubber residue). On the same day, Messrs. Egosi, Themelis and Zucchelli visited the Cuneo cement plant of Buzzi Unicem, Italy's second-largest cement producer. The IG SRF is transported to Buzzi by truck, loaded into a feeding bin and co-fired, at the rate of 1-3 tons SRF per hour, with coal in a cement kiln.

On April 21, Mr. Zucchelli and the EEC engineers visited a large coal-fired power plant close to Venice, operated by the ENEL utility company. The co-firing of an RDF fuel, produced by a nearby third company, was tested satisfactorily by ENEL in a 320 MW boiler, one of the four units of this 1000 MW utility. The ENEL engineer who showed the visitors the feed preparation plant and the co-fired boiler stated that on the basis of this test, ENEL was now preparing to go on full-scale, continuous co-firing of this boiler using about 110 tons of fuel per hour, 9 tons of which will be RDF fuel. The visitors obtained a sample of this fuel. It is of smaller size than the SRF fuel and of apparently lower calorific value than SRF.

2. Meeting with Pirelli Ambiente at conclusion of EEC visit

In the evening of April 21, a meeting was held at the Milan headquarters of PA attended by the visitors, Mr. Nicolo Dubini, Managing Director of PA, Mr. Luca Zucchelli, and other personnel and consultants of PA. At this meeting, the EEC engineers presented their preliminary conclusions on the PA SRF process:

2.1 The Pirelli Ambiente P-SRF Concept: A simple and elegant idea

Although there have been many developments in the U.S. and around the world on the co-firing of refuse-derived fuel (RDF), the Pirelli concept differed in the following aspects:

- the non-recyclable and combustible fraction of MSW are mixed with post-industrial plastic and rubber residues and the mix is subjected to the minimum level of processing (shredding and drying) to "manufacture" a fuel of specified calorific value.
- Use of this product as a marketable fuel in various existing suspension fired processes, such as cement kilns and coal fired utility plants.

2.2 The Pirelli Ambiente patent/licensor position

Although there are many similar processes, the unique features of P-SRF have been recognized by the granting of the European and US patents.

- The patent position of PA is strengthened to the eyes of potential partners by the fact that it is backed by a Pirelli company.
- As a result of involvement in current projects in Italy, PA is accumulating know-how and validating information that will be of increasing value in developing new projects.

2.3 The I.D.E.A. Granda (IG) project at Cuneo

- This project is well integrated with the solid waste management needs of the local municipalities and will be a good example to emulate by U.S. communities.
- The business structure supports a win-win partnership for all parties.
- The MSW feedstock from the municipality plant (ACSR) could be improved with more advanced processing methods.
- The IG plant features good process design and selection of equipment.

The receiving and feed facility for using the P-SRF fuel at the Buzzi cement plant is reliable and effective for co-firing P-SRF. The physical form of the Pirelli SRF is specially designed to allow suspension co-firing of this fuel with coal in the cement kiln and the kiln operators expressed satisfaction with regard to use of SRF fuel.

2.4 The ENEL Project

- ENEL has tested co-firing with coal, at rates of up to 9 tons/h of an RDF fuel. The tests were apparently successful because ENEL is planning to go in full operation next year with co-firing
- ENEL's acceptance of co-firing a crude fuel indicates the strong potential for PA's SRF, a superior fuel to the RDF used at ENEL, in the utility sector.
- PA is benefiting from the past experience of tests with another fuel to advance its own technology.

- The physical form of the Pirelli SRF is specially designed to allow suspension co-firing of this fuel with coal in the combustion chamber of the power plant. The technical relationship between the local SRF producer and Pirelli Ambiente will enable the ENEL project to moved quickly and successfully from the experimental to the industrial phase.

