CIRCULAR
ECONOMY
IN CITIES

MAKING PRODUCTS WITH TECHNIQUES THAT ARE DIGITALLY ENABLED AND INCREASINGLY LOCAL

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Production processes, while often efficient – with supply chains spanning the globe – are inherently harmful due to the pollution and waste they generate. Transition to a circular economy production system can provide many solutions to these challenges, particularly when harnessing new digital technologies. The emerging Fourth Industrial era, which is characterised by disruptive digital technologies (e.g. Internet of Things, virtual reality, robotics, and artificial intelligence), offers exciting new production opportunities that can, if used well, support circular economy practices and thereby improve our use of materials.

THE CASE FOR CHANGE

29% of US greenhouse gas emissions result from goods produced in the US[1]

In 2015, CO^2 emissions from global textiles production totalled **1.2 billion tonnes** of CO^2 equivalent – more than combined total emissions of all international flights and maritime shipping[2]

80%

The typical supply chain of a consumer goods company generates a far greater negative environmental impact than its own operations – often accounting for more than **80%** of CO^2 emissions and more than **90%** of the impact on air, land, water, biodiversity, and geological resources[3]

> **"3D printing won't be an innately green manufacturing technology unless we actively seek to make it one. If we can tap into 3D printing's unique capabilities and invent greener printing materials, we will reap environmental benefits in the form of shorter supply chains and a new generation of optimised products."**
>
> Hod Lipson and Melba Kurman, Fabricated: the new world of 3D printing (2013)

EXAMPLES OF CIRCULAR ECONOMY OPPORTUNITIES

Sourcing locally abundant materials

Selecting renewable and non-toxic materials that are locally abundant (including recycled materials and industrial by-products) offers a key opportunity to create local material loops.

Aligning digital manufacturing with circular economy principles

Digital manufacturing (such as 3D printing) and artificial intelligence create exciting new product production opportunities. Manufacturers can produce goods more efficiently with less waste, customise their products to meet unique needs, and shorten their supply chains by printing parts or products on-demand and near their customers.[4] Crucial to taking advantage of these technologies is ensuring that the materials chosen are safe to cycle (e.g, non-toxic) and designed to cycle (e.g, be reused and recycled). Consumer goods companies can also create supply chain transparency by using blockchain-based solutions, which will increase visibility of choices made during the production process.[5] (See *Products: Designing*)

Increasing the distribution of manufacturing in line with circular economy principles

The term distributed manufacturing covers the decentralisation of production in dispersed, localised production facilities. These facilities can be centrally owned or small, independent enterprises. Desk and office-sized digital machine tools (e.g, 3D printers and laser cutters), backed up by digital knowledge sharing, have made small-scale production possible commercially – giving life to the likes of 'the maker movement', and 'fab labs'.[6] When makers follow circular economy principles in their designs and material sourcing, these distributed manufacturing networks can have a powerful impact on the urban product system (See *Products: Designing*).[7]

CASE EXAMPLES

A material recipe library to enable circular production

To create an effective closed-loop products systems, where all materials can go back into use or are returned to nature, it is important that makers use the appropriate materials. Materiom is a non-profit organisation working to support this by creating an extensive material recipe library. The library covers many types of materials including plastics, ceramics, and composites and the recipes use only biological, locally abundant ingredients that can decompose naturally and therefore stay in natural cycles. As the availability of ingredients differs from place to place, the platform is open-source, encouraging everyone to use it and contribute to it.

