THE BENEFITS OF PIPELINE INNOVATION

The advantages of using plastics for water and sewerage in Italy

AGICI
Finanza d'Impresa

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Summary

Introduction

Up to 86 billion €. It is the benefit of pipeline innovation using plastics for mains and sewers.

The welfare of a nation, its wealth and quality of life, is closely connected with its infrastructural equipment.

Utilities networks (water, gas, telecommunications and electricity) are key factors to guarantee satisfactory services for all the citizens.

Many countries, Italy included, are characterised by infrastructural lacks and lags, that produce poor quality services and high costs for the customers.

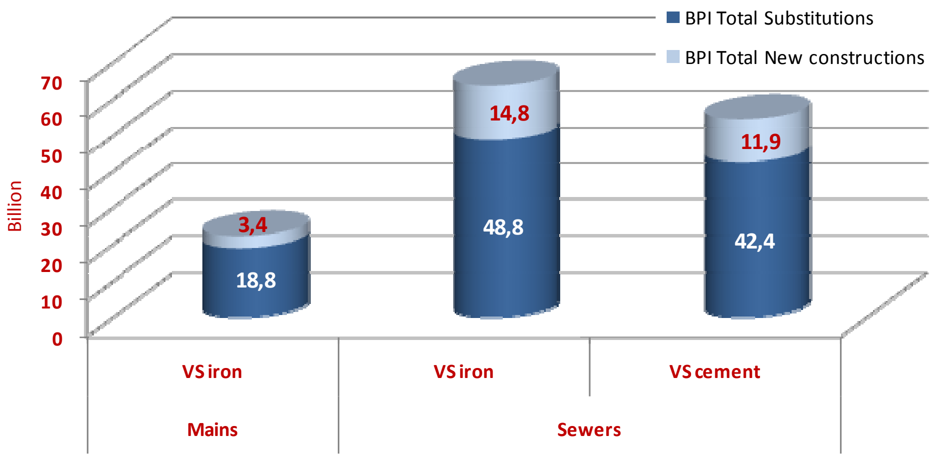
During recent years, development and innovation in pipelines has been stopped or slowed down by bureaucratic delays, low attention to research and development, unclear evolution of authorisations, political apathy, project problems, shortage of financial resources and so on.

Low innovation and lack of satisfactory pipelines – in other words, non action – burden everyone with damages, not only economic, but also of the environment and the community. Costs of non action have a damaging effect on countries, for their industrial activities, for the environment and for the general welfare.

This document summarises the most important findings of a larger study realised by Agici, which analyses the benefits of using plastic materials in order to build mains and sewers. This first study is focused on Italy.

In particular, as shown in Figure 1, the benefit of pipeline innovation (BPI), i.e. cost saving in Italy of using plastics for mains compared with iron, amounts to about 22.2 billion €. The benefits of using plastics for sewers compared with iron pipes amount to 63.6 billion € and compared with cement 54.4 billion €.

Figure 1: The Benefit of Pipeline Innovation (BPI)



The project: aim and assumptions

Aim of the study

The project has as its mission to evaluate the economic, environmental and technical effects of using plastics in drinking water and wastewater networks, through a cost-benefit analysis.

The analysis of using different materials for pipelines has to consider several factors:

- The different impacts: economic, technical and environmental
- The time factor: different impacts are deeply influenced by the considered time range
- The transported product: drinking water, wastewater

Assumptions

Our main assumptions are:

- Innovation is a key factor in the infrastructural development
- Use of plastics for water and wastewater pipelines is a technological change that improves the performance and durability of networks
- Adopting new installation technologies can increase the reliability of pipelines
- All these elements produce important benefits throughout the Italian community

Perimeter of the study

The study is done on homogeneous groups of networks, both mains and sewers.

We consider only public utilities networks for drinking water and wastewater in Italy. The study does not include indoor, agricultural, industrial and private networks.

We consider three materials families and four/five classes of diameters (see Figure 2).

Our analysis considers a period of 50 years, usually assumed as materials' durability. The life of different materials may be, of course, longer. Anyway, we assume 50 years, as a caution, since financial analyses often consider shorter periods.

Figure 2: Materials families and classes of diameters

Materials	
Family	**Type**
Plastics	PE
	PP
	PVC
Iron	Iron
	Steel
Cements	Cement
	Concrete
	Clay

Diameters (mm)		
Size	**Mains**	**Sewers**
S	80-90	100-125
M	150-180	300-315
L	250-315	450-500
XL	500-630	600-630
XXL	-	800

The methodology

The project is based on the Cost-Benefit Analysis approach. It has been applied by Agici to industrial and economic systems as well as on plant projects.