2.5 U.S. Market Potential

- Projects in the US market are regionally different due to transportation costs, tipping fees, competing alternative fuels and the regulatory process. For example, cement kilns are unlikely to pay for SRF fuel (see Perspectives section).
- Project finance opportunities matching the PA business model are available.
- Regulatory agencies have good experience with similar fuels so that there is a small learning curve. For example, NO_X and SO_X are widely known to be reduced with RDF and rubber wastes like tires.
- Municipalities are actively building recycling plants with no solution for the combustible residue.
- Municipal solid wastes (MSW) generation per capita is double that of Italy and there are few technologies that address the disposal and management of non-recyclable plastics and other combustibles.
- Large industrial boilers in the US and independent power producers all represent potential markets.
- Utilities have learned that they can avoid buying low-sulphur coal or upgrading their APC if they co-fire alternative fuels with "cheap" coal.

3. Review of potential for Pirelli SRF application in the U.S.

3.1 Assumed SRF mix in the U.S.

3.1.1 The MSW component

The 2002 national survey of U.S. municipal solid wastes (MSW) generation and disposition by the Earth Engineering Center and BioCycle journal showed the following results (Table 1).

Table 1. Generation and disposition of MSW in 2002 (in million metric tons)

Generated	Recycled	Composted	To WTE	Landfilled
336	64	23	26	220

The fraction of combustibles in the average U.S. MSW is shown in Table 2.

Table 2. Combustibles in MSW

Biomass combustibles	% of MSW
Paper/board	38.6
Wood	5.3
Cotton/wool	1.9
Leather	1.5
Yard trimmings	12.8
Food wastes	10.1
Total biomass	***66.8 %***
Petrochemical combustibles	
Plastics	9.9
Fabrics	
Rubber	
Total petrochemicals	***14.3***
Total combustibles	**81.1**

In considering the SRF application to the U.S., it has been assumed, as a first approximation, that most of the inorganic, yard , and food wastes will be removed from the MSW stream that will be used in the SRF prototype plant. Also that the moisture of the SRF mix will be controlled at about 10%. On this basis, the calorific value of the MSW component was estimated at 16,000 kJ/kg.

3.1.2 The plastics component of the SRF

An EEC study in New York City showed that a large fraction of the plastics reaching the Materials Recovery Facilities consists of polyethylene film that is not marketable and is baled and sent to landfills. It is believed that the same situation exists in many other communities since it is known that most of the discarded plastics are landfilled. Therefore, it is assumed that large amount of polyethylene film wastes will be made available to the SRF prototype. The calorific value of this material is very approximately estimated at 44,000 kJ/kg.

3.1.3 The rubber component of the SRF residue

An estimated 290 million tires are discarded in the U.S., 45 million are stockpiled, and the rest are used mostly as a fuel in cement kilns or as daily landfill cover. A very preliminary look showed that rubber tires would be too costly to reduce them to the –20 mm size required for SRF (see Perspectives section). However, EEC believes that there are many small industrial operations that generate unwanted rubber residues that can be reduced easily to the required particle size. For example, a cursory investigation by EEC this May identified an Ohio manufacturer of automobile and other rubber seals who generates about 360 tons of rubber residue (soft rubber with cross section of about 25 x 50 mm) that is currently landfilled. EEC obtained a large sample of this residue and it is very amenable to comminution. Rubber residues have an estimated calorific value of 27,000 kJ/kg.

3.1.4 One type of MSW-plastics-rubber mix

PA has indicated that the desirable calorific value for the SRF fuel is about 23,000 kJ/kg. This value corresponds to a middle-of-the-range U.S. coal. Table 3 shows the constitution of the MSW-plastic-rubber mix that would have this calorific value. Of course, different calorific values may be required by the end users of the U.S. SRF and they would be obtained by different mixes of the three materials.

Table 3. MSW, plastics, and rubber mix to produce SRF of 23,000 kJ/kg.

	Calorific value	**%**	**kJ/kg**	**kcal/kg**
MSW	16,000	60%	9,600	
Polyethylene film	44,000	30%	13,247	
Rubber	27,000	10%	2,700	
SRF mixture		100%	22,847	5,500
Desirable calorific value as per PA			23,000	5,500

4. Desirable characteristics of projected SRF operations in the U.S.

In looking ahead as to where PA may locate SRF plants in the U.S., the following factors need to be considered.

