SAPPMA

southern african plastic pipe manufacturers association

WEBINAR VIII

21-10-2021

Thermoplastic Pipe Systems:

Important aspects to understand and keep in mind during design and specification

IFPA
Installation and Fabrication Plastics Pipe Association

SAPPMA
southern african plastic pipe manufacturers association
www.sappma.co.za

SAPPMA
southern african plastic pipe manufacturers association
www.sappma.co.za

IFPA
Installation and Fabrication Plastics
Pipe Association

SAPPMA
southern african plastic pipe manufacturers association

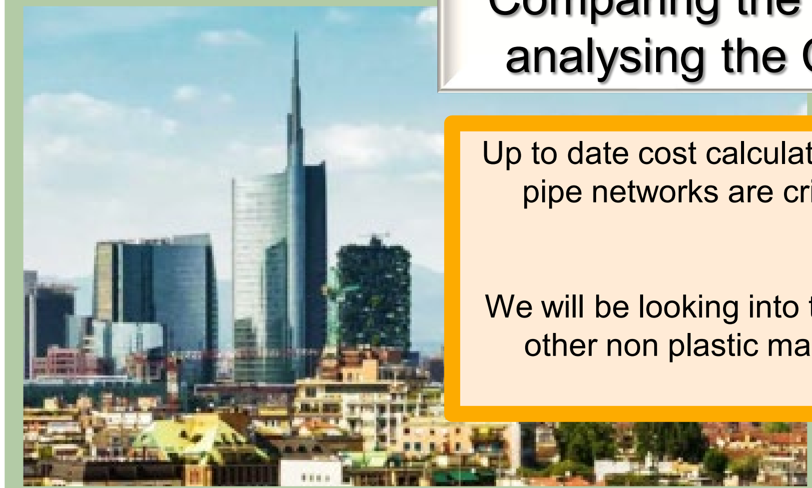
zoom
Video Conferencing

21-10-2021

SAPPMA
southern african plastic pipe manufacturers association

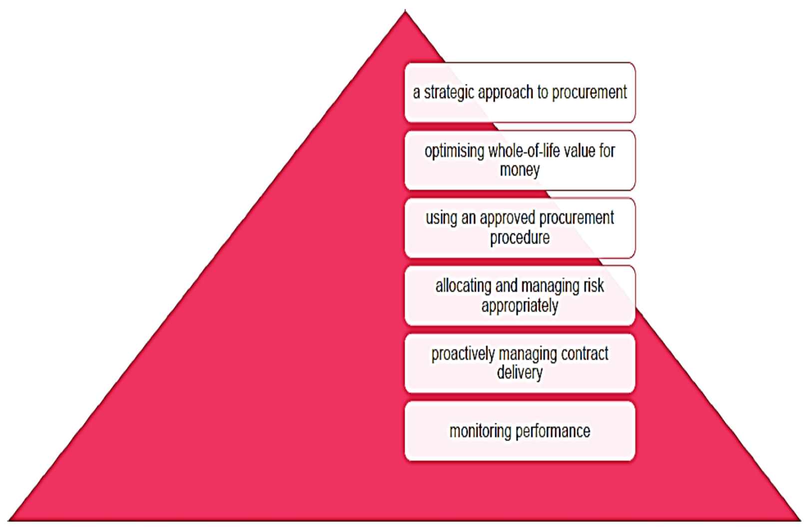
SAPPMA Webinar VIII

Comparing the lifecycle costs of pipe materials and analysing the Cost benefit of PVC Pipe Recycling



Up to date cost calculations across the whole lifecycle of the water and sewer pipe networks are critical to help the owners to make informed selection decisions on the pipe material.

We will be looking into the total cost of ownership analysis comparing PVC to other non plastic materials as well as the recycling of pipes benefit after dismantling



ALTHESYS
Strategic Consultants

Prof Alessandro Marangoni

SAPPMA
southern african plastic pipe manufacturers association

PVC PIPES COMPETITIVENESS

Total Cost of Ownership (TCO) of PVC pipes and Cost Benefit of recycling

Alessandro Marangoni

SAPPMA webinar, October 21 2021

ECVM (Established 1984)

PVC4Pipes (Established 2003)

Vision

- To be a reference partner to promote the use of PVC in pipe systems.

Mission

- Promote the acceptance and utilisation of PVC in pipe systems through technical projects, appropriate standardisation/regulatory/communication activities

Partners

20 organisations across Europe

- Raw materials manufacturers (PVC resin and additives)
- PVC pipes and fittings manufacturer
- Pipe seal manufacturer
- Plastic pipe and PVC associations
- Technology and testing institutes

Summary

Foreword

- Plastics pipes are a key element in infrastructures development and competition with other materials is pushing the price/performance ratio
- In this framework, the PVC pipes competitiveness brings benefits both to the plastics industry and to the public utility sector, end user of pipes in its network
- PVC4pipes and ECVM carried out in 2010 and 2018 a study about the PVC pipes competitiveness showing the advantages of these products
- Sustainability has become more and more a key issue and in 2019 a study about the cost-benefit of PVC pipes recycling has been carried out

So, cost advantages + sustainability show PVC pipes competitiveness as a whole

1. Objectives

Mission: **to analyse the competitiveness of PVC pipes, through:**

a) **assessing the costs saving resulting from the use of PVC instead of the main functional alternatives along its entire lifetime**

b) **Evaluating the cost-benefit of PVC pipes recycling**

Scope: a) the most alternative materials for the following application:

- Pipes for drinking water mains
- Pipes for wastewater - sewerage

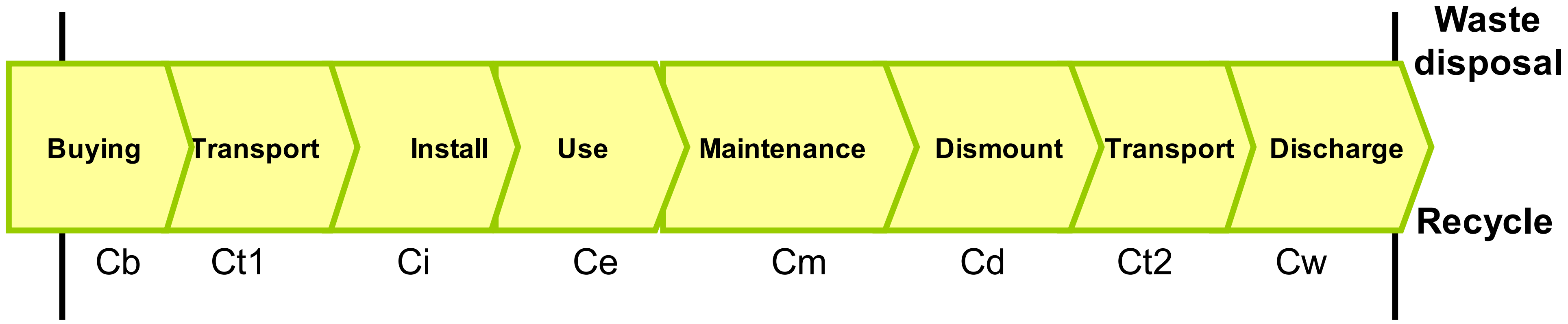
Geographical scope of the study:

