Master's Degree program in Engineering and Management

"Adapting market proposition of a waste management system to customers' needs"

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Introduction

The aim of the work consists in identifying the *ITOI* (Intelligent Tool for Optimized Instructions) suite's sales prospects and ICT skills for the *moltosenso* company's waste management market sector, adapting the market proposition based on the management model of the various companies and developing the best strategy to go to market.

AI in the waste management sector

The waste management processes involve a lot of technical, environmental, socio-economic and legislative parameters; such nonlinear processes are difficult to model, predict and optimize with the use of conventional methods[1]. Recently, artificial intelligence techniques have tried to offer alternative computational approaches to solve **solid waste management (SWM)** problems. AI models such as artificial neural network (ANN), Support vector machines (SVM), linear regression analysis (LR), decision trees (DT) and genetic algorithm (GA) can solve ill-defined problems, configure complex mapping and predict results. Here below the description of these models is reported.

ANNs models are effective in modelling processes with incomplete or uncertain data sets as well as dealing with complicated and imprecise tasks requiring human intuition.

SVMs are supervised machine learning algorithms useful for data analysis and have recently evolved to solve regression problems as it was found to outperform several classical regression techniques.

LR is an overseen technique used to model a target value on the basis of independent predictors; however, since the SWM models depend typically on numerous parameters, the use of multiple LR is more appropriate to simulate these processes. The results obtained from LR are easy to interpret and the

[1] Mohamed Abdallah, Manar Abu Talib, Sainab Feroz, Qassim Nasir, Hadeer Abdalla, Bayan Mahfood, "Artificial intelligence applications in solid waste management: A systematic research review", 30th April 2020

computational costs are low, but this method is generally considered unsuitable for modelling nonlinear data.

DT is a classification technique used to extract a set of rules from unfamiliar data. It is particularly useful for expert systems, capable of generating results similar to those from a human specialist in a given field, but it has a tendency for data overfitting.

GA is a class of metaheuristic algorithms that mimic natural evolution. GAs execute optimization techniques in a binary search space where instead of enhancing a single solution, they improve a set of hypotheses; the negative side is that they require meticulous construction and incorrect selection of operators may adversely affect the results generated by the model.

An analysis of studies covered worldwide from 2004 to 2019 revealed six primary AI application fields in SWM: waste dumpster level detection, forecasting of waste characteristics, process parameters prediction, process output prediction, vehicle routing, and SWM planning.

Dumpster level detection models are developed to predict the fullness of waste dumpsters, which can be effectively used to deal with improper waste disposal and overloading of waste dumpsters. The performance of smart waste collection systems is affected by the temporal variations in the disposed quantities and the algorithms are typically fed with real-time data from level or image sensors installed in smart waste dumpsters.

Efficient collection, treatment and disposal of MSW are dependent on accurate **prediction of waste characteristics**, which are affected by numerous technical, socioeconomic, legal, environmental and cultural elements. The prediction of waste characteristics includes the classification of waste materials, waste compression ratio and waste generation, patterns or trends. Several studies focused on the classification of waste materials to be used in automated sorting systems that eliminate manual waste segregation; most of these studies used ANNs for the identification of different waste fractions and one study used hyperspectral imaging and multi-layer ANNs to recognize various types of plastics in e-waste, showing a 99% accuracy in identifying these materials[2].

[2] Tehrani, A., Karbasi, H., “A novel integration of hyper-spectral imaging and neural networks to process waste electrical and electronic plastics. IEEE Conference on Technologies for Sustainability”, 2017

Modelling and optimization of process variables are crucial in the design and operation of waste-to-energy technologies. Over the last decade, few studies have explored the use of AI in the **prediction of process parameters** such as the waste heating value and co-melting temperature. A study examined the efficiency of ANNs for the prediction of low heating values of solid waste[3]; another study used GM and ANN in the prediction of co-melting temperatures of sewage sludge ash and fly ash generated from an incinerator fed with MSW and concluded that in case of insufficient data, GM can successfully predict outcomes as it requires only a minimum of four data points[4].

Quantifying useful by-products such as biogas and energy, as well as harmful by-products such as leachate and emissions is essential for optimal waste management. Several studies have been developed models to **predict the composition and quantity of different by-products** generated from waste management processes. For example, one study[5] compared different ANN algorithms to predict biogas generation from bioreactor landfills and another one[6] developed an ANFIS - Adaptive Neuro-Fuzzy Inference System, based on fuzzy logic (FL) - model to estimate landfill gas production, reporting a 98% confidence level.

Adequate **waste collection routing** is an essential part of a successful integrated SWM strategy; collection works typically constitute 70 to 85% of the overall SWM costs. Unorganized collection schedules and inadequate allocation of trucks result in unnecessary vehicular emissions and traffic congestions, in addition to increasing the operating costs. Several studies have developed optimization models for the waste collection frequency and route planning; most of them using GA and its hybrid versions. A study implemented GA for route optimization during the collection of electrical and electronic household wastes[7]. Utilizing GA helped to decrease the costs of collection due to optimized route distance, number of collection vehicles and employees. The methodology

[3] Ogwueleka, T.C., Ogwueleka, F.N., “Modelling energy content of municipal solid waste”, 2010
[4] Pai, T., Lin, K., Shie, J., Chang, T., Chen, B., “Predicting the co-melting temperatures of municipal solid waste incinerator fly ash and sewage sludge ash using grey model and neural network”, 2010
[5] Ozkaya, B., Demir, A., Bilgili, M.S., “Neural network prediction model for the methane fraction in biogas from field-scale landfill bioreactors”, 2007
[6] Abdallah, M., Warith, M., Narbaitz, R., Petriu, E., Kennedy, K., “Combining fuzzy logic and neural networks in modeling landfill gas production”, 2011
[7] Król, A., Nowakowski, P., Mrówczyn, B., “How to improve WEEE management? Novel approach in mobile collection with application of artificial intelligence”, 2016

suggested user participation in scheduling waste collection requests to generate optimized routes; the analysis results showed that, even though the AI optimized route length was shortened, the average time of service was longer than the non-optimized solution by 85%. Another study utilized a modified Dijkstra algorithm in GIS for optimal route options, and further assimilated the obtained solutions in GA to determine the optimum route; the proposed approach improved operating distance, travel time, and fuel consumption by 8, 28 and 3%, respectively[8]. The mobility management topic would be further discussed, being the subject of some european projects that would be mentioned in this thesis.

SWM planning covers the decision-making and optimization of management practices in order to accomplish strategic goals. It is a wide domain including the development of waste collection strategies, the site of SWM facilities, illegal disposal prevention and optimization of costs and environmental impacts during waste collection, transportation, treatment and disposal. Various studies have implemented AI methods for waste management planning and one study in particular implemented DTs to detect illegal waste disposal and was successful at discovering more than 500 trucks potentially engaged in illegal dumping. Another study[9] used SVMs and satellite data to locate agricultural plastic waste, and aid in waste facility siting and route mapping. SVM was used to classify images and distinguish between crops and plastic waste, with a 94.5% accuracy.

It is evident that traditional methods - based on mechanistic models and strict algorithms - do not seem to provide an adequate solution in many cases, particularly those suffering from lack of data. Although AI-based SWM systems are still mostly in the research and development (R&D) phase, they offer an alternative effective approach which has gained significant attention in the scientific community and the research in this field is rapidly advancing.

[8] Amal, L., Son, L.H., Chabchoub, H., “SGA: spatial GIS-based genetic algorithm for route optimization of municipal solid waste collection”, 2018

[9] Lanorte, A., Santis, F. De, Nolè, G., Blanco, I., Viviana, R., Schettini, E., Vox, G., “Agricultural plastic waste spatial estimation by Landsat 8 satellite images”, 2017

Big Data and waste management

The evolution of the smart cities

The term *big data* refers both to the confluence of enormous masses of data, heterogeneous between them and from the most varied sources, as - above all - to their reading and re-elaboration for forecasting purposes. This is an epochal phenomenon since, as the curator of TED Talks Chris Anderson observed, the data alone do not speak, but "with a sufficient number of data, the numbers speak for themselves" and must therefore be managed, verified and taken under control.

Between 2016 and 2018 there was a 90% increase in the worldwide produced data[10] and at the same time the analysis techniques have been refined, with an increasingly marked distinction between the descriptive statistics used by business intelligence and the inferential statistics used by big data themselves, more complex and more effective.

With the increase of population density and the rural migration to cities, urbanization is assuming extreme proportions and presents a tremendous urban problem related to waste generation. The increase of waste generation has been considered as a great challenge to large urban centers and represents a problem particularly for countries with accelerated population growth in cities. The Internet of Things (IoT) and cloud computing offer an automation possibility through cyber physical systems that will change the way solid waste management is performed.

The European Union has defined smart cities (SC) as systems where people interact and use materials, services, energy and waste to stimulate development of the economy and improve the life quality. These flows of interaction are considered to be intelligent because they make strategic use of services, infrastructures, information and communication in planning urban management, a way to meet the economic and social needs of society.

Smart cities and the Internet of Things connecting anything to the Internet regardless of its size is the main concept of the Internet of Things (IoT), where

[10] Michele Lovati, 'Quanto sono grandi i Big Data?', 14 giugno 2018 (*http://www.datamanager.it/2018/06/quanto-sono-grandi-i-big-data/*)

objects interact with their surroundings and can be remotely supervised by user[11]. Possibilities for technological developments through smart technologies are extensive, but critical approaches also need to be addressed to enable the sustainable and gradual implementation of IoT technologies (for example to investigate environmental impacts of smart technologies). The number of Internet-connected devices is rapidly increasing and could reach more than 34 milliards by 2025 according to response predictions, which means a significant rise in IoT infrastructure.

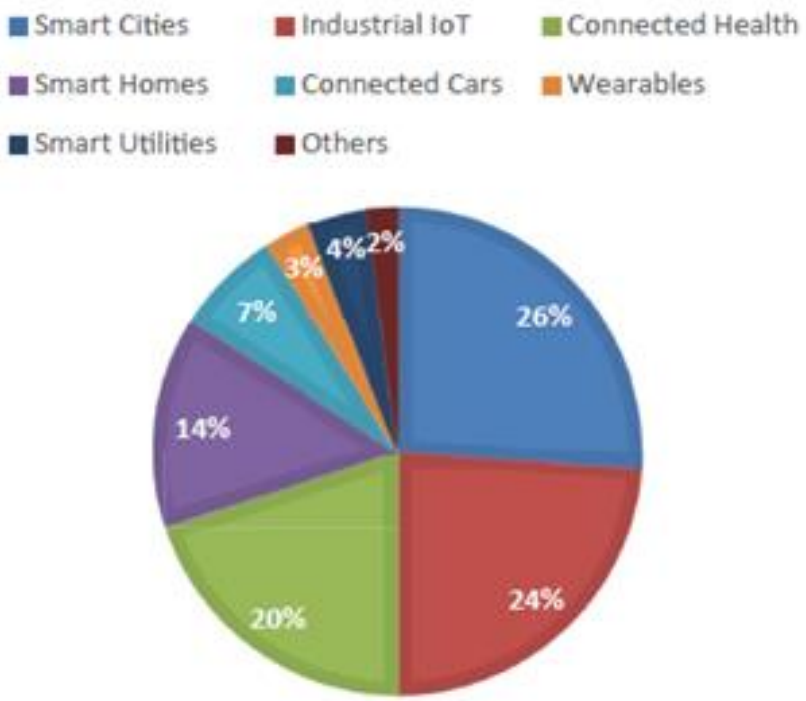


Fig. 24. IoT technologies for different applications (Forbes, 2017)

Recently investigated smart concepts are focused on several topics: smart city's framework, smart metering, smart transportation, security, smart agriculture and smart waste management. Smart technologies are considered as an opportunity for cost reductions, a tool for the improvement of service quality and a way to achieve the reduction of environmental impacts.

In order to achieve the transformation of traditional cities into smart cities, waste management becomes a critical element in achieving sustainability, efficiency in public spending, improving urban mobility, and preserving natural resources.

[11] Sandro Nizetic, Nedjib Djilali, Agis Papadopoulos, Joel J.P.C. Rodrigues, "Smart technologies for promotion of energy efficiency, utilization of sustainable resources and waste management", 3rd May 2019

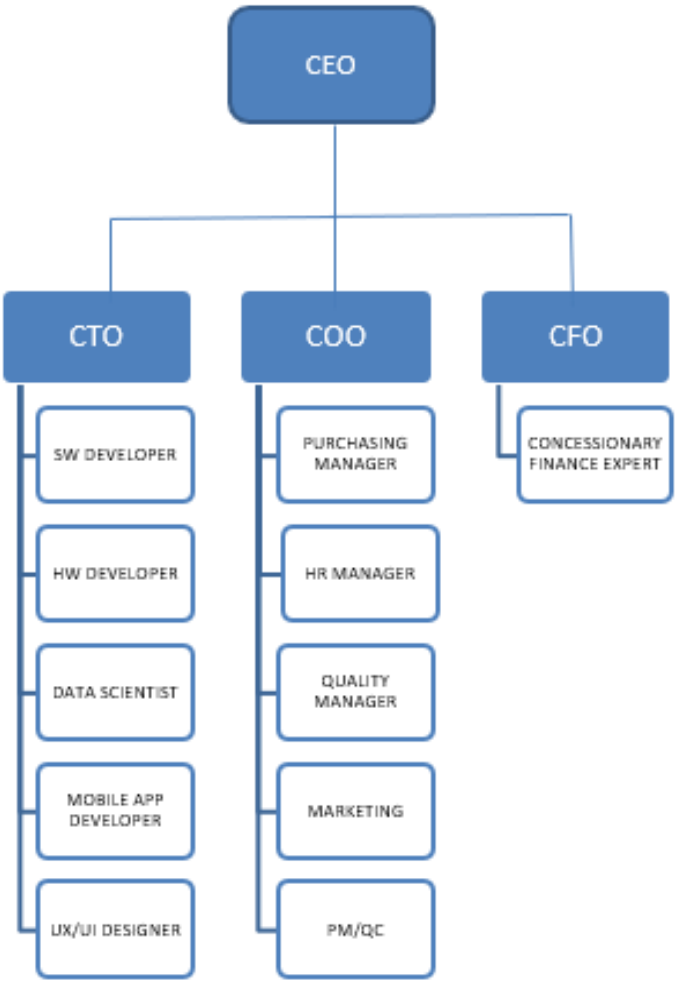
Recent literature has been inspected in order to look for variant characteristics and aspects of intelligent waste management systems using the IoT[12].

With the use of IoT, it is possible to track the waste containers location, monitor the level of deposited garbage, identify locations with the highest demand, suggest the shortest and best routes for collection optimization of solid waste or even interface with citizens to encourage disposal when the container can receive waste, which promotes citizenship and avoids significant problems of garbage accumulation.