4.1 High landfill tipping fees

Geographic locations should be sought where the landfill tipping (gate) fees are high. The EEC/BioCycle survey has identified several states where the tipping fees are in excess of $60. These are (in alphabetical order): Connecticut, Florida, Maine, Maryland, Maine, Michigan, New Hampshire, New Jersey, New York, Oregon, and Pennsylvania The highest landfilling tips reported in the EEC/BioCycle survey were about $90/metric ton.

4.2 Community interest in Integrated Waste Management

Desirable locations would be in communities where there are already active recycling and composting and/or waste-to-energy programs. The front end of the SRF process encourages the separation of non-combustible inorganic materials (metals and glass) and also the separation of organic wastes for composting. Also, Materials Recovery Facilities generate a large amount of plastics (bags, film) that are not recyclable. These materials would be a good source for the plastic component of SRF.

4.3 Small industrial operations generating plastic or rubber residues

Locations should be sought where there are small manufacturing operations that use rubber and generate rubber residues that are not recyclable but are landfilled. As noted earlier, one such operation was already located by EEC. The closer such operations are to the SRF plant, the lower the transportation costs will be. A very preliminary estimate has indicated that trucking costs in 20-ton trucks can be high, at $0.05-0.10 per ton-mile.

4.4 Proximity to suitable SRF users

Again, it is very important to minimize transport costs of the SRF fuel to the user's plant. Pulverized coal-fired power plants and cement kilns would use the SRF. Cement plans that are equipped to use shredded or whole tires would not be interested in this fuel, as discussed in more detail in the Perspectives section of this report.

Pulverized coal-fired power plants that are already equipped with activated carbon injection and fabric filter baghouses (and therefore have very low volatile metal and particulate matter emissions) would be more amenable to using the SRF fuel.

In addition to the lower NOx and SOx advantage, the SRF fuel would provide the additional advantage of lower mercury emissions (U.S. coals contain 0.1 ppm of mercury on the average).

An important class of users that should be explored in Phase 2 are industrial boilers (see Perspectives section).

4.5 High-price coal regions

The price of coal varies considerably across the U.S. The highest prices exist in New England region ($47/ short ton average); Connecticut, $57; New Jersey, $48, New York, $41; Maryland, $42; Florida, $46. The price of coal decreases west of these states reaching a low of only $12 in the Dakotas and increasing to about $25 in the Pacific region. Obviously, SRF plants would be better located in a high-price region.

4.6 Economic incentives for use of MSW in place of fossil fuel

In addition to the documented environmental incentives of using MSW as a fuel (conservation of greenfields, avoidance of mining approximately 2.1 tons of coal for each ton of MSW combusted, reduction of greenhouse gases by an estimated 1.3 tons of carbon dioxide per ton of MSW combusted rather than landfilled, avoidance of future groundwater contamination), at locations where there is no land left for landfilling and the MSW has to be exported to other states for landfilling at relatively high cost there are economic advantages for combusting MSW in properly designed facilities to generate heat or electricity. This is indicated by the fact that there are in the U.S. about 100 waste-to-energy (WTE) facilities that in total generate about 2.6 Gigawatts of electricity.

The economic advantages are due to the fact that the MSW transportation and landfilling costs in such locations are greater than the capital charges and operating costs per ton of MSW combusted minus the value of the net electricity generated in WTE facilities (approximately 550 kWh per ton of MSW combusted). Evidently, the economic benefits for SRF would be even greater than for WTEs since the capital charges for generation and use of SRF in an existing combustion unit (i.e., cement kiln or power plant) are expected to be substantially lower than for a new WTE facility.

5. Perspectives on past and future use of MSW as a fuel

The SRF fuel is in some ways similar to the Refuse-derived-Fuel (RDF) technology that has been developed and used in the U.S. since the early seventies. Therefore, it may be of value to Pirelli Ambiente, especially in developing its business plan for the U.S., to summarize in the following sections of the experience gained in the course of past and current efforts to use waste materials as fuels.

5.1 Recent history of RDF in the U.S.

The production and use of refuse derived fuel (RDF) has been a long practice in the United States and the U.S. is recognized as the leading developer of technologies for converting municipal solid wastes into RDF. RDF refers to the prepared portion of Municipal Solid Waste (MSW) with high calorific value. Early efforts go back to the 1960s and continued throughout the 1970s with the research of the U.S. Bureau of Mines and the National Center for Resource Recovery (NCRR).