To evaluate the Balance of Pipeline Innovation, a keen cost-benefit analysis is applied, to appreciate the direct and indirect effects of using plastics in different types of pipelines.

The basic assumption of the work is that the use of plastics in pipelines is a technological change that improves performances.
We consider different classes of costs/benefits:

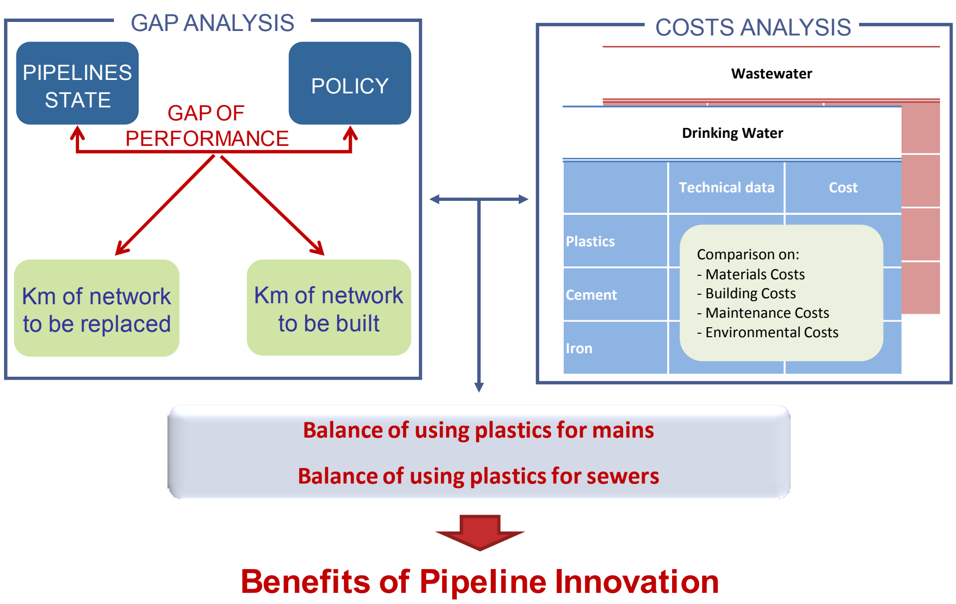
- Economic: benefits (or avoided costs) and costs (or missed benefits) of using plastic;
- Environmental: financial valuation of environmental and social benefits (or avoided costs) and environmental costs (or missed benefits);
- Technical: financial valuation of technical benefits (or avoided costs) and technical costs (or missed benefits).

Steps of the analysis

The analysis is composed of several steps (see Figure 3):

1. Analysis of the state of present networks: materials, diameters and performances, also with reference to other countries.
2. Definition of the policy on the basis of national best practices and benchmarks.
3. Definition of the infrastructural gap, in terms of kilometrage of networks to be built and to be replaced, through the comparison between the state of present networks and the policy.
4. Costs analysis: for each materials family we compare the life-cycle costs. This means to consider all the costs (economic and environmental) of different pipeline materials and of different diameters over a period of 50 years.
5. Balance of Pipelines Innovation: evaluating the difference between the costs and benefits of using plastics instead of traditional materials to build mains and sewers.

Figure 3: Steps of the analysis



Pipelines: the present state

The costs of italian mains leakages are 5,2 billion € per year.

We analyse the equipment of present networks in several European countries and then we focus our attention on Italy. The aim is to compare the state and performance of Italian mains and sewers with those in other parts of Europe.

European Framework

We analyse the present situation of networks in Italy, the United Kingdom, France, Spain and Germany, considering: length of pipelines; leakages (only for mains); density of networks per area (km/km^2) and per capita (km/inhabitants).

In water distribution Italy has very poor performance. Mains have a high rate of leakages (about 38%–45%), compared with the best performers in Europe, Germany (8%–15%) and United Kingdom (15%–16%).

In Italy water leakages amount to 3-4 trillion m^3 per year, thus, the cost for Italy (evaluated at the Italian drinking water tariff), can be estimated in about 3.9–5.2 billion € per year.

Italy is below the European average if we consider km of mains per area, but if we consider the density per capita, Italy seems to be comparable with other European countries.

The situation of Italian sewers is worse. In fact, considering the network equipment, both density per capita and density per area are inadequate compared with other European countries.

