BENCHMARKING OPERATIONAL EFFICIENCY IN WASTE COLLECTION: DISCUSSION OF CURRENT APPROACHES AND POSSIBLE ALTERNATIVES

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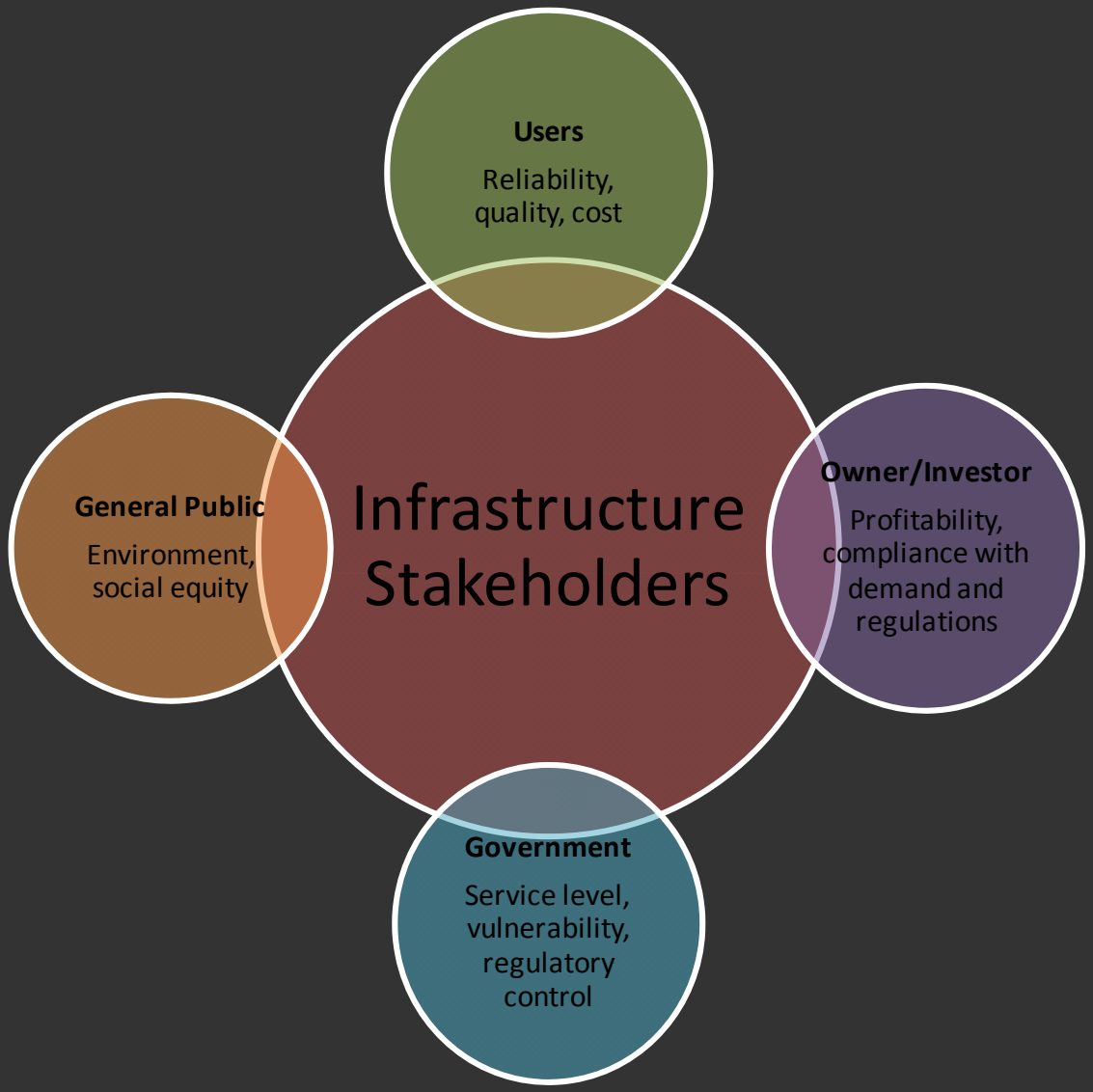
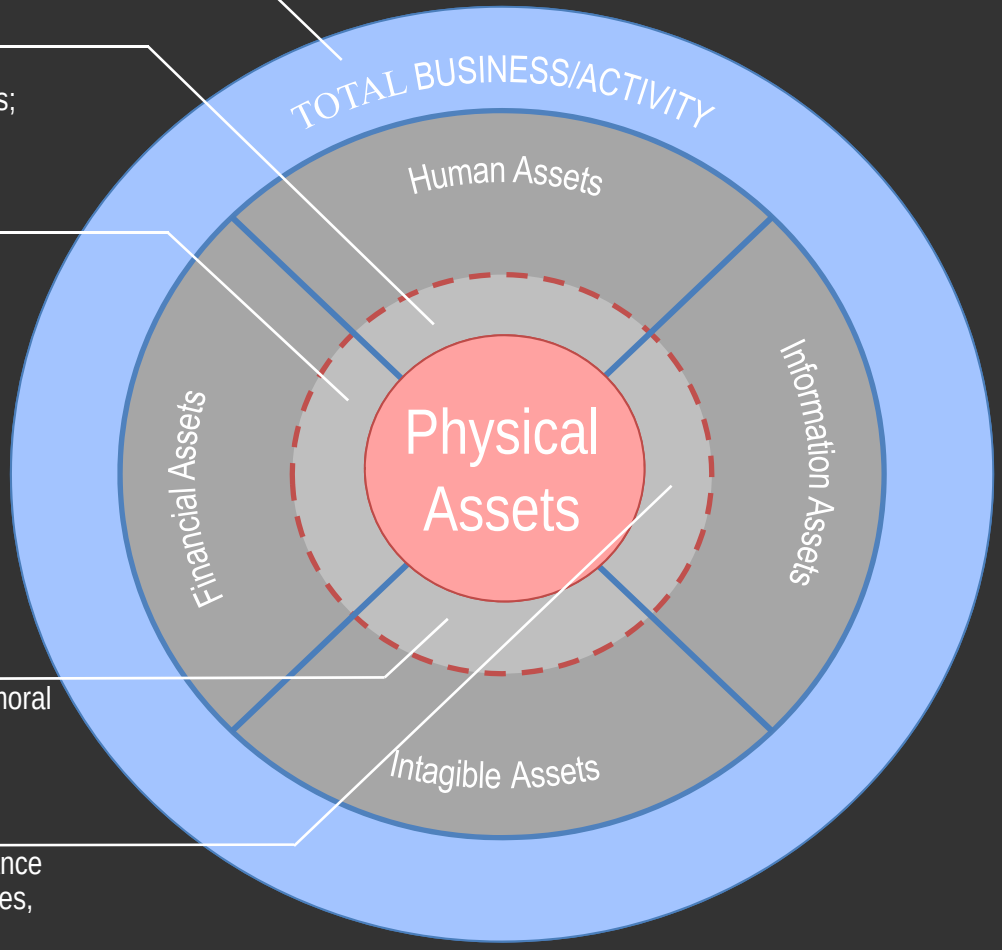