Numerous plants were built in the 70s including Milwaukee (WI), Baltimore (MD), Pigeon Point (DE), Rochester (NY), Philadelphia (PA), Ames (IA), New Orleans (LA), Tacoma WA), Columbus (OH), Bridgeport (CT) and Hamilton (ON). In nearly each instance, the technologies used were adapted from the mining industry: The MSW was processed into a prepared fuel with higher calorific value for co-firing with coal boilers or for dedicated incineration. Typically this was and continues to be accomplished by maximizing the removal of the inert fractions and by blending other discrete waste types to enrich the fuel. Efforts to remove moisture generally were ignored due high cost as well as the found flexibility of boilers to deal with moisture. Other than the Ames plant, all the named plants have been closed either due to age, poor operating history, changed economic conditions and lost markets for the fuel.

The American Society of Mechanical Engineers (ASME) formed the Incineration Committee in the 1961 (renamed in 1974 as the Solid Waste Processing Division) who studied these plants and documented their performance. The lessons learned were widely published and shared amongst the industry. This led to a new generation of plants in the 80s; nearly all of which have had great success. Some of these well-known plants include Norfolk (VA), Hartford (CT), West Palm Beach (FL), Miami (FL), Honolulu (HI), Detroit (MI), Biddeford (ME) and numerous plants in Minnesota. In each instance, the plants constructed were large in size (over 1000 tons per day (TPD) with several at 3000 TPD) and took advantage of all the past lessons regarding explosions, shredder performance, plant reliability, poor removal efficiencies and more realistic economic expectations. RDF users likewise fully addressed the issues of furnace slagging, tube corrosion, etc. Plants like West Palm Beach include a dedicated boiler while others like Hartford co-fire with coal in a utility boiler. With the success of the RDF plants and the continuing increase in MSW quantities, nearly all co-firing plants have discontinued the use of coal, other than in emergencies, since the economics of burning 100% MSW are more favorable given the increased supply of waste.

In the '90s things changed. The NIMBY ("not in my own backyard) movements intensified and it became increasingly difficult to site an RDF preparation plant as well as the companion incineration plant. Even industrial boilers had difficulty convincing communities to allow them to burn RDF. Utilities were deregulated and their interest shifted to only economic solutions corresponding to the increased air regulations and the need to produce cheap power. Legislation requiring utilities to buy energy from independent power producers (IPPs) at a minimum price was repealed. Tax credits for investments in resource recovery projects expired. Tax-exempt financing rules changed thus making investments in resource recovery projects less feasible. Also, waste flow control was deemed unconstitutional, allowing transport across state borders and pushing tipping fees downward. Additionally, intensified efforts by municipalities launching curbside recycling programs steered interest away from energy recovery. In 1989, there were less than 300 community-based recycling programs; today, there are over 10,000. The more the nation's communities recycled, the less interested they were in RDF and WTE. The consensus of the solid waste management plans is to recycle to the greatest extent possible leaving the remainder to landfills.

Nevertheless, during this period of heightened recycling programs, several large RDF facilities were built. Most notable, however, were the failures of two significant projects that even now continue to worry the investment community for the future. Both were non-recourse, tax-exempt revenue bond financings that quickly went into bankruptcy after plant commissioning. Both were RDF projects; one around 1995 and the other around 1999. The BCH Energy project in North Carolina consisted of an offsite RDF preparation plant and new industrial boilers for steam/power generation at a Dupont plant. The engineering was poorly executed and neither plant could operate properly, leading to their ultimate shutdown.; the boiler feed systems never worked correctly and the fuel quality was very poor. Surprisingly, many of the lessons of the 80's were ignored in order to achieve savings by the developer. These facilities were liquidated and the industry was reminded that solid waste projects tend to have high technology risk.