- Italy
- Germany

2. Methodology

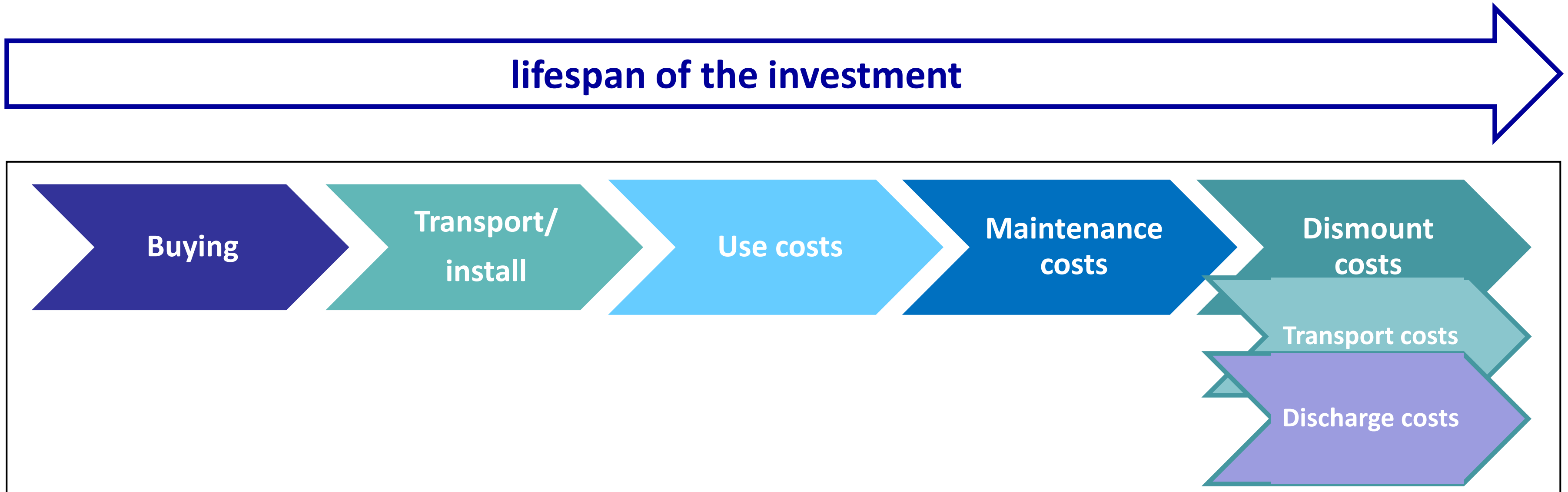
Since the aim of the study (a) is to provide an analysis of the **users' monetary costs** throughout the pipes lifetime", **Total Cost of Ownership (TCO)** is the best method

- A Cost of Ownership assessment is a methodology designed to find the lifetime costs of acquiring, operating and changing something
- TCO is a "customer centric" analysis aimed to account for the difference between the purchase price of something and its long term cost



TCO = ∑ Cx

Applying the TCO methodology to pipes



Pipe costs	Installation costs	Use costs	Maintenance costs	Dismount costs
List prices	Road yard costs	Energy costs	Excavation	Removal old pipe
Discount	Installation costs		Temporary re-establishment costs	Transport + Dispose
	Additional burden		Yard assistance	

Applying the TCO methodology to pipes

- For each family of materials the study compared the costs for the entire life cycle of the pipes. All the cost items related to pipes of various materials and diameters are considered over the selected planning periods
- The total cost of ownership is based on the following formula:

$$C_{Tot} = C_{Materials} + C_{Installation} + C_{O\&M} + C_{dismantling}$$

Where:

- $C_{Materials}$ is the cost of pipes (ex-work);
- $C_{Installation}$ sums up all the industrial costs related to building the networks
- $C_{O\&M}$ considers the Operation & Maintenance costs necessary to allow the network functionality
- $C_{Dismantling}$ estimates the costs for dismantling old substituted pipes

Scope of the analysis

The analysis considers **the currently most adopted materials and sizes**

Drinking water pipes
Ductile Iron (DI)
Polyethylene (PE – HDPE)
PVC
Fiberglass (for larger diameters* - only for Italy)
**The use of fiberglass is limited to diameters over 315 mm*

Sewage pipes**
Concrete
Polyethylene (Corrugated PE)
PVC
Clay (gres)
PVC 3 layer (only for Germany)
***Cast iron is not considered because no longer used in new*

Diameters (mm)		
Size	**Water Mains**	**Sewerage**
S	63	250
M	110	315
L	160	400
XL	200	500
XXL	315	630

The final users are the utilities which, according to the TCO approach, buy, install, operate, repair, replace, dismount water networks over their technical service lives

$$C_{Tot} = C_{Materials} + C_{Installation} + C_{O\&M} + C_{dismantling}$$

Costs of materials

- **Costs of materials relate to the costs of the pipes** in different materials and diameters.
- Lists of pipes manufacturers, as well as engineering consulting firms and utilities public tenders have been reviewed. Significant discounts according to market practice have been applied.

Costs of Installation

- Installation costs are the result of the following formula:

$$C_{Construction} = C_{road\ yard} + C_{installation} + C_{additional\ burdens}$$

- Each entry then depends on multiple factors, the main ones are:
  - ✓ The material installed
  - ✓ The steps involved and the location of the site (urban, suburban, rural)
- Installation costs include dismantling and disposing of old pipes

Cost items of construction

Traditional technologies		
Class	**Cost Items**	**€/km**
Road yard costs	*Asphalt cutting*	Depends on different aspects of underground
	Excavation	
	Refilling	
	Provisional and final paving	
	Trasportation	
	Waste management	
Installation costs	*Laying*	
	Installation of pipe	
	Sealing costs	
	Technical costs	
Additional burden	*Investigation*	
	Planimetry update	
	Safety costs	
	Admistrative costs	
	Test	
	Cathodic protection	

$C_{Tot} = C_{Materials} + C_{Installation} + C_{O\&M} + C_{dismantling}$

O&M - Operational and maintenance costs

1. Network maintenance

Networks maintenance is mainly referred to pipe repairs when failures occur. Therefore these costs depend on the number of failures of different materials and on the repair costs.