Users
Reliability, quality, cost
General Public
Environment, social equity
Infrastructure Stakeholders
Owner/Investor
Profitability, compliance with demand and regulations
Government
Service level, vulnerability, regulatory control

1. INTRODUCTION

Vital context: business/activity objectives, policies and market; legal and regulatory requirements; socio-cultural context; performance and risk goals

Important interface: motivation; communication; roles and responsabilities; knowledge; experience; competence and capability; leadership; teamwork

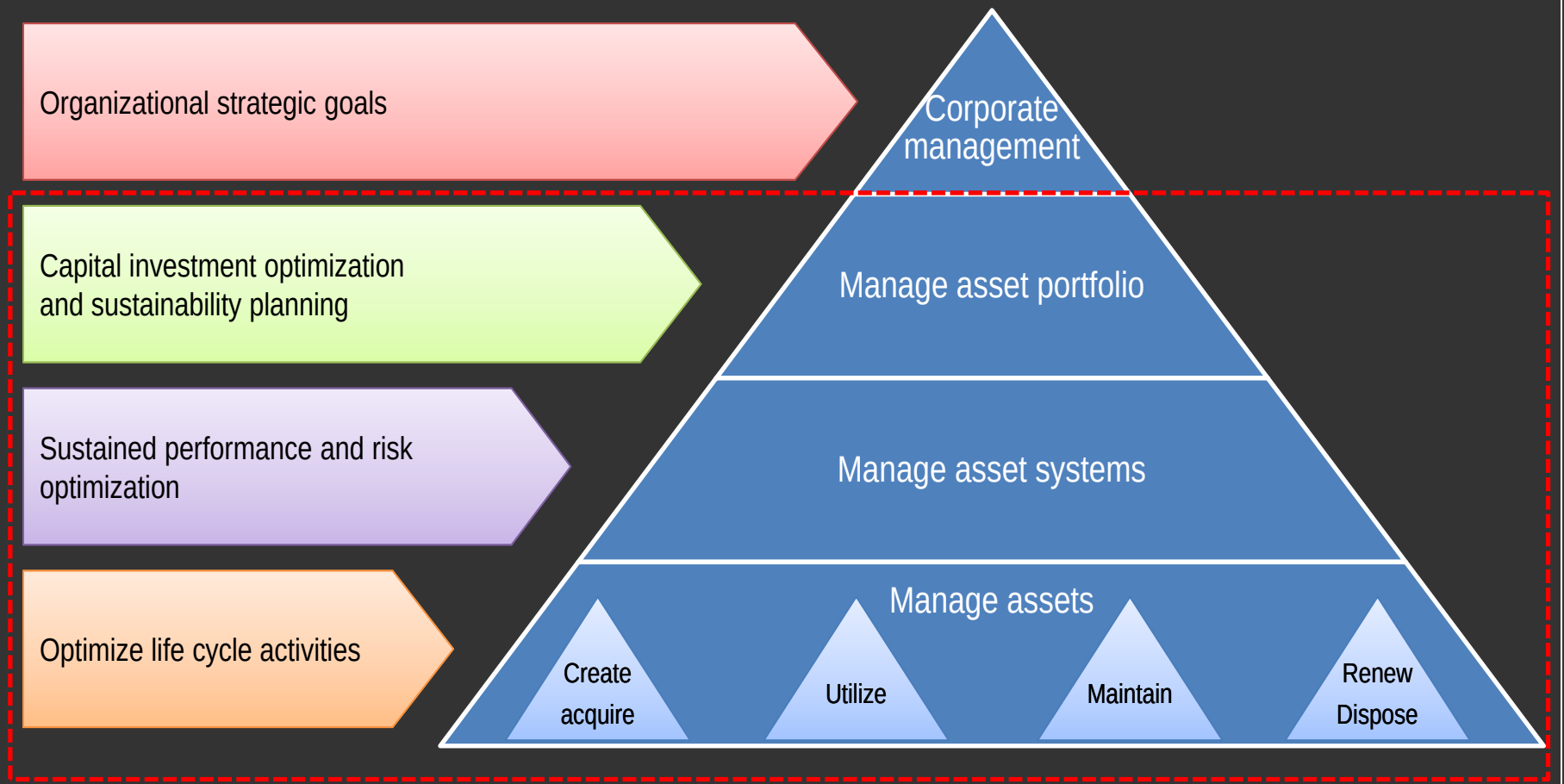
Important interface: life cycle cost; investment criteria, value of asset performance



Important interface: reputation/image; moral and etics constraints; socio-cultural and environmental impact

Important interface: condition; performance level; hazards and opportunities; processes, protocols and activities

1. INTRODUCTION



1. INTRODUCTION

According to the ISO 55000 family of standards (ISO 55001), the performance evaluation includes:

- the asset performance (and associated systems)

- the asset management performance, including financial and non-financial performance, and the effectiveness of the asset management system

These aspects are inter-related, but for the waste sector in the European Union space the focus has been on monitoring the operational asset system performance, in particular the segregate waste collection efficiency, through the use of indicators such as WST 005 - Waste recycling and WST 006 - Diversion of waste from landfill.

The other major performance indicator, WST 004 - Waste generation, measure more policy and socio-economic measures in the waste sector.

