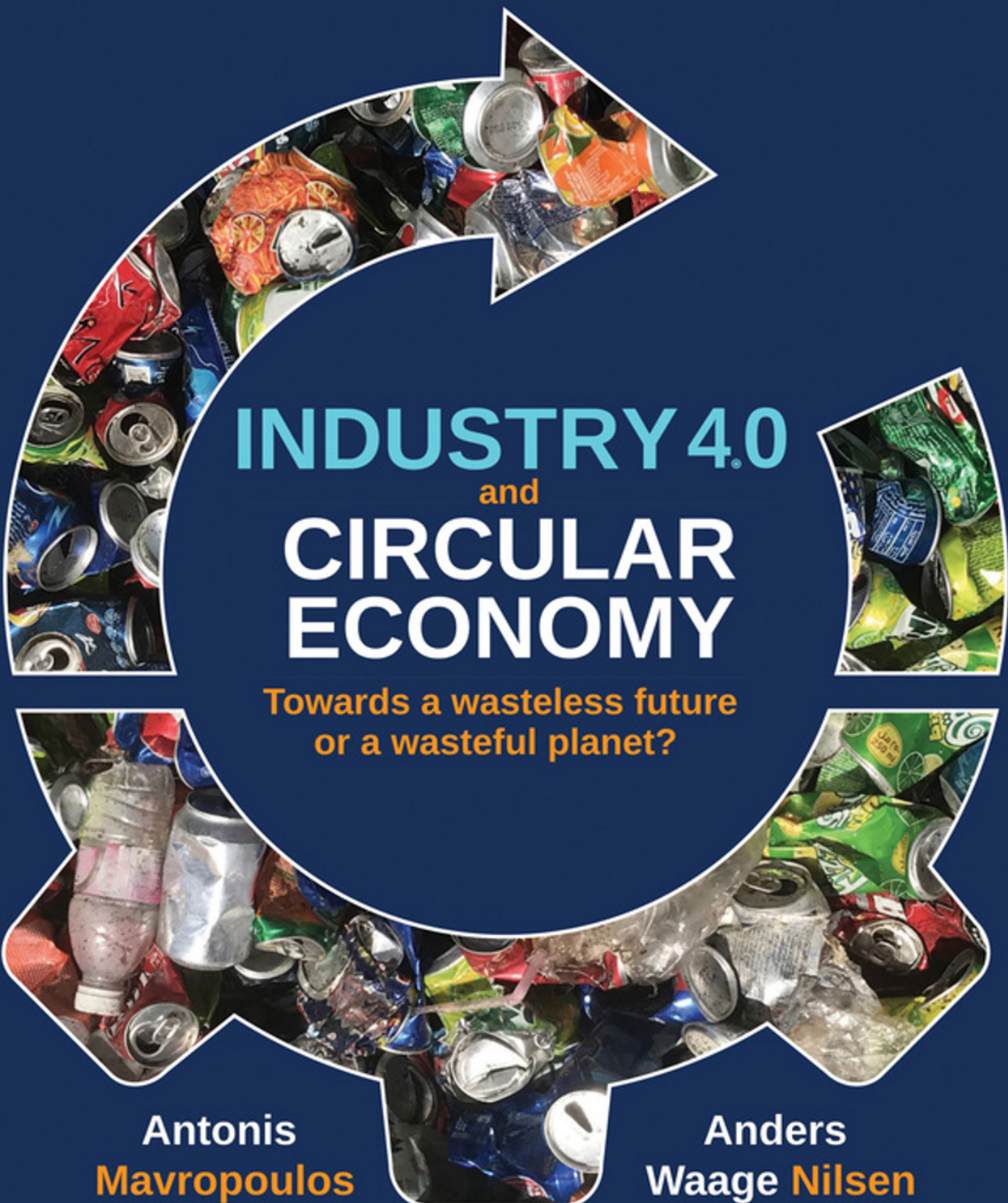




INDUSTRY 4.0 and CIRCULAR ECONOMY

Towards a wasteless future
or a wasteful planet?