The 1999 project was a 2000 ton/day RDF plant in Robbins, IL (a Chicago suburb) with a dedicated fluidized bed boiler that sold energy to the grid. In contrast to the NC project, this project was executed extremely well and surpassed the performance of every prior plant. Even more impressive was the strong support by the local community and the lack of the NIMBY element. This facility was viewed as the best example of how to develop and execute a project. However within one year of opening, the facility suffered a major set-back. The local utility company, assisted by the deregulated market and strong political support, was able to overturn a state law that had artificially subsidized the RDF plant's sale price for the electricity. With the reduction of energy revenues, lack of flow control and highly aggressive landfill tipping areas, the plant quickly went bankrupt.

The investment community lost millions with these two projects. Coupled with the millions also lost in cancelled WTE projects, market creditability and interest in municipal solid waste projects shrunk. At the same time, the economy was booming with seemingly more attractive deals in the "dot.com" and "high-tech" market leaving developers without funding.

However, during this same period many smaller RDF projects were successfully executed. Most were based on commercial wastes and industrial wastes with some blending of MSW. The industry shifted. The level of sophistication increased. Projects were smaller but far more aggressive. They combined different wastes to "manufacture" a fuel consisting of prepared solid waste, sludges, non-recyclable plastics and papers, wood wastes, paper mill residues, etc. These RDF plants typically feature many elements of mixed waste processing facilities (also referred to as "dirty MRFs"- material recovery facilities). Basically any material that is dry and high in energy content, and with little economic chance for recycling, is blended with solid waste to make a fuel.

There are many examples of such operations in the U.S.. Some of the fuel preparation plants are stand-alone and sell the fuel to industrial and/or utility boilers while others are part of an integrated waste-to-energy type of facility. The drivers have varied from rising tipping fees, lack of disposal capacity, community interest, corporate interest and of course regulations. There is a continuing trend towards more of these type of facilities.

As a result of this historical development, the Pirelli-SRF would be viewed in the US market as a trade name to a familiar process. Regulations already provide many incentives to take advantage of various processes that result in a prepared fuel. The benefits of NO_x and SO_2 emissions, accompanying the use of MSW-based fuels, have been widely published and written into regulation.

The prospects for increased interest in an RDF-type fuel that is a blend of various waste materials will follow the same pattern as shown in the past, with one of the largest drivers being transportation costs. With cheap fuel and a large supply of landfills that are managed at the state level, project economics must be realized based on the unique situation of the selected market.

5.2 Perspectives with regard to use of plastics as fuel constituent

The use of plastics has increased every year displacing glass usage. Of course, this has increased the calorific value of the fuel at nearly every WTE and RDF plant. While this has an apparent benefit, the plants have found they are somewhat limited in that their boilers are fixed in size; therefore, higher heating values reduce the amount of MSW processed and therefore their principal revenue of gate fees. On the recycling side, plastics recycling is quite strong for beverage and food containers in the PET and HDPE resin types; however, there are virtually no strong domestic markets for the 3-7 resin types. Plastic film has had mixed interest due to the high costs to remove the contamination. Rigid plastics including engineered resins have great market value if they can be sorted by resin. Plastics' recycling continues to be studied at all levels and there are many advancements that occur each day in this field. Yet the actual amount recycled has been estimated at less than 10% of the generated plastic wastes.

For example, in the past, multi-resin type industrial plastic wastes were landfilled or shredded into a fuel product for blending. This would be in spite of knowing that each resin type if properly separated could bring a market value of , e.g. 25 cents per pound. Recognizing the obvious benefit of separating resins automatically, processors in recent years have developed various advanced sorting and separation technologies. However, the combined capital and operating costs as well as the procurement costs often exceed the market values as discrete resin. New projects have been slow to develop.

In recent years, the entry of China has greatly changed the economics of recycling plastics as well as the routing of materials that were otherwise destined for disposal in US. The Chinese market is now offering better pricing to US processors to export their non-recyclable wastes in lieu of spending capital and ongoing costs for value-adding.

Others have sought to simply size reduce the mixed material for use as a fuel at a cost of 5 -10 cents a pound which often exceeds its market value as a fuel. Finally, others have sought to simply size reduce the material and blend it with other materials to produce a manufactured product such a plastic lumber, traffic barricades, etc.