[12] Kellow Pardini, Joel J. P. C. Rodrigues, Sergei A. Kozlov, Neeraj Kumar and Vasco Furtado, "IoT-Based Solid Waste Management Solutions: A Survey", 2019

The innovativeness of moltosenso's approach and ITOI creation

moltosenso company is an innovative SME founded in 2009 specialized on Internet of Things and Big Data analysis services; here there is the Organisation Chart:



The company mission is to work as a strategic partner of its customers and partners in the research and implementation of new ICT solutions, accompanying them on the path to success. This results into a wide range of services that includes consultancy, the search for subsidized financing tools and the GDPR compliance assistance, as well as the development of applied technology for IoT and Waste Management. ITOI project was co-founded under Regione Toscana POR FESR 2014-2020 funding scheme (ERDF programme) and the first customized deployment was on Cidiu Servizi, delivering great results both in savings and planning procedures.

ITOI is a complex ecosystem consisting of a suite of applications and a set of tools that allows optimal planning of waste collection cycles, minimizing costs, preventing the dumpsters from exceeding the filling limit and reducing the number of shifts and the vehicles cost of use.

Study of the value proposition of ITOI (and the alternative approaches)

The segments to which it applies, the benefits, limits, implementation and switching costs between customers.

In order to realize the optimum planning of waste collection – while minimizing the costs – the market offers three different approaches, some well tested and some other more innovative.

1. **Periodic approach**

It is the most common collection method, applicable to all waste types, with some minor changes.
It is based on the empirical knowledge of the fulfilment rate of the collection area: the level of service is tailored on the most critical dumpster. It defines a periodic scheduling to chase the most producing dumpsters, usually independent from the production seasonality.

The pros are that it is characterised by the limited effort during the high-level definition of the service (usually agreed during the public procurement with the municipalities), the scheduling made using fixed routes, the easy management of vehicles and manpower and the easy forecast of the service costs.

The cons are the low optimization level in the waste collection (no guarantee that all the dumpsters are collected at their highest level of filling), the partial optimization of the collection routes (the ratio between the distance travelled and the volume collected can be not optimal) and poor management of vehicles and manpower (thus producing more emissions and traffic).

2. Asynchronous approach

It is based on the concept of asynchronicity, using sensors of weight or volume, using optical or ultrasound tech. It uses wireless communication devices on each dumpster and it is able to signal the fulfillment state of each dumpster: the collection usually starts when the content of certain dumpsters reaches a defined threshold.

The pros are that the sensor can provide a real time picture of the waste quantity in each dumpster, it allows monitoring with different degree of precision and different fulfillment granularity and it may provide precise information about the invoicing of the service for each municipality and citizen.

The main weak point of the technology is the accuracy of the measurement both on the weight and on the volume waste. Other cons are that each dumpster contains its own sensors, transmission devices and alimentation resources (with the relative costs of deployment and maintenance very high) and also the problems of tampering and repeatability of the measurements in extreme conditions. Moreover, the approach is built around a huge weak point: the collection is due when a trigger from a territory raises up; therefore the system tries to solve a given emergency status and this provides potential complexity in defining a daily scheduling of the activities and in managing the collection routes.

3. ITOI

It provides a planning that considers at the same time a large variety of aspects and it returns an optimal plan by considering all of them for a given time period. It is characterised by:

- Forecast of the dumpsters fulfillment.
- Service planning.
- Optimization of the collection (selection of dumpsters only when needed).
- Optimization of the working time.
- Reduction of the number of shifts.

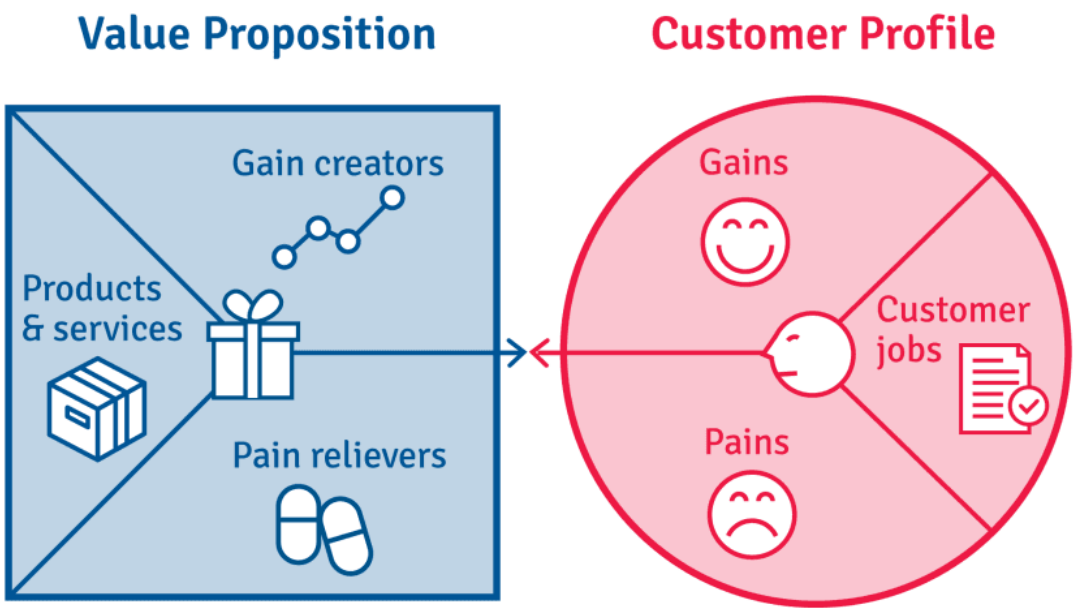
ITOI is an “adaptive temporal planner” in which the exact balance of all the aspects of the collection leads to an effective optimization, subject to the realistic

feasibility of the collection. The solution is computed by means of complex mathematical procedures, derived from the complex optimization theory. It needs a set of input data and it returns the scheduling of the collection and - for each planned day - the ordered list of dumpsters to visit.

For the correct operation of the platform, the data needed are the database of dumpsters information (quantity of dumpsters for each fraction of waste and exact position of each dumpster) and the estimation of the daily fulfillment rate for each dumpster.

Value Proposition Canvas

Realization of a general micro-Value Proposition Canvas



It consists of two sections: on one side we find the Customer Profile to describe a specific customer segment in a more structured and detailed way and on the other one the Value Map to define the characteristics of a specific value proposition.

The Customer Profile is composed by:

1. Customer jobs (or activities): description of what customers try to achieve in their work and life;

    - waste collection companies serving one or more Municipalities, with the objective of optimizing their job by cutting costs while maintaining the same - or higher - quality and respecting the National and European targets about recycling.

2. Pains (or difficulties): description of the negative results, risks and obstacles related to customer activities;

    - the scheduled collection provided on a periodical basis does not guarantee that the dumpsters are emptied when needed; difficulty in

managing all the data when serving more than one Municipality; complexity of finding/planning the optimal route in order to avoid waste of time and fuel: unorganized collection schedules and inadequate allocation of trucks result in unnecessary vehicular emissions and traffic congestions, in addition to increasing the operating costs[13].

3. Gains (or advantages): description of the outcomes that customers intend to achieve and / or the concrete wanted benefits.

    - realizing a positive return on investments; saving money and time; being able to conform to the recycling targets.

The Value Map is composed by:

1. Products and services: reference to the list of all the products and services around which the value proposition of your company is built;

    - a set of custom devices to collect data; a customizable application to remotely monitor equipment status on the territory; an advanced navigator on the trucks; a plugin that exposes, to the legacy budgeting software, the stats, the benchmark of the collection and the proper accounting costs for delivering the service.

2. Pain relievers (or Difficulty reducers): description of the ways in which the products and services decrease, reduce, alleviate the difficulties, risks and obstacles faced by customers;

[13] Mohamed Abdallah, Manar Abu Talib, Sainab Feroz, Qassim Nasir, Hadeer Abdalla, Bayan Mahfood, "*Artificial intelligence applications in solid waste management: A systematic research review*", 30th April 2020

- the driver is guided through the collection service step by step; not rigid cycles, but planned with flexibility (dividing the collection by single fractions of waste when required); further help for those companies that serve several Municipalities, with the system able to provide both the waste and the worked hours per single Municipality; anomalies detection.

3. Gain creators (or Benefit generators): Description of how the products and services create desired advantages, benefits, or outcomes for customers.

    - Benefits for **service**: reduction of the number of cycles needed to offer the same quality of service with respect to the collection provided on a periodical basis; data analyses allow to rethink strategic choices on the equipment.
    - Benefits for **equipment**: more efficient use of waste collection trucks; non-overflowing dumpsters; better dumpsters positioning; remote control of ICT equipment and dumpsters efficiency.
    - Benefits for the **environment**: lower carbon emissions; less traffic jam; lower footprint for the same service.

General framework at European level

About green finance and the incidence of R&D investments in the waste sector compared to financial and environmental benefits.

Sustainable finance generally refers to the process of carefully considering environmental, social and governance (ESG) deliberations when deciding to invest in the financial sector, leading to increased longer-term investments into sustainable economic activities and projects. More precisely, environmental considerations may refer to climate change adaptation and mitigation, as well as the environment more widely, such as the biodiversity preservation, pollution prevention and circular economy.[14]

In the EU's policy context, sustainable finance is seen as finance to support the growth of the economy while reducing environmental pressures and taking into account governance and social aspects. Sustainable finance also covers transparency on risks related to ESG factors that may impact the financial system and the mitigation of such risks through the appropriate governance of financial and corporate actors.

Sustainable finance at EU level aims at supporting the delivery on the objectives of the European Green Deal by channeling private investment into the transition to a climate-neutral, climate-resilient, resource-efficient economy[15]. The European Green Deal is in fact a strategy to make the EU economy sustainable and it includes an action plan to promote the efficient use of resources by moving to a clean and circular economy.

The waste problem, due to the growing global population, the linear approach to industrialization and consumerism, has become an increasingly severe issue globally and even in the European Union in the 21st century.

[14]https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/overview-sustainable-finance_en

[15] https://eurodw.eu/wp-content/uploads/ESG-webinar_27.FINAL_.pdf

Global solid waste generation is expected to triple by 2100[16], landfill rates are still high and waste prevention and recycling rates are too low: therefore, the efficiency and success of waste management are more important than ever.

The growth of waste generation is a serious problem. The EU countries on average produce about 482 kg per capita of waste annually, but a significant difference was found out in terms of municipal waste generation: the level of waste generation significantly depended on economic development, so the richer the country, the greater the amount of waste generated [17].

Waste 3R behaviours (Reduce, Reuse, Recycle) have been widely accepted tools of waste management solving the waste problem. However, it was found out that the level of reducing and reusing behaviours influenced waste generation insignificantly. Therefore, the performance of these behaviours did not offset the waste generation, and countries seeking to reduce waste generation should also pay more attention to the promotion of sustainable consumption and production. Another important factor was the discovery that the relationship between recycling behaviour and waste generation was positive and statistically significant; therefore, in the countries where there was a high waste generation, the level of recycling was high in turn.

In the Municipality of Tehran a study was conducted performing a life cycle and energy flow assessments of Municipal Solid Waste (MSW)[18]. The energy ratio obtained from the energy consumptions for transportation and the energy output resulted high, demonstrating the importance of optimizing especially energy related to transportation; the results obtained from Life Cycle Assessment (LCA) indicated in fact that transportation is considered the most important hot spot in the recycling of MSW.

[16] World Bank, 2013 *(https://www.worldbank.org/en/news/feature/2013/10/30/global-waste-on-pace-to-triple)*

[17] Audronė Minelgaitė, Genovaitė Liobikienė, "Waste problem in European Union and its influence on waste management behaviours", 22nd February 2019

[18] Ashkan Nabavi-Pelesaraei, Reza Bayat, Homa Hosseinzadeh-Bandbafha, Hadi Afrasyabi, Asmae Berrada, "Prognostication of energy use and environmental impacts for recycle system of municipal solid waste management", 6th April 2017

Since unorganized collection schedules and inadequate assignment of trucks result in avoidable traffic congestions and vehicular emissions, mobility management is a main topic to deal with.
Network Traffic Management (NTM) is a methodology that uses network monitoring tools and management techniques such as bandwidth monitoring, deep packet inspection and application based routing to ensure optimal network operation.
It uses systems and techniques to manage traffic behavior on transport networks: bottlenecks across air, rail, road and water can result in system-wide capacity constraints, traffic jams and increased pollutant emissions and environmental impacts.

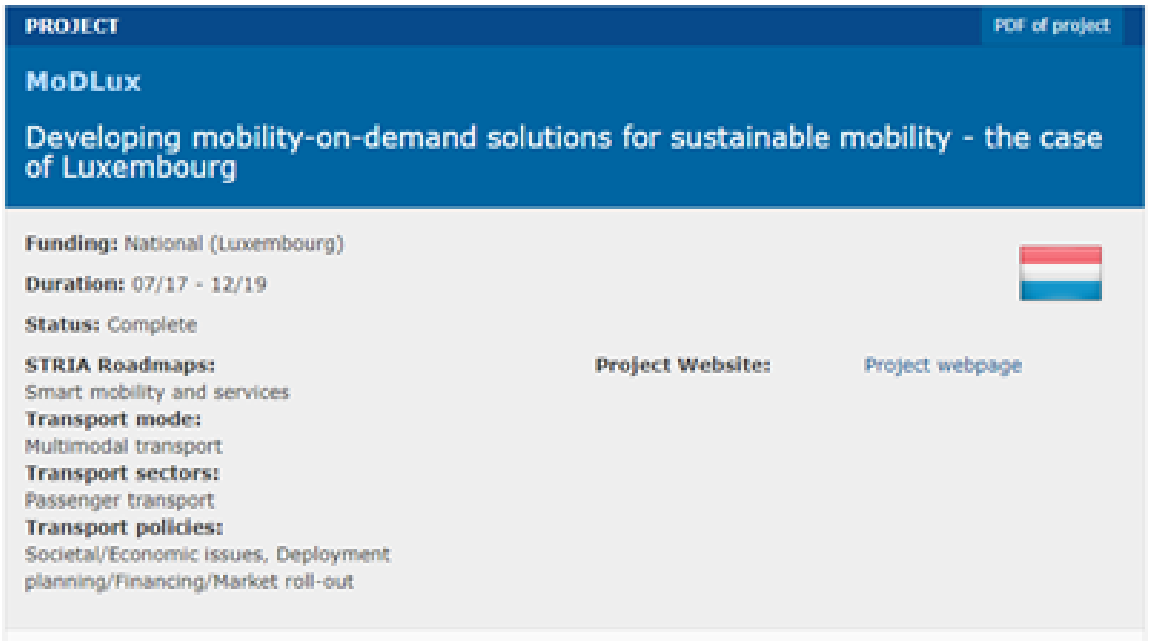
A major challenge in the current status-quo of the transport sector is related to the existing administrative, managerial and organisational barriers between the stakeholders and actors (at political and operational levels) of the various transport modes. Appropriate incentives and legislative frameworks from the political side are strongly required to promote their commitment, cooperation and inter-working, including removal of operational problems at national boundaries. The administrative, organisational and operative barriers for a coordinated cross-sector NTM development are particularly evident when looking at the lack of cooperation in planning and operating the NTM plans between the public and private sectors in any mode of transport. As long as these challenges are not understood and finally accepted by all bodies, the present situation, which is characterised by the waste of capacities and resources within all four transport modes, will continue in the future. Sub-optimal levels of transport performance are produced with the consequence that severe capacity constraints, daily nearly unmanageable traffic jams and undesirable environmental/emissions outcomes will remain[19].
For many years, there have been no doubts that an uncontrolled evolution of transport and mobility services cannot be beneficial in terms of goals and objectives for the society as a whole.

