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COST MINIMIZATION OF WASTE RECYCLING FOR LOWERING ENVIRONMENTAL IMPACT

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Abstract: The costly disorganized waste treatments and reclamation is an increasing factor due to the production processes. Politics of recycling are a model of facing all aspects due to the need of decreasing waste treatment costs and to lower environmental impact. The paper presents a special architecture of a urban bin dedicated for collecting waste for recycling. The bin can be used for promoting politics of recycling by granting people who want to increase their incomes. The idea is to transform cost of waste treatment in gain for people to be encouraged. With this work we want to present the design of a new separate ecological collection or bring system for collecting waste. The technology used is able to remotely manage the history of the users and the status of the containers and of the external structure. For the detection of the waste deposited we use the strain gauges connected to a mobile support.

Keywords: Separate ecological collection, waste management, weight sensors, cost minimization

1. INTRODUCTION

Recycling waste is one of the most important activities in the field of Environmental impact reduction. Managing solid waste requires costly infrastructure and capital investment, and involvement of various stakeholders, particularly local communities if recycling is to be introduced or expanded. Solid waste systems must address evolving waste legislation (including stricter standards) and economic instruments introduced by governments (landfill tax, refund schemes). Managing solid waste is operation intensive, and often labour intensive, thus resulting in high operating costs, particularly for the collection system. There are many choices to be made: choice of waste treatment and disposal facilities, choice of technology, choice of collection system, choice of contractual arrangement, etc. Moreover, the choices should be most cost-effective in the longer term. Yet there are no universal models that could be copied and applied.

Classification of waste management systems (WMS) is depicted in fig.1. WMSs have generally two main strategies: promoting high percentage of recycling according to collection in bring system and kerbside collection; the second strategy is reducing non-recycled materials. The kerbside collection is mandatory for wet household wastes since they cannot be put in public container.

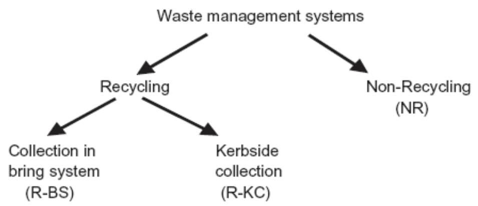

Figure 1. Classification of waste management systems

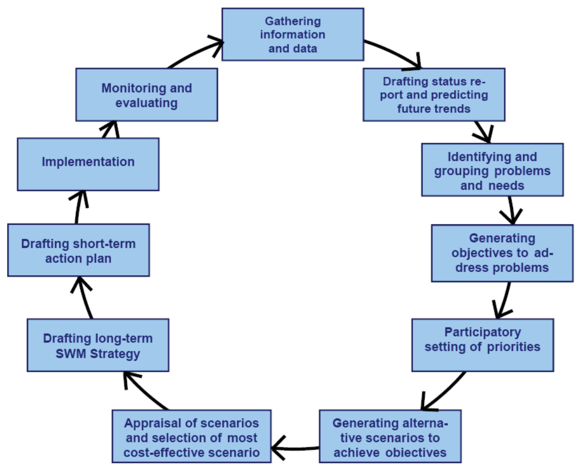

Figure 2. View of strategic planning cycle for solid waste management

The strategy can be expanded as illustrated in fig.2. In this case we are in presence of a system optimization that will bring to cost minimization [1]. Technological aspects are very interesting especially for bins and containers since recycled wastes must be considered as resources [2].

2. AUTOMATIC BRING SYSTEM

Bring system or separate ecological collection is a method (and a location) where people and users bring segregated materials to be put in separate containers or bins [4] [5] [6]. We propose a preliminary approach around a separate ecological collection station or a bring system station. The station composed of 4 electronically controlled containers, and a pole in the iron for the housing of lighting, 3 led camcorders, (in the case of absence of mains) a combined wind / PV and the support for wireless antenna. Within the bins optical switch sensors will be present and will indicate whether the capacity of the bin has reached the maximum volume (or a certain threshold that we want to choose) and a system of electronic scales to record the deposited mass. A card reader is used by people (users) to deal with the system: weighting, quality check, wrong operations, etc… The proposed bring system station is illustrated in fig.3 and in fig.4.