These figures emphasise the investment needed in pipelines infrastructures.

Figure 4: Density of mains and sewers in some European countries

			Italy[1]	UK	France	Spain	Germany
Mains (length of)		km	294.194	409.820	825.000	100.000	500.000
Water Household Consumption		million m3	4.102	7.054	6.276	5.299	5.409
Leakages		%	38%-45%	15%-16%	20%-22%	0	8%-15%
Density of network	mains/area	km/km2	1,24	1,69	1,51	0,20	1,40
	mains per capita	km/ 1000 inh	6,19	6,75	13,71	2,24	6,07

			Italy[1]	UK	France	Spain	Germany
Sewers (Length of)		km	145.354	347.635	328.703	n.a.	486.000
Density of network	mains/area	km/km2	0,61	1,43	0,60	n.a.	1,36
	mains per capita	km/ 1000 inh	3,06	5,72	5,46	n.a.	5,90

[1] The figures concerning Italy regard a sample (source Bluebook) representing only the 83,4% of whole population

Source: Agici estimates on Utilitatis, Drinking Water Inspectorate, Office Parlamentaire d'évaluation des choix scientifiques et technologiques, German technical and scientific association for gas and water, Ofwat and European Commission data

The italian infrastructural situation is very poor, mainly if compared with other european countries.

Italian situation

In Italy there is an heterogeneous infrastructural situation among the different regions of the country. The situation can be summarised by a Present State Index (PSI) that considers the network density related to geographical extent. If we consider the PSI for mains, the Northern regions, with 2.4 km of water pipelines per km^2, are better than the Middle and Southern regions.

We draw similar conclusions with regard to sewers. The Present State Index of the North is 1.4 km/km^2 compared with the Italian average value of 1.0 km/km^2.

In order to define the present situation of Italian mains and sewers, we analyse a sample of ATO Plans[1], representing about 25%-27% of the Italian population. Through this analysis we calculate the breakdown of mains and sewers by material family and pipe diameter.

Italian mains are mostly made of iron (62.1%) and plastics (19.6%). There is also a significant presence of asbestos cement, which must be replaced according to law. In contrast, in Italian sewers the leading type of material is cement (74.2%), which includes clay, asbestos cement, concrete and masonry; plastics represent the second most common type with a share of 14.2% of the present network. The presence of asbestos cement in sewers and in mains requires a rapid programme of replacement and this could represent a great opportunity for plastic pipelines.

Mains diameters are mainly small (60–150 mm); in contrast, sewer pipe diameters are mainly large (>800 mm), with a peak in diameters of between 180 and250 mm.

Figure 5: Drinking water and wastewater Italian networks

		NORTH	MIDDLE	SOUTH	ISLANDS	ITALY
Drinking Water Network	km	107.677	64.359	88.002	34.156	294.194
Area	km^2	119.899	69.081	62.469	49.800	301.249
Present State Index (PSI)	km/km^2	2,4	1,6	1,7	0,8	1,8

Source: Bluebook

		NORTH	MIDDLE	SOUTH	ISLANDS	ITALY
Wastewater Network	km	55.823	28.450	41.475	19.606	**145.354**
Area	kmq	119.899	69.081	62.469	49.800	**301.249**
Present State Index (PSI)	km/km^2	1,4	0,8	0,9	0,5	**1,0**

Source: Bluebook

[1] An ATO Plan is an official strategic plan made by each Italian local water Authority. According to Italian law 36/1994 (Galli Law), Italy is divided into 92 ATO (Ambito Territoriale Ottimale), that can be defined as optimal water management areas.

The infrastructural gap

To improve performances of italian network we need 155.000 km of new mains and 67.000 km of new sewers.

In this section we calculate the network need in terms of new construction and replacement for the present Italian pipelines.

New construction

The infrastructural gap for new pipes is calculated by assuming as our policy target the infrastructural parameters of the best performing area in Italy.

This assumption is prudential, as it represents a minimum goal, not enough to reach the average of other European Countries, but aimed to reduce the Italian delay in local infrastructural equipment.

Anyway, this hypothesis assumes that a bigger equipment in Italian network could improve performance, in terms of safety, leakage rates, service quality, population coverage and costs saving.

Our policy target is the level of the present state of infrastructure in North Italy, called $PSI_{Benchmark}$.

In order to convert this parameter into km of new network, we apply the $PSI_{Benchmark}$ to the entire Italian area, weighted on population.