The Strategic Transport Research and Innovation Agenda (STRIA) Roadmap for Smart Mobility and Services focuses on assessing arising new technologies like multi-modal, autonomous and electric vehicles, drone technology and on-demand

[19]https://ec.europa.eu/research/transport/pdf/stria/network_and_management_systems.pdf

mobility services. It will set up and estimate the impacts of such technologies on transport and mobility services and systems.

An example of a project for sustainable mobility is MoDLux, born from a collaboration between LISER and the Department of Civil & Urban Engineering and Centre for Urban ITS at New York University in 2017-2019.



The primary objective of the project is researching collaborations in developing smart and sustainable multimodal mobility-on-demand (MOD) transit solutions for sustainable urban mobility; it is about the development of new methodology and decision support tools to model and assess different MOD solutions.[20]

The methodology consists in three research work packages related to the central development of multimodal flexible transit service are designed[21].

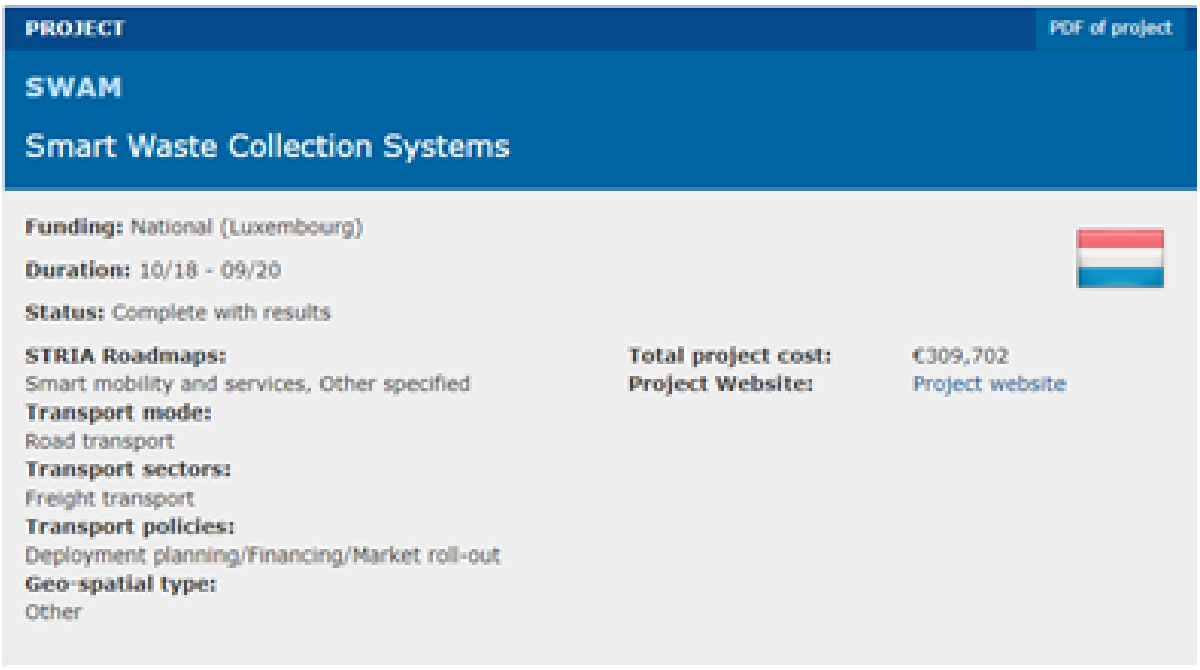
The first work package focuses on users' route choice behaviour modelling for the multimodal MOD transit service under capacity constraints and social network influence.

The second work package focuses on the development of a testbed of the multimodal MOD transit service; an agent-based approach will be used to evaluate different operation design and scenarios for the operators.

[20]https://trimis.ec.europa.eu/entityprint/node/18687
[21]https://liser.elsevierpure.com/en/projects/developing-mobility-on-demand-solutions-for-sustainable-mobility-

The last work package concentrates on studying potential strategies and collaborative partnerships between private service operators and public agencies. The interactions of different operation designs between private operators and public agencies in the network is studied based on the stable matching theory[22].

Another project, SWAM, - still in progress - is specifically about the Waste Collection:



Waste recycling has lately been underlined as a priority industry in Luxembourg. In this situation, LIST has partnered with the Polygone to suggest a new approach in the smart waste collection market, which for several years has been looking for mechanisms to automatically adapt collection routes to changing constraints and needs, rather than relying upon fixed schedules[23].

SWAM aims at proposing and validating a novel smart waste collection platform relying on multi-objective optimisation processes, in order to combine business, customer, and operational criteria – including data generated by new filling sensor technologies integrated into waste dumpsters. This approach does not only open the way for new services for the Polygone's waste recycling business sector, but

[22]https://trimis.ec.europa.eu/project/developing-mobility-demand-solutions-sustainable-mobility-case-luxembourg
[23] https://trimis.ec.europa.eu/country-profile/luxembourg

also addresses a variety of R&D topics, including data collection, prediction and multi-objective optimisation on technological platforms[24].

Research hypotheses will be validated in real-life scenarios with Polygone's professional customers (as opposed to private individuals, who are in most cases the target of existing solutions), paving the way for the implementation of new business models and market opportunities[25].

The methodology adopted by the project consists in exploring IoT and optimisation techniques to improve waste collection systems and is made of three complementary activities:

proposition of a real-time data collection and analysis system, using heterogeneous data sources and waste dumpsters fill-level sensors; proposition of a new multi-objective optimisation models to improve operational business activities; generation of personalised, real-time and predictive recommendations through a web interface (for the dispatcher), and a mobile app (for the drivers).

At the end of the project, it will be developed a prototype of a business intelligence platform for the waste recycling sector. This prototype will open the way for the implementation of new business models to fulfil the service and new opportunities for the market, primarily for the Polygone. Thanks to its involvement in the project, the company will be able to develop new services for waste management and implement new business models[26].

Anyway the transportation problem is not the only topic that Europe considers of fundamental importance for a sustainable economy; in fact, the European Commission has adopted a new Circular Economy Action Plan, one of the main pieces of the European Green Deal.
The new Action Plan states initiatives along the whole life cycle of products, targeting their design, promoting circular economy processes, promoting sustainable consumption and focusing on ensuring that the resources used are maintained in the EU economy for as long as possible[27].

[24]https://www.researchgate.net/publication/303823263_Smart_Waste_Collection_Platform_Based_on_WSN_and_Route_Optimization
[25] https://trimis.ec.europa.eu/project/smart-waste-collection-systems
[26] https://trimis.ec.europa.eu/project/smart-waste-collection-systems
[27] https://ec.europa.eu/environment/circular-economy

Waste management in Italian cities and the new Directives on the circular economy

The analysed Italian regions are:

- Northern Italy: Lombardia, Piemonte, Liguria, Veneto, Trentino-Alto Adige, Friuli-Venezia Giulia, Valle d'Aosta.
- Central Italy: Emilia Romagna, Toscana, Lazio, Marche, Umbria.
- Southern Italy: Abruzzo, Basilicata, Calabria, Campania, Molise, Puglia e Sardegna.

According to ISPRA[28] data, the production of Urban Waste (RU) has grown over the last few years (2013-2018): at the national level it has increased from 29.6 to 30.2 Mt (+ 2%).
In Northern Italy the increase was more marked: from 10.8 to 11.4 Mt (+ 5%); in Central Italy the production of waste grows less than the national figure, from 9.4 to 9.5 Mt (+ 1%), while in Southern Italy the production of waste between 2013 and 2018 is constant and equal to 7 Mt (+ 1%).

The per capita data also confirm an increase in production with greater growth in the North than the national figure: urban waste in Italy grew by 3%, in the North by 11%; in the Center they are practically stable (-0.22%), while in the South they grow slowlier (+ 1%).

All the considered Italian regions (with the exception of Basilicata, which has a low production) have a waste production close to the average, thus recording an average performance.
In the past years the EU has decided to stimulate more the national policies, firstly by inserting in the 2008 Directive a list of examples of measures that could be

[28] Italian public research body (*Istituto Superiore per la Protezione e la Ricerca Ambientale*)

acquired. Subsequently, imposing with the 2018 Directive a minimum content of the prevention programs that must be undertaken by the Member States.

Italy has equipped itself with a prevention program with the directorial decree of 7 October 2013, which proposes to achieve by 2020, compared to 2010, the following reductions:

- 5% of municipal waste production per unit of GDP;
- 10% of the production of non-hazardous special waste per unit of GDP;
- 5% of the production of special hazardous waste per unit of GDP.

In Northern Italy as regards the prevention objectives - except for Lombardia and the autonomous Province of Bolzano - they are all in line with those expected by the national program regarding urban waste;
however, none of these programs set targets for both hazardous and non-hazardous special waste.
Analyzing the data, the best known and most applied prevention measure in the North is providing guidelines on good practices to be followed in the offices (34 provinces); then the theme of the management of the wet fraction of waste follows: in fact, measures have been taken in order to promote self-composting, local or community composting in 29 provinces.
A very felt problem is that of diapers, which are estimated to represent about 3% of urban waste and in 14 Provinces actions have been planned for the diffusion of reusable diapers.
An equal number of provinces reported actions with the Grande Distribuzione Organizzata (GDO, the large-scale retail trade), mainly consisting of measures to reduce packaging (distribution of reusable bags, sale of the product unpackaged or on tap).

The survey carried out on the sites of the Central Regions has revealed that all of them have adopted a waste prevention program following both Directive 2008/98 / EU and the national program; the most recent one is that of Lazio, in 2019, which, however, does not include a monitoring plan. Instead, all the other Regions

have envisaged a monitoring program to assess the effectiveness of the prevention measures adopted.
There is little attention to the problem of food waste (11) and the initiative on the promotion of washable nappies was followed only in 9; there is no particular interest in Green Procurement (GPP).
Overall, therefore, the evaluation of the results of prevention actions and, consequently, of the publication of the results achieved results scarce.
This probably reflects also the approximate level of national and regional policies, the lack of clear objectives and the substantial non-existence of economic incentives.

In the South there is a scarce- if not even nonexistent - evaluation of the results of prevention actions and, consequently, of the publication of the results achieved.

Separate collection of urban waste and new EU targets

The separate collection (RD) of urban waste in the last years for which ISPRA data are available (2013-2018) has grown considerably: at national level, the amount of urban waste collected has gone from 42% to 58% (+16 percentage points).
In the same period, the North passed from 55% to 68%, the Center from 41% to 58% and the South from 34% to 52% of RD.
The four bands used for evaluating the RD performances of the Regions are: *excellent* if the RD is greater than 78%; *high* if the RD is between 78% and 73%; in the *average* if the RD is between 73% and 68%; *low* if the RD is less than 68%.
According to this classification, 4 Northern Regions have a RD with a low performance (less than 68%), 2 have an average performance, while Veneto reaches a high performance achieving 73.7%.
About the Center, 4 Regions have a RD with low performance (less than 68%), and only the Marche has an average performance; all the Southern Regions appear to have a RD with low performance (less than 68%).

In conclusion, the overall growth trends of the separate collection of urban waste bring the Northern Regions in line with the urban waste recycling target set at European level for 2025.
The only Region that records some delays in separate collections and, consequently, in the recycling of urban waste, is Liguria; this delay is also evident in the municipality of Genova, which appears to be the municipality with the lowest per capita collection and growth trend in RD.

The Central Regions are close to the national average, but some of them are still far from the urban waste recycling targets set at European level for 2025, 2030 and 2035.
Lazio and Toscana recorded the greatest delays in separate collection and, consequently, in the recycling of urban waste; this delay is evident for all the main towns of Lazio which, having the lowest per capita collections, need to adopt improvement actions to align themselves with the other towns of the Center.

On the other hand, almost all the Southern Regions are lagging behind the national average data, still far from the urban waste recycling targets set at European level for 2025, 2030 and 2035.
Molise, Calabria, Puglia, Basilicata and Campania recorded the greatest delays in separate collection and, consequently, in the recycling of urban waste; such delay is evident for the County Seats of Molise and for almost all those of Puglia and Calabria which, having the lowest per capita collections, need to take improvement actions to align themselves with the other Southern capitals.

If the quantitative aspect of RD is measured, less known is the one concerning the harvest quality. We only know that the national average of waste (RD minus recycled municipal waste) is 13%, we do not know instead that of the Regions.

Following the indications of the Green Deal Plan, recently adopted by the EU, it is essential to promote digitalization also in separate collections.
On one hand, the introduction of an electronic passport for products was planned and it should provide important information on the correct management of the product, its characteristics and the methods of repair and/or treatment in the post-

consumer phase, on the other hand, the creation of a European data bank on circularity has been announced and it should collect all useful information to promote circularity in products;
it would also be advisable to promote the diffusion and use of Apps that allow citizens to have information on how to correctly separate waste.

Finally, an economic stimulus can also contribute to the promotion of quality separate collection. Activating rewarding tools on the amount of conferred differentiated waste is one of the tools suggested by the EU; to this we can also add economic stimuli to the delivery of waste to collection centers.

Urban waste management modalities

In Italy, out of a production of urban waste of 30.2 Mt in 2018, 45% is sent to recycling (13.6 Mt), 20% to incineration / co-incineration (6 Mt), 22% to landfill (6 , 5 Mt) and 2% is exported abroad (467 kt).

In Northern Italy, out of 11.4 Mt municipal waste production, 55% is sent for recycling (6.3 Mt), 37% for incineration / co-incineration (4.2 Mt), 14% for landfill (1.5 Mt) and 2% is exported abroad (217 kt).
The waste recycled in the North corresponds to about 46% of national recycling and among the Northern Municipalities consulted, 60% treats the differentiated waste within their own Region.

In Central Italy, out of a production of urban waste of 9.5 Mt, 45% is sent for recycling (4.3 Mt), 7% for incineration / co-incineration (653 kt), 20% for landfill (1, 9 Mt) and 1% is exported abroad (77 kt).
The waste recycled at the Center corresponds to about 32% of national recycling and there is a widespread need to turn to structures outside the Region for the

management of the collected waste: 57% of the Municipalities, in fact, treat the differentiated waste outside their own Region.

In Southern Italy, out of a production of urban waste of 6.9 Mt, 39% is sent for recycling (2.7 Mt), 17% for incineration / co-incineration (1.2 Mt), 26% for landfill (1.8 Mt) and 2% is exported abroad (169 kt).
The waste recycled in the South corresponds to about 20% of national recycling and 53% treats the differentiated waste outside their region;
compared to the national figure (44%), there are more municipalities in the South that declared that they send their waste outside the Region and are 9 percentage points higher than the national average.