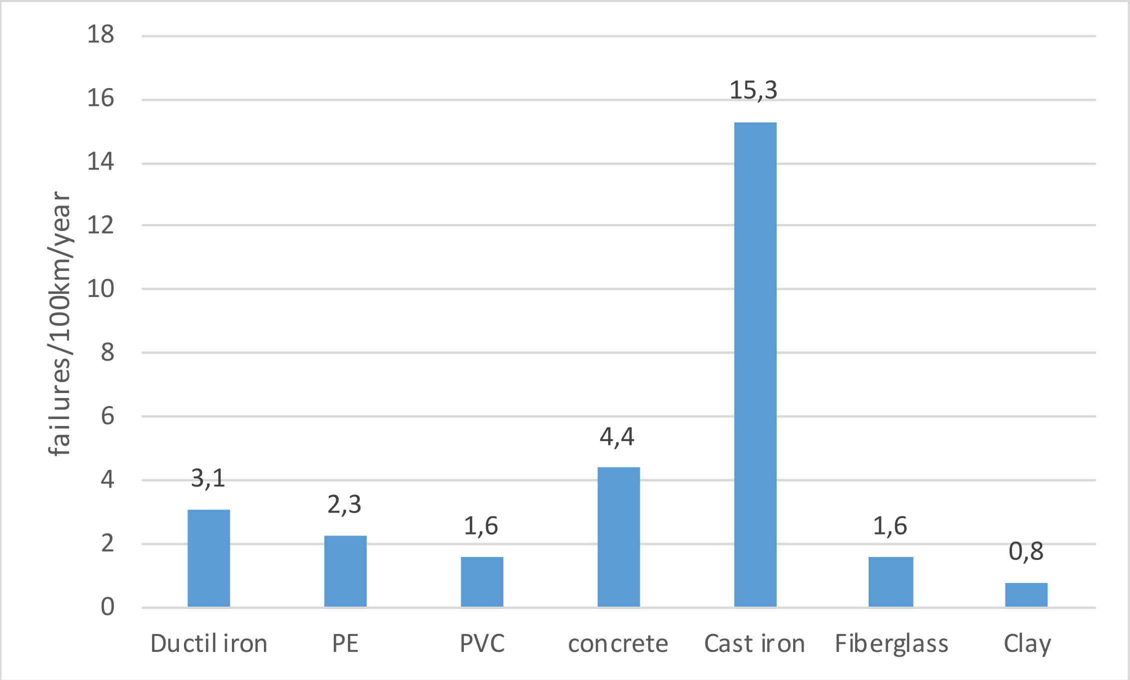
$C_{Maintenance} = (\text{N° failures} \times C_{Maintenance})$

for each material

The number of failures has been estimated on the basis of national data provided by Utilitalia for Italy and DVGW for Germany. Other relevant sources have been reviewed.

"Old" materials like cast iron suffer higher rates

N° of Failures /100 km



Source: Althesys elaboration on data "AWWA, Utah University, Utilitalia and and DVGW

$C_{Tot} = C_{Materials} + C_{Installation} + C_{O\&M} + C_{dismantling}$

O&M - Operational and maintenance costs

2. Energy consumption (drinking water pipes)

- **In drinking water network energy consumption is related to friction loss**. Different materials roughness and internal diameters result in different energy costs
- According to a caution principle, we set a sensitivity on energy consumption**: a scenario with energy consumption of PVC lower than Ductile Iron and another with similar energy consumption**.
  This second scenario is also considered for cases in which water is pushed by gravity rather than by pumping systems.

Service life and planning period

Drinking water pipes

The analysis for all materials is set on **two scenarios:**

- **100 years lifetime**
- **70 years lifetime**

Sewerage pipes

50 years planning period is considered, due to the applications of these pipes, exposed to extremely corrosive agents

3. The key findings

4.1 Drinking water pipes

Total Cost of Ownership drinking water pipes (€/m) - DCF 100 years

	PVC					PE (HDPE)					Fiberglass	Ductile Iron				
diameters (mm)	**63**	**110**	**160**	**200**	**315**	**63**	**110**	**160**	**200**	**315**	**315**	**63**	**110**	**160**	**200**	**315**
Buying	1.6	3.7	7.9	12.3	30.5	2.5	8.4	12.7	19.9	49.1	46.0	10.7	14.5	23.9	31.2	56.1
Installation	59.5	62.4	73.7	78.0	92.1	59.5	62.4	73.7	78.0	92.1	92.1	68.1	73.4	82.4	85.4	100.1
Old pipe dismantling	6.8	11.1	13.7	16.7	18.7	6.8	11.1	13.7	16.7	18.7	18.7	8.8	14.5	17.8	21.7	24.3
Use	26.6	25.3	24.8	24.3	23.8	24.0	22.8	22.3	21.9	21.4	23.8	32.5	30.9	30.3	29.7	29.1
Maintenance	0.2	0.3	0.4	0.5	0.6	0.2	0.3	0.4	0.4	0.5	0.5	0.5	0.7	0.7	0.9	1.1
Total cost of ownership	**94.8**	**102.9**	**120.5**	**131.7**	**165.7**	**93.0**	**105.0**	**122.8**	**136.8**	**181.9**	**181.2**	**120.6**	**133.9**	**155.1**	**168.8**	**210.6**
%						-1.9%	2.1%	1.9%	3.9%	9.7%	9.3%	27.1%	30.1%	28.7%	28.2%	27.1%
Avg. Increase compared to the minimum	**minimum TCO**					**3.1%**					**9.3%**	**28.2%**				

Discount rate = 3.0%
Inflation rate = 1.5%

Total Cost of Ownership drinking water pipes (€/m) – DCF 100 years

	PVC					PE (HDPE)					Ductile Iron				
diameters (mm)	**63**	**110**	**160**	**200**	**315**	**63**	**110**	**160**	**200**	**315**	**63**	**110**	**160**	**200**	**315**
Buying	1.6	3.7	7.8	12.0	29.9	2.5	8.2	12.5	19.5	48.1	10.5	14.3	23.4	30.6	55.0
Installation	71.7	75.1	88.7	93.9	110.9	71.7	75.1	88.7	93.9	110.9	82.0	88.4	99.3	102.8	120.5
Old pipe dismantling	8.1	13.4	16.5	20.1	22.5	8.1	13.4	16.5	20.1	22.5	10.6	17.4	21.4	26.1	29.3
Use	25.3	24.0	23.6	23.1	22.6	22.8	21.6	21.2	20.8	20.4	30.9	29.3	28.7	28.2	27.6
Maintenance	0.3	0.4	0.4	0.5	0.6	0.3	0.4	0.4	0.5	0.6	0.5	0.7	0.8	1.0	1.2
Total cost of ownership	**107.0**	**116.6**	**137.0**	**149.6**	**186.6**	**105.3**	**118.8**	**139.3**	**154.7**	**202.5**	**134.5**	**150.1**	**173.6**	**188.7**	**233.6**
%						-1.6%	1.8%	1.7%	3.4%	8.5%	25.6%	28.7%	26.8%	26.1%	25.2%
Avg. Increase compared to the minimum	**minimum TCO**					**2.8%**					**26.5%**				

Discount rate = 1.0%
Inflation rate = 1.5%

Values change in different countries, but PVC remains the best TCO performer

Sensitivity on lifetime: 70 years

Total Cost of Ownership drinking water pipes (€/m) – DCF 70 years

	PVC					PE (HDPE)					Fiberglass	Ductile Iron				
diameters (mm)	63	110	160	200	315	63	110	160	200	315	315	63	110	160	200	315
Total cost of ownership	92,6	93,7	111,4	122,8	156,9	85,5	95,2	113,2	127,4	172,6	168,1	103,9	118,0	139,4	153,4	195,4
%						-7,7%	1,6%	1,6%	3,7%	10,0%	7,1%	12,3%	26,0%	25,1%	25,0%	24,5%
Avg. Increase compared to the minimum	minimum TCO					1,9%					7,1%	22,6%				