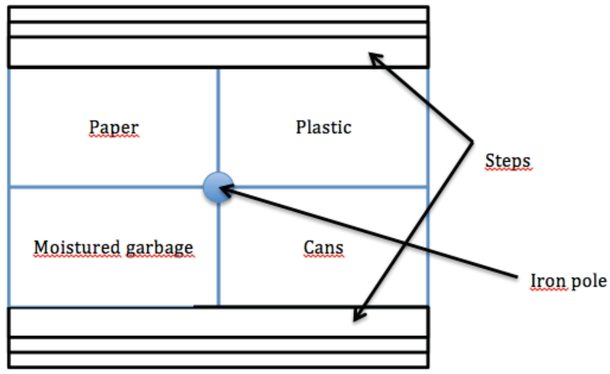

Figure 3. Separate ecological collection station – view from the top.

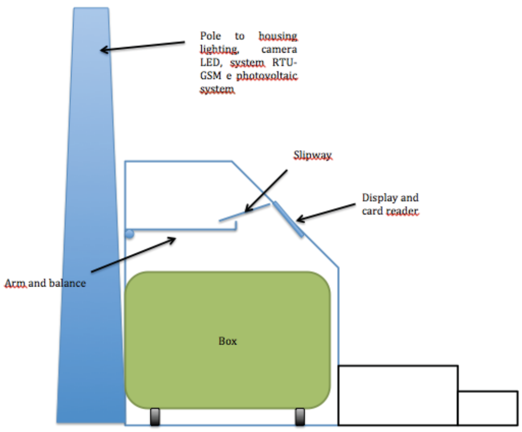

Figure 4. Side view for bring collection station

The bring collection has some necessary sensors for receiving and controlling waste characteristics. The management of the system and sensors network, which can be implemented in the system, is assigned to a control circuit with microcontroller and remotely (fig.5) manageable via a GSM-RTU (Remote Terminal Unit) connected directly to a fixed location (fig.6). They can be used various types of optical sensors to monitor the capacity of the container, the sensors in ohmic contacts crawling for digital scale, a card reader for reading magnetic cards of different users, registered at a municipal office for gaining bonus points.
For easier reading, the system is equipped with a display for illustrating various steps.

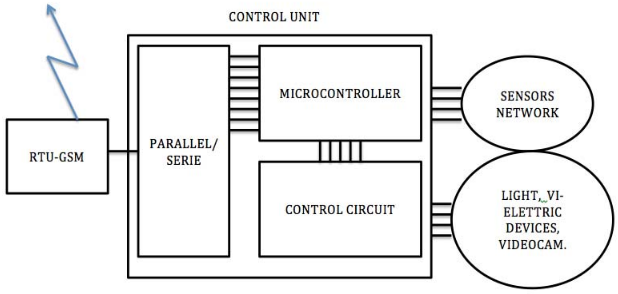

Figure 5. Electronic management of bring collection station.

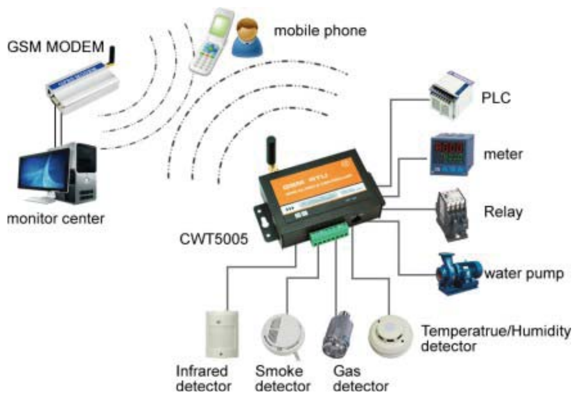

Figure 6. RTU-GSM connection [3]

3. WEIGHT SENSOR ANALYSIS

For the detection of the waste deposited mass we use strain gauges (fig.7) connected to a mobile support [7]. If we have the sensing element inside a Wheastone bridge (fig.8), it is well balanced in the absence of force, instead of the resistance change due to mechanical deformation generated by the weight force of the waste, that produces an unbalance of the bridge, and then generates a potential difference in output.
We know that a conductor of length l and section S presents a resistance

$$R = \rho \frac{l}{S} \tag{1}$$

where ρ is the electrical resistivity. If the conductor is subjected to tensile stress its length l increases and cross-section decreases. Consequently, both the length l that the section S help to increase the resistance of 'extensometer.

