Economic evaluation of waste management options for remote areas.

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Abstract

Municipal solid waste management is one of the most pressing issues of today's societies as the consequences of growing economies in waste generation have serious effects on the environment. These effects are even more difficult to tackle in remote areas such as islands or mountainous areas, both types of which are dominant in the Greek topography. More specifically, the current situation is compared financially to a municipal solid waste transportation scenario for treatment in large scale facilities. A statistical analysis of population data and waste generation in the past years will be used to predict the future waste generation in the examined regions. This research concentrates on areas where sanitary landfills are either obsolete or non-existent, and where the common practice is using open dumps. Using geographical data in conjunction with satellite information and some rough estimations for fuel cost in the future, transportation costs are calculated. Advantages of the examined scenario are not limited to monetary terms, but also include social gains for these regions along with new job opportunities. Potential benefits arising from the concentration of transported waste will be explored, and the scope for further research will be presented.

Keywords: municipal solid waste management; waste transportation; waste generation, treatment technologies, logistics

1.INTRODUCTION

The European Union's approach to waste management is based on three principles: waste prevention, recycling - reuse and improving final disposal. Along with these principles, the EU has set a number of directives for each of the member states to follow, and for Greece[1] it is the reduction in municipal solid waste (MSW) landfilled to 75%, 50% and 35%, of what was produced in 1995, by years 2010, 2013 and 2020 respectively. According to Eurostat[2] (2001) in 1995 waste production was 3600000 tons. However, in 2002, still 91.2% (4559 thousand tons) of the municipal solid waste was collected and disposed in landfills (56%), and in 1260 open dumps (44%) while only 8.8% (375thousand tons) was

recycled. This study will focus on the potential alternative options that Greece has for waste management in islands of the Aegean (not including Crete and Euboea islands) and the Ionian seas.

In the aforementioned regions, out of the about 100 inhabited islands (of which about half have populations over 1,000 people), the vast majority relies on open dumps for waste disposal. According to the Hellenic ministry for the Environment, Physical Planning & Public Works[3] (2007), 11 large sanitary landfills existed in the examined islands (none in Northern Aegean islands), 21 were under planning or construction, and 6 smaller landfills were under planning in Southern Aegean islands. One transfer station operates in Kerkira, while no mechanical-biological treatment facilities (MBT) or energy recovery units are located in any of these islands. Finally, one recycle center operates in Rhodes, two in Kerkira and 10 are under consideration in S.Aegean, 3 in N.Aegean and 2 in Ionian islands. It is obvious that with this strategy, many islands are expected to continue using open dumping as the prime waste management option, an unacceptable option by the EU, and as such, heavy fines are to be expected.

2.POPULATION PROJECTIONS AND WASTE GENERATION

Using 2001 census data[4], a statistical analysis of the population per region took place. It was found that in 2001, 6.58% of Greece's population resided in islands (not including Crete and Euboea). Out of these islands, only Rhodes hosts a centre for recovering recyclables. This study concentrates on the remaining populated islands of the Aegean and the Ionian sea. In 2001, the total population of these areas was 604784, and the daily waste generation per capita was 1.128 kg/person*day. Eurostat provides population projections for these islands for years 2011 to 2030. The total permanent population, neglecting the effects of tourism, residing in islands is expected to be almost fixed at about 730000, while the projections for the country's total population indicate a steady increase. A small decline in the percentage of residents in islands to the country's population is therefore predicted, more specifically, from 6.49% in 2011, a gradual imperceptible reduction to 6.33% in 2030?.

At this point, it should be acknowledged that the examined regions attract an important number of tourists each year. According to data from the national statistical service of Greece, in 2006 the total documented overnight stays in hotels, campings etc, were over 20 million nights. It must be noted, that there is a seasonal variation from island to island, and that some islands attract more tourists than others. In addition, these overnight stays do not include people owning properties in these islands and using them for their vacations (not permanent residents). Compared to the 2006 Eurostat estimates for population in the same regions, the percentage of visitors to permanent residents is 8.59% for Ionian, 1.87% for N.Aegean and 11.71% for S.Aegean.

The waste generation differs in each country dependent on the quality of life the residents enjoy. There has also been observed that waste generation per person varies. For what this study is concerned, annual waste generation data for years 1995 to 2008 (European Enviroment Agency[5]) per capita in Greece were used, then using a logarithmic regression estimate to predict waste generation until year 2030[6] (Zis, 2010). It can be calculated that in 2020, the total annual waste generation in said Greek islands, will reach near 360000 tons. Assuming the same increase to waste generation in the islands due to tourism as in 2006, a total of 29232 additional tons of waste is calculated. The total respects to 30.9% of the maximum waste to be landfilled according to the EU directives. Considering that this

waste will be generated in regions housing only 6.33% of the country's total population, it is apparent there is great scope for waste management options in said areas.