Total Cost of Ownership drinking water pipes (€/m) – DCF 70 years

	PVC					PE (HDPE)					Ductile Iron				
diameters (mm)	63	110	160	200	315	63	110	160	200	315	63	110	160	200	315
Total cost of ownership	99.0	102.2	121.4	133.3	168.2	93.1	103.5	122.9	137.5	182.5	112.3	127.6	149.8	164.1	206.4
%						-5.9%	1.3%	1.3%	3.1%	8.5%	13.5%	24.9%	23.5%	23.1%	22.8%
Avg. Increase compared to the minimum	minimum TCO					1.7%					21.5%				

4.2 Sewerages pipes

Total Cost of Ownership sewage pipes (€/m) - DCF 50 years

	PE (CORRUGATED)					PVC					CONCRETE			Clay				
diameters (mm)	**250**	**315**	**400**	**500**	**630**	**250**	**315**	**400**	**500**	**630**	**400**	**500**	**630**	**250**	**315**	**400**	**500**	**630**
Buying	12.0	17.1	26.9	44.7	68.6	13.5	21.4	34.7	59.5	98.1	45.4	56.9	68.5	30.0	39.6	71.2	89.6	125.0
Installation	85.6	131.4	180.8	236.8	300.2	85.6	131.4	180.8	236.8	300.2	207.6	257.8	320.4	100.7	147.8	207.6	257.8	320.4
Old pipe dismantling	19.6	22.5	32.0	39.0	67.0	19.6	22.5	32.0	39.0	67.0	54.3	66.3	113.8	33.3	38.3	54.3	66.3	113.8
Maintenance	0.4	0.5	0.5	0.6	0.8	0.2	0.5	0.6	0.4	0.9	1.6	1.9	2.3	0.2	0.3	0.3	0.3	0.4
Total cost of ownership	**117.6**	**171.6**	**240.2**	**321.1**	**436.5**	**118.9**	**175.9**	**248.1**	**335.6**	**466.1**	**308.9**	**382.9**	**505.0**	**164.1**	**225.9**	**333.4**	**414.0**	**559.7**
%						1.1%	2.5%	3.3%	4.5%	6.8%	28.6%	19.3%	15.7%	39.6%	31.6%	38.8%	29.0%	28.2%
Avg. Increase compared to the minimum	**minimum TCO**					**3.6%**					**21.2%**			**33.4%**				

Discount rate = 3.0%
Inflation rate = 1.5%

Total Cost of Ownership sewage pipes (€/m) - DCF 50 years

	PE (CORRUGATED)					PVC					PVC 3 LAYER			CONCRETE			Clay				
diameters (mm)	**250**	**315**	**400**	**500**	**630**	**250**	**315**	**400**	**500**	**630**	**250**	**315**	**400**	**400**	**500**	**630**	**250**	**315**	**400**	**500**	**630**
Buying	11,8	16,8	26,4	43,8	67,2	13,2	21,0	34,0	58,3	96,2	21,3	33,3	53,5	44,5	55,8	67,1	29,4	38,8	69,8	87,8	122,6
Installation	100,4	152,8	209,6	274,2	347,1	100,4	152,8	209,6	274,2	347,1	100,4	152,8	209,6	241,8	299,5	371,5	118,5	172,5	241,8	299,5	371,5
Old pipe dismantling	22,3	25,6	36,3	43,2	74,1	22,3	25,6	36,3	43,2	74,1	22,3	25,6	36,3	61,7	73,4	126,0	37,9	43,5	61,7	73,4	126,0
Maintenance	0,4	0,6	0,6	0,7	0,9	0,3	0,6	0,7	0,4	1,0	0,2	0,3	0,3	1,8	2,1	2,6	0,2	0,3	0,3	0,4	0,5
Total cost of ownership	**134,8**	**195,8**	**272,9**	**361,9**	**489,4**	**136,2**	**200,0**	**280,6**	**376,1**	**518,4**	**144,1**	**212,0**	**299,7**	**349,8**	**430,8**	**567,2**	**186,0**	**255,1**	**373,6**	**461,1**	**620,5**
%						1,0%	2,1%	2,8%	3,9%	5,9%	6,9%	8,3%	9,8%	28,2%	19,0%	15,9%	37,9%	30,3%	36,9%	27,4%	26,8%
Avg. Increase compared to the minimum	**minimum TCO**					**3,2%**					**8,3%**			**21,0%**			**31,9%**				

Discount rate = 1.0%
Inflation rate = 1.5%

Plastics are the winners, spread in the family is small

4. Take-aways

Total Cost of Ownership of plastics is the lowest among materials

Drinking water networks:

- **Italy**: PVC pipes are the best TCO performer. Fiberglass is on average 9,3% more expensive. Ductile Iron is the most costly: 28.2% more than PVC
- **Germany**: PVC pipes are the best TCO performer. Ductile Iron is 26.5% more costly.

Sewerage networks:

- **Italy**: Concrete is on average 15,7% more expensive than PVC; clay +28,9%;
- **Germany**: Cement is on average 16,2% more expensive than PVC, whereas clay +27.9%

In **all criteria** of calculation (yearly total costs, or DCF, assuming different planning period 70-100 years), the results are very similar and the ranking doesn't change

The main cost is installation:

- In Italy this cost is on average 57% in water networks and 68% in sewerage;
- In Germany it is on average 56% in water networks and 68% in sewerage.

Materials are a small share of TCO

- In **drinking water pipes** they range from:
  - In Italy: 2-3% of TCO up to 27% depending on material. For PVC small diameters this item is negligible (less than 2%).
  - In Germany: some 1.5% of TCO up to 24%, as diameter grows.
- For **sewerage** the weight of material cost is higher than drinking water (10%-20%) due to bigger diameters and better technical features (e.g. resistance to corrosion).

5. Beyond TCO: the PVC recycling benefits

- The European PVC industry has been working hard since the late 90's to address the challenges of sustainable development. Great progress has been achieved in waste management, innovative recycling technologies and responsible use of additives.
- Recycling is a key challenge for the PVC industry, given the increasing importance of the Circular Economy Package adopted by the European Commission and its Plastics Strategy.
- The VinylPlus® sustainability program has put the European PVC industry on track toward a model of circular economy and demonstrated that PVC pipes are recyclable.

The aim of the study (b) is to provide a

Cost-Benefit Analysis (CBA) of the recycling of PVC pipes

CBA methodology

- The methodology used for the study is the Cost-Benefit Analysis (CBA).
- This approach allows to examine the direct and indirect impacts of a project (investment, system, technology, plant, etc.) for the community (or a country) as a whole.
- The CBA aims to verify that costs incurred by a project are lower than its benefits.
- The analysis is based on the comparison of different scenarios of carrying on (or not) a project.
- CBA has been developed according to the best practices described in the literature and OECD guidelines.