Within the limits of the deformations of the elastic type, for a cylindrical body, we got that the relative variation of the radius is connected to the relative change in length by the relation of
Hooke

$$\frac{dr}{r} = -\mu \frac{dl}{l} \tag{2}$$

The quantity μ is called Poisson coefficient.The minus sign shows that with increasing r decreases vice versa. With reference to a circular conductor being

$$R = \rho \frac{l}{\pi r^2} = f(r,l) \tag{3}$$

we have that the total variation of the resistance to change of r and l can be written:

$$\begin{aligned} dR &= \frac{\partial R}{\partial r} dr + \frac{\partial R}{\partial r} dl = -2\rho \frac{l}{\pi r^3} dr + \rho \frac{l}{\pi r^2} dl = \\ &= -2\frac{R}{r} dr + \frac{R}{l} dl \end{aligned} \tag{4}$$

Suitably rearranging the relationship we have:

$$\frac{dR}{R} = \frac{dl}{l} = -2\frac{dr}{r} \tag{5}$$

that Hooke's law is written

$$\frac{dR}{R} = (1+2\mu)\frac{dl}{l} = k_E \frac{dl}{l} \tag{6}$$

The relative variation of the gage resistance is proportional to the relative variation of its length. The proportionality factor $k_E = k$ also takes the name of Gauge Factor and in commercial strain gages it takes a number between 2 and 4. In other words, $k_E = k \in [2{:}\ 4]$. Ideally, the strain gauge resistance varies in response to the applied stress. However, the material of the gage, which is the specific material to which the effort and applied, and is sensitive to temperature variations.By using two strain gauges in the bridge, you can further reduce the effect of temperature. The proposed configuration is able to recognize different type of waste dedicated to bring collection station [8] [9]. The separate wastes can be used for recycling: plastic, glass, metal and paper. A bonus can be given to individuals bringing their wastes to the station if the reach a given threshold quantities in terms of weight [10]. This practice saves money and resources because municipal authorities do not invest in specific lorries and machines for collecting wastes to be recycled [11]. It also allows to prepare materials as less hazardous combustible for further energy production.

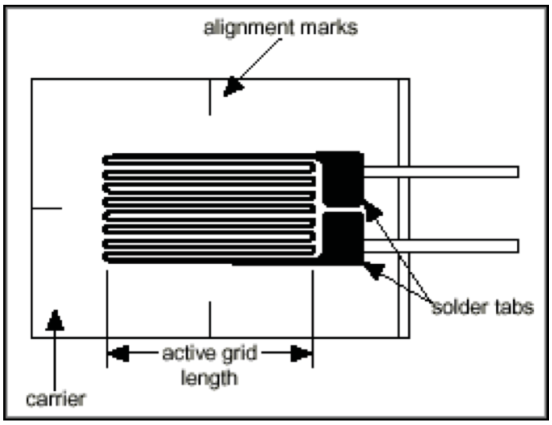

Figure 7. Single strain gauge

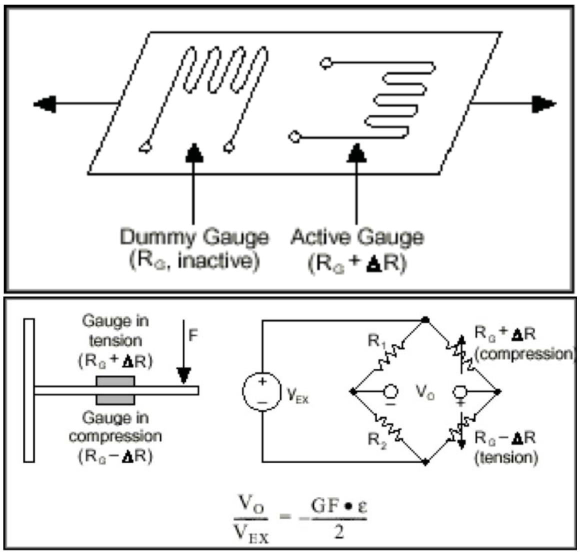

Figure 8. Double strain gauge.

4. FINAL COMMENTS

This paper has highlighted cost issues for waste recycling by taking into account the fact individuals, especial by walk, can bring their wastes to the separate ecological collections located in different areas of a town [12]. However, attention must be paid for hazardous wastes and unfitted ones that can be dropped in the containers or bins. A clear example could be waste contaminated and containing radionuclides from biomedical applications [13]. In some cases, even rarely, they are included in urban wastes. This is a fraud and a bad practice. The impact of bring collection system is to reduce transport costs and to increase the quality of wastes to be recycled. Table I illustrates the effect of recycling on our daily life [14].