The various difficulties in increasing the quantity of RD encountered by the municipalities were also analyzed and the primary cause appears to be the lack of collaboration (and incorrect, uncontrolled and unsanctioned waste disposal) by users.
As for the increase in the quality level of RD, the main difficulty is the lack of knowledge and sensitivity of citizens in correctly separating waste.

Recycled materials market

The GPP (Green Public Procurement, or Green Purchases of the Public Administration) is a tool that intends to promote the development of a market of products and services with a reduced environmental impact through the lever of public demand, contributing, in a decisive way, to the achievement of the objectives of the main European strategies such as that on the efficient use of resources or on the Circular Economy.
The GPP, introduced in Italy in 2008 and becoming mandatory with the new Procurement Code (D.lgs 50/2016 - Legislative Decree), establishes the adoption, with subsequent ministerial decrees, of the Minimum Environmental Criteria (CAM) for each category of products, services and works purchased or entrusted by the Public Administration. CAMs are the environmental requirements defined for the various phases of the purchasing process, aimed at

identifying the best design solution, product or service from an environmental point of view along the life cycle, taking into account market availability.
To date, CAMs have been defined in Italy for 19 categories of supplies, works and services, as well as at the European level.

Attention to the use of recycled materials was also found in the Northern Municipalities consulted, which for 60% promoted various initiatives for the use of recycled materials in tenders and purchases (value 7 percentage points higher than the national average).
Among the consulted Municipalities of the Center, 57% have promoted various initiatives for the use of recycled materials in tenders and purchases, while attention to the use of recycled materials is not widespread in the Municipalities of the South, which, for 62% , did not promote such initiatives.

Landfill disposal and EU reduction target

In Italy, municipal waste disposed of in landfills in 2018 amounted to 6.5 Mt, equal to 22% of production.

Analyzing the data relating to the various forms of management implemented at the regional level, it is highlighted that in the Northern Regions the use of landfills is limited; the highest percentages of waste allocated to landfills without preliminary treatment are found in the Val d'Aosta (100%) and in Trentino Alto Adige (76%) regions.
In the Center, landfilling concerns 20% of the materials produced (corresponding to 1.9 Mt), while in the South, landfilling is related to 26% of the waste produced. It is evident that in the Southern Regions landfill is used above the national average, but it should be noted that the indicator of the percentage of landfill disposal out of the total urban waste produced at the regional level, due to waste flows from or sent to other regions, turns out to be, in some cases, inappropriate.

In order to achieve the target of landfilling of municipal waste at 10% by 2035, national performance will need to improve: in fact, currently Italy disposes of 21% of urban waste (approximately 6.5 Mt) in landfills, which must therefore be reduced by 12 percentage points by 2035 (-3.6 Mt).
In particular, the Center will have to reduce disposal by 10 percentage points - going from 1.9 to 0.95 Mt disposed of in landfills - and the South will have to reduce disposal by 16 percentage points, passing from 1.8 to 0.69 Mt disposed of in landfill.

Urban waste and separate collection management costs

The analysis of the overall costs of urban waste management compared to the percentages of separate collection allows us to evaluate the presence of correlation between the two parameters.
The total volume and weight of municipal waste to be collected and transported should be about the same with low and high RD: with high RD it is necessary a greater number of collection turns and a better organization to optimize collections, personnel and means of transport employed.
On the other hand, while landfill disposal or incineration only entails a cost for those who collect municipal waste, at least the RD of packaging waste (paper, plastic, glass and cans) also involves receiving a fee, in addition to saving the cost of disposal.

In practice, however, several factors intervene in the determination of urban waste management costs: the efficiency of the service, the availability of treatment plants, their quality and distance, the non-linear trend of the unit cost curve of the RD (generally higher at the lowest levels), the size of the city and the efficiency of the collection model, etc.

Based on the survey carried out by ISPRA on Total Urban Waste Management Costs (CGTOT), on the Management Costs of Separate Waste Collection (CGD)

and on the Management Costs of Unsorted Waste (CGIND) and on the RD levels achieved, it emerges that for the 2018:

- The CTOT of the North is similar for all Regions, with the exception of Liguria, the Region with the lowest RD rate and the highest total waste management cost (43.25 € cent / kg); among the Northern Regions with the most advanced separate waste collection, over 70%, Lombardia and Trentino-Alto Adige have a lower average total cost of urban waste management.

  Even in the Center, the CTOT is similar for all the Regions, except for Lazio, the Region with the lowest RD rate and the highest total waste management cost (41.92 € cents / kg); Emilia Romagna with 67% of separate waste collection has the lowest average total cost of urban waste management (€ 26.59 cent / kg), while the Marche, with a slightly higher RD (69%), has a cost of € 30.68 cents / kg;

  The South in turn appears to have a similar CTOT for all the regions analyzed. The costs that stand out are those of Campania, which is the highest (44.42 € cent / kg) compared to an average separate collection (53%), and of Basilicata which, with an even lower RD (47%), has a cost similar to that of Campania (€ 43.89 cents / kg).

- The average cost of managing separate collections (CGD) shows in the North the non-linear trend of the unit cost curve of RD; the cost is in fact high in Liguria and Piemonte, which record the lowest RD levels, it assumes an average value for the other Regions and returns to grow in Veneto, which has the highest RD rate.

  In the Center, on the other hand, the CGD shows a linear trend in the curve of unit costs of RD. The cost is in fact high in Lazio, which has the lowest level of RD and gradually decreases as the collection rate

increases; Tuscany is an exception since, with RD values among the lowest (56%), has a low cost (€ 15.38 cents / kg), intermediate between that of the Marche and Emilia Romagna which reach the best collection performance.

Also in the South the CGD shows a linear trend. The cost is in fact high in Molise, which records the lowest RD level and takes on values gradually decreasing as the collection rate increases; the exceptions are Campania and Basilicata which, with intermediate RD values (53% and 47%), have high management costs for separate waste collection (26.14 and 25.85 € cent / kg);

- The average management cost of unsorted waste (CGIND) is higher in Regions with high RD rates due to economies of scale and vice versa. The exceptions are Lazio in the Center and Basilicata in the South, which are affected by the high costs of transferring unsorted waste outside the Region.

Analyzing the trend of waste management costs of the three areas compared to the national average, it is found that:

- The North has an average total cost of € 32.46 cents / kg - 7% lower than the national average cost (€ 35.00 cents / kg) -, an average management cost of the RD of € 15.10 cents / kg - 17% lower than the national average cost (€ 18.20 cent / kg) - and an average cost of managing unsorted waste of € 29.68 cents / kg - 8% higher than the national average (€ 27.47 cents / kg).

- The Center has an average total cost of 33.86 € cent / kg - in line with the national average cost -, an average management cost of the RD of 18.30 € cent / kg - in line with the national average cost - and a cost

undifferentiated waste management average of € 24.60 cent / kg - 10% lower than the national average.

- As regards the South, it is found that the three cost items analyzed are always higher than the national average cost: it has an average total cost (39.48 € cent / kg) - 11% higher than the national average cost - average cost of management of the RD (€ 23.39 cent / kg) - 22% higher than the national average cost - and an average cost of managing unsorted waste (€ 29.82 cents / kg) - 8 higher than the national average cost.

The data confirm that the higher the RD increases, the lower the costs of waste management: high separate collection is good for the citizen's wallet, as well as for the environment.

In the North, the maximum cost of managing the differentiated fraction per kg is recorded in Veneto (and still remains below 20 euro cents), while the minimum cost of the undifferentiated fraction is recorded in Friuli Venezia Giulia and is close to 25 euro cents per kg.
It is interesting to notice that the lowest unit cost of managing the differentiated fraction is for the Region that reaches the highest RD level.
In the Center, Lazio confirms this theory, given that with a lower RD rate it has the highest total waste management cost (41.92 € cents / kg).

The study of urban waste management costs in the Southern Regions shows an exception with respect to the phenomenon recorded in the rest of the country. If in all the other Regions - except Sicily - the average cost of managing undifferentiated waste is on average lower than that collected separately, in Molise the average cost of managing the unsorted fraction is lower by almost 18% compared to to the management of the differentiated fraction.
This is also due to the fact that that Region makes extensive use of landfills, which have low disposal costs in that Region.
The overall figure for the South, whose RD rate is on average lower than the rest of Italy, however, shows an average cost of managing all urban waste 11% higher than the Italian average.

It is very likely that in this case the costs of transport or higher costs for inefficient management have a significant impact.
Therefore, it is necessary to both stimulate a process of approaching waste recycling and increase the taxes for landfill disposal, as well as improving the management of municipal waste collection and treatment companies.

The distances to be bridged in order to reach the new European targets in waste management

In order to achieve the urban waste recycling target of 55% by 2025, 60% by 2030 and 65% by 2035, national recycling performance will have to improve: currently Italy has achieved a 45% recycling of municipal waste (about 13.6 Mt).

The results of the analysis lead the Northern Regions to have achieved a recycling rate of 55% of urban waste in 2019, anticipating the new European target that sets this rate to 2025. It can therefore be said that the North pulls national performances upwards. The Region that will have to make the greatest effort in order to increase the recycling of urban waste is Liguria which, thanks to focused actions to increase the RD, will be able to achieve recycling rates in line with those of the other Northern Regions.

As far as the Center is concerned, the estimates on the regional recycling rate place it in line with the national trend and with a gap to be filled in order to achieve the urban waste recycling targets set at European level.
The Regions that will have to make the greatest effort to increase the recycling of urban waste are Lazio and Toscana.

The South, on the other hand, has a performance lower than the national average and with an important gap to fill in order to achieve the recycling targets for urban waste set at European level.

In order to achieve these objectives, all the Regions will have to make a great effort to increase the recycling of urban waste exploiting focused actions to increase the RD.

Waste management between costs and opportunities

The waste sector has deeply changed in the last years. From service companies, the firms have become industrial production and technology companies. As observed in the Was Report 2019 of Althesys, until a few years ago the activity of the waste companies was to manage garbage by moving it from the places of production (the dumpster) to the places of disposal (the landfill).

The mergers and acquisitions that led to large unifications were "horizontal", but now a wave of "vertical" agreements and investments is underway. Technology assets are acquired, business segments once different - such as energy or chemistry - are integrated, licensing agreements are formed, plants are started up.

ISTAT has published the update to 2018 of the annual indices of waste management costs, which show how, compared to 2017, there is an increase of 0.6% driven by purchases of goods and services.
Compared to 2017, the cost of waste management increased by 0.6%, driven by the purchase of goods and services (+ 1.4%), against reductions in personnel expenses (-1.2%) and the capital cost of use (-1.0%).

ISTAT underlines that "with respect to the two economic sub-sectors that make up the total index (first the collection, treatment and disposal of waste, second the material recovery), the costs trend in 2018 shows that the sector that recorded the greatest increase was that of materials recovery (+ 1.1%) compared to that of waste collection, treatment and disposal (+0.3 %) ".
The cost of managing approximately 135 million tons of special waste and 30 million tons of municipal waste is huge and involves dedicated investments, but it has undoubted environmental and social advantages, as long as the perspective is one that hinges on sustainability and on proximity.

The circular economy and the strengthening of recycling activities represent the road to grow in the name of multiple sustainability (environmental, but also economic, financial, social), also in order to respond to the increasingly scarce availability of raw materials.

FISE Assoambiente - Association representing private companies that manage environmental services at national and community level - argues that, in order to take up the European challenge of the Circular Economy (65% effective recycling and 10% in landfills by 2035 for urban waste), it will be necessary
to significantly increase the separate collection (up to 80%, considering the yield rate compared to urban waste intercepted) and the recycling capacity (+4 million tons) of our country and to limit the landfill rate and raising the percentage of energy recovery of waste to 25%.

In particular, in order to achieve the sustainability objectives, it will be necessary to:

- resort to economic instruments to support the use of recycled materials;
- increase the use of by-products and end of waste materials;
- adopt a clear regulatory framework for the sector that simplifies the authorization procedures and encourages investments and competition between companies, allowing the creation of all the necessary plants;
- adopt a National waste management strategy that provides a medium-long term vision.[29]

In fact - as sustained by the Association President Chicco Testa - in Italy we need recovery plants (of material and energy) capable not only of supporting the growing flow in particular of separate waste collections, but also of withstanding phases of crisis in foreign markets.

According to FISE Assoambiente, in order to achieve the goals set for 2035, Italy will have to move along 4 directions:

[29] FISE Assoambiente, "Per una Strategia Nazionale dei rifiuti", Report 2019

1. limitation of the import / export of waste to and from Italy, which handles almost 10 million tons of waste every year: a diseconomy that, due to a lack of facilities, produces a loss of potential of material and energy;
2. adoption of a plant system suited to one's needs, planning the construction in the next 15/20 years;
3. block of the so-called "waste tourism" within national borders: waste that is moved from one region to another, due to the lack of disposal facilities;
4. reconsideration of the landfills management, referring only to modern and sustainable plants to which only the appropriately treated residual fractions should be allocated.

Waste management after the 116/2020 legislative decree

Old and new rules

I took part in a webinar of the Chamber of Commerce on December, 2nd about this topic and a lot of concepts have been outlined.
The fundamental change produced by this legislative decree is the modification of the economic system: from a linear model to a circular one (Economy of Recycle).

The directive 2018/851/Ue - which modifies and integrates the 2008/98/Ce and is in effect since the 4th July 2018 - has been received in Italy through the legislative decree 116/2020, which is active since the 26th September 2020.

Between the introduced modifications there are some measures amplifying the Action plan on themes such as eco-design, production processes, consumption models and waste management.
The National program for the waste management establishes some macro-objectives, defines criteria and strategic directives for Regions and autonomous Provinces, contains data about National production and also about the waste collection rationalization and support.

The fourth part of the legislative decree 152/2006 (Unic Environmental Text), which is dedicated to general rules about waste and packaging is directly modified by this new legislative decree.

Important innovations have been introduced, such as the strengthening of the system of extended liability of the producer of goods (articles 178-bis and 178 ter) and the prevention of waste production (article 180), but also the now underlined importance of reduction and avoidance of waste production, in the perspective of the circular economy.

Above all we can find a modification to the definition of urban waste (Article 183), now extended to unsorted waste and separate collection from other sources and therefore also from non-domestic users.

Point b-quinques was also introduced in the same article 183 and it specifies that the new definition of municipal waste does not prejudice the division of responsibilities regarding waste management between private and public actors.
The assimilation of special waste to urban waste means that in the percentage of waste that - according to the European directive - Italy will have to use for recycling, both urban and industrial waste can be taken into consideration, while it does not impact on the person who can manage the waste.

The final disposition of the articole 6 gives time to the trusted subjects of waste management service until the 1st January 2021 in order to operatively adjust the activities to this new definition of urban waste.

This legislative decree has reviewed the traceability system, confirming the fundamental role of the Single Environmental Declaration Model (MUD), reproposing the National Electronic Register (REN, introduced with the decree law 135/2018), revising the FIR and Registers and rewriting the penalties.