Antonis
Mavropoulos

Anders
Waage Nilsen

INDUSTRY 4.0 AND
**CIRCULAR
ECONOMY**

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or a Wasteful Planet?*

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International Solid Waste Association

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Foreword by Ad Lansink

TOWARDS SOCIAL CIRCULARITY

Is it really a hard choice between a wasteless future and a wasteful planet? The question mark behind the subtitle of *Industry 4.0 and Circular Economy*, the comprehensive and fascinating book of Antonis Mavropoulos and Anders Waage Nilsen, shows that a straightforward answer is difficult. The same is valid for defining circular economy. The question mark gives room for further consideration, looking for a sustainable road to circularity, at the same time addressing the issues of global warming, resources scarcity, and biodiversity losses. The large economic differences between rich and poor countries also require a consistent policy. Until 2020, globalization was a main topic for economy and, often as a counterpart, ecology. Trade and transport became issues for politicians and policy makers, developing treaties to defuse tensions and barriers. Since the international community is going through turbulent times by the outbreak of Covid-19 and the grim fight against this pandemic, a social and even cultural component must be added to the paradigm of globalization. 2020 will be referred as a historical year, because of the long-term impact of the Covid-19 pandemic. The consequences for the international community will outweigh the effects of previous crises. Therefore, combined efforts on climate policy, circularity, and disease control require a worldwide basis of public support, governance, leadership, and cooperation. Spreading knowledge is as important as sharing responsibilities, both in the field of fundamental research, applied sciences, and practical innovation. International cooperation will be stimulated by new technologies, especially in the implementation of digitalization, networking, and tools such as blockchain technology, artificial intelligence, and worldwide communication channels, presenting society a sustainable future. But social aspects such as solidarity, social justice, and human rights are even essential. Inclusive system thinking seems the right way to defeat all challenges.

Talking about challenges: about four decades ago, concerns about scarcity of raw materials and fossil energy besides increasing waste streams brought me to the idea of the waste hierarchy. The original proposal contained five steps: prevention, source separation, post-separation, incineration with energy recovery, and functional landfilling. During legislation, source and post-separation were replaced by product and material reuse. Recycling does not occur in the preference order but is merely a means of facilitating material reuse. So waste hierarchy and circular economy are greater than recycling. Nowadays, the waste hierarchy is a universal model, an essential route map to circularity,

otherwise respecting thermodynamic laws. Progress in effective waste management, especially waste prevention and product reuse requires “rethinking” society as a whole: a tough task due to the habituation to prosperity and freedom of choice. Therefore, action is needed. Abandoning unnecessary items and services should be a key priority. However, that’s a difficult task in a market-driven society. Extending the lifespan of products and (weight) savings of materials are easier to achieve, as is eco-design with a focus on quantitative prevention, optimal reuse, and high-quality recycling. All transitions require a solid basis of support in society. Communication remains an indispensable instrument for increasing environmental awareness, against vested interests and opportunistic media violence. The return of a strong environmental awareness is necessary to maintain and strengthen public and political support for the transition to a circular economy.

After all, chain management implies a revolution of thinking and doing in services and industry. History learned us that water and steam power founded the first industrial revolution. Thereafter, electrical power facilitated by fossil energy allowed mass production of goods during the second one. Meanwhile, the transition to sustainable energy, forced by active climate policy, requires attention for eco-design of materials and products, with large lifetime and reuse possibilities. Meanwhile, automation and digitalization founded the third industrial revolution. The fourth version is no simple continuation of the third one. Characteristic 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. But a real disruption is not necessary and even impossible due to the large international differences. However, population growth and depletion of raw materials require a clear circular approach, changing the chain of production, distribution, and consumption of the well-known waste hierarchy to a new resource hierarchy. Of course, governments need to set clear goals and ensure transparent and enforceable legislation, if needed with applicable financial instruments. Meanwhile, Industry 4.0 must facilitate major changes in commodity policy, waste management, resource policy, and value creation. These changes are influenced by three principal context factors: time, place, and function. In other words, the speed of the transition is partly defined by the geographical location and function of the product and material flows.

At the end of their interesting and important book, the authors of Industry 4.0 and Circular Economy ask another black-white question: will Industry 4.0 be “a stairway to heaven or a highway to hell”? Hopefully by then, the reader will have already found a series of answers: useful guides on the successful road to circular economy, paved with indispensable building blocks of social justice, employment, selective growth, environmental awareness, and real governance: international, national, and local.

