Research work conducted by
Duccio Bianchi
Istituto Ambiente Italia

Foreword by Stefania Prestigiacomo
Minister of the environment
and of territorial and marine safeguard

AMBIENTE ITALIA WORK GROUP
Elio Altese, Duccio Bianchi, Silvia Castello

The **EXECUTIVE SUMMARY** is taken from

Eco-efficient recycling
Economic, environmental and energetic performance and perspective

Published by Edizioni Ambiente, Milano
Translation by Carlo Pesso

Eco-efficient recycling

Economic, environmental and energetic performance and perspective

EXECUTIVE SUMMARY

EDIZIONI AMBIENTE SRL
Via Natale Battaglia, 10, 20127 Milano
www.reteambiente.it

AMBIENTE ITALIA SRL, Istituto di ricerche
Via Carlo Poerio, 39, 20129 Milano
www.ambienteitalia.it

In collaboration with
ECOMONDO - RIMINI FIERA

CIAL - CONSORZIO IMBALLAGGI ALLUMINIO

COBAT - CONSORZIO OBBLIGATORIO BATTERIE ESAUSTE

COMIECO - CONSORZIO NAZIONALE RECUPERO E RICICLO DEGLI IMBALLAGGI A BASE CELLULOSICA

COOU - CONSORZIO OBBLIGATORIO DEGLI OLII USATI

CONSORZIO NAZIONALE PER IL RICICLO ED IL RECUPERO DEGLI IMBALLAGGI IN ACCIAIO

COREPLA - CONSORZIO NAZIONALE PER LA RACCOLTA, IL RICICLAGGIO E IL RECUPERO DEI RIFIUTI DI IMBALLAGGI IN PLASTICA

FISE UNIRE - UNIONE NAZIONALE IMPRESE RECUPERO

FEDERAMBIENTE - FEDERAZIONE ITALIANA SERVIZI PUBBLICI IGIENE AMBIENTALE

MP AMBIENTE S.P.A.

FOREWORD

by **Stefania Prestigiacomo**
Minister of the environment and of territorial and marine safeguard

In order to tackle the environmental challenge that stands before us, we need to link the safeguard of our rich natural and cultural legacy to the requirements of economic development. In this sense, the study presented here offers some encouraging results. It shows how recovery and recycling policies adopted by this country to ensure environment safeguard and protection have been able to transform potential binds into extraordinary industrial opportunities. Furthermore, analysis highlighted numbers that clearly demonstrate that Italy has responded to the EU community legislator by implementing policies that have determined the expansion of the recycling sector both in terms of economic value and in terms of employment.
The investigation has shed some light on interesting facts about the value embedded in the so called "secondary raw materials" by looking at CO_2 emission reduction and energy savings. In fact Energy and material recovery have emerged clearly on the master path to sustainable development, a path on which our country is set for several reasons. These include the scarcity of available raw materials but also the need to achieve appreciable energy savings, even more so since it will become necessary to reconsider national targets within the Kyoto Protocol.
Data brought forward by this study underlines how recycling substantially contributes reaching for the system's overall eco-efficiency and brings forward significant proof of the available occasions to link environment and economic development to attain sustainable development.
We now are at a turning point. The environment is an extraordinary resource for our country, and also an extraordinary opportunity for economic growth. The government's engagement on this course will be maximal.

INTRODUCTION

by **Carlo Montalbetti**
Coordinator of the Work Group on Recovery and Recycling of the Kyoto Club

Research work conducted by Duccio Bianchi and the Ambiente Italia Research Institute, presents a detailed analysis of Italian recycling economics within the global market that builds on previous work published in 2006 and already supported by the Kyoto Club's Work Group on Recovery and Recycling.
Altogether, CiAl, CNA, COBAT, Comieco, Corepla, COOU, Federambiente, FISE UNIRE and MP Ambiente, the sponsors of this effort, represent the family of industrial activities described as "recycling". These encompass activities such as the collection and the mechanical or chemical treatment of wastes and scraps, either differentiated or not differentiated, for recovery so that secondary raw materials may be reused as feed stock in industrial processes. This study shows how these activities make up a very dynamic component of the economic cycle and – in particular – how these have become an essential source of supplies for a consistent part of the industrial system.
The opening lines of the first "eco-efficient recycling" report stated: "Recycling is not merely an element of the waste management chain. Rather, it is a component on the national economic and industrial system." Recently, this same concept was captured by the Report produced by the Environment Committee of the Chamber of Deputies, as it concluded investigations on the recycling industry it had initiated in 2006 through a series of auditions that have involved local authorities, industrial organisations, and specific waste-stream recycling consortia. The report underlines the numerous positive aspects offered by the industrial sector, to the point of considering that the model may be successfully exported in many countries, from China to India and North Africa.
The recovery-recycling economy, which has grown by a fifty percent since the year 2000, contributes very substantially to the overall eco-efficiency of the system. On one side, it achieves significant resource use reduction and energy savings. On the other, it enables very significant emission reductions during production and during final disposal.
However, when public policies are defined and whenever economic mechanisms aimed at the environmental conversion of the economy are established, the role taken by this economic sector remains largely underestimated. That said, material recovery and recycling policies incorporate all the key words contemplated by such a conversion: energy savings, renewable resource use, and greenhouse gas emission reduction.
Through this report, it is our wish and intent to stimulate the ability of all stakeholders to support an industrial sector that brings benefits to the environment while bringing economic development to the country.

EXECUTIVE SUMMARY

1 RECYCLING ECONOMICS: ITALY WITHIN THE GLOBAL MARKET PLACE

Waste management and waste recycling have long been pictured as activities generating negligible added value and innovation. Indeed, they were perceived as being minor or residual businesses operating on the margins of mainstream economic activity, more often standing on the thin line between legal and illegal practice.
Today this picture is outdated. Without doubt, in country such as Italy, and more particularly in those parts of the country where organised crime is rooted within the social and economic texture, efficiency and unlawful practices still matter and remain a major issue.
However – in Europe and in Italy – the overall picture has dramatically changed. The recycling industry, together with all its various components, has become a fully-fledged economic sector, characterized by high innovation content, particularly if waste reprocessing and product innovation are considered.
Waste management, the major component of both the recycling industry and recycling economics, has become a distinct and clearly recognizable service, product and energy generating industry.
Moreover, there are ample margins for further development, particularly in those areas where integration between enterprises and technological research is scarce. However waste management and waste recycling industries already are forerunners and, in some instances, leading edge thus setting the pace towards sustainability.

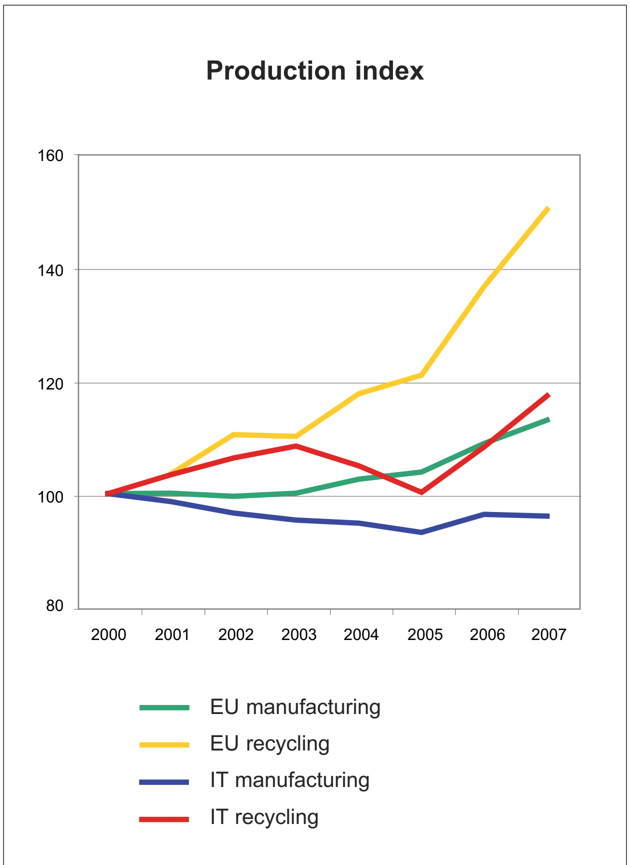


FIGURE 1 - SOURCE: PROCESSED BY AMBIENTE ITALIA BASED ON EUROSTAT 2008, INDUSTRIAL PRODUCTION INDEX.

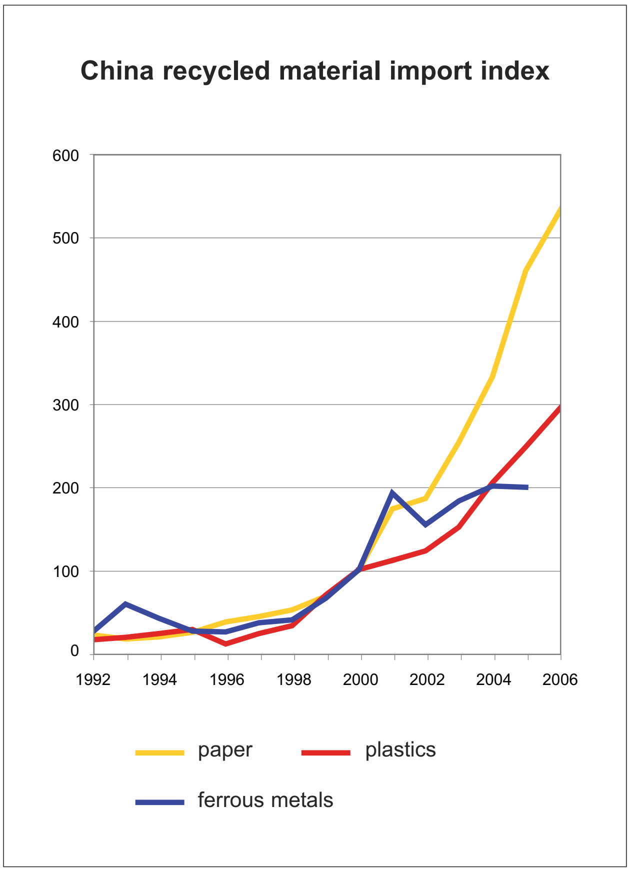


FIGURE 2 - SOURCE: UNITED NATIONS COMTRADE DATABASE, 2008.