CBA methodology

- For the purpose of this study, the CBA considers the direct and indirect impacts of PVC pipes recycling.
- Both economic as well as environmental aspects are considered.

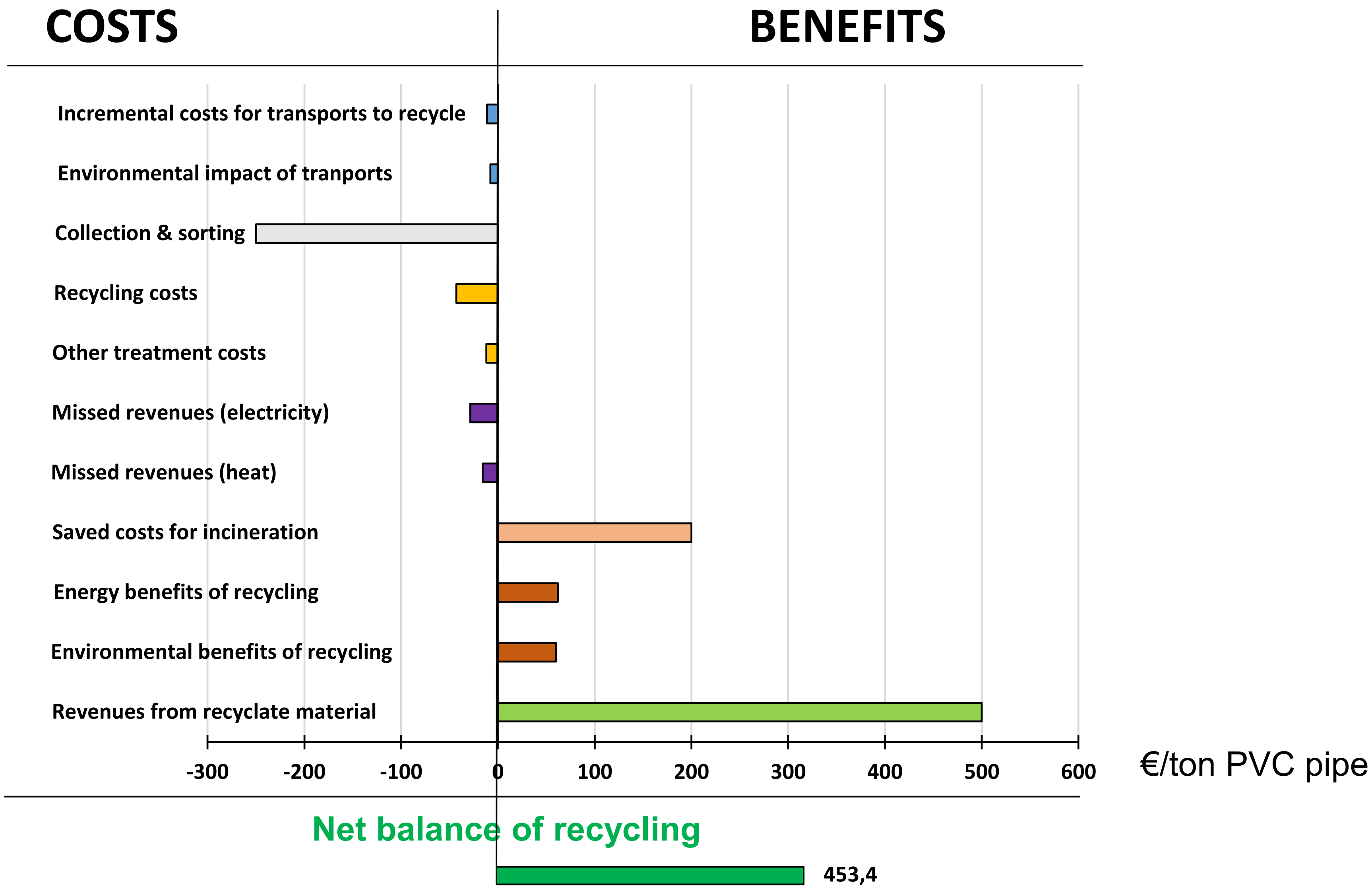
Economic aspects	Environmental aspects
▪ Costs (or missed benefits) ▪ Benefits (or avoided costs) of the PVC pipes recycling	▪ Monetary evaluation of environmental costs (or missed benefits) ▪ Benefits (or avoided costs) of the PVC pipes recycling

CBA study scope

- Geographical scope: Germany and Italy.
- Products: solid wall pipes (Germany and Italy); 3-layer pipes, with inner layer made of recycled PVC (Germany).
- Functional unit: 1 ton of PVC pipe, in order to conduct a diameter-independent CBA analysis. Items expressed in different units of measure have been parametrised according to the functional unit.
- Two different scenarios are considered :
- a) recycling vs. incineration (Germany and Italy)
- b) recycling vs. landfill (Italy)

