ISWA
International Solid Waste Association

HOW INDUSTRY 4.0 TRANSFORMS THE WASTE SECTOR

OCTOBER 2019

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AMCS BIR ubq بيئة be'ah

ACRONYMS

AI	Artificial Intelligence
API	Application Programming Interface
B2B	Business to Business
B2C	Business to Clients
BI	Business Intelligence
CRM	Customer Relationship Management
EfW	Energy from Waste
EPR	Extended Producer Responsibility
ERP	Enterprise Resource Planning
GHGs	Green House Gases
GPRS	General Packet Radio Services
GPS	Global Positioning System
HQ	Headquarter
ICT	Information & Communication Technologies
IND 4.0	Fourth Industrial Revolution
IoB	Internet of Bins
IoT	Internet of Things
ISWA	International Solid Waste Association
IT	Information Technology
KPIs	Key Performance Indicators
ML	Machine Learning
MRF	Material Recovery Facility
MSW	Municipal Solid Waste
PAYT	Pay As You Throw
PET	Polyethylene Teraphthalate
PHAs	Polyhydroxyalkanoates
PLA	Polylactic Acid
R & D	Research & Development
RFID	Radio Frequency Identification
SDGs	Sustainable Development Goals
SWM	Solid Waste Management
UAV	Unmanned Autonomous Vehicle
UN	United Nations

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INTRODUCTION

The rise of the Fourth Industrial Revolution (IND 4.0) is reshaping our world and many industries have already felt the impacts. ISWA started the discussion about the future of waste management in relevance to IND 4.0 from the beginning of 2016. In September 2017, we published the results of ISWA's global survey on the impact of the Fourth Industrial Revolution in waste management and recycling, according to the opinions and views of more than 1000 members of the industry.

This report is a follow-up to the survey. Encouraged by the positive comments received about ISWA's survey, we decided to move on with a new report that aims to present the tangible ways in which IND 4.0 already transforms the waste industry. The results presented in this report offer a practical overview on currently available applications and serve as a guide as to what should be expected as IND 4.0 is already advancing.

Besides the practical guidance, it was impossible to elaborate such a report ignoring some basic questions that need further discussion. Questions regarding the future of labour in the waste industry (and not only), the overall impact of IND 4.0 on the planet, the opportunity for a new scientific paradigm and the need for new advanced governance patterns.

The course of IND 4.0 involves both great hopes for a better planet and the potential to accelerate environmental degradation and resource depletion. W.B. Yates has said that "Education is not the filling of a pail, but the lighting of a fire". We really hope that this report will inspire and light up fruitful discussions regarding both the environmental and the social footprint of IND 4.0 in our sector.

Last but not least, this report is a result of a collective effort, so I would like to thank warmly the team that worked hard to finalize this report and all the experts that contributed with great content.

Antonis Mavropoulos
ISWA President

TESTIMONIES

CIRCULAR ECONOMY AND IND 4.0 ARE COMPLEMENTARY

Circular Economy is a paradigm shift that will change the way we produce and consume products and services. It is a new economic model where the value of products, materials and resources is maintained for as long as possible and waste is minimized.

The waste management industry had long pointed out that the linear “take-make-use-dispose” economy was not sustainable, even before the Club of Rome’s report on limited resources in 1972. Scarce resources have to be managed on a circular manner. Today, the so-called Industry 4.0 can make a substantial contribution to achieve the ambitious targets set in the EU New Circular Economy package. These targets will require not only new investment and advice to project promoters but also innovative financing instruments taking into consideration, for example, the real costs of environmental degradation.

In the discussion on how to achieve environmental sustainability, ISWA has made it clear how complementary Industry 4.0 and the Circular Economy are. However, the use of this technology should aim not only at achieving sustainable development but also at shifting business processes. ISWA has rightly put the Industry 4.0 and the technologies of the Internet of Things (IoT) on top of its agenda to demonstrate how to stimulate the transition from a linear to a circular economy.

I would like to wish ISWA a successful and fruitful discussion. Its output is not only highly relevant for academia, practitioners but also but international organisations involved in the waste sector.

Dr. Oec. Patrick L. Dorvil
Senior Economist at European Investment Bank
Lecturer at University College London
Member of the International Solid Waste Association

Keith Alverson

Director International Environmental Technology Centre
United Nations Environment Programme

The first three industrial revolutions were powered by massive extraction of natural resources (first coal, then gas and oil, and finally exotic materials for biotech, chemicals and electronic components). Each resulted in exponential increases in living standards, but also a concomitant increase in both the volume and complexity of waste. Unless we take clear and proactive action to ensure otherwise, there is a real risk that the fourth will be precisely the same. I am very pleased to see ISWA's vision for a completely different kind of revolution, fueled by information exchange efficiency, allowing society to benefit more from ecosystem services and less on the unsustainable extraction of natural resources that imperil them.

Ad Lansink

Founder of the Waste Hierarchy
Author of the book "Challenging Changes"

Water and steam power founded the First Industrial Revolution. Electrical power allowed the mass production of goods during the second one. Since the nineteen sixties, automation and digitalization have laid the foundation of the Third Industrial Revolution. The fourth version is not a linear continuation of the third one. Typical of Industry 4.0 is the demolition of boundaries between physical, chemical, and biological domains. Also, scale and velocity are higher than in previous times, sometimes leading to disruptive innovations: a new term in the social-economic vocabulary. Globalization changes the trade economy too. Therefore, the Fourth Industrial Revolution will cause major changes in commodity policy and waste management, in resource policy and value creation, influenced by three important context factors: time, place and function. Industry 4.0 will use new tools such as blockchain technology and worldwide communication channels, presenting society a just and sustainable future.

Prof. Agamuthu Pariatamby

Editor-in-Chief, Waste Management & Research - Institute of Biological Sciences
Faculty of Science University of Malaya

Previous global industrial revolutions have led to the release of unprecedented amounts of pollutants into the environment. One such pollutant is the toxic heavy metal, mercury (Hg). However, the Fourth Industrial Revolution is evidently contributing to the dynamism in transforming the technologies for sustainable waste management. At the same time, the ever-increasing Municipal Solid Waste (MSW), especially in developing nations, is a real challenge to waste experts. These challenges are acknowledged by ISWA which is championing the revolution to create a better environment with minimal pollution. The strategic approach from ISWA in all angles will enhance the waste management solutions.

Mohab Ali Al-Hinai, Ph.D.

Head of the Environmental Center of Excellence
Oman Environmental Services Holding Company (be'ah)

As the Fourth Industrial Revolution (IND 4.0) dawns upon us, the promise of finding new innovative ways to attaining sustainable waste management and closing the circular economy loop becomes even more achievable. In the past year, the world produced 2.1 B tons of MSW, of which only 16% was recycled. The 4Rs (Reduce, Reuse, Recycle and Recover) have always been at the forefront of sustainable waste management. With the emergence of IND 4.0 technologies, adding another R to "Redesign" our products and processes makes sense. The possibilities are endless. For example, using big data and artificial intelligence could help us build products that are more durable. While machine learning and robotics could help us, more efficiently recover and recycle material, thus making reutilizing waste more economically viable.

Since its inception, the Oman Environmental Services Holding Company (be'ah) has strived to set an example as a regional and global leader in sustainable waste management. As we embrace the era of IND 4.0, be'ah is evolving into a state-of-the-art resource management entity that is keen on setting the bar high.

David Biderman

Executive Director and CEO

Solid Waste Association of North America

The status quo for managing solid waste is neither acceptable nor sustainable, particularly in many developing countries. The inter-related and complex problems associated with improper waste disposal systems, marine litter, IND 4.0 and Climate Change demand action. SWANA looks forward to working with ISWA, the World Bank and others to address these growing problems, which affect billions of people throughout the world.

Prof. Linda Godfrey

Manager, Waste RDI Roadmap Implementation Unit

Principal Scientist, Waste for Development

It is clear that IND 4.0 provides tangible benefits for the waste sector, from waste prevention, through smart logistics, to improved resource recovery. It is however, also clear that it has the potential for unintended consequences, which need to be closely monitored. This includes creating an even greater gap between developed and developing countries. As developed countries adopt innovative, high-tech, automated solutions, developing countries face very real waste management challenges, such as weak collection services, uncontrolled dumping and open burning, and an urgent need for labour-intensive solutions to address growing unemployment rates. It is therefore critical to understand IND 4.0 within the context of developing countries and how they can unlock associated opportunities given current capacity constraints. Echoing the '2030 Agenda for Sustainable Development' pledge, it is important that we leave no one behind.

KEY-MESSAGES

TOWARDS THE END OF BUSINESS AS USUAL

We are living in an era where there are a lot of indications that our dominant economic model is getting close to the end of business as usual and requires fundamental changes. Unprecedented levels of pollution (e.g. 1 million deaths per year due to waste related pollution), a continuous increasing population (projected to almost 10 billion by 2050), and the expected doubling of the global material resource use till 2050 create serious restrictions and pose questions regarding the planetary limits and the continuous economic growth.

RESHAPING THE FUTURE OF WASTE MANAGEMENT

The end of business as usual concerns the waste management sector too. IND 4.0 together with Global Warming, Circular Economy and Marine Litter are fueling innovative policies, technological disruption, new business models and financial schemes. Their combined influence reshapes the future of waste management and makes it a core component for all policies that are heading towards a more sustainable planet. IND 4.0 should be considered at the centre of those trends as it represents the hope, the technological means and the social transformation required to address Global Warming, Circular Economy and Marine Litter.

HIGH POTENTIAL FOR A WASTELESS FUTURE

IND 4.0 opens new ways to prevent, reduce and even eliminate waste from specific sectors and streams, to advance resource recovery, to achieve high standards of treatment and disposal, to substantially reduce pollution and environmental impacts. At the same time, it provides new tools to stimulate stakeholders' interaction, awareness and citizens' participation, to apply the "polluter pays" and the "extended producer responsibility" principle on a global scale, to make the governance of cities (including waste management) more inclusive and participatory, and to reduce or eliminate "dirty – dangerous – difficult" jobs and improve occupational safety and working conditions.

FURTHER RESOURCE DEPLETION AND POLLUTION?

However, the same advances that open the way towards a more sustainable and circular economic system can be easily turned to drivers for further resource depletion, pollution, as it has already happened in previous industrial revolutions. As things are going on today, without strong links and interaction between product designers and the waste management sector, the expected plethora of new products, constructed from new, innovative composite materials would easily become a tsunami of end-of-life objects without possibilities for developing circular loops, modularity, reuse and recyclability. We have seen this already with e-waste. It took almost 20 years to understand their importance and develop proper policy responses and methodologies to manage the problem. Still, out of the 50 million tonnes of e-waste that are generated annually, 76% is dumped or not properly recycled. The losses in terms of valuable resources are USD 62.5 billion per year.

TOWARDS A DIFFERENT LABOUR FORCE

It is clear that in waste treatment facilities, in landfills, and probably in waste collection, the rise of robots and unmanned autonomous vehicles will fundamentally alter the role of the labour. Based on the experiences gained from the existing robotic recycling advances, it is obvious that we are heading towards a reduced reliance on manual sorters. The main trend is to increase the working distance between the actual handling of materials and human beings and reduce the relevant occupational health and safety problems. Thus, it's not that treatment facilities and MRFs will run without workers but that workers will have to work in close cooperation with intelligent robots that will do all the dirty work. Similar conclusions can be made for the waste collection crew and the landfill workers. "Dirty – dangerous – difficult" jobs are in high risk – but higher skills and better educated / trained labor force would be crucial for the operation of the new robotic facilities and vehicles.

NEW GOVERNANCE PATTERNS ARE URGENTLY REQUIRED

We are uncertain of many things regarding IND 4.0 but we can be certain that governance is the key to unlock the benefits and restrict the problems. New principles, protocols, rules and policies are needed to accelerate the positive and inclusive impacts of these technologies, while minimizing or eliminating their negative consequences. IND 4.0 makes necessary a revolution in governance in all the levels involved: international cooperation, national, regional, municipal and corporate. This requires a new role for the private sector and academia working alongside public officials to provide expertise on the technologies they are developing, their applications and potential consequences.

ISWA COMMITMENTS

ISWA is committed to play its own unique role on this task. ISWA is committed:

- To follow up, monitor closely and evaluate the advances of IND 4.0 in the waste management industry.
- To work together with governments, regional authorities, municipalities and the private sector to ensure that the advances of IND 4.0 will be utilised towards a Wasteless Future and that they will stimulate circular loops and business models.
- To work closely with all the relevant stakeholders to develop proper governance models and patterns in accordance with the governance shift required to utilise IND 4.0.
- To provide technical support, capacity building and roadmaps that will allow the adoption and adaptation of the IND 4.0 developments to both the developed and the developing world.
- To contribute with proper policy suggestions and interventions in global fora towards a transformation of the waste management sector by IND 4.0 that will not create additional inequalities and a widening technological gap.

CHAPTER 1

TOWARDS THE END OF BUSINESS AS USUAL IN WASTE MANAGEMENT

Global Warming, Circular Economy and Marine Litter have a common denominator. First, to move towards a Circular Economy and to effectively manage Global Warming and Marine Litter, fundamental changes are required in the global and local economic systems, as well as in the way we manage resources and waste. Second, in all cases, new business models are required. Third, while Global Warming and Marine Litter are a measure of the global environmental impacts of improper waste management practices, Circular Economy shows that the necessary solutions involve the waste sector but go far beyond it. To address those challenges, it is necessary to re-design processes and products for more and better circular loops, to achieve longer life-cycles and to stimulate waste prevention, repair and reuse. But all those changes literally mean that we need a new, different economy. In this way, Global Warming, Circular Economy and Marine Litter demonstrate that waste management can't be separated from the scope, the objectives and the practices of the dominant economic system. They are signals for the end of business as usual in our economies and in waste management practices too.

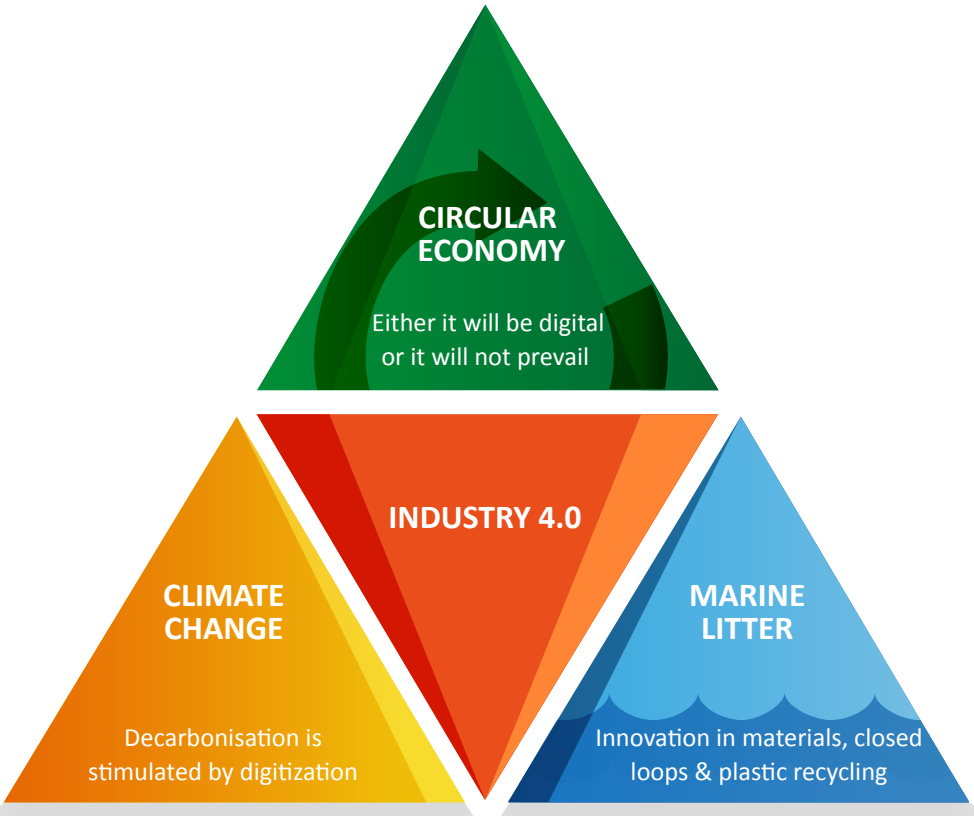
IND 4.0 is an overriding trend that covers gradually the whole world. IND 4.0 will fundamentally change the way we live, work and interact with each other. It introduces a whole new range of opportunities for societal transformation, with breakthroughs in fields such as the Internet of Things, autonomous vehicles, robotics, 3D printers and block-chain that are further embedding technology into our daily lives to improve how we function as a society. The more IND 4.0 is unfolded the more it recreates the economic systems and delivers new business models and in some cases new social patterns. This is also true for waste management.

FOUR CHALLENGES RESHAPING THE FUTURE OF WASTE MANAGEMENT

IND 4.0 together with Global Warming, Circular Economy and Marine Litter are fueling innovative policies, technological disruption, new business models and financial schemes. Their combined influence reshapes the future of waste management and makes it a core component for all policies that are heading towards a more sustainable planet. Even though the four challenges are acting in parallel reshaping the waste industry in different ways, IND 4.0 should be considered at the centre of those trends as it represents the hope, the technological means and the social transformation required to address Global Warming, Circular Economy and Marine Litter. The future of waste management will be shaped, for better or worse, by the continuous interaction and influence by those four trends.

IND 4.0 HAS ALREADY DELIVERED RESULTS

The Fourth Industrial Revolution is already a reality in the waste industry. Hundreds of thousands of sensors are already monitoring waste collection, semi-driverless collection vehicles are tested, robotics and advanced automation are becoming integral components of new waste treatment facilities, drones are already in use for landfill monitoring and 3D printers are tested for recycling different types of plastics. All of these technologies require software platforms and big data systems to transform the oceans of data points to meaningful information. This IND 4.0 has already created an impact on the waste industry, and it is reasonably expected that the footprint of IND 4.0 will become gradually bigger and more obvious quantitatively and qualitatively. ISWA believes that it's time to study this impact and provide key-insights that will help the industry to adapt better and stimulate more sustainable waste management systems.



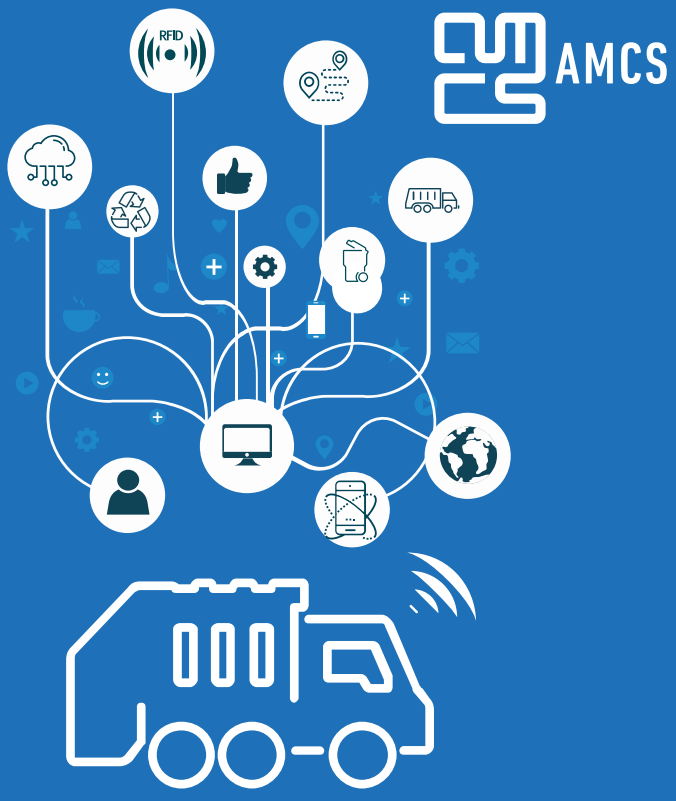
DIGITAL TRANSFORMATION FOR VALUE-CHAIN OPTIMIZATION

Trying to outline both the pathways and the root causes of the on-going digital transformation of the waste industry, ISWA's Georgina Nitzsche discussed with AMCS Group Chief Marketing Officer, Mark Abbas. AMCS Group is one of the leading software and technology providers for the waste and recycling industry with more than 2,450 clients worldwide and a history that goes back to more than 20 years. On January 2019, AMCS released the first Digital Transformation Barometer for the Waste Industry which details how organizations in the waste industry use technology to improve the performance of their operations and how they adapt to changes. The discussion below reveals many useful insights about the digital transformation of the waste industry, the expected benefits, the real problems and the future of the industry.

Georgina Nitzsche: How has AMCS started its journey to the digital world?

The cost of waste management is going up for many years, and up is the only direction we can expect it to go in the foreseeable future! Meeting this challenge and to stay relevant and competitive in the industry, will mean optimizing efficiency and automating processes: a digital transformation is the only way.

The first version of our software was more a billing system. But as time progressed; companies needed a full scope operational software to support the business. When I arrived at the firm I brought 22 years of experience as an entrepreneur, of working with waste management companies, talking to people about their problems and finding ways to help them. With this 'eye' for improvement and a heart for technology, we saw how software could drive efficiency - adding mobile apps to better manage the collection routes and information gathering. We were sure that "we can do something better, cheaper, and digital."



For example, by combining truck data of a bin lift with GPS data and route data we could visualize where there had been a pick-up of waste that are not being paid for. In some cases, operators were not aware of some of the collection stops being made and they could update their invoicing of clients. Nevertheless, there was some resistance to this pioneering view, "with some technologies we were way too early, nobody wanted to listen." It was 1996 and mobile computers were big. The amount data being collected was hard to handle. The software programming was complex and moving to integrated technologies did not always work smoothly at first.

What were the main challenges you faced on the way to digitalization?