The waste traceability system is made of tracking instruments and procedures of waste integrated in the REN and it's managed with the operative technical support of the National register managers.
The subjects exonerated from the traceability system are the agricultural entrepreneurs (art. 2135 c.c.) with less than 8000€ annual turnover, the enterprises collecting and transporting their non-dangerous waste and the enterprises of non-dangerous waste composed of less than ten employees.

The waste transportation must go with an identification formulary (FIR), which contains data about the origin, type and quantity of waste, date and path to the destination plant and names and addresses of the producer and of the recipient.

The Chronological Register of Loading and Unloading is a document where, in addition to the information on the produced, managed and transported waste, are now reported also the information about the quantity of the material obtained from the treatment operations: preparation for reuse, recycle and recover activities. All in the perspective of a real circular model.

Companies data collection and elaboration

Analysis of the technological ecosystem on which ITOI was developed, by collecting data on companies operating at national level with technological equipment similar to those in which ITOI is already operational, currently supplied to Cidiu Servizi

moltosenso developed ITOI and the first customized deployment on Cidiu Servizi - which collects wastes in an area of 260.000 inhabitants, serving 17 Municipalities in the Province of Turin - provided remarkable results both in planning and in saving procedures.

Analysed companies

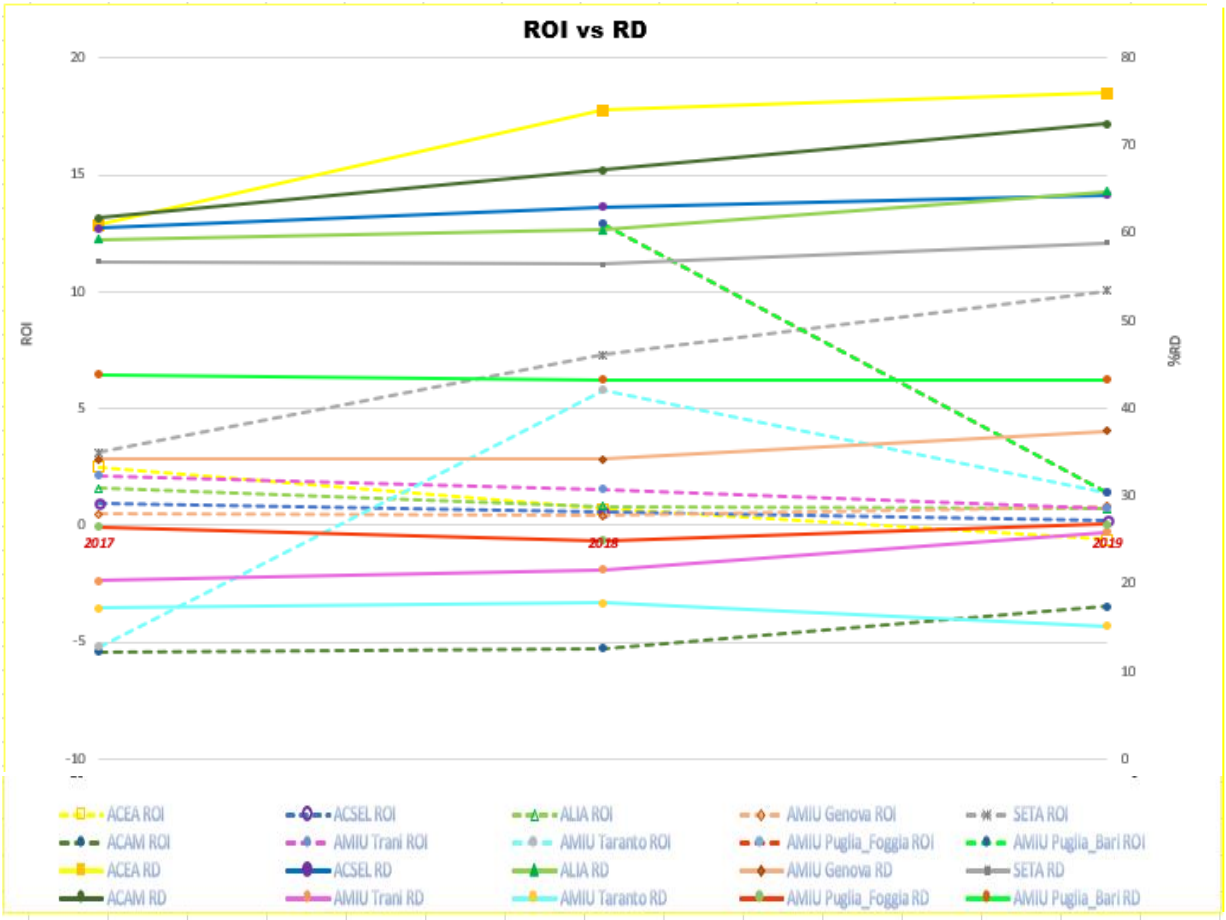
Waste collection companies from various Italian origins, from north to south, were taken into consideration as the object of the study; they all have in common the fact of being supplied by Nord Engineering or Farid Industrie (companies operating in the ecology sector, engaged in designing and implementing automatic and highly technological solutions for the management of the entire waste collection process).
In particular, the companies that have been analyzed are: Acea Pinerolese Industriale SpA (Settimo Torinese), Acsel Spa (Sant'Ambrogio di Torino), Seta SpA (Chivasso), AMIU Genova SpA, ACAM Ambiente SpA (La Spezia), Alia Servizi Ambientali Spa (Firenze), AMIU Trani Spa, AMIU Taranto SpA, AMIU Puglia SpA (suburban areas of Bari and Foggia).

Outline of each reality

Study of the financial statements of the waste companies

Analysing the financial statement of each company, some common trends have been found out.
Here the excel tables and graphs are shown:

	ROI (%) 17	ROI (%) 18	ROI (%) 19	RD (%) 17	RD (%) 18	RD (%) 19	
ACEA ROI	2,5	0,7	-0,62	61	74	76	ACEA RD
ACSEL ROI	0,97	0,59	0,23	60,58	63,05	64,42	ACSEL RD
ALIA ROI	1,6	0,8	0,7	59,3	60,4	64,78	ALIA RD
AMIU Genova ROI	0,5	0,4	0,8	34,22	34,2	37,45	AMIU Genova RD
SETA ROI	3,11	7,29	10,05	56,76	56,48	58,95	SETA RD
ACAM ROI	-5,42	-5,27	-3,45	61,76	67,23	72,48	ACAM RD
AMIU Trani ROI	2,15	1,55	0,73	20,32	21,61	25,87	AMIU Trani RD
AMIU Taranto ROI	-5,2	5,8	1,4	17,19	17,81	15,22	AMIU Taranto RD
AMIU Puglia_Foggia ROI		12,91	1,4	26,55	24,94	26,75	AMIU Puglia_Foggia RD
AMIU Puglia_Bari ROI		12,91	1,4	43,9	43,3	43,3	AMIU Puglia_Bari RD
	2017	*2018*	*2019*	*2017*	*2018*	*2019*	

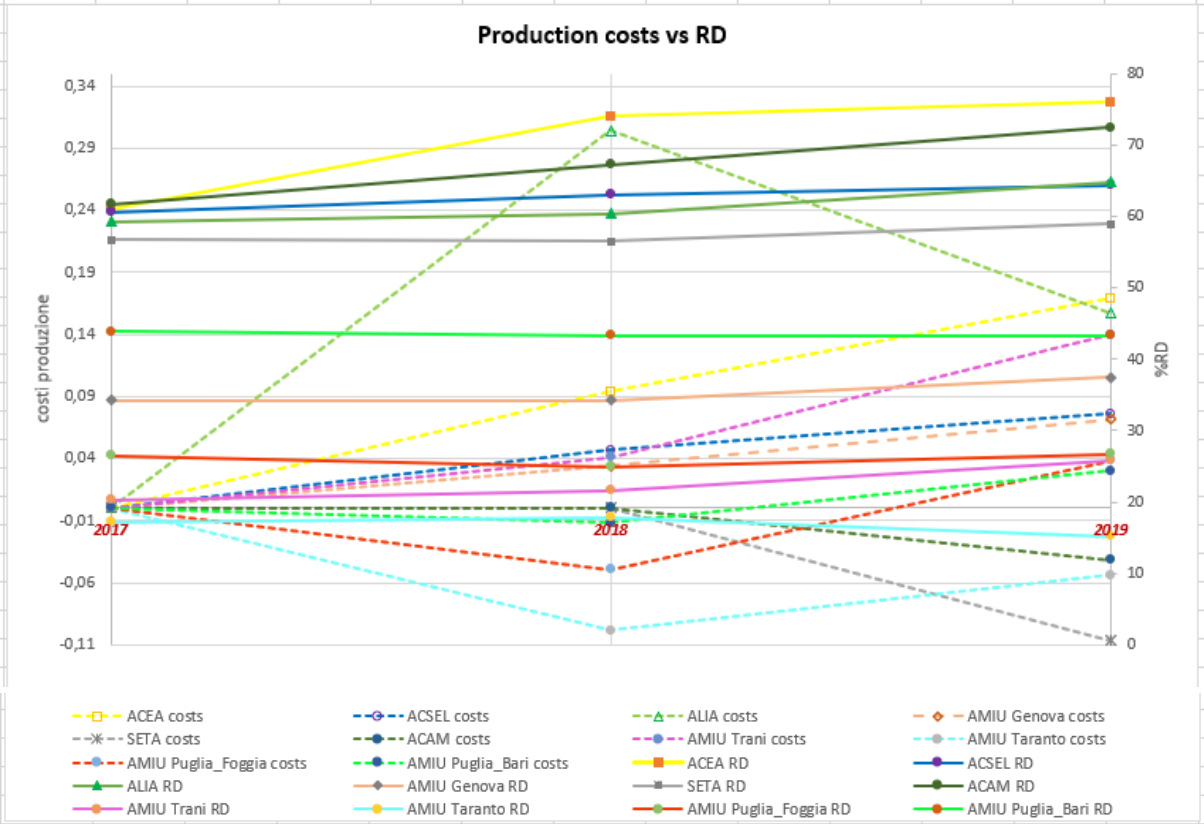


We can see how in 6 out of 10 cases the increase in the percentage of recycling is correlated to the decrease in ROI over the years; in the case of Foggia there is actually a decrease in the percentage of recycling in 2018, but there is still an increasing trend between 2017 and 2019, while in the case of Bari the 2017 recycling data is missing (and is replaced with 2016) and the value remains unchanged between 2018 and 2019. The value of 2017 ROI of Amiu Puglia has

not been reported since it was untrusted and would have messed up the graph (1376%), but anyway showed an increasing trend.
This ROI trend seems to indicate that the investments were functional exclusively to comply with legal obligations.

In three other cases (AMIU Genova, SETA and ACAM Ambiente) the increase in the percentage of recycling is accompanied by a slight increase in ROI;
the case of AMIU Taranto seems to be an anomaly, since the percentage of differentiated decreases over the years and the value of the ROI increases exponentially between 2017 and 2018 and then decreases radically the following year, reaching a low - but in the average - value.

	costs (€) 17	costs (€) 18	costs (€) 19	RD (%) 17	RD (%) 18	RD (%) 19	
ACEA costs	0	9,37%	16,88%	61	74	76	ACEA RD
ACSEL costs	0	4,68%	7,61%	60,58	63,05	64,42	ACSEL RD
ALIA costs	0	30,42%	15,68%	59,3	60,4	64,78	ALIA RD
AMIU Genova costs	0	3,43%	7,19%	34,22	34,2	37,45	AMIU Genova RD
SETA costs	0	0,01%	-10,69%	56,76	56,48	58,95	SETA RD
ACAM costs	0	0,02%	-4,17%	61,76	67,23	72,48	ACAM RD
AMIU Trani costs	0	4,08%	13,97%	20,32	21,61	25,87	AMIU Trani RD
AMIU Taranto costs	0	-9,83%	-5,37%	17,19	17,81	15,22	AMIU Taranto RD
AMIU Puglia_Foggia costs	0	-4,93%	3,83%	26,55	24,94	26,75	AMIU Puglia_Foggia RD
AMIU Puglia_Bari costs	0	-1,16%	3,03%	43,9	43,3	43,3	AMIU Puglia_Bari RD
	2017	2018	2019	2017	2018	2019	



The cost percentages of 2018 and 2019 are respectively obtained through the formulas: (costs 18-costs 17)/costs 17 and (costs 19-costs 17)/costs 17. In this way we can underline the production costs increase during the three years.

We can see how in 7 out of 10 cases the increase in the percentage of recycling goes in parallel with the increase in total production costs; in the case of Foggia there is actually a decrease in the percentage of recycling in 2018, but there is still an increasing trend between 2017 and 2019, while in the case of Bari the 2017 recycling data is missing (and is replaced with 2016) and the value remains unchanged between 2018 and 2019.

This could be an incentive for the sale of ITOI, as it could lead the company to save on costs as well as to make the collection system more efficient.

As for the 3 cases that do not follow this trend (ALIA, SETA and ACAM Ambiente), production costs increase between 2017 and 2018, while they decrease - although in a non-radical way - in the following year.

About Bari, the following calculations were carried out to obtain the production costs of 2017 (given the costs of the fraction of Bari in 2018 and 2019 and the costs of Amiu Puglia over the 3 years):

Bari fraction=78,13% of AMIU Puglia

Year 2019: 0,7813 x 102.750.008 (costs Amiu Puglia 2019) = 80.278.581,3
80.278.581,3 / 71.192.271 (costs Amiu Bari 2019) = 1,127-> 1,1

Year 2018: 0,7813 x 97.192.371 (costs Amiu Puglia 2018) = 75.936.399,5
75.936.399,5 / 68.297.203 (costs Amiu Bari 2018) = 1,111-> 1,1

Year 2017: 0,7813 x 97.283.746 (costs Amiu Puglia 2017) = 76.007.790,7
-> Production costs of BARI=76.007.790,7 / 1,1 = 69.097.991

About Foggia, the following calculations were carried out to obtain the production costs of 2017 (given the costs of the fraction of Bari in 2018 and 2019 and the costs of Amiu Puglia over the 3 years):

Foggia fraction=21,87% of AMIU Puglia

Year 2019: 0,2187 x 102.750.008 (costs Amiu Puglia 2019) = 22.471.426,7
22.471.426,7/ 31.557.739 (costs Amiu Foggia 2019) = 0,712->0,7

Year 2018: 0,2187 x 97.192.371 (costs Amiu Puglia 2018) = 21.255.971,5
21.255.971,5/ 28.895.169 (costs Amiu Foggia 2018) = 0,735->0,7

Year 2017: 0,2187 x 97.283.746 (costs Amiu Puglia 2017) = 21.275.955,3
-> Production costs of FOGGIA=21.275.955,3 / 0,7 = 30.394.222

About the percentage data of the separate waste collection (RD), since the 2017 data could not be found, the value considered was the one of the 2016.