This is explained in the following formula:

$$\sum_i (PSI_{Benchmark} - PSI_i) \cdot km_i^2 \cdot \frac{POP_i}{POP_{Benchmark}}$$

Where:

i = Middle, South, Island

$PSI_{Benchmak}$ = PSI of North Italy

PSI_i = Present State Index of i area

$Km^2_{i=}$ Extension of i area

POP_i = Population of i area

$POP_{Benchmak}$ = Population of North Italy.

If we apply this formula to the Italian situation, we obtain an infrastructural gap of 30,247 km for mains and of 20,606 km for sewers (see Figure 6).

Replacement

In order to calculate the kilometrage of old networks that should be replaced, we estimate a fair rate of replacement for Italian networks on the basis of a selected sample of ATO plans, representing about 25%-27% of the Italian population, respectively for mains and sewers.

We apply the mentioned rate of replacement to the whole Italian networks, both for drinking water and for wastewater.

By the analysis of our sample, 42.5% of present mains and 31.6% of present sewers should be replaced in a period of 50 years.

This represents an infrastructural replacement of 125,000 km of whole Italian mains and 46,000 km of whole Italian sewers in a period of 50 years (see Figure 6).

Figure 6: Infrastructural gap for mains and sewers

km	New construction	Replacement	Total gap
Mains	30.247	125.000	155.247
Sewers	20.606	46.000	66.606

Costs analysis

Italian utilities have to consider not only pipes costs, but also installation, maintenance and deeply environmental costs.

This part of the study concerns the costs analysis. For each materials family we compare the life-cycle costs. This means to consider all the unit costs (€/km) of different materials pipelines and for different classes of diameters over a period of 50 years. We identify at least four classes of costs as shown in Figure 7.

Figure 7: Classes of costs

Materials Costs	Construction Costs	Maintenance Costs	Environmental Costs
• Pipe costs	• Yard costs • Installation costs • Fitting costs	• Number of failures • Maintenance Costs	• Energy consumption • Externality of yard • Externality of maintenance

Material costs

The materials costs consider the cost of pipes in different materials and for different diameters.
We have surveyed about 20 different sources of Italian pipe supplies, in order to define an average price for each class of diameters and materials family.

Construction costs

The construction costs derive from the analysis of some case studies and of some specifications of Italian utilities. They have been calculated by summing the cost items of each step (Figure 8) of a traditional construction project, both for the different materials and the various diameters. The advantages of plastics are very high and the use of No Dig may increase them. We have therefore assumed the use of 30% of No Dig technologies only for plastics. This assumption does not reflect the actual Italian situation, where trenchless technologies are only 5%, but reflects

Figure 8: Cost items and technologies

Traditional technologies

Class	Cost Items	€/km
Road yard costs	Asphalt cutting	Depends on different location and differnt aspects of underground
	Excavation	
	Refilling	
	Provisional and final paving	
	Trasportation	
	Waste management	
Installation costs	Lying	
	Installation of pipe	
	Welding costs	
	Technical costs	
Fitting costs	Investigation	
	Planimetry update	
	Safety costs	
	Administrative costs	
	Test	
	Cathode protection	

Trenchless technologies

Class	Techniques	Cost saving
Renewal	Slip Lining	30-50%
	Compact Pipe	20-30%
	Roll-Down	10-20%
Substitution	Pipe Bursting	20-30%
	Pipe Splitting	20-30%
Restoration	Cured in Place Pipe (CIPP)	15%

Source: Agici estimates on case studies, general contractors' interviews and utilities data the European situation, and represents a goal for Italy.

On the basis of case studies and interviews with contractors, we estimate that the use of No Dig involves an additional reduction in construction costs of about 20%–25%.