Performance indicators:

- Easy to develop, communicate and interpret
- Flexible

Author	Indicators	Scope	Context / Application
Cailean and Teodosiu 2016	18	Environmental / Waste management	National - Romania
Teixeira and Neves 2009	167	Global / Waste management	National - Portugal
Desmond 2006	13	Global / Waste management	International - Europe
Teixeira et al. 2014	3	Operational / Waste collection	Regional - Portugal
Bertanza et al. 2018	13	Operational / Waste collection	Regional - Italy
Ferreira et al. 2017	3	Operational / Waste collection	National - Portugal
Vivanco et al. 2012	2	Service / Waste management	Regional - Spain
Passarini et al. 2011	1	Service / waste collection	Regional - Italy
Dahlén et al. 2007	7	Service / Waste collection	Regional - Sweden
Gallardo et al. 2010	5	Operational / Waste collection	Regional – Spain
Karagiannidis et al. 2004	4	Service / Waste collection	Regional - Greece
Huang et al. 2011	5	Service / Waste collection	National - Taiwan
Greene and Tonjes 2014	11	Service / Waste management	Regional – New York
Rigamonti et al. 2016	3	Environmental / Waste management	Regional - Italy

2. BENCHMARKING APPROACHES

Regression models:

- Can be developed with common data software
- Communicable and interpretable by some elements of the public

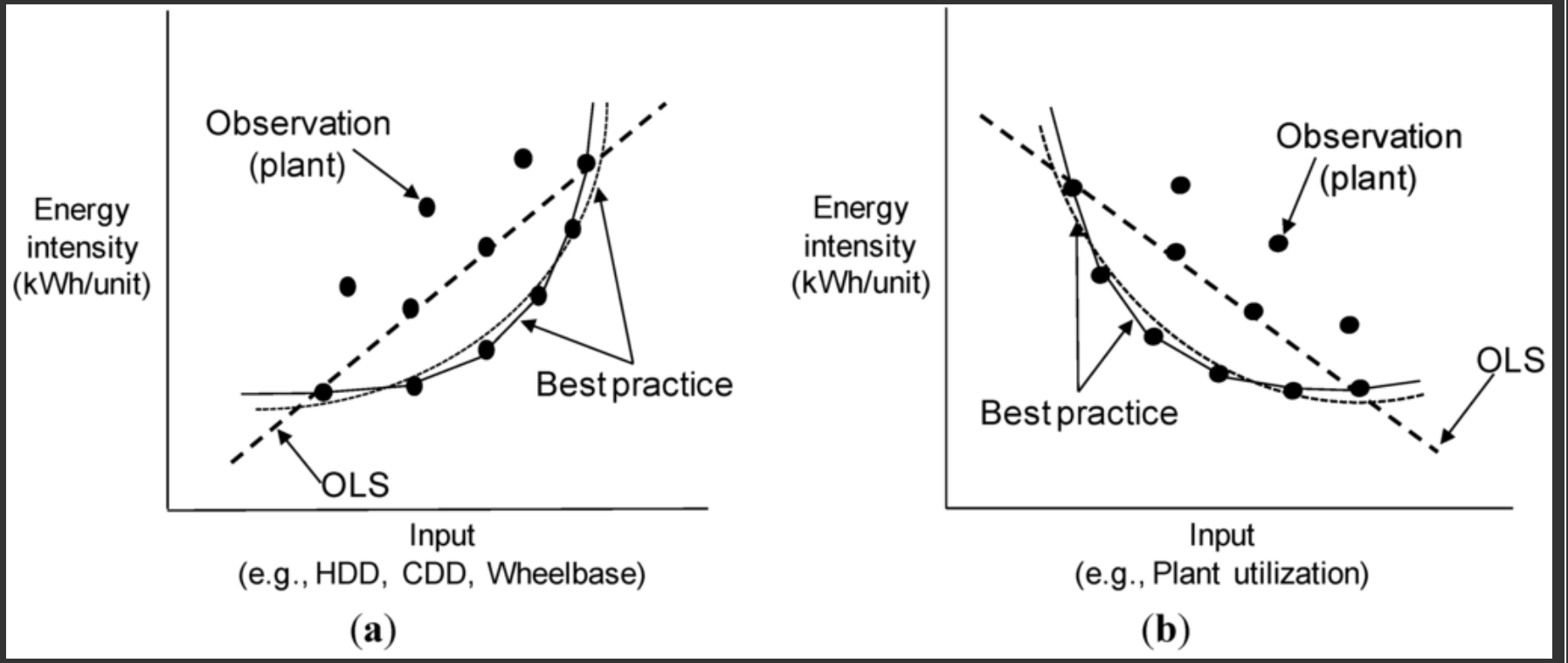
	Bel and Fageda 2010	Plata-Díaz et al. 2014	Greco et al. 2015	Lombrano 2009
INPUTS[1]				
Demographics				
Percentage of non-residential customers			X	
Population served		X	X	X
Population density			X	
Land				
Location			X	
Area			X	
Topography			X	
Service				
Ownership	X		X	
Waste treatment / disposal	X			X
Service Cost		X		
Waste collected	X		X	X
Staff	X		X	
Collection method				X
Collection frequency	X			
Vehicles			X	
Shifts			X	
Other				
Tourism flows	X			
Fiscal stress		X		
Infrastructure quality		X		
Political aspects		X		
OUTPUT	Cost	Management model	Cost	Cost
REGION	Galicia (Spain)	Spain	Italy	Italy
SAMPLE	65	685	67	18
MODEL	OLS Regression	Logistic regression	OLS / Robust Regression	OLS Regression