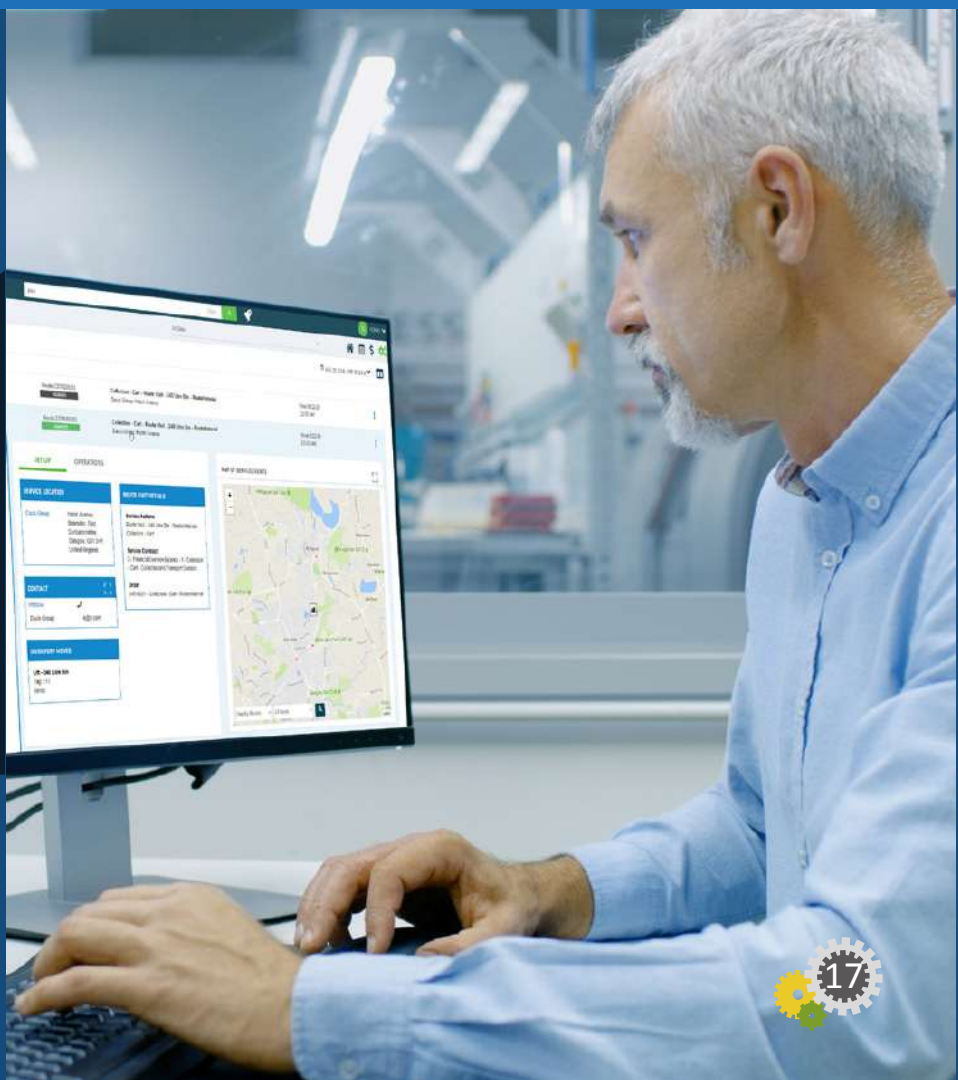
It is interesting that AMCS were in some ways leading the changes in industry through their own company vision rather than reacting to client's demands. For example, I am a so-called Early Adopter, when the Apple iPad was launched I flew to the US to be among the first to own one. I loved the gadget, it's haptic, visual appeal and versatility and was sure it would be a great tool for drivers.

One problem is that the tablet was seen as a personal tool, for entertainment and home use. Drivers are seen as rough and treating equipment roughly. The two did not seem to be a good match. AMCS then had to persistently break down stereotypes, showing that tablets were rugged enough and in fact drivers loved to work with them. AMCS had to convince an entire market that it would work, to see the opportunities for business applications with commercial hardware.

The biggest technical challenges of digital transformation tend to be some combination of adopting new technologies, using data science as a driver for business improvement and the problems with integrating legacy systems. Legacy systems that do not communicate and share information contain corrupted data, can create real roadblocks for digital transformation.

AMCS

On the people side of digital transformation, the main challenge is for companies to understand that digital transformation requires leadership in change management. It's not a question of investing in some software and it's done. Digital transformation means incremental and permanent changes to the way processes are being executed and thus the way people work.



We have heard AMCS Customers describe your solutions as “solutions in the middle of technology, people and the environment.” Why is that?

The AMCS platform solves the main challenge of integrating siloed systems and is inspired by global market and sustainability trends, driving automation and delivering end-to-end standardization and optimization of all business processes of waste & recycling companies. A platform that enables established companies to operate smarter, more seamlessly and more digitally leveraging latest technologies like Artificial Intelligence and Internet of Things capabilities.

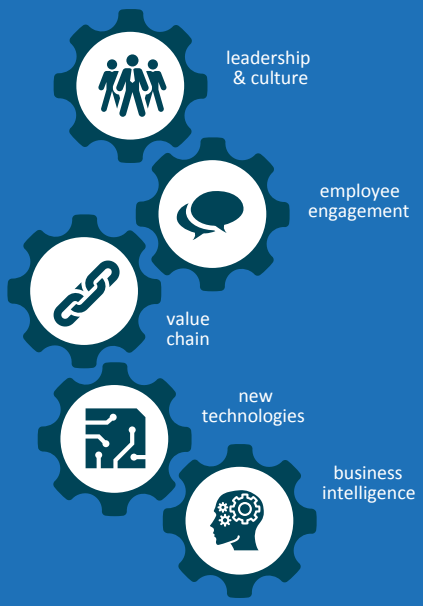
Integrating digital engagement solutions like customer portals, customer service automation and automated subcontractor management, a robust enterprise management (ERP) system, mobile applications and vehicle technology (RFID, On board weighing, PTO and Can BUS). End users are very important to AMCS and they may expect to get the best-in-class user experience running their day-to-day business. With the platform we help our clients to digitize their business and to support the transformation of their business to the circular economy.

The platform was developed in close cooperation with our clients across the globe. We were fortunate to have strong client relations because there was a trust in the company. We listen to the customer’s need and we spent serious amounts of time understanding the clients’ business processes and persevered to defining best practice processes.

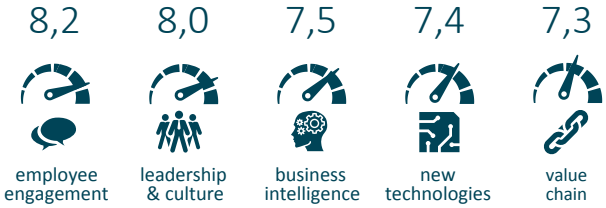
Digital transformation is not all about adopting new technology. Managing the change in your business is just as important. For example, for the client Returpack, their entire transport chain was optimized using the AMCS Intelligent Optimization suite. First the master routes are planned into the AMCS route planning system and then they are optimized using data collected directed from the clients repeat journeys. In this way, the client’s involvement is a fundamental part of the process. The routes can be optimized to avoid heavy traffic, improve safety by avoiding schools during opening and closing times, to make extra stops to collect waste in full bins or leave out bins that are not full enough.

About AMCS Group

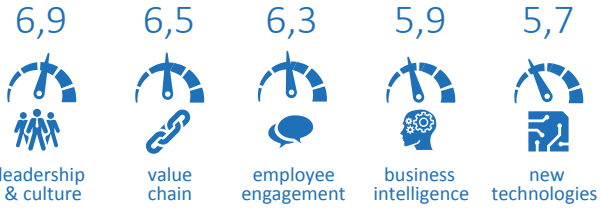
AMCS is the leading supplier of integrated cloud-based software (based on big data and predictive algorithms) and vehicle technology for the circular economy, waste, recycling and material resources industries. Its solutions reduce the paperwork, time and costs of operating waste, resource management and recycling businesses. At the same time, they optimize transportation, assets, back office and processing operations with clear visibility, mobility and decision support. The result is improved margins, rich customer service and getting paid faster. AMCS have clients in twenty-two countries, spanning Europe, Australia and North America. The company HQ is in Ireland, and is considered one of the fastest growing technology companies in Ireland.



Operational driver importance ranking (on a scale from 1 to 10)



How well have the digital transformation drivers been implemented?



What are the expected tangible results from a client's perspective?

The usual results are invoice accuracy, efficiency in processes, route optimization and strongly improved customer satisfaction. With better route optimizations, fewer vehicles are needed to make the total collection, this means better use of personnel and reductions of operating (vehicle) costs. Optimized routing has resulted in significant fuel and emissions savings bringing both cost and environmental benefits as well. Increased accuracy and availability of data leads to better informed business decisions. Other critical outcomes are improved safety, streamlining of back-office paper work and cost savings.

The success stories posted on the AMCS website show that in many cases there was a 100% switch to a paperless office. Or for AES, a 15% reduction in cost per lift. For Reinis there were 30% savings on mileage by using mobile and routing technologies. In general, customer satisfaction improved, driver satisfaction improved, and operational cost savings increased.

One could say however, that the clients could not fully envisage these positive results beforehand so the AMCS platform and its various applications provided solutions beyond their expectations in fact.

What are the critical factors for a successful digitalization?

Digital transformation is more of an evolution than a revolution, and a successful transformation is one that follows a step-by-step process of implementing the best solutions for where the business is at right now. Our research in the Digital Transformation Barometer shows that there are five elements that are critical to success in transitioning into a digital organization. Besides engaged employees and a management team that gives people the space to innovate, it is very important to have a comprehensive understanding of the digital trends and advancements in the value chain. It is also down to a smart application of new technology within the organization and using (reliable) data to make decisions.

Which organizations are pioneering the digital transformation?

Simply speaking, for the large enterprises within our industry, the larger the fleet size, the greater the need for efficiency and optimization. The same tends to occur as revenues and budgets grow. This growth creates a greater sense of urgency for digital transformation. Our research shows that the early adopters are already very nearly paperless, they use digital invoicing systems and they have self-service web portals available for their customers. They are also more likely to already be using other digital techniques and applications, such as RFID, GPS Monitoring, Route Optimization, and in-vehicle tablets.

The Digital Transformation Model

Leadership and culture

Having a winning leadership team, (city) council or government, and an organizational culture that enables people to do their best work.

BI and data science

Using data to inform and guide decisions.

Employee engagement

Driving digital excellence with employees that are engaged in the process.

New technologies

Being able to successfully implement and make use of new and emerging technologies.

Value chain, partners and trends

Having an in-depth understanding of what the digital trends are in the industry and collaborating with partners and suppliers who are best in class.

Finally, how AMCS foresees the future of waste management?

The foreseeable future will be about evolving from data to information. Analytics and Business Intelligence are making it possible to immediately calculate the profitability of routes and jobs. Coordination with subcontractors is optimized when information can be exchanged digitally. And investing in applications like digital invoicing and payments mean offices can become completely paperless. Today's waste is tomorrow's raw material. Collaboration and simplification within the value chain are essential for progress and creating value. A circular economy is not a liability; it is an opportunity for growth. Technology, ICT and big data will all play an important role in the new standards of sustainability.

Digital ways to a cleaner world

By Mark Abbas, CMO & Director of Business Development at AMCS Group

AMCS are pioneering the digital transformation of waste management and recycling processes in back-offices and fleet management, enabling operators to grow while reducing costs and improving services and safety as well as reducing the carbon footprint. The question is no longer when to make the digital transformation, but rather how to get started and what to speed up.

In 2018, we launched The Waste Management Barometer 2018 – a senior management survey of digital transformation in the waste management industry. We developed a 5 point Digital Transformation Model and asked participants to rate their levels of awareness and progress.

More than 80% of participants believe that digital innovation is important for the success of the business. Outdated legacy IT systems, paperless operations and a culture resistant to change are the biggest barriers.

At AMCS we believe that the digital transformation is not so much a revolution as an evolution –it starts with leadership in change management: a committed and empowered team supporting employees through the necessary adaptations, to overcome their natural resistance and become fully engaged in the processes.

We help scrutinise every step of their value chain, to understand the people and processes in their business as well as those who are the best in their class. Only then can companies successfully select and implement the appropriate new and emerging digital technologies that will transform their business. When done well companies can collect their own big data and live analysis to continually inform their daily and longer term decisions.

Digitisation promises leaner and cleaner fleet management, easier document management and legal compliance, more accurate and up-to-date information for smart decisions – the possibilities are expansive and exciting for open-minded and tenacious!

CASE STUDY THE FUTURE IS IN DIGITAL INTEGRATION

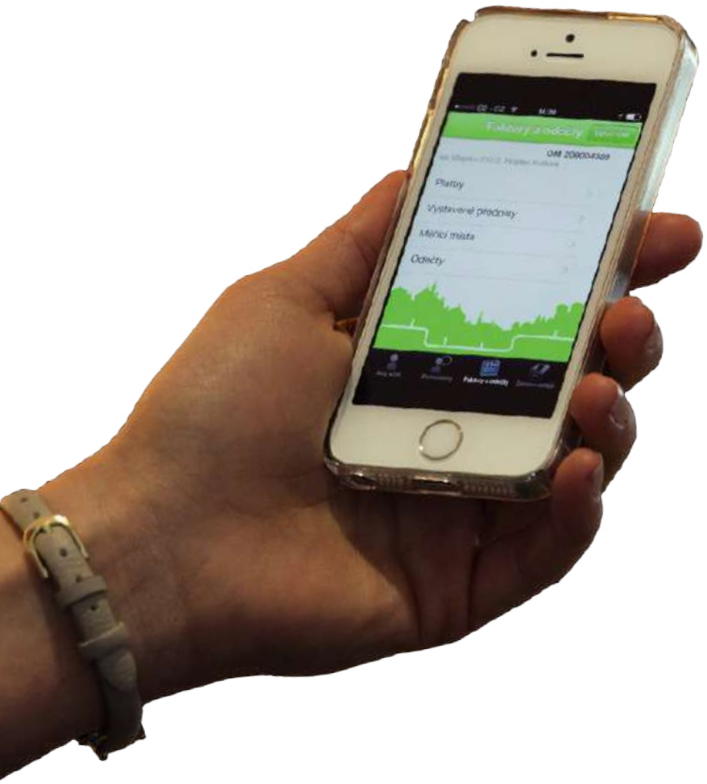
SMART URBAN METABOLISM THROUGH HUBGRADES

How can cities, businesses and industries boost growth in the face of resource scarcity? Firstly, they can start by measuring their consumption in order to manage it more effectively. Then, they can move away from a linear model of consumption. This transition is accelerated today, thanks to IoT, the digital revolution. Veolia is already monitoring and optimizing water, energy and material flows in real-time. It is also developing smart monitoring centers called Hubgrades relying on connected products and artificial intelligence. With these centers, new jobs are created and resource efficiency business opportunities are becoming streamlined, accelerating the shift towards a Circular Economy where nothing is wasted.

Highlighting opportunities to save resources in real-time

The new generation of data solutions allows a deeper study of urban metabolism. Urban metabolism is a model representing the transformation of natural resources into products and services. This model quantifies economic value of what we use and what we waste. Now it is possible to have a higher temporal resolution of consumption. This enables us to build smart urban metabolism models, using real-time data. Such virtual models represent the interconnectivity between different subsystems, which can be urban infrastructures, offices, schools, hospitals, industries and even households.

Smart urban metabolism models offer the required holistic approach on resource saving. These models to analyze resource consumption are used for several years by Veolia, transformed into performance contracts, with guaranteed savings. So, what's the added value of a Hubgrade?

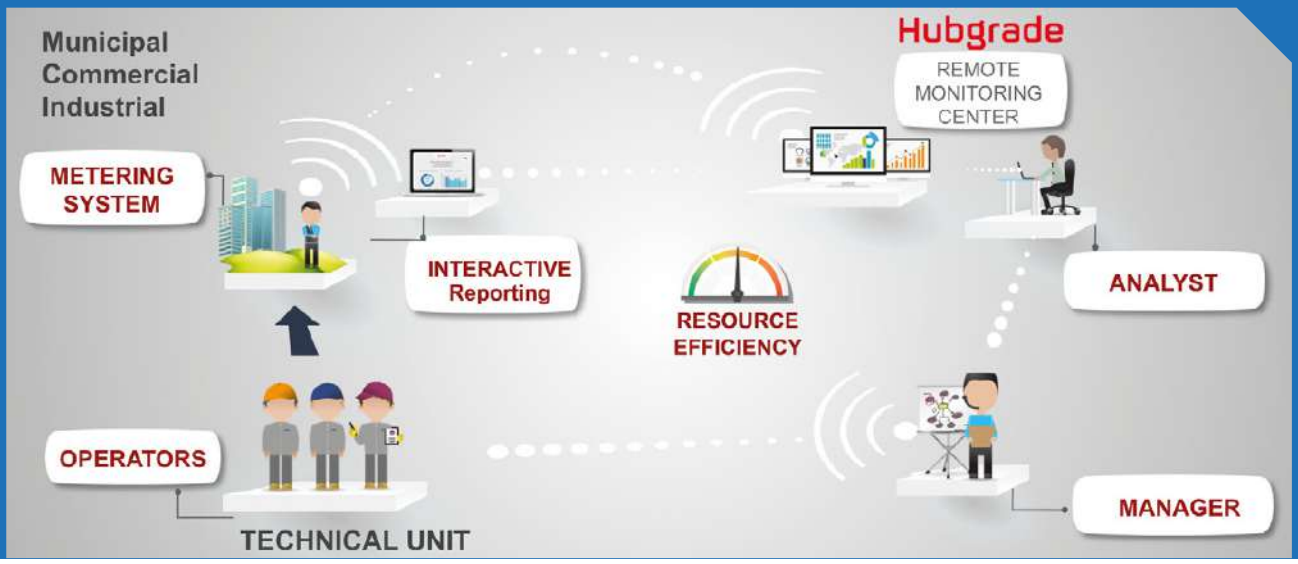


With Hubgrades, the resource and cost savings are significantly more because the value chain of resources is analyzed beyond the limits of traditional operations, using sensors, smart products and other digital technologies. Besides implementing and operating efficient systems, end-users are also engaged to play a major role in the solution because they foresee the benefits for them and they receive the insight they need to save more.

Of course, no one can monitor every resource flow in a city. However, through Hubgrades Veolia can commit to improve resource efficiency for the perimeter of operations. This is why the municipality of Pudong in Shanghai has chosen Veolia to manage its water networks. More recently in Shanghai, Veolia launched a Hubgrade for Water, Energy and Waste management, offering a higher level of commitments to existing customers to new clients all over China. This way, they too, can save even more.

What is a Hubgrade?

Energy and water savings, waste minimization and recycling rates, carbon emission reduction are key performance indicators that are always monitored. Now, they can be tracked in real-time and from anywhere. However, this requires a major organizational change. For this reason, Veolia deploys a dedicated organization, digital tools and new business models. This is what is called a Hubgrade, Veolia's smart monitoring center. Through Hubgrade, Veolia is bringing operational synergies to all our water, energy and waste activities. In Hubgrade, data management is combined in real-time with the technical expertise in the field. This results in significant risk mitigation. At the same time, the system becomes more flexible and easily adapted to customers' needs. Hubgrade is a real asset for change management to boost operation performance and to offer new services.



How does a Hubgrade work?

Clients want control over costs and consumption, so their systems are fitted with sensors. These sensors transmit data in real time to Hubgrade. Then, analysts manage this data to identify savings. This can result into immediate action or a roadmap for improvements.

Recommendations are transmitted to clients and Veolia's experts to help them identify and prioritize resource saving measures. The way in which these systems work can be broken down into four stages:

1. Collection of information from sensors
2. Supply of information to databases
3. Data visualization through dashboards and reports
4. Reporting to operational teams, client and end-users

Hubgrade relies on statistical models, optimization algorithms, geographic information and forecasting tools. correlations between consumption patterns and production profiles are continuously analyzed to identify improvements. From an online dashboard, clients can monitor their own indicators and compare them to benchmarks. This way, they can clearly measure their progress and see the reduction in their bills. As a result, clients and end users become more aware of how they can make savings.

Contribution by
Patrice Novo, Veolia, Marketing and Sales Support Deputy Director, VP Marketing
Gary Crawford, Veolia, Vice President - International Affairs

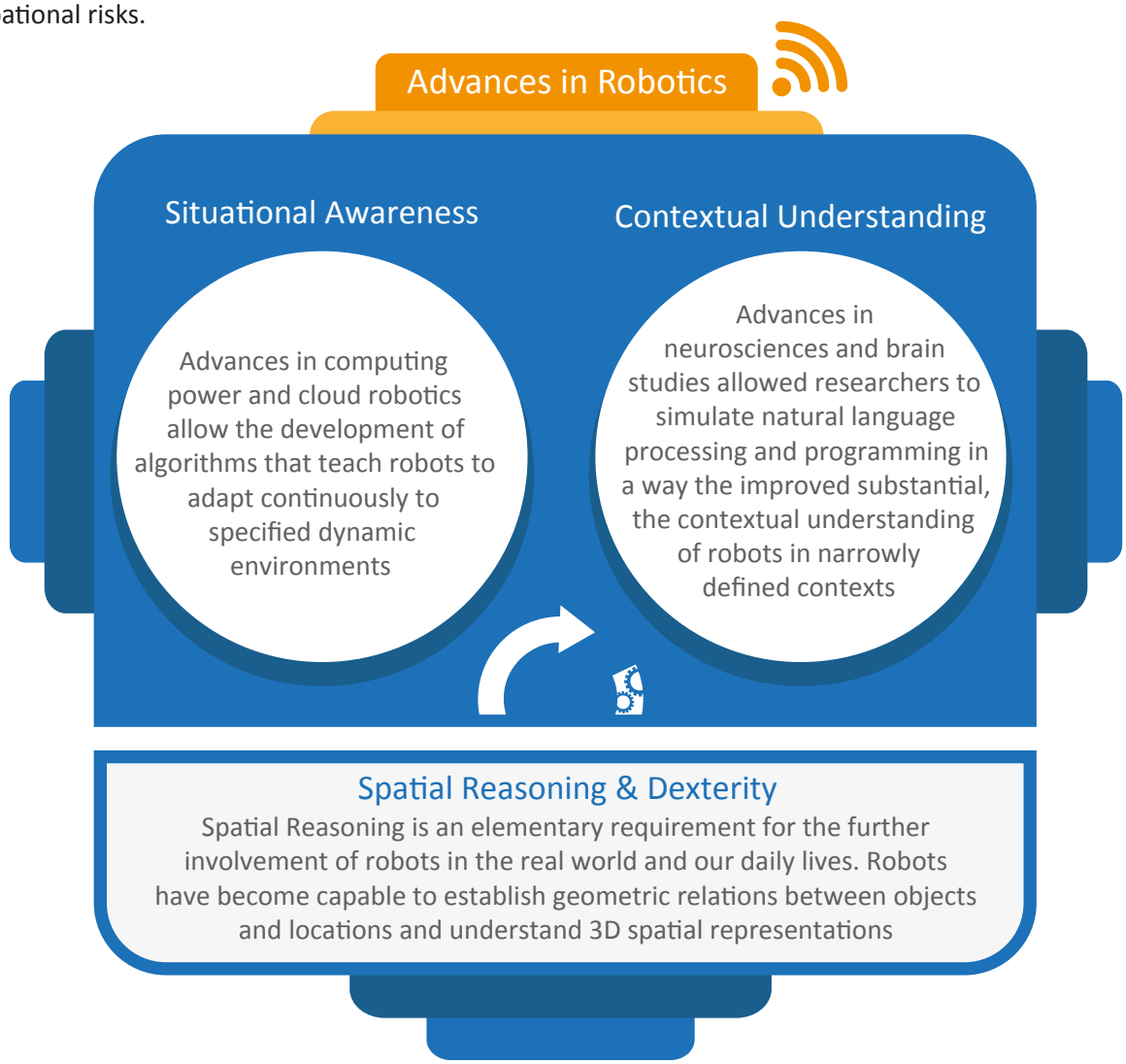
CHAPTER 2

THE DIGITIZATION OF WASTE COLLECTION AND RECYCLING

Waste collection and source separation recycling programs are already digitized in many cities while important private and public sector operators are preparing their digitalization strategies. Using different types of sensors in vehicles, bins, software platforms, and mobile apps the digitization of waste collection and recycling programs provides important benefits like:

- Cost and resource recovery optimization
- Full control of the operations and their efficiency
- A better understanding of the spatial and temporal patterns of waste generation and storage and in depth profiling of the users' behavior
- Higher flexibility, easy adaptation of the services to changing patterns and targeted interventions
- The rise of on demand services and tailor made services
- Easier and faster application of Pay as You Throw Systems
- Important user / provider interfaces (through mobile apps & web platforms) that allow direct complain management and easy identification of problematic points.