Dr. Ad Lansink

Founder of the waste hierarchy

Author of the book *Challenging Changes – Connecting
Waste Hierarchy and Circular Economy*

Former Member of Parliament, the Netherlands

Foreword

by Dimitris Kaliampakos

SEARCHING FOR REAL “OUT OF THE BOX” ANSWERS TO PRESSING QUESTIONS ABOUT WASTE AND CIRCULAR ECONOMY

Currently, I am lucky (or maybe unlucky) to wear two hats. I am the dean of the School of Mining and Metallurgical Engineering at the National Technical University of Athens. I am also the President of the Associated research Centers for the Urban Underground Space (ACUUS), a pioneer international organization that promotes the systematic utilization of the underground space of cities. While reading the fascinating book of Antonis Mavropoulos and Anders Waage Nilsen, I witnessed the continuous confrontation of two schools of thought, a fact that, among other things, comprises an interesting personal experiment.

What is, therefore, the response of a mining engineer to the intriguing questions posed throughout the book? It is widely known that mining is one of the most unwanted activities at a local level (local unacceptable land uses). Perhaps, not unjustly. For many years, the mining sector, being the visible backbone of at least the first and the second industrial revolution, entrenched itself, with a pinch of arrogance, behind the proverb “you can’t make an omelet without breaking eggs.” The problem is that during this time, when we falsely believed that the “eggs” were unlimited, we were breaking more eggs than necessary for the “omelet,” making a mess of our “home” (our planet) at the same time. These times have irrevocably passed. Today, the prevailing thinking of the public is to reduce mining activity. In addition, one point of view considers mining no longer necessary, since circular economy is able to essentially marginalize it. Even more so if it is combined, as we should do, with a reasonable constrain to the rampant consumerism, a disease that developed world suffers from. But, let me say, this is a false view. Not only it is not based on actual proof (Industry 4.0 is thirsty for more quantities and increasingly more rare raw materials), but it is also socially unfair, if not half blind, seen from the developed world’s perspective. Have we considered how huge quantities of raw materials are required to satisfy the basic needs

of the 2.2 billion people of this planet that do not have access to safe-drinking water and the 4.2 billion of those who lack safe sanitation services?

What are the limits of circular economy? How feasible is a goal, e.g. for a zero waste future? Does it reflect modern and real technological capabilities or is it another arrogant statement of intent, without a real meaning? If we consider the second thermodynamic law, any energy transformation for a pursued purpose is accompanied by a loss of energy. In my opinion, the most general term of waste is exactly this loss of energy. Even if we exploit this loss of energy, the “waste,” in another process, there will be a new loss of energy and so on. This does not mean that the core idea of circular economy is wrong. We are living in a world of finite resources, which in many ways is reaching its limits. However, the clarity of goals is the first factor in achieving them.

Wearing my other hat this time, I had the opportunity to reflect on some of the critical observations made in the book. One of them is the rebound effect. An iconic example of our emerging era is e-commerce. Indeed, the modern consumer can buy almost everything from home and also benefit from the reduced prices that cost savings entails. In practice, however, this has led to a rapid increase in consumption and thus a linear increase in the relating environmental impacts. It is very interesting to analyze the impact of e-commerce on the everyday life of cities and especially the megacities. While one would expect an improvement in the environmental conditions due to reductions in unnecessary commuting, the situation is very different. Take China, for example. China’s online retail market is set to hit US \$1.99 trillion by the end of 2019. How does this translate in terms of waste and the environment? Delivery packaging is accounting for 93% of solid waste growth in China’s megacities. Moreover, delivery trucks (~10% of all automotive in China) are contributing to more than 75% of harmful particulate matter released into the atmosphere. Last mile deliveries have a significant impact, unconceivable just a few years ago. The scientific community that I work with is systematically working towards underground, automatic transportation of goods to cities using many of the technologies of Industry 4.0 (e.g. big data analysis). Then again, only a “paradigm shift,” as is often referred to in the book, can protect us from a second rebound effect.