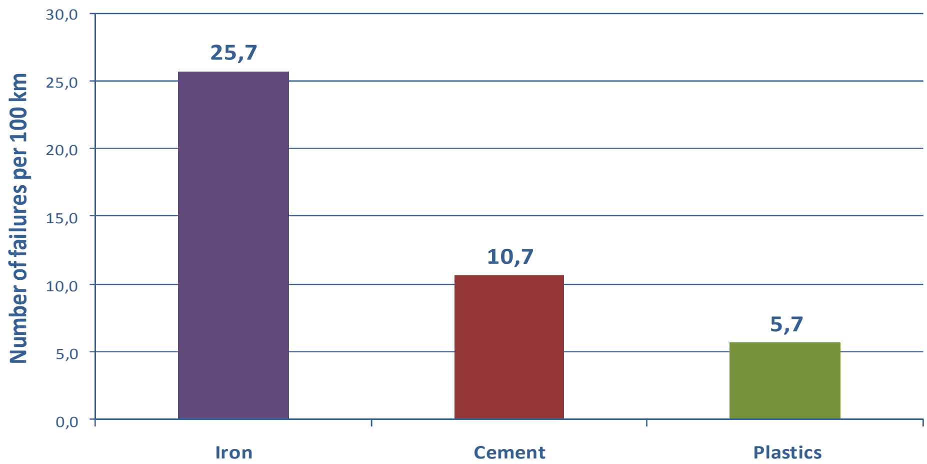
Maintenance costs

Maintenance costs depend on the number of failures of different materials and on the repair costs. The number of failures, described in Figure 9, is based on international data, weighted on present Italian pipeline breakdowns per material. The repair costs derive from costs forecasts in specifications of Italian utility companies.

Environmental costs

The environmental costs derive from two classes of externalities. The first class is impacts of the phase of pipe production, considering the energy consumption. Starting from data on energy consumption, we convert this into electric power and CO^2 emissions, evaluated at the price of the emission certificates. Producing 1 km of pipe in plastic, instead of iron, saves about 33–249 tonnes (depending on pipe diameters) of CO^2 emission. The second class of environmental costs considers the externalities of the operations for installation and maintenance. In particular it refers to the impact of the transportations to the construction site[2], considering the costs in terms of: accidents, noise, pollution, climate change, nature and landscape changes and urban effects. According to the assumptions of previous sections, the use of trenchless technologies could produce additional savings in such operational externalities.

Figure 9: Number of failures per materials family



Source: Agici estimates on DVGW, Arhus Water Supply Company and UKWIR data

[2] See INFRAS values estimated in the document: “Les couts externs des Transports. Etude d’actualisation “, 2004

The Benefits of Pipeline Innovation

Up to 86 billion €, are the benefit of using plastics. 58 billion depend on environmental aspects.

Finally we calculate the Balance of Pipeline Innovation, whose results lead to calculation of the Benefit of Pipeline Innovation (BPI). The figure, indeed, shows a huge cost saving by using plastics in mains and sewers. In order to evaluate the cost of new realization and replacement gaps, we apply the unit costs, for each materials family, to the infrastructural gap (155,300 km of mains and 66,600 km of sewers) weighted on diameters. The BPI is the differential cost of gaps improving using plastics instead of traditional materials. In particular, for mains the BPI derives from the comparison of plastics with iron; for sewers the BPIs derive from the comparison of plastics with both iron and cement. Innovation with plastics produces huge BPI:

- 22.2 bn € is the cost saving of making plastic mains instead of iron ones;
- 63.6 bn € and 54.4 bn € are respectively the cost savings of making plastic sewers instead of iron and cement ones.

The BPI materials

Plastic pipes are cheaper compared with iron ones both for mains (800 m €) and sewers (5.9 bn €). An opposite situation applies if they are compared with cement pipes (-900 m €).

The BPI in construction

The installation costs for plastic pipes are lower than iron (4.4 bn € for mains and 16 bn € for sewers) and cement ones (14.1 bn € for sewers). The costs savings are due partially to the use of trenchless technologies.

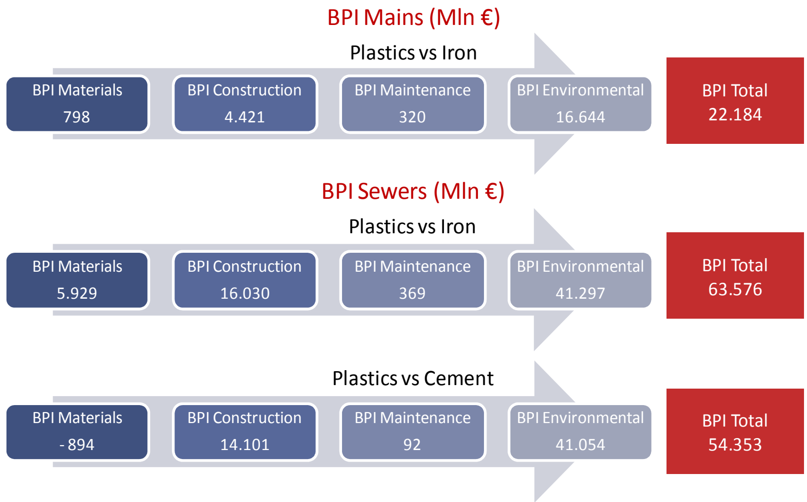
The BPI in maintenance

Repair costs for plastic pipes are cheaper, particularly if compared with iron ones (321 m € for mains and 370 m € for sewers); less for cement (92 m €). This is due to the proven high rate of failures of iron pipes.