A joint venture to increase locally available PET recyclates for packaging

Coca-Cola has invested EUR 13 million in two strategic partnerships to increase the recycled content of its plastic bottles. The aim of this venture, called *Continuum*, is to improve the capacity for plastics reprocessing in Great Britain and France. In these countries, around half of the discarded PET plastic is not collected for recycling and much of what is collected is sent abroad for reprocessing – limiting the supply of locally available recycled PET (rPET) with which to manufacture. This joint venture ensures that the increasing demand for rPET can be met. *Continuum* in Great Britain has been operational since May 2012 and is now the biggest plastic bottle reprocessing facility in the world, producing 25,000 tonnes of food-grade rPET a year – double the amount previously produced in the country. The project saves around 33,500 tonnes of CO^2 per year – the equivalent of taking over 15,715 cars off the road – and has created 30 new skilled jobs.[8]

A global design platform for local making

Opendesk is a furniture platform that connects designers, makers, and customers. The customer can select a design on the website and then pick between a range of quotes from local independent workshops that bid to produce the order, eliminating the shipping needs. Each piece of furniture is designed by a designer in the network and consists of modular pieces that can be made on digital plywood cutters in any of the local workshops of the platform. Currently, Opendesk operates in 16 cities across the world and is experimenting with creating closer links with local material suppliers. The model reduces the number of intermediaries and the length of the supply chain while increasing pay for designers and makers and giving customers access to high-quality furniture at more affordable prices.[9]

EXAMPLES OF WHAT URBAN POLICYMAKERS CAN DO

Awareness raising and **capacity building** programmes on circular economy and new distributed production methods for entrepreneurs, small companies, and community initiatives are ways in which urban policymakers can help create new skills, jobs, and innovation opportunities. A key barrier for people to set up makerspaces is the lack of affordable space.[10] Through **asset management policies**, city governments can allocate surplus city-owned space to such activities or incorporate them in existing facilities such as libraries and educational institutions.

To explore further see **Policy Levers**

EXAMPLES OF LINKS TO OTHER SYSTEMS AND PHASES

Products: Planning Effective resource management schemes that enable easy recovery and redistribution of materials and by-products are key to enabling the supply of locally appropriate materials for product manufacturing. Policies that support upstream developments, such as increasing urban manufacturing capacity, also play a role.

Products: Designing Product design decisions can be central to enabling the adoption of new production methods and the use of local materials.

Buildings: Accessing Access to affordable urban space for the making of products can play an important role in nurturing urban manufacturing capacity. Circular economy opportunities such as increased space sharing can alleviate this problem and support inter-business collaboration.

EXAMPLES OF BENEFITS

ECONOMIC PRODUCTIVITY

Reducing manufacturing costs

Studies suggest that 3D printing can reduce manufacturing costs by USD 170–593 billion by 2025 depending on the rate of uptake.[11]

Generating cost savings in the textiles industry

Stimulating automation and 3D printing, water and energy efficiency, and textile recycling, in China's urban textiles industry could decrease the need for virgin materials and other primary resources, while generating CNY 0.3 trillion (USD 48 billion) in savings by 2040.[12]

Increasing urban economic resilience

Greater diversification and localisation of production and feedstock supply can support cities and their inhabitants in becoming more self-sufficient and resilient to changes in global markets.[13]

JOBS, SKILLS, AND INNOVATION

Lowering barriers to market entry

Distributed manufacturing lowers barriers to market entry by reducing the amount of capital required to build the first prototypes and products.[14]

Increasing citizen-centric innovation

Access to affordable digital fabrication tools and expert knowledge, combined with involving users in co-creation, can provide new sources of innovation that derive from citizens.[15]

Accelerating prototyping and development

3D printing for injection-moulding tools helped Unilever to cut lead times for prototypes by 40%.[16]

COMMUNITY AND SOCIAL PROSPERITY

Increasing social cohesion

Distributed production in the form of common maker-spaces, and peer-to-peer learning can support social cohesion and inclusion as less affluent actors have increased opportunities to sustain themselves and grow businesses.[17]

HEALTH AND ENVIRONMENT

Decoupling production from CO^2 emissions

It is estimated that, if 3D printing was applicable to larger production volumes in consumer products, it has the potential to decouple energy and CO^2 emission from economic activity.[18]

Reducing CO^2 emissions in the textiles industry

Stimulating automation and 3D printing, water and energy efficiency, and textile recycling, in China's urban textiles industry could would reduce CO^2 emissions in Chinese cities by 200 million tonnes by 2040 compared with the current development path.[19]

