

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.

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