Changes in the typical composition are expected and welcome from the EU's directives, as waste prevention is the number one priority. However, one should not expect radical changes in the composition over the next few decades. As previously mentioned all islands still rely on sanitary landfilling (at best). In Greece, in large cities only the last few years have the authorities attempted to promote source separation by collecting two different streams: fermentables and recyclables. If the same project is to be applied in the islands which up until now do not collect any recyclables, up to 49% of total waste could be recovered, helping the country cope with EU's targets, and provide additional revenue from the recyclables.

3.THE CASE STUDY.

Aim of this research carried out in the National Technical University of Athens (NTUA), is to examine if there is scope for sea transportation of waste from remote islands to large scale transfer stations in ports of coastal Greece. If the transportation costs prove to be acceptable, two options emerge. Either collecting all waste from the islands in to two different streams (recyclables and not recyclables) as in large cities, and from there transportation to integrated waste treatment facilities (IWMF) and recyclable centers, or only transporting recyclables, and bury remaining waste in the islands as before, but accomplishing a significant reduction in the final waste deposits. Here a small case study will be presented, sufficient to indicate if there is scope for further research of the subject.

3.1 Landfills in each island

For this study, it has been assumed that these landfills will have a life cycle of ten years, and as such, after this time period , a new landfill must be designed or the existing must be renewed. Since no exact delivery dates were found, it has been assumed that the completed landfills started operating in 2007, while the under construction or design, will be delivered by 2013 (given press articles). Costs of building sanitary landfills anew, maintaining existing ones and renewing those at the end of their cycle were taken from the Hellenic ministry of the environment[3].

The country considers building 5 sanitary landfills in islands Sikinos, Koufonissi, Donoussa, Iraklia and Sxinoussa. The total construction cost for these projects is 2.5 million €, whereas the total population served from these works was 1124 according to the 2001 census. The assumptions were that these landfills will be delivered in 2012, that their life cycle is 8 years each (after which at minimum another 0.5 million € will be needed for renewing the landfills), and the operating costs are 8€ per ton of waste. Using population projections of Eurostat for the Southern Aegean, the populations served for the next 20 years were calculated. To these populations, a steady increase of 11.8% due to tourism was also incorporated. Using the waste generation projections, the total waste generation for the future was calculated. Finally, assuming a 6% interest rate, the net present value (in 2012 prices) of the 5 landfills was estimated close to 3M€. It is noted that these islands are supposed to only bury their waste, so no benefits may arise from recyclables, nor relieving the country for the targets set by the EU.

3.2 Sea transportation scheme

The idea is hiring a ship which will visit each island and receive waste loaded in containers. Instead of routing waste collecting vehicles(WCV's) in open areas as is now happening in the 5 islands, the WCV's will collect waste, and unload it in containers near the ports of these islands. It is assumed that the transportation costs in the island by the WCV's will not alter significantly, as only the destination will change. It is even possible that it will decrease, as in most Greek islands the waste is unloaded in distant cliffs. Then, the ship will collect the loaded containers from each island (visiting them in the most effective order – a small travelling salesman problem), and deliver them in a bigger harbor where a transfer station will operate, readying the containers for road or rail transport to IWMF. For what this case study is concerned, it is suggested that the ship will visit no sooner than when three 19.3 ton containers are filled in any island, while seasonal variation is neglected for waste generation. The necessary investments are buying twice the number of containers needed for that period (so that the ship will unload in the harbors empty containers once it loads the filled ones), and that in each port a ramp for the WCV's will be built to facilitate the loading of the containers.

The results showed, that every 87 days, one container will be filled in the least populated island of the lot (Iraklia), and at the same moment two containers and part of the third will be filled in the most populated islands. This means that the total number of containers required for the project is 20 (10 at the islands at all times, and 10 replacements while the filled ones are transported). A typical cost of buying the containers, is 2000€ each, though it is possible that the municipalities may locate cheaper ones. The costs of building the ramps, to facilitate WCV loading the containers with waste, are assumed to be 1000 € per island, while the cost of the transfer station is not calculated, as there were plans for building 4 transfer stations of 2million € in 4 of the 5 islands (not in Sikinos). It is assumed that a transfer station would be situated near Perama (solely for the case study feasibility, though more research is required to provide for the optimal placement, depending on how many islands will be served by this project and thus what should the capacity of the transfer station be). The optimal path (figure 1) is visiting the islands in the order: Perama-Sikinos-Iraklia-Sxinoussa-Koufonissi-Donoussa-Perama. This was calculated using distances provided by open government data[7], and by modifying straight line distances to travel distances (using a statistical analysis correlating straight line distances between ports and known travel distances) and then by using exhaustive search of potential paths. In each trip, the total distance travelled is 314.96 nautical miles.