Each year the market has changed as the value of regrinds from recycling have increased. While today we are experiencing some of the highest pricing levels that can support advanced sorting and separation; the industry is still faced with the cost of producing the required quality. China has solved much of these problems. With cheap freight on the back-haul, cheap labor, limited natural resources to produce primary materials, limited refinery infrastructure and a fast growing economy fed by an enormous population, the Chinese are "mining" the US waste stream. Their only competition is the landfill; that is the same competition that all the domestic solutions face.

The advantage of lower risk and lower demand for capital has driven many processors to simply export their waste materials. Left behind is the municipal household wastes; in fact, one can view the U.S. household wastes as the residues of the U.S. and Chinese recycling efforts. This leaves the more difficult wastes that are typically discrete and separate from residential wastes such as batteries, electronics, tires, solvents, carpeting, etc.

The Pirelli-SRF process would need to target some of these discrete streams as a source of feedstock for blending with the MSW fraction to produce the SRF. Given the strong presence of industrial plastics recycling, the best supply opportunity for plastics is mixed #3-7 bales processed at new facilities. They remove the PVC component leaving the remainder as a fuel feedstock.

5.3 Perspectives with regard to use of rubber tires as fuel constituent

The Pirelli-SRF process targets rubber wastes sized to 20 mm as derived from industrial processes or tires. Regarding passenger tires, the minus 20mm (nominal -¾") would be produced by a granulator with a properly sized screen. This size however is quite unusual to find in the US other than in limited quantities, usually to order. The normal size for size reduced tires is either chips (shreds) as a nominal 2" and granulated material, from 4 mesh (3/16") on down to 40 mesh. A cost-effective system to process tires to chips, and then chips down to the 20 mm size, would include a primary shredder, a secondary granulator for down sizing the shred and a tertiary granulator for cleaning (recovering) rubber from the liberated steel. The steel would be recovered by a cross-belt magnet located above a stainless steel vibratory pan conveyor. The secondary granulator would likely be powered by two 400 hp motors corresponding to a processing rate in excess of 10 tons per hour. The tertiary granulator would be on the order of a 400 hp unit. These are very large units; most production size granulators run in the 150 to 250 hp range and process 2 to 4 tons per hour. The 2" (50mm) chip material sells in the range of $35 to $40 per ton. We would assume the cost to purchase the 20 mm chip would be somewhat more, probably $45 to $50 per ton. Tire processors receive a tipping fee (or pick-up fee) for whole tires, usually between $0.75 and $1.00 per tire depending on quantity and location. The difference between the pick-up fee and the selling price covers the cost of freight both ways and the cost of producing the product size desired free of steel.

Cement kilns are in a unique position and are leaning toward burning whole tires rather than chips. Many kilns can or have already been modified to accept whole tires. They usually source the tires for free, leaving the tipping or pick-up fee for the tire hauler. The cement kiln industry tries not to use chips because they would have to pay for them; certainly they have no interest in even finer material with the added acquisition cost.

One of the key factors for the cement kiln industry is that many alternative fuels are available to them such as paints, solvents, textiles, plastics for which they can charge a fee rather than pay for it. Paints and solvents, due to flammability and for environmental safeguarding, are regulated as Hazardous Wastes and therefore provide a significant source of revenue to the cement industry as they get paid for accepting the waste and also have a one-to-one saving on coal. For the vast majority of these types of wastes, EPA has designated thermal treatment for treating them safely, such as energy recovery in cement kilns, as the Best Demonstrated Available Technology (BDAT).

Tires compete against these fuels. Large tire recyclers who desire to add value to their product by-pass the cement kiln market and grind the 2" chip size down to 4 mesh and finer in cryogenic systems. Markets for crumb rubber used in rubberized asphalt, compression moulding, rubberized sport surfaces require a product of 4 to 10 Mesh (4mm to 2mm) or a 10 to 20 Mesh (2mm to 0.85 mm). With further screening and size reduction even higher markets for rubber/plastic extrusions, foam/rubber materials and pavement crack sealants. In this case the requirements are for either a 20 to 30 Mesh (0.85 to 60mm) size or 30 to 40 Mesh (0.60mm to 0.425 mm) size. The highest value material (and of course most demanding specification to meet) are 40 to 60 Mesh sizes for injection molding and compounding applications.