Questionnaires data

Data analysis on the size of the urban basins served, on the number of vehicles used for waste collection, on the management model (mixed, door-to-door only, road / proximity only) of road collection cycles.

I contacted the companies and proposed them a questionnaire with the following requests: number of vehicles in the collection fleets, quantification of weekly passages, weekly mileage, quantity of dumpsters and respective capacity for plastic/ paper/ glass/undifferentiated waste and finally the privileged area for the investments made in the last financial year in the waste collection plan.
These data are a fundamental base in order to have a proper vision of the companies we are facing - and thus being able to create *personas* or customer prototypes.

I started a first analysis of the mileage data:
I took Acam Ambiente (La Spezia) as a reference company - as it provided me with the most complete and specific data - and I worked out some calculations for the most efficient choice of means of collection.

Choice of collection vehicles

The vehicles set up by Nord Engineering or Farid are IVECO Stralis, with the following data in the case of traditional or hybrid:

IVECO Stralis*	Traditional	Hybrid
average consumption (l/km)	0,3	0,27
average fuel price (€/l)	1,2	
average CO_2 emission (kg/km)	0,795	0,7155

* the data refer respectively to the tractor vehicle AS440S45TP Iveco Stralis and the Ecostralis hybrid[30].

30 https://www.iveco.com/altraen/collections/catalogues/Documents/tutti%20prodotti/ECOSTRALIS_CAT_ITA.pdf

At the moment the fleets are on average with mixed engines, with 20% hybrid. By knowing the annual mileage of a company and then calculating its consumption in liters and the amount of CO2 emitted, three exemplary scenarios can be analyzed and the various savings in terms of costs and emissions can be noted.
The three analysed scenarios are:

1) 80% traditional, 20% hybrid (scena attuale)
2) 20% traditional, 80% hybrid
3) 100% hybrid

I decided to consider the case of Acam Ambiente (La Spezia), which serves twenty municipalities (for a total of about 196,000 inhabitants) and whose fleet annually travels about 2600000km. Below are reported the data and calculations carried out in the 3 scenarios:

SCENARIO 1	*traditional*	*hybrid*
%	80%	20%
CO2 emissions (kg)	1.653.600	372.060
total CO2 emissions (kg)		2.025.660
annual consumption (l)	624.000	140.400
total annual consumption (l)		764.400
total annual cost (€)		917.280

SCENARIO 2	*traditional*	*hybrid*
%	20%	80%
CO2 emissions (kg)	413.400	1.488.240
total CO2 emissions (kg)		1.901.640
Delta scenario 1-2 (kg)		124.020
saving of scenario 2 (%)	6,1%	
annual consumption (l)	156.000	561.600
total annual consumption (l)		717.600
total annual cost (€)		861.120
Delta scenario 1-2 (€)		56.160
saving of scenario 2 (%)	6,1%	

SCENARIO 3	*hybrid*
%	100%
CO_2 emissions (kg)	1.860.300
Delta scenario 1-3 (kg)	165.360
saving of scenario 3 (%)	8,2%
annual consumption (l)	702.000
total annual cost (€)	842.400
Delta scenario 1-3 (€)	74.880
saving of scenario 3 (%)	8,2%

It can be seen that by choosing vehicles with increasingly higher percentages of hybrid engines, a maximum saving of 8.2% can be achieved, both in terms of costs and CO2 emissions.

On the basis of the assumptions adopted (reduction in consumption of the single vehicle equal to 10% in the transition from traditional to hybrid), these hypothetical values of saving can be indicatively applied to any other reality.
Since savings can change in absolute value, the incidence in the overall budget may be different.

Prioritization

Evaluation of the most appropriate KPIs for the companies prioritization.

Taking Cidiu as the use case – the so-called client zero - I anchored the work with respect to the truth of the management numbers, since it wasn't possible to make an attitudinal characterization of the companies given the lack of data.

In order to create an analytical basis for decision making I created 6 KPIs:

- The 3 particular costs (collection personnel, fuel, maintenance & machine stop) obtained from calculations on the use case data.

- The impact of savings on ROI;

- The operating costs size: if they are similar to the use case's, the problems are comparable, showing the same type of daily management reality;

- The spatial closeness with the use case;

For the calculations of the three particular costs for the ten companies, I had to collect those particular costs of Cidiu.
Not being able to obtain them directly from Cidiu, I calculated them by taking data from Acam Ambiente and Amiu Puglia (given that in any case the vehicles in use have the equipment useful for ITOI: the "Easy" models by Nord Engineering fitted to IVECO Stralis): once obtained the particular costs, I divided them by the operating costs of the given companies, then - keeping in mind the percentages obtained - I modified the particular costs of Cidiu in such a way that, divided by its operating costs, they led to those percentages.

ACAM AMBIENTE		
	operating costs (€)	47.435.000
	number of collection vehicles	186
	annual worker cost (€)	43.000
	average workers per vehicles	1,5
	% vehicles not in maintenance	0,8
	collection personnel cost (€)	9.597.600
	particular cost/operating costs	20,23%

The reported annual worker cost refers to the annual average worker cost (medium range) environmental services operator - public and private companies[31]. The vehicles in maintenance are 20% of the total used vehicles, as reported in the ISPRA report[32].

To tend, vehicles fitted with equipment useful for ITOI (Nord Engineering's "Easy" models fitted to IVECO Stralis) are intended as vehicles that can be managed by a single person. Sizing to 1.5 is justified for two reasons. The first is that, generally, especially in southern Italy, the vehicles are managed on average with a team of 3 people, a driver and two urban cleaners; the second reason is that a fleet must be managed with a number of drivers higher than the number of vehicles to allow them to be shifted.

[31] https://www.lavoro.gov.it/documenti-e-norme/normative/Documents/2019/DD-7-e-tabelle-dipendenti-servizi-igiene-ambientali-2019.pdf

[32] https://www.isprambiente.gov.it/contentfiles/00003500/3528-manuali-2001-06.pdf/ (page 109)

ACAM AMBIENTE		
	annual km	2.600.000
	€/l	1,2
	l/km	0,3
	fuel cost (€)	936.000
	particular cost/operating costs	1,97%

The €/l and l/km data refer to the traditional Iveco Stralis vehicle.

AMIU PUGLIA		
	operating costs (€)	102.750.000
	maintenance & machine stop cost (€)	2.268.701
	particular cost/operating cost	2,21%

CIDIU	*2019*
Collection personnel cost	8.350
Fuel cost	800
Maintenance & machine stop cost	930
(Values in €/000)	
Collection personnel cost/Total operating costs:	20,2%
Fuel cost/Total operating costs:	1,9%
Maintenance & machine stop cost/Total operating costs:	2,2%

(Values in €/000)

Then I multiplied these percentages for each company's operating costs.

Total operating costs	2019
Acea Pinerolese	57.734
Acam Ambiente	47.435
Acsel	16.694
Alia	350.163
Amiu Genova	163.850
Amiu Puglia_Bari	71.192
Amiu Puglia_Foggia	31.558
Amiu Taranto	35.903
Amiu Trani	11.579
Seta	31.909
CIDIU	41.359

(Values in €/000)

Collection personnel cost	(Values in €/000)
Amiu Trani	2337,77
Acsel	3370,37
Amiu Puglia_Foggia	6371,26
Seta	6442,14
Amiu Taranto	7248,56
Acam Ambiente	9576,76
Acea Pinerolese	11656,02
Amiu Puglia_Bari	14373,17
Amiu Genova	33080,03
Alia	70695,25

Fuel cost	(Values in €/000)
Amiu Trani	223,98
Acsel	322,91
Amiu Puglia_Foggia	610,42
Seta	617,21
Amiu Taranto	694,47
Acam Ambiente	917,53
Acea Pinerolese	1116,74
Amiu Puglia_Bari	1377,07
Amiu Genova	3169,34
Alia	6773,20

Maintenance & machine stop cost	(Values in €/000)
Amiu Trani	260,37
Acsel	375,38
Amiu Puglia_Foggia	709,61
Seta	717,51
Amiu Taranto	807,32
Acam Ambiente	1066,63
Acea Pinerolese	1298,22
Amiu Puglia_Bari	1600,84
Amiu Genova	3684,36
Alia	7873,84

Then I applied the 50/30/15 ITOI percentages - optimization batches of ITOI: 50% super optimal, 30% optimal, 15% suboptimal - to the obtained voices and I was able to see how much and where the savings were more significant.

50% OPTIMIZATION

savings on collection personnel cost	savings on fuel cost	savings on maintenance & machine stop cost	total savings
5.828,01	558,37	649,11	7.035,49
4.788,38	458,77	533,32	5.780,46
1.685,18	161,45	187,69	2.034,33
35.347,63	3.386,60	3.936,92	42.671,15
16.540,02	1.584,67	1.842,18	19.966,87
7.186,59	688,54	800,42	8.675,54
3.185,63	305,21	354,81	3.845,65
3.624,28	347,24	403,66	4.375,18
1.168,89	111,99	130,19	1.411,06
3.221,07	308,61	358,75	3.888,43

30% OPTIMIZATION

savings on collection personnel cost	savings on fuel cost	savings on maintenance & machine stop cost	total savings
3.496,81	335,02	389,46	4.221,29
2.873,03	275,26	319,99	3.468,28
1.011,11	96,87	112,61	1.220,60
21.208,58	2.031,96	2.362,15	25.602,69
9.924,01	950,80	1.105,31	11.980,12
4.311,95	413,12	480,25	5.205,33
1.911,38	183,13	212,88	2.307,39
2.174,57	208,34	242,20	2.625,11
701,33	67,19	78,11	846,64
1.932,64	185,16	215,25	2.333,06

15% OPTIMIZATION

savings on collection personnel cost	savings on fuel cost	savings on maintenance & machine stop cost	total savings
1.748,40	167,51	194,73	2.110,65
1.436,51	137,63	159,99	1.734,14
505,55	48,44	56,31	610,30
10.604,29	1.015,98	1.181,08	12.801,34
4.962,00	475,40	552,65	5.990,06
2.155,98	206,56	240,13	2.602,66
955,69	91,56	106,44	1.153,69
1.087,28	104,17	121,10	1.312,55
350,67	33,60	39,06	423,32
966,32	92,58	107,63	1.166,53

For the KPI about the ROI impacts, I calculated for each company and for each optimization scenario (50/30/15) the difference between the EBIT and the savings on the three particular costs, then I calculated the new ROI with savings ((EBIT-savings)/invested capitals) and I obtained the Delta ROI - the differences between the pre- and post- optimization ROI.

The values of EBIT and invested capitals of the operative units of Bari and Foggia of Amiu Puglia have been calculated with the same methodology (and the same discovered coefficients) used for the calculations of the production costs:
having the value of EBIT and invested capitals of Amiu Puglia, I calculated the Bari values multiplying the Puglia values for 78,13% (Bari participation in Amiu Puglia's capitals) and divided for 1,1 (the coefficient discovered in the production cost calculations); the same thing for Foggia, with a participation value of 21,87% and a coefficient of 0,7.

30% ITOI OPTIMIZATION	ROI	ROI with savings	Δ ROI
Acea Pinerolese	-0,62%	4,91%	895,81%
Acam Ambiente	-3,46%	14,43%	517,50%
Acsel	0,23%	3,49%	1415,78%
Alia	0,70%	10,34%	1376,49%
Amiu Genova	0,80%	9,14%	1042,28%
Amiu Puglia_Bari	1,40%	72,37%	5068,53%
Amiu Puglia_Foggia	1,40%	72,92%	5107,78%
Amiu Taranto	1,40%	7,66%	447,46%
Amiu Trani	0,73%	4,58%	527,28%
Seta	13,35%	27,50%	105,98%

30% ITOI OPTIMIZATION	ROI	ROI with savings	Δ ROI
Acea Pinerolese	-0,62%	2,70%	537,48%
Acam Ambiente	-3,46%	7,28%	310,50%
Acsel	0,23%	2,18%	849,47%
Alia	0,70%	6,48%	825,89%
Amiu Genova	0,80%	5,80%	625,37%
Amiu Puglia_Bari	1,40%	43,98%	3041,12%
Amiu Puglia_Foggia	1,40%	44,31%	3064,67%
Amiu Taranto	1,40%	5,16%	268,48%
Amiu Trani	0,73%	3,04%	316,37%
Seta	13,35%	21,84%	63,59%

15% ITOI OPTIMIZATION	ROI	ROI with savings	Δ ROI
Acea Pinerolese	-0,62%	1,04%	268,74%
Acam Ambiente	-3,46%	1,91%	155,25%
Acsel	0,23%	1,21%	424,73%
Alia	0,70%	3,59%	412,95%
Amiu Genova	0,80%	3,30%	312,68%
Amiu Puglia_Bari	1,40%	22,69%	1520,56%
Amiu Puglia_Foggia	1,40%	22,86%	1532,33%
Amiu Taranto	1,40%	3,28%	134,24%
Amiu Trani	0,73%	1,88%	158,18%
Seta	13,35%	17,59%	31,79%

For the KPI about the operating costs' size I calculated the difference between the operating costs of the companies and those of Cidiu. To the companies with a delta <20.000 were assigned a score of 10, to those between 20.000 and 50.000 a score of 8 and to the remaining ones a score of 4.

Total operating costs (2019)		Δ Cidiu	
Amiu Trani	11.579	29.779	8
Acsel	16.694	24.665	8
Amiu Puglia_Foggia	31.558	9.801	10
Seta	31.909	9.450	10
Amiu Taranto	35.903	5.456	10
Acam Ambiente	47.435	6.076	10
Acea Pinerolese	57.734	16.375	10
Amiu Puglia_Bari	71.192	29.834	8
Amiu Genova	163.850	122.491	4
Alia	350.163	308.805	4
CIDIU	41.359		
(Values in €/000)			

The last KPI was about the distances of the companies from Torino, the location of moltosenso (and also of Cidiu, which is in Collegno -TO); to the companies with a distance <100km from Torino were assigned a score of 10, to those between 100 and 500km a score of 8 and to the remaining ones a score of 4.

	Km from Torino	score
Seta (Settimo Torinese)	13	10
Acsel (S.Ambrogio di Torino)	30	10
Acea Pinerolese	50	10
Amiu Genova	170	8
Acam Ambiente (La Spezia)	270	8
Alia (Firenze)	410	8
Amiu Puglia_Foggia	900	4
Amiu Trani	950	4
Amiu Puglia_Bari	1000	4
Amiu Taranto	1100	4

After the analysis of the single KPIs I created a final tab summarizing the companies' classifications and giving each KPI a justified weight:

	3	1	1,5	0,8	0,8	0,8	7,9
weights:	**0,38**	**0,13**	**0,19**	**0,10**	**0,10**	**0,10**	1,00
	% ROI impacts	Δ operating costs (vs Cidiu operating costs)	distances (vs Torino)	Collection personnel cost	Fuel cost	Maintenance & machine stop cost	SUM
Alia	2,66	0,51	1,52	1,01	1,01	1,01	7,7
Amiu Puglia_Bari	3,42	1,01	0,76	0,81	0,81	0,81	7,6
Acea Pinerolese	1,90	1,27	1,90	0,71	0,71	0,71	7,2
Amiu Genova	2,28	0,51	1,52	0,91	0,91	0,91	7,0
Amiu Puglia_Foggia	3,80	1,27	0,76	0,30	0,30	0,30	6,7
Acsel	3,04	1,01	1,90	0,20	0,20	0,20	6,6
Acam Ambiente	1,14	1,27	1,52	0,61	0,61	0,61	5,7
Seta	0,38	1,27	1,90	0,41	0,41	0,41	4,8
Amiu Taranto	0,76	1,27	0,76	0,51	0,51	0,51	4,3
Amiu Trani	1,52	1,01	0,76	0,10	0,10	0,10	3,6

The weights stand for the importance of each KPI.