Today the combination of urban and industrial waste collection activities and industrial activities classified as *recycling* (which includes the mechanical and chemical treatment of wastes, scraps and by-products not used as secondary raw material feedstock in other production processes) provides raw materials to a very significant part of the industrial system.
The dynamism of the recycling industry confirms the newly acquired economic relevance of the sector. In fact, in Italy – and even more significantly in Europe, the sector has experienced greater growth rates than the overall industrial system. For instance, between the year 2000 and 2007, while the Italian manufacturing index contracted by 4%, the recycling activity index grew by 17.2%. Over the same period, the same European indexes (27 countries) grew by 13% for industry and by an impressive 50% for recycling. In 2005 the value of recycling production in Italy reached 4.2 billion euro (as defined by NACE classification), up 13% over the previous year, double that of 2000, and three times the value measured 10 years before (current value).
All the other economic indicators tell the same story: they show a powerful surge of the sector over the previous year and over the medium term. Between the year 2000 and 2005 the number of enterprises increased by 13% and employment grew by 47% (13.000 in 2005, without considering personnel employed for waste collection purposes or for the production of products based on recycled materials).
The structure of the recycling industry is more evolved than its current image would suggest. In Italy, and in Europe, it outperforms most of the manufacturing industry both in terms of investment per employee and in terms of value-added per employee. Within the recycling industry, the metals component is dominant. Metal recycling was worth 1,968 million euro in 2005, roughly 47% in value of the entire sector, and prevails in number of enterprises (standing at 55% of recycling businesses) although it does not in terms of employment (39%). Meanwhile the other compartments of the recycling industry have experienced greater growth rates by moving, over the past 10 years, from 485 millions euros worth to 2,215 million euros (i.e. from 45% to 53% of the sector's value), and by multiplying by three the number of overall employed workers, which stands today at 7.800 employed. Today the availability of recovered raw materials is crucial to a variety of industrial sectors, even more so at a global scale. The growth of the global economy, and the coming of the Asian tigers, requires huge quantities of raw (and recovered) materials. Hence a comeback of traditional commodities, most needed to nourish growth, the building of infrastructures, and the diffusion of social wealth.

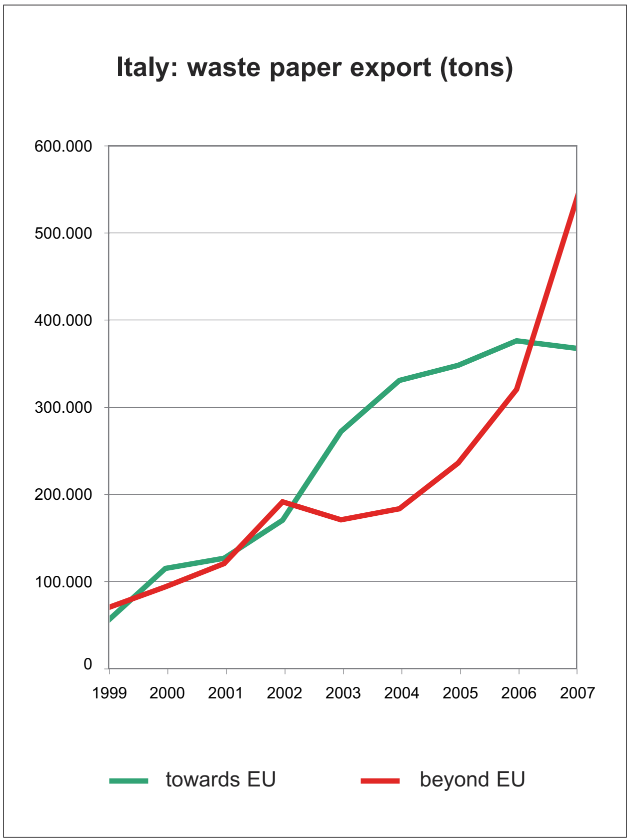


FIGURE 3 - SOURCE: ITALIAN FOREIGN TRADE INSTITUTE, NATIONAL INFORMATION SYSTEM FOR FOREIGN TRADE, 2008.

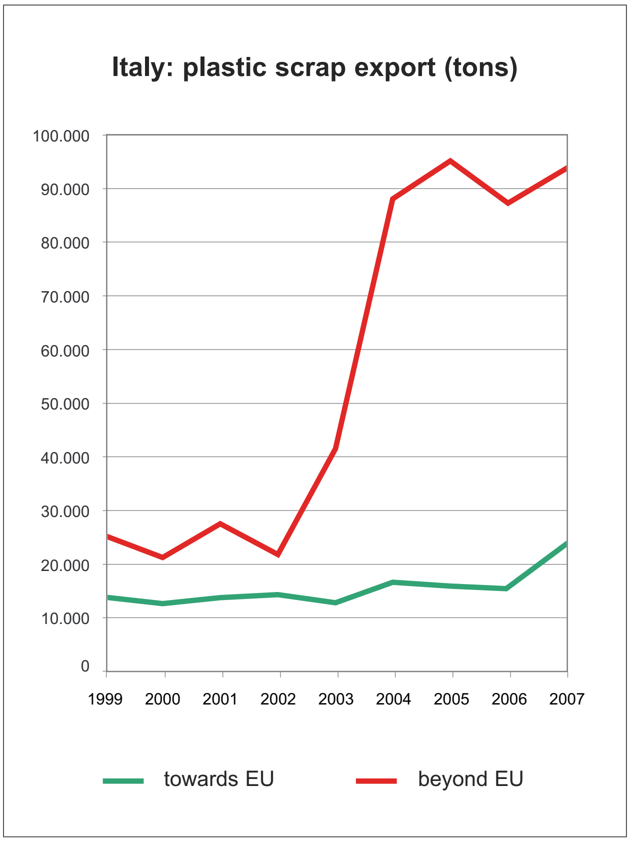


FIGURE 4 - SOURCE: ITALIAN FOREIGN TRADE INSTITUTE, NATIONAL INFORMATION SYSTEM FOR FOREIGN TRADE, 2008.

The shear dimension of globalisation – and that of recycling – can best be captured by looking at numbers describing the surge of Chinese demand. In the period going from 1997 to 2007, Chinese imports of paper for recycling have grown from 1.6 million metric tons to 22.5 million tons; that of plastic wastes have swelled from 0.5 to 6.9 million tons. Similarly metal scrap for recovery has moved from 1.8 to 10.1 million tons in 2005 (and falling back to 3. 4 million tons in 2007 for political reasons); aluminium scrap moved from 300.000 tons to over 2 million tons.
Growth in commodity imports (which has boosted the value of materials for recovery) has also concerned, although to a lesser but significant extent, emerging economies.
This state of affairs has radically modified the scenario experienced by Italian industry sectors exporting scrap materials and wastes. Although Italy essentially remains a secondary material importer, materials for recycling exports have grown very significantly in some sectors.
Between 1999 and 2007 (based on estimates of the first three quarters), exports in the pulp and paper sector were multiplied by eight, moving from 120,000 to 910,000 tons/year (with a steep growth over the last two years). Over the same period of time, plastic material exports tripled from 39,000 to 117,000 tons. Exports have doubled over the period 2002-2006 even for materials such as aluminium, which set the commercial balance in the red by 30,000 tons (while imports increased by 17% to attain 50,000 tons).
This expansion was marked by a sharp change in trade geography. A predominant European share was displaced by non-European countries (particularly Asian). While infra European pulp and paper related trade dropped from 64% to 40% in the period 2004-2007, China has practically caught up with Germany (the traditional Italian scrap paper importer) by absorbing 225,000 tons of paper destined to recycling up from 43,000 tons.
Similarly, today 80% of scrap plastics are exported from Europe (up from 60% in 2002) with China absorbing two thirds of the amount (that stood at 22% in 2002).
The quest for sustainability, together with resource scarcity and increasing material costs, through an environmentally sound growth has become the engine of the maximisation of material recycling. For this reason the globalisation of recycling is rooted in a structural change, hence it is set on the long term. Asian countries (and other countries) experience a strong demand of raw materials which largely surpass the rate of waste generation and end of life of products. Furthermore, social and environmental infrastructures that allow for optimisation are scarcest exactly where the demand for materials is greatest. Such increasing demand can only be catered for by stabilizing or reducing the extraction of raw materials (and its energy intensive needs), and through the further development of the recycling capacity of western economies, and through the development of integrated waste management schemes in emerging economies.

2 COLLECTION AND RECYCLING IN ITALY

Several Italian industrial sectors are highly dependent on the availability of secondary raw materials. The iron and steel industry, the aluminium industry, and the metal industries at large are highly dependent. So are, albeit to a lesser extent, the pulp and paper sector, the glass industry, the wood and furniture sector, the wool textile industry and the plastics sector. Over 50% of the feedstock destined to the iron and steel, aluminium, lead, and pulp and paper industries is made of materials either recovered from production scrap or from waste collection and selection. All sectors, with the exception of the wool textile sector, that is undergoing radical restructuring, are increasingly relying on recovered material inputs.
Over the last ten years, recycling in Italy has been shaped both by the advent of new public policies aiming at waste recovery and by the evolution of industrial processes. New actors concerned by the recycling of paper and cardboard, plastics, wood, dismissed oils and batteries have emerged and consolidated. They now stand firmly, next to traditional metal scrap recycling operators who, in terms of economic value, still represent the greatest part of the industry. That said, an exhaustive and reliable picture of the recycling sector is hampered by the lack of homogeneous data, by variations in registered quantities – largely caused by changes in legislation, and by considerable uncertainty about material fluxes.
However, on the whole, collection and recycling operations on the domestic market underwent generalised and constant growth. The collection of both pre-consumption and post-consumption secondary materials, as part of urban collection schemes or industrial waste collection schemes, has swelled.
Commodities for which the recycling industry has only developed recently (such as plastics and wood) have experienced impressive growth rates. In fact, all types of materials have been marked by sharp growth, including those that are subject to mandatory recycling (such as lead batteries and engine oils). It is important to note that both urban and industrial waste collection have contributed to such developments.

