

Optimization of the Pay As You Throw system in the municipality of Aglantzia, Cyprus

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Keywords: Pay As You Throw, EU Policies, Waste Management,

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Waste management is a continuously evolving sector at the forefront of the European Union's transition towards a circular economy. The increase of municipal waste quantities and the inefficient practices followed for their process and disposal can pose a serious threat towards human health and the environment through contamination and pollution. To address these issues, the EU has introduced new legislation imposing the implementation of "Pay As You Throw" (PAYT) system to member states. For the first time, emphasis is given to the prevention of waste generation, re-use, recycling and the recovery of materials rather than their disposal.

The PAYT system is based on "The Polluter Pays" Environmental Policy Principle. The total cost of waste management is passed on to the citizens, while providing financial incentives to encourage the separate collection of mixed waste, organic waste and recyclable materials reducing the amount of comingled waste sent for processing or landfilling, thus reducing the overall cost of waste management. Simultaneously, the charge system becomes more transparent to citizens as each individual step is calculated, providing municipal authorities a chance to optimize their services by identifying problems, miscalculations, ineffectiveness of equipment, machinery, process or facilities.

This study focuses on the implementation of a PAYT system in Aglantzia, a municipality belonging to the district of Nicosia (Cyprus) the first area to introduce this system in the island. After an incomplete first attempt in 2013, the municipality chose to implement a PAYT system utilizing pre-paid bags, as a simple and low-cost system to implement using the existing equipment and infrastructure. Moreover, the size of the municipality (roughly twenty-two thousand people) allows for easy monitoring through both the waste collection system operated by the municipal authorities and the recycling system operated by the Non-Profit Packaging Recovery Organization, Green Dot Cyprus for free.

The PAYT pilot program was introduced in 2020 in a small area of the municipality and the overall positive results lead to its full implementation in 2021, as the municipality commenced the circulation of their pre-paid bags of three sizes (10, 35 and 56 liters) with corresponding prices for the citizens to dispose their waste. The first-year results were unexpected as comingled waste quantities were reduced by almost 40%, something that could not be explained by the small increase in the recovery of recyclables or separate collection of green waste. Moreover, even with the financial assistance of the state, the income generated could not cover the necessary expenditures. One possible explanation to this development, is that many citizens chose to bypass the system and discard their waste in neighboring municipal authorities rather than purchase the pre-paid bags and thus pay the municipality's waste management services. Yet, the implementation of the PAYT system was initially celebrated by the municipality as a success.

As the study evaluates the implementation of the PAYT system in the municipality of Aglantzia, it utilizes waste management data obtained by the Municipality of Aglantzia and the Municipal Waste Management Plan 2022-2028 created by the State's Department of Environment, to project the produced waste quantities, the cost of waste management and the relative PAYT charge for the following years. To address the financial losses while simultaneously ensuring that the cost of waste management services does not over exceed the required amount, discouraging citizens to participate in the system, the study introduces two new innovative approaches to optimize the PAYT charge system. First, the introduction of a new Weight to Volume Conversion Coefficient, created specifically for the area of study, based on comingled waste composition. The conversion coefficient is crucial for the calculation of the charge as the total amount of prepaid bags used per year is derived from the volume of waste produced by each household. Second, the system's charge for waste management services is extracted using the new PAYT Charge Optimization Equation, which is then minimized using programming, ensuring both the

system's financial stability and the lowest possible charge for municipal residents providing financial incentives to participate.

Using these two optimization factors, the PAYT charge of three different PAYT charge systems is calculated and analyzed for the projected waste quantities of the years 2022-2028: the current system incorporating the municipal fee in its entirety to prepaid bags and two Dual Charge systems with 60 and 30 percent partial fixed charge and the rest by incorporating the municipal fee to the cost of prepaid bags. Following these calculations, four scenarios were created with different increasing rates of diversion for the four main waste streams, Organic Waste, PMD (Plastic, Metal, Drink Cartons), Paper-Carton and Glass, to calculate the total cost of waste management and the reduced charges of the PAYT system as well as simulate the effect of reaching the targets imposed by the EU. Especially for the first year of implementation 2021, the study compares the calculated PAYT charge and the subsequent municipal income using: the current PAYT charge of the prepaid bag and weight to volume coefficient, the current weight to volume coefficient with the proposed charge optimization equation and the proposed weight to volume coefficient incorporated to the charge optimization equation. Finally, the study presents a sensitivity analysis of the use of the new waste to volume coefficient based on the PAYT charge, the number and cost of prepaid bags per household and the generated income for the municipality.

The study concludes that the current state of the PAYT system of Aglantzia presents three main limitations. The municipalities' failure to anticipate the public's reaction to the system, the miscalculations regarding the cost of the prepaid bags and the lack of a fixed source of income to prevent financial losses. Simultaneously, the study proves that a well thought out plan, amending and optimizing the current system can be proven successful, reducing the overall cost of waste management services both for citizens and the municipal authorities while ensuring a continuous stream of income providing financial stability. Most importantly, the diversion of a significant amount of packaging and biodegradable waste from commingled waste can make a difference, as recycling, reusing and composting becomes a practice in people's everyday lives.