- The '%ROI impacts' KPI can be considered the most significant KPI since the ITOI optimization scenarios (15/30/50) can have a great impact on the economic performance of a company.
- The 'Delta operating costs' KPI has a basic weight of 0,13 (1/non-normalized-weights sum) since it only stands that a company with the operating costs similar to the ones of Cidiu - company where ITOI has been proved to be functional and efficient - has a good chance to work well in turn.

- The 'distances' KPI is a bit more than 0,13 since it is more comfortable implementing ITOI in a company near Torino, but if a company is far away it is not seen as a deal breaker.
- The 3 particular costs KPIs could have had the basic 0,13 weight, but since the numbers showed that the companies classification was the same for all the 3 of them, I decided to shrink the coefficient a bit in order to avoid imbalance with respect to the other KPIs' weights.

Market proposition and customers characterisation

Elaboration of a distinct market proposition for each reality according to the management model and development of the companies representatives' profiles .

Looking at the final tab we can see that six companies have a score greater than 6.5/10: Alia, Amiu Puglia (Bari), Acea Pinerolese, Amiu Genova, Amiu Puglia (Foggia) and Acsel. For these companies I have elaborated customer profiles in order to have the background and the needs of each company in the foreground and have marketing support.

Alessia Scappini – CEO and COO of Alia S.p.A.	
Demographics: Age/Gender: 46, F Role: CEO/COO Territory: Italy	*Background:* Degree in Chemical Engineering from the University of Pisa, with a curriculum entirely dedicated to environmental issues, in particular to the planning and management of the integrated waste cycle and a continuity of research towards innovative solutions for environmental contexts. Her professional experiences in the public utilities sector are significant and she holds top responsibilities in Tuscan companies of excellence, operating in the integrated waste cycle chain.
Objectives: differenziate growth; set up a business process control system that contemplates the need to verify multiple compliance aspects such as those deriving from ISO standards for the environment, safety and quality.	
Needs: optimal planning; user empowerment; automation of collections.	
Motivations: • Making the promotion activity in schools increasingly effective (ITOI could be an additional factor of interest in the promotion). • Making more efficient consulting assignments for public bodies and private companies, in the context of the design, planning and development of urban and environmental hygiene services.	*Critical issues:* • Resources management

Alia shows a great improvement on the ROI thanks to the savings and proves to be the greatest investors in the three particular costs; the company shows an

average distance from Torino (score 8), but it has the highest Delta operating costs with respect to Cidiu (due to its bigger size).
ITOI can help solve the needs for optimal planning and collections automation, since the driver is guided through the collection service step by step and the cycles are not rigid, but planned with flexibility. Also the objective of environment compliance (respect of ISO standards) can be accomplished given the lower carbon emissions and less traffic jam created by the reduction of the number of cycles needed to offer the same quality of service with respect to the collection provided on a periodic basis.

Sabino Persichella – President of Amiu Puglia S.p.A.	
Demographics: Age/gender: 49, M Role: Company president Territory: Italy	*Background:* Graduated in Law, he has been working professionally in his Bari office since 1998, mainly dealing with administrative law issues. He was for three years the Sole Director of Puglia Sviluppo S.p.A. - whose purpose is to contribute to the economic and social development of the territory - and since June 2017 he has been President of Amiu Puglia S.p.A.
Objectives: involvement of citizens, activating projects to raise awareness of the environment and the culture of the territory.	
Needs: route optimization and verification of collection loads on each zone.	
Motivations: • Protection of the environment, respecting and enhancing natural resources • **"Chi differenzia ci riguadagna"** is the title of the initiative that is now able to credit the 30% discount on the Tares to all families who want to deliver the differentiated waste to one of the five Amiu collection centers or to one of the new mobile ecological islands.	*Critical issues:* • Nodal system not yet fixed, but "liquid", not controlled

Amiu Puglia (Bari) shows a great improvement on the ROI thanks to the savings and proves to be a great investor in the three particular costs; the company shows a great distance from Torino (score 4) and it has an average Delta operating costs with respect to Cidiu.
ITOI can help solve the need of route optimization and verification of collection loads, since the offered services include a customizable application to remotely

monitor equipment status on the territory, an advanced navigator on the trucks and a plugin exposing the stats and the benchmark of the collection.

Francesco Carcioffo – CEO and General Manager of Acea Pinerolese	
Demographics: Age/gender: 71, M Role: CEO and General Manager Territory: Italy	*Background:* Graduated in Electronic Engineering, in 1991 he assumed the position of General Manager of the Acea Consortium and subsequently, in 2003, with the transformation into ACEA PINEROLESE INDUSTRIALE S.p.A., he became General Manager and CEO of the company. Currently he also holds other roles, including Director of 'COOPERATIVE CULTURE AND SOCIAL COMMUNICATIONS' and Member of the management committee of 'WATER ALLIANCE - ACQUE DEL PIEMONTE'.
Objectives: efficient management of collection services; reduction of operating costs; acceleration of the market consolidation process; investment optimization of the integrated waste service.	
Needs: completion of the review and computerization process for the internal management of collection services; development of a service management software that allows updating and monitoring of the main collection services; determination of calculation criteria to obtain a reduction in operating costs and an optimization of the investments.	
Motivations: • Focus on the rebirth of the territory in the 'Pinerolo Model' • Maintain a strong alliance on development and research with the Politecnico di Torino • Improve the operational results	*Critical issues:* • Resources management

Acea Pinerolese shows an improvement on the ROI thanks to the savings - even if this improvement is not great enough to make the ROI positive: therefore it results to be clear that the adoption of ITOI should be envisioned, in some cases, as a mid term tool for a greater improvement of companies' global efficiency - and proves to be an average investor in the three particular costs; the company shows a short distance from Torino (score 10) and it has a good Delta operating costs with respect to Cidiu, showing the same type of daily management reality.
Given the need of developing a service management software that allows to update and monitor the main collection services, ITOI can come into help since it offers a set of custom devices to collect data, a customizable application to remotely monitor equipment status on the territory and an advanced navigator on

the trucks; moreover it offers a plugin that exposes, to the legacy budgeting software, the stats, the benchmark of the collection and the proper accounting costs for delivering the service.

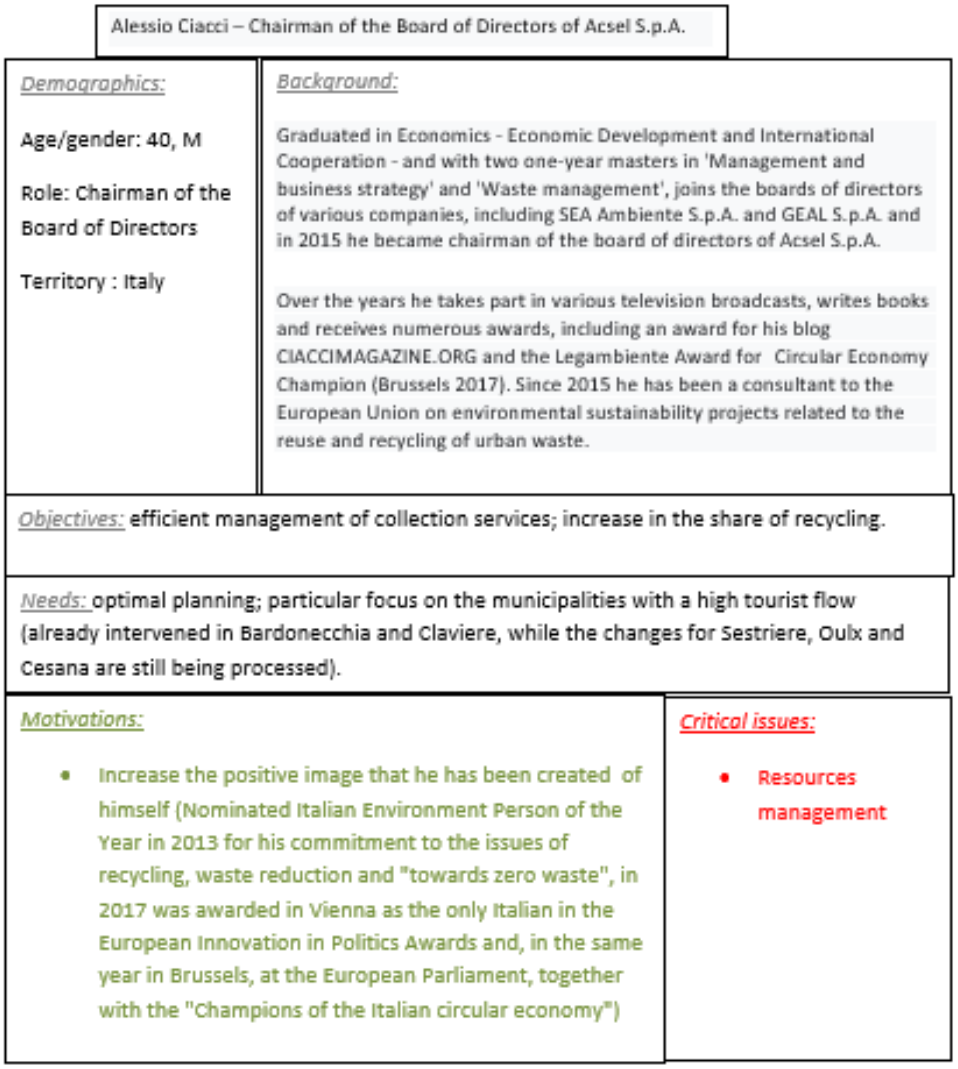
Tiziana Merlino – General Manager of Amiu Genova S.p.A.	
Demographics: Age/gender: 46, F Role: General Manager Territory: Italy	*Background:* Graduated with honors in Political Science and with a master's degree in 'Public Administration Innovator', she develops fifteen years of professional experience in the Public Administration sector to become General Manager of Amiu Genova S.p.A. in October 2017. Author of two books, she also deals with lectures and testimonials in Specialized Courses and Masters at the University of Genova.
Objectives: commitment to achieve European objectives (in 2019 the company reached the threshold of 37.45% of recycling); to be the cornerstone of an intelligent system for the collection and management of secondary raw materials.	
Needs: completion of the review and computerization process for the internal management of collection services; constant investments in means and technologies in order to satisfy the needs of a complex city like Genova.	
Motivations: • Strong focus on problem solving and process efficiency • Interest in the environment	*Critical issues:* • Heavy logistical and operational reorganization caused by the loss of approximately 30,000 square meters of plants and operating units with the collapse of the Morandi bridge in 2018: slowdown of a process of improving collection performance aimed at increasing the differentiated waste and the recovery of materials.

Amiu Genova shows a great improvement on the ROI thanks to the savings and proves to be the second greatest investors in the three particular costs; the company shows an average distance from Torino (score 8), but it has the second highest Delta operating costs with respect to Cidiu (due to its bigger size).
ITOI can help solve the need of completing the computerization process for the internal management of collection services, given the provided plugin that exposes, to the legacy budgeting software, the stats, the benchmark of the collection and the proper accounting costs for delivering the service. Moreover, the complexity of a city like Genova, ITOI can further help with the system able to provide both the waste and the worked hours per single Municipality.

Ambrogio Giordano – Technical Manager of Foggia operative unit of Amiu Puglia S.p.A.	
Demographics: Age/gender: 59, M Role: Technical Manager Territory: Italy	*Background:* After a degree in Sociology, another in Civil Engineering and another one in Territorial, Urban and Environmental Planning, he completed a second level master's degree in Criminological Sciences, followed numerous training courses (from construction to energy). He has played the role of speaker at numerous conferences and in 2017 he was the designer of the plants of Amiu Puglia S.p.A. both for the Bari and Foggia offices; from October 2020 he is Technical Manager of the Foggia operating unit of Amiu Puglia S.p.A.
Objectives: strengthening of structures and personnel to be used for RD services.	
Needs: consolidating the geographic information system, which rationalizes the positioning of bins and baskets.	
Motivations: • Great experience in territorial, urban and environmental planning and in the waste cycle • Specific expertise in the field of communication aimed at the management of human resources	*Critical issues:* • Difficulty in enforcing the Municipal Ordinance which imposes a ban on the conferment of MSW on Sundays and public holidays

Amiu Puglia (Foggia) shows a great improvement on the ROI thanks to the savings and proves to have invested a little in the three particular costs; the company shows a great distance from Torino (score 4), but it has a good Delta operating costs with respect to Cidiu, showing the same type of daily management reality.

ITOI can help with the need of consolidating the geographic information system, since it provides a more efficient use of waste collection trucks, assuring non-overflowing dumpsters, better dumpsters positioning, remote control of ICT equipment and dumpsters efficiency; it can do this thanks to a set of custom devices to collect data and a customizable application to remotely monitor equipment status on the territory.



Acsel shows a great improvement on the ROI thanks to the savings and proves to have invested a little in the three particular costs; the company shows a very short distance from Torino (score 10), and it has an average Delta operating costs with respect to Cidiu.

ITOI can satisfy the objective of efficiently managing the collection services, since the driver is guided through the collection service thanks to a customizable application to remotely monitor equipment status on the territory, an advanced navigator on the trucks and a plugin that exposes the benchmark of the collection and the proper accounting costs for delivering the service.

Also, given the need to focus particularly on the municipalities with a high tourist flow, ITOI proves to be able to give further help for those companies that serve several Municipalities, with the system providing both the waste and the worked hours per single Municipality.

Conclusion

Identification of **the best strategy** to go to market.

The targets of ITOI are the waste collection companies which have the objective of optimizing their job by cutting costs while improving the quality and respecting the targets about recycling. Given the obtained results, the best strategy is to aim first of all at companies with a high turnover, but also taking into consideration the issue of the distance.

In fact, ITOI optimization scenarios can have a great impact on the economic performance of a company: the higher the turnover, the more the set of tools and services offered helps to achieve a positive (or in any case a better) ROI and to save on costs and timing.

Anyway, the distance must also be taken into consideration, as it is more convenient to implement ITOI in a company near Turin, but if the distance is greater it should not be seen as a deal breaker. The sale of the ITOI service necessarily passes through a consultancy phase where it is made an assessment of how the company manages resources and data on the territory; this phase of characterization implies a relationship with the customer and a collaboration that is obviously facilitated by the possibility of going to the site, even if it could be done in smart working. However, it is also a question of size and since moltosenso is not a large company, it would probably be better to opt for consulting companies that are very far from Turin (to be clear, those that on the 'distance' KPI classification got a score of 4, so with distances greater than 500km) once that it is consolidated as a reality.