SUMMARY TABLE FOR MATERIAL RECOVERY AND RECYCLING IN ITALY, 1997-2006					
			DOMESTIC RECOVERY	DOMESTIC RECYCLING	IMP-EXP BALANCE
MATERIAL	SOURCE	YEAR	1,000 t	1,000 t	1,000 t
PAPER	ASSOCARTA	1997 2006	3.508 6.000	4.381 5.578	-873 422,4
WOOD	RILEGNO ET AL.	2001 2006	1.484 ND	2.450 3.300	-966 ND
PLASTICS	UNIONPLAST	1998 2006	576 958	839 1.343	-260 -385
FERROUS METALS	FEDERACCIAI	1998 2006	10.100 15.454	17.160 24.298	-4.950 -5.802
ALUMINIUM	CIAL, ASSOMET	1997 2006	232 487	552 885	-320 -398
GLASS	COREVE	1997 2006	1.000 1.597	1.080 1.843	-80 -246
BATTERIES PB (1)	COBAT	1997 2006	165 198	165 195	ND
USED OILS PB (2)	COOU	1998 2006	177 216	163 173	ND
TIRES	ETRMA (3)	2006	370	190	35
DEMOLITION		2006	4.265	4.465	ND

(1) Collection concerns lead batteries (COBAT and others)
(2) Collection includes oils for energy recovery: recycling only covers regeneration.
(3) Recycling includes regeneration and reuse.

TABLE 1 - SOURCE: PROCESSED BY AMBIENTE ITALIA.

In Italy, over the last ten years, recovered material volumes and recycling rates (i.e. the percentage of recycled material being used) have augmented for all major commodity materials. However, such trends are far from being steady. For some materials, growth in recycling capacity has lagged behind the increase in volume of materials collected at domestic level, hence imports have slowed down and capacity has scarcely been affected.
Instead, for other materials, only increasing imports have satisfied the development of domestic recycling capacity. National recycling capacity presents an extremely irregular structure that varies according to the industrial sector. The use of scrap, and the production of recovered raw materials, is strongly entrenched and growing in the metal industry. So much so that Italian production of recovered steel, aluminium, copper and lead, still requires significant imports.
In the pulp and paper sector, the growth of domestic recycling capacity has largely been overcome by the increase

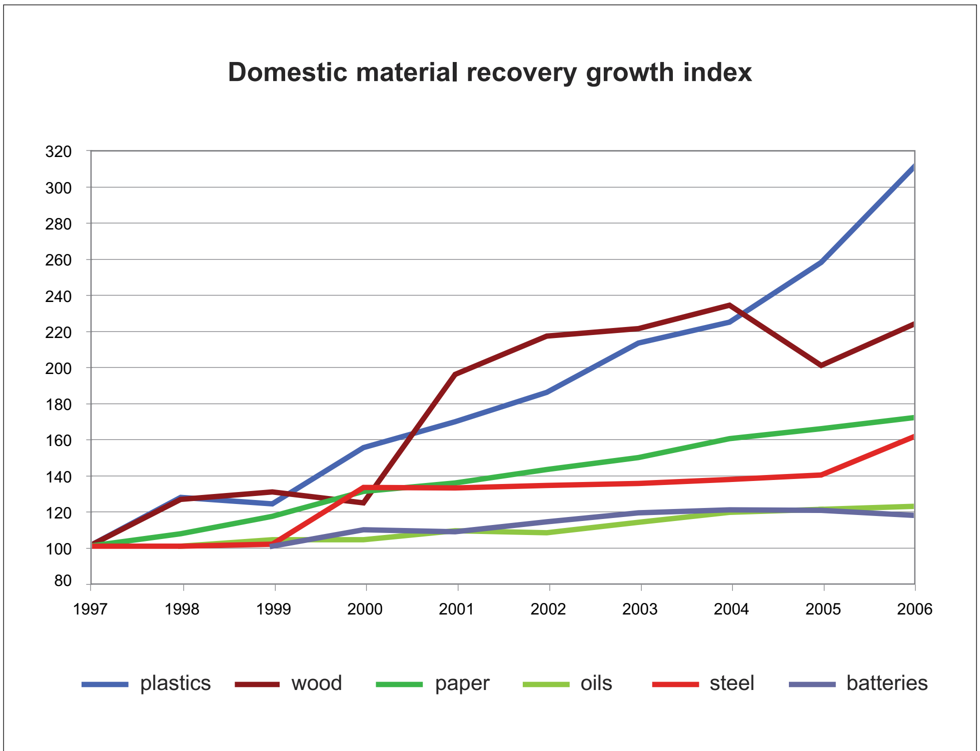


FIGURE 5
SOURCE: PROCESSED
BY AMBIENTE ITALIA.

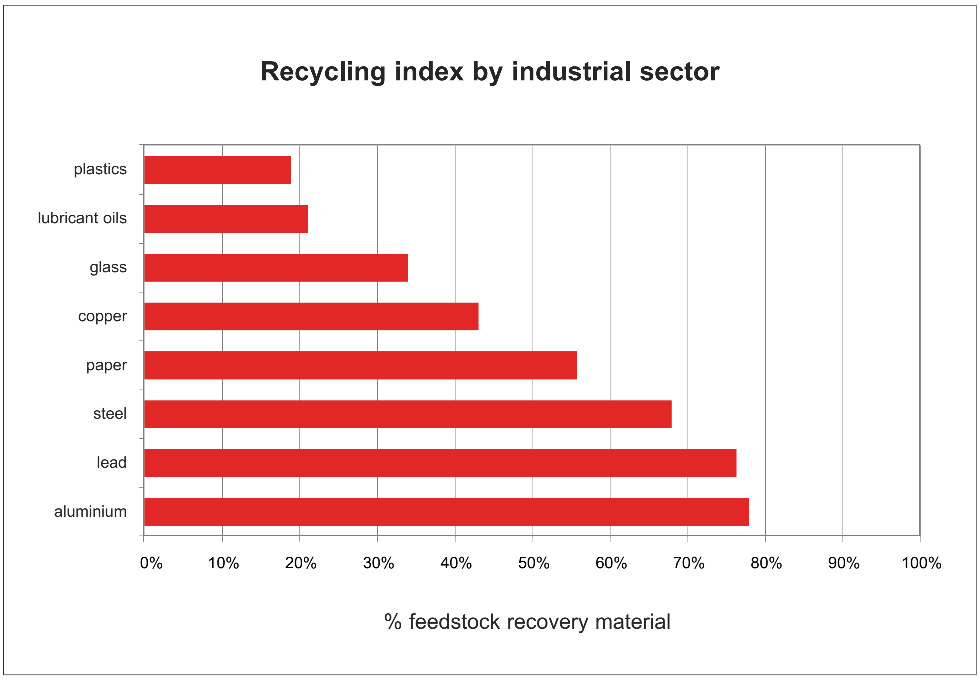


FIGURE 6
SOURCE: PROCESSED BY AMBIENTE ITALIA.

of material collected on the national market (+71% over the last 10 years). In fact after being for years a major scrap paper importer, Italy has become a net exporter.
The recycled textile sector – which lacks reliable statistics – has, according to most operators, experienced a severe reduction of recovered quantities (as testified by the dramatic contraction in volumes treated by the traditional production sectors). The plastics sector has experienced a very relevant increment of collected materials (+73% between 1998 and 2006), of recycling capacity (+61%) and of absolute value of imports (+35%).
The picture differs for the glass-recycling sector, essentially because of market specific policies. In this sector the growth of domestic recycling (+64%) has outstripped the increase in internal collection rate (+57%) and complemented the growth of imported quantities (+126%).
After 2005, the surge of commodity prices boosted the national recycling industry, which (particularly in some sectors, such as packaging), took full advantage from a favourable secondary material pricing policy.
However, on the medium long-term, these favourable conditions may well fade away.

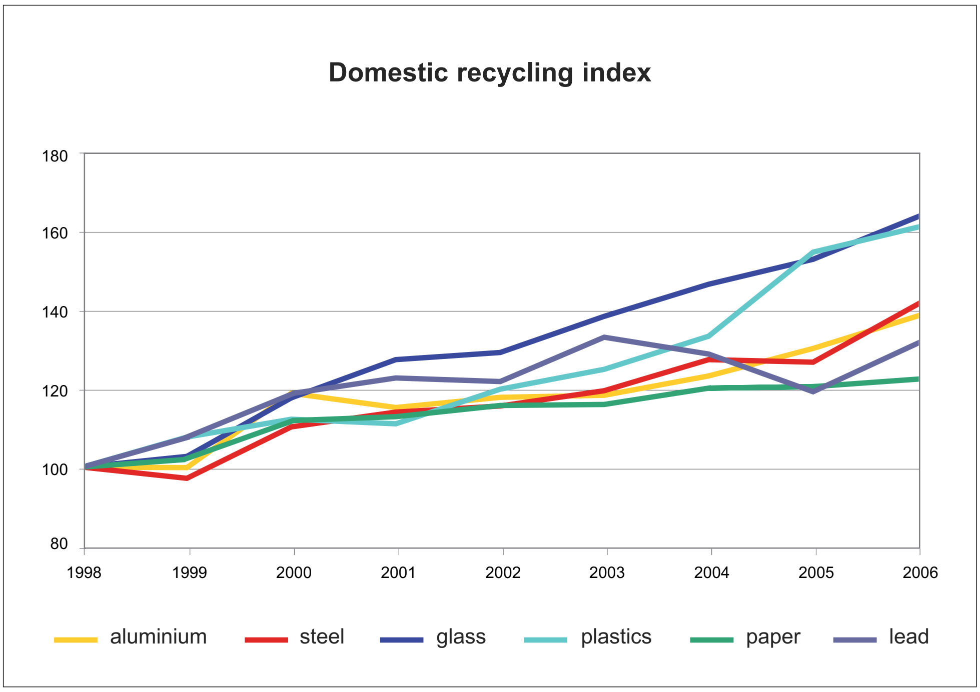


FIGURE 7
SOURCE: PROCESSED BY AMBIENTE ITALIA.