Our planet will be more urbanized than ever. The megacities, 34 today, are in danger of collapsing under their own weight, like the high mountains. It seems that the Biking–Metro–Walking model, the BMW model, as urban planners playfully have named it, is perhaps the only solution for a livable city, supporting a more natural way of life. However, that requires again enormous quantities of raw materials and huge public interest investments in order to build an efficient subway system. The problem of social inequalities is also evident here. Africa, for example, is a glaring proof. The International Association of Public Transport (Union Internationale des Transports Publics [UITP]) reports that only two of the 54 African countries (Algeria and Egypt) have a metro system.

The book of Antonis Mavropoulos and Anders Waage Nilsen has the advantages of, first of all, asking the right questions, of the multidimensional analysis, and of searching for real, “out of the box” answers. If you are looking for a “handbook” on waste management in the new era, you may feel uncomfortable with the number of definitive answers in relation to the questions raised. But if you, like me, are tired of the same answers served with a different wrapper each time, you will enjoy the fresh oxygen of original thinking.

Dimitris Kaliampakos
Dean of the School of Mining and Metallurgical Engineering at the
National Technical University of Athens
President of the Associated research Centers for the
Urban Underground Space (ACUUS)

Foreword

by Erik Solheim

GETTING OUT OF THE COVID-19 CRISIS

A New, Better, and More Circular World Is Possible and Necessary

Moving from a linear to a circular economy is a no brainer. It is not a matter of *if*, but of *how*.

By the midst of this century we will be 10 billion people on our planet, Earth. We strive to bring everyone into the global middle class, to enjoy life, free of extreme poverty, in good health, educated, and with a decent living standard. Our aim is to leave no one behind. The planet simply doesn't provide the resources for the realities of this ambition at the present level of inefficiency in our economies.

We need to treat waste as resources for new products, rather than, yes, waste.

Whales, sea birds, and turtles are dying from plastic waste. Slum dwellers perish from sewage systems choked with plastics. Nations declare waste emergencies and see plastic pollution as a major economic threat because tourists are not flocking to beaches overflowed with plastics. The miracle material of plastics, which once was heralded as the eighth wonder of the world, is turned into a menace.

In this important book (*Industry 4.0 and Circular Economy*), Antonis Mavropoulos and Anders Waage Nilsen present us the choice between a wasteless future and a wasteful planet.

The authors set us on the track to the wasteless future of a true circular economy. The book answers practical questions as regards waste management. At the same time, their book guides us through the wider societal issues of social justice, creation of much needed jobs, and an ecological civilization. The benefits of the circular economy are there to be reaped.

Let's just do it.

The twentieth century was marked by a rather unfruitful debate between economists and ecologists. The economists would point to the fantastic global progress since the first industrial revolution occurred in the United Kingdom in the 1780s. At that time life expectancy on the planet was around, or may be even below, 30. Now it's 72. Also, extreme poverty has gone from being the global rule to the fate of a suffering but small minority. Experts will argue the price to be paid was environment degradation, pollution, the destruction of ecosystems, and climate change.

The very good news is that this is a debate of the past. There is no longer a choice to be made between environment and prosperity.

When the price of renewables like solar and wind creeps below the price of coal, we are on to a stellar shift. A green, sustainable economy is for the first time in human history open to us. If we want to reap the benefits the technologies bring us and at the same time protect Mother Earth, the circular economy is an important part of this puzzle.

Why do we waste plastics everywhere rather than see used plastics as a raw material for new plastics, or for fuel or for energy? How long will we buy a computer or cellphone built from virgin material when the old one goes broke or we desire a new fashion? Why don't we recover the components of the old equipment and use them in the new, establishing at least in theory an endless loop of innovation and improvements?

Today a third of all food produced globally is wasted, at a time where still too many humans go to bed hungry. Of course, we can avoid food loss, and we just need to see it as a priority.

Time has come to establish a truly circular economy. It's also time we avoid and abandon products we simply don't need.

I am writing this in the midst of the corona crisis. The virus has brought some unintended environment benefits. Climate emissions haven't been so low in decades. Pollution is way down in cities around the globe; Indian skies are so clear that many Indians can even see the Himalayas for the first time. Wild animals are roaming our cities. Penguins are seen walking in empty Cape Town streets and wild bears in Barcelona; wild Turkeys are coming out in California, deer in Japanese towns, and wild goats in the United Kingdom. American conservationists speak about wildlife having a party in empty national parks like the Yosemite.