The environmental BPI

The environmental BPI is the most relevant saving. This is mainly due to the smaller scale of the construction site for plastic pipes. The production of plastic pipes also assures significant energy savings. Moreover, there are additional cost savings if we consider the use of No Dig technologies, when usable. The BPI calculated for environmental costs are 16.6 bn € for plastic mains compared with iron and about 41 bn € for plastic sewers compared with both iron and cement.

Figure 10: The Benefits of Pipeline Innovation



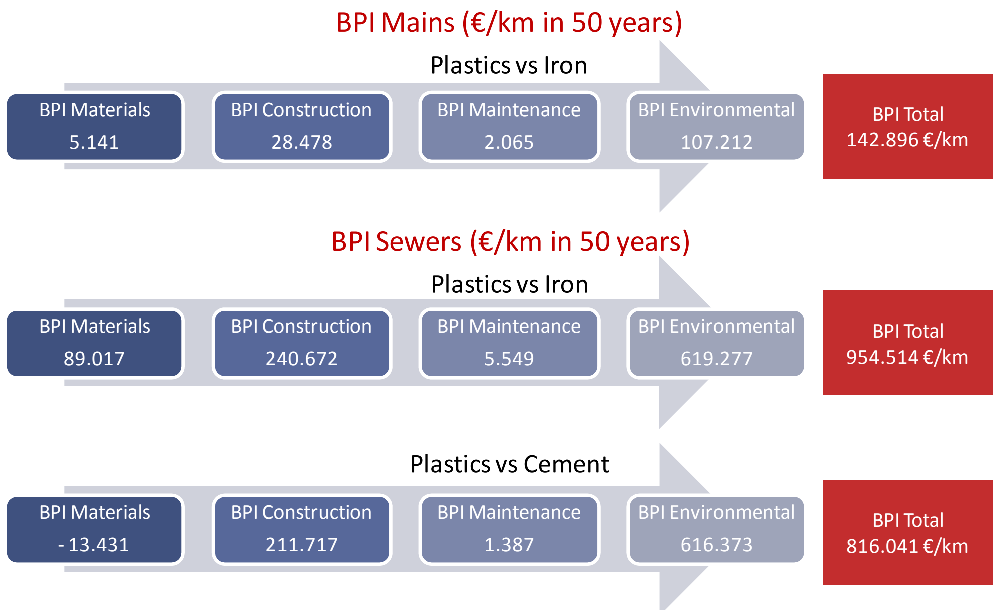
Conclusions and recommendations

143.000 €/km are the benefits of building mains with plastics. Up to 955.000 €/km are the benefits of building sewers with plastics.

In conclusion, our study leads to these final considerations:

- The use of plastics in water and wastewater networks assures important cost savings.
- In Italy, these savings amount to 22,2 bn € for mains built with plastics instead of iron. The benefits of using plastics for sewers compared to iron are 63,6 bn € and compared with cement 54,4 bn€.
- The costs of not investing are not sustainable in the long term. The cost of leakages in Italy amounts to 3.9–5.2 bn € per year.
- No dig technologies are an innovation opportunity for the utility companies. They may enhance the already huge advantages of plastic pipes.
- From the point of view of the utilities companies, an overall cost analysis instead of a traditional one, may radically change investment choices. The Unit BPI (see Figure 11), in fact, shows the different classes of cost/benefit of each km of network installed.
- The reference to material costs does not explain completely the benefits of using plastic; indeed plastic pipes are cheaper than iron but more expensive than cement pipes.
- Plastic's advantages emerge clearly when we consider not only materials cost, but also the construction, maintenance and environmental ones.
- In Italy, the utility companies should adopt choosing criteria that consider also the impacts on quality of environment and services.
- At present in Italy, environmentally-friendly solutions are not properly considered by pipeline installers, because their additional costs are not recognized by public administrations. The tenders for pipelines building should consider also criteria that evaluate financial benefits of environmentally-friendly solutions.

Figure 11: The Unit Benefit of Pipeline Innovation



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The present work is part of wider Agici study "The Benefits of Pipeline Innovation. The advantages of using plastics for water and sewerage in Italy".

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