In the absence of specific protective mechanisms, a strong demand of secondary materials on international markets may well translate itself in supply difficulties on the domestic market (from this standpoint, the architecture of the Italian system of consortia has acted as a factor of stabilisation).
Meanwhile, Italian manufacturing industry is undergoing considerable restructuring. This entails that the production of low added value goods is being progressively cut back, thus possibly determining a contraction (or stagnation) of domestic recycling capacity.
As already pointed out in the previous report, such a scenario could determine an asymmetry between trends in material collections and recycled material production trends. In such a case, Italy, which up until now traditionally imported materials for recovery, could become a net-exporting country (as has already happened for other European countries). However, a trend of this kind – possibly originating from a standard evolution of the industrial economy – can impact the efficiency of the entire waste management system, including the urban and the industrial waste collection systems.
If such a perspective holds, it becomes necessary to identify appropriate strategies to:
- capture the Italian industry's residual recycling potential (certain areas still offer opportunities for considerable growth of recycling rates), through actions apt to support the *market for recycled materials and goods* and *green procurement*;
- favour *the export of collected materials* that are scarcely used on the domestic market, towards countries that, on the whole, can better capture the associated environmental benefits of recycling, by reinforcing logistic capacities and trading operations;
- identify *new or alternative markets*, such as the production of fuels from waste to recoup energy from residues whose value cannot otherwise be captured on a biogenic basis.

3 THE ENVIRONMENTAL EFFECTS OF RECYCLING

It is commonplace, today, to consider waste collection and recycling as an important environmental action. However, the significance of recycling is principally linked to waste management issues.
In fact, it is needless to point out, waste collection and treatment – particularly of wastes containing dangerous substances – stand as *the* core priority of each and every national waste management scheme.
Nevertheless the effects of waste collection and recycling are not limited to waste management; furthermore, waste collection and recycling started off before (and independently) from environmental legislation. By collecting and recovering waste materials, the recycling sector strongly contributes to overall eco-efficiency, meaningfully reducing energy consumption and the use of non-renewable resources, thus significantly curbing emissions both in the production and treatment phases.
According to available aggregate data, in 2005 over 52 million tons of production and consumption wastes were recovered (APAT, 2008). It must be noted that data describing volumes of collected special wastes (i.e. all wastes except urban wastes) are probably imperfect, since they do not account for recycling fluxes within industrial plants and for some types of production scraps (hence the differences in data released from different industrial sources).
In the course of 2006 recycling has enabled to recover over 8 million metric tons of materials (including organic matter). A varying proportion of these material flows were used as feedstock for industrial processes; on the whole – and prudentially – it is estimated that the share stands at 75-80% of the flows, on average.
Today, material recovery from urban wastes (generating over 50% recouped material) is still driven by packaging waste collection, although organic waste collection is playing an increasing role (reaching 30% of volumes collected for recovery).
According to data collected in 2005 (APAT, 2008), recycling operations concerned 44,5 million tons of industrial wastes (1.2 million tons of which were dangerous and toxic wastes). Most recovered materials are non-organic (31 million tons, the greatest part of which stems from demolition building materials), followed by metals and metal composites (8.8 million tons).
The share of recycled organic matter (nearly 5 million tons), together with the environmentally doubtful recovery through scattering over croplands (3.8 million of essentially sewage sludge and agricultural and animal wastes), is also very relevant. Although solvent recovery and regeneration (230,000 tons), acid and motor oil regeneration (respectively approximately 70,000 tons and 70,000 tons) represent a negligible share in terms of volume, they are important for environmental purposes.
Energy recovery through combustion in industrial plants concerns 2.9 million tons of special wastes that comprise scraps and wastes produced by: the wood, cardboard and paper sector (1.3 million tons), the agro-food busi-

ness (500,000 tons), the biogas production sector (490,000 tons), and also refuse derived fuels and the dry urban waste component (194.000 tons), dismissed rubber tyres (107,000 tons), motor oils and sludge. These wastes have been used as feedstock for power plants (1.05 million tons), in heat production plants used by the wood, cardboard and paper sectors (768.000 tons) and cement factories (300,000 tons).
The incineration of special wastes concerns 1.1 million tons, 520,000 tons of which are dangerous wastes (stemming from the petrochemical industry).
Dismissed rubber tyres, motor oils and refuse derived fuels also offer a further significant contribution to combustion (107.000 tons).
They constitute a fundamental and growing share of wastes that are being diverted from landfills in order to be more effectively returned to the industrial production cycle. Then again, the diversion from a landfill is only the most blatant and self-evident environmental benefit captured through waste recycling.
By dislodging the use of virgin materials, by means of the industrial reuse of materials, recycling operations offer a number of – mostly hidden – further environmental benefits:
- lessened extraction of non-renewable resources (both through direct resource substitution and indirect substitution of ancillary substances);
- decreased extraction of renewable resources that imply biodiversity reduction (although, at a European scale, the increased use of forestry products is balanced by an expansion of forested areas);
- diminished energy consumption, particularly for fossil fuels (with varying impact according to the types of fuel and their geographical origin), which characterises the production of all types of recovered materials);
- reduced emissions to the atmosphere directly or indirectly linked to the substituted production cycles (that needs to be balanced with relevant emissions generated by secondary material cycles);
- avoided consumption of water and reduced effluent emissions directly and indirectly linked to conventional production cycles (which, again, need to be balanced with relevant uses and emissions generated by recovered material cycles).

AVOIDED ENVIRONMENTAL DAMAGE

The principal purpose of waste recovery and recycling is to protect the environment and public health. Consumption and production wastes can cause considerable damage to eco-systems and human health unless they are appropriately treated and disposed of. This is true for both urban wastes and special wastes (dangerous and toxic wastes). Urban waste collection and treatment are also moved by health and environment concerns. Such concerns are at the core of modern waste management systems and guide the activities of waste management and recovery operators, and stands as the major objective of both mandatory and voluntary recycling consortia. Recovery activities are responsible for a very significant benefit: avoided environmental damage.
When certain products are dismissed, they become potentially dangerous and toxic. For instance, not only do dismissed lubricant mineral oils contain hydrocarbons, but they also carry a number of combustion residues and metals. If released in the environment they may be highly polluting: they accumulate on farmland, are absorbed by plants and so end up in the human food chain; in sewage treatment, they clog biological purification plants and destroy useful micro-organisms; over surface waters they generate a film that acts as a barrier to atmospheric oxygen that can no longer be used by plants and animals. Hence, not only does the recovery and regeneration of used motor oils allow for noticeable energy and resource savings, but it prevents that very dangerous forms of disposal take place.
Lead batteries offer a further emblematic case: the lead and the electrolytic acid contained in the batteries are extremely toxic when released in the environment. Lead, for instance, is a highly bio-accumulative carcinogenic substance. The risks associated to its accidental (or intentional) release in the environment vary according to its bio-availability, which increases either in proportion to the size of the particles, or because of its chemical shape when it is released, or according to the level of ambient acidity, or owing to the presence of an organic substance in the solution. It is very likely that such undesirable conditions are attained for releases over land and water surfaces. Apart from generating considerable damage to plant and animal life, it may enter the human food chain causing relevant toxic effects. A simulation developed by COBAT shows that, in case of an accidental release over farmland, the toxic risk factor for human health is multiplied by 3600 as compared to recycling. While bringing noticeable energy benefits related to recovered lead, the recovery of lead batteries is principally motivated by environmental protection.
A similar reasoning applies to the recovery of electric and electronic products, ranging from fridges to computers. Recycling of these products avoids the release of cooling liquids that may damage the ozone layer (and climate), and highly toxic heavy metals.
As a matter of fact, packaging waste recycling also associates the benefits deriving from energy savings and emission reduction with those deriving from an appropriate management and treatment of wastes. Although the products by themselves pose no threat to the environment, when inappropriately dismissed they may cause considerable aesthetic damage, and even cause some pollution. This is case for the uncontrolled combustion of paper, plastics or electric wiring, and for cardboard and wood burned in the otherwise innocuous household fireplaces: the quantity of released pollutants exceeds that produced by recycling and thermal recovery by several orders of magnitude.

3.1 ENERGY SAVING AND CLIMATE CHANGE BENEFITS

A particular attention should be given to the benefits deriving from the reduction of both energy consumption and the production of climate change emissions.
Currently, this aspect is largely underestimated, particularly in a policy-making context. For instance, it is missing when establishing economic instruments reaching for an environmentally sound economy, based on energy saving, renewable energy use, and climate change gas emission reduction. Yet, on these very subjects, material recycling and recovery play even quantitatively, a very significant role. All the more, this role is bound to strengthen itself for three structural reasons:
- recycling provides a source of substitute secondary materials replacing raw materials on an international market place characterised by swelling demand;
- industrial production that is based on recovered materials determines a strong reduction of primary energy consumption, all the more important for carbon intensive developing economies;
- waste recovery provides a renewable energy source and, wherever it contains synthetic products, an alternative and substitute of more polluting fuels.