Emerging out of the crisis, our challenge is not to restore the world as it was when we embarked upon the critical year of 2020 but like the authors of this book to impress upon ourselves that a new and better world is possible.

The economic stimulus packages and global politics should focus on the green exit from the crisis. Moving toward a circular economy is at the core of that.

Mavropoulos and Waage Nilsen are right in showing the many opportunities arising from artificial intelligence, big data, block chain, and every other corner of the digitized economy of the future.

The circular economy is critically linked to the fourth industrial revolution. The main technological and economical quantum leaps happening in front of our eyes give major tools for a circular economy.

The current crisis enhances the current trends. We get used to get clothes, electronics, and pizza delivered by the Alibaba and the Amazon of this world. We get used to consult medical expertise over the net rather than by face-to-face encounter. We now know from experience that meetings conducted at Zoom, Teams, or WeChat will not replace all physical meetings, but surprisingly many of them. While staying at

home, we did not buy new vehicles or a new dress for every party. There were none. It is likely that the sharing economy will take off. We have experienced the pains of social distancing, but the crisis has also opened new and exciting opportunities for the future.

Of course, there is no real choice between a circular economy and wasteful planet. A circular economy is feasible, desirable, and necessary. The wasteful planet does not work for us. In the end it makes our beautiful planet inhabitable.

The wealth of ideas, numbers, and arguments in this book will help us get there.

Erik Solheim

Former Minister of Environment and Development, Norway

Former Executive Director, UN Environment Programme

CEO, Plastic REvolution Foundation

Series Preface

As the world's population, and with it the amount of resources we consume, continues to grow, it becomes ever more important to properly manage the "waste" that is generated by this growth. With the expanding volume and complexity of discarded domestic and industrial waste, and changing household consumption patterns, waste management is fast becoming one of the key challenges for the modern society.

According to some estimates, up to 2 billion people lack access to sound waste management. Uncollected municipal waste that ends up at illegal or improper dumpsites close to waterways and coasts generates marine litter, affecting marine ecosystems as well as the fishing and tourism sectors. Marine litter is primarily caused by the improper management of waste on land, which finds its way into the marine environment. Dumpsites, again caused by the improper collection and management of waste, can be sources of greenhouse gases and other short-lived climate pollutants. It is therefore recognized that the inadequate removal and treatment of waste poses multiple threats to human health and the environment. Particularly in low- and middle-income countries, open dumping and burning close to urban centers represent a substantial threat to human health and climate. However, advanced economies have shown that through effective waste management it is possible to significantly reduce these impacts and even, through recirculation of the materials in waste back into the production of new goods, minimize the broader impacts associated with consumption. Hence, the proper management of waste and resources is critical to successfully realizing several of the Sustainable Development Goals set out by the UN in 2015.

A sound and sustainable waste management system is a fine balance of a number of elements – technical, legislative, financial - carefully planned to unlock the economic potential of waste, including the creating of new jobs and development of new enterprises.

This series of books will address a range of topics that are integral to sound waste management systems. This will include technical solutions for waste collection and treatment, as well as addressing financing opportunities and the value of waste management, organizational and management challenges, and policy development and enforcement. The series will also explore global trends like the 4th Industrial Revolution and how it can transcend boundaries and can have an impact on both high- and low-income settings when it comes to waste management. Moreover, the books will emphasize the need to adopt a holistic view of waste management by considering the total waste system, and then developing the most appropriate mix of infrastructure and services to manage the specific waste streams.

This series will stress the importance of well-planned and well-managed waste management systems and will highlight the centrality of waste management within all spheres of human activity. It will attempt to bring into focus how waste management links to the climate, human health, resources, the environment and various other aspects.

Björn Appelqvist

Chair of the ISWA Scientific and Technical Committee (STC)

Any opinions expressed in this publication are solely those of the authors. They do not necessarily reflect the opinions or standpoints of ISWA, or its members, on any specific issue – unless explicitly stated.