5.4 Perspectives regarding the business of manufacturing a high-calorific value fuel using a mix of MSW and other solid wastes

The Pirelli patent describes combining various waste streams to produce a high heating value fuel for economic co-firing with coal. In different forms, such processes can already be found in practice at various installations in US. The most common form is the mixture of a blended product consisting of non-recyclable paper with various other waste materials. Non-recyclable paper generally is plastic coated paper (laminates). These papers are trimmings, cuttings, misprints from converters, etc. The non-recyclable paper is shredded and blended at a specified ratio with other materials such as shredded MSW, granulated plastic film, granulated rubber wastes, sawdust, paper mill screen rejects, sludges, paper cores and/or ground pallets. The mixed fuel is co-fired with coal and/or Tire Derived Fuel in industrial as well as utility boilers. Sizing can be as large as 30 mm for stoker fired boilers and as small as 7 mm for pulverized boilers.

The Pirelli process is configured on a business model that produces a branded fuel of controlled calorific value that can be marketed on a multi-facility basis. To date, no company has successfully launched such a venture. Past attempts have not gone past the first facility and each of those facilities was tailored to a particular set of industrial boiler, waste supplies and market prices.

Several factors affect the technology decisions for US applications when considering an RDF project. Tipping (gate) fees are generally low in most markets. Landfills have a strong competitive advantage in that they are able to lower their fees quickly during a defensive effort to maintain market control. In the absence of flow control, landfill tipping fees are highly competitive today. Therefore, whenever alternative technologies attempt to compete with landfills there have been serious concerns over continued market supply. Only in those markets where landfills are already at capacity can alternative technologies compete based on price. Given that plastics and rubber scrap generally have a positive market value to the generator, a prospective RDF plant operator is more inclined to maximize the use of MSW. With a good front-end preparation plant, the expected continued increase in curbside recycling programs, and the constantly improving characteristics of the typical US waste stream, a high heating value product can readily be produced. The principal challenge will be find a user of the fuel that will cover the costs to produce it.

5.5 Perspectives of end-users of RDF

Not surprisingly, potential users of RDF as an alternative fuel will consider foremost the economic benefits. Cement kilns are paid well for accepting all sorts of waste materials that can be used as alternative fuels. Many will accept and burn tires in whole form for free so there is little benefit to deliver to them a "prepared fuel" in today's market. With the price of coal being cheap compared to Europe, they certainly will not pay more than coal.

The utility companies have mixed views on RDF and have historically been unable to set a policy and keep it in place without change. Their primary concern is to produce power and they can not accept any chance of interruption. Their conservative posture has been reflected in their general aversion toward the solid waste industry by way of their actions. The words are good but the actual follow-through is generally not present.

Other industrial boilers such as paper mills are always looking for inexpensive fuels, as are sugar refineries and some other users of industrial boilers. Generally, they burn their own waste by-products, such as bark or bagasse, and operate as co-generation plants. It is likely that such steam and power producers would welcome the opportunity of a cheap alternative fuel, however the revenue stream will not be high. Since it is obvious that an RDF plant cannot maintain a positive cash flow simply based on a tipping fee structure, its success will depend on the resulting fuel being sold at a reasonable price.

The tipping fee structure must be set sufficiently low to compete with nearby landfills while the price of the fuel being sold must be sufficiently low to compete with other alternative fuels as well as traditional fuels. The variable within this tends to be the cost of freight. Freight is driven by location and therefore it is clear that the potential of future RDF projects that sell fuel to the open market will depend largely on the transportation cost element. Many of the past RDF projects have recognized this importance and have studied rail transport as well as densification into pellets or cubes. Densification has also been important for use on stoker-type boilers. However, its cost tends to be prohibitive in many cases (on the order of $15 to 20/ton).