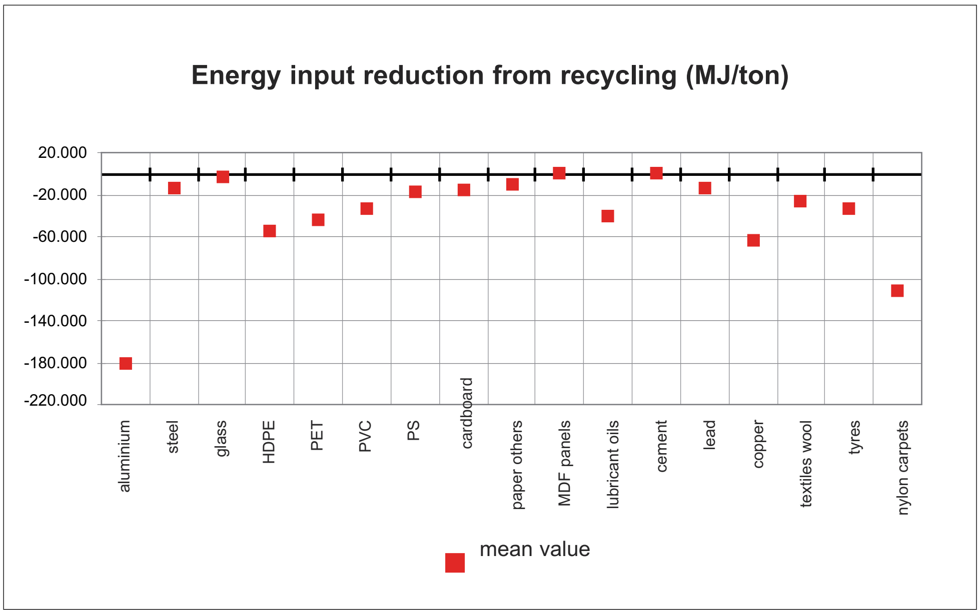


FIGURE 8
ENERGY INPUT REDUCTION PER UNIT OF END PRODUCT (MJ/T).
PROCESSED BY AMBIENTE ITALIA FROM VARIOUS SOURCES.

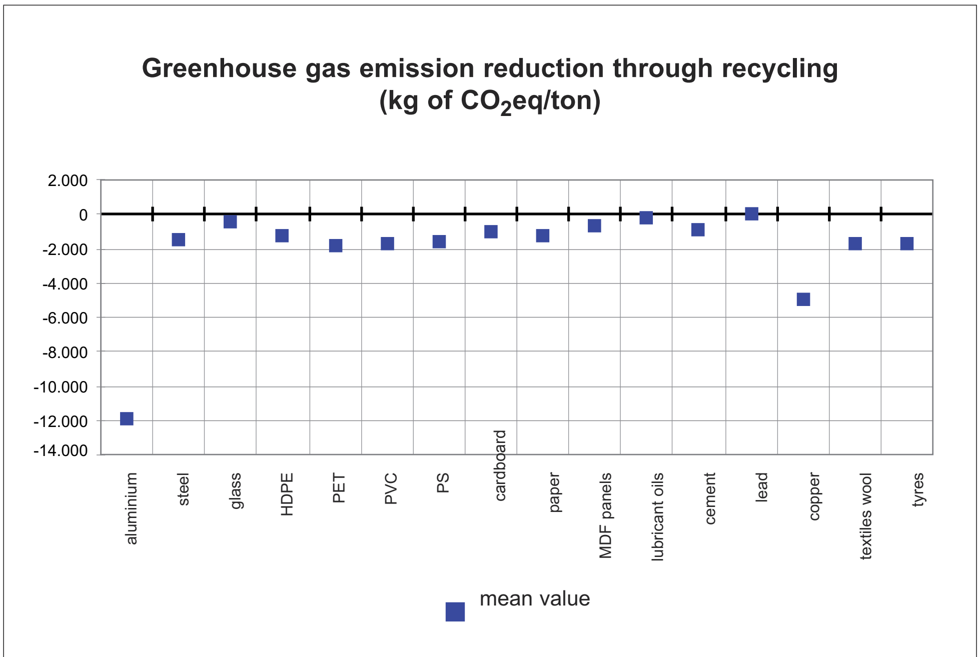


FIGURE 9
GREENHOUSE GAS EMISSION REDUCTION PER UNIT OF END PRODUCT (KG OF CO_2EQ/T).
PROCESSED BY AMBIENTE ITALIA FROM VARIOUS SOURCES.

ANALYSIS OF STUDIES ON MATERIAL END-OF-LIFE (WRAP, 2006)						
	RECYCLING VS INCINERATION			RECYCLING VS LANDFILL DISPOSAL		
MATERIAL	RECYCLING PREFERRED	INCINERATION PREFERRED	NO PREFERENCE	RECYCLING PREFERRED	INCINERATION PREFERRED	NO PREFERENCE
PAPER	22	6	9	12	0	1
GLASS	8	0	1	14	2	0
PLASTICS	32	8	2	15	0	0
ALLUMINIUM	10	1	0	7	0	0
STEEL	8	1	0	11	0	0
CEMENT				6	0	0
TOTAL	80	16	12	65	2	1

TABLE 2 - SOURCE: WASTE RESOURCE ACTION PROGRAM, ENVIRONMENTAL BENEFITS OF RECYCLING, 2006.

The present study, based as it is on diverse data sources, points at the relevance of the recycling economy to capture energy saving and emission reduction targets.
The extent to which these benefits may contribute energy saving and emission reduction is swiftly captured by the following two diagrams which illustrate them on a material basis and according to different sources of investigation.
It is important for the reader to bear in mind that available data generally reflects both differing and non-homogenous assumptions, material life cycles, production technologies, and energy production systems.
This is why it is understandable and reasonable to be confronted with differing quantitative data, since these are acquired from studies that are grounded in a variety of national contexts, rather than referring to a global scenario, or limited by scope, by referring to specific applications rather than raw materials by themselves.
Nevertheless – and here lies the point we are making – not only do all the studies agree on the benefits deriving from material recycling and recovery as compared to raw material production, but they express consensus about the benefits of recycling and recovery relative to alternate forms of waste treatment. The full substantiation of the point just made has been provided by two major investigations published over the last two years: the new United States Environmental Protection Agency's report and the United Kingdom's Environment Agency's report.
A further confirmation has recently been provided by a wide spectrum meta-analysis (conducted by the Polytechnic University of Denmark on behalf of the UK's Waste Resource Action Program) of studies examining the end-of-life of materials (272 studies were considered, 55 were reviewed for a total of 201 scenarios examined and included in the study). This thorough screening showed that, from an environmental standpoint, recycling proved to perform better in 83% of cases (96% better performance over landfill disposal, 75% better performance over incineration, which – incidentally – is the better performer in 14% of cases).
The evolution towards a more efficient and less carbon intensive energy production system (in short, including a higher proportion of renewable energies and combined gas cycles) will render, on the grounds of energy use, recycling all the more advantageous with respect to other materials.
The only energy uses to remain environmentally competitive with recycling – and environmentally advantageous in absolute terms – are those connectd with wood or cellulose based biomass, especially when they substitute the most polluting fuels (coal or fossil sources).

3.2 THE EFFECTS OF RECYCLING ON ENERGY CONSUMPTION: SAVINGS FOR 15 MILION TEP

In 2006, energy savings achieved through recycling are estimated to be worth 15 million TEP (Ton of Equivalent Petroleum) of primary energy. The estimate reduction in primary energy need, generated through recycling, is based on data showing that 40 million tons of materials were re-used by Italian industry (deriving from consumption and production cycles). A certain amount of these materials is imported. The estimate energy figure was based on coefficients that incorporate differences between recovered material and virgin material yields.
Achieved energy consumption reduction that can be traced back to recycling – measured relative to energy requirements in absence of recycling – and without considering the energy feedstock, covers an interval that stands between 8.7 and 22.5 million TEP (the interval is largely due to differences in estimate figures for steel). The reference value, expressed as a mean of estimate values (min-max interval value), stands at 15,3 million TEP. This is a very considerable figure, which represents 8% of total domestic energy consumption (which stands at approximately 196 million TEP) and 38% of the industry sector's consumption (approximately 40 million TEP).
Part of the energy savings is achieved abroad, i.e. upstream from the industrial processes that take place in Italy (as currently happens in the pulp and paper sector), but most benefits are achieved directly in Italy (this holds true for aluminium, iron and steel, glass, plastics, etc.).

ENERGY SAVINGS				
	DOMESTIC RECYCLING 2006	ENERGY SAVINGS PER TOTAL DOMESTICALLY RECYCLED MATERIALS 2006		
	(KT)	MIN (TEP)	MAX (TEP)	AVERAGE (TEP)
ALUMINIUM (1)	885	-2.790.198	-4.847.546	-3.828.436
STEEL (2)	21.472	-3.989.972	-10.804.609	-6.759.134
GLASS (3)	1.843	-98.500	-145.968	-122.234
PE-PP (4)	930	-177.701	-1.625.745	-1.203.905
PET (4)	167	44.674	-319.298	-173.209
PVC (4)	113	-48.581	-131.061	-89.821
MIXED PLASTICS	140	37.451	37.451	37.451
CARDBOARD (5)	4.183	-847.230	-2.225.978	-1.566.086
PAPER&OTHERS (6)	1.394	-114.535	-579.508	-332.657
WOOD (7)	3.300	71.547	-108.770	-12.461
LUBRICANT OILS	173	-164.488	-164.488	-164.488
LEAD	132	-42.216	-42.216	-42.216
CEMENT	4.465	-11.256	-11.256	-11.256
COPPER	548	-523.550	-1.140.996	-832.273
TYRES (9)	190	-56.590	-248.885	-152.737
TEXTILES (8)	100	-29.378	-95.419	-62.398
TOTAL	40.035	-8.740.525	-22.454.292	-15.315.860

(1) Energy savings for the production of ingots.
(2) Energy savings for the production of cans.
(3) Energy savings for the production of bottles.
(4) Energy savings for the production of granules.
(5) Energy savings for cardboard production.
(6) Energy savings for the production of drawing paper.
(7) Energy savings for MDF panel production.
(8) Estimate of recovered quantities; energy savings for wool production.
(9) Including reused, recovered and regenerated quantities; energy savings for the production of tyres; benefits may be scarcer over the entire life-cycle (see report).

TABLE 3 - SOURCE: PROCESSED BY AMBIENTE ITALIA.