Main results

Solid wall pipe
-
Recycling vs. Incineration

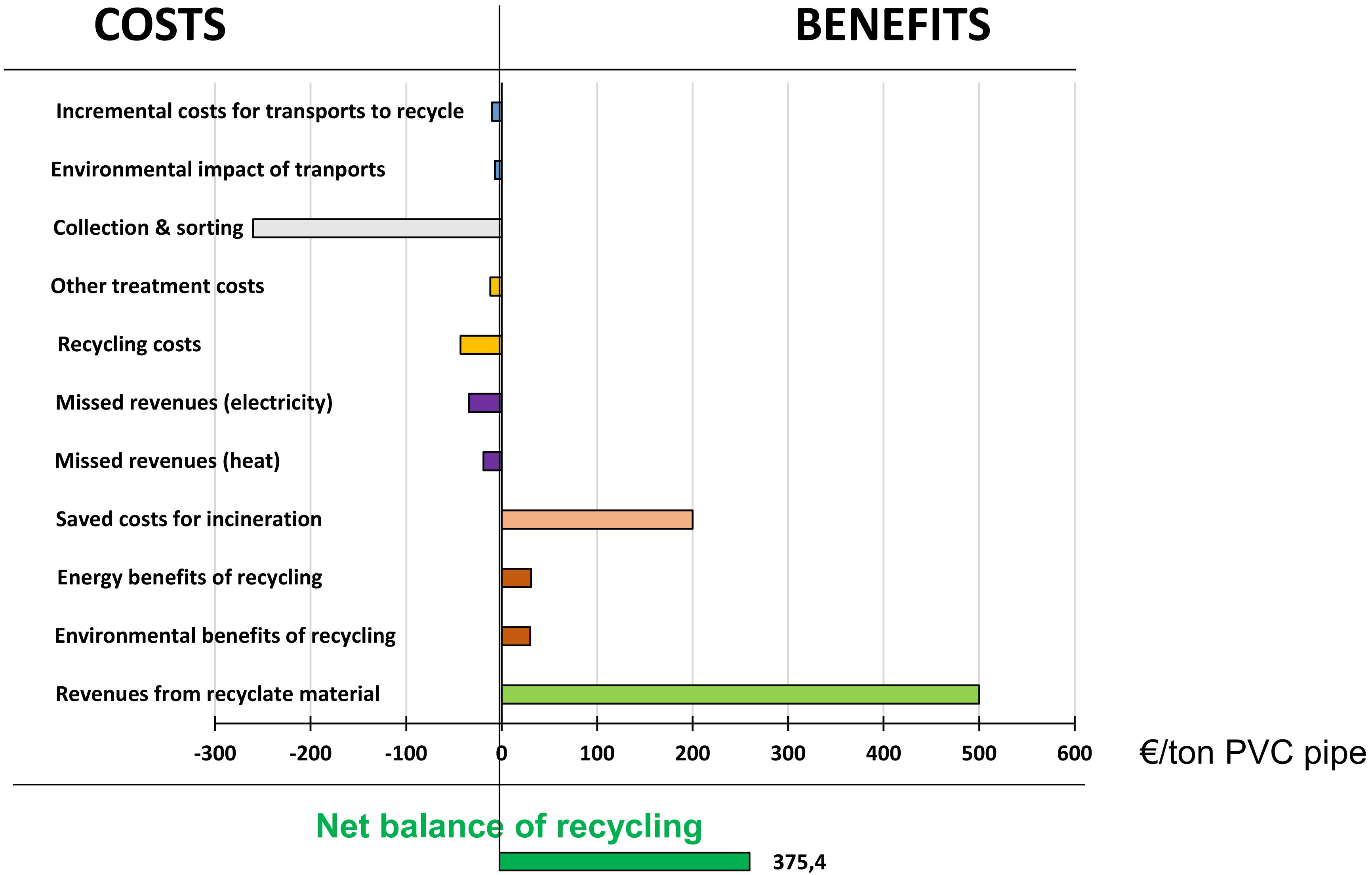


Main results

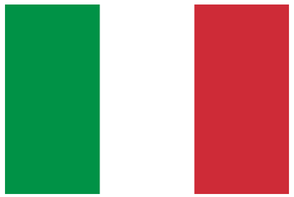
3-layer pipe

-

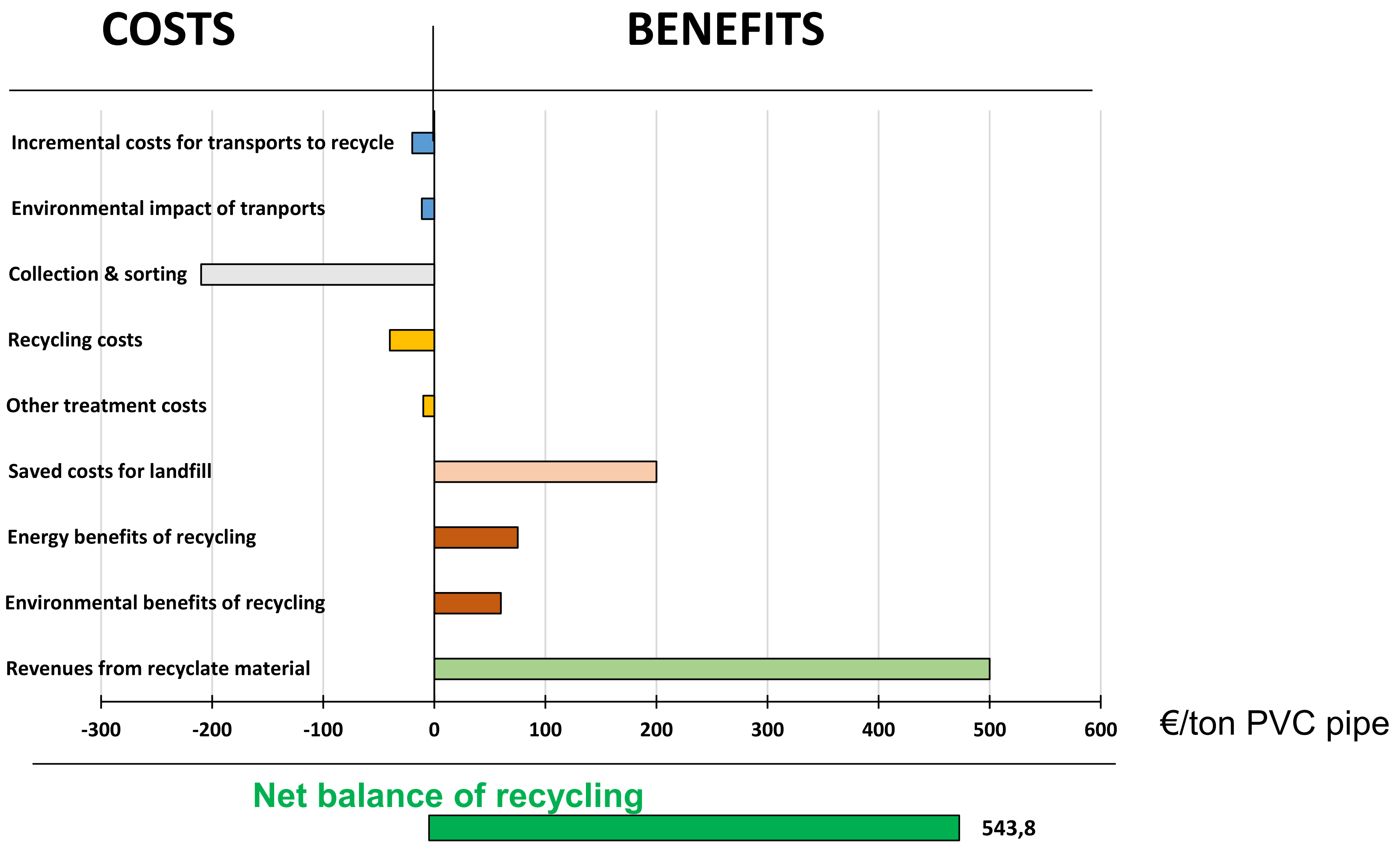
Recycling vs. Incineration



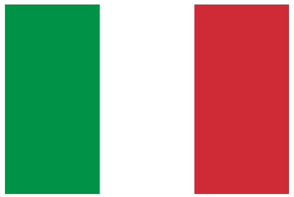
Main results



Solid wall pipe
-
Recycling vs. Landfill



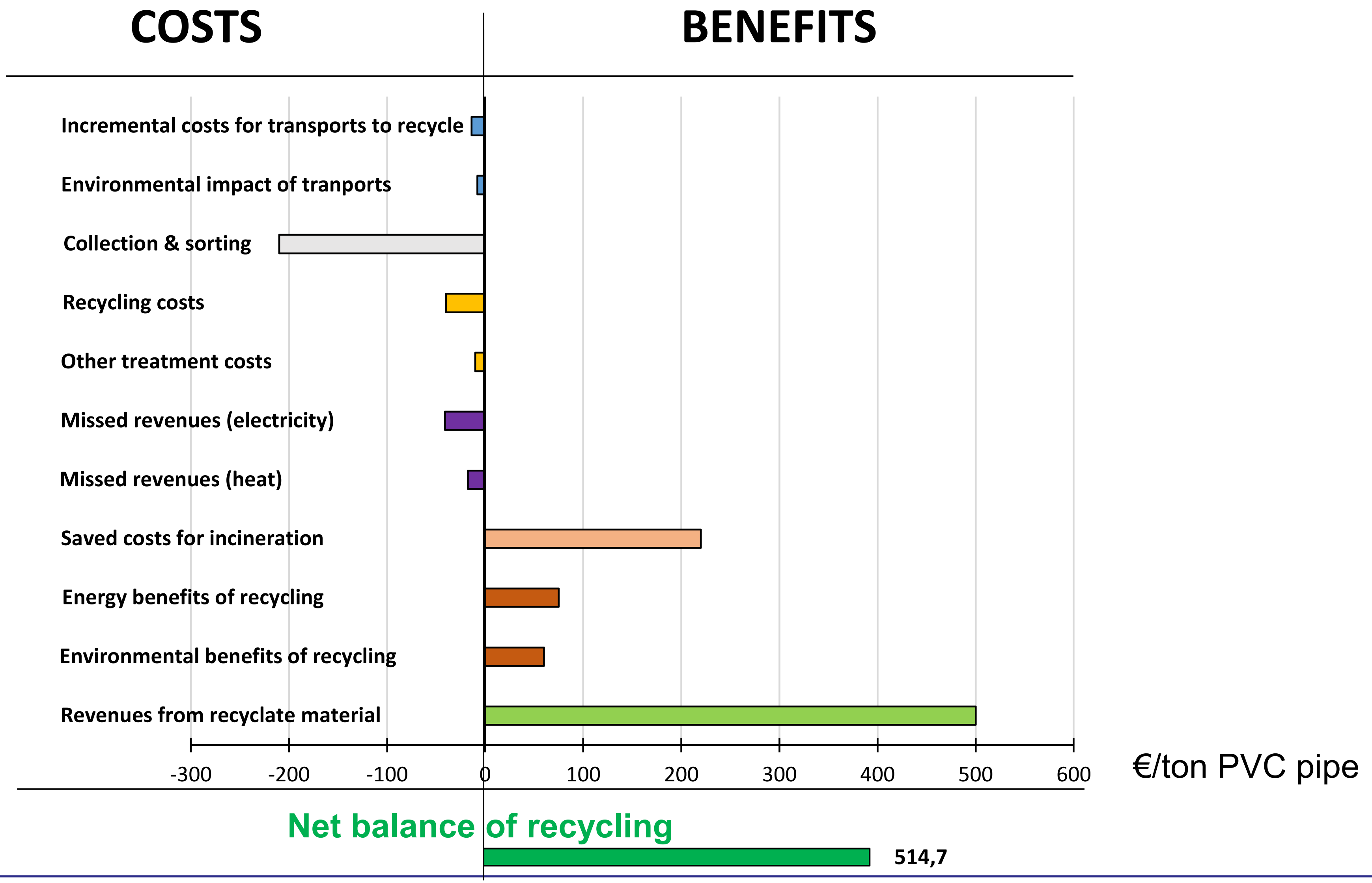
Main results



Solid wall pipe

-

Recycling vs. Incineration



Conclusions

- CBA results show a net benefits balance for recycling in all cases considered.
- In Italy, the net benefits of recycling vs. landfill are greater than recycling vs. incineration due to energy recovery (electricity and heat) during incineration.
- In Germany, the net benefits for 3 layer PVC pipes is lower than for solid wall PVC pipes as the former contain an inner layer of (previously) recycled PVC.
- In all cases, the revenues from recycled material are the main benefits and collection and sorting lead to the main costs. Fluctuations in raw materials' prices will impact the balance.
- Net benefits of recycling vs. incineration are higher in Italy than in Germany (+13,5% for the solid wall pipes) due to lower collection & sorting costs and higher energy price.
- Recycling enhances the cost competitiveness of PVC pipes, already demonstrated in previous TCO assessment as outperforming the alternative non-plastic materials.

Backup – CBA: assumptions and input data

- *Energy consumption of recovered PVC: - 50% vs. primary PVC production.*
- *Environmental benefits of recycling are estimated in terms of CO2 avoided emissions (Emissions Trading Scheme, average price EUAs).*
- *Energy from incineration: power valued to wholesale market price; heat linked to gas price.*
- *Cost for disposal: incineration/landfill: German/Italian national market prices.*
- *Collection-sorting costs: German/Italian national current WM companies costs.*