2. BENCHMARKING APPR

Econometric models:

- Require specific software to develop
- Communicable and interpretable by informed members of the public

	Marques and Simões 2009	Simões et al. 2010	Simões et al. 2012b	Rogge and De Jaeger 2012	Rogge and De Jaeger 2013	Carvalho and Marques 2014	Pérez-López et al. 2016	Guerrini et al. 2017	Sarra et al. 2017
EXOGENOUS FACTORS									
Demographics									
Percentage of non-residential customers								X	
Population served						X		X	
Population density	X	X						X	
Population dispersion									X
Population demographics					X				
Average household size								X	
Land									
Elevation									X
Area						X			X
Wealth									
Income					X				X
Gross Domestic Product	X	X				X			
Service									
Regulation		X				X			
Ownership		X							
Management model						X	X		
Composting		X							
Incineration		X							
Distance to landfill	X								
Distance to treatment facility		X							
No. of years with curbside collection								X	
Collection method								X	
Collection frequency					X				
Tons of waste collected per load								X	
Pricing method					X				
Other									
Road length									X
Tourism flows								X	X
INPUTS									
Service quality							X		
Service Cost	X	X		X	X	X		X	X
Waste collected composition						X			
Staff			X						
No. of containers						X	X		
Vehicles			X						
OUTPUT	Treated waste	Treated and recycled waste	Waste	Waste fractions	Waste fractions	Separated waste	Cost	Recycled and residual waste	Separated and unsorted waste
DMU	29	29	196	293	293	37	771	40	289
Model	DEA	DEA	DEA	DEA	DEA	SFA	PFA	PFA	DEA


Energy intensity (kWh/unit)
Observation (plant)
Best practice
OLS
Input (e.g., HDD, CDD, Wheelbase)
(a)
Energy intensity (kWh/unit)
Observation (plant)
Best practice
OLS
Input (e.g., Plant utilization)
(b)

3. PORTUGUESE SYSTEM

DATA		PERFORMANCE		
		Asset	Management	System
Identification				
dRU01ab	Identification of the utility			
dRU02ab	Governance model		X	
dRU03b	System user			
dRU04ab	Type of area			
dRU05ab	Shareholders positions			
dRU06ab	Contract period			
Households				
dRU07b	Households with waste collection		X	
dRU08ab	Households with selective waste collection		X	
dRU09ab	Existing households			
Complaints				
dRU10ab	Complaints and suggestions		X	x
dRU11ab	Replies to complaints and suggestions		X	x
Waste amount				
dRU12ab	Total waste collected		X	
dRU16ab	Packages selectively collected		X	
dRU17b	Waste collected conveyed for recycling		X	
dRU24b	Unseparated waste collected		X	
dRU26b	Package collection goal		X	
Vehicles, equipment and their use				
dRU28ab	Distance covered by the vehicles	X	x	
dRU29ab	Number of waste collection vehicles	X		
dRU30b	Installed waste collection vehicles capacity	X		
dRU31ab	Waste collection vehicles CO2 emissions	x	X	
dRU32ab	Number of containers washed	X	x	
dRU33ab	Number of containers	X		
Energy				
dRU36b	Fuel consumed	x	X	
Economy				
dRU39b	Average cost of the waste management service		X	
dRU40ab	Average family income			
dRU41ab	Total revenue			
dRU42ab	Total expenditure		X	
Human resources				
dRU44ab	Waste management service in-house personnel		X	
dRU45ab	Waste management service outsourcing personnel		X	
Infrastructures				
dRU46ab	Number of ecopoints (i.e. bring-banks)	X		
dRU47ab	Number of ecocenters	X		
dRU52ab	Number of transfer stations	X		
dRU54b	Installed container capacity	X		
Certifications				
dRU55ab	Environmental management system certification			X
dRU56ab	Quality management system certification			X
dRU57ab	Health and safety management system certification			X
dRU58ab	Other certification			X