Semi-driverless waste collection vehicles have already been tested with good results. Their commercialization will deliver substantial benefits in operational costs, endless optimization opportunities, better safety and less occupational risks.



DEVELOPING AN AUTONOMOUS REFUSE TRUCK

Volvo Group, a Swedish multinational transport solution company and one of the top leading truck manufacturers in the world, is pioneering the research and development for autonomous vehicles in general for waste collection is one area of research. In this interview, prepared by ISWA's Georgina Nitzsche, with Johan Tofeldt, Volvo Group Automation Project leader, we are focusing on the project Autonomous Refuse Truck (co-developed by Volvo Group and Renova) that demonstrates a high potential for improved safety, health, efficiency and reduced costs. The project highlights the added value of continuous data collection and big data systems to stimulate future optimization of processes. The project Autonomous Refuse Truck run for almost 5 years, utilizing a software that was developed from a continuous project that began with a mining truck.

Why did Volvo Group decide to invest in Autonomous Refuse Trucks?

Volvo Group decided to do research on autonomous vehicles and we were looking for interesting use cases and the refuse truck was the most promising application for us, from a research point of view. With refuse trucks, we could work on public roads in a safer way, but we also wanted to find ways of improving the overall processes.

As a research project, we were looking in to what is possible and what is not possible. Of course, there were other areas to consider: the potential marketability of an automated truck, the appeal to the users and potential reduction of costs through greater efficiency.

The main motive was to explore the possibilities of automated vehicles, keeping safety standards high as a core value to Volvo, and then efficiency as the third component. .

So, how did the project start?

Five years ago, when we started there was not very much happening in this area of automation. We brainstormed ideas and at the same time we set out to challenge ourselves in this technology. Our approach was to reach out to potentially interested customers and as we already have good relations to Renova, and they were interested, we had a good match.

It certainly helps to have a good partner to work with us, they very much guided our technology, they told us what was important for safety and how the user would perceive any new system. Technology research can be interesting for research sake, but at Volvo Group we try to always work in a relation to a customer to develop the right kind of project. It's important to have that kind of connection, otherwise you can do something technologically interesting but has no value for the future.

Could you share with us the most important concerns that were identified from the view of waste collection operations, things that played a central role to stimulate the project's development?

One of Renova's major concerns was that if you have one person driving and emptying the trash bin, he must jump in and out of the cab between every trash bin and that is actually a dangerous maneuver, especially in the suburban centre of Gothenburg in the winter because if he jumps out and lands on the icy patch he can fall and be very much hurt. But even if he doesn't fall, just jumping in and out the cab a couple of hundred times a day, for ten years or so, then that hurts his hips and knees quite a lot. If he instead can walk beside the truck and the truck moves itself, then you remove that maneuver of jumping in and out of the truck. That was quite an important matter for Renova. Safety is our absolutely biggest challenge, it's a huge challenge compared to every other one, if ever we are going to do a product. We are working with safety and society's confidence in Volvo Group – safety is part of our DNA and we don't release anything for sale until we are sure.

Also, there is also the issue of driving or reversing – if you are driving into a dead-end and you are reversing all the way back out, those are dangerous maneuvers, so the safety for the people who live in the suburban area is also very, very important for Renova.

Thirdly comes efficiency, making it a little bit cheaper to empty the bin – but actually the safety and working environment were more important for Renova than that part. But of course, you can put two operators in the truck and say that one drives around all day and another empties the trash bin all day. Then one can keep watch outside as the truck reverses, but then you have two operators instead of one and an operator cost is quite high. So, you must look at the whole picture. It is not just that one or another factor is the single important result, it is the whole picture.

Let us know some of the practical challenges you faced

For example, one of the more obvious things that came up through this collaboration, is that as we are running the refuse truck we are mainly reversing – the business end of the truck is at the back - that was something we found with discussions with Renova. We were able to shorten the lead time for every trash bin by about 30 seconds

Another thing was the location of the operator in connection to the truck when the truck is moving, e.g. how should he walk to have a good view of everything and to feel comfortable. So that was one of many things we learned about the interaction between an autonomous vehicle and a human.

Another interesting example, when the operator is walking, and the truck keeps, say, 2 meters behind you. When you decide for whatever reason to walk a little bit faster, the truck will then accelerate to maintain the distance, it's a very quick adjustment and it feels that you are being chased, and the operators feel uncomfortable. That's not a good solution. So, it was very much better that the truck keeps a certain speed not related to the operator, and the operator should be placed a little bit to the side and he feels that if something happens, then the truck will pass by.

So, this sort of things you have to try and try, testing and testing, over again to get it right. When you do this kind of research project, you build something, you test it, find out what works or does not work, and try many, many solutions until you find something that works. It's very repetitive! You need elbow-grease.

Looking at the human psychology and the machine is central to the design of Volvo Group – we always look from the point of the view of the driver. One of the key issues was to develop a comfortable relationship between the operator and the autonomous truck. The operator should always feel confident and comfortable in the system.

> We were able to shorten the lead time for every trash bin by about 30 seconds

How about the software the Autonomous Refuse Truck project?

For the Autonomous Refuse Truck, all the software that replaces the driver is completely new. We needed to have software that looks around at the surroundings and identifies what it sees, that we don't bump into something and we look at moving objects and try to see if it is moving closer or away from the truck, we needed to regulate the speed. This is a huge a software project since we are replacing one of our best sensors: the human. We are also replacing one of the best control algorithms, again a human one, and the captain of the vehicle. There are many, many capable systems performing when driving that we are trying to replace with software, so this is a huge software development.

Can we speak about a new potential?

We see potential in many different places. A software driver can look 360 degrees, in all places and always, it never gets tired or distracted. But it is also a challenge to make a software intelligent enough to understand things that a human instinctively understands and avoid dangerous situations.

We also see a great potential to improve safety, and, when it comes to the environment, we also expect much better fuel efficiency.

But let's put is like this: the best human on their best day is very, very hard to beat. On the other hand, if you take the worst human on their worst day, then we have already improved on this level.

With regards to data (relevant to this project) – you can look that up – generally 90% of accidents are caused by human error. When it comes to fuel efficiency data, that's not that hard to understand or measure: you can put a driver and automated driver on the track and drive 100 laps then compare the results. But a big difference is that you can force an automated driver to do things that you cannot force a human driver may not do. You can go slower, accelerate much slower, break earlier and things like that – a much more boring driver really – but you lower the fuel consumption by doing that.

> One of the key issues was to develop a comfortable relationship between the operator and the autonomous truck.

How about the results of the project?

One result is the data collection itself. We have not saved all the data from our research, the GDPR tells us which data we can or cannot save and we are following that. But several things are interesting, one thing is what is happening inside the truck; with the engine and with the transmission and using that data to optimize the system to be more efficient – so that is a good thing itself.

But also, if you are looking at the surroundings around the truck, understanding how the traffic situation changes and how we handle the situation and just analyzing these kinds of data in that sense it is of course very interesting.

Surprisingly with sensors we could see more details that I even expected, for instance we could see the curb very clearly, and another thing we learned is that the traffic situation is extremely dependent upon which time of the day you are in the suburban area. It was very clear when people woke up in the morning and went to work, there was another peak around lunchtime and when they came home from work and so on. And these traffic peaks were very visible in the suburban area among the houses. If you time where you went with your refuse truck according to the clock you could avoid of this traffic and you could find times when there was almost no traffic at all.

We knew that that the situation was like this but having the data made it clearer, more edgy. I thought it was more spread out, say between 7 and 9 there was lots of traffic, but it was actually a smaller window. And this will of course vary with different suburban areas, but it made it possible for us that if you run the refuse truck in a suburban area and we used the log data whilst we were running there over the different times, then we could optimize the route – to find the sweet spots when there was no traffic – which is different in different areas. So that kind of optimization you can do continuously, you can do that over time since you are registering the traffic situation in your autonomous vehicle anyway.

Renova were happy with the results and we had only positive feedback from them. Volvo Group does a lot research and development and we though we may not bring every project product to the market, we do capture all the learnings for the future.

How about the dynamics between IND 4.0 and the waste industry, what are VOLVO GROUP's views on self-driving trucks?

"Safety is in our DNA" and we think that it will be definitely improved.

The rapid advancement of vehicle automation technologies holds exciting potential for the waste sector. Seemingly radical new concepts are now within reach, transforming work in the near future.

The Volvo Group is a frontrunner in the development of automation technology and is already implementing automation in a stepwise approach through advanced driver assistance systems; utilizing intelligent electronics such as the I-Shift, Volvo Dynamic Steering (VDS), the Active Driver Assist so regardless of experience or training, every professional driver achieves increased safety, efficiency, productivity and convenience.

Self-driving trucks will be a reality on our roads and part of our society, probably starting under controlled conditions as a complement to today's transportation systems. Volvo Group's 2017 truck automation pilot project in the refuse industry successfully demonstrated great potential to not only enhance health and safety for operators and pedestrians, but also increase productivity, reduce fuel costs and CO2 emissions, reduce equipment wear and optimize traffic management and route planning. This is especially relevant where low-speed maneuverability is critical in suburban streets, enabling controlled travel, such as reversing, at slow speeds.

The Volvo Group prepares for this evolution with higher levels of advanced driver assistance systems, but exact timing depends on many factors, namely national and international regulations, infrastructure and safety standards, as well market demand. Safety and quality remain the priority focus of Volvo Group global automation teams: a software driver can look 360 degrees, in all places at all times, it never gets tired or distracted, but it is a challenge to build a software intelligent enough to beat the best driver on his or her best day.

Connectivity, real-time data and machine learning is another technological area that is undergoing exponential development. This digitization, combined with new business models, has shown potential to contribute to greater societal sustainability, less congestion and better accessibility in the waste collection sector.

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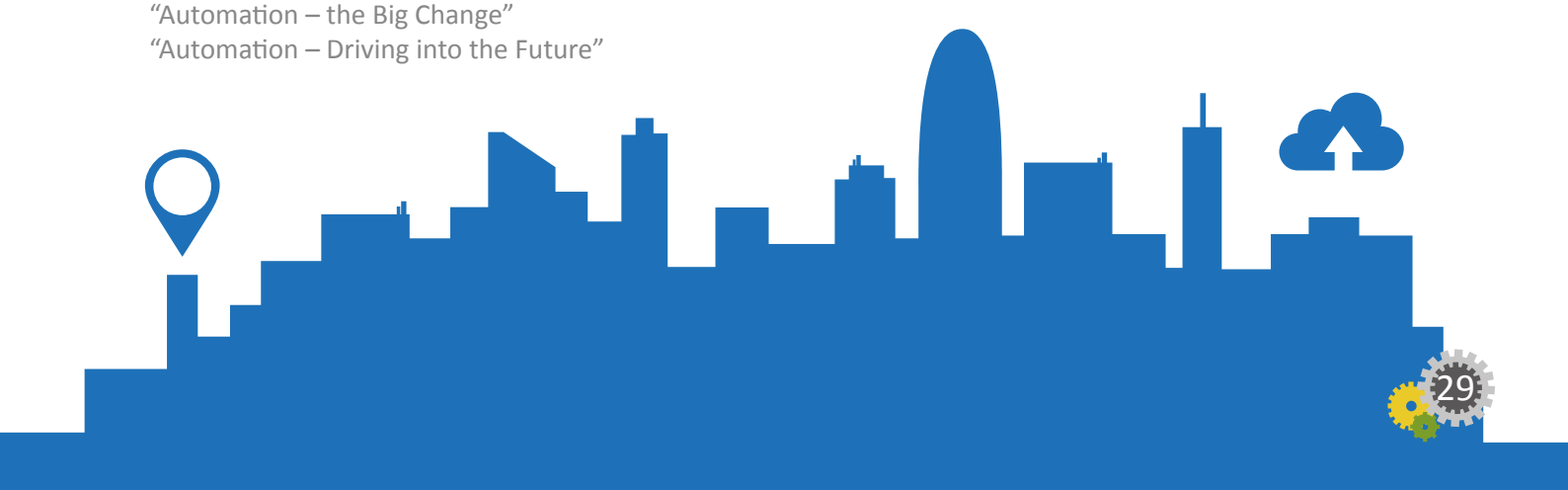


CASE STUDY INTERNET OF BINS

EWAS PROJECT SENSORS IN BINS

The EWAS project was implemented in the framework of the Life+ EU funded projects. It was implemented by a Joint Venture consisting of Wellness Telecom (Spain), D-Waste (Greece), DEDISA (Greece), ENT (Spain) and LIPASAM (Spain). The project aimed to the application of ICT tools, namely wireless sensors in bins to monitor waste collection, in order to contribute to more efficient waste collection methods i.e. bins placement, routing, reduction of environmental impact, etc. In the context of the EWAS project, two pilot projects in Seville (Spain) and in Chania (Greece) were run to identify the results of the use of ICT tools in the bins collection in real conditions. The sensors were installed in 268 bins for paper and glass in the urban area in Seville and in 355 bins for recycling material (paper, plastic, metal, and glass) in a touristic area in Chania. The data collected from the installed sensors in a period of 6 months (January – June 2016) were used to optimize recyclables collection method based on the bins completeness level leading to a direct reduction in vehicles' routes in Seville and in Chania (in the winter period). This optimization concluded to significant collection costs savings (estimated almost 30,000€ in the Seville pilot) due to less fuel consumption and vehicles maintenance needs and consequently to the reduction of air emissions.

www.life-ewas.eu

BENEFITS FROM SENSORS IN WASTE COLLECTION

- Optimization of routes and fuel consumption
- Reduction in collection costs
- Completeness status information of containers in real-time
- Fire alarms in real-time
- Reduction of air emissions
- Better service quality and hygiene
- Decongestion of traffic

The Results

Seville

The pilot has been carried out in the city centre and has shown very good results (reduction of 66% of collection costs). This is the area where collection is more difficult because of traffic.
These results have created a lot of interest for the replication of the experience in other routes.

Glass Routes	Data prior deployment	Current Data	Reduction
No.Routes	3	1	66%
No. Annual Services	10	34	
No. Hours of service	700	255	

	Service Unit	Data prior to deployment (100 services)	Current Data (34 services	Savings
Cost (PM, Maintenance, Management)	460€	46.070€	15.642€	30.364€
Km Distance	107 km	10.700 km	3.638 km	7.062 km
Consumption (litres)	56 l	5.600 l	1.904 l	3.696 l

Chania

The pilot has been carried out in the Region of Chania and has shown very good results (reduction of 30% of collection costs of glass). These results have created a lot of interest for the replication of the experience in other routes.

Glass Routes			
	Number of routes	Routes per week	Reduction
Monitoring state	1	5	Aprox. 30%
After the monitoring	1	3 to 4	

Recyclables Routes (blue bin)				
		Number of routes	Routes per week	Reduction
Summer period	Monitoring state	3	5	Approx.0%
	After the monitoring	3	5	
Winter Period	Monitoring state	3	5	Approx.30%
	After the monitoring	2	5	

CASE STUDY INTERNET OF BINS

RFID/GPS SYSTEMS FOR MSW COLLECTION AND PAYT CHARGES

Altares is an innovative Italian company developing integrated solutions for collecting MSW especially with curbside schemes. Altares equipments consists of high-frequency RFID transponders embedded into collection bins and bags combined with controller devices on collection trucks and specifically developed data management software. Combining RFID and GPS identification systems for separate waste collection, it is possible to track the operations performed in real time and locate the vehicles. The integrated solution also offers Fleet Management including route optimization, equipment control, actual work timing and monitoring of collection operations.

All data can be viewed in real time on the Altares web application, customized according to the needs of clients. Data are managed in compliance with the European GDPR 2018 and the data integrity is certified according to ISO/IEC15408 and "Waste Bin Identification System" WBIS-PP certified by the German BSI.

IND 4.0 revolution applied to collection services of MSW

By Marco Ricci – Jürgensen, CEO of Altereko sas

PAYT charges are a fundamental element of modern collection schemes for MSW; the aim is to have single waste producers to pay for the amount of collection service provided and lowering waste fees for those that engage in recycling and reduce the amounts of waste disposed.

The municipality of Sommacampagna (Italy) adopted Altares's solutions in 2015, enabling the waste office to track the service provided by private MSW-contractors and to measure the amount of residual waste delivered by single households equipped with a personal collection bins; users are charged according to the amount of residual waste produced. Today the municipality can check in real-time if collection routes are fulfilled by private contractors and visualize the households that are skipped by the service or other problems occurring during the service. The equipment and IT solution of Altares gave significant benefits in terms of MSW management; during the first year with the new service, the amounts of residual waste dropped significantly and today less than 50 kg percapita and year of residual waste are collected; recycling reaches almost 84% of all MSW collected, placing Sommacampagna among the best performing cases in Italy.

After 6 months the number of collection rounds for residual waste was shifted to fortnightly with important economical savings and optimizing the routes of collection vehicles. Today households deliver residual waste on average less than once per month and the satisfaction about the service provided is high among customers.

RFID TAG

A passive transponder with a unique code that is detected by the antenna at reading distance.

You can schedule the delivery and assign the identification code of the TAG to the user identification number.

It is writable and it allows the overwriting.

ON BOARD DEVICE

UHF frequency multiple reading system.

Tags reading up to 5 meters distance and up to 30o km/h in motion.

Additional information to be linked to the TAG or be geo-referenced.

DATA TRANSMISSION

Usually the container emptying data is sent automatically, but it can be sent manually by the operator at any time. This allows a form of validation of data in situ, allowing the possible the entry of addition-al information (eg. a damaged bin to be replaced, a bin put out the wrong day, food waste collected with bags that are not compostable etc). If required, transmission of data can be 100% automatic.

All data, routes, stops, pauses, extra information is sent via GPRS

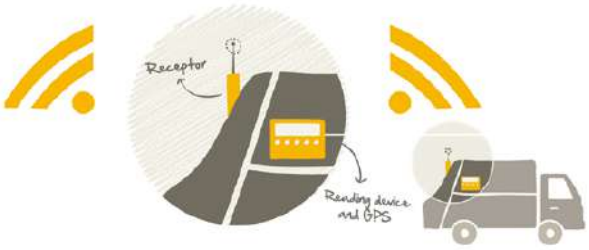
CONSULTING AND EXPORTING DATA

All data can be viewed in real time on the Altares website applica-tion and corresponding to the data management software. It is possible to create customized reports and upload the data in various formats -. Pdf. Xls,. -.shp. etc. for further processing and analysis.

MANAGING AND ANALYZING DATA

The system gives different service data and customers may select the information they gain from it.

HOW IT WORKS ?



CASE STUDY INTERNET OF BINS

HOW SAN FRANCISCO SECURED AN 80 PERCENT DECREASE IN OVERFLOWING TRASH CANS

A new solution to an old problem

On an annual basis, San Francisco Public Works was receiving 10,000 service requests for overflowing trash cans. The city wanted to find a solution that could tackle this issue effectively, decrease the number of annual complaints and ensure cleaner streets. The department turned to technology, partnering with Nordsense to deploy sensors in 48 cans initially to monitor trash-levels in real time.

Project goals

- Provide a better and cleaner experience for community members
- Detect service needs before community members complain
- Reduce the number of collections necessary and subsequently reduce cost
- Assess and optimize the placement of bins

> "We are expanding the number of smart trash cans across the City to ensure that our trash is properly disposed of and does not end up on our streets."
> Mayor of San Francisco, London Breed in the San Francisco Examiner.

San Francisco achieved:

- 80 percent decrease in overflowing trash cans
- 66 percent decrease in street cleaning service requests
- 64 percent decrease in illegal

Nordsense is making sense of waste management

After a highly successful pilot, San Francisco Public Works – with support from Mayor London Breed and in alignment with San Francisco's Sustainable City Plan to "ensure a beautiful, healthy and prosperous city," – expanded the program to 1,000 additional cans out of a total of 3,800.

Using data to optimize resources

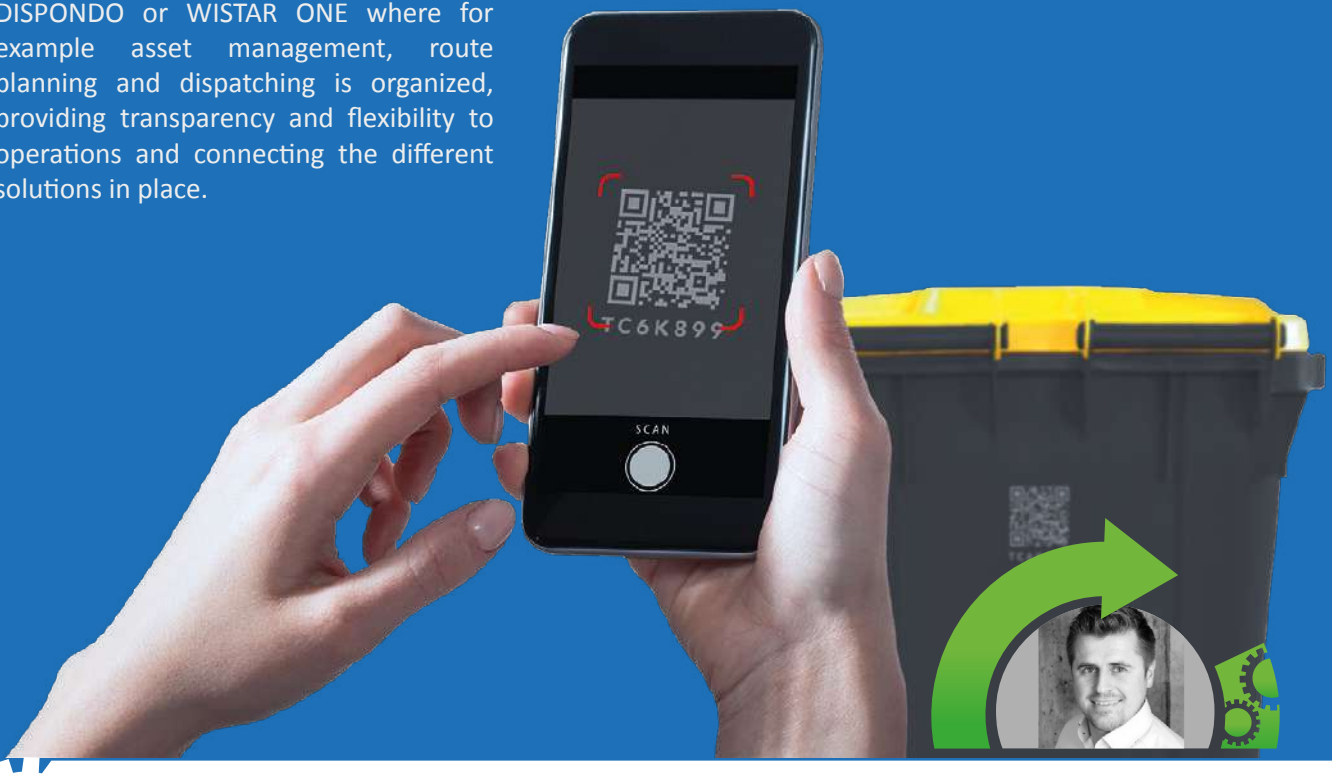
Many cities across the world have "zero waste" ambitions and are turning to technological innovation to help transform the waste collection industry. In addition to ensuring a cleaner environment, the data gathered from the sensors has enormous potential to help cities predict waste generation activity in specific areas, fine-tune the routing of collection trucks and even help to increase recycling rates.