3.3 THE EFFECTS OF RECYCLING ON GREENHOUSE GASES: -55 MILLION TONS OF CO_2

In 2006, achieved reduction of green-house gas emissions through recycling are estimated to be worth 55 million tons of CO_2. The estimate reduction in green-house gas emissions, generated through recycling, is based on data showing that 40 million tons of materials were re-used by Italian industry.

CO_2 EMISSION REDUCTION				
	DOMESTIC RECYCLING 2006	EMISSION REDUCTION PER TOTAL DOMESTICALLY RECYCLED MATERIALS 2006		
	(KT)	MIN (t)	MAX (t)	AVERAGE (t)
ALUMINIUM (1)	885	-12.009.450	-8.705.745	-10.542.246
STEEL (2)	21.472	-43.158.720	-17.821.760	-30.787.781
GLASS (3)	1.843	-1.057.882	-516.040	-756.859
PE-PP (4)	930	-1.683.300	-613.800	-1.211.558
PET (4)	167	-410.820	-169.004	-297.861
PVC (4)	113	-203.400	-189.840	-196.620
MIXED PLASTICS	140	119.000	119.000	119.000
CARDBOARD (5)	4.183	-13.009.130	-439.215	-4.039.105
PAPER&OTHERS (6)	1.394	-4.934.760	-78.064	-1.694.090
WOOD (7)	3.300	-8.151.000	3.960	-2.120.910
LUBRICANT OILS	173	-35.984	-35.984	-35.984
LEAD	132	-117.480	-117.480	-117.480
CEMENT	4.465	-44.650	-17.860	-31.255
COPPER	548	-2.740.000	-2.696.160	-2.718.080
TYRES (9)	190	-345.800	-304.000	-324.900
TEXTILES (8)	100	-303.100	-93.000	-174.875
TOTAL	40.035	-88.086.476	-31.674.992	-54.930.603

(1) CO_2 emissions measured for the production of ingots.
(2) CO_2 emissions measured for the production of cans.
(3) CO_2 emissions measured for the production of bottles.
(4) CO_2 emissions measured for the production of granules.
(5)/(6) CO_2 emissions measured for cardboard and drawing paper production.
(7) CO_2 emissions measured for MDF panel production.
(8) Estimate on recovered quantities; CO_2 emissions measured for wool production.
(9) Including reused, recovered and regenerated quantities; CO_2 emissions measured for the production of tyres.

TABLE 4 - SOURCE: PROCESSED BY AMBIENTE ITALIA.

A certain amount of these materials is imported. Total domestic recycling figures do not include materials collected within the agricultural sector which holds a non–indifferent potential to absorb CO_2 (as can be deduced from the urban waste estimate).
The estimate figure describing achieved green-house gas emission reductions that can be linked to recycling – calculated relative to emissions in absence of recycling – covers an interval that stands between 32 and 88 million tons of CO_2eq (the interval, wider than that presented in the previous report, is largely due to differences in estimate figures for steel). The reference value, expressed as a mean of estimate values, stands at 55 million CO_2. This is a very considerable figure, which represents 9.5% of domestic gross emissions (which stand at 581 million tons) and 44% of emissions generated by energy consumption and specific industry emissions (126 million tons). As is the case for energy savings, part of the emission reductions are achieved upstream from the industrial processes that take place in Italy.

4 NEW WASTE MANAGEMENT SCENARIOS FOR 2020

What is the role of waste collection and recovery within an urban waste management system? What is the possible evolution of waste management system in order to support energy and green house gas reduction objectives? This study offers an attempt draw up such a trend.

2020 FORECAST: BASE CRITERIA

The following scenario has purposely incorporated realistic and economically sustainable objectives. The principal assumptions made for the scenario are:
Waste prevention: reduce the production of specific wastes in order to decouple waste generation from GDP growth.
Separate collection of waste: in order to account for existing territorial disparities, the accelerated overall development rate for separate waste collection has been broken down so as to allocate different rates to different parts of the country. A national mean of 56% builds on a 65% rate for northern Italy, 55% for central Italy and 43% for southern Italian regions.
Recycling rates: recycling rates are assumed to increase far all materials, and either are set within current levels of domestic demand or, anyway, on level with current recycling rates for comparable EU nations.
Energy recovery: promotion of the more efficient technologies for energy recovery with a particular attention for co-generation (this option will become economically beneficial as the value of green certificates for wastes diminishes). An increase in the proportion of energy recovered from organic materials, through biogas production and anaerobic digestion.
RDFs: development of refuse derived fuels within the limits of the absorption capacity of co-combustion plants (cement plants, electric power plants).
Landfills: shutting-down of waste landfills.

CONDITIONS FOR THE SCENARIO

Average GDP growth index: 1.65% (in line with the 2020 estimate value adopted in 2005 by national authorities for energy planning purposes)
Assumed average growth index for urban waste production: 1.1% per year (the average growth rate over the last ten years stood at 2.2%; the average growth rate of waste production has exceeded by 74% that of GDP; this entails the assumption of decoupled rate at 67% rate of waste production relative to GDP).
Population: incorporated within GDP and waste generation data.
Legislation: only targets established by EU legislation were considered (recycling and material recovery rates; rate of biodegradable waste destined to landfill); in this scenario, recommended recycling rates for separate waste collection established through legislation do not constitute an obligation (firstly, they have not been endorsed and offer considerable uncertainty; furthermore, this scenario aims at “suggesting” new objectives and new legislation).
Technology: present state and forecast, in consideration of the fact that the present scenario is set on the 2020 horizon (hence, it is not relevant for the 2020 scenario that presently existing equipments result in excess quantity since many of the concerned plants are reaching their end-of-life); all envisaged infrastructural equipments belong to presently commercialised technologies.

The present study focuses on a unique scenario, which – according to the authors of this report (i.e. without committing our clients to these conclusions) – appears as to be the more realistic. Indeed, more realistic and environmentally sounder, since it offers a combined and viable alternative to landfilling – by far the most inefficient solution from an environmental stand-point and in terms of energy-usage: by supporting material recycling within the industrial limits of recovery, by preferring efficient recovery (through, for instance, anaerobic digestion), by

developing the use of refuse derived fuels within the limits of effectively advantageous conditions of exploitation (in co-combustion plants), by strengthening the use of heat recovery incinerators together with a significant use of combined heat and power plants.
The suggested waste management scenario is developed within the 2020 horizon essentially because this is the time span necessary to implement its necessary components, but also because it constitutes the reference year for the European Union's policies on green-house gases and energy savings.

4.1 URBAN WASTE PRODUCTION AND DIFFERENTIATED WASTE COLLECTION: FORECAST VALUES FOR 2020

The production of urban wastes is estimated to reach, in the year 2020, the amount of 37.4 million tons, up 5 million tons from 2005, corresponding to a 5% increase, which is slightly lower than the envisaged GDP increase. The projected values for overall differentiated waste collection, calculated for the Italian domestic market and used in the present study, indicate that a 55% average capture rate should be attained, which corresponds to 20.4 million tons worth of materials.
Collection rates foreseen for each packaging material are set above existing targets, but are below the 80% limit value. The processing paths for materials gathered through differentiated waste collection are: material recycling (a largely predominant solution for all materials, while providing the only outcome for metals and glass), composting and anaerobic digestion (for the organic component), energy recovery (paper in co-combustion with bio-masses).
Globally, scrap should make-up 15% of collected materials and, hence, should be sent to energy recovery. A certain amount of exportation is attributed to the paper and plastics sectors (1 million tons for paper, and 500,000 tons for plastics). As compared to the present situation, paper, metals, plastics and organic materials should achieve the greatest increments.

2020 FORECAST: MATERIAL RECOVERY THROUGH SEPARATE COLLECTION (1000 TONS)

MATERIAL	COLLECTION	% SEPARATION	RECYCLING AND COMPOSTING	ANAEROBIC DIGESTION	EXPORTS	ENERGY USE	DISPOSAL
PAPER	6.281	70%	4.281		1.000	1000	942
ORGANIC	7.589	70%	5.692	1.897			1.138
PLASTICS	897	20%	397		500		135
METALS	1.308	70%	1.308				196
WOOD	935	50%	935				140
GLASS	2.094	70%	2.094				314
OTHER	1.271	20%	1.271				191
TOTAL	20.374	55%	15.977	1.897	1.500	1.000	3.056

TABLE 5 - SOURCE: PROCESSED BY AMBIENTE ITALIA.

