Future Outlook

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Abstract Given the crisis humanity is facing today, this chapter urges all stakeholders to take coherent action today and tomorrow for the transition to a circular economy. To help readers visualize a circular economy of the future, it provides a scenario of a circular economy in a community where both biological and technical cycles are closed; renewable energy drives transportation, production, and consumption. The community take care of the health of themselves and their environment and practice 6 Rs (re-use, repair, refurbish, remanufacture, recycle and recover) along the life cycle of a product at personal and professional levels. Circular supply chain is mapped. The chapter further summarizes circular economy transition enabling factors such as life cycle thinking, materials passports, and ubiquitous digitization to become integral of industries and services. In addition, it addresses the challenges ahead and concludes on the importance of education for providing circular economy workforce.

Keywords Renewable energy · Circular economy · 6Rs · Stakeholders · Action · Circular economy · Transition · Biological cycle · Technical cycle

At the time of writing this book, the world population is close to eight billion people (https://www.worldometers.info/world-population/). Assuming a growth rate of one percent per year, about eighty million people per year are added to the total population. In other words, an equivalent of Germany’s population is added to the world every year. As per the current projections, the world population will reach ten billion people in the year 2057. The World Health Organization (WHO) recorded that the urban population in 2014 accounted for 54% of the total global population, and the urbanization trend is projected to grow further in the coming decades (https://www.who.int/gho/urban_health/situation_tre
The world economic forum forecasts that over the coming decades the rural to urban migration will continue to shoot up to six billion by 2050 (https://www.weforum.org/agenda/2019/09/mapped-the-dramatic-global-rise-of-urbanization-1950-2020/). The urbanized population will continue to shape the global economy via increased spending and consumption of products and services as they seek better comforts and happiness. In other words, the Earth needs to provide for more resources and accumulate waste and pollution, if the humanity to continue the current path of modern-society. The gravity of this situation is grasped by the Earth Overshoot Day calculated by an international research organization called the Global Footprint Network (https://www.overshootday.org/about-earth-overshoot-day/). Earth Overshoot Day is defined as the date when humanity’s demand for ecological resources and services in a given year exceeds what Earth can regenerate in that year. In 2019, the Earth Overshoot Day was on July 29. In 1987, the Earth Overshoot Day was on October 23. In other words, with growing consumption the Earth Overshoot Day is getting shorter and shorter. Aforementioned facts clearly indicate that the humanity has no choice but to transition from the modern-society to new-modern society. Desired characteristics of the new-modern society encompass the visions of circular economy and sustainability development and growth. Simply put it is an economic system aimed at eliminating waste and the continual use of resources (https://en.wikipedia.org/wiki/Circular_economy). If we adopt the Ellen MacArthur Foundation definition of circular economy, it is a systemic approach to economic development designed to benefit businesses, society, and the environment (https://www.ellenmacarthurfoundation.org/explore/the-circular-economy-in-detail). A circular economy practitioner, Metabolic company describes it as a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries (https://www.metabolic.nl/about/our-mission/). In other words, in the new-modern society resources and consumption are not constraints for growth and higher standards of living, thus suited for the ever-growing world population.

Given the aforementioned background, what would be the future outlook? A circular economy transformation requires all stakeholders to act coherently toward the same direction. Figure 1 represents stakeholders involved in the circular economy. Table 1 summarizes the action of different stakeholders today and tomorrow for a circular economy transformation.

A circular economy transition is undergoing three streams:

1. **Continue to Improve clean production through reduction in resource extraction, energy consumption, wastage, and emission.**
2. **Practice 4Rs (Refuse, Reduce, Reuse, and Repair) at the consumer site and 6Rs (Reuse, Repair, Refurbish, Remanufacture, Recycle, and Recover) at the production site.**
3. **Redesign product, provide function to Serve the needs of consumer.**
The economic transition provides business opportunities in all sectors along the life cycle of a product. It also demands R&D innovations and drives business model innovations. To accelerate the transition, it needs regulations and monitoring and assessment. Most importantly, it requires life cycle thinking and circularity/sustainability mindset that drives the power of consumers as well as the stakeholders’ action.

Products (from materials, component, module to system) and manufacturing processes are designed to reduce/eliminate waste. They are to retain the highest value for the longest time. Components and materials are reused, repurposed, remanufactured, and recycled. Maximum usage of energy, water, and materials are from renewable sources. Producers offer services and establish close relationships with consumers to build a business that is environmentally, socially, and economically sustainable. Consumers, driven by life cycle thinking and sustainability mindset, practice sustainable consumption achieving zero waste and choosing sustainable products. Digital technologies are adopted to provide continuous monitoring and assessment and guide both consumers and producers to ensure circularity and sustainability at local and global levels.