"The pilot program showed us firsthand the benefits of the sensor technology to improve cleanliness on our city's streets and we're looking forward to implementing the expansion," San Francisco Public Works Director Mohammed Nuru says. "The partnership with Nordsense will allow us to use real-time data to better service the public trash cans and deploy resources more strategically."

CASE STUDY INTERNET OF BINS

THE INTERNET OF BINS BY SSI SCHÄFER

Platforms are one of the major drivers of digitalization. With the Internet of Bins (IoB) SSI Schäfer started to define a new standard of intelligent processes for bins and containers. The IOB bin standard enables residents to connect easily to the municipality by the help of an adjustable QR Code and the waste collection company can verify services by the integrated and standardized RFID tag in the handle of the bin. The On-Board solutions are designed to meet the specific requirements of different applications. All these information end in the customer oriented digital platforms DISPONDO or WISTAR ONE where for example asset management, route planning and dispatching is organized, providing transparency and flexibility to operations and connecting the different solutions in place.



Christian Bremer General Manager SSI Schäfer / Vice Chair of ISWA's Working Group on Collection and Transportation

Based on our experiences, it makes no sense to start at 0 % digital and to have to goal to race it to 100 % digital immediately. The reliability of digital solutions is getting higher when focusing on the pain points and significant needs. A step – by – step approach is the best way forward.

As an example, the right starting point is usually to digitalize the asset / container management first, to ensure the good base of operations. Then, more flexibility can be added to the operations by understanding the number of collections per day. Bin Sensors can help also to improve the frequencies of collections for bigger containers. Finally, the service of on demand operations can be implemented in the daily business and with the help of our platforms.

3.1 THE RISE OF ROBOTS & AUTOMATION IN WASTE TREATMENT

Robotic waste sorting systems are autonomous, multitasking, learning and scalable systems that can operate tirelessly 24/7. Robotic systems capable to separate specific materials are already commercially available for different waste streams. Their accuracy varies depending on the type of recognition methods they use and the target materials but it is continuously improved. Till now, the experiences gained demonstrate that the robotic recycling revolution is driven most importantly by significant cost savings generated by process efficiency, and improved revenue streams from high-purity recyclables that are now more diverse, thanks to unique recognition capabilities made possible by artificial intelligence.

In brief, the impact of robotic recycling in treatment facilities involves:

• Reduced reliance on manual sorters – the main trend is to increase the working distance between the actual handling of materials and human beings and reduce the relevant occupational health and safety problems. Thus, it's not that treatment facilities and MRFs will run without workers but that workers will have to work in close cooperation with intelligent robots that will do all the dirty work.

• More flexible sorting lines – merging visual data with sensors and big data analytics, robotic sorting lines create opportunities for operational benefits that were never imagined before like direct identification of where, when and how many losses in materials occur or real-time data about what is recovered and quick adjustments based on daily or weekly targets.

• Better knowledge of the waste input: using the information provided by sensors and visual recognition, operators are now able to understand the input waste composition in depth, to easily predict daily and seasonal effects and automatically adjust the lines in the expected inputs.

• Market adaptation: As the revenues relevant to recycling are depending on market prices and conditions, a core function of resource recovery facilities is to advance the recovery of materials that are priced higher and reduce the recovery of low-value materials. According experienced operators in robotics, such adjustments will gradually become completely automatic and the robotic operations will be guided by market prices inputs to their software and algorithms.

It is stressed that till now robotic systems are used to optimize specific material separation activities. But as robotics are becoming better and gradually they will be the mainstream for material separation, a completely new design of facilities is expected to appear within the next 3-5 years. This design will have the robots at the center of the operations and humans in a more supervisory role, probably in distance from the waste streams.

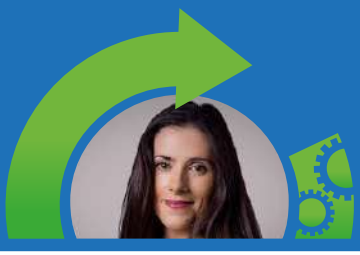
CASE STUDY

THE RISE OF ROBOTS ON WASTE SORTING

MAX-AI® ROBOTIC SORTER

Max-AI® technology is an artificial intelligence system that identifies recyclables and other items for recovery. Through deep learning technology, Max employs both multi-layered neural networks and a vision system to see and identify objects similarly to the way a person does. The technology is driving improvements in Material Recovery Facility (MRF) design, operational efficiency, recovery, system optimization, maintenance, and more. The system was selected by CarbonLite for its newest post-consumer recycled PET plant in Lehigh Valley, PA USA. The plant will produce 36,320 tons of PET pellets per year. It will incorporate Max-AI AQC-2 units (for Autonomous Quality Control), featuring dual robotic sorters with each robot capable of picking and placing up to 60 items per minute.

The system also gathers material composition data and performance metrics from its AI and optical equipment, scales, motors, bunkers, baler and other sources, all of which is communicated to the customer with BHS' new Total Intelligence Platform (TIP).



Challenges and perspectives of robotics in SWM

Belen Garnica Co-founder and CFO of Sadako technologies

The waste sorting includes many tasks with "three D's" (dirty, dull and dangerous) that are typical targets of work that would be better done by a machine. A robot needs highly sophisticated visual and manipulation skills to be able to work on the extremely heterogeneous and complex waste environment. These skills were not available until AI and advanced robotics disruption occurred in recent years, with companies like Bulk Handling Systems and Sadako Technologies in the forefront.

With the help of AI, we envision future waste treatment plants as very automatized and optimized facilities where no human will be in direct contact with waste, and where almost all recyclables will be recovered, no more going to incineration or landfills.

Big challenges are involved as well: the perfection of visual and manipulation capabilities and its extension to all kinds of waste streams, the increasing complexity of packaging materials, financial availability for the plants robotization and the existence of sustainable markets for the recovered materials.

CASE STUDY

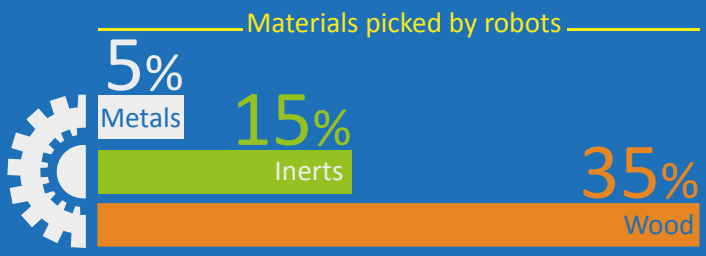
THE RISE OF ROBOTS ON WASTE SORTING

ROBOTIC SORTING STATION

Remeo was the first company that partnered with ZenRobotics to build the first robotic waste sorting station at Vikki, Helsinki, Finland. The first pilot unit was installed in 2010. The result of years of testing and evolution is that the entire waste separation process has been designed around three sorting robots.

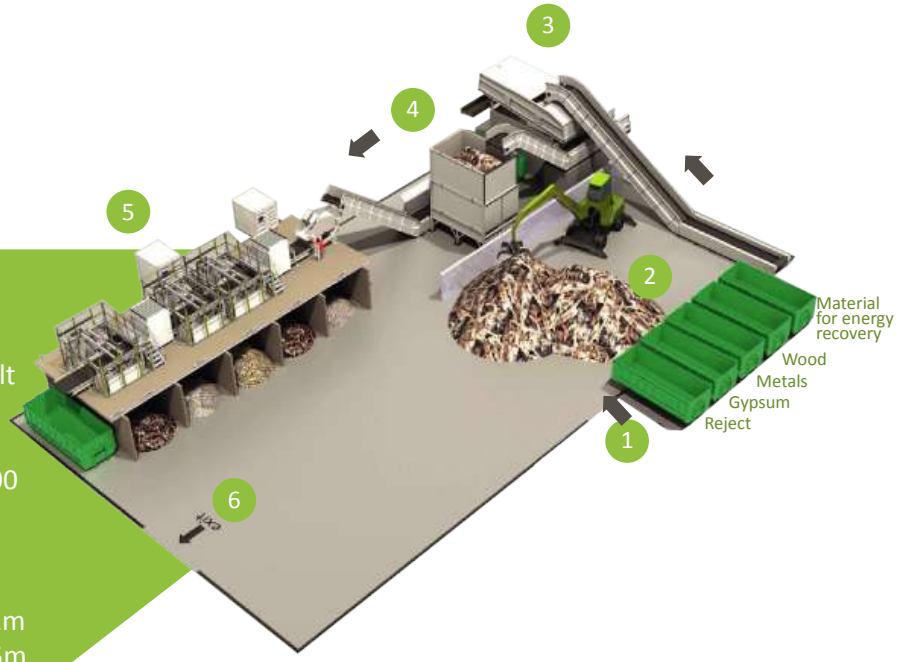
The plant runs virtually unmanned, with only an excavator driver doing the rough pre-sorting on the tipping floor. A storage bunker feeds continuously the robotic sorting line, even when the excavator driver is not there. As a result, the robots produce very impressive results: the utilization of waste is already up from 70% to 90%, with the next target set at 95%.

Waste Input: 25,000 tons of C&D/C&I annually
The robot line, that's equipped with 3 Heavy Picker units, receives 20-25% of the incoming waste. Before the robots, oversized objects, fines, and 2D fractions are removed



Sorting Line for Recovery of Construction and Demolition Waste

1. Reception, weighting and quality control
2. Pre - sorting
3. Ballistic separator
4. Buffer Chamber
5. ZenRobotics Recycler
   - a.Sensor Fusion
     - • material identification
     - • fraction shape detection
     - • locations on the sorting belt
   - b. Artifical intelligence
   - c. 2 + 1 ZRR robots
   - d. average picking speed 1500 2000 picks/hour/robot
   - e.mechanical features
   - f.max. lifting capacity 20 kg
   - g. max. working area 1,4mx2m
   - h. max. length of fraction 1,5m
   - i.Belt speed control
6. Unsorted Waste
   - a.Reject



"New technology has created new business. Now we can make revenue by selling high-purity recyclables to the industry."

ANASA ROBOTIC SORTER

The ANASA project aims at developing, integrating and commercializing an autonomous robotic system for categorizing and separating recyclable materials. The development of an automated procedure for recyclable waste separation is significantly contribute in increasing the (currently low) recycling rates in Greece, for the benefit the local societies and the economic enhancement of recycling activities across the country.

The "ANASA" Robotic Waste Separator (RWS) has significant advantages over the existing ordinary recycling systems; i.e. high reliability in object recognition (material detection), short separation cycle (high speed), significantly low installation volume, low cost and ease of application to both old and new recycling industries. The development of the Robotic Waste Separator is based on the integration of mature technologies, namely the identification and spatial recognition of recyclable materials and the targeted robot picking-and-placing of these materials to the appropriate classification bin, providing a complete solution for both the main parts of the recycling process.

By now, a trial version of the system has implemented and installed in a lab-room. The mechanical system integration is composed by six main parts: (i) the ABB IRB360 DELTA robot, (ii) an external vision camera system for object detection, (iii) a conveyor belt of 4,5x0.8m length and 135-277 mm/sec speed range (iv) a robot workspace cage with steel construction for high speed, (v) a vacuum generator with pressurized air supply of 10 bars which provide a low pressure to the suction cup, and (vi) a vacuum gripper suction cup that designed and made in-house for the specific application.

The final goal is ANASA RWS be deployed in two different urban waste management industrial units, in ESDAK (processing composite wastes) and in DEDISA (processing recyclable wastes), where the system's reliability and validity will experimentally be tested in real industrial environments. The long and extensive operation of the system in hard industrial conditions will directly focus the adjustment of the RWS parameters to achieve optimal performance and excellent waste separation results.

Nikitas Mavrakis
Tierra Enviromental Services

"The ANASA project aims at developing, integrating and commercializing an autonomous robotic system for categorizing and separating recyclable materials."

CASE STUDY ADVANCED AUTOMATION

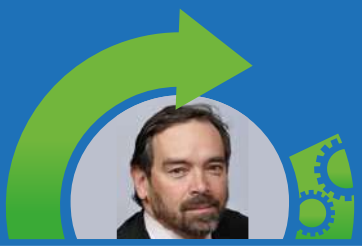
THE DIGITALIZATION OF WtE FACILITIES

Computers size, speed and memory capacities have increased hugely over the last 50 years from kilo- to Tera-units (bytes, Hz…). To try to illustrate this colossal low cost evolution (ten by ten), we have moved, respectively, from turtle speed to light speed, and from storage spaces the size of an apartment to those the size of the surface of France!

Energy-from-Waste (EfW) facilities benefit from this for the automation of their complex industrial processes. Figures 1 & 2 show the visible part with the evolution of the interfaces in CNIM EfW control rooms, from the design 50 years ago to the latest. We are now able to transfer process information from this control room to the site with augmented/virtual reality glasses.

Thanks to this huge advance in Information Technologies, the digitalization allows CNIM to improve performance by acting on technology and human behavior at key stages such as:

- engineering, thanks to Building Information Modelling (BIM)
- operation and maintenance thanks to process predictive systems, computer assisted production management or operator training tools.



Christophe CORD'HOMME

CNIM Group Business & Products Development Director

Vice Chair of ISWA's Working Group on Energy Recovery

CNIM has developed its EfW Dynamic Plant Simulator (DPS), a high-fidelity process digital twin, structured around a very realistic dynamic thermodynamic and chemical process model and the real Digital Control System (DCS), implemented on site.

By computing and integrating time-dependent variables and real features of the plant, the DPS provides a "full-length movie" of operation from cold start-up up to maximum load

Figure 1:
Paris EfW control room 1969

Figure 2:
Kemsley (UK) EfW control room 2019

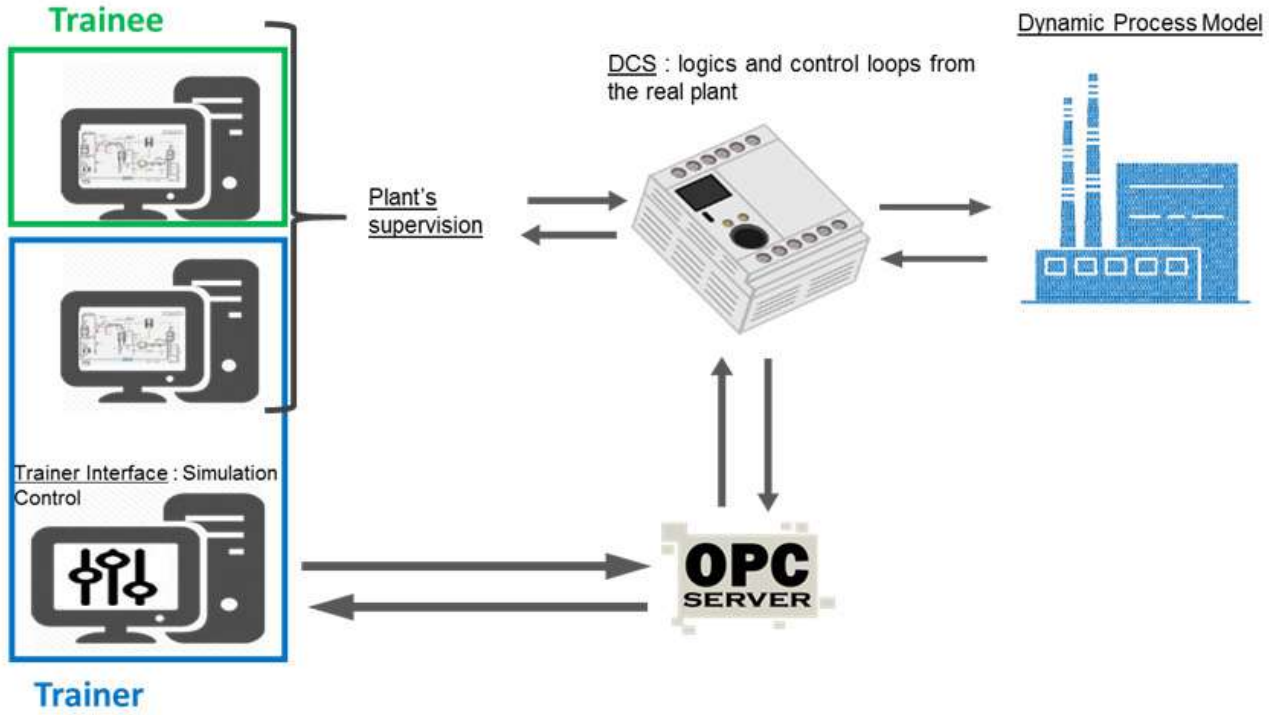


Figure 3: Simulator training architecture

Like in a professional flight simulator, it provides the feeling of real operation with three major benefits:

- optimize the plant process as early as engineering phase especially by studying transient modes
- train operators to react smartly to unforeseen events
- provide a gap analyzer tool by dynamically comparing actual process data with expected theoretical values

Without neglecting the essential cyber security measures, digitization is improving reporting and data management. Operators can obtain remote technical assistance from CNIM experts and on-line training

Thanks to its in-depth knowledge of plant process and design, CNIM digitalization is a reliable, state-of-the-art, comprehensive and pragmatic solution for “iEnergy-from-Waste” plants!

Figure 4: CNIM process simulation available on remote access for training

3.2 TOWARDS BETTER LANDFILL MONITORING AND MANAGEMENT

Landfills already do benefit from the new opportunities opened by IND 4.0

Drones are widely used to monitor the evolution of landfill volume and for monitoring leachate leakages and landfill gases. Driverless compactors have been tested with good results and there are several small robotic vehicles that are tested for monitoring surface fractures and biogas leakages. IoT based remote monitoring systems will gradually become mainstream making landfill monitoring much easier and real-time representative. The growth of IoT allows the connection of different sensors installed in landfills devices and equipment generating data regarding landfill operations and driving data sets in a single software platform.

This allows for real-time monitoring of all landfill operations. The relevant benefits are:

- Better cost efficiency and space utilization
- Continuous landfill monitoring performed on a 24/7 reducing the possibility of accidents and unexpected events.
- Improved health and safety for the landfill workers.
- Better management of the landfill degradation rates.

However, the debate on the use of autonomous or semi-autonomous vehicles for sanitary landfills goes on, since there are experts that insist that there is no need for precision tools in a non-precision application like landfilling, while other experts believe that some of the most important works like proper compaction would be better implemented by autonomous vehicles.

CASE STUDY

SANITARY LANDFILLS

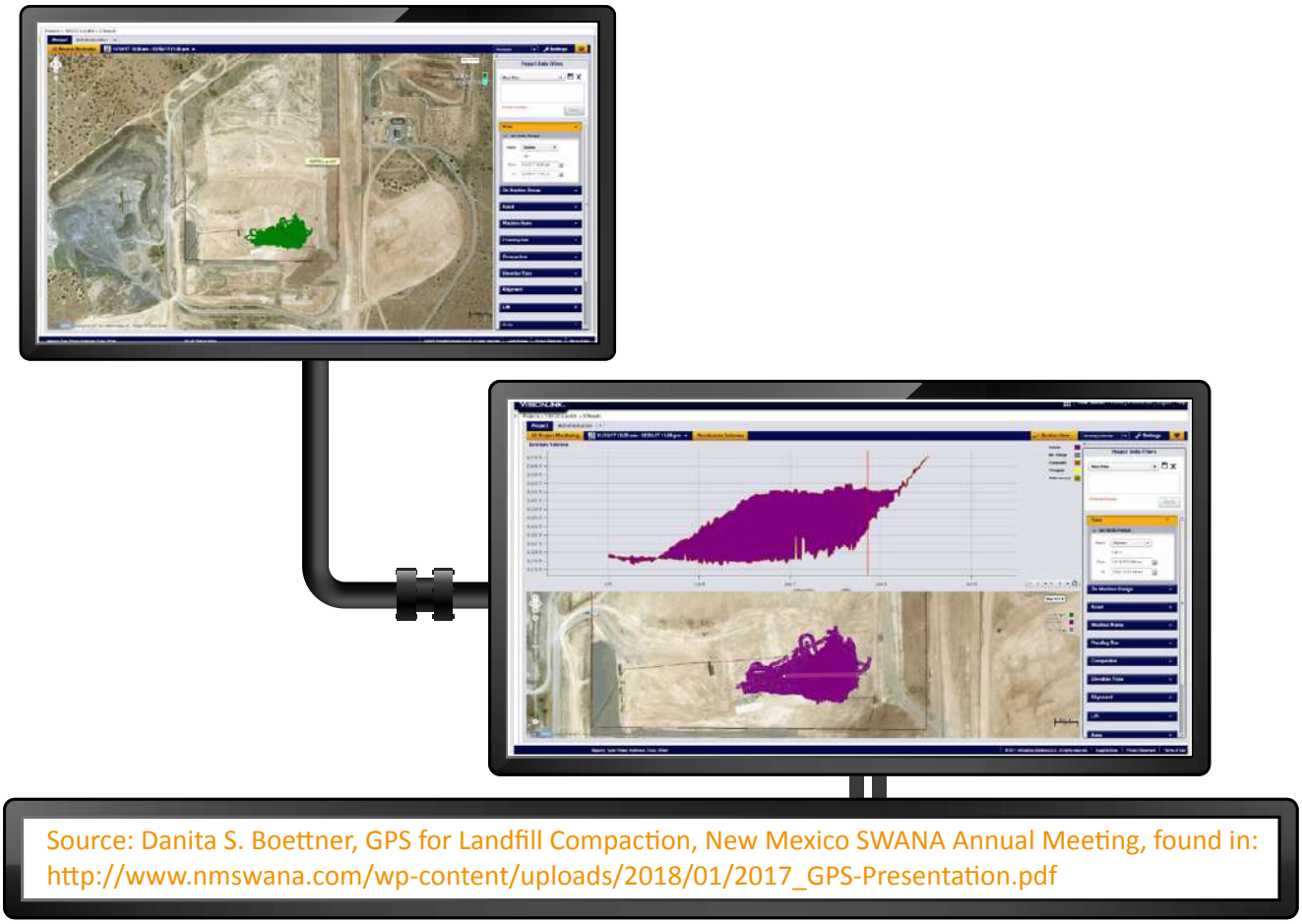
Landfill operation is always an intricate activity. It's a demanding process that requires a lot of effort from operators and personnel to achieve environmental and public health protection within an acceptable and affordable financial context for the waste management authorities and the served population. Concurrently, the maximization of landfill's airspace utilization must be achieved, since the development of a new one is a very hard and challenging task for many reasons especially due to the NIMBY syndrome and the lack of available land amongst others.

New technologies provide landfill operators with useful and effective tools not only to support them for proper landfill operation but also to give them the potential to further improve their facility's performance, operational efficiency and decrease the relevant costs. Over the past few years, these tools became widely applicable due to lower sensors and equipment cost, improvement in low-cost communication technologies and improved systems integration software.

The growth of IoT allows the connection of meny different sensors installed in landfill devices and equipment (such as weighbridges, biogas flare stations, pumps, leachate management systems, landfill compactors, cameras, security installations, etc) generating a range of data regarding landfill operations. The collection and management of these data in a single software platform allows the real-time monitoring of all landfill operations, through information related to the environmental performance of the facility (amount and composition of leachate and biogas generated), visualizations, alarms, etc. Through these systems, landfill monitoring can be performed on a 24/7 basis, making possible any intervention and responsive action to off-hours issues.