- *Incremental cost for transportation to recycling site + indirect environmental impacts (assuming a distance of 100 Km between the collecting area and the recycling site).*
- *Recycling/treatments costs: German/Italian national market prices.*
- *Revenues from recovered material: market price at time of the study (2019).*

Backup – CBA: assumptions and input data

Germany

- *Cost for disposal: incineration 200 €/ton PVC.*
- *Collection and sorting costs: a) 250 €/ton for the solid wall pipes; b) 260 €/ton for the 3-layer pipes.*
- *Recycling costs: 43 €/ton PVC + 12 €/ton PVC for other treatments.*
- *Revenues from recovered material: 500 €/ton for both solid wall and 3-layer pipes.*

Italy

- *Cost for disposal: a) landfill 200 €/ton PVC; b) incineration 220 €/ton PVC.*
- *Collection and sorting costs: 210 €/ton for solid wall pipes.*
- *Recycling costs: 40 €/ton PVC + 10 €/ton PVC for other treatments.*
- *Revenues from recovered material: 500 €/ton for solid wall pipes.*

Backup – CBA: assumptions and input data

Some inputs can significantly impact results of the CBA:

- *Raw (and recovered) materials prices are volatile. Study assumed an average price for 2019. Current quotations for plastics are significantly higher than those at the time of the study; today net benefits will be higher.*
- *Carbon emissions price too is volatile. The CBA assumed a CO_2 EUA price of 30 €/ton, by far overcome in the last months; therefore also this item could improve the results*
- *Waste management costs are increasing in many countries. Impacts may be different. On one hand, higher disposal costs could promote recycling; on another hand, collection and sorting costs could slow it down.*

Via Larga, 31 - 20122 Milan - Italy
Tel: +39 02 5831.9401 - info@althesys.com
www.althesys.com

althesys-strategic-consultants

@althesys

Althesys Strategic Consultants

Questions and Answers

ALTHESYS
Strategic Consultants

Prof Alessandro Marangoni

IFPA

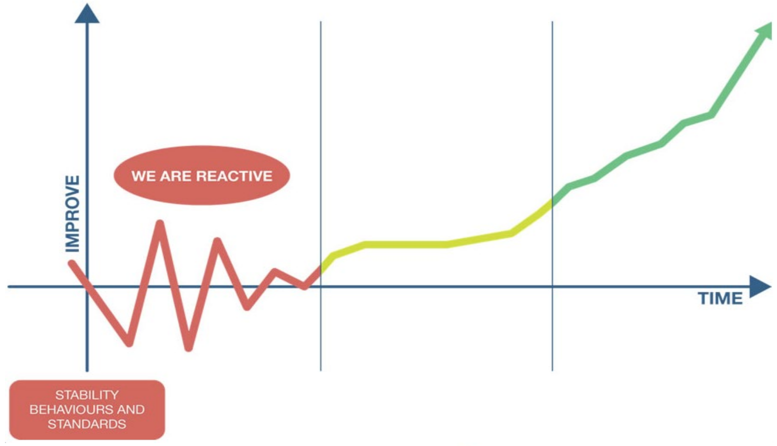
SAPPMA
southern african plastic pipe manufacturers association