To help readers visualizing circularity of the future, Fig. 2 presents a scenario of a circular community where energy sources are renewable including solar, wind, and hydro managed by a community micro-grid; mining and production sites are practicing circularity with remanufacturing, recycle and recovery processes built in; consumers are practicing sustainable consumption with zero waste through composting organic food and packaging materials to fertilize the community gardens/farms; consumers receive communication, energy, and transport services from providers who will practise reuse, repair, refurbish, and resale. See Fig. 3 for the circular supply chain representation mapped in Fig. 2.
Table 1  Summary of circular economy stakeholders action today and tomorrow

| Type          | Today working action                                                                 | Tomorrow action                                                                 |
|---------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Policy-makers | 1. CE policy framework  
2. Regulations-EPR  
3. Promote best practices | 1. Prioritize funding programs to support PPP for circularity solutions and sustainable financing  
2. CE entrepreneurship ecosystem building  
3. Adopting digital technology for circularity/sustainability monitoring and assessment  
4. iEPR implementation  
5. Regional and global CE coordination |
| Investors     | Sustainable/ESG financing                                                             | Scaling up circular and sustainable financing                                     |
| Researchers   | 1. Open innovation platform  
2. Green Chemistry for processing, recycling, and recovery  
3. Bioeconomy focusing on bio-base materials  
4. Energy efficiency technology and solutions | 1. Prioritize R&D areas and industry partnership along the value chain focus on scalable solutions for circularity and sustainability  
2. Circular product design  
3. Applying digital tech and AI |
| Educators     | CE experiential modules, programs both online and offline                               | 1. LCA thinking is imbedded in all education program  
2. Training CE educators  
3. Entrepreneurship training for circularity and sustainability |
| Producers     | Large and small corp  
Industry symbiosis, environmental compliance and EPR, remanufacture, recycle, recover | 1. Product service provider with zero waste by design, remanufacturing, recycling, and recovery  
2. Workforce upskills  
3. Partnership with the circularity ecosystem  
4. Sustainability/ESG compliance in every part of the value chain |

(continued)
| Type               | Today working action                        | Tomorrow action                                                                 |
|--------------------|---------------------------------------------|--------------------------------------------------------------------------------|
| Service provider   |                                             |                                                                                |
| Logistics          | Green packaging, decentralization            | 1. Zero emission transportation                                               |
|                    |                                              | 2. Adoption of digital technology to achieve transparency and efficiency       |
|                    |                                              | 3. Minimizing logistics through onsite production and consumption             |
| Retail             | Resale                                      | Digital “farmer’s market” platform bringing producer and consumers together   |
| End of product life| Repair, repurpose, refurbish                | No end of product life                                                        |
| Waste management   | Sustainable waste management                | 1. Waste minimization included in product design and processing               |
|                    |                                              | 2. Waste composting onsite of community garden                                |
|                    |                                              | 3. Repair and refurbish of used products                                       |
| Consultancy        | 1. CE advisory on strategy and implementation| Deploy digital technology such as IoT, big data analytics, and digital twins for monitoring and assessment |
|                    | 2. Developing circularity indicators for monitoring and assessment                        |                                                                                |
| Consumers          | 1. Refuse, reduce, reuse (3R)                | Making sustainability personal: 3R +Repair, practising gardening and community farm, become a sustainable and zero waste consumer |
|                    | 2. Green Choice, Minimize waste             |                                                                                |
| Media              | 1. Reporting on all circularity practices at mainstream and social media                | 1. Focus on sustainability broadcasting                                        |
|                    | 2. Build relationships with stakeholders to promote circularity                        | 2. Promote harmony between nature and human society                            |
|                    |                                              | 3. Featuring sustainable business practices                                    |
Moving ahead, life cycle thinking, materials passports, and ubiquitous digitization are integral of industries and services. More pervasive use of life cycle assessment, life cycle costing, and symbiosis methodologies to deeply understand the resources flow and trade-offs to implement policy and leadership interventions that would drive the new-modern society transition. Bottlenecks for the transition include lack
of quality information and data, which are often proprietary and business confidential; transparency in regulations and incentives implementation; maturity of governing international and national standards and frameworks; and risk attitude toward new business models. Such challenges will be overcome as there is growing awareness from the public, pressure from the NGOs and more importantly humanity is capable of innovation in the face of necessity for sustainable survival.