GPS Systems are usually incorporated to landfill equipment to track equipment's location. But these systems can substantially support substantially landfill operations even further. GPS systems can provide real-time topographic data regarding the construction of daily cell and final landfill volume maximizing landfill lifetime and reducing significantly the amount of soil needed. Moreover, the GPS systems can be used to the development of driverless (or autonomous) landfill compactors that allow proper compaction of the waste with limited possible supervision and control, even outside the landfill's working hours.

Possibly the most widely applied of new technologies in sanitary landfills is the one related to the utilization of Unmanned Aerial Vehicles (UAV or Drones). Aerial topographic surveys are implemented with the use of UAV technology providing information about the waste volume, the landfill capacity consumed and the landfill compaction rate. Moreover, UAV's can provide thermal images to identify hotspots that can indicate subsurface fires.



Source: Danita S. Boettner, GPS for Landfill Compaction, New Mexico SWANA Annual Meeting, found in: http://www.nmswana.com/wp-content/uploads/2018/01/2017_GPS-Presentation.pdf

During the last five years, the company ReSource International company has developed a UAV program to deliver to its customers new services and more efficient data collection focusing on landfill sites, waste facilities and energy facilities. With this program and the use of drone based data acquisition the accuracy is much higher than usual, the time taken is 10-20% of the manual GPS measurement method and the safety and ease of the work are also improved. It is possible for waste facility operators to access to new kind of data that was impossible to consider economically viable not so long time ago.

As a result of this program, ReSource International ehf. signed an agreement in March 2018 with the municipal waste management company SORPA bs. (for Greater Reykjavík) for monthly drone surveys at their landfill site. The company is also starting surveying landfills in Sweden and is looking in developing further in the Nordics.

A very important benefit of UAVs is their modularity - it is possible to collect a wide range of data by changing the camera or sensors onboard a single airframe. In this context, the company uses also thermal mapping technology for early fire potential recognition and near infrared for vegetation monitoring. In year 2019, a new project was initiated on measuring methane and carbon dioxide concentrations and fluxes from landfills using high accuracy drone mounted GHG sensors. The project in the short term can revolutionized gas emitting facilities and GHG potential assessment projects.

OPINION

MACHINE LEARNING AND THE FUTURE OF SWM FACILITIES

The Waste Sector has always complained about waste being heterogeneous. Unpredictability is where machine learning (ML) and Artificial Intelligence (AI) algorithms fits best. In general, ML can be supervised learning or unsupervised learning. Most of the applications for AI are of the second, the machine is feed data, until it can perform a task. Like recognition of Plastic bottles.

Unsupervised learning allows us to approach problems with little or no knowledge about how our results look like. We can derive structure from data where we do not necessarily know the outcome. This means, ML understands the reality in a totally different form as humans do. The IND 4.0 collaborates with the Human operator enhancing his ability to make the right decisions.

Today ML equipment is a reality offering flexibility, nevertheless waste facilities still are designed as a fixed process. Capacity is estimated at the drawing board leaving no room for operator adaptation. In the IND 4.0 there is a shift from fixed to flexible, from quantitative to qualitative design to achieve higher volumes of higher quality recyclables.

In the IND 4.0 the processing flow is adapted in real time from the data gathered to the rotating speed of trommel to improve uniformity and maximize the autonomous sorting of the facility. Furthermore, blank spaces in conveyors and big volumes of waste are avoided. High value batches of recyclables can be detected on vision systems at the feeding of the facility providing to the system information to reduce processing speed to maximize the recovery process or to increase the processing flow when there is a lower quality waste.

Interestingly, IND 4.0 stimulates Landfill 4.0 biogas management. In the Landfill 4.0 continuous monitoring and automatic valves improve the quality and quantity of Biogas. Holistic adjustment is done from an infinite iteration of possibilities and far greater number of variables. ML application in the Landfill 4.0 regulates the overall degasification process considering interactions between wells, allowing for predictability of resource and stability of quality.

To conclude, Waste Facility Machine Learning algorithms are becoming operators' partners, that can assess the facility performance communicating with other AI and to the rest of the sensors in a way that the facility can adapt in real time.

Jacobo Moreno Lampaya, Consecuente
Environmental Consulting Partner

> Waste Facility Machine Learning algorithms are becoming operators' partners

CHAPTER 4

STIMULATING CIRCULAR ECONOMY AND RECYCLING MARKETS

IoT allows the continuous monitoring of all connected products for the optimization of their design and the customization to the users' needs. The same feature allows the stimulation of preventive maintenance practices, the expansion of the products' life-cycle and makes easy the application of Extended Producer Responsibility schemes on a global scale, especially for equipment like cars, e-waste, white goods and machinery. In addition, as the recent progress in robotic dismantling of mobile phones demonstrate, IND 4.0 creates a serious possibility to eliminate certain types of e-waste that they have high value in recoverable materials under the condition that their loops will close involving the manufacturers. Re-design of many products (increasing recyclability, modularity and reuse) will also become easier based on the information available from IoT and the user's feedback. However, it is stressed that all the above remain a clear opportunity with huge benefits under the condition that proper governance and international cooperation systems will be in place that will stimulate and regulate EPR systems and provide the manufacturers the proper framework and incentives.

In addition, the emergence of materials exchange platforms and the rise of digital material footprints allows better informed, faster and more transparent market transactions, creating the basis for more resilient and less turbulent recycling markets.

The adoption of more circular business models would be accelerated and advanced by the introduction of material passports, a concrete measure that can be of great help in stimulating reuse of materials by increasing transparency to develop a circular business case and enabling reallocation. To understand the potential value of circular materials, products, and systems, a reliable set of information is necessary and material passports are created with the aim of providing such information.

> Therefore, it can be said that Circular Economy either it will be digital or it will not exist.

ARTIFICIAL INTELLIGENCE ADVANCES RESOURCE RECOVERY

Artificial Intelligence is the core of IND 4.0.
It will stimulate the transformation
of the waste management industry
with three main ways

1 Big Data for the service users

Using advanced sensors to households, bins and vehicles. The analytics will provide an in-depth knowledge of the waste stream and they will drive tailor made resource recovery programs

2 Robotic Recycling

Robotic Recycling is already a reality - it will become mainstream within the next 10 years, providing more accuracy, better flexibility, quick market adaptation and transforming the MRFs

3 IoT and waste prevention

Through IoT applications, household and industrial equipment can advance preventive maintenance and expand the life cycles. They can also stimulate EPR applications and track hazardous materials.

CASE STUDY INNOVATION ON RESOURCE RECOVERY AND TREATMENT

A NEW REVOLUTIONARY CONVERSION TECHNOLOGY READY TO SCALE UP

IND 4.0 will radically reshape waste treatment facilities and techniques. One of the most surprising and promising treatment technologies, otherwise known as advance waste conversion, has been developed by the Israel-based company, UBQ Materials.

UBQ has developed an advanced waste conversion technology, leveraging alternative (third generation) feedstocks in producing the 'Most Climate Positive Material' available today [verified by Quantis and to the best of their knowledge]. This bio-based thermoplastic material can displace or even replace traditional oil-derived polymers in hundreds of applications.

According to the company, every 1 ton of UBQ™ material produced reduces 11.7 tons of CO2e. UBQ achieves these immense CO2e reductions by diverting waste from landfills, whereby this alternative feedstock includes all the organics (±70%) and typically unrecyclable plastics (±30%).

UBQ's core innovation breaks the waste input down to its basic natural components (cellulose, lignin, sugars, and fibers etc.), after which the conversion process reconstitutes it into a binding matrix for all of these particles, resulting in the novel, homogeneous composite, bio-based material.

ISWA's Daniel Purchase sat down with Christopher Sveen, UBQ's Chief Sustainability Officer, to discuss the company, its revolutionary technology and innovative approach to dealing with waste.

Please explain briefly how your technology works?

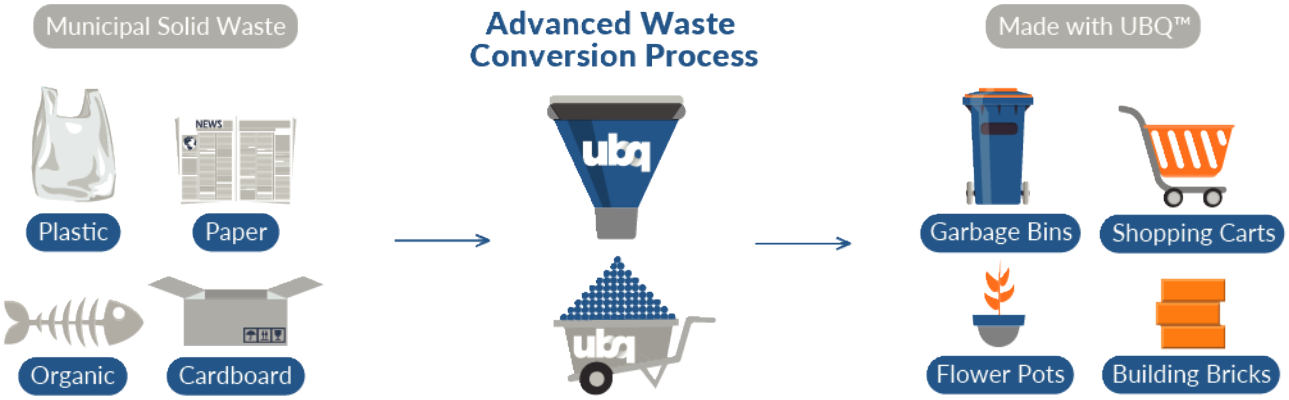
UBQ is not focused on plastics treatment or recycling, but on addressing the waste crisis as a whole.

Our patented advanced waste conversion technology breaks down and combines virtually all household waste – everything from mixed plastics to food waste, dirty diapers, cardboard and paper – and converts it into a new, sustainable, raw material industry can use to make the everyday familiar goods they produce today.

UBQ™ material is a bio-based composite with thermoplastic properties that can be used in place of, or in combination with, plastic and other raw materials, a one-of-a-kind solution that has been granted patents worldwide.

Working seamlessly with today's current manufacturing processes, UBQ™ can be used as a substitute/replacement for synthetic plastics without additional adaptation costs. From injection to compression molding through to extrusion, the UBQ™ material has been tested and proven to be compatible with PP, PE, PLA, and PVC. In addition to core environmental and strategic value propositions, UBQ™ material is 1:1 price competitive with current market plastics.

Converting Household Waste Into Sustainable Products



Through robust partnerships, hundreds of material and final production application developments have been completed over the last several years. UBQ™ is fit for use in the production of durable plastic products, everything from municipal trash cans to shopping carts, shipping pallets, pipes, car parts and flower pots. Today, UBQ is commercializing its material to Israeli and international manufacturers.

Quite a few companies are offering chemical recycling technologies / services – what sets you apart?

There are several factors that set us apart:

- We use the entire waste stream. Except for metals and minerals, which have high recycling values, there is no separation required, enabling a truly circular model of zero waste.
- Our process and product are economically viable, providing a cost-efficient polymer displacer to the plastics industry. UBQ™ can substitute polymers in the production of plastic goods today, without the need to change standard process or production tools.
- The UBQ advanced waste conversion technology is highly energy efficient, using no water and producing zero effluents or fumes.
- UBQ™ is certified as the 'Most Climate Positive Material' available today. By preventing the decomposition of organic materials in landfills, we avoid poisonous methane emissions. Verified by Quantis, there is no other known material with a similar contribution.
- In fact, the climate impact of chemical recycling, to the best of our knowledge, is at the same level to its virgin counterparts.

How would you measure yourself against, for instance, a Plastic Energy-type solution and/or process or another similar company?

Alongside SystemIQ, a leading consulting company who also acts as the Ellen MacArthur Foundation's Knowledge Partner for Systems Initiatives, the UBQ solution was mapped and compared to all conventional technologies in the marketplace and confirmed UBQ to be the only truly economical, and viable 'Target Technology'. This was in context of being the only economically viable technology to treat unsorted municipal waste as well as when accounting for full system costs, before subsidies for collection and sorting.

Market Technology Comparison

Treating unsorted municipal solid waste

Technology Comparison Criteria	ubq	Mechanically Recycled Plastics	Chemically Recycled Platics	Composting	Anaerobic Digestion	Sanitary Landfill Producing Electricity	Paper Recycling	Incineration
Net Commercial Viability*	✓	✗	✗	✗	✗	✗	✗	✗
Environmental Benefits	✓	✓	✓	✓	✓	✓	✓	✗
Downstream Systerm Compatible	✓	✓	✓	✓	✓	✓	✓	✓
Upstream system compatible	✓	✗	✗	✗	✗	✓	✗	✓
Health and Safety	✓	✓	✓	✓	✓	✗	✓	✗
Circularity	✓	✓	✓	✓	✓	✗	✓	✗

*NOTE:
Net commercial and economic viability when accounting for full system costs before subsidies for collection, sortation, and disposal.

LEGEND:
✓ Problem addressed ✓ Problem partially addressed ✗ Problem not addressed

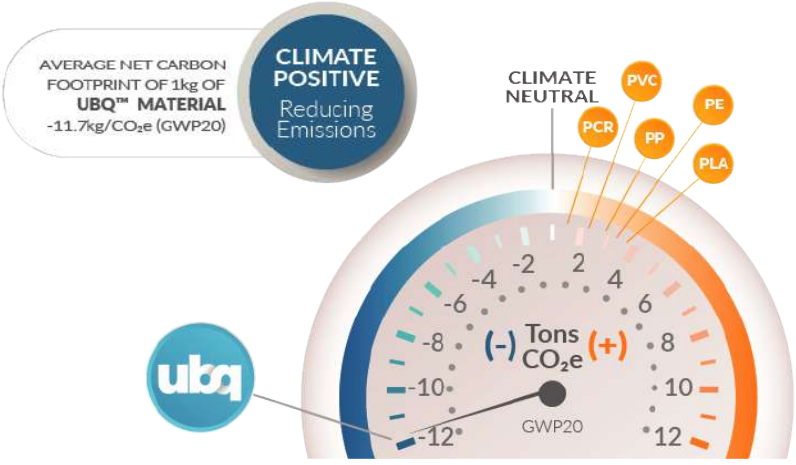
Expand on the UBQ impact both in terms of operations and materials output?

The UBQ conversion process was developed to have ZERO impact. With a relatively small amount of energy, no emissions, waste, effluents or use of water, we are able to convert a widely heterogeneous stream of materials into a homogeneous, valuable composite.

Committed to Zero Impact & Beyond

The resulting UBQ™ material is a bio-based, climate positive, sustainable material that carries an enormous environmental value proposition. By preventing the decomposition of organic materials in landfills, we avoid their potent methane emissions, which compared to CO2 is 86 times more toxic over a 20-year time horizon. Our Life Cycle Assessment (LCA) shows a reduction of 11.7 tons of CO2e for every ton of UBQ™ material produced. On an industrial scale, using 1 ton of UBQ™ in place of 1 ton of virgin polypropylene can save the environment an estimated 14.5 tons of CO2e emissions (total offset value).

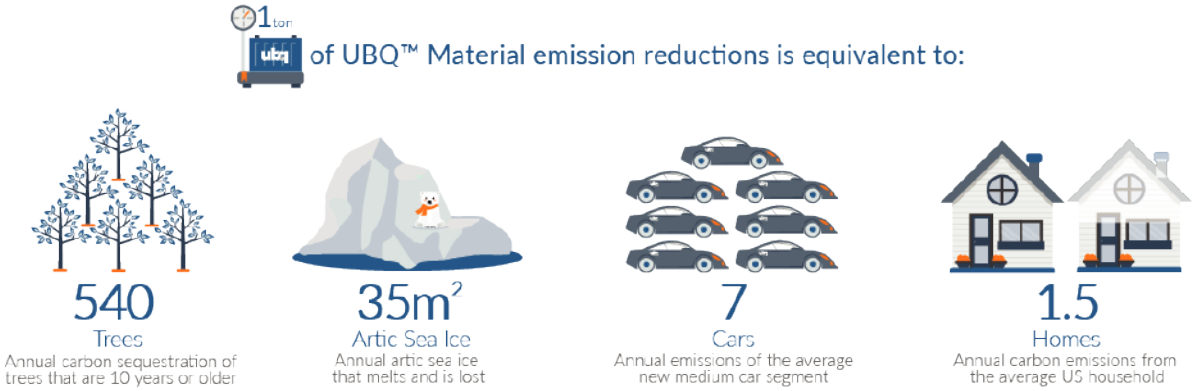
Most Climate Positive Material Available In The Market Today



According to Quantis, the international sustainability company which developed our LCA, and to the best of their knowledge, there is no other known material that can make such a claim, leading the organization to designate UBQ™ as 'The Most Climate Positive Material on the Planet'.

But what does this all really mean at the end of they day, as the everyday citizen has a hard time connecting with the impact of 1 ton of gas, let alone almost 12 tons. According to UBQ's research, they have been able to quantify this climate impact into more relatable equivalencies, where for example, 1 ton UBQ™ material effectively offsets the equivalent annual emissions of 7 cars within the EU new medium car segment.

UBQ Climate Impact Equivalency

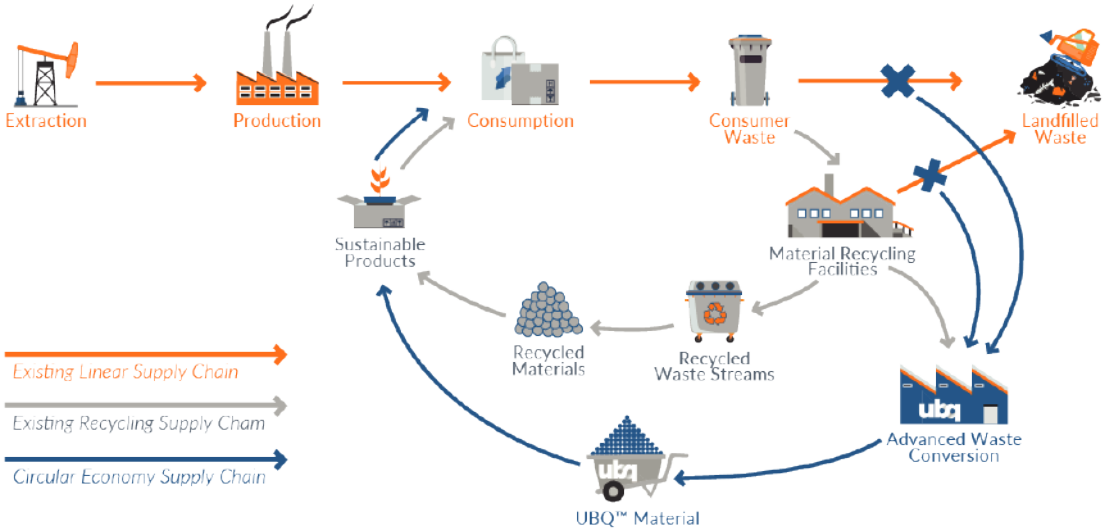


To extrapolate this impact example further, UBQ is currently in the process of expanding operations into the US where their next facility will have a throughput capacity of minimum 90,000 tons. Under the same car comparison, that would then equate to taking 630,000 cars 'off the street' for a full year.

What does Circular Economy mean to you in terms of the plastic sector? In what ways could your solution close the loop?

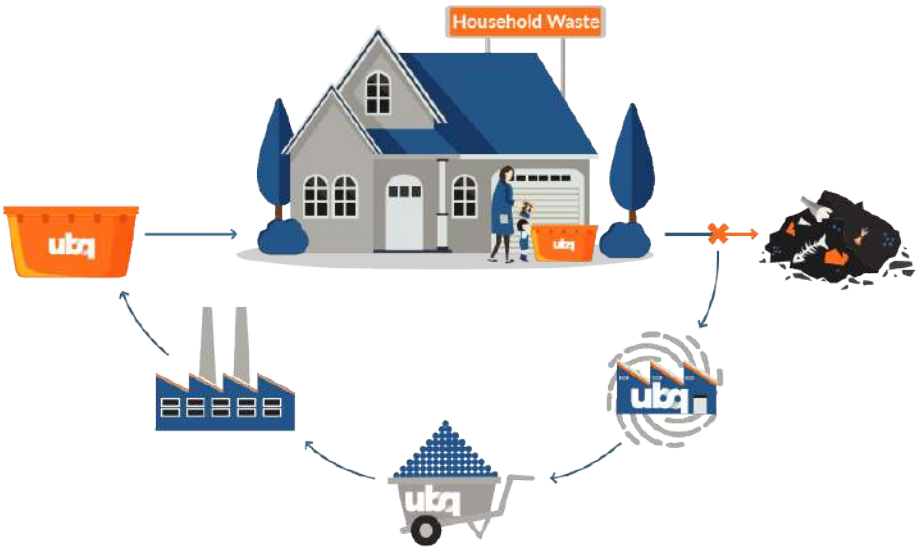
The UBQ conversion solution was developed to process all waste, not just plastic, into a singular and homogenous upcycled material. Having proven the UBQ method effective, we can now divert waste directly from landfills or illegal dumps, including from dumping directly in the oceans. The significance of this being that UBQ can close the loop on unsustainable waste disposal, bridging the gap for material demand with sustainable bio-based materials, whilst at the same time reducing carbon emissions and waste pollution.

Closing the Loop with UBQ™ Materials



To narrow the scope even further and showcase the solution on a localized level, UBQ is converting household waste into recycling bins that will further bolster segregated curbside collection to improve recycling rates. From a circular point of view, converting unsorted household waste into products that will then in turn stem the flow of more waste being dumped in landfills nicely frames the circular opportunity of both UBQ as a waste solution but also an upcycled renewable material source to produce more sustainable products.

Household Waste Converted to Recycling Bins



What scale are current / future operations and how are you positioned within the value chain?

Today's pilot industrial plant has a 5,000 ton capacity per year, and we are planning our first fully industrial facility in the United States with a capacity of 80,000 to 100,000 tons per year. The UBQ conversion process is a modular system that can be easily scaled and adapted per the requirements of any location. We receive our municipal solid waste (MSW) as a residual from the transfer station, after recyclers have selected and removed valuable materials (metals, plastics, paper and cardboard).

It is important to note that while a material may be recyclable, the state in which it is found in the waste stream, soiled or contaminated, it is deemed unrecyclable and therefore forwarded into the UBQ conversion process. This diverts the residual waste from being sent to a landfill while providing recyclers with a more efficient, cost effective and clean way to dispose of their unrecyclable streams. We complement recycling, rather than compete with it.

As the above implies, the UBQ solution was developed to be robust enough to serve even underdeveloped infrastructures, where waste is sent to landfills, either partially or completely unsorted.

How many times could you recycle a recycled product with your process - infinitely? Is there a degradation in the quality of the feedstock or does it remain consistent? How does it compare with a virgin polymer?

UBQ™ is a fully recyclable material. As dictated by circular economy requirements, UBQ™ is capable of being looped back into its original material value, to be utilized over and over again. Unlike existing oil plastic resins, UBQ™ materials can be reused at least five times without losing their quality or performance properties.

Like with any other polymer, virgin or recycled, UBQ™ can be compounded with additives commonly used in the industry to address product specifications such as coloration, resistance to heat, impact strength or even UV resistance.

Why is there not more noise about solutions?

The industry is conservative, standards are rigid, and consumers are not necessarily willing to pay more. These facts, as well as the substantial time and capital required, work against emerging technologies displacing the traditional products and processes in plastics. With that said, there is no lack of noise. The problem is that this noise tends to be more marketing than substance, and large-scale industry players from both the waste and materials (including plastics) sides don't consider many of the technologies to be scalable or economically viable. What 'noise' there is, should be better leveraged for the solutions that do work, enabling them to gain traction, create partnerships and achieve adoption.