3. PORTUGUESE SYSTEM

INDICATOR		DATA	PERFORMANCE		
			Assets	Management	System
Costumer relation adequacy					
Service accessibility					
RU01b	Service coverage	dRU07b / dRU09ab		X	
RU02ab	Selective collection coverage	dRU08ab / dRU09ab		X	
RU03b	Affordability to the service	dRU39a / dRU40ab			
Service Quality					
RU04ab	Waste containers cleaning	dRU32ab / dRU33ab	X		
RU05ab	Replies to written complaints	dRU11ab / dRU10ab		X	x
Service Sustainability					
Economic					
RU06ab	Coverage of total costs	dRU41ab / dRU42ab		X	
Infrastructure					
RU07b	Waste packaging recycling	dRU16ab / dRU26b		X	
RU11ab	Waste collection vehicles renewal	dRU28ab / dRU29ab	x	X	
RU12b	Waste collection vehicles efficient use	dRU24b / dRU30b	x	X	
Human resources production					
RU13b	Adequacy of human resources	(dRU44ab + dRU45ab) / dRU12ab		X	
Environmental sustainability					
Natural resources use efficiency					
RU14b	Efficient energy use	dRU36b / dRU24b	x	X	
Pollution prevention					
RU16b	Greenhouse gas emissions	dRU31ab / dRU24b	x	X	

Most performance indicator used are adequate for monitoring purposes or assessing performance against a given target.

However, for benchmarking purposes most tend to fail since:

- they are context dependent, limiting the correct comparison between the performance of utilities operating in highly distinct contexts (extrapolation of strategies from the best performing to the worse performing may not apply)
- they are not absolute, limiting the possibility to assess if performance can be improved or if optimum has already been attained (the classification of the level of performance will depend on the sample of utilities used for comparison)

$$CCU = \frac{WaC}{WCC}$$

WaC is the waste collected

WCC is the waste collection capacity

The indicator:

- can report to any time interval
- can be calculated for each type of waste stream individually or for the total waste collection service
- depending on the waste stream, the WaC and WCC may be in volume or weight, depending on which is the limiting unit for the waste collection vehicles.

If the same units are used for WaC and WCC (volume or weight), the CCU is an absolute and almost unbiased indicator ranging from 0 to 1. It is absolute indicator in the sense that the performance rating of an utility can be assessed directly and not in comparison with others.

$$SWE = \frac{SWC}{SWC + SWM}$$

SWC is the amount of segregate waste collected

SWM is the amount of waste that could be source-segregated but is currently disposed as unsorted waste

The indicator:

- can report to any time interval
- can be calculated globally or for each segregated waste stream individually

Requires the evaluation of the unsorted waste composition periodically, it is an absolute indicator (a value of 1 means that all waste possible to collect separately is conveyed to the segregate collection) and is unbiased to the differences in waste composition between regions.

5. FINAL REMARKS

Waste managers need to monitor their service performance and identify improvement margins

Regulators need to monitor and compare utilities performance correctly, avoiding biased assessments penalizing utilities operating in very distinct contexts

Since regression and econometric models are not so easy to develop, communicate and interpret, performance indicators are still a highly used option both in research an practice

Despite their limitations, it is possible to develop unbiased and absolute performance indicator in some cases