5.6 Other potential incentives for use of MSW/SRF by power plants, etc.

Although the U.S. has not signed as yet the Kyoto protocol, there is legislative action in the federal government and various states, e.g. New York, to provide incentives for the use of MSW and RDF by including them in the category of renewable energy sources.

The most immediate incentive will be a $0.018 tax credit per kWh of electricity generated by using MSW to generate electricity. This benefit will amount to about $10/ton of MSW or an estimated $20/ton of SRF.

Also, when trading of carbon emission rights starts in the U.S., as it has been implemented for sulfur emission rights, there will be an additional economic benefit for the use of MSW and SRF.

5.7 Perspectives regarding the ownership of WTE facilities in the U.S.

Most U.S. WTE facilities are operated by four major companies: Covanta Energy, American Ref-fuel, Wheelabratorm and Montenay. Some of these facilities are owned by the operating companies, e.g. the SEMASS one-million-ton plant at Rochester, Mass. Many were financed and are owned by the municipality where they are operating. By and large, municipalities that committed to long-term use of WTE, either as owners or as providers of MSW, have benefited financially from the WTE ownership because the cost of landfilling has increased substantially with time. For example, the communities that committed their MSW to the SEMASS plant for a period of twenty years are paying an inflation-adjusted tipping fee of only $45 while ”outside” communities pay the “merchant” tipping fee of $75/ton.

6. Conclusions

The physical form of the Pirelli SRF is specially designed to allow suspension co-firing of this fuel with coal in the combustion chamber of a power plant or a suspension-fired cement kiln. This has been demonstrated by the Buzzi kiln operation in Cuneo. Also, ENEL’s decision to proceed with full implementation of co-firing their power plant with an RDF fuel that is judged to be inferior in combustion characteristics to to the PA SRF fuel indicates the strong potential for SRF for coal-fired power plants.

Following the EEC visit to Italy, more detailed examination of the SRF process and of the SRF fuel confirmed that they are both technically feasible. There is no technical risk in designing and building a facility that will produce SRF fuel of the specified size, moisture and calorific value. In fact, Mr. Nathiel Egosi, the EEC Researh Associate who participated in this study, has designed and built facilities that are very similar to the SRF concept.

From the economic point of view, the U.S. offers several advantages for the application of SRF, such as large per capita generation of MSW, and ample supply of plastics and rubber residues. However, landfill tipping fees are low relatively to E.U. and coal supply is plentiful and relatively inexpensive; therefore, the economic advantages of disposing MSW and conserving fuel will not be as great as in Europe.. Also, in the recent past, there has been considerable opposition to new coal-fired power plants and WTE facilities. Although the SRF fuel offers definite advantages over both raw MSW and coal, there is bound to be some environmental opposition.

Nevertheless, the U.S. presents an enormous market for gradual adoption of the SRF fuel as a substitute for part of the coal used presently. The Phase 2 study may identify opportunities where there is a confluence of favorable conditions: A municipality that is interested in providing a sorted fraction of its MSW to an SRF plant instead of landfilling it; availability of not-too-distant sources of the plastics and rubber residues; and nearby users (power plants, cement kilns) of the SRF fuel. There maybe more than one SRF plants proceeding in parallel but it is most likely that additional plants would have to await the satisfactory performance of the first U.S. prototype.

The strength of the Pirelli Ambiente technology and patents in the U.S. will be a) the accumulated know-how of Pirelli Ambiente and their operation of reference facilities such as the I.D.E.A. Granda operation, b) the PA know-how for implementing a business model that will be driven principally by economics rather than technology, c) the fact that implementation of SRF requires lower capital investment than transitional WTE facilities and that PA may provide seed funding of SRF facilities in the U.S. .

At the present time, there is no company in the US that markets an RDF or RDF-like product for use as a supplemental alternative fuel. However, an RDF industry already exists with many businesses operating in a fragmented form. With proper marketing, great interest can be generated for an inexpensive waste fuel that includes MSW. Further study is needed to determine and evaluate the "why" and "how" the Pirelli Ambiente SRF fuel can have an economic market advantage over RDF processes that have been tried or are in use, by taking into full consideration the projected trends and shifts of solid waste disposal in the US.

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