Do you think that in a few years waste will no longer be an issue and it will become a resource…?

Considering over two billion tons of MSW are produced annually, waste is, and will continue to be, an issue for the foreseeable future. Without a major paradigm shift connecting readily available solutions, major industry partners, and government agencies, there is little potential for real change. When emerging innovative solutions garner the much-needed implementation in such a collaborative landscape, either locally or globally, big or small, only then does the notion of waste transform into a valuable renewable resource, a true asset.

Why is all the focus on banning single use plastics, etc.?

Single-use plastics, or any single use-material, whether it be paper, cardboard, bamboo or any other material, is a big issue. As stated in the report, Stop Trashing the Climate, "A Zero Waste approach is one of the fastest, cheapest, and most effective strategies we can use to protect the climate and environment."

With that said, it is important to acknowledge that the industry has grown accustomed to the low price, light weight, and general effectiveness of plastics within single-use applications. The problem with single use plastics is not their use, but their inefficient unsustainable disposal

Only a cultural shift paired with economically viable solutions will be substantial enough to change the industry. Like the LOOP project, we need to advance an effective reusable packaging model within an infrastructure that enables proper recycling of packing materials.

CASE STUDY CIRCULAR LOOPS

INNOVATIVE PROCESS TO RECOVER NON-FERROUS METALS FROM BOTTOM ASH

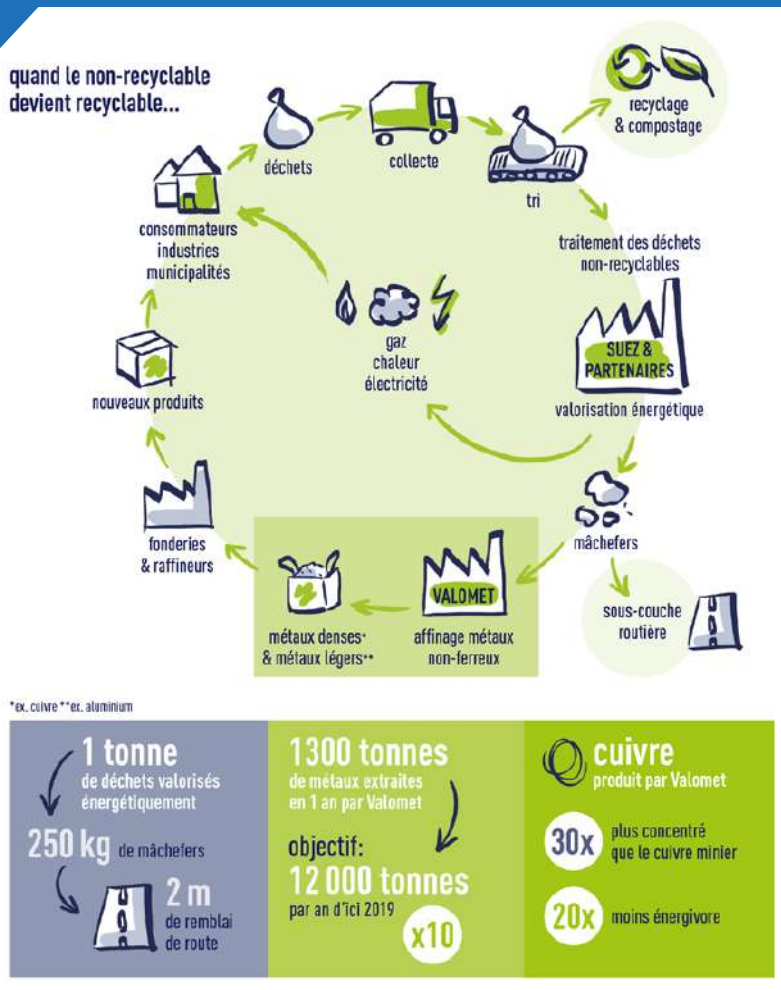
Bottom ash is the incombustible part of waste incinerated at an energy-from-waste plant.
Its mineral fraction can be reused for roads and runways or to produce stackable building blocks mixed with cement. Today is going even further using the internally developed Valomet process. During this process fine non-ferrous metal particles of between 0 and 20 mm in size are recovered from bottom ash, creating new resources. In Europe, until recent years, this ultra-fine metal fraction was considered unrecoverable and unusable.

The metal mix is composed primarily of aluminum and copper, but in proportions that cannot be used by the specialized foundries and refineries.
SUEZ subdivided this mix to extract two distinct flows based on the density of the metals:

- a flow of aluminum, a light metal that can be reused directly in foundries;
- a "copper" flow, made of dense metals which can be reused as feedstock at the copper and precious metals refineries.

Over a one-year trial period, a pilot project recovered around 1,300 tonnes of fine metal particles, which were then returned to the production process, through foundries and metal refineries.
Valomet's innovative recovery process is completely dry. As the traditional process involved moisture, foundries were wary to take in these ultra-fine metals due to high oxidation levels and risk of explosions.

SUEZ is currently building a new industrial plant in the port of Ghent in Belgium. The new site is scheduled to be operational at the end of 2019. Its aim is to process up to 12,000 tonnes a year. The materials processed will come from European countries, including Belgium, France, the UK and Poland. The recovered metals will be reused in European foundries and refineries.

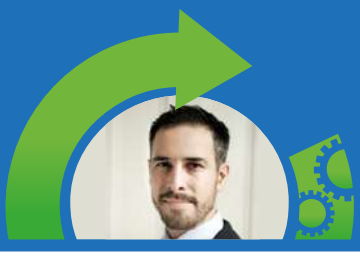


CASE STUDY THE ERA OF PLATFORMS

RECYCLEBLU ® - ECOMMERCE PLATFORM FOR WASTE MATERIALS

Much as eBay and Amazon have done for B2C and Alibaba for B2B. RecycleBlu.com , the award-winning platform for the B2B commerce of waste materials has brought significant E-commerce innovations to the trade of recyclables and waste materials. The Platform's match-making algorithms and material classification ensure that finding the right material and grade of materials is easily achieved. The messaging service allows negotiation and communication between buyer and seller and a registry for possible mediation in case of disputes.

The platform's architecture allows users to create their own online shop with their brand and company identity and manage all their inventory online in one place. Users can upload their materials to the platform straight from their warehouse using their mobile phones. Payments and transactions are carried out through a state of the art Escrow system, specifically tailored for the sector, allowing for partial payments and full release of payment against documents.



Goncalo Baptista, Managing Director RecycleBlu.com

The issue for us in the 21st century is the sheer scale of the recyclables market and its transnationality. Today, waste material is created in one place and reprocessed on the other side of the world.
When I started RecycleBlu.com I knew next to nothing about the trade of recyclables. What I found out, as an outsider, was an extremely fragmented market ridden with fraud and bit time players trying to connect multiple parts of a mismatched supply chain.

Trying and risky transactions and inconsistency of supply were and still are a daily occurrence. Finding new suppliers and customers is done informally and using outdated marketing channels.

I am now more convinced than ever, that E-commerce, as imagined by eBay , Amazon and now RecycleBlu.com , is the future for this industry.

UBUNTOO: CONNECTING STAKEHOLDERS TO DRIVE INNOVATION

Launched in 2019, Ubuntoo is a collaborative platform that aims to scale up impactful innovations by connecting key stakeholders together. The platform connects innovators and industry leaders to collaborate on solutions and technologies in support of the United Nations Sustainable Development Goals (UN SDGs). The team at Ubuntoo believes that the issues we face as a planet cannot be solved in individual silos. Therefore, we must find and facilitate connections that make us more than the sum of our parts.

Ubuntoo's initial focus is to promote circular economy solutions to end plastic pollution. Future focus areas will go beyond plastic waste to include innovations addressing food, water, climate, agriculture, energy and other issues as outlined in the UN SDGs.

ubuntoo

By Peter Schelstraete, Venkatesh Kini, Co-founders

Ubuntoo does not get paid for innovation listings and its individual subscription-based business model enables it to remain neutral and unbiased. The solutions found on Ubuntoo are featured purely based on their merits. The platform chooses to focus on solutions rather than the issues and recognizes that the challenges we face as a global society are complex and no single solution can solve them all. The team at Ubuntoo recognizes that steady and sustained progress depends on collaboration among key stakeholders, including those who consider each other competitors.

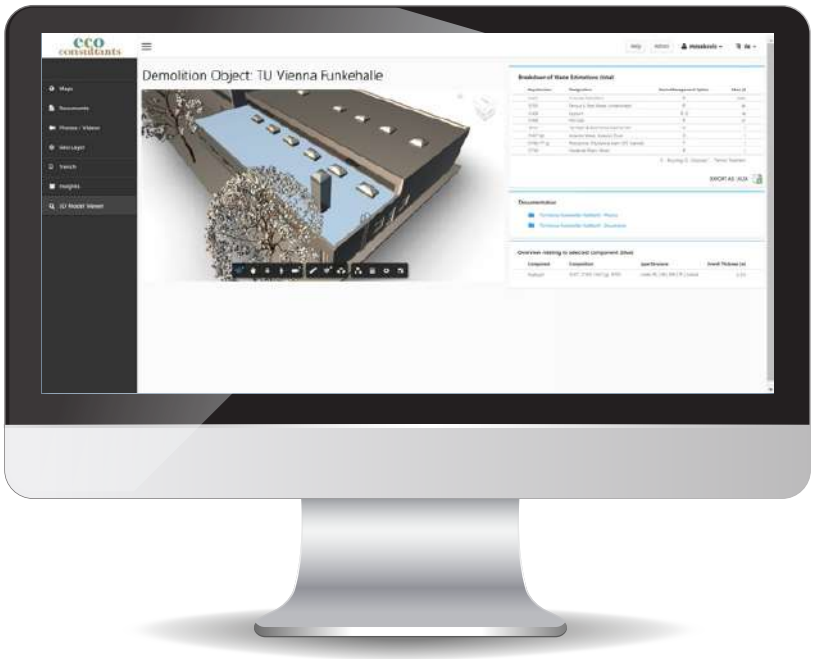
Ubuntoo connects entrepreneurs and innovators, academics, experts and influencers, governments, NGOs, corporations and investors in the Sustainability Grid to foster collaboration and accelerate change.
According the company's co-founders "It takes just a couple of minutes to book your next AirBnB. But when it comes to sustainability solutions, there is still no effective marketplace at all. That is what we are solving with Ubuntoo."

CASE STUDY CIRCULAR LOOPS

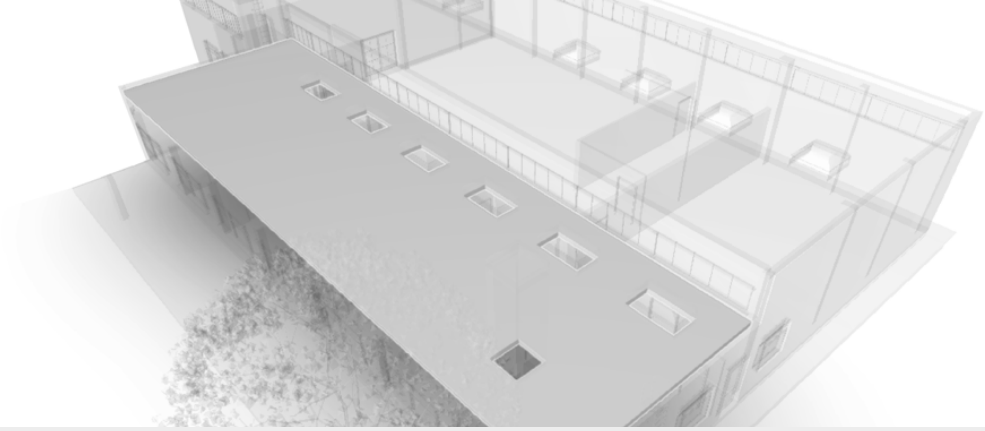
BUILDING INFORMATION MODELLING

As with many sectors of our economy, the waste sector is undergoing a major transformation at present. Much of which is a direct or indirect consequence of the 4.0th industrial revolution causing changes in business models, products and processes with effects for the waste sector. In addition to that external effects brought about to our sector IND 4.0 poses a huge potential to improve processes in the waste sector, such that productivity and performance can be brought to the next level which is also needed in order to capitalize the waste management sector´s potential to tackle major waste related societal challenges such as Marine Litter, Climate Change and Circular Economy. The threat of this is less about IoT and robots replacing workforce but more about a change in the services needed and the tasks to be performed and thereby skills to be offered. Debating about threats but also potentials of IND 4.0 in the waste sector is crucial in order for all actors to remain fit for the challenges to come.

Arne Ragossnig, Managing Partner of Ecoconsultants

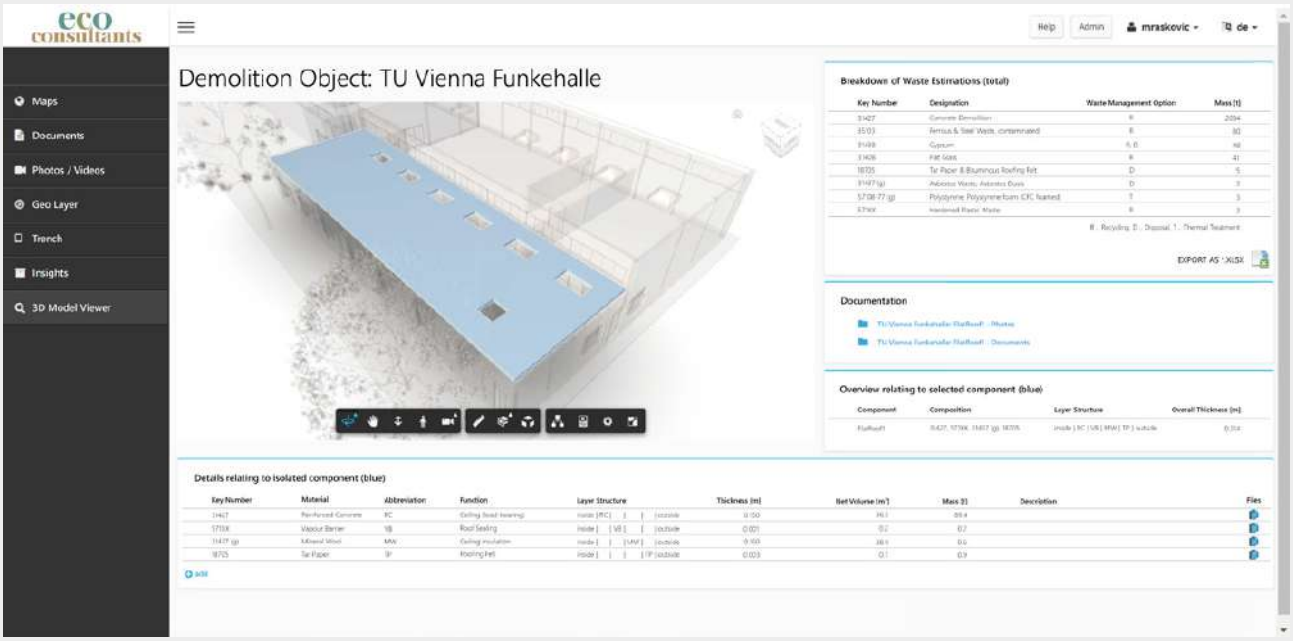


Waste from the construction sector poses huge challenges for sustainable waste management. This is not only due to the vast quantity of waste – more than 70% of the mass of waste is from the construction sector – but also due to the long time products remain in the anthropogenic stock before they become waste. Waste management must ensure to recover as much resources as possible while making sure to keep material loops clean.



This task requires more knowledge about the building stock and an adaptation of demolition processes. Based on European Union law building products that have been used for example as insulation only a few years ago – such as extruded polystyrene with CFC as foaming agent or expanded polystyrene with flame-retardants – become hazardous waste due to their ecotoxicity and health impacts once they become waste.

Innovative technologies such as Building Information Modelling (BIM) which is just about to become mainstream in the planning and operating of newly build houses and structures offer a high potential to provide material information for future demolition. The challenge is the transition phase as there is no data available for the existing building stock. Innovative methods of data capturing allow for acquiring the information to establish an as-built BIM where respective information for individual building components can be attached to these in order to allow for planning and execution of a selective deconstruction and appropriate waste stream routing serving the objectives of establishing clean recycling loops.



CASE STUDY INNOVATION ON RESOURCE RECOVERY AND TREATMENT

3D FILAMENT FROM PET BOTTLES

The Institute for Polymers, Composites and Biomaterials (http://www.ipcb.cnr.it/index.php/en/) of the Italian CNR, as part of the project PON-04a2_OR.C.HE.STRA, has experimented the collection of plastic (PET) with a machine for the compaction of materials easily recyclable. In addition to release paybacks, the aim was to transform recyclable plastics into objects of art through a 3D printer according to the needs of local artisans. The keywords of the project are proximity and innovation. Proximity because the material collected will be transformed on site, according to the needs of local artisans, such as for the creation of lucky horns. Innovation due to the processing technique: the production of these objects will take place with the use of a 3D printer, technology that is emerging as the new production frontier in various sectors.

Mario Malinconico, President of ATIA ISWA
International Science Council ISC CNR Representative

The global filament market for 3D printers has already reached the value of about 800 million dollars, and is expected to increase; however until now we have always used virgin plastic filament for prints. Although existing recycling installation does not work for every type of plastic yet, it can be expected that in the near future the threshold of virgin plastics used for printing will collapse, giving way to recycled filaments. It should be noted that in today's technological state the quality of the filaments obtained with this methodology is not the best: the resulting plastic filament has in fact some sporadic imperfections that may compromise the quality of the printed product. However, it is undeniable that this approach will be necessary to exploit the resources already at our disposal optimally, without producing new raw materials to work with. The prospects for potential economic savings are diminished by the possibilities of a positive impact on global ecology, on which we have already left our footprints in the form of milky spots of plastic pellets in the oceans and for too long we have remained at to watch.

3D PRINTER FILAMENT FROM MIXED FOOD WASTE

The advent of 3D printing technology has led the way for innovation efficiency and waste minimization in production processes, but the most classic types of printer filament such as ABS and PLA are classified by ASTM standards as Type 7 plastics that are not usually recycled by regular recycling programs. Canadian Biotech startup Genecis Bioindustries Inc. has, however, developed a sustainable solution to this problem with a technology that not only produces a biodegradable and compostable plastic that can be used to make new 3D filament and flexible packaging (amongst others), but also the process uses restaurant and kitchen food waste as raw materials. By partnering with large food service providers and waste haulers, they are able to leverage large quantities of food waste that are destined for less sustainable ends and convert them to biodegradable polymers.

The technology uses two cultures of bacteria to break the food waste down to create PHA bioplastics (polyhydroxyalkanoates) as a by-product through a two-step process. The first culture of bacteria breaks down food waste into short-chain carbons, (volatile fatty acids) which are then induced to the PHA-assembling bacteria that produce and store the bioplastic granules in their cells before being extracted through a proprietary method.

Genecis

PHAs are currently made with expensive food crops such as corn and sugar cane. With this technology, Genecis can replace these raw materials with mixed food waste that can dramatically reduce production costs. Genecis is currently scaling their process, developing large bacterial databases and further increasing its operation to an industrial level.

With their current production capacities, they aim to enter into premium plastic applications, including personal care products, 3D printing filaments, and applications that require certain functionalities that PHAs offer such as high tensile strength and UV resistance. With reduced production costs, they are able to deliver PHAs at competitive price-points, while maintaining the functionality that is required by plastics used in the aforementioned applications, generally not afforded by other types of bioplastics.

CHAPTER 5

NEW GOVERNANCE PATTERNS ARE AVAILABLE BUT NOT EASY

In municipal governance around the world, the use of collective intelligence methods with dedicated tools, mobile apps and platforms is becoming the norm as a way to involve citizens, users and stakeholders in the design and implementation of policies. This new “open policy making” approach stands to benefit from the rise of artificial intelligence which can act as a cognitive agent to organize and summarize content, as well as a social agent interacting directly with participants. Artificial Intelligence can also help fact check information and help generate automatic summaries and map concepts.

Location information plays an essential role in the far majority of Digital Platforms and the importance of location intelligence is reaching new heights thanks to the more than 25 billion devices that will be connected to the “Internet of Things” by 2021.

Digital Platforms enable multi-directional network effects and value creation and allow platform owners - managers to address the markets. The near-zero marginal cost curve of Digital Platforms create the possibility of market domination by one platform and the high barriers to entry or exit lead to monopolistic and oligopolistic market structures.

On the other side Developing Digital Platform businesses requires a shift in design thinking from resource ownership to resource orchestration.

Several recommendations have been developed by EU for how Digital Platforms could more easily apply and expand in the context of government environments. The main ones concern that governments should focus on orchestrating and reusing existing government services as a starting point for developing their Digital Platforms, they should start building IoT capabilities and optimise the use of their open data services by defining a service delivery approach that matches the needs of their target consumers

OECD has recommended “that governments develop and implement digital government strategies” to assist and guide them to achieve that digital transformation. The Recommendation emphasises the crucial contribution of digital technologies as a strategic driver to create open, participatory and trustworthy public sectors, to improve social inclusiveness and government accountability, and to bring together government and non-government actors and develop innovative approaches to contribute to national development and long-term sustainable growth.

The greatest challenge of collective intelligence lies in engaging citizen. It is extremely difficult to mobilize a large range of the population that has a diversified base of knowledge on specific public policy issue. This is compounded by the challenge of finding the right balance of key stakeholders and citizens to provide political legitimacy to the consultation.

The application of EPR and other recycling schemes, their supervision and monitoring is becoming easier through the digitization of the waste sector.

Tracing hazardous materials and substances, restricting illegal treatment and disposal and preventing waste trafficking is also advanced due to digital footprints, IoT and modern surveillance techniques.

CASE STUDY GOVERNANCE

TOOLS FOR PUBLIC PARTICIPATION

Public participation and citizen's engagement is a key-problem in waste management decision – making. Fortunately, there are several innovative powerful tools for civic innovators allowing greater collaboration, transparency and participation for civic projects. Here we present several participatory tools that could enhance the work of civic innovators, particularly government innovation teams and labs, looking for more decentralised, open ways of working in waste management.

https://consider.it/
Consider.it can help you collect feedback, engage stakeholders, make group decisions, teach critical thinking, and more.

https://www.loomio.org
Open Source tool for collaborative decision-making

http://assembl.bluenove.com/
Assembl is an online application that enables hundreds or even thousands of people to work together effectively on the definition of new ideas. The application supports the belief that with the proper conditions, people working together think smarter than any one member of the group could alone.

https://www.nova-ideo.com/
Nova-Ideo is a participatory innovation tool, the merger of the box ideas and collaborative portal.

http://www.appgree.com/
Appgree finds the ideas a community agrees on the most, making a group conversation possible

A very interesting relevant project is the OGP Toolbox that was developed for the French Government and can be found at https://ogptoolbox.org/en/tools/?tagIds=9932

The use of mobile applications for better governance, and especially for improving waste management and recycling, is a key-tool that is already applied in hundreds of cases worldwide.