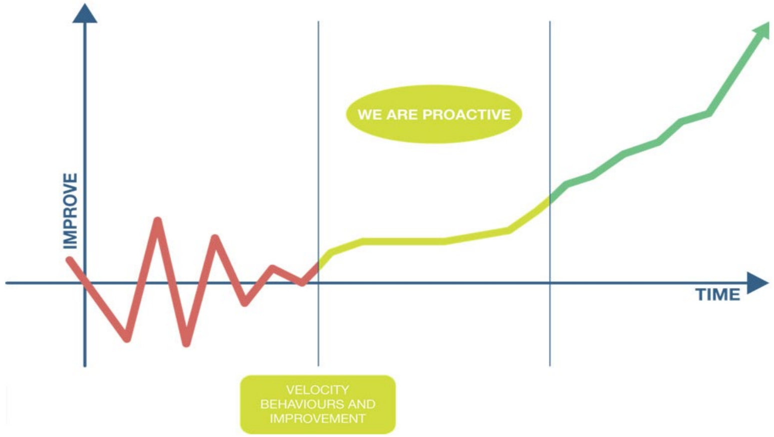
It brings Together

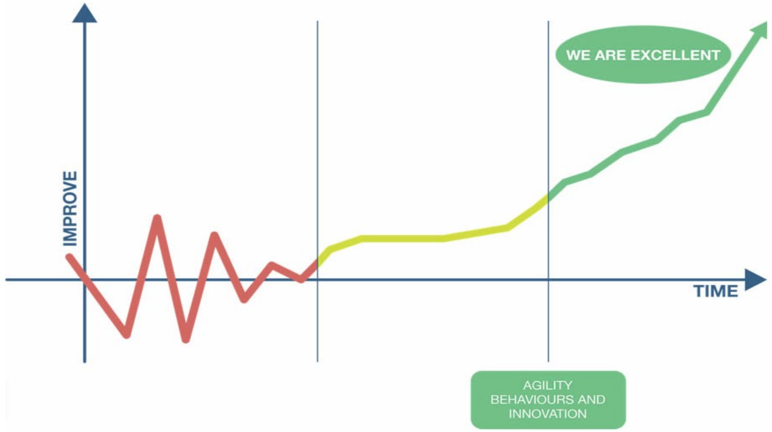
Local Needs

International Support

Satisfied End users



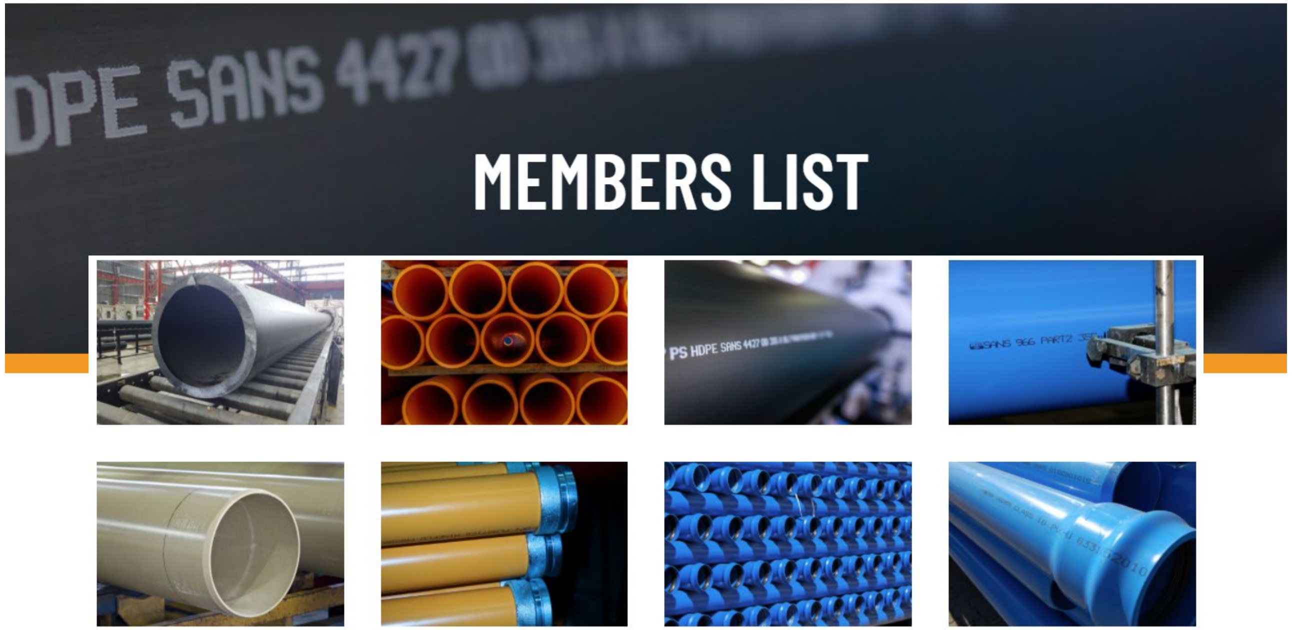




SAPPMA
southern african plastic pipe manufacturers association

Introduction to Member Categories

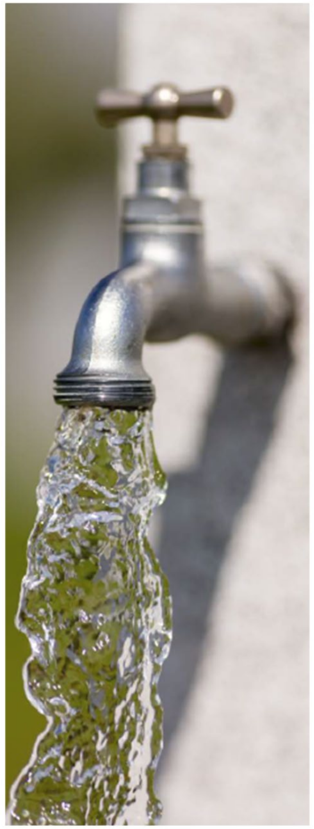
SAPPMA
southern african plastic pipe manufacturers association



- PIPE MANUFACTURERS
- POLYMER MANUFACTURERS
- SUPPLIERS
- CERTIFICATION BODIES
- SPECIALISED MANUFACTURERS
- INDIVIDUAL MEMBERS

"Someone's sitting in the shade today because someone planted a tree a long time ago."

Warren Buffett



INSTALLATION AND FABRICATION PLASTICS PIPE ASSOCIATION

SAPPMA

southern african plastic pipe manufacturers association

Questions and Answers

ian@sappma.co.za
admin@sappma.co.za