Decreasing embedded freight kilometres

Distributed manufacturing can reduce embedded freight kilometres as digital information is shipped over the web rather than physical products being transported in freight vehicles. In addition, if raw materials are sourced locally, freight is further reduced.[20]

RESOURCE USE

Reducing energy consumption

The energy demand of manufacturing polymer products can be reduced by 41–64% with existing low-cost open-source 3D printers.[21]

Supporting resource efficiency

Additive manufacturing can be a more resource-efficient option because it enables the on-demand production of spare parts, and the reduction or elimination of inventory, production waste, and transportation costs.[22]

Increasing material efficiency in electronics production

Artificial intelligence, such as automated and quality control checks, can help reduce waste in the global production of consumer electronics worth USD 8 billion.[23]

ENDNOTES

1 US EPA, *Climate change and waste* (2009). This includes the extraction or harvest of materials production and transport of goods, provision of services, reuse of materials, recycling, composting, and disposal.

2 Ellen MacArthur Foundation, *A new textiles economy: redesigning fashion's future* (2017) p. 20

3 McKinsey, *Starting at the source: sustainability in supply chains* (2016)

4 Ellen MacArthur Foundation/Google, *Artificial intelligence and the circular economy* (2019)

5 Blockchain can be described as a 'chain' of 'information/ data blocks' put together in a ledger in the cloud (a bit like a Google excel sheet). All relevant stakeholders can access the ledger and submit information each time a transaction occurs. For example, when a material or product passes hands, moves on to the next production stage or changes in some way, new blocks are added onto the end of the digital 'product information chain', allowing a complete overview of the life cycle of that product. It has the advantage that the ledger is decentralised and thereby information cannot, once logged on the blockchain, be changed or modified. *Source:* Design-Longevity, *Blockchain Information Technology* (n.d.)

6 A fab lab (fabrication laboratory) is a small-scale workshop offering (personal) digital fabrication and was set up by Massachusetts Institute of Technology with the mission to allow anyone to make (almost) anything. The Fab Lab programme has developed into a global community of designers, makers, and learners. To learn more see: www.fabfoundation.org, World Economic Forum, *Top 10 emerging technologies of 2015*, weforum.org (4 March 2015)

7 With 3D printing for example, it is possible to use less material with minimal waste in prototyping and production compared to traditional manufacturing. As customised products can be made on the spot the need for freight and spare part stocks can also be reduced. Z. Liu *et al.*, *Sustainability of 3D printing: a critical review and recommendations* (2016) p. 3

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10 J. Warden, *Making space for manufacturing in the city*, Royal Society for the encouragement of Arts, Manufactures and Commerce (11 May 2018)

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12 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018)

13 OECD, *Enhancing the contributions of SMEs in a global and digitalised economy* (2017) p. 6

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15 K. Fleischmann *et al.*, *Making things in Fab Labs: a case study on sustainability and co-creation*, Digital Creativity (2016), p. 128

16 C. Wyman, *Unilever accelerates consumer product prototyping by 40% with 3D printed injection molds*, Stratasys (20 January 2015)

17 S. Leyronas *et al.*, *How fab labs help meet digital challenges in Africa*, The Conversation (4 July 2018); International Development Norway, *FabLab based concept as a way to social inclusion* (NGO sector), id-norway.com (n.d.)

18 M. Gebler *et al.*, *A global sustainability perspective on 3D printing technologies*, Energy Policy (2018)

19 Ellen MacArthur Foundation, *The circular economy opportunity for urban and industrial innovation in China* (2018) p. 101

20 World Economic Forum, *Top 10 emerging technologies of 2015,* weforum.org (4 March 2015),

21 Z. Lieu *et al.*, *Sustainability of 3D printing: a critical review and recommendations*, conference paper (2016)

22 Z. Lieu *et al.*, *Sustainability of 3D printing: a critical review and recommendations*, conference paper (2016)

23 Ellen MacArthur Foundation/Google, *Artificial intelligence and the circular economy* (2019) p. 27