Preface

The idea for this book was firstly conceived during a wet but not so cold afternoon in Bergen, Norway by the end of November 2016. I (Antonis) had been invited to make a lecture on the fourth industrial revolution and the future of waste management by Avfall Norge, the national member of ISWA in Norway, and after my lecture I got involved in a very interesting discussion with Toralf Igesund, head of planning at BIR, Bergen's waste management company. The discussion was so interesting that we decided to continue it in a nice but rather dark coffee shop, few blocks behind the Radisson hotel in Bergen. Since then, and for the next four years, the idea for this book was getting more mature but also more difficult, because the fourth industrial revolution was unfolding so fast and, at the same time, the circular economy narrative was actually reshaping the waste management policies. But by September 2019, the final decision was made to proceed with a book, although not with the same content we were imagining in 2016. The decision was to combine the fourth industrial revolution with circular economy and try to portray the new landscape that is formulated not only for the waste sector but also for the whole world. In this crucial moment, Toralf introduced me to Anders Waage Nilsen, a business developer, design strategist, investor, technology columnist, and public speaker, who likes the combination of big ideas and hands-on practical work. After some minutes of discussion, we easily concluded that the book will be written by me and Anders, although Toralf has also contributed a lot with ideas and information.

Writing this book was a great adventure for both of us, a trip to the unknown, which seems to be known but is not, a rush through the Symplegades rocks. On the one side the anxiety and the responsibility to keep the deadlines – on the other side the anxiety and the responsibility to write something good enough, well documented, and valuable.

The completion of this book in time was an achievement. As all human achievements, it is by definition imperfect. But we also went further than we expected, discovering things about science, and ourselves, that we did not know. In this effort, we had the pleasure to work with Nick Rigas, a very creative designer who takes deadlines very seriously. Nick was not only patient enough to manage several cycles of changes and corrections, but he also contributed substantially with his visual creativity to the final outcome and the graphics of this book. Without his contribution, the book would be less interesting and certainly, less visually attractive.

Writing this book, we had in mind that we have to express our opinion, as Gustave Flaubert suggested: “The art of writing is the art of discovering what you believe.” The result is now in your hands or in your screens and you will make your own evaluation about the book – from our side, we hope that you will enjoy it and find it useful.

Athens and Bergen, March 2020

Antonis Mavropoulos
Anders Waage Nilsen

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About the Authors

Antonis Mavropoulos is a chemical engineer that was prepared for a career in quantum chemistry and optoelectronics but, in a mysterious way that is still subject of scientific research in psychology, he found himself in the field of waste management. He is obsessed with social change and innovation, and he believes that the fourth industrial revolution provides an historical opportunity to reshape human societies and their environmental footprint. Professionally, he is a waste management consultant with working experiences in 30 countries, and he has founded D-Waste, a company that aims to make waste management services accessible to everyone that needs them. He has invented the Waste Atlas, designed several mobile apps and information systems, and written many papers and reports. He was privileged to serve the International Solid Waste Association (ISWA) as the chair of the Scientific and Technical Committee (2008–2016) and as the president (2016–2020). He is also a member of the advisory board of UNEP's International Environmental Technology Centre. All his writings can be found at his blog wastelessfuture.com.

Anders Waage Nilsen is a business developer, design strategist, investor, technology columnist, and public speaker. He likes the combination of big ideas and hands-on practical work, because the big picture is made from the important details. During his career, he founded several companies, events, and not-for-profit initiatives. He started out as a newspaper journalist and then founded Fri Flyt skiing magazine, which turned into the leading publisher of sports/outdoor magazine in Norway. He also founded Fjellfilmfestivalen (mountain film festival), Stormkastkonferansen (business conference), and Netlife Bergen (design agency). For some years, he worked with the business cluster projects NCE Tourism and MediArena (currently known as NCE media). In 2018, he co-founded NEW, a business building new start-ups with industrial partners. He focuses on high-impact business ideas. Currently, he is developing WasteIQ – a digital platform for public waste management, based on open standards and IoT integrations. He believes that a data-driven resource management is necessary to create circular business models and new behavioral incentives.

About the Graphic Designer

Nick Rigas is a graphic designer, with a master of arts and a bachelor's degree in animation and interactive media. Besides being a creative designer, he used to play the guitar in rock music groups, and when he was younger, he was playing basketball too. He has designed almost everything, from websites, logos, books, reports, and infographics till mobile applications and T-shirts. For the last eight years he is working as the master designer in D-Waste.