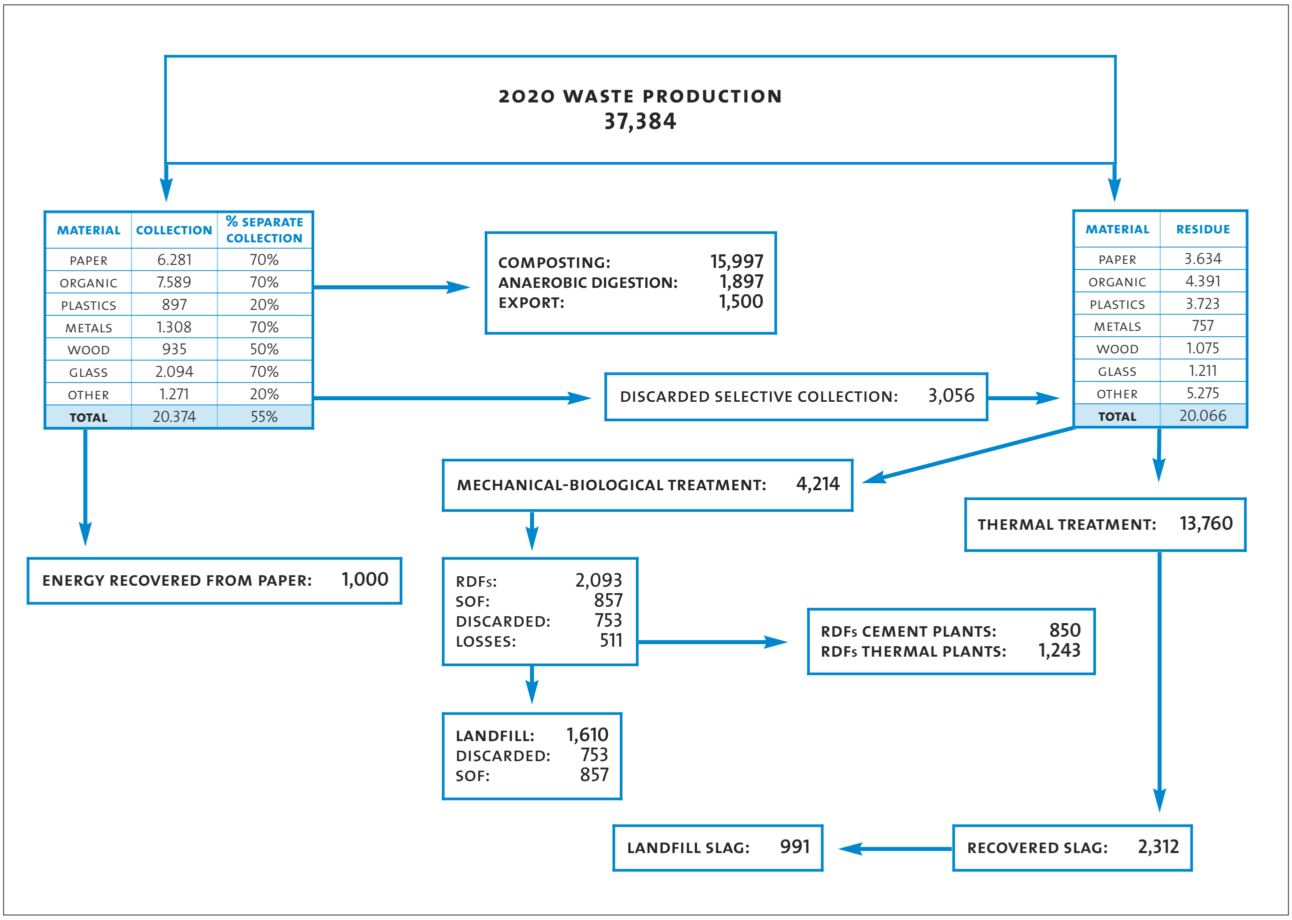
4.2 THE MANAGEMENT OF RESIDUAL WASTE: 2020 FORECAST

Projections for 2020 indicate that residual wastes will amount to 20 million tons, 17 millions tons of which are undifferentiated waste, and approximately 3 million tons of which stem from differentiated waste collection. The proposed management system for residual waste is based on three criteria:
- energy recovery maximisation through systems that allow to reduce overall emission generation and to maximise avoided emissions, with particular attention to green house gases;
- minimisation of the quantity of wastes destined to landfills, to the greatest technically achievable extent, with a particular attention for those components that may generate emissions such as biogas;
- streamlining of the waste treatment cycle so as to maintain a sufficient margin to absorb fluctuations in waste generation and waste recovery operations.

The envisaged waste management development path calls for the enhancement of existing infrastructure and especially of heat power plants and plants for anaerobic digestion.
The considerable number of existing mechanical-biological treatment plants may be re-qualified for the production of refuse derived fuels for co-combustion in cement production plants and coal based electric power plants.

INFRASTRUCTURAL REQUIREMENTS: EXISTING CAPACITY AND NEEDS FOR 2020					
	2006 AUTHORISED CAPACITY	2006 OPERATIONAL CAPACITY	2006 REQUIRED CAPACITY	OPERATIONAL CAPACITY DIFFERENCE 2006-2020	
COMPOSTING	5.901.214	3.185.597	5.692.000	2.506.403	79%
ANAEROBIC DIGESTION	360.000	229.000	1.897.000	1.668.000	728%
MECHANICAL-BIOLOGICAL TREATMENT	13.748.861	9.046.509	4.134.000	-4.912.509	-54%
INCINIREATION		4.505.000	13.760.000	9.255.000	205%

TABLE 6 - SOURCE: PROCESSED BY AMBIENTE ITALIA AND APAT 2008.



4.3 THE EFFECTS OF THE 2020 SCENARIO ON ENERGY USE AND THE ENVIRONMENT

A very strong growth of energy and material recovery characterises the envisaged 2020 scenario. This should allow for a very consistent reduction of emissions contributing to climate change.
From an energy standpoint, the foreseen waste management system should achieve a total amount of 5.7 million TEP energy savings in 2020 (which become 3.2 million TEP if recycling is excluded), and a total reduction of 9 million tons CO_2 equivalent emissions (entirely ascribable to recycling benefits).
Hence the 2020 scenario offers, as compared to the present state of affairs, to reduce energy consumption by 3.4 million TEP and to abate emissions contributing to climate change by 12.5 million tons.
The climate change estimate abatement potential, included in the 2020 scenario, was prudentially calculated considering electricity production from gas plants as a substitute value for electricity produced from waste recovery. Furthermore, sensitivity analysis points at the optimisation of power producing incinerators as a substitute source. The 2005 estimate selected a substitute average emission value for the overall electric power-generating sector. In short, there are two major factors of improvement:
- *the increase in recycling*: since 2006, recovered quantities have doubled (climbing from 8.4 to 20 million tons of material), and – excluding the organic component – material streams for recovery increase from 5.7 to 11.8 mil-

lion tons. Thus the recycling sector achieves 2.4 million TEP in energy savings and avoids the production of 9.3 million CO_2eq worth of green house gases. Organic waste treatment through composting and anaerobic digestion circumvents the production the release of 1.2 million tons of CO_2, one million tons of which can be attributed to the sinking of carbon in agricultural lands and through the production of humus. Compared to the current situation, the increasing share of recycling and composting abate CO_2 emissions by 4 million tons and determine 900,000 TEP worth of energy savings.
- *the replacement of landfills by incinerator heat production and heat recovery plants*: every ton of materials diverted from landfilling and destined to heat recovery prevents the production of 420 kg of CO_2, which taken as a whole, means that the production of 6 million tons of CO_2 is avoided. The 2020 scenario comprises an estimate 12,660 GWh of electricity produced from wastes and approximately 750,000 TEPs worth of thermal energy. Overall, the energy balance for waste treatment and disposal operations accounts for savings that are worth 3.25 million TEP. The green house gas emission balance is in the red by 320,000 tons, since the 2.2 million tons of additional emissions (mostly originating from incinerator heat production) surpass the 1.9 million tons worth of avoided emissions through co-generation in heat recovery plants, cement or biomass plants. Landfill emissions are substantially frozen since they would be reduced from 8.4 to 0.2 million tons CO_2eq in the period between 2006 and 2020.

2006-2020 ENERGY CONSUMPTION AND EMISSIONS FOR WASTE TREATMENT AND DISPOSAL						
	2006			2020		
	QUANTITY (THOUSAND t)	ENERGY USE (TEP)	CO_2 EMISSIONS (t)	QUANTITY (THOUSAND t)	ENERGY USE (TEP)	CO_2 EMISSIONS (t)
MECHANICAL- BIOLOGICAL TREATMENT	8.458	103.897	290.986	4.214	78.936	159.279
INCINERATION	3.951	-568.025	236.269	13.760	-2.281.663	1.845.249
RDFs CEMENT PLANTS	120	-47.714	-84.700	850	-337.972	-599.956
RDFs THERMAL PLANTS	0	0	0	1.243	-494.055	-877.029
RECOV. ENERGY PAPER	0	0	0	1.000	-214.552	-432.931
LANDFILL	14.726	-152.209	8.261.378	753	1.797	178.788
SOF LANDFILL	2.500	5.966	115.237	857	2.046	39.519
SLAG LANDFILL	759	1.810	5.310	991	2.364	6.935
TOTAL TREATED		-656.274	8.824.480		-3.243.099	319.855
RECOV. ENERGY		-615.739	151.569		-3.328.242	-64.666
LANDFILL		-144.432	8.381.924		6.207	225.242

TABLE 7 - SOURCE: PROCESSED BY AMBIENTE ITALIA.

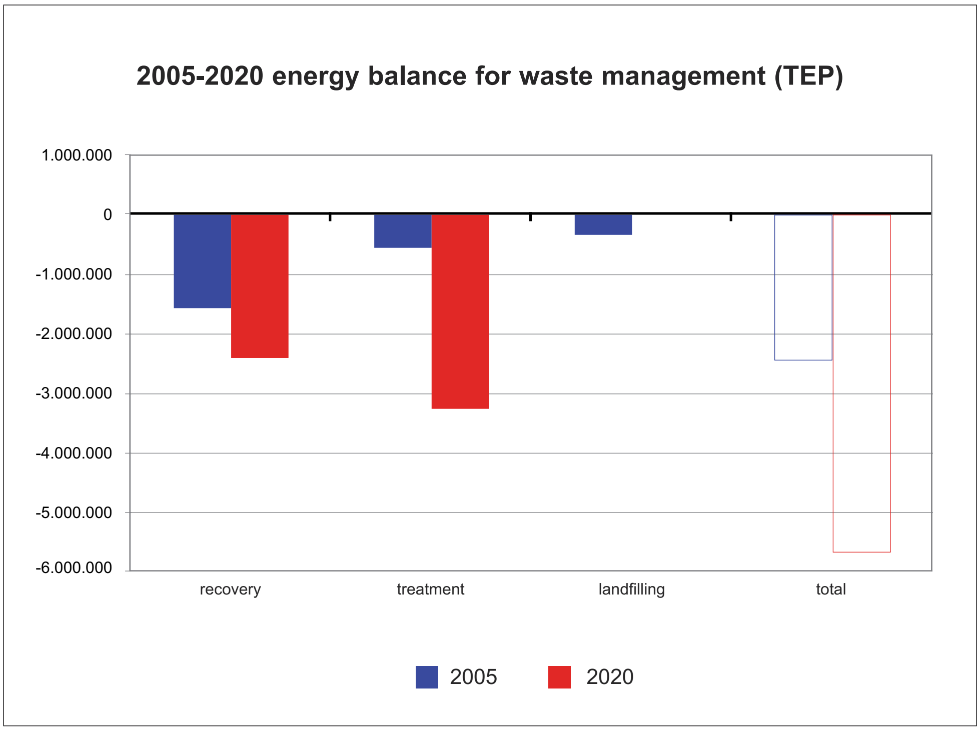


FIGURE 10
SOURCE: PROCESSED BY AMBIENTE ITALIA (NEGATIVE VALUES INDICATE A BENEFIT: ENERGY RECOVERY).