A ROADMAP FOR THE DIGITALIZATION OF WASTE MANAGEMENT – THE CASE OF BIR AND WasteIQ

BIR, a public waste management company owned by nine municipalities around Bergen, Norway, has developed the WasteIQ digital platform that enables plug and play integration with several vendors of access controlled containers, vacuum systems, car weights and scanners. The system can receive data from a wide range of sensors . Antonis Mavropoulos, ISWA President, discussed with Toralf Igesund, Head of Planning at BIR, and Anders Waage Nilsen, product lead at WasteIQ, about the roadmap to digitilization of the waste services and the key-lessons learnt.

Antonis Mavropoulos: Let us know the story of WasteIQ in brief

The story of WasteIQ started in 2009. BIR wanted to establish access control and a pay-as-you-throw scheme. The public waste management of BIR looked for a solution that worked across different waste solutions, including the complex vacuum system in the inner city, different container solutions in the wider city are and traditional waste bin collection. The IT department started building an application internally, that connected the CRM-system with the physical infrastructure to ease access management and create an automated invoice process for access controlled solution. The PAYT scheme gained impressive results in recycling rates, and improved data quality increased operational efficiency. As other cities wanted a similar solution, BIR decided to establish a separate software company, in collaboration with New & Company. The application was reprogrammed - and made available through the cloud. The architecture was built to fit different cities and business models, and modernized to meet modern standards. In March 2019, the new platform took over the data management for BIR. After the launch the digital operations have been more efficient, the organization now has access to more dynamic data reports. A range of new technologies are about to get their certified integrations with the system. An administration client is being built in collaboration with the BIR staff. The ambition is to ease the time-consuming tasks and make the transformation of data to information immediate.

What should municipalities consider before they start and during the implementation of their own digitization projects?

There are many reasons to start the digital journey. Some need to gain more control over their different containers, bins and other equipment. Some need to improve the logistical operation. Others need more data to improve infrastructure planning. The most mature companies are running PAYT-schemes, where the amount of residual waste from individual household is tracked and where the fee reflects recycling performance. Soon we will also get AI-driven solutions. The key to all of this is structured data. Creating this structure is the groundwork for your digital future. WasteIQ is built around a structure that reflects the waste management reality. Within the system there are representations of things like households, containers of different size, sensors. We created a universal definition of different events that occur within an urban waste management reality. By creating this information model, we make it easy and fast to start structuring the data.

WasteIQ reflects the fact that there are several paths to digitization. By combining data from usage and sensors into a holistic model, the data can be distributed in different ways - and serve both CRM systems, logistical planning software and data-warehouses. The administration client can be used as a standalone component, as a plug & play data-warehouse, but the main feature of the solutions is the API. The value of data increases when it is shared.

The flow of information across solutions is key in a modern digital ecosystem. Many waste management companies do not give this focus when they invest in technology. They either get locked-in by one solution or they get trapped in the complexity of combining a wide range of different single-purpose applications. The goal of WasteIQ is to liberate the data, and put them into a structured form. This form should reflect the operational needs and the business models of the individual company. A flexible API makes the data accessible for third parties. By standardizing the data into a standardized format a good route optimization tool can subscribe to data from a range of different sensors, not only from one specific provider. If we combine the sensor data with historical usage statistics, we can enable accurate predictive planning for individual containers.

Not many waste management organizations are this sophisticated yet. But if we collaborate more and share more and learn more across cities (and countries) we might get there quickly. During the WasteIQ development stage we visited many municipalities, and one of the important realizations was that almost everyone works hard to solve the exact same problem, but in their own way. And due to complexity, everyone spends way more money on generic integration than on actual innovation. Therefore, we built WasteIQ platform as a bundle of microservices, that can be reused across cities, and continuously developed. Like Lego bricks, the components are standardized, but they can be put together locally - in a flexible way.

How should we start?

The best tip: Start where you are, identify low hanging fruits, but wherever you start do not create new silos. In early days, data were numbers in a book, analogue and only accessible by one person at a time. Then different departments introduced computers with relevant business systems; accounting in the economy department, Customer Relations Management (CRM), truck maintenance systems in the transport department, weight data in weight statistics system etc. The data was stored in separate databases, often in non-compatible formats. It was hard, or at least expensive, to utilize data from one solution for creating value in another.

The key to interoperability across systems is open standards and APIs. This makes data sharing between business systems way easier. The data can create more value for more people. By providing data from different sources into a data-warehouse, data from different parts of the organizations and from different systems can be analyzed and processed by business intelligence systems. In BIR, this allows different parts of the organizations to analyze relevant key performance indicators (KPI) in real time. Earlier, relevant business decisions were based on old data, often months back in time. Data from many business systems and different companies in a group can be analyzed together.

Next step is using these data to predict future trends, applying artificial intelligence. With WasteIQ, we started thinking of the urban infrastructure in Bergen as a complex industrial operation, that includes the citizens as contributors to the process. The data can be presented as a “virtual twin”, and we can observe the resource flow on a map. Trough AI, we can also increasingly simulate or predict the future load of the system. We can probably increase capacity before vacations with more waste, or change collection pattern according to road accidents or the weather forecast.

All of this can already be done, by today's technology. But to get there, every city needs to start by applying structure to the increasing, sometimes overwhelming, amount of data from different systems. And the data should be kept in a form that makes it easy to use it for different purposes.

Building a data storage and distribution capacity can be done internally, but this requires competence and the right team. In BIR, we created WasteIQ get a professional team of developers that can work across cities with the solving the same digital challenges. We wanted state-of-the-art security levels and we wanted to create a culture of collaboration and technology sharing.

WasteIQ is not an internal project and is not a traditional outsourced product. It is something in between, a startup that evolved from something we missed in the marketplace. So far, this model worked really well. After we went into the cloud the reliability of the system increased, we improved data quality, we integrate with more solutions and data sharing is way easier than before. The big benefit will come when WasteIQ gets more clients, and we can start learning across cities. The combined budgets will help reduce the cost and increase the speed of innovation.

How will big data improve the performance for the users?

In BIR all waste bins are tagged. There is a scanner mounted on the lift on the collection truck. All emptyings are logged. Similarly, the containers and vacuum system have access control that require an RFID key. The usage data is used to calculate the fee. Little residual waste gives you a lower fee, more residual waste gives you a higher fee.

Sounds easy, but the dataset needed is big and complex. We need data on RFID keys, households and a log of all the events - across different waste solution. But it is worth the hassle! When BIR introduced PAYT fees for the households in Bergen, we experienced a reduction of residual waste by eight percent (8%). Recycling of paper/ cardboard was reduced by 5 %, plastic packaging increased by 29%, glass and metal packaging increased by 9%. There are sectors in the city with shared containers that are yet to be included in the PAYT program, It is expected that this will increase recycling even more.

Incentives work, and can probably be enhanced by providing our user with real-time nudging and feedback. Did they improve this month compared to last? How is their recycling rate compared to the average in their neighborhood? This kind of personalized communication has proven efficient in research projects. And what if we try gamification? This fall WasteIQ will be a part of a hackathon (innovation contest) where the gaming industry will try to come up with new solutions. Who knows what they will come up with?

The key to this is access to big data and APIs that makes external developers capable of making sense of the data. Thanks to WasteIQ we can now also open the door into solutions that we have not even started thinking of.

How do you imagine the future of waste management?

The waste management industry will be challenged by technology, regulations and circular business models. More of the waste will be considered resources, and we will optimize the use of both humans (through economic incentives and friendly solutions) and robots in the process. Tracing all the way through the (circular) value chain will be a requirement. New business models will emerge. A new generation of upcycling businesses will create a demand for more fine-grained fractions. As IoT-revolution will create a flood of sensors' data, a new generation of digital services will be introduced. We believe there will be many startups trying to challenge the industry. Logistical planning will optimize for both cost-efficiency and environmental footprint. Transport will be electrified, and smart waste solutions will become an integrated part of urban planning. Predictive algorithms will make planning faster, adaptable and easier. Maintenance will be triggered by sensor data, not schedules. Users expectations will change. Mobile will be default, and user will expect instant feedback. Reward systems will become more sophisticated. Due to the efficiency of PAYT, this reward mechanism might even be enforced by regulation, like in Flanders. In this case, it will be very important to share knowledge across borders.

About WasteIQ

WasteIQ is a digital platform for public and private waste management companies. The platform is built by a startup created by BIR, the public waste management company in Bergen, Norway. The platform enables plug and play integration with several vendors of access controlled containers, vacuum systems, car weights and scanners. The system can receive data from a wide range of sensors. Data is provided in a private cloud and is accessible through an API. By enriching and combining data, the solutions represent a fast track for new digital solutions, such as pay-as-you-throw (PAYT) schemes, responsive maintenance, dynamic route optimization and personalized instant-feedback mobile applications. The platform also support business-to-business circular schemes, where the waste management company serves as a resource broker. The solution is currently operational in Bergen, and several other Norwegian cities have signaled interest in taking part in developing the platform further. The company is also looking for pioneering cities outside of Norway to take part in the project.

About BIR

BIR is a public waste management company owned by nine municipalities around Bergen, Norway. BIR was established in 1881 and is one of the largest waste companies in Norway with 360.000 inhabitants and 350 employees. BIR is organized as a group of companies and cover the complete value chain with companies for household waste collection, transport, sorting and treatment, including WtE. BIR has also activity in the commercial sector.

About Anders Waage Nilsen

Anders Waage Nilsen is product lead at WasteIQ. He is an experienced business developer, design strategist - and is an acknowledged technology columnist and public speaker. He likes the combination of big ideas and hands-on practical work, combining the big picture and the important details.

About Toralf Igesund

Toralf Igesund, Head of Planning at BIR, Bergen, Norway, is an engineer and have worked with waste management for 37 years. He is one of the architect behind many of the strategic desicions in Bergen, Norway - both regarding infrastructure, business models and investments in new ventures.

CHAPTER 6

NEW WASTE STREAMS REQUIRE NEW SOLUTIONS

IND 4.0 comes with a plethora of
a. new end-of-life objects corresponding to outdated products (e.g. CDs, first and second generation mobile phones, old photovoltaics)
b. new products and composite materials that will become waste streams sooner or later like the coffee capsules, new gadgets, wearables, nanomaterials etc. Our waste management systems are not prepared to handle them, especially considering that a lot of them are not designed to be recyclable or modular or repairable or reusable. On the other side, most of those products include valuable resources that can justify proper resource recovery activities.

A serious increase is expected in the amount, the diversity and the complexity of the e-waste stream. The experiences of the efforts in place to manage e-waste are representative of the timescale required, the difficulties and the efforts involved to identify solutions for such complex waste streams.

ISWA calls for a shift towards eco and modular design that will stimulate circularities and it is ready to be involved in a constructive dialogue with the designers and manufacturers. ISWA also calls for the global application of Extended Producer Responsibility schemes on the most important e-waste components and warns that every delay to advance to circular practices in manufacturing will result in:

- Serious environmental and health impacts, and
- Losing substantial and/or vital resources

> Global number of Connected Devices: **17** billion
>
> The number of connected devices that are in use worldwide now exceeds 17 billion, with the number of IoT devices at 7 billion (that number does not include smartphones, tablets, laptops or fixed line phones).

The number of IoT devices that are active is expected to grow to

10 billion by **2020**

22 billion by **2025**

Global IoT Market: $151 Billion market in 2018, forecasted to grow to

$1,567 billion by **2025**

CASE STUDY SOLUTIONS FOR E-WASTE

ROBOTIC DISASSEMBLY OF MOBILE PHONES

Apple has developed Daisy, a robot that can more efficiently disassemble iPhones to recover valuable materials. Created through years of R&D, Daisy incorporates revolutionary technology based on Apple's learnings from Liam, its first disassembly robot launched in 2016.

Daisy is made from some of Liam's parts and is capable of disassembling fifteen versions of iPhone and sorting their high-quality components for recycling. Daisy can take apart up to 200 iPhone devices per hour or roughly 1.2 million iPhones per year, removing and sorting components and recovering different high quality materials that traditional recyclers can't.

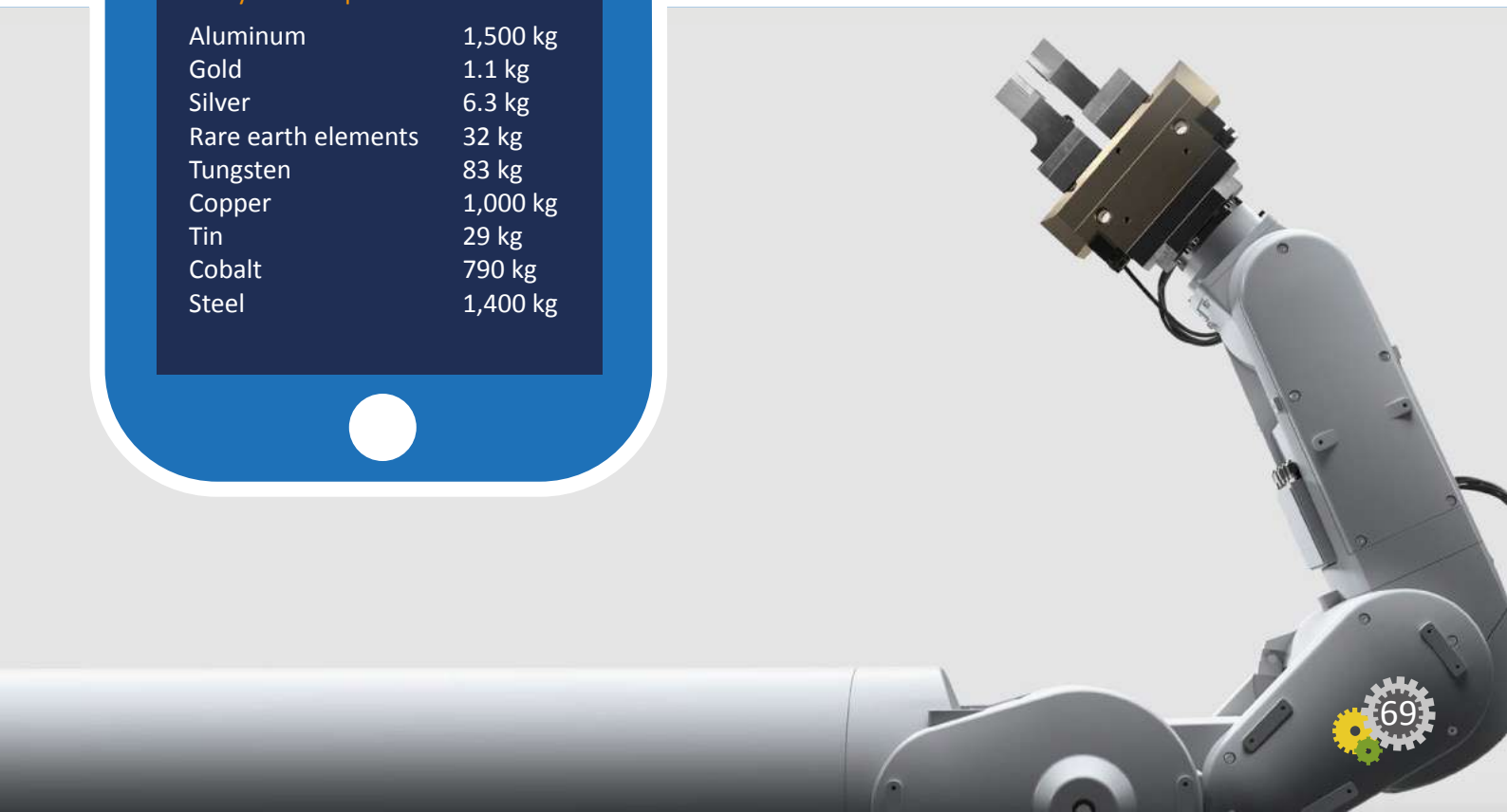
Two of these robots are already operational contributing to the utilization of 7.8 million of Apple's devices in 2018. According the company this has brought a serious change in the supply chain of materials because for the first time in 2018, materials recovered by Daisy are making their way into new Apple products this year.

For example, aluminum the robot extracts from an older iPhone is being reused in new Macbook Air laptops, and cobalt recovered from iPhone's battery is used to make brand-new batteries.

For every 100,000 iPhone devices, Daisy has the potential to recover:

Aluminum	1,500 kg
Gold	1.1 kg
Silver	6.3 kg
Rare earth elements	32 kg
Tungsten	83 kg
Copper	1,000 kg
Tin	29 kg
Cobalt	790 kg
Steel	1,400 kg

Based on those advanced recycling capability of robots, the company has developed the program Apple Trade In that allows users of iPhones to exchange their old device for credit so that it can be reused by a new owner. If it isn't eligible for credit, it goes for recycling. More than two-thirds of all devices returned through Apple Trade In are passed on to new owners.



CASE STUDY SOLUTIONS FOR E-WASTE

ARTIFICIAL INTELLIGENCE FOR SORTING BATTERIES

The OBS 500 is an automatic sorter for waste portable batteries. The system is a complete identification and sorting system for all cylindrical and 9V batteries with a total capacity of more than 500 kg per hour. The machine sorts consumer waste batteries of sizes AAA, AA, C, D and 9V into 5 main chemistries: Alkaline, Zinc-Carbon, Nickel Metal Hydride, Nickel-Cadmium and Primary Lithium. The purity rate in the fractions is at least 97%, and usually above 99% in the Alkaline fraction.

The system enables collectors and recyclers to efficiently sort mixed streams of batteries into separate material fractions with minimal labour and expertise required.

The machine uses computer vision and machine learning/artificial intelligence algorithms that allows for high speed, precision and cost-efficiency. The digital solution allows the machine to present data about its operations (throughput, uptime) and its sorting statistics (brand, chemistries, sizes).

Refind Technologies is the Swedish company behind the innovation. The first version of the machine was installed at G&P Batteries in Walsall, UK, in 2012, and has sorted approximately 15 000 tonnes since then. The latest installation was in Melbourne, Australia.

Artificial Intelligence in Resource Recovery
By Johanna Reimers, CEO Refind Technologies

AI is useful when it comes to handling and analysing large amounts of data, and should preferably be used to automate manual tasks that are dangerous or difficult. In combination with more and more advanced material based sensors and robotics, it will be possible to automate more and more areas in the society, not only within resource recovery.

We were the first to use AI for battery sorting, and possibly also the first ones for fish sorting, and have learnt a lot by experience. Our main challenge so far has always been the actual physical handling of objects – how to act as fast as the mind thinks, or how to move things as fast as the software works. This is usually the case for humans too.

CHAPTER 7

THE NEW ROLE OF LABOUR

Several studies estimate huge job losses due to the on-going automation wave.
A recent report by the World Economic Forum suggested that while robots will displace 75 million jobs globally in the next 10 years, 133 million new jobs could be created because of automation. Similarly, the McKinsey Global Institute reckons that although between 400 and 800 million jobs are at risk, advances in AI and automation could transform our working lives, creating new roles and freeing people up to fill them.

It is clear that in waste treatment facilities and in landfills, and probably to a lesser extent in waste collection, the rise of robots will alter fundamentally the role of the labor. However, there is a need for a closer examination of what the expected changes will be. Although this goes beyond the scope of this report, some remarks will help the reader to think the perspectives in a broader way.

Based on the experiences gained from the existing robotic recycling advances, it is obvious that we are heading towards a reduced reliance on manual sorters. However, due to the complexity of the waste streams, the main trend is to increase the working distance between the actual handling of materials and human beings and reduce the relevant occupational health and safety problems. Thus, it's not that treatment facilities and MRFs will run without workers but that workers will have to work in close cooperation with intelligent robots that will do all the dirty job. Similar conclusions can be made for the waste collection crew and the landfill workers. So, dirty – dangerous – difficult jobs are in high risk – but this is not necessarily a real problem, at least as alternative employment is created in other economic sectors.

Overall, someone can categorize the expected changes in employment related to the following three waves:

- Algorithm wave: focused on automation of simple computational tasks and analysis of structured data in areas like finance, information and communications – this is already well underway in consulting firms and administrative structures related to waste management.
- Augmentation wave: focused on automation of repeatable tasks through dynamic technological support, and statistical analysis of unstructured data in semi-controlled environments such as aerial drones for landfills and robots in MRFs – this is also underway, but is likely to come to full maturity after the 2025.
- Autonomy wave: focused on automation of physical labour and manual dexterity, and problem solving in dynamic real-world situations that require responsive actions, such as in manufacturing and transport (e.g. driverless waste collection vehicles) – these technologies are under development already, but may only come to full maturity on an economy-wide scale in the 2030s.

Finally, it must be clear that the introduction of robots creates also serious changes to the working relationships. A recent study by the US National Bureau of Economic Research found that each new robot added to the workforce meant the loss of between 3 and 5.6 jobs in the local commuting area. Meanwhile, for each new robot added per 1,000 workers, wages in the surrounding area would fall between 0.25 and 0.5 percent. It's also important to remember that these job and wage losses are not distributed evenly among the population. Some jobs are — expectedly — more fragile than others. According the authors: "Predictably, the major categories experiencing substantial declines are routine manual occupations, blue-collar workers, operators and assembly workers, and machinists and transport workers." The only jobs not affected were managerial ones.

DRIVERLESS SWEEPERS IN SHANGHAI

On April 2018, a fleet of driverless sweeper trucks has been put on a trial run at an industrial park in Shanghai.

Designed and developed by Shanghai-based firm Autowise.ai, the fleet – it comprises 6-meter-long and 3-meter-long vehicles – was tested at the Tus-Caohejing Science Park in Shanghai.

The unmanned vehicles self-activate every night at 2 am to clean the roads before dumping the waste and returning to the parking space.