Last, not the least, fostering the next generation of circular economy workforce is most critical for driving humanity toward a sustainable future. We hope this book inspires youth leadership with knowledge and entrepreneurship to transform our society and economy toward sustainability.

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Dr. Lerwen Liu specializes business development and education in the emerging technologies, circular economy and sustainability. She focuses on strategic development, assessment, and support of emerging technologies including nanotechnology and Artificial Intelligence with applications in all sectors. She has 20 years of practices in global business development in strategic partnership & communication and marketing. She has worked in both the developed and developing world focusing on youth leadership and entrepreneurship development toward sustainability.

She was a founding secretary of Asia Nano Forum supporting strategic development of Nanotechnology in 17 countries in the Asia Pacific region. She founded the STEAM Platform in 2018 focusing on youth empowerment with convergent STEM knowledge, strategic communication skills, and entrepreneurship for SDGs2030, Circular Economy and Industry 4.0. She has been an invited expert in nanotechnology, innovation, entrepreneurship, and circular economy by different agencies in the United Nations, Islamic Development Bank, Asia Development Bank (ADB), and other government bodies. She has co-founded a number of emerging technology start-ups and mentored hundreds of youth leaders in Asia.

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Professor Seeram Ramakrishna FREng, Everest Chair (https://www.eng.nus.edu.sg/me/staff/ramakrishna-seeram/), is among the top three impactful authors at the National University of Singapore, NUS (https://academic.microsoft.com/institution/165932596). NUS is ranked among the top five best global universities for engineering in the world (https://www.usnews.com/education/best-global-universities/engineering). He is the Chair of Circular Economy Taskforce. He is a member of Enterprise Singapore’s and ISO’s Committees on ISO/TC323 Circular Economy and WG3 on Circularity. He also the Chair of Sustainable Manufacturing TC at the Institution of Engineers Singapore and a member of standards committee of Singapore Manufacturing Federation (http://www.smfederation.org.sg). He is an advisor to the Ministry of Sustainability & Environment—National Environmental Agency’s CESS events, (https://www.cleanenvirosummit.sg/programme/speakers/professor-seeram-ramakrishna; https://bit.ly/catalyst2019video; https://youtube.com/watch?v=ptSh_1Bg11g). European Commission Director-General for Environment, Excellency Daniel Calleja Crespo, said, “Professor Seeram Ramakrishna should be praised for his personal engagement leading the reflections on how to develop a more sustainable future for all”, in his foreword for the Springer Nature book on Circular Economy (ISBN: 978-981-15-8509-8). He is a member of UNESCO’s Global Independent Expert Group on Universities and the 2030 Agenda (EGU2030). He is the Editor-in-Chief of the Springer NATURE Journal Materials Circular Economy—Sustainability (https://www.springer.com/journal/42824). He is an Associate Editor of eScience journal (http://www.keapublishing.com/en/journals/escience/editorial-board/). He is an opinion contributor to the Springer Nature Sustainability Community (https://sustainabilitycommunity.springernature.com/users/98825-seeram-ramakrishna/posts/looking-through-covid-19-lens-for-a-sustainable-new-modern-society). He teaches ME6501 Materials and Sustainability course (https://www.europeanbusinessreview.com/circular-economy-sustainability-and-business-opportunities/). He also mentors Integrated Sustainable Design ISD5102 project students. Microsoft Academic ranked him among the top 25 authors out of three million materials researchers worldwide based on H-index (https://academic.microsoft.com/authors/192562407). He is named among the World’s Most Influential Minds (Thomson Reuters) and World’s Highly Cited Researchers (Clarivate Analytics). Listed among the top three scientists of the world as per the Stanford University researcher study on career-long impact of researchers or c-score (https://drive.google.com/file/d/1bUJrvurVVbxBsI9eFZRSHFif7tt30-5U/view). He is an Impact Speaker at the University of Toronto, Canada Low Carbon Renewable Materials Center (https://www.lcrmc.com/). He is a judge for the Mohammed Bin Rashid Initiative for the Global Prosperity (https://www.facebook.com/Make4Prosperity/videos/innovation-inclusive-trade/479503539339143/). He advises technology companies with sustainability vision such as TRIA (www.triabio24.com),
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