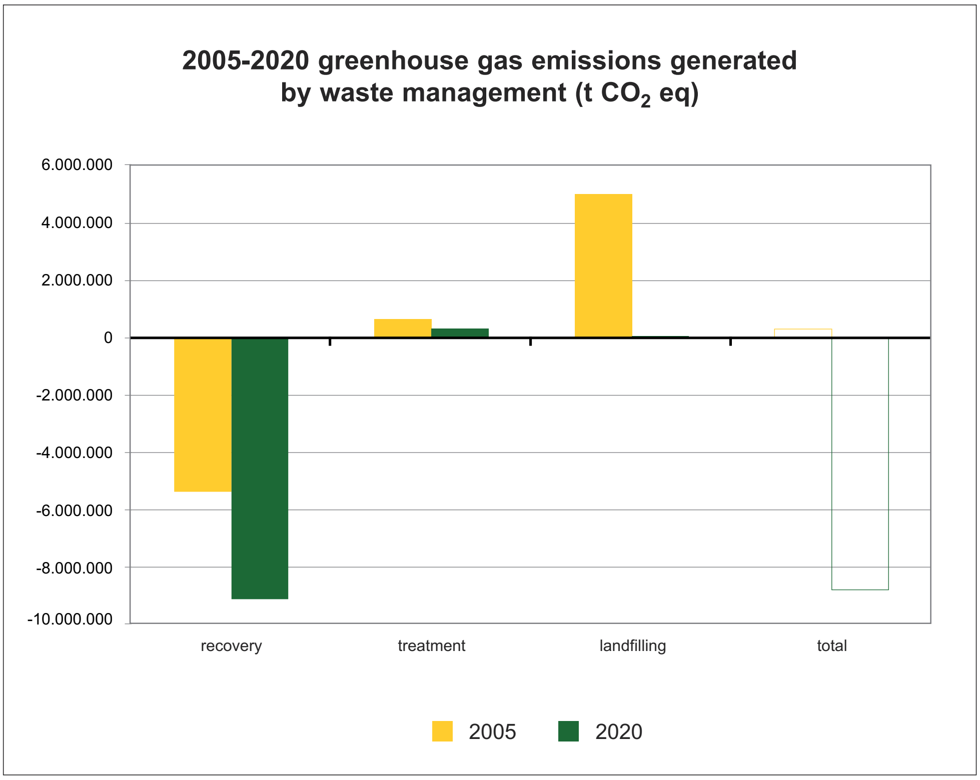


TABLE 11
SOURCE: PROCESSED BY AMBIENTE ITALIA (NEGATIVE VALUES INDICATE A BENEFIT: REDUCED EMISSIONS).

5 ENERGY EFFICIENCY AND GREENHOUSE GAS EMISSION REDUCTION

The European Union has adopted an ambitious program, widely known as the 20-20-20 program, which aims to achieve both the reduction of emissions contributing to climate change and enhance energy efficiency and security. The program envisages that, within 2020, the European Union (as a whole, and through a burden sharing allocation exercise that is currently underway) should reach the objective of reducing energy consumption by 20% relative to forecasted levels, cover 20% of energy requirements through renewable sources, and cut emissions contributing to climate change by 20% relative to 2005 levels (with the further objective of a 30% reduction if an international reduction agreement is reached). Italian targets have yet to be accurately defined, however, a few indicative targets can be desumed from proposals put forward in January 2008:
- *climate change gas emissions*: the objective set for Italy – for sectors not included in the ETS scheme (which are worth 350 million tons CO_2 out of a total of 580 million tons) – is a reduction by 13% relative to levels attained in 2005. This implies that Italy shall have to cut down its emissions levels by 5 to 5.5% of their overall 1990 level. This means achieving an overall emission reduction equivalent to 96 million tons of CO_2 within 2020 and 51 million ton reduction in the ETS sectors within 2020.
- *renewable resources*: Italy aims for a 17% renewable energy consumption target (today, on the basis of European accounting mechanisms, energy generated from renewable sources accounts for 5.2% of final consumption);
- *energy efficiency*: the Italian National Action Plan tables on a 126,000 GWh reduction of final energy consumption within 2016 (corresponding to 15.3 million TEPs worth reduction of primary energy) distributed among the residential sector (57,000 GWh), the service sector (25,000 GWh), industry (22,000 GWh) and the transport sector (23.000 GWh). Adopted actions concern both electricity consumption (with 33,000 GWh savings) and thermal energy consumption (8 million TEPs worth of savings). The action plan does not consider actions in waste recycling (which, strictly speaking, cannot be considered as being part of a package of energy efficiency measures).

5.1 THE PRODUCTION OF URBAN SOLID WASTE AND SEPARATE COLLECTION: A 2020 FORECAST.

Benefits deriving from waste management and industrial recycling policies still remain at the margins of policies for emission reduction and energy saving. Quite surprisingly, Italian public policies do not take into account the energy and gas emission reduction benefits stemming from efficient waste management and recycling. In practice,

these effects are significant and, to a certain extent, represent a by-product of policies principally aimed at curbing the undesirable environmental effects of the treatment and disposal of wastes.
Considering a 2020 perspective scenario, both an absolute growth of recycling and a relative growth of recycled materials versus raw materials are more than likely.
Domestic recycling by itself (i.e. without considering collected materials destined to export) should reasonably achieve a 15% increase by 2020. This implies moving up from a 48% recycling rate to reach for a 55.2% recycling rate. A 15% increase in the collection of materials – assuming the increase to be evenly distributed over all types of materials – should achieve energy savings worth 2.3 million TEP and reduce greenhouse gas emissions by 8.2 million tons.
An increase by 15% of the domestic industrial recycling rate should correspond to:
- roughly, a 16% CO_2 emission reduction (51 million tons) within those sectors concerned by emission trading and over the 2005-2020 period;
- approximately, a 15% increase in energy efficiency (15.3 million TEP) affecting all sectors (households, industry and transports) within 2016;
- an approximate 9% global reduction of CO_2 (just under 96 million tons) necessary to achieve the 2020 reduction targets.

The benefits captured by industrial recycling could be augmented of those deriving from an improved management of the cycle of urban waste residues. In such a case, most benefits are generated by the dismissal of landfills (since the advantages of biogas production are largely surpassed by those deriving from the re-routing of wastes).
Considering the 2020 perspective, this package of measures causes a reduction of 9.3 million tons of CO_2 emissions relative to the level attained in 2006 (principally ascribable to the closure of landfills) and 2.6 million tons of energy savings that need to be added to those already captured through recycling (the effects of industrial recycling are taken into account in the 15% growth scenario considered earlier).
Hence, the conversion of the waste management system roughly engenders:
- 18% of the CO_2 emission reductions required from those sectors concerned by emission trading;
- 17% increased energy efficiency within 2016;
- 10% of the overall reduction target set for 2020.

The combined effects of recycling and the improved management of urban wastes is worth 32% of the target for energy efficiency and 18% of the overall required reductions in CO_2 emissions. In the light of the critical contribution that waste recycling and a more environmentally conscious management of urban wastes could make for the attainment of energy efficiency objectives and for the reduction of gases contributing to climate change, it may be necessary to implement political and economic instruments that act as incentives and cancel, instead, the perverse incentives which today impede such desirable outcomes.

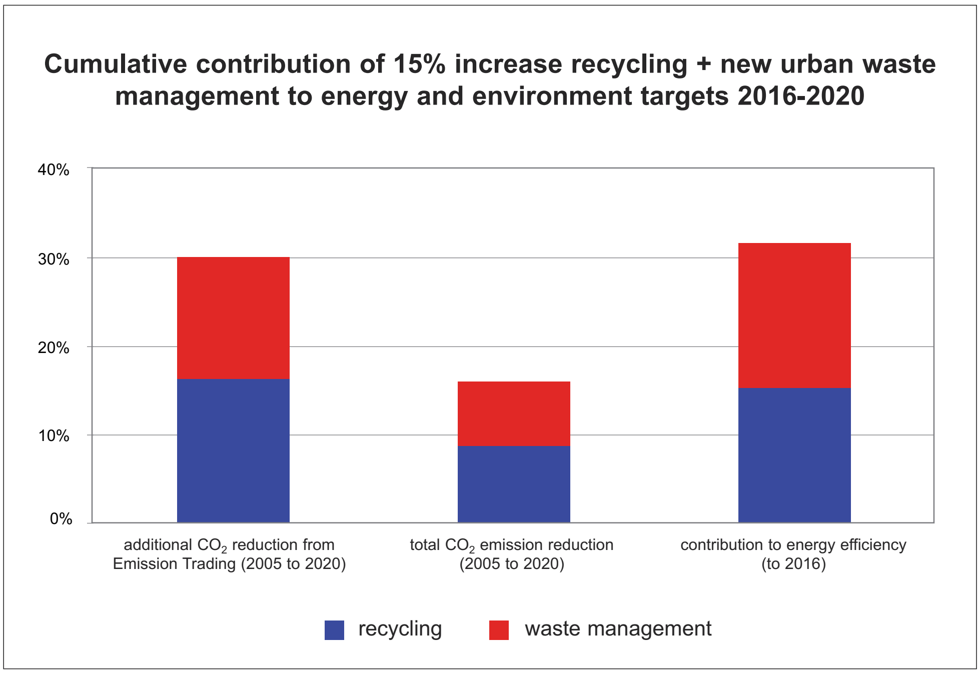


TABLE 12
SOURCE: PROCESSED BY AMBIENTE ITALIA.