Table I
Analyzed processes, ecological effects and process parameters [14]

Waste types	Process		Ecological effects	Process parameters
Residual and bulky waste	Mechanical–biological waste treatment		Electrical net energy use	120 kWh/t
	Thermal treatment of combustible residues	Paper	Air emissions	20% (R), 75% (NR)[a]
			Energy savings (natural gas equivalent)	234.4 Nm3/t
		Plastic	Air emissions	30% (R), 70% (NR)[a]
			Energy savings (Natural gas equivalent)	390.6 Nm3/t
	Materials recycling	Ferrous metals separated	Energy savings and emissions reductions[b]	80%[a]
	Landfill	Compression with compactors	Diesel consumption	2 l/t
		Landfill gas production	Air emissions	6.2 Nm3/t
Organic waste	Compost production		Electrical net energy use	30 kWh/t
			Emissions	Collection rate[c]
Plastic packaging	Collection	Polyethylene bags (production)	Emissions and energy use	Material consumption[c]
	Sorting		Electrical net energy use	67 kWh/t
	Materials recycling	Film	Energy savings and emissions reductions[b]	25% of the collection rate[c]
		Rigid	Energy savings and emissions reductions[b]	25% of the collection rate[c]
	Thermal treatment	Sorting residues	Air emissions	50% of the collection rate[c]
			Energy savings (Natural gas equivalent)	390.6 Nm3/t
Waste paper cardboard	Materials recycling		Energy savings and emissions reductions[b]	Collection rate[c]
Waste glass	Materials recycling		Energy savings and emissions reductions[b]	Collection rate[c]
Metals	Materials recycling	Ferrous metals	Energy savings and emissions reductions[b]	Collection rate[c]

[a] Efficiency of separation as a percentage of the mass input of each waste fraction.
[b] Energy savings and emissions reductions by means of materials recycling relative to the production of raw material.
[c] Depending on the waste management system.

5. REFERENCES

[1] Dariusz Kobus (ed.), "Practical Guidebook on Strategic Planning in Municipal Waste Management", Bertelsmann Stiftung, Güterslo, The World Bank, Washington, D.C., 2003

[2] P. Costi, R. Minciardi, M. Robba, M. Rovatti, R. Sacile, "An environmentally sustainable decision model for urban solid waste management", Waste Management 24, 277–295, 2004.

[3] http://www.mobq2000.com/

[4] A. Lombrano, "Cost efficiency in the management of solid urban waste", Resources, Conservation and Recycling, 53, 601–611, 2009.

[5] A. Paci, C. Becagli, "Public policies and corporate strategies for successful models in waste management", Sinergie, 78, 79–95, 2009.

[6] L. Spinosa1, C. Carella, "Planning the Management of Municipal Solid Waste: The Case of Region "Puglia (Apulia)" in Italy", Integrated Waste Management, 1, 55–78, 2011.

[7] www.ni.com

[8] P. Fiorucci, R. Minciardi, M. Robba, R. Sacile, "Solid waste management in urban areas Development and application of a decision support system", Resources, Conservation and Recycling, 37, 301–328, 2003.

[9] Integrated Solid Waste Management: a Life Cycle Inventory, Second Edition, Forbes R McDougall, Peter R White, Marina Franke and Peter Hindle, Blackwell Science, 2003.

[10] S. Rathi, "Optimization model for integrated municipal solid waste management in Mumbai, India", Environment and Development Economics,12, 105–121, 2007.

[11] P.Beigl, G. Wassermann, F. Schneider, S.Salhofer, "Forecasting Municipal Solid Waste Generation in Major European Cities", iEMSs 2004Proceedings, International Environmental Modelling and Software Society, 2004.

[12]V. Maniezzo, "Algorithms for large directed CARP instances: urban solid waste collection operational support", Technical Report UBLCS-2004-16, 2004.

[13] V. Pelillo, D. Laforgia, " Recovering energy from liquid sanitary waste for direct alcohol fuel cell", Energy and sustainability II, Mammoli & Brebbia (Eds), WITpress, Proceeding of second international conference on energy and sustainability 2009.

[14] P. Beigl, S. Stalhofer, "Comparison of ecological effects and costs of communal waste management systems", Resources Conservation & Recycling, vol.41, pp.83-102, 2004.