Figure 1: optimal Route
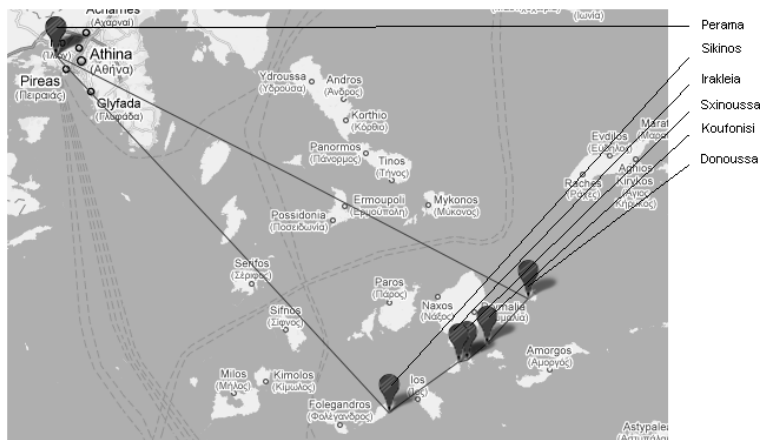
Assuming the ship used for these trips travels with a speed of 10knots, and that it stays 1 hour for loading and unloading the containers in each port, each trip requires at most 3 days to be completed. The fuel consumption is assumed to be 1600 liters per day. The holding costs of the containers near each port are assumed to be 1000€ per container per year. Port dues for the ship were taken as 20€ per day per port (Sambracos[8] et al. 2004) About 80trips will be made throughout the 2012-2030 examination period. This raises the question of whether it is profitable to rent each time a vessel, or even buy one for the whole period. However, for this small case study it is assumed the vessel is rented each time for three days at 10000€ per day. Also, one heavy goods vehicle (HGV) is bought to help loading and unloading the ship, by disembarking at each port and move the containers aboard ship one by one. A typical cost of buying an HGV is around 90000€. The HGV will have to travel from Perama to an IWMF, chosen to be an existing one in Ano Liossia. The return trip distance is found by GIS data to be 23.6km, and given that 10 containers must be transported, with a fuel consumption of 40 lt/100 km, the transportation costs are calculated. Finally, the cost (gate fee) for disposing the five islands' waste in the Attiki's landfill was included at 60€ per ton (Karagiannidis[9]) It should be noted that the 2011 fuel prices (Ministry of development[10]) and the gate fees, were assumed to increase annually by 3%, and that the net present values of both scenarios were calculated assuming an interest rate of 6%. The NPV of this scenario was found to be 1.5M€, which is a close to one half of the proposed solution with 5 sanitary landfills. Both are presented in figure 2.

Figure 2: Cost Flows and NPV comparison
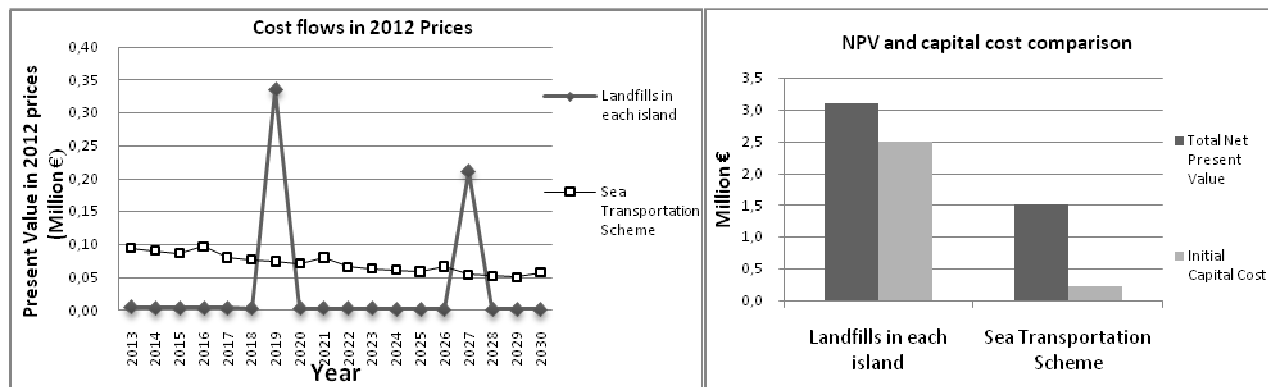
Even though many estimations were made, there is strong indication that this proposal could actually help save money, and that the more islands will be incorporated to a scheme like this, the bigger the benefits (potential economies of scale). Other benefits of this idea will be briefly described. According to Economopoulos[11] (2009), subsidies from recovering all recyclables is ranging from 80 to 135 € per ton, whereas for paper the subsidy is 10€ per ton. The sale price per ton is highly volatile (paper dropped from 55.8 €/ton to 17.6 in only 7 months) according to the same study, so no safe conclusions can be drawn. However, considering that 30% of that waste is paper, selling that paper to the IWMF processing the transported waste (or even trading it for having the IWMF accept the islands' waste), could generate some income. Given that about 600 tons of waste will be annually transported, and that this waste includes around 120 to 150 tons of paper up to 9000€ each year could be a profit, without even considering the relief of the country's targets.

4.CONCLUSIONS

It appears that there is scope for a more extensive use of this option in several of Greece's islands. Especially in islands with low populations as the ones in this case study, where building a sanitary landfill proves not as beneficial. The next step in this research will be to explore the potential in bigger islands, and if it is profitable to use landfills in the islands, or just transport the recyclables via sea to coastal Greece for further processing.

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