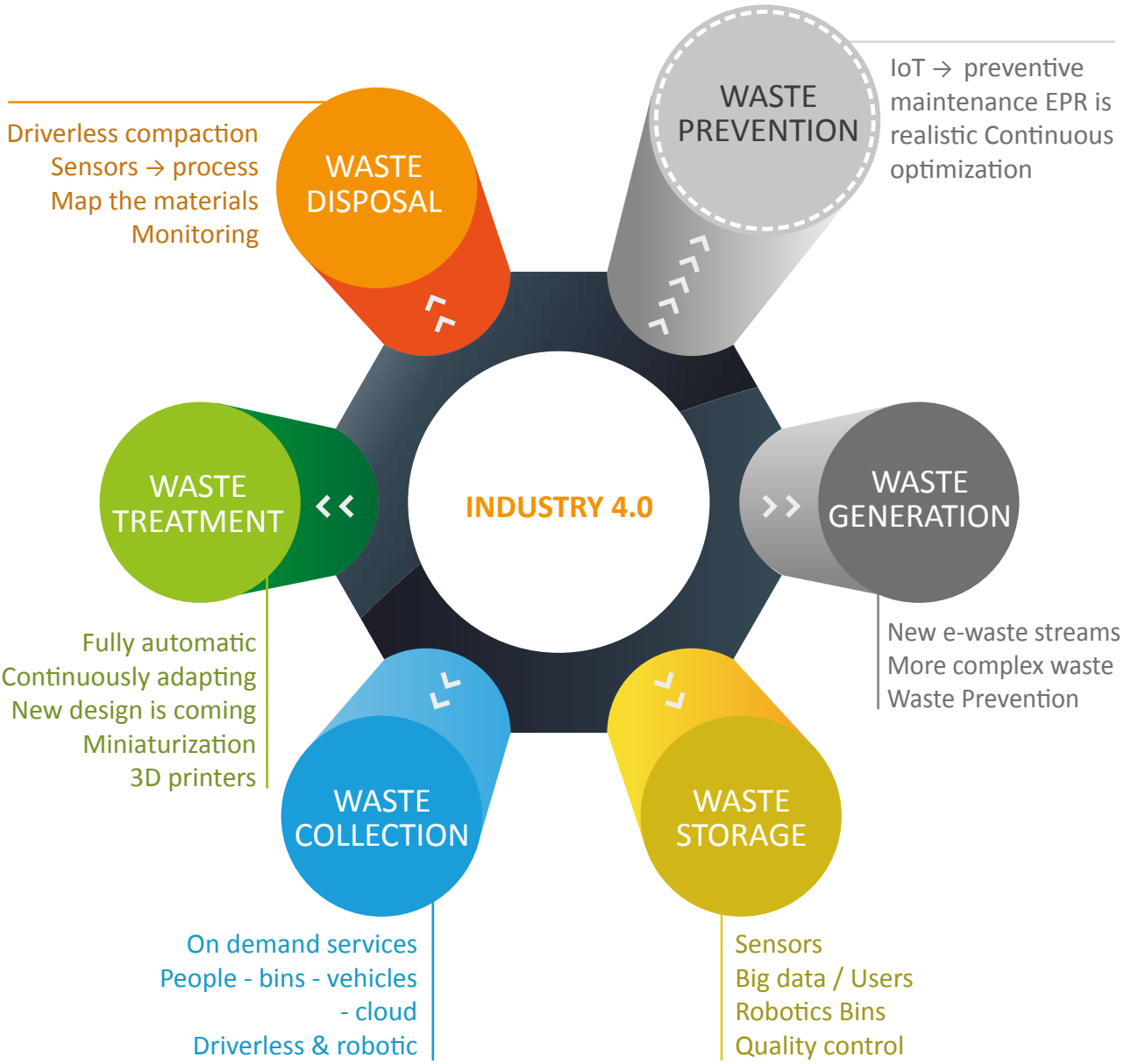
The cleaning trucks, which can detect traffic lights, roadside barriers and deal with other traffic conditions, are operating at a reduced speed and only within the designated region during the test period.
According to the company, the fleet can be easily mass produced as the hi-tech sensors used cost just 300,000 yuan ($47,500).

Driverless technology has huge potential in the street cleaning business because they would be able to perform under the same conditions as conventional sweeper trucks currently do – on fixed routes and in the hours of the morning when traffic is low.

CHAPTER 8

VISUALISING THE TRANSFORMATION OF SWM

Waste Management stages and the impact of IND 4.0

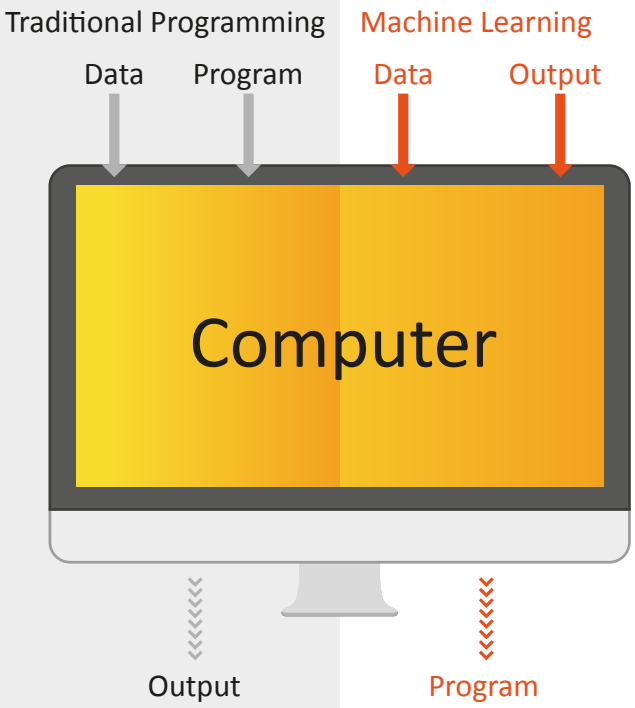


OPINION

IND 4.0: TWO DISRUPTIVE POSSIBILITIES

Societies are defined by how they generate and manage waste. A society defined by Industry 4.0, could be the critical step towards eliminating the very concept of 'waste'. Two key dirsutpive possibilities stand out: First, artificial intelligence (AI) will enable us to locate, transport and sort post-consumer items in unprecedented ways at scale and to fine resolution. Combined with digital passports of materials, we will be able to win the fight against uncontrolled variability of material flows and accurately quantify their potential to pollute - the main underpinning reasons for after-use items becoming 'waste'. Automated logistics of movement, augmented reality for human-items interaction and robotic sensor-based sorting means that after hundreds of years of lagging behind, the secondary resources sector will be elevated on a par with the other facets of manufacturing, in huge leap forward. Second, advanced and real time data analytics (AI algorithms for big data) will allow us to develop genuine novel and important insights on how societies and the World manages post-use items/ materials, knowledge which will feed back in institutions and policies, such as those for global bentchmarking (e.g. SDGs targets). Get ready for a genuine revolution in our sector and well beyond!

Dr Costas Velis,Lecturer in Resource Efficiency Systems - University of Leeds
ISWA Marine Litter Task Force Leader



IND 4.0 and the shifts on the the hardware and software of waste management

Sound & Proactive Policies

The digitalization of the SWM services provides a real-time monitoring of their performance and efficiency, allowing improved and on-time decision making and preventive measures. Benchmarking will become easier and a key-tool that will drive policy shifts.

Inclusivity

Public consultation and participation in key-decisions is becoming easier through the use of specially designed platforms and mobile apps. Transparency in decision-making is advanced through digital governance patterns.

Financial

The digitalization of the SWM services provides better accountability, advanced monitoring of the financial flows and cost optimization opportunities. PAYT systems and performance based charges are becoming easier to apply, allowing new business models to emerge.

Software of SWM

Hardware of SWM

Public Health

IND 4.0 redefines the business models in waste collection and recycling and allows the rise of on-demand services. Big data systems open new horizons for the users and providers management

Environmental protection

IoT and robotics drive the redesign of the waste treatment facilities. Soon, they will allow their rapid optimization and adaptation to changing waste quantities and composition. Drones and AUVs are already used for landfill management. The miniaturization of some treatment units is expected, allowing a more decentralized SWM.

Resource recovery

The rise of big data systems creates new opportunities to simulate and customize recycling programs according the users' behaviors. The IoT makes possible the preventive maintenance, the life cycle extension and the application of EPR to a wide range of equipment and machinery.

OPINION

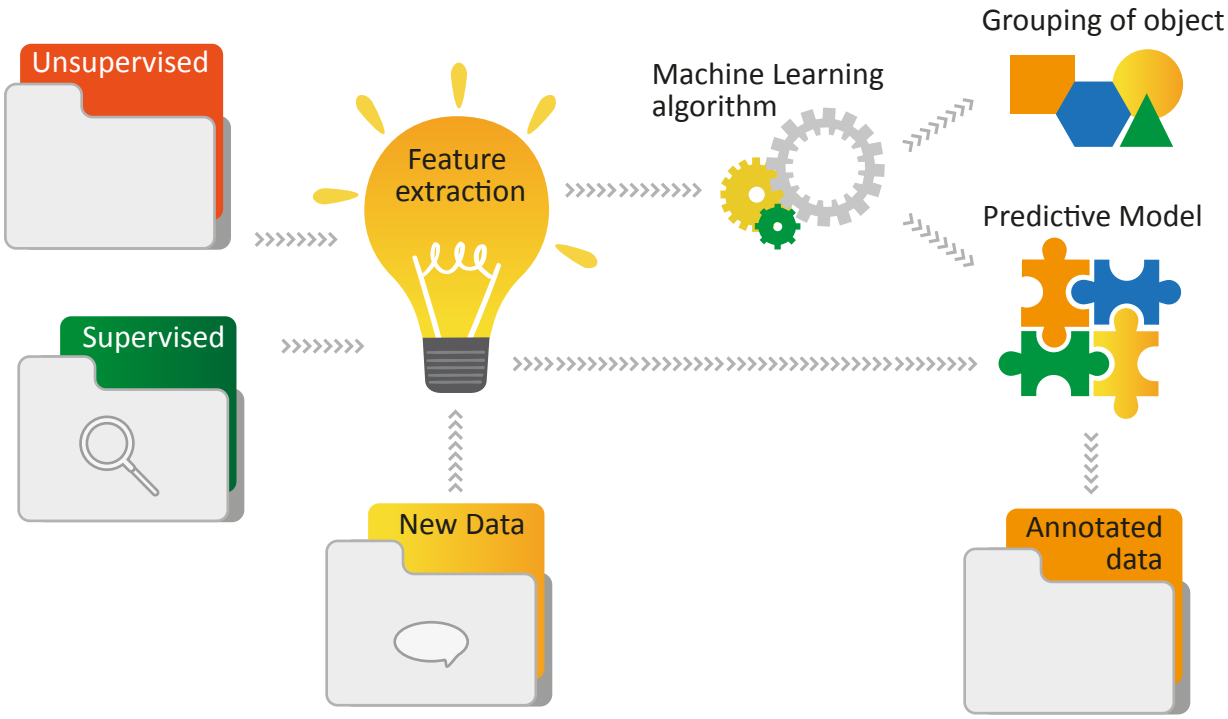
IND 4.0 SHOULD INTEGRATE SUSTAINABILITY

The fourth industrial revolution will induce large shifts in the waste and resource management sector. Sensor-based technologies and the use of mobile platforms for ordering will change the nature of the services we provide, and big data and artificial intelligence will change the way we run our operations. When it comes to recycling and reuse, robotics and machine learning together with NIR-scanners and picture recognition technologies will significantly enhance our ability to recover materials and reuse products.

The fourth industrial revolution brings a paradigm shift affecting all aspects of society. Advances in biotechnology, artificial intelligence and automation brought together through extensive interconnectivity will change the way we live, learn, produce and consume. Our sector must keep up with pace in material and product development, ensuring that we can handle end-of-life materials and products in an environmentally-friendly and resource-efficient way. But that alone is not enough. If not sustainable, the fourth industrial revolution may induce environmental destruction at an even higher pace than today. To make sure that it does not happen calls for wise management and regulation, ensuring that all aspects of sustainability and the concept of circular economy are integrated into the concept of the fourth industrial revolution.

Björn Appelqvist, RAMBOLL Department Manager-ISWA STC Chair

Machine learning workflow



CHAPTER 9

TOWARDS A NEW SCIENTIFIC PARADIGM?

Data are the very lifeblood of science, technology, and engineering, and in more recent years have begun to play an increasingly central role in economics, finance, politics, and business.

The extensive use of mobile phones and the emergence of the IoT provide oceans of data regarding the daily habits and the environmental footprint of billions of people around the world. IND 4.0 and especially Artificial Intelligence is critical not just in assembling and gathering data, but in analyzing and organizing the massive amounts being generated into a manageable form from which insights can be gained, regularities deduced, or predictions made and verified. With big data systems and proper tools, those oceans of data provide very meaningful, temporally and spatially detailed information regarding the patterns of the collective behavior of humans. Thus, for the first time in human history, urban systems can be described and quantified in a level of detail and accuracy that was never possible before the adaption of mobile phones as a key element of our lives and the rise of IoT.

Using big data systems, we can also manage energy, water, waste and other environmental information in a single system and analyze their interconnections with population movements and habits, with income and education, with transportation systems, residential types, commercial activities etc.

This opens the way for new scientific approaches and theories capable to describe, model and forecast the complex behavior of urban areas based on real information. Thus, it is the first time that we can face the possibility to advance a new scientific discipline, the one that will describe urban behavior and sustainability in a holistic, systemic and systematic way rather than today's fractured approaches, narratives and metrics.

CHAPTER 10

WASTELESS OR WASTEFUL?

In all the industrial revolutions till today, humans were capable of increasing their productivity and efficiency, to produce more with less resources, more energy efficiency and cost effectiveness. In each industrial revolution, humans had the opportunity to rebalance their relationship with nature and ecosystems, to sustain better lives with less effort due to the productivity gains of the industrial revolutions.

However, the serious productivity gains were counterbalanced by the continuous increase of the population, the prolonged life expectancy and the serious increase of the average consumption rates. The result was that the industrial revolutions, the ones that were responsible for all the positive transformation of human lives from the medieval misery to the modern world, were also stimulating and accelerating resource depletion and pollution.

For the last 500 – 600 years, continuous economic and population growth seemed to be negligible on a planetary level, the Earth and its ecosystems seemed to be too big to be affected. Economic growth fueled by the industrial revolutions seemed to be the only way towards prosperity.

Today, we know well that the dominant paradigm of economic growth brings planetary level pollution and environmental problems that threat the very existence of the modern way of life. A recent study assessed that one (1) million people die every year due to health problems created by pollution created by uncontrolled waste disposal practices. Air pollution is responsible for eight (8) million premature deaths annually .

We are also aware that there are nine planetary boundaries, like the concentration of CO2 in our atmosphere, that should not be overpassed because the consequences will be lethal and uncontrolled, as in the case of Global Warming. There is evidence that for two of them (biochemical flows and biosphere integrity) we are already in a high-risk zone and that for another two (climate change and land-system change) we are getting towards the high-risk zone.

The world population is projected to reach 9.8 billion in 2050, and 11.2 billion in 2100. Today, 55% of the world's population lives in urban areas, a proportion that is expected to increase to 68% by 2050. Projections show that urbanization, the gradual shift in residence of the human population from rural to urban areas, combined with the overall growth of the world's population could add another 2.5 billion people to urban areas by 2050, with close to 90% of this increase taking place in Asia and Africa .

Extraction of material resources – biomass, fossil fuels and non-metallic minerals – from the Earth could reach 88.6 billion tonnes in 2017, or three times that used in 1970, according to estimates from the International Resource Panel . Global material resource use is likely to more than double by 2050 on current trends.

About
50 million
tonnes of e-waste

=

USD
62.5 billion
lost annually

Source

The Global E-waste Monitor 2017 Quantities, Flows, and Resources
www.ewastemonitor.info

It has therefore become clear that the on-going industrial revolution will not be like the previous ones. If IND 4.0 will, as the previous ones, accelerate resource depletion and pollution, the consequences will be astonishing for the human civilization and the only way to counterbalance them will be either a serious decrease of the population or of the living standards worldwide.

IND 4.0 brings unimaginable opportunities for energy and resource efficiency. It brings technological advances that can deliver prosperity, better living conditions and a more sustainable world for everyone on this planet.

For the waste management sector, IND 4.0 makes the potential of a Wasteless Future more realistic than ever. As it was explained already, IND 4.0 opens new ways to prevent, reduce and even eliminate waste from specific sectors and streams, to advance resource recovery, to achieve high standards of treatment and disposal, to substantially reduce pollution and environmental impacts. At the same time, it provides new tools to stimulate stakeholders' interaction, awareness and citizens' participation, to apply the "polluter pays" and the "extended producer responsibility" principle on a global scale, to make the governance of cities (including waste management) more inclusive and participatory, and to reduce or eliminate "dirty – dangerous – difficult" jobs and improve occupational safety and working conditions.

However, all those new opportunities should be faced more as a potential and less a realistic expectation, and this is because IND 4.0 also creates substantial risks and challenges.

The same advances that open the way towards a more sustainable and circular economic system can be easily turned to drivers for further resource depletion, pollution and a more Wasteful future, as it has already happened in previous industrial revolutions. Some examples are very illustrative of the other side of IND 4.0.

Take the example of energy consumption. Although the IT industry has long argued that it can considerably reduce carbon emissions by increasing efficiency and reducing waste, academics forecast that information and communications technology could create up to 3.5% of global emissions by 2020 – surpassing aviation and shipping – and up to 14% 2040, around the same proportion as the US today. The communications industry could use 20% of all the world's electricity by 2025, hampering attempts to meet climate change targets and straining grids as demand by power-hungry server farms storing digital data from billions of smartphones, tablets and internet-connected devices grows exponentially.

As things are going on today, without strong links and interaction between product designers and the waste management sector, the expected plethora of new products, constructed from new, innovative composite materials would easily become a tsunami of end-of-life objects without possibilities for developing circular loops, modularity, reuse and recyclability. We have seen this already with e-waste. It took almost 20 years to understand their importance and develop proper policy responses and methodologies to manage the problem. Still, out of the 50 million tonnes of e-waste that are generated annually, 76% is dumped or not properly recycled. The losses in terms of valuable resources are USD 62.5 billion per year[11].

If robotics will become mainstream in waste collection, treatment and disposal, then we need to question their broader impact. On the one side, they will probably make the operations easier, more accurate and efficient, but on the other side they will have a serious drawback. They would easily deliver the wrong message that with robots doing the jobs, citizens don't have to think a lot about waste prevention, resource recovery and recycling. This would increase the misleading perception "out of sight – out of mind" and make the active involvement and participation of citizens more problematic than it is today.

Robots and 3D printers create another question: what will be their fate after their end-of-life? Are they going to be under EPR systems that will undertake the responsibility to manage them, recovering as much valuable materials as possible and taking care of the required treatment and disposal in an environmentally safe way? Or they will be left as high-tech scrap and they will feed a new robotic (but still) waste stream?

On another level, we should ask also the question "Robots for What" ? Robots will determine the future of manufacturing and waste management according the problems we will ask them to resolve. If we ask them to support circular economy, reuse, waste prevention, repair and modular — eco design, they will do it. If we ask them to support the business as usual approaches and the current fast production — fast consumption linear economy, they will do it and a much more wasteful world will be created, while the speed of resource depletion will be higher due to the advanced productivity of robots.

Material passports are necessary to advance circular business models – but they involve also the risk that their control (so the valuable materials' control as well) can be easily monopolized and manipulated by the software owners or developers or simply by the platform managers that would issue the material passports.

There is also the issue of the expected inequality related to the fourth industrial revolution. Concurrent to the digital revolution, there is a set of socio-economic, demographic, financial drivers of change which is reinforcing one another and leading to consequences as:

- decrease in the number of highly repetitive low-skill jobs and routine medium-skill job. In this context, artificial intelligence will initially affect clerical work, sales, customer services. The World Bank estimates that increasing automation will put 57% of the jobs in the 35 countries in OECD at risk, including 47% of US jobs and 77% of the jobs in China;
- efficiency improvement of existing jobs and increase in demand for customized human work;
- go up the magnitude and probability of risks related to cybersecurity;
- raise income inequality – the return to skills is likely to benefit those who are rich and lower-paid workers suffer from income underperformance.

The problem of inequality is also reflected in the risk of an increasing digital gap between the developed and the developing world. In 2019, the World Economic Forum (WEF) released its first 'Readiness for the Future of Production Report', assessing how well-positioned global economies are to shape and benefit from changes in production being driven by the Fourth Industrial Revolution. The report finds that global transformation of production systems will be a challenge, and the future of production could become increasingly polarised in a two-speed world. Of the 100 countries and economies included in the assessment, only 25 countries from Europe, North America and East Asia are Leading countries, or in the best position to benefit from the changing nature of production. These 25 countries already account for over 75% of global Manufacturing Value Added (MVA) and are well positioned to increase their share in the future.

So, while the Fourth Industrial Revolution is enabling extraordinary levels of innovation and knowledge, it is also contributing to a widening inequality gap. In the recent discussions of the World Economic Forum in Davos, on February 2019, tech and political leaders sounded the alarm bell today about the potential for IND 4.0 and artificial intelligence to exacerbate huge inequalities across the world and worsen the economic, racial, gender and environmental inequalities. There is a clear risk for a new high-tech divide between those who will have access to the advances of IND 4.0 and artificial intelligence and those who will not.

Closing that divide requires us to recognise that we are living in a new type of innovation-driven economy, and that new global norms, standards, policies and conventions are needed to safeguard the public trust. The new economy has already disrupted and recombined countless industries, and dislocated millions of workers. It is also fueling distrust, particularly of technology companies and their stewardship of our data.

CHAPTER 11

AN URGENT NEED FOR NEW GOVERNANCE PATTERNS

IND 4.0 makes realistic a huge step towards a better, more prosperous and sustainable planet. But, as things are going on right now, it stimulates a new high-tech gap between the developing and the developed world and a widening inequality.

For the waste management sector, IND 4.0 brings the potential for a Wasteless future and the advancement of Circular Economy. It can also easily turn to accelerate resource depletion and pollution, creating a more Wasteful Future.

Although it's difficult to predict how IND 4.0 will finally influence the planet, it seems that it is progressing at a faster and more aggressive pace than any of the prior three revolutions. Certainly, it runs much faster than our governance structures and patterns can adapt.

We are uncertain of many things regarding IND 4.0 but we can be certain that governance is the key to unlock the benefits and restrict the problems. New principles, protocols, rules and policies are needed to accelerate the positive and inclusive impacts of these technologies, while minimizing or eliminating their negative consequences. The institutions that have traditionally had the responsibility of shaping the societal impacts of these technologies – including governments, companies and civil society organizations – are struggling to keep up with the rapid change and exponential impact.

Klaus Schwab, the founder and executive chairman of the World Economic Forum, rightly points out that "…the challenges associated with the "fourth industrial revolution" are coinciding with the rapid emergence of ecological constraints, the advent of an increasingly multipolar international order, and rising inequality. These integrated developments are ushering in a new era of globalization. Whether it will improve the human condition will depend on whether corporate, local, national and international governance can adapt in time." IND 4.0 makes necessary a revolution in governance in all the levels involved : international cooperation, national, regional, municipal and corporate. There is an urgent need for a more agile approach to governing emerging technologies and the business models and social interaction structures they enable. The complex, transformative and distributed nature of IND 4.0 demands a new type of governance to address the interlinked dynamics of the pace and synergistic nature of emerging technologies; the transnational impact of technologies and broader societal implications; and the political nature of technologies.

The dynamics of IND 4.0, and the fact that the myriad of challenges facing humanity cannot be solved by any single sector alone, suggests that governance must become a multi-stakeholder endeavour. This shift in governance is also occurring because governments and policy-makers are finding themselves increasingly constrained to just being reactive to the speed of technological innovation. This creates a new role for the private sector and academia working alongside public officials to provide expertise on the technologies they are developing, their applications and potential consequences.

ISWA COMMITMENTS

As we use to say in ISWA, solid waste management is about people – not waste. The same is true for IND4.0, it's about people and their lives not about technologies. IND 4.0 will only be successful if we will be able to reimagine policy-making to ensure that citizens, companies and governments are all capable of:

- Understanding and using advanced technologies;
- Being able to develop policies through a collaborative process; and
- Driving the IND 4.0 advances towards a better, more equal and sustainable world.

ISWA is committed to play its own unique role on this task. ISWA is committed:

- To follow up, monitor closely and evaluate the advances of IND 4.0 in the waste management industry.
- To work together with governments, regional authorities, municipalities and the private sector to ensure that the advances of IND4.0 will be utilised towards a Wasteless Future and that they will stimulate circular loops and business models.
- To work closely with all the relevant stakeholders to develop proper governance models and patterns in accordance with the governance shift required to utilise IND 4.0.
- To provide technical support, capacity building and roadmaps that will allow the adoption and adaptation of the IND 4.0 developments to both the developed and the developing world.
- To contribute with proper policy suggestions and interventions in global fora towards a transformation of the waste management sector by IND 4.0 that will not create additional inequalities and a widening technological gap.

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HOW INDUSTRY 4.0 TRANSFORMS THE WASTE SECTOR

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HOW INDUSTRY 4.0 TRANSFORMS THE WASTE SECTOR

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