The first company to turn to should therefore be Alia SpA, of Florence.
It shows a great improvement in the already good ROI, it spends a great amount of money – and consequently shows a great enhancement with the optimization scenarios – for collection personnel, fuel and vehicles maintenance (resulting to be in the first place for all these three particular costs classifications) and it has an average distance from Torino since it is less than 500km far away. The only theoretical problem could be the fact that its operating costs are very different from those of Cidiu - company where ITOI was proved to be efficient and effective - but it can be explained by the fact that Alia SpA has greater

dimensions of Cidiu and so the revenues and the operating costs are inevitably different and this shouldn’t be a reason for not believing in its potential.

The best way for ITOI to capture the company’s interest is to offer solutions in order to solve its needs for optimal planning, collections automation and compliance with the environmental directives. With the ITOI services as a matter of fact the driver is guided through the collection service step by step and the cycles are planned with flexibility; the respect for the ISO standards can also be accomplished given the advantages created by ITOI that helps reducing the number of cycles needed, bringing to lower carbon emissions and less traffic jam and still offers the same quality of service.

Italian summary

Dal 26 ottobre al 29 dicembre 2020 ho svolto il mio tirocinio curriculare presso l'azienda moltosenso, una S.r.l. fondata nel 2009 specializzata nella consulenza ICT.

Il mio lavoro è consistito nello studio dell'ottimizzazione del ciclo di raccolta rifiuti e in particolare nell'individuazione delle prospettive di vendita della suite ITOI (Intelligent Tool for Optimized Instructions, un complesso ecosistema costituito da una suite di applicazioni e da un set di strumenti che permette una pianificazione ottimale dei cicli di raccolta rifiuti).

Ho studiato la value proposition ed il funzionamento di ITOI ed ho poi creato un Value Proposition Canvas, strumento di supporto nella definizione della value proposition per ogni segmento di clientela.

Come oggetto di studio sono state prese in considerazione varie aziende italiane, con la particolarità comune di essere tutte fornite da Nord Engineering o Farid Industrie (compagnie che operano nel settore dell'ecologia, impegnate nel design e nell'implementazione di soluzioni tecnologiche per la gestione dell'intero processo di raccolta rifiuti) e dunque provviste di un set up tecnologico simile a quello in cui è nato ITOI (sostanzialmente veicoli con GPS e sistemi di raccolta a pesata).

Le aziende analizzate sono le seguenti: Acea Pinerolese Industriale SpA (Pinerolo), Acsel Spa (Sant'Ambrogio di Torino), Seta SpA (Chivasso), AMIU Genova SpA, ACAM Ambiente SpA (La Spezia), Alia Servizi Ambientali Spa (Firenze), AMIU Trani Spa, AMIU Taranto SpA, AMIU Puglia SpA (frazioni di Bari e Foggia).

In primo luogo, ho analizzato i singoli bilanci, evidenziandone le voci di costo e gli investimenti più rilevanti; in questo modo ho potuto creare grafici Excel che mostrassero le relazioni tra percentuale di raccolta differenziata svolta e ROI e tra percentuale di raccolta differenziata svolta e costi di produzione annuali. Nella prima situazione ho potuto rilevare– per la maggior parte dei casi considerati - una relazione inversamente proporzionale, mentre nella seconda ho evidenziato un incremento parallelo di raccolta differenziata e costi: questo dato potrebbe costituire un incentivo per l'acquisizione di ITOI, in quanto potrebbe

portare l'azienda a risparmiare sui costi oltre che ad efficientare il sistema di raccolta.

In parallelo con l'analisi dei bilanci, ho preso parte a tre webinar: il primo riguardante la customer centricity, il secondo sulla blockchain nella filiera dei rifiuti e il terzo riguardante il cambiamento della gestione rifiuti dopo l'approvazione del decreto legislativo 116/2020 (il quale ha portato ad un'importante modifica nel sistema economico: da un modello lineare a uno circolare).

Ho analizzato la situazione generale a livello europeo, esaminando la green finance ed esempi di investimenti conseguiti in questo settore, e a livello italiano, facendo riferimento ai dati di ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale) ed esaminando gli obiettivi europei da raggiungere.

Tornando alle aziende analizzate, per ognuna di esse ho studiato i profili di Dirigenti/Amministratori delegati e li ho contattati per proporre un questionario con le seguenti richieste: numero di mezzi nelle flotte di raccolta, quantificazione dei passaggi settimanali, chilometraggio settimanale, quantitativo di cassonetti e rispettiva capienza per plastica / carta&cartone / vetro&alluminio / organico / indifferenziata e infine l'ambito privilegiato per gli investimenti effettuati nell'ultimo anno finanziario sul piano della raccolta rifiuti. Ho deciso di iniziare una prima analisi sui dati relativi al kilometraggio.

Ho preso come azienda di riferimento Acam Ambiente (La Spezia) - in quanto mi ha fornito i dati più completi e specifici – e ho elaborato dei calcoli per la scelta più efficiente dei mezzi di raccolta, studiando tre scenari con una proporzione diversa di motorizzazione ibrida. Ho notato come scegliendo veicoli con percentuali sempre più elevate di motorizzazione ibrida si possa arrivare ad un massimo risparmio di 8,2%, sia in termini di costi che di emissioni di CO2. Sulla base delle ipotesi adottate, questi valori di risparmio ipotizzati possono essere indicativamente applicati a qualunque altra realtà (ma dal momento che può cambiare il risparmio in valore assoluto potrà essere diversa l'incidenza nel bilancio complessivo).

Per studiare un modello generale degli impatti di ITOI sulla gestione quotidiana di un'azienda, ho contattato Cidiu Servizi - che ha sperimentato per prima la distribuzione personalizzata di ITOI, ottenendo ottimi risultati sia nella pianificazione che nel risparmio – per conoscere gli impatti che ITOI ha sulle

singole voci di costo a bilancio. Non avendo però ricevuto riscontri ho deciso di calcolare l'incidenza dei costi particolari (costo di carburante, personale impiegato nei turni di raccolta, manutenzione e fermo macchina) sui costi imputati a bilancio con i dati che avevo a disposizione dalle altre aziende. Applicando poi la griglia 50/30/15 (scaglioni di ottimizzazione di ITOI: 50% super ottimale, 30% ottimale e 15% sub ottimale) alle voci così ottenute, sono riuscita ad andare a vedere quanto e dove monetariamente il risparmio è significativo.

Ho quindi scelto come KPIs i tre costi particolari calcolati, l'incidenza dei savings sul ROI, il Delta dei costi operativi rispetto a Cidiu (in quanto se i costi sono simili, allora le situazioni sono paragonabili, mostrando lo stesso tipo di realtà gestionale quotidiana) e la distanza rispetto a Torino.

Ho quindi creato una classifica finale e dato dei pesi ad ogni KPI.

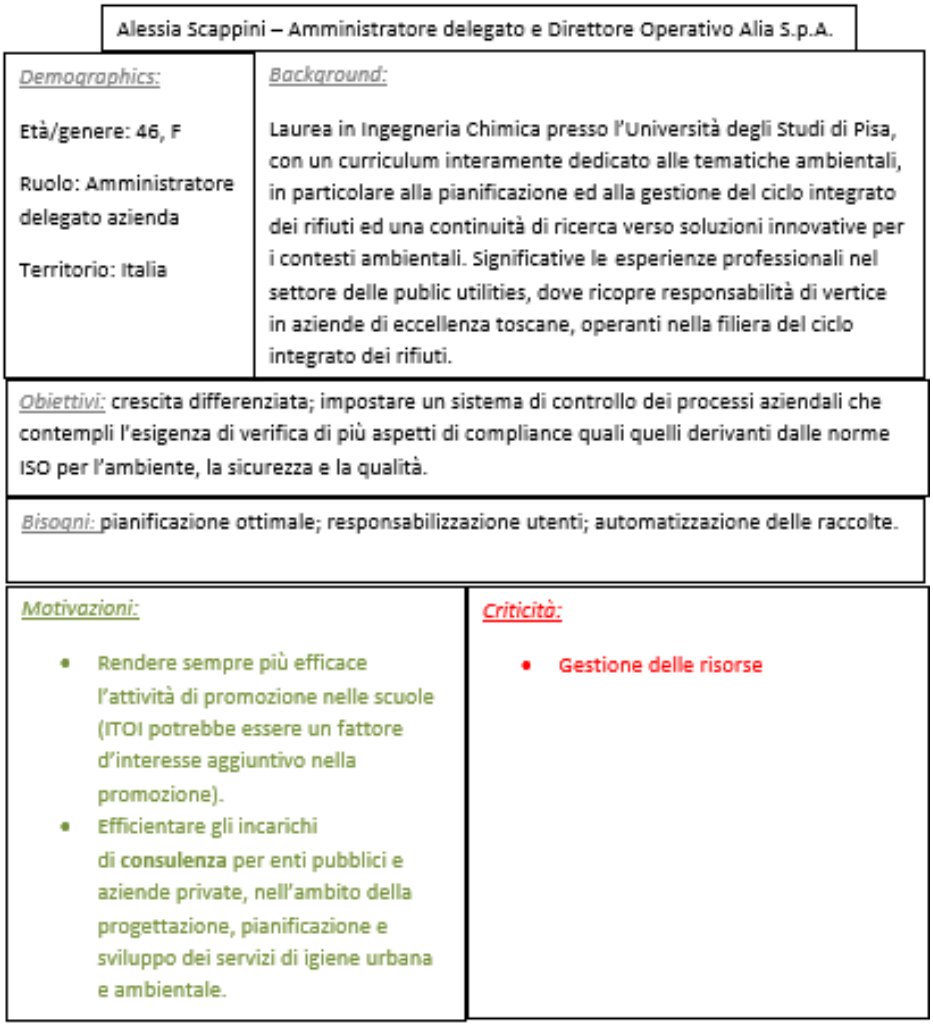
· Il KPI relativo all'incidenza dei savings sul ROI si può considerare come il più significativo in quanto gli scenari di ottimizzazione di ITOI (15/30/50) possono avere un grande impatto sulla performance economica di un'azienda.

· Il KPI relativo al Delta dei costi operativi ha un peso base di 0,13 (1/somma dei pesi non normalizzati) in quanto si riferisce unicamente al fatto che un'azienda con costi operativi simili a quelli di Cidiu – azienda dove ITOI è stato provato essere funzionale ed efficiente – ha una buona possibilità di funzionare bene a sua volta..

· Il KPI relativo alla distanza è leggermente più alto di 0,13 in quanto è più comodo implementare ITOI in un'azienda vicina a Torino, ma nel caso dovesse trovarsi in un luogo più lontano non sarebbe visto come un deal breaker.

· I KPI relativi ai 3 costi particolari avrebbero potuto avere il peso base di 0,13, ma dato che I numeri hanno mostrato che la classifica delle aziende era la stessa in tutti e tre i casi, ho deciso di ridurre parzialmente il coefficiente per evitare sbilanciamenti rispetto ai pesi degli altri KPIs.

Data la tabella finale ho notato che sei aziende avevano un punteggio superiore a 6.5/10 e per queste aziende ho elaborato dei profili del personale in modo da avere background e necessità di ogni azienda in primo piano e il supporto marketing. Ad esempio, ho elaborato il profilo dell'Amministratore delegato/Direttore operativo di Alia SpA, la prima azienda in classifica:



In questo caso, ITOI può aiutare a risolvere le esigenze di pianificazione ottimale e automazione dei ritiri, poiché l'autista è guidato passo dopo passo nel servizio di raccolta ed i cicli non sono rigidi, ma pianificati con flessibilità. Anche l'obiettivo della compliance ambientale (rispetto degli standard ISO) può essere raggiunto date le minori emissioni di carbonio e il minor ingorgo creato dalla riduzione del numero di cicli necessari per offrire la stessa qualità di servizio rispetto alla raccolta erogata su base periodica.

Dati i risultati ottenuti, la migliore strategia di ITOI è puntare innanzitutto ad aziende con un alto fatturato, tenendo in buona considerazione anche la questione della distanza. Gli scenari di ottimizzazione di ITOI possono infatti avere un grande impatto sulla performance economica di un'azienda: più il fatturato è alto, più il set di tools e servizi offerto aiuta a realizzare un ROI positivo (o comunque migliore) ed a risparmiare su costi e tempistiche.

Anche la distanza va comunque tenuta in considerazione, in quanto è più comodo implementare ITOI in un'azienda vicina a Torino ma, nel caso in cui la distanza

fosse maggiore, questo fattore non va visto come un motivo valido per non scegliere quella data azienda. La vendita del servizio ITOI passa necessariamente attraverso una fase di consulenza dove si opera una valutazione di come l'azienda gestisce le risorse e i dati sul territorio; questa fase di caratterizzazione implica una relazione col cliente ed una collaborazione che ovviamente è facilitata dalla possibilità di recarsi in loco, ma può comunque risultare efficace anche a distanza. Si tratta comunque anche di una questione di dimensioni e poiché moltosenso non è un'azienda di grandi dimensioni, probabilmente farebbe meglio ad optare per svolgere attività di consulenza aziende molto lontane da Torino una volta che si sarà consolidata come realtà.

La prima azienda a cui rivolgersi sarebbe quindi preferibilmente Alia Servizi Ambientali SpA, di Firenze. Dimostra infatti un grande miglioramento nel ROI, spende una grande quantità di denaro - e di conseguenza mostra un grande miglioramento negli scenari di ottimizzazione - per il personale di raccolta, il carburante e la manutenzione dei veicoli (risultando al primo posto per le classifiche di questi tre costi particolari) e si trova ad una distanza media da Torino, in quanto è a meno di 500 km. L'unico problema teorico potrebbe essere il fatto che i suoi costi di gestione sono molto diversi da quelli di Cidiu - azienda dove ITOI si è dimostrata essere efficiente ed efficace - ma si può spiegare con il fatto che Alia SpA ha dimensioni maggiori di Cidiu e quindi i ricavi ed i costi operativi sono inevitabilmente diversi e questo non deve essere motivo di offuscamento della sua potenzialità.

Il modo migliore per catturare l'interesse dell'azienda è offrire soluzioni per risolvere le sue esigenze di pianificazione ottimale, automazione dei cicli di raccolta e la necessità di conformarsi alle direttive ambientali. Con i servizi offerti da ITOI, infatti, il conducente del mezzo per la raccolta viene guidato passo dopo passo nel servizio di ritiro ed i cicli di raccolta vengono pianificati con flessibilità; anche il rispetto degli standard ISO può essere ottenuto grazie ad ITOI dati i vantaggi che riesce ad apportare, aiutando a ridurre il numero di cicli di raccolta necessari e portando di conseguenza a minori emissioni di anidride carbonica e meno traffico in circolazione, offrendo comunque la stessa qualità di servizio.

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